SHAPES

Smart and Healthy Ageing
through People Engaging in supporting Systems

D5.3 – SHAPES Digital Solutions V2

Project Title	Smart and Healthy Ageing through People Engaging in Supportive Systems
Acronym	SHAPES
Grant Number	857159
Type of instrument	Innovation Action
Topic	DT-TDS-01-2019
Starting date	01/11/2019
Duration	48

Work package	WP5 – SHAPES Digital Solutions
Lead authors	Marco Manso, Barbara Guerra, José Pires (EDGE)
Contributors	George Bogdos (FINT), Liverios Stavropoulos, Dimitris Patelis, Fotis Gonidis and Thomas Tsouskos (GNO), María José Santofimia and Xavier del Toro (UCLM), Óscar Villacañas Pérez (CH), Sara Cooper (PAL), Jorge Fontenla, Joaquín García and Adrián Menéndez (TREE), Luis Unzueta Irurtia, Manex Serras Saenz, Meritxell García Perea and Nekane Larburu Rubio (VICOM), Wai Hang Shek (OMN), Ioanna Dratsiou, Annita Varella and Evangelia Romanopoulou (AUTH), Ana Isabel Martins, Anabela G. Silva and Telmo Silva (UAVR), Tereza Norbertova and Ladislav Stanke (FNOL), Lucia D'Arino (WFDB), Frankie Picron (EUD)
Peer reviewers	Simone Schmitz, Sonja Grigoleit and Diana Freudendahl (FhG), Rudi Villing (NUIM)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Version	V1.0
Due date	M24 – 30/10/2021
Submission date	30/10/2021
Dissemination Level	PU Public

Revision History

Table 1 - Revision History

Revision #	Date	Editor	Comments
0.1	26/05/2021	Marco Manso (EDGE)	ToC and creation of new document structure
0.2	04/06/2021	Barbara Guerra (EDGE)	Introductory comments in new sections
0.3	04/07/2021	Barbara Guerra (EDGE)	Contributions from participating partners concerning their specific digital solutions.
0.4	07/10/2021	Barbara Guerra and Marco Manso (EDGE)	Final integration of partners' contributions and preparation for reviews
0.5	15/10/2021	Simone Schmitz, Sonja Grigoleit and Diana Freudendahl (FhG)	Internal Review
0.6	18/10/2021	Rudi Villing (NUIM)	Internal Review
0.7	22/10/2021	Barbara Guerra (EDGE)	Processing of reviewers' comments
1.0	27/10/2021	Barbara Guerra and Marco Manso (EDGE)	Final version to be submitted

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table of Contributors

Table 2 - Deliverable Contributors

Section	Author(s)
Table of Contents	Marco Manso (EDGE)
1 Introduction	Barbara Guerra (EDGE)
2 SHAPES Digital Solutions	Barbara Guerra (EDGE)
3 Digital Solutions for an Intelligent Living and Care Environment	George Bogdos and Anargyros Sideris (FINT), Barbara Guerra, Marco Manso and José Pires (EDGE), Wai Hang Shek (OMN)
4 Application Suite for Healthy Ageing	Liverios Stavropoulos, Dimitris Patelis, Fotis Gonidis and Thomas Tsouskos (GNO), Ioanna Dratsiou, Maria Metaxa and Evangelia Romanopoulou (AUTH), María José Santofimia (UCLM), Óscar Villacañas Pérez (CH), Wai Hang Shek (OMN), Ana Isabel Martins, Anabela G. Silva and Telmo Silva (UAVR)
5 Robotics and Assistive Technologies	Sara Cooper (PAL), Jorge Fontenla, Joaquín García and Adrián Menéndez (TREE), Luis Unzueta Irurtia and Manex Serras Saenz (VICOM), Wai Hang Shek (OMN)
6 Decision Support, Risk Assessment and Prediction Services	Jorge Fontenla, Joaquín García and Adrián Menéndez (TREE), Meritxell García Perea and Nekane Larburu Rubio (VICOM)
7 Solutions for Health and Care Service Providers	Liverios Stavropoulos, Dimitris Patelis, Fotis Gonidis and Thomas Tsouskos (GNO), Ioanna Dratsiou, Annita Varella and Evangelia Romanopoulou (AUTH)
8 Lifestyle Management and Wellbeing Assessment Solutions	Meritxell García Perea and Nekane Larburu Rubio (VICOM), Jorge Fontenla, Joaquín García and Adrián Menéndez (TREE), Tereza Norbertova and Ladislav Stanke (FNOL)
9 Security Assessment as a Service	-

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

10 COVID-19 Response Digital Solutions	Barbara Guerra and Marco Manso (EDGE), Liverios Stavropoulos, Dimitris Patelis, Fotis Gonidis and Thomas Tsouskos (GNO), Sara Cooper (PAL)
11 SHAPES Front-end App	Marco Manso and José Pires (EDGE)
12 Conclusion	Barbara Guerra (EDGE)
13 Ethical Requirements Check	Barbara Guerra (EDGE)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table of Acronyms and Abbreviations

Table 3 - Acronyms and Abbreviations

Acronym	Full Term
ADL	Activity of Daily Living
AELTD	Access Earth Limited
AI	Artificial Intelligence
API	Application Programming Interface
App	Application
ASAPA	Authentication, Security and Privacy Assurance
AUTH	Aristotle University of Thessaloniki
BLE	Bluetooth Low Energy
CH	Clínica Humana
CO_2eq	Carbon Dioxide Equivalent
COPD	Chronic Obstructive Pulmonary Disease
COVID-19	COronaVIrus Disease 2019
CPU	Central Process Unit
DNN	Deep Neural Network
DS	Digital Solutions
EAR	Eye Aspect Ratio
EDGE	EDGENEERING Lda
eHealth	eletronic Health
EHR	Electronic Health Record
EUD	European Union of the Deaf
FHIR	Fast Healthcare Interoperability Resources
FINT	Future Intelligence Limited
FNOL	University Hospital Olomouc
GDPR	General Data Protection Regulation
GP	General Practitioner
GNO	GNOMON Informatics SA
GW	Gateway
HF	Heart Failure
HL7	Health Level Seven
HMU	Hellenic Mediterranean University
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technologies
ID	IDentification
IMU	Inertial Measurement Unit

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Acronym	Full Term
IoT	Internet of Things
JSON	JavaScript Object Notation
KOM	KOMPAI Robotics
MARS	Medication Adherence Report Scale
MDBS	Medical Database Solution
MedSyn	MedicalSyn GmbH
MQTT	Message Queuing Telemetry Transport
MS	Multiple Sclerosis
MVP	Mobile Virtual Patients
NFC	Near Field Communication
NGIS	Next Generation Service Interfaces
NLP	Natural Language Processing
OMN	Omnitor AB
PAL	PAL Robotics SL
PT	Pilot Theme
REST	REpresentational State Transfer
ROS	Robotics Operating System
SAREF	Smart Applications REFerence
SciFY	Science for You
SDK	Software Development Kit
TLS	Transport Layer Security
TREE	Tree Technology SA
TRL	Technology Readiness Level
UAVR	Universidade de Aveiro
UC	Use Case
UCLM	Universidad de Castilla - La Mancha
ULS	University of Ulster
UNRF	University of Nicosia Research Foundation
URL	Uniform Resource Locator
VICOM	Vicomtech
VPS	Virtual Patient Scenarios
WCAG	Web Content Accessibility Guidelines
WebRTC	Web-based Real Time Communications
WFDB	World Federation of the Deafblind
WiFi	Wireless Fidelity
WP	Work Package
YOLO	You Only Look Once

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Keywords

Digital Solutions, intelligent living, remote monitoring, accessibility tools, COVID-19 response, older persons, data analytics, predictive systems.

Disclaimer

This document contains information which is proprietary to the SHAPES consortium. Neither this document nor the information contained herein shall be used, duplicated or communicated by any means to any third party, in whole or parts, except with the prior written consent of the SHAPES coordinator.

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

List of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

List of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Executive Summary

This document presents the SHAPES Digital Solutions that specifically address users' requirements and expectations on the use of innovative technologies to support and extend older people's independent living and active and healthy ageing at-home. In particular, this document provides an overview and the main outcomes of the work performed by the SHAPES Consortium on the different tasks of Work Package 5 – SHAPES Digital Solutions for a period of twelve months (from month 13 or November 2020 to month 24 or October 2021).

Based on the system specifications identified for the SHAPES Platform in WP4 – Building the SHAPES Technological Platform, which considered the user requirements defined in WP3 and ethical principles and requirements compiled in WP8, this document updates deliverable *D5.2 – SHAPES Digital Solutions V1* with the work developed in the past year by the SHAPES partners to adapt and develop their digital solutions to meet the needs, requirements and expectations of the seven pilot themes and associated use cases forming a sound basis for the SHAPES large-scale piloting campaign, while enriching the SHAPES digital solutions ecosystem. From telecare systems to wearables and sensors, memory aids, virtual assistants, visual and communication aids and service and companion robots, SHAPES digital solutions aim to capture the greatest possible breadth of the SHAPES technological capabilities in realistic conditions, involving different stakeholders across Europe.

Following an introductory chapter presenting this document and its rationale, the second chapter provides an overview of the SHAPES ecosystem of digital solutions and their main areas of application, whereas the following seven chapters focus on the SHAPES digital solutions considered by Tasks 5.2 through 5.8, respectively. Hence, chapter 3 presents the Digital Solutions for an Intelligent Living and Care Environment addressed in Task 5.2; chapter 4 reveals the Application Suite for Healthy Ageing tackled in Task 5.3; chapter 5 introduces the Robotics and Assistive Technologies approached in Task 5.4; chapter 6 highlights the Decision Support, Risk Assessment and Prediction Services pertaining to Task 5.5; chapter 7 enunciates the Solutions for Health and Care Service Providers adopted in Task 5.6; chapter 8 identifies the Lifestyle Management and Wellbeing Assessment Solutions developed in Task 5.7; and chapter 9 notes the Security Assessment explored in Task 5.8. In addition, the SHAPES ecosystem of digital solutions was enriched with the COVID-19 Response Solutions described in chapter 10 and with the SHAPES Front-end App, a new development tackled in chapter 11 to facilitate the users' interaction with the different digital solutions in the SHAPES ecosystem, during the SHAPES large-scale piloting activities. The remaining of the document includes a concluding chapter, an ethical requirements' checklist chapter and a bibliographical references chapter.

The key innovation attained in the WP5 work activities, and reflected in this document, is the adoption of robust co-design and co-development practices that, joining technical partners and end-users, have enabled the in-depth adaptation of the SHAPES Digital Solutions to be well-aligned with the goals set out for the SHAPES pilots and use cases and with the SHAPES results concerning the understanding of the older people life worlds and the social-technical characterisation of the organisations within the SHAPES ecosystem. Transversally to the digital solutions herein presented, the new sections in this document account for the transformation on the SHAPES partners' digital solutions throughout the concept and ideation, design and development and prototyping and adaptation stages, as applicable to support the pilot themes and associated use cases. Further, it is also innovative the concept of the SHAPES Front-end Application, a creative form to enable a user-friendly navigation among the different SHAPES Digital Solutions supporting the piloting activities.

Deliverable *D5.3 – SHAPES Digital Solutions v2* is the intermediate result of WP5 and reflects the prevailing project's multidisciplinary work synergies, delivering on the clear objective of presenting a panoply of digital solutions with the potential to empower older people to optimise their health, mental and physical wellbeing and participate in civic life, while maintaining a degree of independence as they age.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

1 Introduction

Deliverable *D5.3 – SHAPES Digital Solutions V2* adds to the description of the different Digital Solutions (DS) to be used in the SHAPES Project a detailed presentation of the work performed by the SHAPES partners in WP5 tasks for the past year to transform their respective DS to meet the applicable system specifications, user requirements and ethical principles and requirements and to support adequately the proposed SHAPES large-scale piloting activities.

The SHAPES Digital Solutions aim to support older people as they embrace independent living and active and healthy ageing at home, covering a wide spectrum of assistive technologies such as assisted living platforms, online communication and accessibility tools, cognitive stimulation and rehabilitation programmes, conversational assistants and chatbots, robots telehealth and remote monitoring platforms, security solutions and COVID-19 response tools, as well as data analysis solutions in the domains of predictive systems, anomaly detection and wellbeing assessment. For the past twelve months, these digital solutions have been adapted/improved to meet the SHAPES user requirements and needs and to enable integration in support of different pilot themes and associated use cases, thus contributing to a large-scale validation of the SHAPES digital solutions by SHAPES users (older persons, informal caregivers, health and care professionals and health and care organisations) during the SHAPES large-scale piloting campaign.

It should be noted that, as different digital solutions support different SHAPES pilots and associated use cases and these pilots have different timeframes in the project, the adaptations conducted in the last year do not apply equally to all digital solutions. The next version of this document (deliverable D5.4 – *SHAPES Digital Solutions V3*), due to be submitted in month 36 (October 2022), will provide the final overview of the adaptations conducted by the SHAPES partners in their digital solutions, within the SHAPES ecosystem.

1.1 Rationale and Purpose of the Deliverable

This document, named "*SHAPES Digital Solutions v2*", is elaborated as part of the different tasks within Work Package 5 (Tasks 5.2 to 5.8) and presents an intermediate version of the SHAPES Digital Solutions, focusing on the work performed in the past year to adapt those solutions to support the SHAPES pilots and associated use cases. Involving the concept and ideation, design and development and prototyping and adaptation stages, the work addressed the SHAPES system specifications, user requirements and ethical guidelines in order to build SHAPES-compliant digital solutions that would adequately support the project's piloting activities and contribute

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

to the creation of the SHAPES Integrated Care Platform, providing a broad range of digital solutions to improve the health, wellbeing and independence of older individuals, while enhancing the long-term sustainability of health and care systems in Europe. Importantly, the SHAPES digital solutions facilitate the understanding of the added-value of the innovative SHAPES vision, allowing for the clarification of the long-term benefits and positive impact brought by SHAPES.

1.1.1 Key Inputs and Outputs

This deliverable incorporates the results from the work carried out in T5.2 - Solutions for SHAPES Intelligent Living and Care Environment, T5.3 - Applications Suite for Healthy Ageing, T5.4 - Robotics and Assistive Technologies, T5.5 - Decision Support and Risk Assessment and Prediction Services, T5.6 - Solutions for Health and Care Service Providers, T5.7 - Lifestyle Management and Wellbeing Assessment Solution and T5.8 - Security Assessment As a Service. As such, deliverable D5.3 builds on the previous deliverable's version (D5.2 [1]) and takes into consideration as key inputs not only the SHAPES partners' existing digital solutions, but also the work conducted in Task 5.1 - Platform User Experience Design Guidelines and Evaluation, concerning the guidelines for the design and development of memorable user experience for older audiences, the work unfolding in WP4 concerning the development of the SHAPES Technological Platform and the activities in WP6 concerning the organisation and execution of the SHAPES pilots.

In addition, the results of the activities performed in WP2 and WP3 addressing the older persons' lifeworld and the socio-technical structures of health and social care organisations, respectively, have been duly tackled as they inspired the SHAPES user requirements that were *translated* into the SHAPES Platform's system specifications, which is one the basis for the adaptation work that the SHAPES digital solutions are undergoing. It is noted that the SHAPES user requirements and system specifications also refer to the ethical dimension of SHAPES, a perspective brought by the WP8 tasks that is consequently embedded into the work performed in WP5 tasks.

On its turn, this document delivers valuable outputs to different project tasks and work packages: the digital solutions' technical features and specifications are relevant to support the integration work to be accomplished in WP4. Also, the document provides essential information for the WP6 tasks currently defining, organising, conducting and assessing the large-scale SHAPES pilots and use cases, which aim to validate the added-value and potential impact of the SHAPES digital solutions, in support of the SHAPES vision. In this context, Deliverable D5.3 also provides guidance towards the definition of strategies to enable the scale-up of the SHAPES integrated care vision, whilst being a key element of the work performed in WP7 targeting the exploitation and long-term sustainability of the SHAPES results, including the SHAPES partners' digital solutions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

1.2 Structure of the Document

This report is divided into the following chapters:

- **Chapter 1 – Introduction –** this chapter introduces this document, providing details on its rationale and purpose, including key inputs and outputs. In addition, it delivers a summary of the document's structure and content.
- **Chapter 2 – SHAPES Digital Solutions** – this chapter provides an overview of the SHAPES Digital Solutions ecosystem and their main areas of application, which are then detailed in the following chapters.
- **Chapter 3 – Digital Solutions for an Intelligent Living and Care Environment** – this chapter presents the digital solutions addressed in Task 5.2, focusing on the creation of intelligent living and care environments, through the use of smart IoT devices and sensors.
- **Chapter 4 – Application Suite for Healthy Ageing** – this chapter describes the digital solutions tackled in Task 5.3, centred in the enablement of self-management of specific physical and cognitive conditions or diseases.
- **Chapter 5 – Robotics and Assistive Technologies** – this chapter introduces the digital solutions approached in Task 5.4, focusing on the use of service and companion robots and assistive technologies to support digitally-enabled care delivery.
- **Chapter 6 – Decision Support, Risk Assessment and Prediction Services** – this chapter is focussed on the digital solutions pertaining to Task 5.5 that deliver advanced risk assessment, predictive analysis and decision support systems to support guidance on healthy lifestyle and disease prevention.
- **Chapter 7 – Solutions for Health and Care Service Providers** – this chapter enunciates the digital solutions adapted in Task 5.6 to support caregivers and care professionals in the efficient delivery of high-quality care.
- **Chapter 8 – Lifestyle Management and Wellbeing Assessment Solutions** – this chapter identifies the digital solutions developed in Task 5.7 that benefit from advanced data analytics to improve the lifestyle and wellbeing of older individuals.
- **Chapter 9 – Security Assessment as a Service** – this chapter addresses the digital solutions explored in Task 5.8, aiming at identifying vulnerabilities and risks in order to improve the level of cybersecurity and data protection of Information and Communication Technologies (ICT) infrastructures.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **Chapter 10 – COVID-19 Response Solutions** – this chapter describes several digital solutions proposed by the SHAPES partners to support the COVID-19 pandemic response.
- **Chapter 11 – SHAPES Front-end App** – this chapter presents the SHAPES Front-end App, a new development of the SHAPES Consortium to facilitate the users' interaction with the different digital solutions in the SHAPES ecosystem, during the SHAPES large-scale piloting activities.
- **Chapter 12 – Conclusion** – this chapter provides a summary of the document, making broad statements that highlight the most important insights of the work performed within Tasks 5.2 to 5.8 in Work Package 5.
- **Chapter 13 – Ethical Requirements Check** – this chapter identifies the verification of the relevant ethical requirements/topics applicable to the document.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

2 SHAPES Digital Solutions

SHAPES ambitions to promote a large-scale piloting campaign, validating the added-value and impact of a broad range of digital solutions in supporting the planning for extended lifespans while maintaining independent, healthy and active lifestyles. The SHAPES digital solutions range from assistive robots to electronic health (eHealth) wearables, Internet of Things (IoT) sensors and devices and mobile applications (Apps), cognitive stimulation and rehabilitation tools, conversational assistants and chatbots, wellbeing assessment and anomaly detection solutions and predictive systems. In all, they have the potential to ensure that older people may continue to enjoy healthy, productive, independent and dignified lives at home, delaying or preventing the need for long-term institutionalised care.

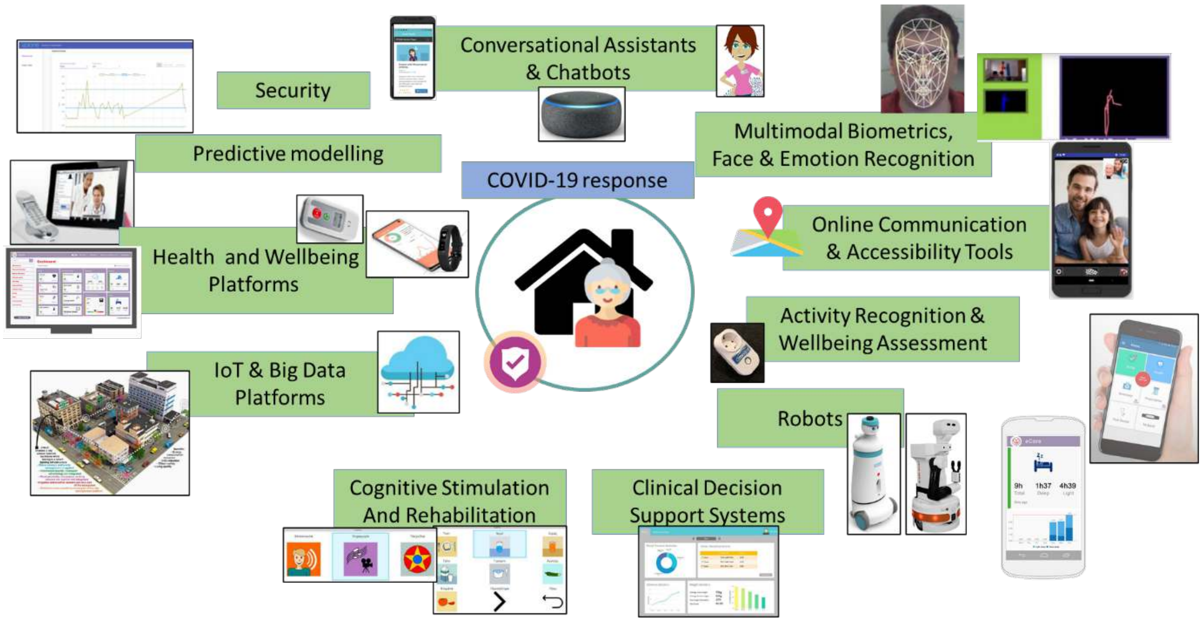


Figure 1 - Overview of SHAPES Digital Solutions and Their Main Application Areas

Through the piloting campaign, the SHAPES project will provide a significant body of evidence of the benefits and impact of the SHAPES digital solutions in the promotion of quality of life of older individuals, their families, and caregivers. Simultaneously, the pilots' data will allow cost-benefit assessments of SHAPES digital solutions role in the optimisation of efficiency of health and care delivery in Europe.

For the time being, the SHAPES partners are adapting their digital solutions to meet the requirements, needs and expectations of the SHAPES pilots and associated use cases. Structured in accordance to the seven active WP5 tasks, the following chapters present the different Digital Solutions to be deployed in the large-scale SHAPES piloting campaign, including the work performed to shape them to the specifications of the pilot themes and use cases they will be supporting.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3 Digital Solutions for an Intelligent Living and Care Environment (Task 5.2)

The continuous introduction of artificial intelligence (AI) capabilities in mobile devices, wearables, robots and home appliances has led to an ecosystem of products and services where everything is interconnected, acting as a unified contextual information and making possible the provision of timely services to users. Living and acting in such environment is now known as "Intelligent Living". Such kind of services and smart devices help users get through their daily lives more efficiently and with extended autonomy or independence so that they may contribute to building healthier lifestyles and safer ambients and focus on what truly matters to them. This benefit becomes even greater when such technologies solve true human problems especially related to health and social care.

Nowadays, many technological systems and platforms target the domain of improving health and social care environments, bringing together a wide range of devices, applications and solutions within the living environment adapted to remote health monitoring, fitness programs, monitoring of chronic diseases, and elderly care providing fundamental blocks for sense, awareness and interaction. Many of these platforms utilise the concept of IoT because it allows to have a platform connecting multiple devices (or things) to create and manage applications, to run analytics, and to store and secure data. IoT-enabled platforms are designed to deploy applications that monitor, manage and control various connected devices, often a particularly challenging task if the devices that need to be controlled are diversified and located in areas with bad connectivity. Notwithstanding, IoT-enabled platforms support intelligent living and care environments and are instrumental in the redesign of modern health and social care with promising technological, economical, and social prospects.

Medical equipment, health sensors, imaging devices and data analytics are viewed as smart devices or things constituting a core part of an IoT infrastructure and associated healthcare services are expected to reduce costs, increase the quality of life, and enrich the users' experience. Compliance with treatment and medication at home and monitoring of the health and wellbeing conditions of older individuals are increasingly important to improve the quality of life of the elderly population, while considering the budgetary constraints in health and social care systems.

This section describes the SHAPES IoT-based platforms, components and eHealth applications that will become part of the SHAPES Platform to assist in the creation of intelligent living and care environments, integrating homes, neighbourhoods, and cities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.1 FINoT Platform (FINT)

FINoT platform is an a FIWARE-based IoT cloud management platform able to orchestrate embedded systems, to interconnect almost any kind of sensor, actuator and data logger and it is dedicated for industrial and semi-industrial usage. The platform provides data intelligence services while is capable for real-time handling of data artefacts including data fusion. The integration of FINoT Platform into SHAPES Technological Platform will bring significant advantages allowing the shifting of various services to the cloud, provide required computational resources and handle massive chunks of collected data at a location-transparent centralised infrastructure and at the same moment retain historical data.

The main purpose of FINoT Platform in SHAPES is to provide smart neighbourhood and city capabilities like data acquisition and handling for weather, air quality, pollution, local public works, local transportation, local activities and others based on pilot's needs while also collect and provide information for day-to-day activities within a specific community like available readings or exhibitions.

The main objective is to provide to SHAPES intelligent living ecosystem capabilities for supporting smart neighbourhood, community, city and rural areas.

Figure 2 - Various Applications Running on FINoT Platform

Table 4 - FINoT Platform Data

Data Category	Measurements Type	Collection Method
Sensors	Acquire the output of a sensor that detects and responds to some type of input from the physical environment (e.g. home level, neighbourhood level)	Automated (from connected devices)
Actuators	Acquire the output of a device and provide input based on specific parameters and measurements (e.g. home level, neighbourhood level)	Automated (from connected devices)
Internet Data	Local public works Parking Local transportation	Automated (from connected devices)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Data Category	Measurements Type	Collection Method
	Local activities Local Useful Information	
Environmental Data	Climate Air quality Pollution Urban noise levels	Automated (from connected devices)
Data from Industrial Devices	Energy Water Mobility	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances	Automated (from connected devices)

3.1.1 Technical Specifications

FINoT Platform is an IoT ecosystem based on Kubernetes for remotely located devices supporting various data sources and application types, it is easy deployable and configurable exploiting microservices (e.g Tenant Creation, Instance Creation, Gateway configuration). It has three layers of Intelligence that are supported (Device Level, Gateway level, Cloud Level). The main purpose is to provide the appropriate data management middleware for intelligent handling of different kind (heterogeneous) data sources.

FINoT is fully compatible with FIWARE providing great interoperability features allowing the scalable and adaptive expansion both in Hardware (various devices) and Software (services). Almost any sensor and actuator can be connected on the core platform and become a managed asset instantly. It also incorporated build in custom functionalities for reminders, notifications and alerts services.

3.1.2 Interfaces and Interoperability

FINoT Platform's front-end is a Web application while back-end provides application programming interfaces (APIs) for third-party interconnection. Also, FINoT Platform will be used as a mediation layer for connection to SymbioTe platform and SHAPES Gateway (GW). The supported data type is based on the Next Generation Service Interfaces (NGSI) protocol while interconnection to the platform is supported through Hypertext Transfer Protocol (HTTP) Representational State Transfer (REST), JavaScript Object Notation (JSON) and Message Queuing Telemetry Transport (MQTT) for inputs and outputs.

FINoT Platform will provide to SHAPES's users relevant information on climate, air quality, pollution, urban noise levels, energy, local public works, parking, local transportation and local activities where this information will be available.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 5 - Summarised Technical Description of the FINoT Platform

General Description	A FIWARE-based IoT platform used as cloud orchestrated embedded systems' management solution able to interconnect almost any kind of sensor, actuator and data logger, dedicated for industrial and semi-industrial usage.
Features	• Main goal of FINoT® Platform is the Creation, Development and Integration of an intelligent living and care environment for SHAPES • FINoT® Platform is an IoT ecosystem for remotely located devices Interconnection and Intelligent Management, supporting various data sources and application types • It is easy deployable and configurable exploiting Microservices (e.g Tenant Creation, Instance Creation, GW configuration) • Three layers of Intelligence are supported (Device Level, Gateway Level, Cloud Level) • FINoT ® is fully compatible with FIWARE providing great interoperability features • The scalable and adaptive core platform allows the effective expansion both in Hardware and Software • Almost any sensor and actuator can be connected on the core platform and become a managed asset instantly • Build custom reminders, notifications and alerts
Application Areas	Provide smart neighbourhood and city capabilities (e.g. data acquisition/handling for: weather, air quality, pollution, local public works, local transportation and local activities and other)
TRL	From TRL6 to TRL8
Data Type	NGSI protocol, any data type (Boolean, data/time, integer, number, text, geo:json, file)
Inputs	http(s) rest, JSON, MQTT
Outputs	http(s) rest, JSON, MQTT
Actions to be performed	• Provide to SHAPES users relevant information on climate, air quality, pollution, urban noise levels, energy, local public works, parking, local transportation and local activities • Provide to intelligent living ecosystem capabilities for supporting smart neighbourhood, community, city and rural areas (e.g. data acquisition/handling for: weather, air quality, pollution, local public works, local transportation and local activities and other based on the pilot's needs) • Provide the appropriate data management middleware for intelligent handling of different kind (heterogeneous) data sources • Provide the interfaces and APIs for third-party solutions, systems, sensors and applications
Interface	FINoT® Platform (front-end): Web application FINoT® Platform (back-end): APIs for third-parties

3.1.3 Applicable Pilot Themes

In SHAPES, the FINoT Platform will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes (PTs):

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT1 – Smart Living Environment for Healthy Ageing at Home.
- PT2 – Improving In-Home and Community-based Care.

All other pilots that utilise the SHAPES Gateway and IoT data management middleware.

3.1.4 Adaptations for PT1-UC001

This digital solution has been adapted to use case PT1-UC001 so that the air quality and the weather forecast data can be provided through the FINoT Platform to the tablets of the end-users providing them information about the external weather conditions and the indoor air quality levels; in this way, users can plan their daily outdoor activities based on the presented weather forecast and also use the information from the indoor air quality sensors to be informed about their surrounding air quality conditions and act preventively if the measured levels tend to or are exceeding the pre-specified safety thresholds.

3.1.4.1 Concept and Ideation Stage

The DS aims to support the remote In-Home Wellbeing Monitoring and Assessment objective. In this context, the applicable SHAPES persona is Isabelle (Persona 4) that lives on her own in an apartment, her son Marco takes the role of the caregiver.

Scenario

Isabelle (75) has early stage of Alzheimer and lives on her own in an apartment. She recently started to have some problems with memory – forgetting names, loosing things, recently she also accidentally switched off the electricity in the whole house and the heating was off for two days. Her son Marco lives with his family in a nearby village and visits Isabella every day, does the chores, brings food. Thanks to the SHAPES Project, they decided to use the Remote In-Home Wellbeing Monitoring and Assessment. Several sensors will be installed in Isabelle´s house to monitor her complex daily living activities, and also to identify possible risky situations or detect signs of early physical or cognitive decline. The daily data recorded will be available for Marco for review.

Table 6 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	SHAPES platform shall support multilingual user interface.	Y	English and German languages in the dashboard are supported. So far

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
			English and German translations of the App screens have been compiled, other languages may be supported depending the available resources and the project's priorities.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including devices they use.	Y	The screens provide tooltips and in the case of the air quality information is given in the form of visual cards about the measured air quality metrics.
SPS-059	User friendly dashboard should be offered to care receivers and care takers.	Y	Both screens are simple and intuitive displaying a clearly as possible the appropriate information, interactions with the user are kept to the minimum. The screens were designed having minimalism and easy of use in mind; nevertheless, this requirement should be finally assessed by end-users during the pilots; based on the feedback, the necessary remedy actions can take place to assure that the requirement fulfils the use needs.
SPS-065	SHAPES may offer environmental, pollution and weather info, relevant to older population in a given area.	Y	Weather forecast and indoor air quality data are provided.
SPS-117	SHAPES should support sensor monitoring high risk situations.	Y	Air quality sensors can notify if the measured levels exceed the predefined safety thresholds.
SPS-118	SHAPES should offer monitoring of home environment.	Y	The DS provides weather forecast and indoor air quality data.
SPS-133	SHAPES Digital solutions shall be able to send	Y	Air quality sensors can notify if the measured levels

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	alerts and notify the care givers.		exceed the predefined safety thresholds.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Both screens are simple and intuitive displaying a clearly as possible the appropriate information, interactions with the user are kept to the minimum.
SPS-147	SHAPES shall support IAM (identity and access management).	Y	The DS supports the ASAPA authentication module of SHAPES.
SPS-156	SHAPES shall support registration of devices.	Y	Both the weather sensor node and the air quality device will be registered and recognisable from the FINoT and consequently the SHAPES platform.
SPS-158	SHAPES user interface shall support automatic adaptation to visual capabilities of the access device.	Y	Both screens are responsive to the devices' orientation and screen dimensions.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Weather forecast and air quality data are available to other authorised/legit SHAPES tools and DSs via SHAPES SymbIoTe platform and also via FINoT's public API.
SPS-173	SHAPES services and application should be accessible using Android and iOS based mobile devices.	Y	The used development framework supports both Android and iOS devices.

Table 7 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-08	HOW1: Capture unobtrusively the relevant health and wellbeing parameters of the older individuals at home (the parameters listed below).	Y	The DS captures indoor air quality data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	Using wearables, sensors and other devices. Recording quantifiable health data. Using Ambient Intelligence Health and Wellness Platform / Smart Living at Home Platform.		
UR-11	HOW4: Give personalised tips and recommendations based on health and well-being needs. Using a "personal coach"-concept, the older individuals receive tips to maintain their well-being and health status (e.g. reminders to drink water, walk a few steps, stand-up and sit-down). Using Wellbeing and Lifestyle recommendations (physical activity and nutrition recommendations).	Y	The DS informs the care receiver, if the measured air quality levels are close to exceed the predefined safety thresholds.
UR-12	HOW5: In case the system monitors unusual data, the informal caregiver/ a predefined person of trust is informed/alerted. Using smart data analytics & predictive algorithms: analysis of anomalies and alert generation based on the data gathered from the different sensors.	Y	The DS informs the caregiver, if the measured air quality levels are close to exceed the predefined safety thresholds.

3.1.4.2 *Design and Development Stage*

The digital solution was designed using Figma mock-up cloud service for a tablet end device, having in mind the ease of use and the clear visual display of the provided information.

In more detail, FINT designed and developed two subcomponents for this use case, namely the Weather Information and the Ambient Monitoring. Both subcomponents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

are utilising technology and sensors from our FINoT Platform to better inform and aid the everyday life of our users.

FINoT Weather Information subcomponent for SHAPES

The Weather Information subcomponent presents the weather information of both the neighbourhood and the city of the end-user in an easy-to-understand manner, as well as the daily forecast information for the end-users' neighbourhood.

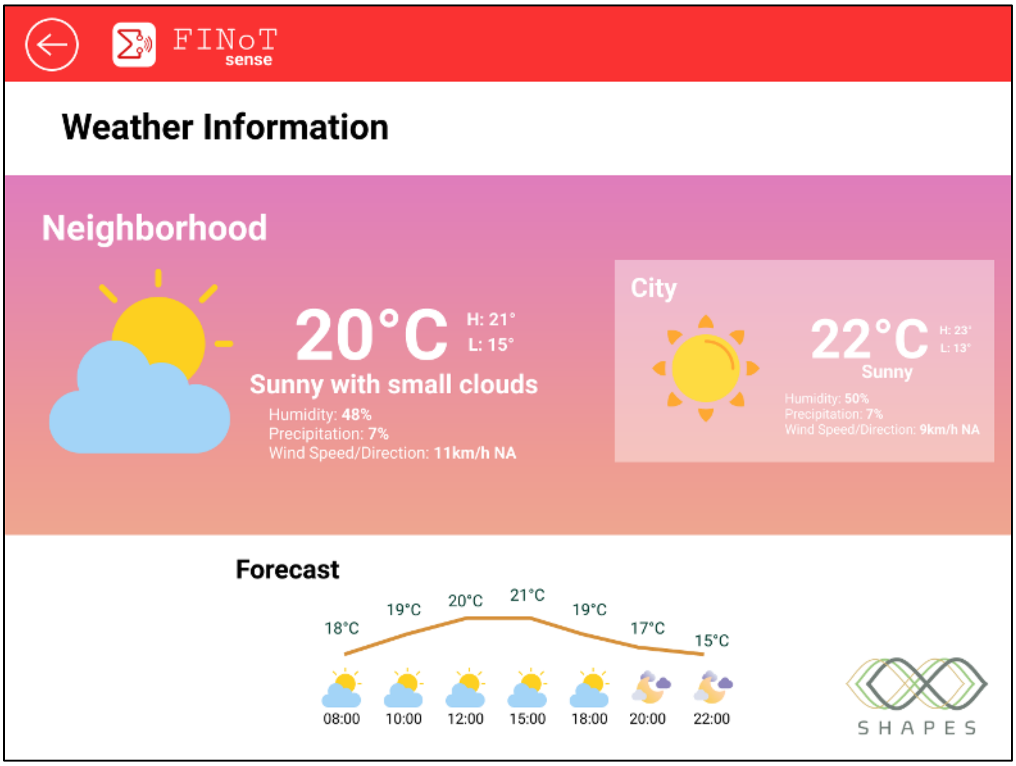


Figure 3 - FINoT Weather Information Subcomponent for SHAPES Mock-up Screen

By utilising technology and sensors from FINoT Platform, FINT presents to the end-user accurate weather information and a forecast localised for his/her neighbourhood. With the help of external inputs, FINT may also show the end-user's city weather information in order to help the end-users compare the neighbourhood's weather information with the generalised city's weather information. In both Weather Information boxes, the end-user can see the current weather conditions graphically represented with the help of weather icons and explained in text. The end-user can also see, in both cases, the Current Temperature, the Humidity, the Precipitation, the Wind Speed/Direction and the Highest/Lowest predicted temperature for the day.

In the Forecast section, the end-user can see the Daily Forecast for his neighbourhood. The forecast is separated by preselected key hours. In order to help the end-user, we present the changes in temperature both with text and with a comparative line graph. In that way, the end-user can understand the changes in temperature without reading the text. The predicted weather conditions are

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

represented with weather icons that help the end user better understand the forecasted weather conditions.

FINoT Ambient Monitoring subcomponent for SHAPES

FINoT sensors and technology have the ability to help and protect the end-user from the nuances of the surrounding environment. The FINoT Ambient Monitoring subcomponent helps the end-user to understand and react to the environmental conditions.

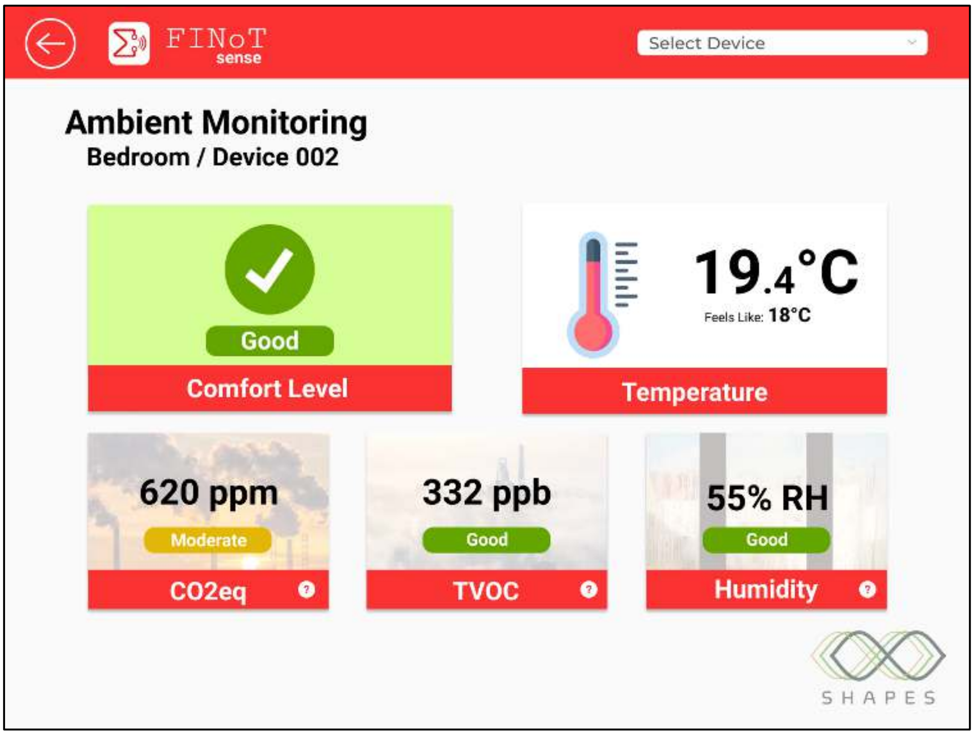


Figure 4 - FINoT Ambient Monitoring Subcomponent for SHAPES Mock-up Screen

The subcomponent's screen is separated into two sections, the upper section where the end-user can see the general condition of his environment and the lower section where the end-user can see more targeted info about his environment. In the upper section, the user can see a general score about his environment in the left, as well as the current temperature measurement right of the screen. In the Temperature section, there is a "Feels Like" measurement that helps the user understand how the current environment conditions will alter the current temperature of the environment. In the lower section of the screen, the user can see the Carbon Dioxide Equivalent (CO_2eq), Total Volatile Organic Compound (TVOC) and Humidity measurements of his/her environment. All the information is presented to the user in a grading system (Good, Moderate, Unhealthy) in order to help the end-user understand the measurements without knowing exactly what are these measurements. If the user wants to learn what exactly are these measurements, he/she can press the help icon (?) next to the measurement's title and a pop up will appear informing the user about the measurement.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

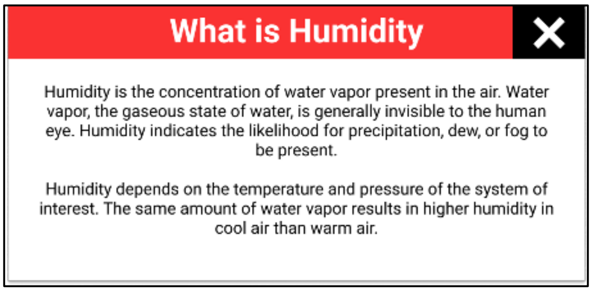


Figure 5 - Humidity Explanation Pop-up

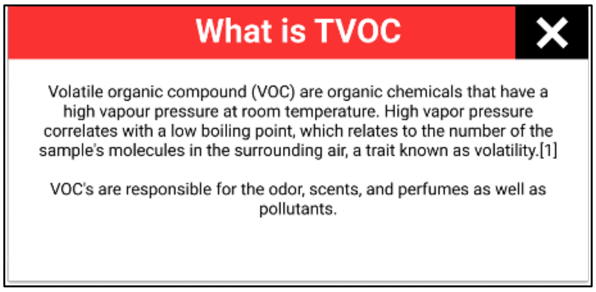


Figure 6 - TVOC Explanation Pop-up

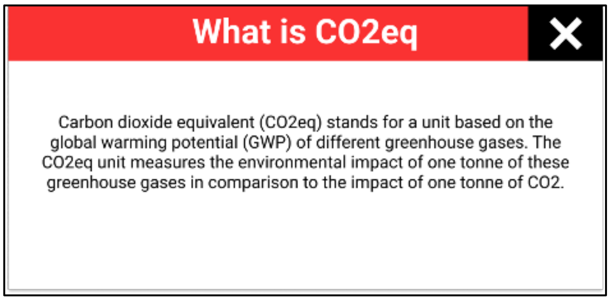


Figure 7 - CO2eq Explanation Pop-up

If the condition of the environment changes to a “Unhealthy” grading, the end-user’s caregiver is alerted, as the screen mock-up bellow shows, in order to act to the changes presented in the dashboard.

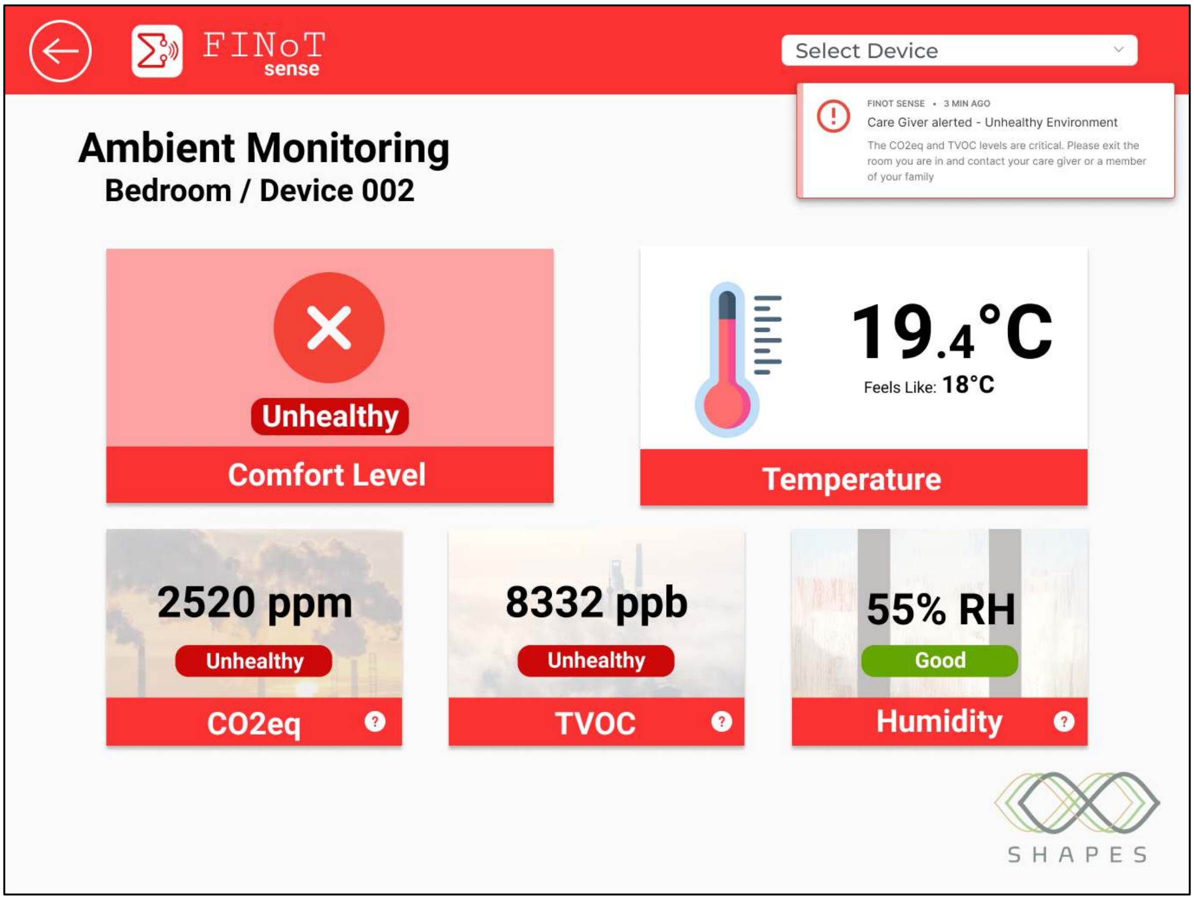


Figure 8 - Unhealthy Comfort Level and Caregiver Alert in the Ambient Monitoring Mock-up Screen

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

3.1.4.3 *Prototyping and Adaptation Stage*

As the below diagram presents, there are 5 distinct interfaces, 1 graphical (IF-5) representing the DS dashboard and 4 APIs used to exchange information between the basic architectural components. The next table provides a short description of the interfaces.

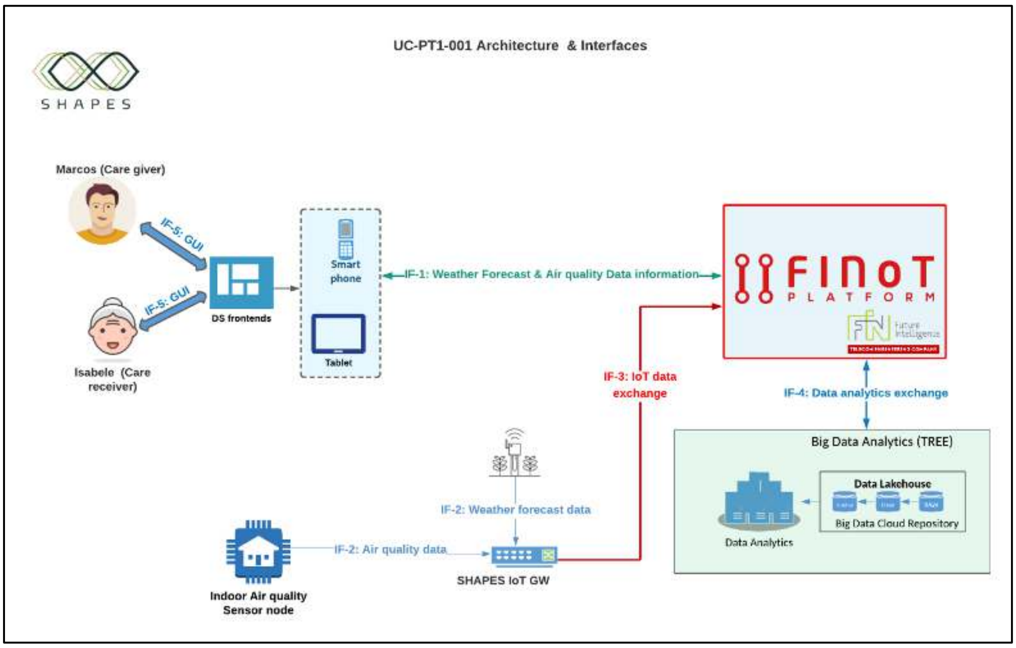


Figure 9 - Architecture and Interfaces for PT1-UC001

Table 8 – FINoT Platform Interfaces

Interface	Description
IF-1	Used to provide from FINoT the collected Weather Forecast and Air Quality Data information to the DS relevant App.
IF-2	Used to forward to the gateway the Weather Forecast & Air quality Data information from the relevant sensor devices.
IF-3	Used to forward from the gateway to the FINoT the collected Weather Forecast and Air Quality Data information.
IF-4	Used to provide the collected IoT data to the SHAPES Data Lake and receive results from the run analytics.
IF-5	Used for enabling the end user to graphically interact with the DS and for visualising the relevant information.

The data models describing the weather and air quality data are presented below:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 9 – FINoT Platform Data Model

Data Models	Type of variable
Weather Data	
Temperature	Number
Humidity	Number
Precipitation	Number
precipitationType	Text
windSpeed	Number
windDirection	Number
solarRadiation	Number
Air Quality Data	
Temperature	Number
Humidity	Number
Co2Eq	Number
Total Volatile Organic Compound	Number

3.1.5 Adaptations for PT2-UC002

This digital solution has been adapted to use case PT2-UC002 so that the available community events, tailored to the given care receiver's preferences and possibly physical constraints, along with information about the weather conditions in the area of interest (e.g. near to the event time) can be provided through the FINoT platform to the tablets of the end-users. In this way, users have their engagement to the community activities facilitated and may form bonds with other members that have the same interests and preferences.

3.1.5.1 Concept and Ideation Stage

The DS aims to support the interaction of the older individual with the community. If older individuals are already somewhat distanced from their community and they do not take part in day to day activities within the community, they also do not necessarily hear about new developments or opportunities for engagement, sports, educational or cultural events.

In this context, the applicable SHAPES persona is Roisin (Persona 5) that lives together with daughters' family, in a suburb of a big city; her daughter Ciara takes up the role of the caregiver.

Scenario

Roisin moved to her daughter Ciara and her family in the suburbs of a large city. There she feels very alone, because the family members work or are at school during the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

day and in the evening, Roisin does not want to restrict them. But Roisin does not feel comfortable in her new surroundings. She has hardly any contact with community, but she would be very happy if she could have more social contact playing bingo or doing exercises for her knee.

Roisin could use the platform very well and she would like to try it out. She has a medium affinity for technology, but also a low digital competence. That is why she asks her daughter Ciara to register with her on the platform. Ciara notices that her mother is not well, and she feels lonely, so she thinks it is a good idea. The registration process takes about 10 minutes. Roisin and Ciara are asked where Roisin lives, how she is physically fit, whether she has mobility problems, what topics she is interested in and what interests and hobbies she has. The platform creates a profile and activities are suggested to Roisin. Ciara shows Roisin how she can use the platform's functions. As Ciara has to work early the next morning, she wants to sleep, and they postpone the booking of events. The next morning Roisin opens the computer and receives basic information about the day, such as the weather and individually selected news topics. In addition, the ageing person gets a look at her calendar. This gives a good overview of the day. So far Roisin has only entered the birthdays of her family and a doctor's appointment next week. The platform remembers individual interests and can make offers tailored to the needs of each person. For example, the platform recognises that good weather is to be expected during the day and suggests that the user take part in the senior citizens' walk in the afternoon. For the next few days, Roisin will propose a bingo afternoon, a trip to a city museum, a visit to the cinema, a reading by an author and sports activities. Roisin is very happy and has the possibility to favour the session of bingo, the author's reading and a gymnastics course, so that she can later show the offers to Ciara. In the evening, Ciara comes home from work and because Roisin favours the activity she wants to participate in, the booking process is very fast. Roisin is pleased with Ciara's support, because she does not dare to register for the courses on her own or book a ticket for an event. Roisin is looking forward to next week, as she has some nice activities planned.

There is a bus stop directly in front of the Roisin flat. The platform suggests a route to Roisin, which will allow her to arrive on time and with enough time to change buses for the bingo afternoon. She is very happy about this, because nobody can drive her by car at this time of day.

After Roisin has taken part in an activity, she can evaluate the event. In this way, the platform can remember what Roisin liked and propose similar events to her in the near future.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 10 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-067	SHAPES may offer search for contacts.	Y	The App enables the care receiver to contact the caregiver and vice versa.
SPS-097	SHAPES should make use of Machine Learning Matching for matching info services to user needs.	Y	The DS is able to utilise Data Lake analytics to provide, tailored to their preferences, recommendations to the care receivers.

Table 11 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-03	AIM1: Inform users about activities in the community in the surrounding area.	Y	The DS provides to the user a list of available community events and activities that could attend.
UR-07	AIM5: The feeling of participation in the community through current and region-related information transfer. Information about the weather, local news, etc. should be available.	Y	The DS provides weather forecast.
UR-08	HOW1: Proposals of activities and events adapted to the interests and possibilities of the individuals. Offers that are matched to individual needs are possible due to a machine learning component.	Y	The DS is able to utilise Data lakes' analytics to provide recommendations to the care receivers, tailored to their preferences. The interface has been built, but still the training/refinement of the recommendation algorithms is pending, until then the recommendations will not be accurate. It is expected that, during the pilots' lifetime,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
			enough data will be gathered as feedback that will be used to improve/refine the utilised algorithm's accuracy.
UR-09	HOW2: The platform allows easy access to the activities.	Y	The DS utilises an easy to use tablet Application, with informative and intuitive widgets.
UR-10	HOW3: Chat option through which individuals can exchange information online (ROSA, Chatbot).	Y	The DS supports chat option.

3.1.5.2 Design and Development Stage

The digital solution was designed using Figma mock-up cloud service for a tablet end device, having in mind the ease-of-use and the clear visual display of the provided information. The mock-ups were reviewed by end-users and the received feedback was used to refine the mock-ups.

This digital solution is an easy-to-use and interactive application that FINT are building in order to help the end-users simplify their day, facilitate the interaction between Caregivers and Care Receivers and connect them with their community. The first screen is the one for registering or logging.

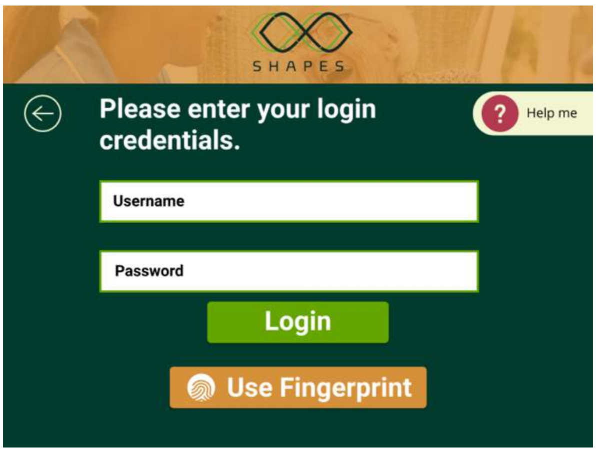


Figure 10 - SHAPES App Home Screen

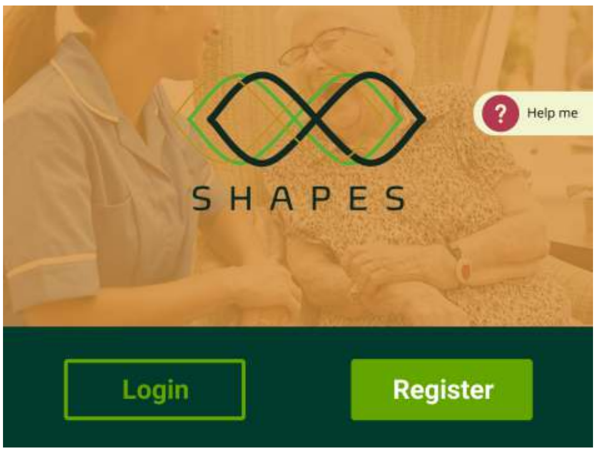


Figure 11 - End-User Login with Credentials

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

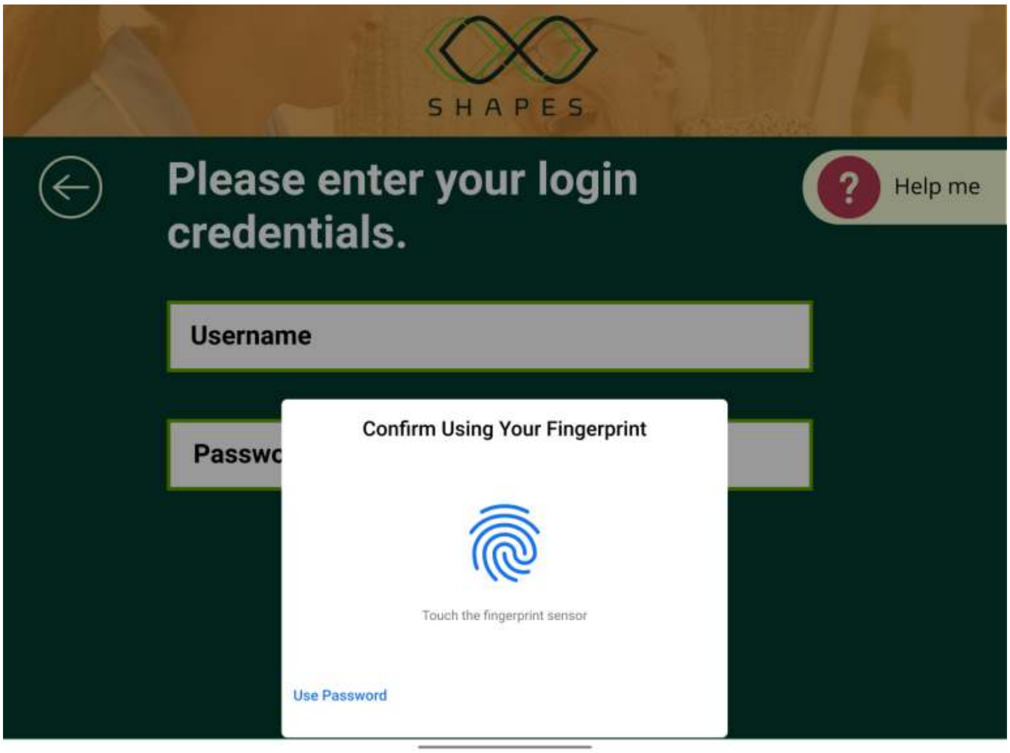


Figure 12 - End-user Login with Biometrics (if supported by the tablet)

If the end-user chooses to Register, the application will ask the user as to what he/she would like to register. He/She can choose to either register as a Caregiver or as a Care Receiver. In either case, a series of questions will follow, allowing the SHAPES programme to become familiar with the end-user and their needs.

Figure 13 - New User Registration Screen

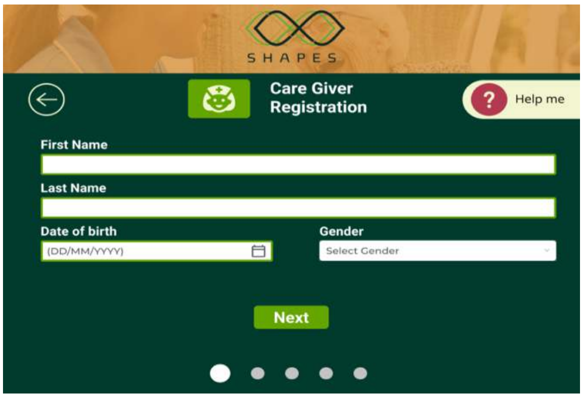


Figure 14 - Caregiver's General Questions

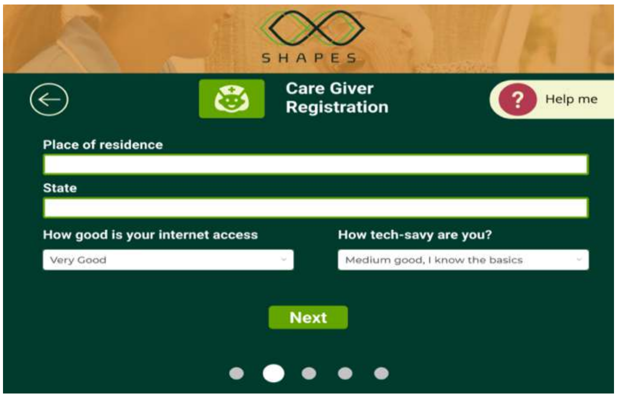


Figure 15 - Caregiver's General Questions Follow-up

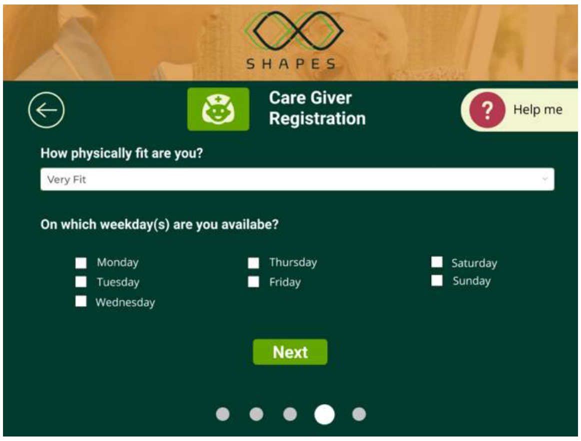


Figure 16 - Caregiver's Physical Fitness and Availability Question

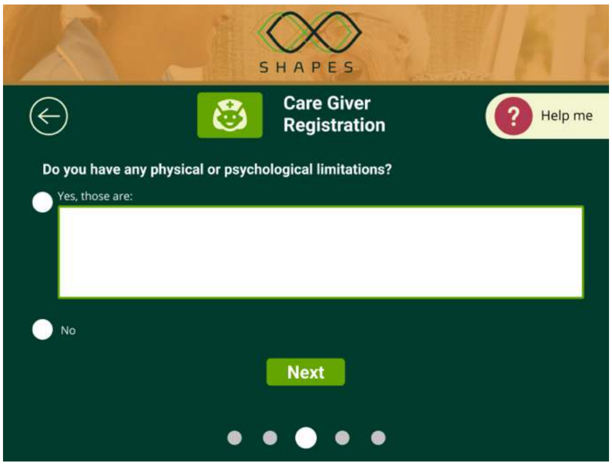


Figure 17 - Caregiver's Physical or Psychological Limitations Question

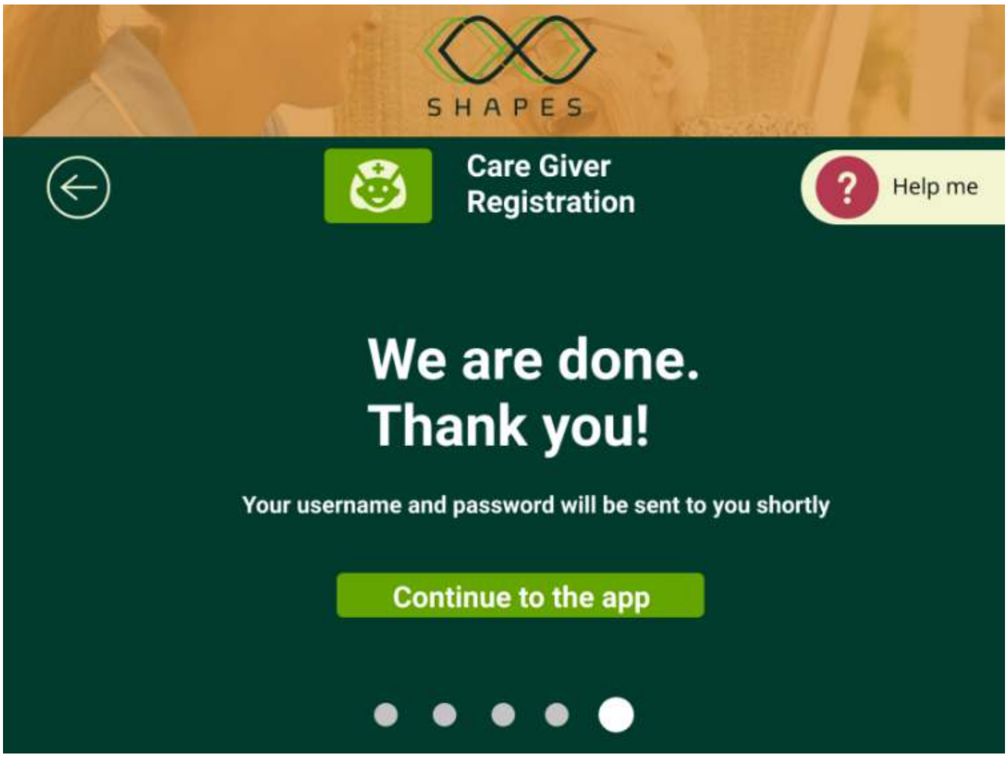


Figure 18 - Caregiver's Registration End

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

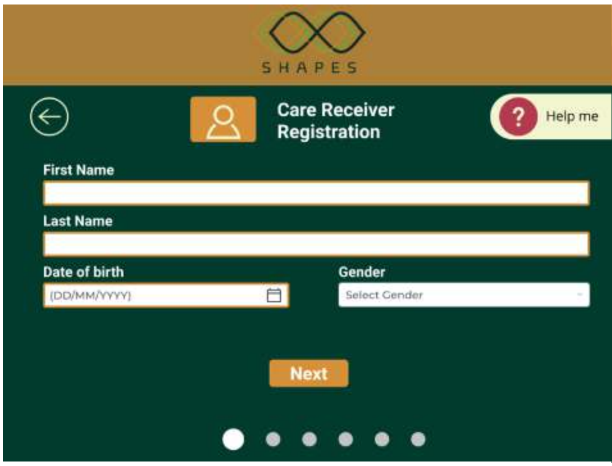


Figure 19 - Care Receiver's General Questions

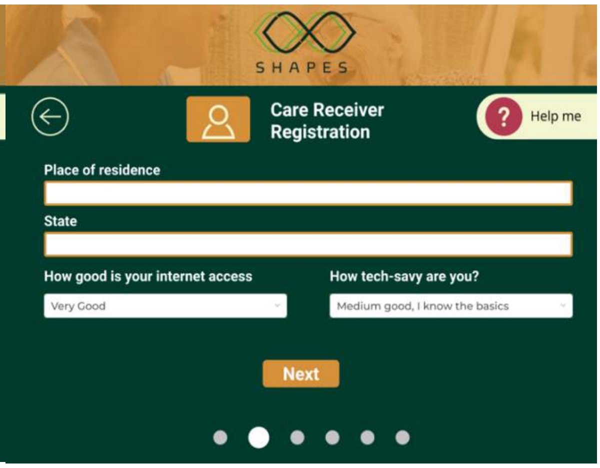


Figure 20 - Care Receiver's General Questions Follow-up

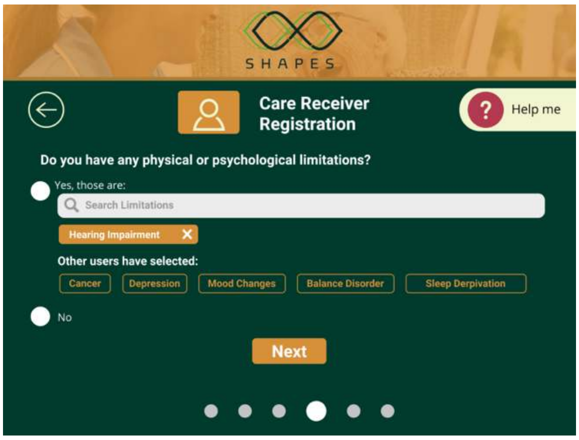


Figure 21 - Care Receiver's Physical or Psychological Limitations

Figure 22 - Care Receiver's Physicality and Interests

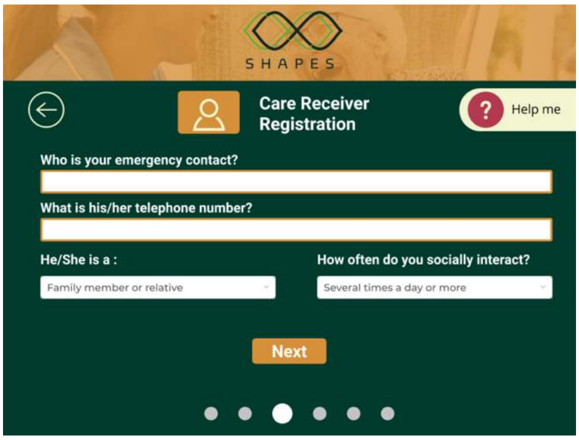


Figure 23 - Care Receiver's Emergency Contact Information

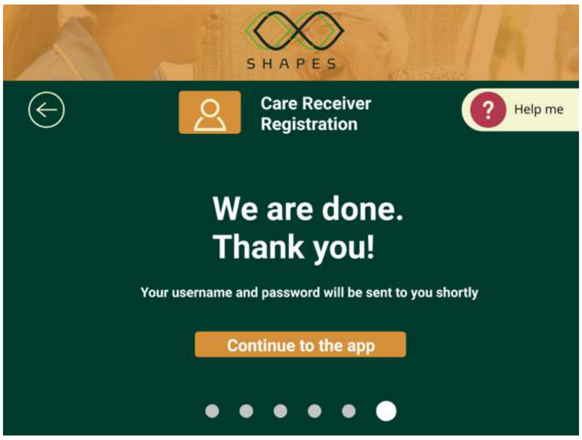


Figure 24 - Care Receiver's Registration End

When the end-user finishes the Registration procedure, he/she can then login to the SHAPES App as either a Caregiver or a Care Receiver.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SHAPES App as a Caregiver

As a Caregiver, the end-user has a dashboard that will help him/her maximise his/her efficiency as a Caregiver and connect with his/her Care Receivers.

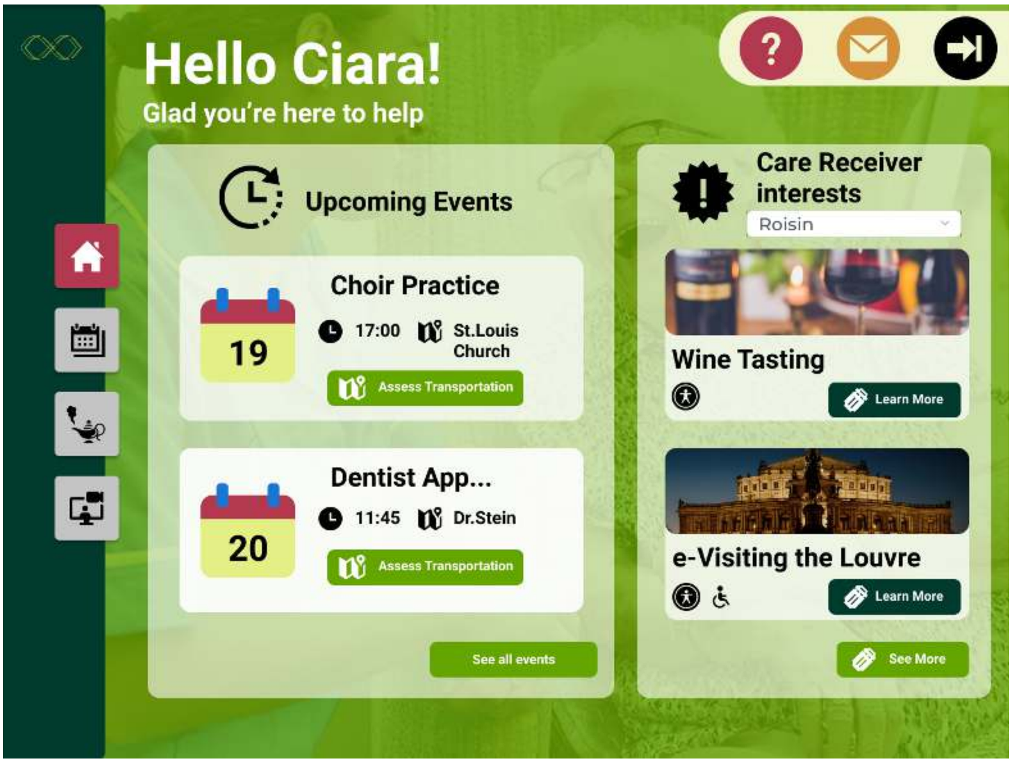


Figure 25 - Caregiver's Homepage

In the homepage, a Caregiver can see in a glance his/her Upcoming Events and the Event Interests of his/her Care Receivers. Both of these sections can help him/her organise the day and plan ahead. In the Interests page, the Caregiver can, by pressing in an event, open a modal that will allow him/her to see and evaluate the event.

Figure 26 - Event Evaluation Pop-up

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This modal shows the Caregiver important information about the event, like the time and place that the event will take place, and it has a small description about the event. From this pop-up, the Caregiver can either virtually Book this event for the Care Receiver or Propose that the Care Receiver should not go. The Caregiver can also call the events host, open a Global Positioning System (GPS) Navigation program (like Google Maps) to review the location of the event and, finally, in the bottom right, can see if the event is accessible to people with disabilities.

Figure 27 - Caregiver's Calendar Page

The Calendar is an important tool for the Caregiver because he/she can organise better the day, see all the meetings that he/she has and add new events. The Calendar component is partially synchronised with the Calendar of their Care Receivers in order to allow better cooperation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 28 - Caregiver's Digital Personal Assistant Calendar Page

The SHAPES Genie personal assistant is a completely digital personal assistant that either works via voice or via text. The personal assistant can help the end-user with a touch of a button, even if that end-user is not very technologically savvy.

Figure 29 - Caregiver's Video Chat Mock-up Page

Finally, the Caregiver can use the Video Chat functionality that allows him/her to directly video chat with his/her Care Receivers in order to have a more meaningful connection with them.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SHAPES App as a Care Receiver

For the Care Receivers, the SHAPES Tablet App could be a useful tool that can help them with their everyday life. It allows them to connect with their Caregiver and their community as well as to motivate them to be more active.

Figure 30 - Care Receivers Homepage Mock-up

By login into the App, the Care Receiver is redirected to this Homepage. This Homepage is separated into three sections, the Weather, the Upcoming Event and the personalised Latest News. The Weather component shows them the Weather of their Neighbourhood, with the help of our FINoT Platform's sensors and technology. In a glance, the Care Receiver can see the current weather information, a small weather prediction for the day, as well as a motivational quote. If the Care Receiver presses on the Weather component, a small pop-up will appear with more information about the Weather.

In this pop-up, the Care Receiver can see the current weather conditions/temperature via text and icons as well as the Humidity, Precipitation and Wind Direction/Speed values for their Neighbourhood and their City. An important value that is annotated in the pop-up is the Rain Probability that allows the Care Receiver to make plans about the day without the fear of the rain. Finally, in the bottom of the screen, the Care Receiver can see the Daily Forecast for the neighbourhood. The forecast is separated by preselected key hours. In order to help the end-user, FINT presents the changes in temperature both with text and with a comparative line graph. In that way, the end-user can understand the changes in temperature without reading the text. The predicted weather conditions are represented with weather icons that help the end-user to better understand the forecasted weather conditions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

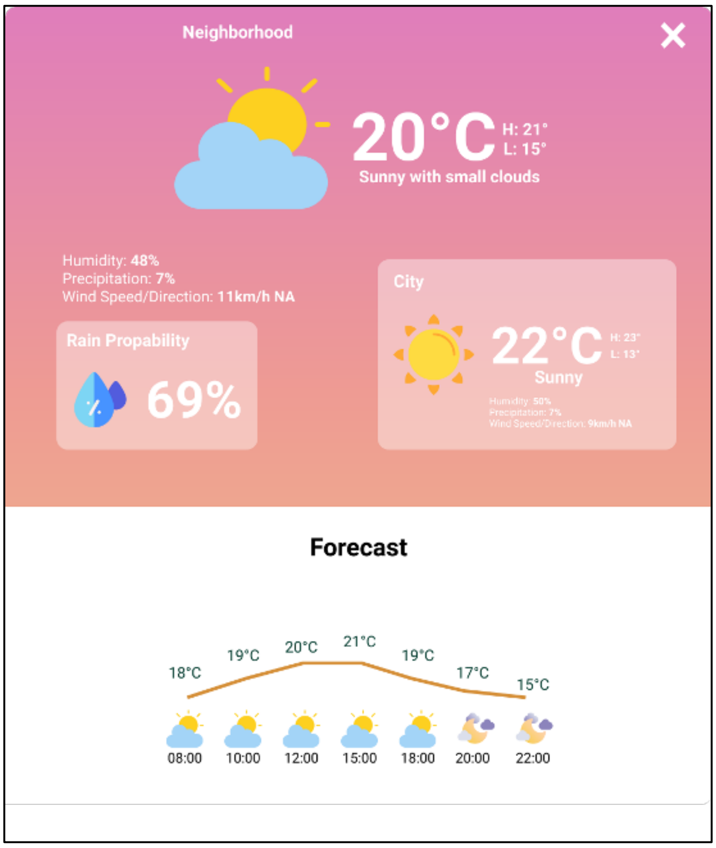


Figure 31 - Pop-up for more Weather Information

Continuing in the Homepage, in the right side, the Care Receiver can see his/her Upcoming Event. In this section, he/she can see the name of the event and the hour/place that the event will take place. Additionally, in this section, the Care Receiver can open an GPS Navigation program (ex. Google Maps) to help him/her navigate, Call the event's host and Open the Calendar page. Lastly, in this page, the Care Receiver can see personalised Latest News, based on his/her interests. By pressing the Read More button, the user will be redirected to the news article.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

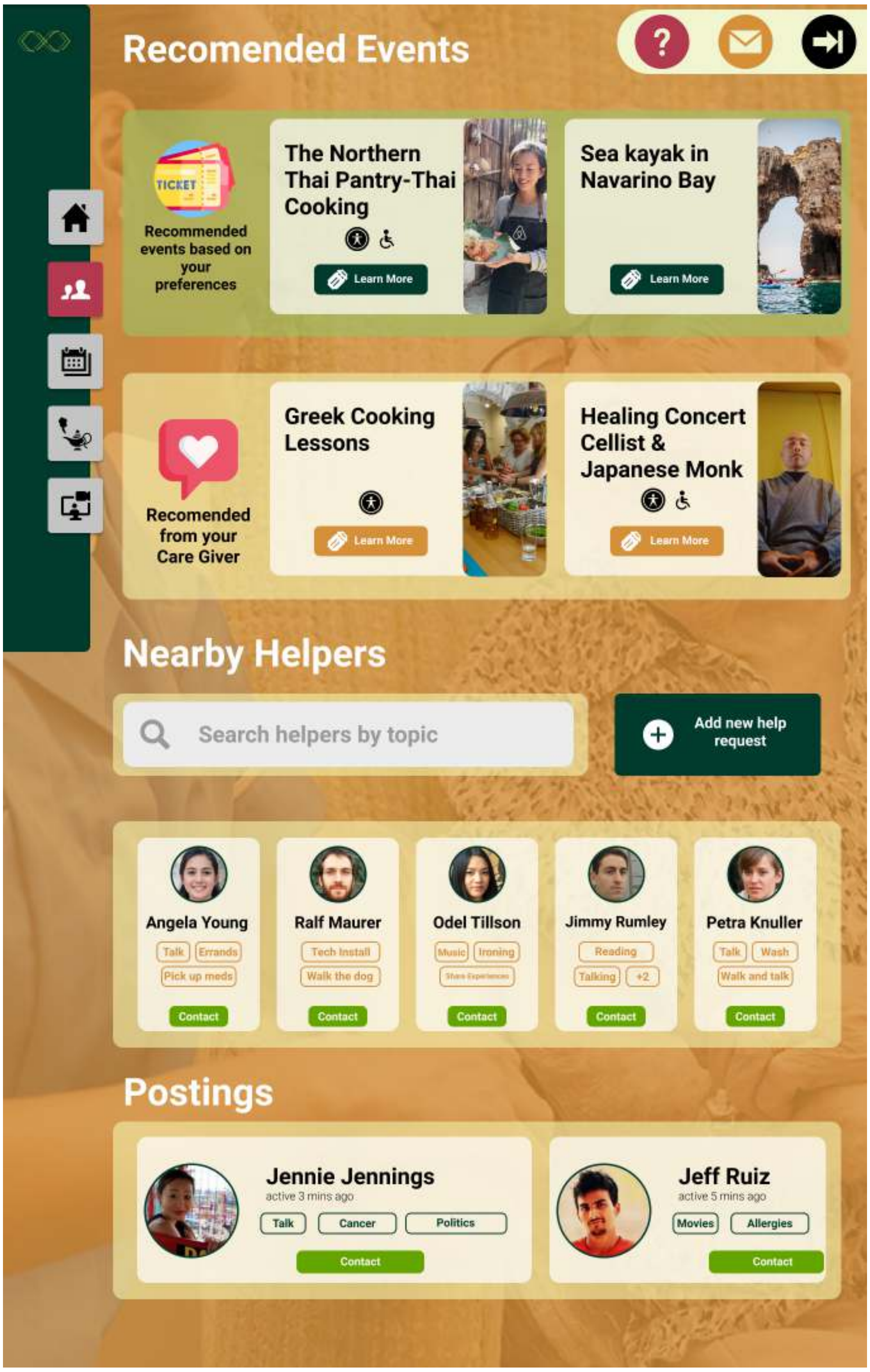


Figure 32 - Care Receiver's Community Page Pop-up

The next page for the Care Receiver is the Community Page. This is a very important page that allows the Care Receiver to connect and interact with his community. The page has two big sections, the Events Section and the Community Helping section.

In the Events section, the Care Receiver can learn, select and book events that interest him. There are two types of events: the ones that are recommended via an algorithm based on the Care Receiver's preferences and the ones that are recommended from the Caregiver. In a glance, the Care Receiver can see the name

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

of the event and if that event is accessible to people with disabilities. By pressing the Learn More button, a pop-up will appear in the screen.

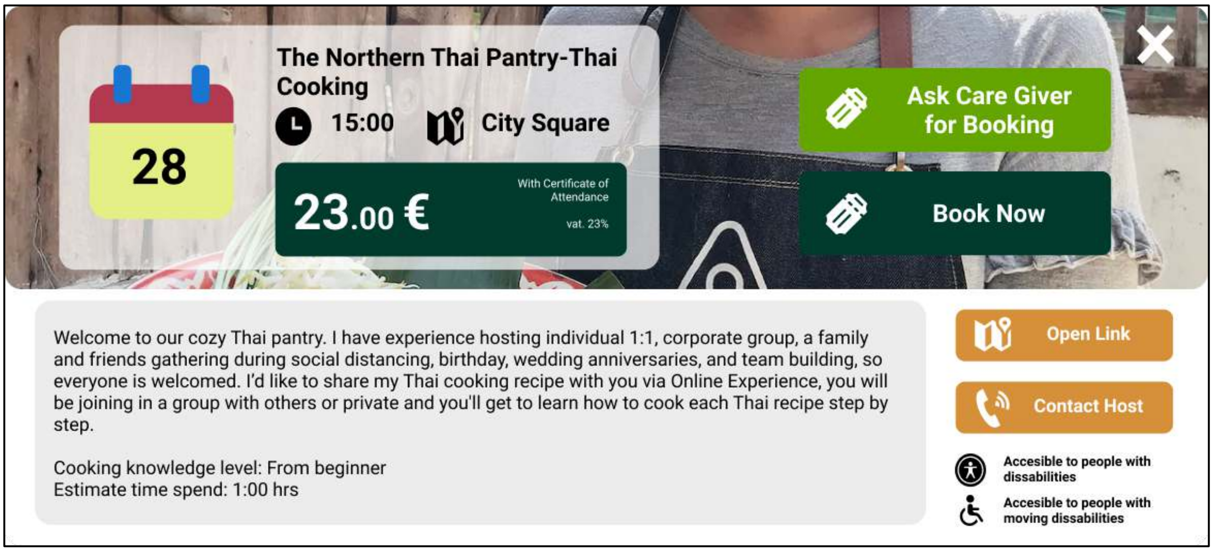


Figure 33 - Additional Information About Event

This pop-up will show the Care Receiver more information about the event (like the Time/Place that it will take place), the price of the event and more information about the event. From there, the Care Receiver can either Ask his/her Care Receiver to book this event for him/her or, if he/she has the capability, book this event himself/herself. Additionally, the Care Receiver can open an GPS Navigation program (ex. Google Maps) to help him/her navigate to the event or Contact the event's host.

In the Community Helping section, the Care Receiver can either add a new help request or connect with people that can either help Care Receiver or can be helped by the Care Receiver. By pressing the Add new help request, a new modal will appear that will allow the Care Receiver to select the topics that he/she wants to be helped. FINT notes that every help request will have to first be accepted by the Caregiver and then be posted in the App.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

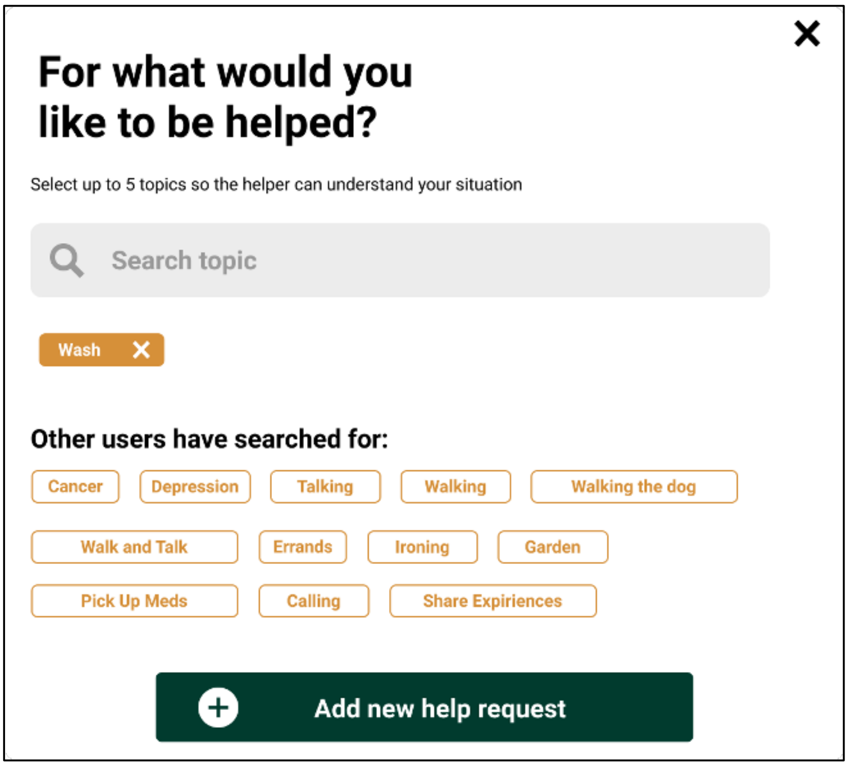


Figure 34 - Care Receiver's New Help Request

Finally, the Care Receiver can connect with people that can help the Care Receiver or, in the Posting section, can be helped by the Care Receiver. For every posting, the Care Receiver can see the available topics of the person, as well as their face. By pressing Connect, the Care Receiver and the Connected Person will be able to chat in the Video Chat Page.

Figure 35 - Care Receiver's Calendar Mock-up Page

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The Calendar is an important tool for the Care Receiver because he/she can organise better the day, see all the booked events and see their meetings with their Caregiver. The Calendar component is partially synchronised with the Calendar of their Caregivers in order to allow better cooperation.

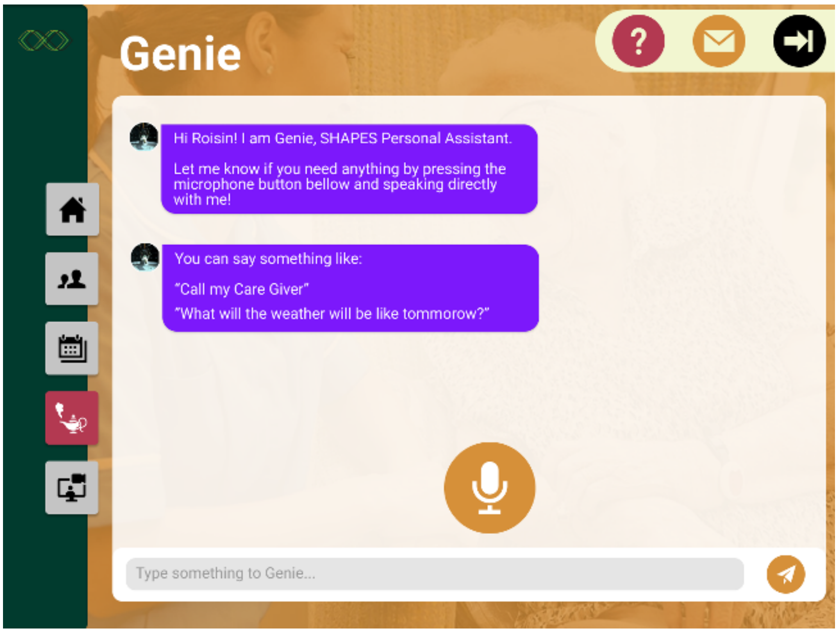


Figure 36 - Care Receiver's Personal Assistant Mock-up Page

The SHAPES Genie personal assistant is a completely digital personal assistant that either works via voice or via text. The personal assistant can help the end-user with a touch of a button, even if that end-user is not very technologically savvy. That makes FINT's App available to a large portion of the population, even with disabilities.

Figure 37 - Care Receiver's Video Chat Mock-up Page

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Last but not least, the Care Receiver can video chat with people in the Video Chat page. In the Video Chat page, the Care Receiver can directly contact their Caregivers and allow them to better connect with them. In this component, the Care Receiver can contact and communicate with all the people that the Care Receiver was connected in the Community Page.

3.1.5.3 Prototyping and Adaptation Stage

As the below diagram presents, there are 9 distinct interfaces, 1 graphical (IF-7) representing the DS dashboard and 8 APIs used to exchange information between the basic architectural components. The following table provides a short description of the interfaces.

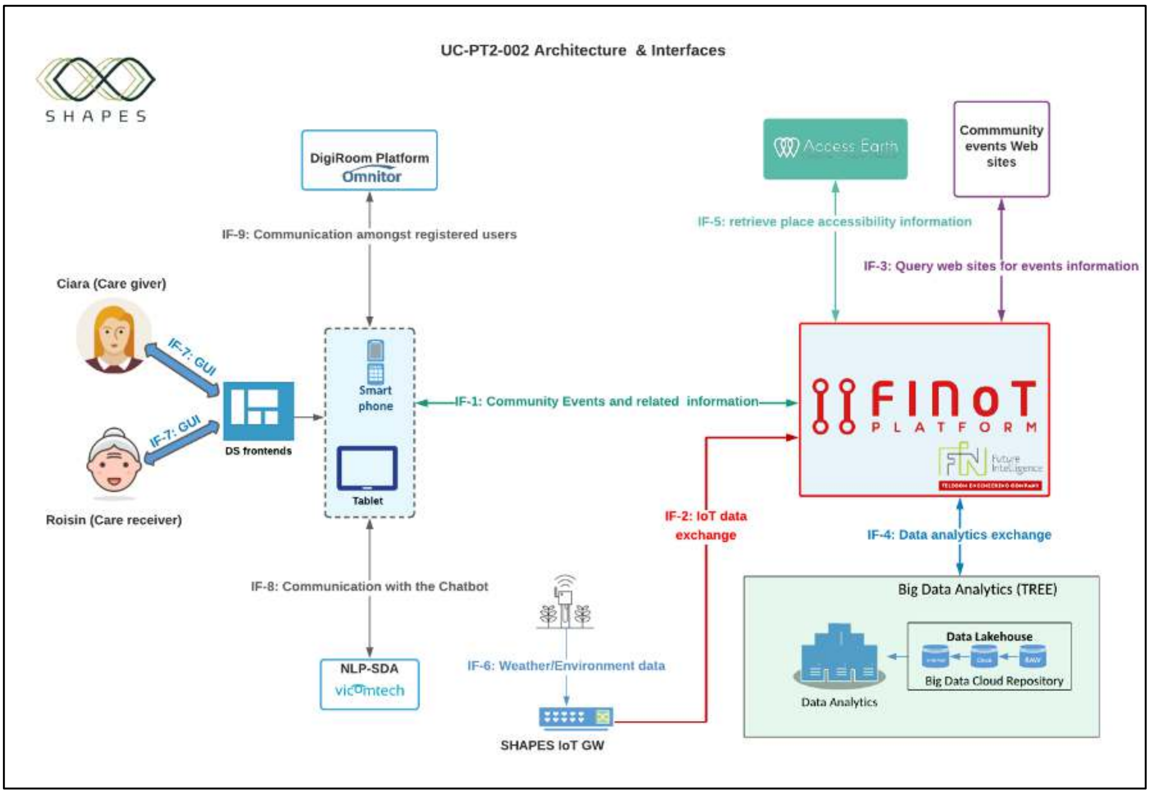


Figure 38 - Architecture and Interfaces for PT2-UC002

Table 12 – FINoT Platform Interfaces

Interface	Description
IF-1	Used to provide from FINoT the collected Weather Forecast Data information and the information related to the available and recommended community events/activities to the DS relevant App.
IF-2[1]	Used to forward from the gateway to the FINoT the collected Weather Forecast.

[1] It is noted that IF-2 interface corresponds to the IF-3 interface for the PT1-UC001 use case. A per use case rationale has been followed for labelling the interfaces.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Interface	Description
IF-3	Used to retrieve programmatically future community events and activities.
IF-4	Used to provide the collected IoT data to the SHAPES Data Lake and receive results from the run analytics.
IF-5	Used to retrieve data related to the place of the event (e.g. accessibility).
IF-6	Used to forward to the gateway the Weather Forecast data information from the relevant sensor devices.
IF-7	Used for enabling the end user to graphically interact with the DS and for visualising the relevant information.
IF-8	Used to activate/launch the chat app provided by Omnitor.
IF-9	Used to activate/launch the chatbot app provided by VICOM.

The data models describing the weather and the community events related data are presented below:

Table 13 – FINoT Platform Data Model

Data Models	Type of Variable
User Profile (Care Receiver)	
Name	text
user id	text
Date of birth	number
Gender (m/f/d)	text
Internet access	text
Skills how to use devices	text
Place of residence	text
Frequency of contact	number
Emergency contact	text
Physical or psychological limitations	text
Physical fitness	text
Interesting topics/news (Selection of politics, economy, sports, literature, music)	text
Interest in culture (Selection of readings, museum visits, historical offers, exhibitions ...)	text
Interest in sport (Selection of ball sports, gymnastics, outdoor and indoor sports, dancing…)	text
Area in which to find activities (Selection 2km, 5km, 10km)	text
Availability (days/times)	date & time
Usage data with regard to care receiver	
Days used	number
Time/Duration of interactions	number
Number of interactions	number

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Data Models	Type of Variable
Events registration completed	number
Events attended	number
Events attended history	text
Event assessment	
User Score	number
Comments	text
Precision	number
Recall	number
F1 Score	number
Weather Data	
Temperature	number
Humidity	number
Precipitation	number
precipitationType	text
windSpeed	number
windDirection	number
solarRadiation	number
Event Data	
Event type	text
Event place	text
Event date	date
Event time	time
Event participation cost	text
Event physical prerequisites	text
Event cognitive prerequisites	text
Event URL	text
Event description	text
Event recommendation assessment	
Relevance score	number
Number of views by user	number
Number of selections by user led to registered events	number
Number of selections by user led to user participating events	number
User profile (Caregiver)	
Name	text
user id	text
Date of birth	number
Gender (m/f/d)	text
Internet access	text
Skills how to use devices	text
Place of residence	text
Care receiver id	text
Physical or psychological limitations	text
Physical fitness	text

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Data Models	Type of Variable
Availability (days/times)	date & time
User chat communication (Caregiver & Care Receiver)	
Text	text
Image	image file
Video	video file
Audio	audio file

3.2 eCare – Personalised Care Intelligence Platform (EDGE)

eCare is EDGE's smart and personalised ambient intelligence platform that, collecting and integrating well-being, quality of life and environmental data, empowers individuals to create smart living environments that promote healthy lifestyles and independent living conditions.

Figure 39 - EDGE's eCare Platform

EDGE's ambient living intelligence solution provides (1) day-to-day non-intrusive and responsible monitoring of wellbeing parameters of individuals as well as (2) the delivery of remote monitoring of health parameters of patients at home who live with a chronic condition requiring periodic or permanent monitoring or who have undergone a medical intervention and need further observation.

Fostering a non-intrusive, privacy-by-design, secure and patient-friendly experience, **eCare** enables a reliable and highly-scalable monitoring environment, ensuring the individuals' safety on a continuous 24/7 basis and contributing to improve the level of care in home environments.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

eCare gathers a wide range of measurements acquired through sensors and devices that are seamlessly embedded in the living environment or are worn or interacted with by the individual. Amongst the measurements registered in **eCare**'s intelligence ambient platform are vital signs, physical measurements, health data and lifestyle and wellbeing data. In addition to wellbeing-related data, **eCare** includes the **MAESTRA** module that delivers ambient living data (room temperature and humidity, air quality, motion) and facilitates the integration of environmental data including pollution, dust and pollen levels, especially relevant for individuals suffering from asthma and chronic obstructive pulmonary disease.

Table 14 - eCare Health and Wellbeing Data

Data Category	Measurements Type	Collection Method
Vital signs	Body temperature Heart rate (and variability) Blood pressure (diastolic and systolic) Oxygen saturation Respiratory rate Blood glucose level	Automated (from connected devices) or Manual
Physical	Height Weight Waist circumference	Automated (from connected devices) or Manual
Health	Medication Allergies Medical conditions Disability Symptoms Side effects	Manual (fill-in questionnaires)
Lifestyle and Wellbeing	Habits Diet and nutrition Mood Sleep quality Physical activity	Automated (from connected devices) or Manual (fill-in questionnaires)
Ambient Living (in house)	Room temperature Room humidity Air quality (e.g., PM levels) Detection of gas/smoke Motion detection (movement) Appliances (on/off) Energy (metering)	Automated (from connected devices)
Environmental (outdoor)	Weather Air quality (pollution, dust, pollen) Water quality	Automated (from existing open access databases)

Individuals interact with the **eCare Platform** through the **eCare App** that enable an easy manual or automatic collection of health and wellbeing parameters. Automated parameters may be collected via health and medical devices and wearables. Also, the App allows individuals to answer to simple and short questionnaires and feedback forms on symptoms (e.g., pain, anxiety), medication adherence, nutrition and diet, mental state and quality of life.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Overall, **eCare**'s key features for individuals or patients are:

- The efficient collection of health and wellbeing-related parameters:
  - Health data, including vital signs;
  - Body measurements;
  - Lifestyle and wellbeing data.
- The efficient collection of information from smart living environments;
- An App for easy use, incorporating reminders and alerting mechanisms.

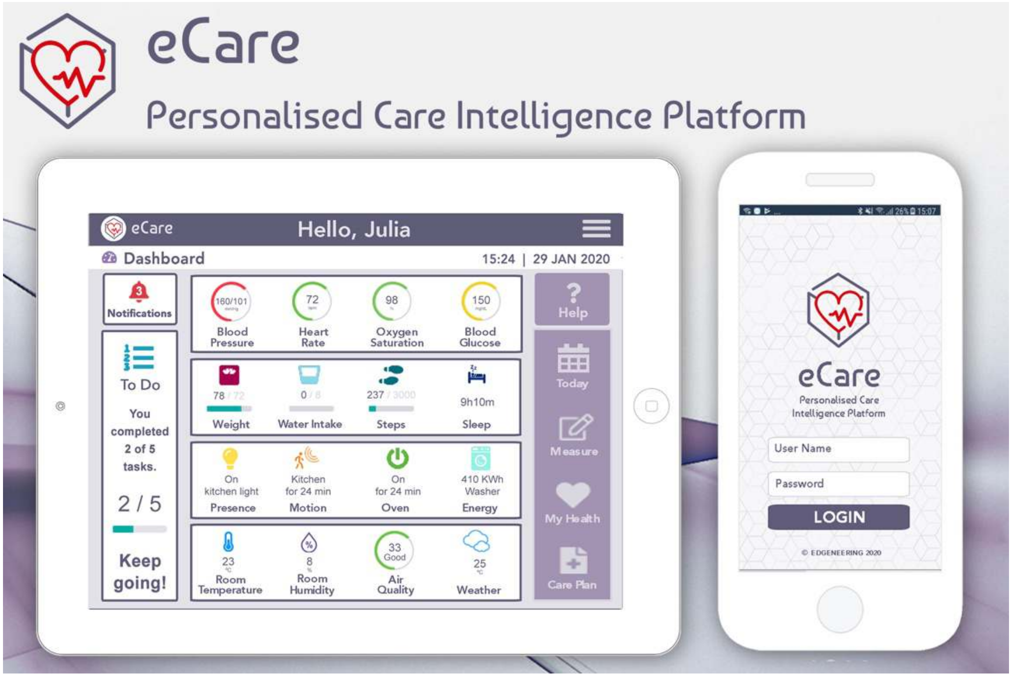


Figure 40 - eCare App for Individuals

Through the eCare Platform, health and social care professionals are able to easily and efficiently remotely monitor the health and wellbeing parameters of a large number of individuals or patients under their care (significant high scalability is given to the one-to-many monitoring healthcare model), by means of intuitive dashboards and rich visualisation tools that highlight localised risks of relapse or hospitalisation, being aware of their condition at all times and receiving notifications or alerts in case any patient symptoms become severe and their condition worsens, thus justifying the patient's immediate hospitalisation. Moreover, the eCare Platform monitors the individual's conditions, enabling the application of smart analytics and AI-based algorithms to deliver early diagnosis, risk prediction (enabling prevention measures) and adjustment of personalised treatment plans on-the-fly, to the benefit of individuals. These, in turn, can generate alerts that may feed into the remote eCare monitoring platform installed at the point of care (hospitals, clinics, day care units and medicalised residences).

Upon the individuals' or patients' explicit consent, the data are shared with the healthcare professionals (care team) responsible for accompanying the individuals or

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

patients, allowing the former to remotely access the (self)reported health and wellbeing parameters, easily update their health and wellbeing status during domiciliary visits or following telemedicine consults or phone calls, follow the evolution of the individuals' or patients' condition and to act promptly if needed (e.g., adjustment of medication, change of treatment, immediate phone contact).

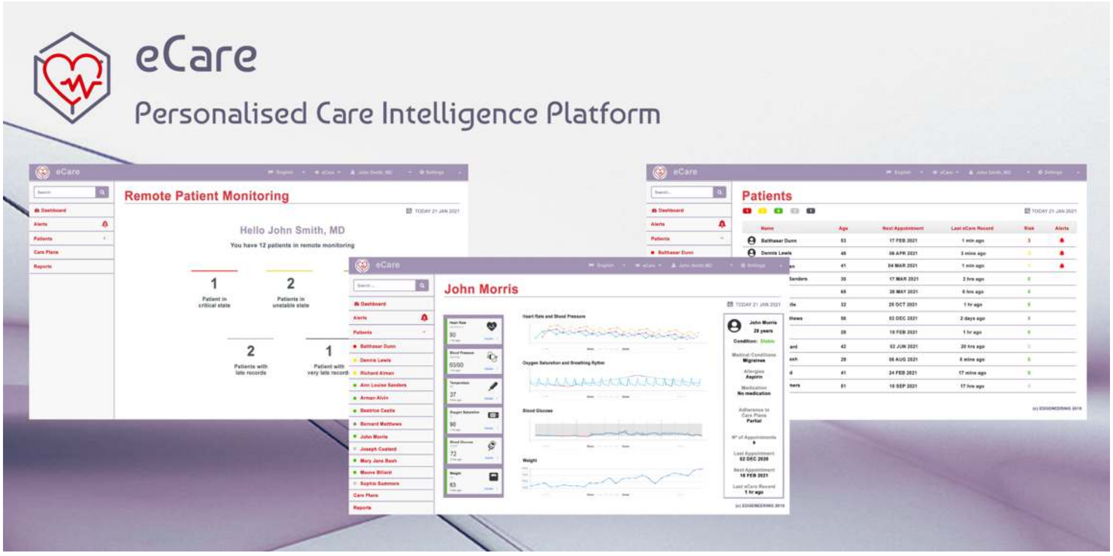


Figure 41 - eCare Platform for Healthcare Professionals

eCare's key features for professional caregivers, namely medical teams, and care service providers, particularly healthcare organisations, are:

- 24/7 monitoring of patients' conditions, via intelligent dashboards, with status indication in near real-time;
- Follow-up of the evolution of a particular condition or disease;
- Early identification of health and wellbeing deterioration signs;
- Generation of alerts in case of anomalies or worrisome signs;
- Application of smart analytics and AI-based algorithms for:
    - early diagnosis;
    - risk prediction;
    - adjustment of treatment plans on-the-fly.

eCare provides Healthcare and Wellness Services customised data access, personalised scores, rich visualisation tools, alert functions and services for professionals (e.g., doctors and nurses), enabling the follow-up of multiple patients or users by hospitals, clinics, day care units and, even, informal carers. Those services are provided over multiple channels (e.g., browsers, mobile apps) and enable individuals or patients to be empowered on their health and wellbeing care and the accompanying medical staff to be constantly aware of the individuals' or patients' health and wellness status and alerted in case of need for assistance.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Data quality and security are also key concerns of the **eCare Platform** that uses advanced technologies to ensure an efficient access to trustworthy data. **eCare** deals with a high degree of personal and sensitive information pertaining to individuals, thus it is critical that high standards for security and privacy (fully adopting the General Data Protection Regulation or GDPR) are implemented, resulting in a highly trusted platform among its users and stakeholders. **eCare** adopts a privacy-by-design scheme to guarantee full compliance with EU and national legislation and regulations (e.g. GDPR) on data privacy, especially in regard to the use of personal and/or sensitive data. Likewise, security-by-design principles is assumed not only for the **eCare Platform** itself and security mechanisms, but also for the communication channels with external sources and components.

For any patient data to be sent, shared or anyway exchanged with the healthcare professional, it is required that the individual authorises, consents and enables the so-called data transfer. **Strict authentication, authorisation, and accounting security measures** are in place in the **eCare Platform** to guarantee the safeguard of the users' privacy and the protection of all personal data. Robust authentication mechanisms and secure access protocols are adopted and strong end-to-end encryption (e.g., transport layer security or TLS) is used. Individuals or patients always retain the power to individually grant access to the different elements of their reported health and wellbeing information to healthcare professionals, thus remaining in control of their own data. Individuals have the option to delete all their data and their account with the **eCare Platform**, effectively leaving the Platform, in full compliance with GDPR's article 17 *Right to be forgotten*. The **eCare Platform** records in a secure log system all actions involving the data and information held within, that is, all access, creation, modification, archival and deletion actions concerning the Platform's data, including the identification of the user responsible for the action. Data access management is based on an Attribute-based Access Control (ABAC) approach, enabling finer grained data access control and a system better fitted to operational efficiency.

3.2.1 Interfaces and Interoperability

The **eCare Platform** includes an API that supports the interoperability of the Platform with third-party applications or software. Following a pre-defined data model, the **eCare** API enables the exportation of anonymised data collected by the **eCare Platform** to third-party applications or software. The **eCare Platform** may also be extended to import data provided by external applications and devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 15 - Summarised Technical Description of the eCare Platform

General Description	Big data platform presenting the older individuals' health (psychophysiological parameters), wellbeing and lifestyle data captured by diverse information sources, including smart home devices, health devices, wearables and open source databases, to support the creation of intelligent environments capable of promoting superior quality of life.
Features	• Gathering and presentation of the older individual's o **health** (psychophysiological parameters) information, based on data captured by health devices and wearables (automatic or manual input); o **wellbeing and lifestyle behaviour** information, based on data provided by the individual in the eCare App (forms, surveys and questionnaires); o **living environment** information, based on data captured by smart home devices and open source databases. • Integration of real-world data to improve the quality of care; • Statistics on the evolution of the older individual's health and wellbeing conditions; • Remote monitoring of patient condition by healthcare professionals (workload reduction); • Delivery of reminders, notifications and alerts.
Application Areas	• Remote monitoring of health and wellbeing conditions by health and care service providers; • Patient empowerment (manage own care plan and adoption of preventative behaviours); • Support to the creation of intelligent environments fostering independence, autonomy and superior quality of life.
TRL	From TRL5 to TRL7
Data Type	JSON format. Used standards: • Openmhealth (https://www.openmhealth.org); • Smart Applications REFerence or SAREF (https://saref.etsi.org). EDGE extensions for specific fields.
Inputs	HTTP(S) REST, JSON messages.
Outputs	HTTP(S) REST, JSON messages.
Actions to be performed	**Older individuals** use the eCare App or the eCare System to insert information to the eCare Platform. **Professional and informal caregivers** use the eCare System to insert information to the eCare Platform. Compatible **smart devices** provide automatic information to the eCare Platform.
Interface	eCare App: Smartphone eCare System (front-end): Web browser eCare System (back-end): API for third-parties to access eCare information (using HTTP(S) REST) eCare Platform: API for third-party systems (e.g., data analytics) to insert automatic information in eCare (using HTTP(S) REST)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.2.2 Applicable Pilot Themes

In SHAPES, the **eCare Platform** and specific comprising modules will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1 – Smart Living Environment for Active Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

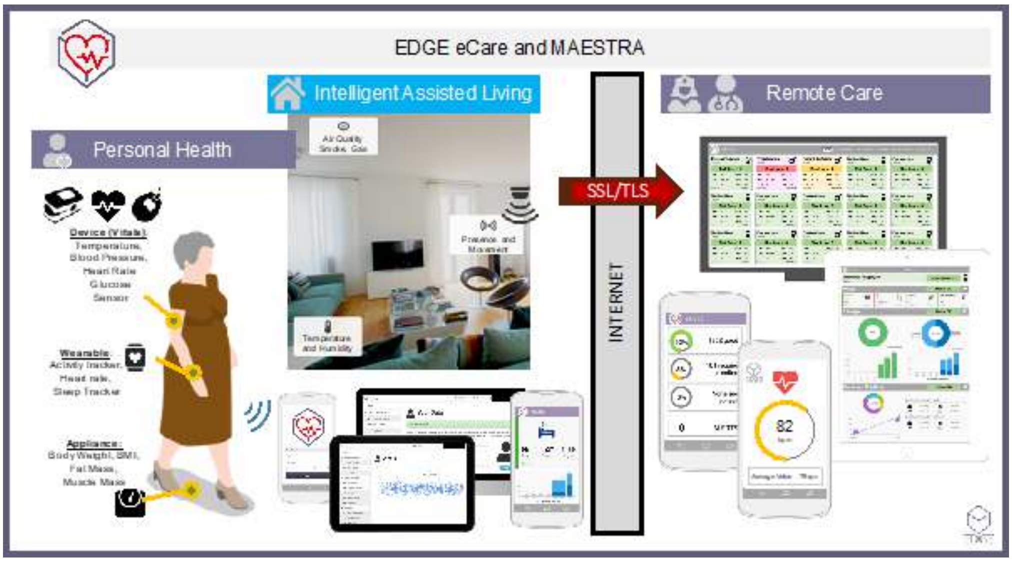


Figure 42 - Application of the eCare Platform in SHAPES Pilot Themes

3.2.3 Adaptations for PT1-UC001

The following sections present the adaptations and new developments performed in the **eCare Platform** digital solution, in order to meet the specific requirements of ***PT1-UC001: Remote in-Home Wellbeing Monitoring and Assessment*** and adequately support the use case's pilot activities.

3.2.3.1 Concept and Ideation Stage

In this use case, the targeted audience is the older people (65+ years) living independently, in rural or urban environments, either alone or with their spouse, and being visited by a family member or caregiver on a regular basis. According to Deliverable D2.7 – *SHAPES Personas and Use Cases V3* [2], the SHAPES personas

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

applicable to PT1-UC001 are Ernst (Persona 1), Roberto (Persona 2), Ayesha (Persona 3), Isabel and Marco (Persona 4) and Helena (Persona 7). Details on these SHAPES personas are available in Deliverable D2.7.

The use case PT1-UC001 aims to foster the early identification of risky situations at home and to detect signs of early physical or cognitive decline. To that end, digital technologies are to be deployed, in order to unobtrusively monitor the pilot participants' wellbeing and lifestyle, as well as the accomplishment of daily living activities. The involved technologies include smart plugs (to register whether home appliances and lights are on or off), air quality sensors (to record the presence of toxic gases or smoke), weather information (to inform on climate conditions affecting outdoor activity or wellbeing) and a fitness tracker (to monitor heart rate, physical activity and sleep quality). In addition, users will answer a daily wellbeing survey. Based on the collected data, data analytics solutions will determine normality patterns and detect emerging anomalies (risky situations) in those patterns, triggering specific notifications, reminders or recommendations to the pilot participants so that appropriate intervention could be carried out.

In order for the **eCare Platform** to properly support the use case PT1-UC001, an analysis of the applicable system specifications (as defined in Deliverable D4.1 – *SHAPES Technological Platform Requirements and Architectu*re [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.2 – *Smart Living Environment for Healthy Ageing at Home - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

Table 16 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	eCare has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	eCare adopts a modular and configurable architecture.
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	eCare follows universal accessibility policies.
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCare adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	eCare has its own APIs and adopts interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	eCare delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	eCare has a multilingual interface and eCare adaptations benefitted from SHAPES partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, a dedicated user manual has been created, including relevant instructions on the use of the devices.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	eCare supports health data collection, sharing and processing.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCare complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCare storage is handled in EU Member States.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-033	All classes of users shall be able to review the historical data.	Y	eCare maintains a data repository that includes historical data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	eCare supports fitness trackers.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	eCare supports fitness trackers.
SPS-038	Devices recording sleep quality should be supported.	Y	eCare supports fitness trackers allowing to calculate sleep quality data.
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.)	Y	eCare supports medical devices that monitor vital signs.
SPS-042	The SHAPES Platform should support manual data entry.	Y	eCare supports manual data entries.
SPS-043	The SHAPES Platform shall support risk assessment and action plans as part of its data processing of health data.	Y	eCare displays the results of risk assessment data analytics integrated with the platform.
SPS-046	The SHAPES Platform should support reminders.	Y	eCare delivers reminders.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	eCare delivers alerts.
SPS-052	The SHAPES Platform should support monitoring of appliances.	Y	eCare supports IoT devices that monitor appliances.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	eCare provides a set of daily tasks for the user.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-058	The SHAPES Platform may motivate care receivers.	Y	eCare delivers motivational notes.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	eCare delivers user friendly dashboards. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	eCare supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data is defined by the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	eCare maintains system access logs for all data.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	eCare offers robust authentication and authorisation features.
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	eCare provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from	Y	eCare supports mobile and web-based platforms and devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	desktop/laptop/smartphone and tablet.		
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	eCare provides users with comprehensive feedback.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	eCare supports the creation and personalisation of care plans.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	eCare supports the users' health literacy.
SPS-117	The SHAPES Platform should support sensor monitoring of high risk situations.	Y	eCare enables the identification of risk situations detected by connected sensors.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	eCare supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	eCare enables traceability of personal data.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCare is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCare complies with relevant cybersecurity rules for mobile and online services.
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	eCare follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	eCare delivers alerts and notifications to its users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCare offers user friendly and attractive interfaces. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCare offers user friendly interfaces for all users. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCare applies user interfaces resembling other technologies used by the elderly.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	eCare adopts an efficient navigation scheme to facilitate user interaction. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	eCare implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	eCare adopts a data minimisation policy that restricts data processing.
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	eCare presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	eCare adopts a data minimisation policy that supports storage minimisation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	eCare complies with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	eCare offers robust authentication and authorisation features. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	eCare implements password-based authentication.
SPS-149	The SHAPES Platform shall support password management.	Y	eCare has a password management feature. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	eCare is a scalable solution in terms of users, services and geographical coverage.
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	eCare is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	eCare was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	eCare supports the registration of IoT and medical devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	eCare supports the recognition of connected devices.
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	eCare supports the accessibility features of the access device.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	eCare delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	eCare supports an offline operation mode at the user device.
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	eCare maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	eCare supports service continuity.
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	eCare maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical	Y	eCare delivers user friendly and intuitive graphical user interface. Adaptations to eCare

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	elements linked with respective services.		consider the collected user feedback on design mock-ups and prototype.
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	eCare has its own APIs, allowing the exchange of data among digital solutions. eCare was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	eCare is accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	eCare web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	eCare shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	eCare shall support the exchange of data with SHAPES components.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	eCare shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	eCare is being adapted to support the management of notifications among core SHAPES components.
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	eCare shall support SHAPES's single sign-on mechanism, provided via ASAPA.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	eCare offers robust authorisation features for data access.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	eCare API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	eCare implements anonymisation features.
SPS-200	All passwords shall be unique per device and per user.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	eCare adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	eCare adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	eCare adopts robust verification mechanisms for software updates.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	eCare implements encryption features to protect data exchange with devices.
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	eCare supports an offline operation mode.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	eCare allows users to easily delete own data from the device.
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	eCare enables the validation of specific fields of information or data provided by the user or received via the eCare API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

Table 17 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the on/off status of appliances and lights at the home of the elderly pilot participant.	Y	eCare displays the on/off status of appliances and lights at home based on IoT data from smart plugs.
R2	Monitor the duration of the on status of appliances and lights at the home of the elderly pilot participant.	Y	eCare displays the on/off status of appliances and lights at home based on IoT data from smart plugs.
R3	Monitor the elderly pilot participant's physical activity.	Y	eCare collects data on physical activity from the fitness tracker wearable. eCare displays the results of the physical activity data analytics integrated with the platform.
R4	Establish the elderly pilot participant's physical activity goals.	Y	eCare displays daily tasks for the pilot participant, including those addressing physical activity goals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R5	Deliver to the elderly pilot participant reminders on their physical activity goals.	Y	eCare displays reminders on the daily activities to be accomplished by the pilot participant.
R6	Monitor the elderly pilot participant's sleep quality.	Y	eCare collects data on sleep quality determined via data collected from the fitness tracker wearable. eCare displays the results of the sleep quality data analytics integrated with the platform.
R7	Deliver to the elderly pilot participant recommendations on their sleep routine.	Y	eCare displays information concerning sleep routine and quality to the pilot participant, including those addressing sleep quality goals.
R8	Monitor the elderly pilot participant's heart rate.	Y	eCare collects and displays data on heart rate from the fitness tracker wearable.
R9	Allow the caregiver pilot participant to remotely monitor the on/off status of appliances and lights at the home of the elderly pilot participant in their care.	Y	eCare displays in the caregiver dashboard the on/off status of appliances and lights at the home of the elderly pilot participant.
R10	Allow the caregiver pilot participant to remotely monitor the duration of the on status of appliances and lights at the home of the elderly pilot participant in their care.	Y	eCare displays in the caregiver dashboard the on/off status of appliances and lights at the home of the elderly pilot participant in their care.
R11	Allow the caregiver pilot participant to remotely monitor the physical activity data of the elderly pilot participant in their care.	Y	eCare displays in the caregiver dashboard the physical activity data of the elderly pilot participant in their care.

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R12	Allow the caregiver pilot participant to remotely monitor the sleep quality data of the elderly pilot participant in their care.	Y	eCare displays in the caregiver dashboard the sleep quality data of the elderly pilot participant in their care.
R13	Allow the caregiver pilot participant to remotely monitor the heart rate data of the elderly pilot participant in their care.	Y	eCare displays in the caregiver dashboard the heart rate data of the elderly pilot participant in their care.
R14	Create a Researcher Dashboard allowing pilot organisers to follow the progress of the pilot activities and the elderly pilot participants' adherence to the research protocol.	Y	eCare provides an overview of the daily activities performed by the elderly pilot participants, allowing pilot organisers to monitor the pilot activities' progress and the participants' adherence.

3.2.3.2 *Design and Development Stage*

A design system that is functional, accessible and emotive is crucial to excellent user experience and a positive brand image. Consequently, the design of the user interface and the selection of colours, fonts and font sizes do impact the usability of the system or application.

Concerning the **eCare Platform**, the font choice fell on the *Roboto* font for the mobile **eCare application**, for it is a sans-serif font that is very comfortable to the eyes thanks to large x-heights and wide letterforms. The font choice for the web-based **eCare System** has been *Helvetica Neue*, also a sans-serif typeface that is the most legible version of the Helvetica font family, due to the enlarged space between numbers and the bigger punctuation marks, readable even in motion.

The choice of colour was determined by the SHAPES project's brand and the use of green and gold colouring. This selection fits with recognised accessibility guidelines and prevent issues associated with user colour-blindness. In addition, for recognition purposes, it was decided to apply both the SHAPES logo and the logo of the SHAPES partner responsible for conducting the pilot activities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

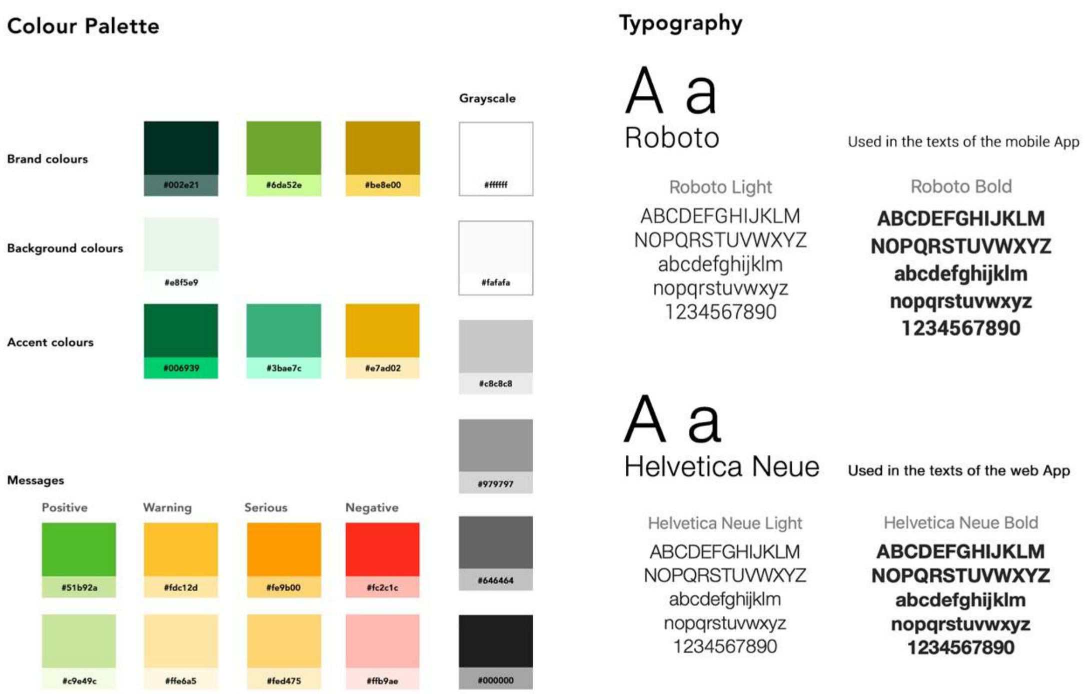


Figure 43 - Colour Palette and Typography of the eCare Platform in SHAPES Pilot Themes

Since the **SHAPES eCare App**'s dominant users are older adults, compliance with accessibility best practices has been at the front-and-centre of the design approach. The rules applied observe WCAG 2.1 Standards, Universal Design principles and Material Design's accessibility guidelines, following the recommendations of Deliverable D5.1 – *SHAPES User Experience Design and Guidelines* [4].

The overarching challenge is to adapt the **eCare Platform**'s user interfaces to improve the accessibility to older adults, experiencing widely different levels of physical and cognitive conditions. And the key difficulty is to render the information on the screens large enough to be comfortable to read and, at the same time, small enough so that enough information can be seen on the screen at any given moment to reduce cognitive load.

Selecting highly readable typefaces and adopting font sizes of 14 points (typically, large font or 18.66px) or larger complied with accessibility guidance and allowed to smartly apply white spaces to not overwhelm users. Older users tend to read screens as they would a paper document, line by line from top to bottom. Hence, effort was placed to ensure entire screens were meant to be read linearly along the vertical axis. Navigation privileged clear tasks and flows with minimum steps, reinforcing information through multiple visual and textual cues, such as colour, shape and text. The concerns on readability, cognitive load and relevant information display are also relevant for the caregiver/care professional audience. Therefore, the same attention was placed in the adaptations performed in the web-based **eCare System**. Importantly, since the use case's leading partner (CCS) operates in Germany and will be recruiting German pilot participants, the texts were translated to the German language.

The mock-up designs of the **SHAPES eCare App** for the PT1-UC001 use case are presented next.

Figure 44 - SHAPES eCare App for PT1-UC001 – Home Screen

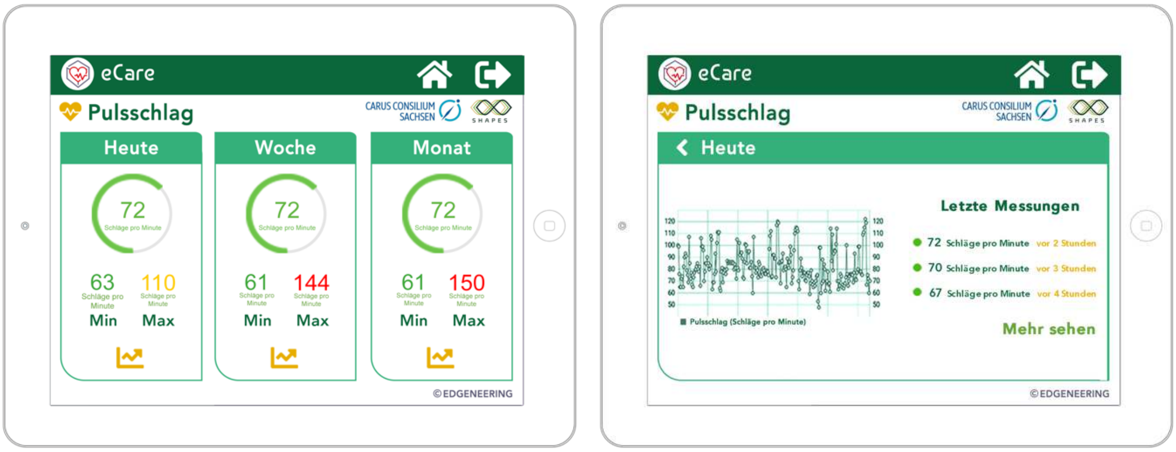


Figure 45 - SHAPES eCare App for PT1-UC001 – Heart Rate Monitoring Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

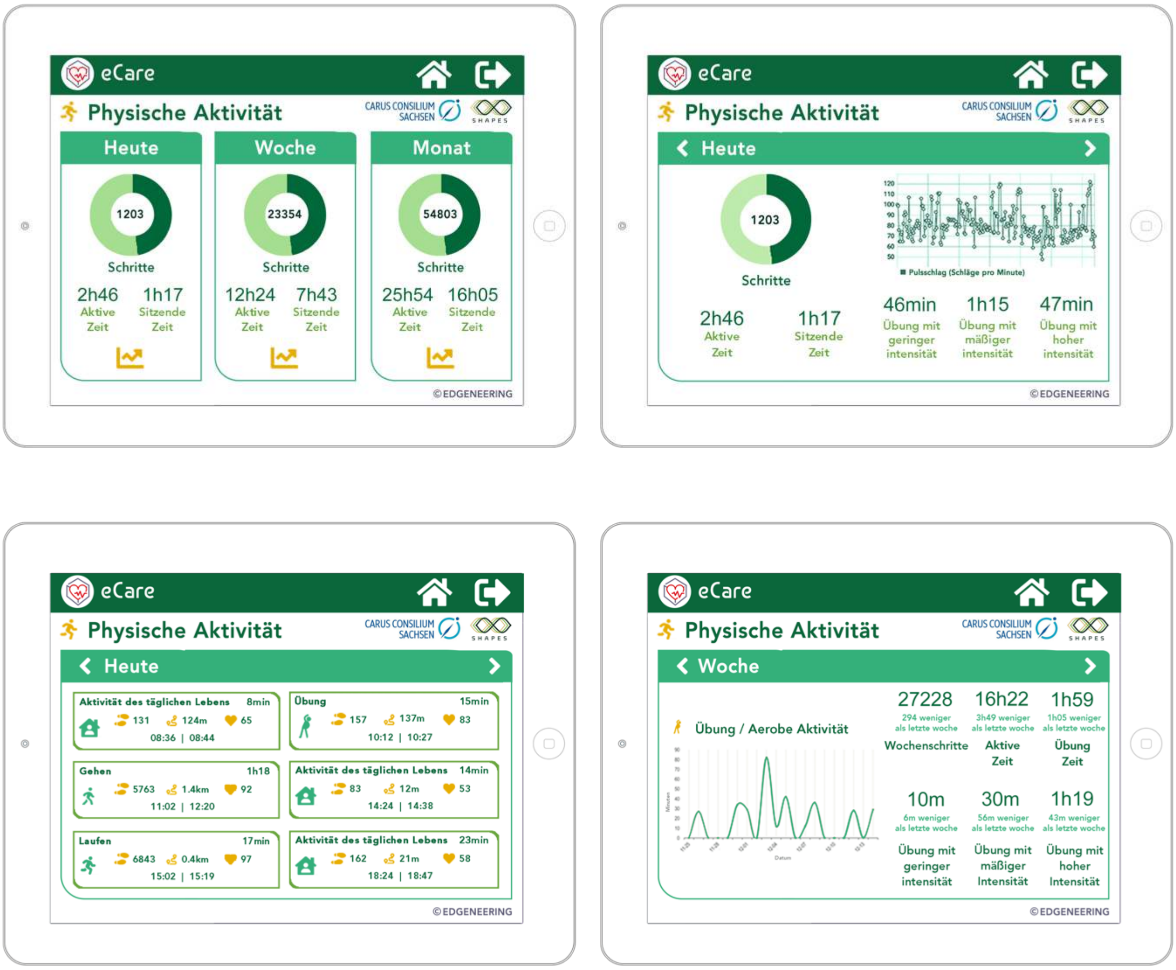


Figure 46 - SHAPES eCare App for PT1-UC001 – Physical Activity Monitoring Screens

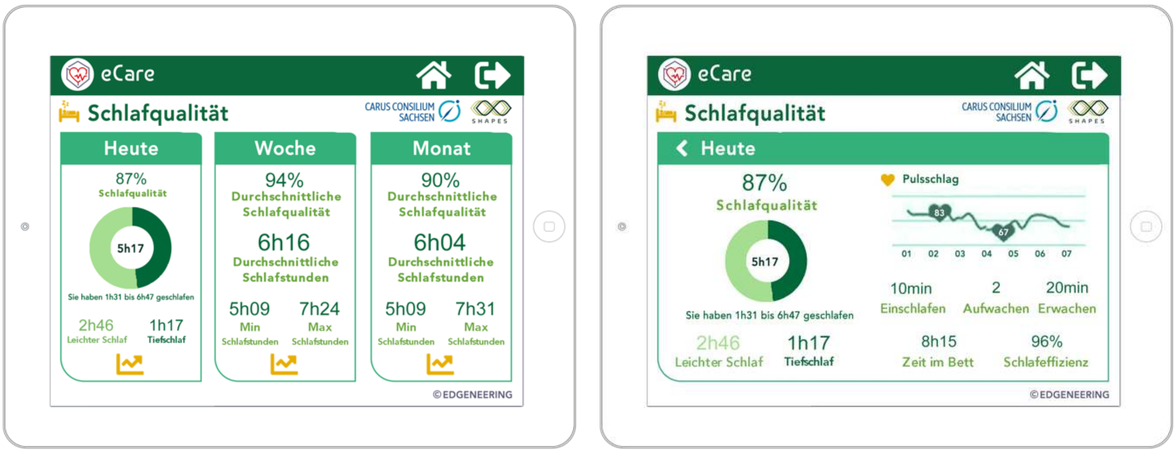


Figure 47 - SHAPES eCare App for PT1-UC001 – Sleep Quality Monitoring Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

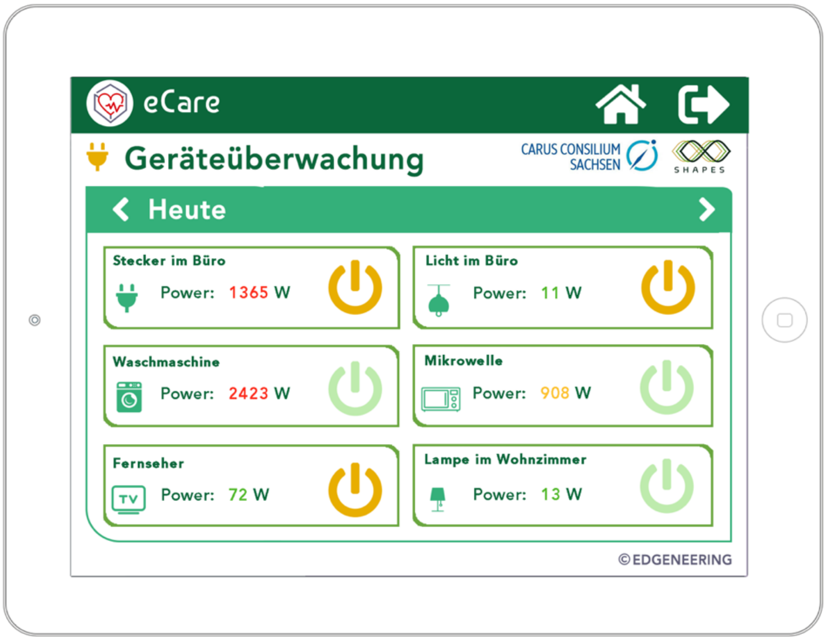
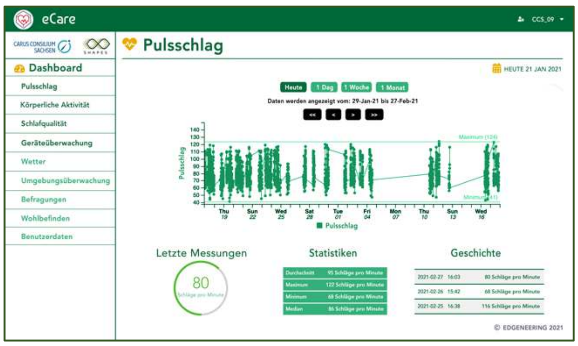


Figure 48 - SHAPES eCare App for PT1-UC001 – Home Appliances Monitoring Screen

In July 2021, the mock-up designs were presented by CCS to a set of 18 representatives of the pilot participants in six different meetings involving small groups of three or four participants. Aside from the immediate feedback received, CCS provided also questionnaires to be taken home and answered afterwards. Overall, the collected user feedback on the **SHAPES eCare App** was quite positive, with participants highlighting that the screens were very friendly, attractive and understandable.

The web-based **SHAPES eCare Systems** allows the caregiver pilot participants to access and view the information pertaining to the elderly pilot participant in their care. The mock-up designs of the SHAPES eCare System for the PT1-UC001 use case are presented next.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

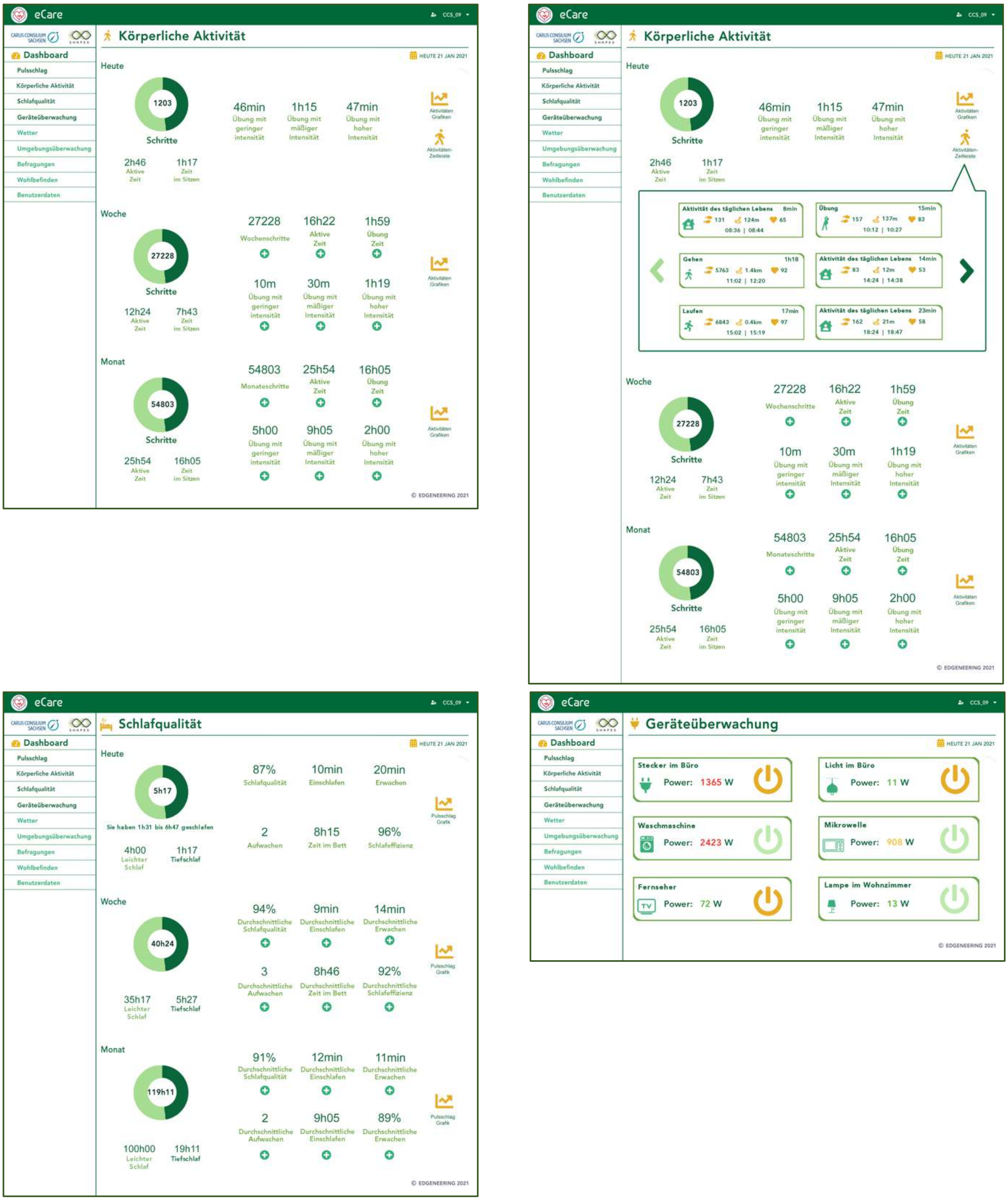


Figure 49 - SHAPES eCare System for PT1-UC001

The web-based **SHAPES eCare System** also was adapted for a novel development, named the SHAPES Researcher Dashboard. This dashboard allows the CCS researchers' team to access and view the information pertaining to the activities performed by the elderly pilot participants during the pilot, so that researchers may understand the pilot participants' adherence level to the research plan or protocol, allowing them to early detect anomalous behaviour or deviations with respect to the research plan and intervene, if required (for example, by directly contacting the pilot participant to understand if there are any difficulties understanding or implementing the research protocol). The mock-up designs of the **SHAPES Researcher Dashboard** for the PT1-UC001 use case are presented next.

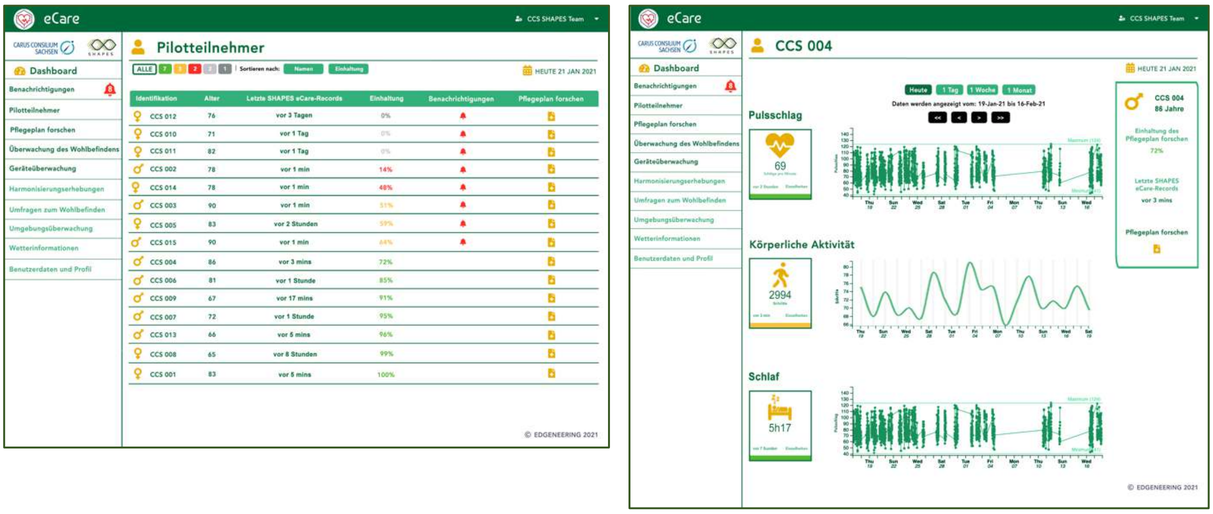


Figure 50 - SHAPES eCare System for CCS Researchers in PT1-UC001

3.2.3.3 *Prototyping and Adaptation Stage*

Following the concept and ideation and design and development stages, the prototyping and adaptation stage focused on the creation of the **SHAPES eCare App** and **SHAPES eCare Portal** to adequately support the piloting activities of use case PT1-UC001.

The **SHAPES eCare Platform** for PT1-UC001 is responsible for retrieving the data from the connected device (the fitness tracker wearable) and providing user interfaces with the elderly pilot participant (the **SHAPES eCare App**) and the caregiver pilot participant (the **SHAPES eCare Portal**). The eCare third-party API allows for the direct exchange of data with the different SHAPES digital solutions supporting this use case, so as to display the most up-to-date information to the user. In addition, the eCare third-party API allows the **SHAPES eCare Platform** to exchange information with the SHAPES Platform, namely the SHAPES Data Lake repository and the SHAPES Authentication module (ASAPA). The **SHAPES eCare Portal** will also be adapted to deliver the **eCare Researcher Dashboard**, enabling CCS to remotely accompany the pilot's progress, providing an overview of the pilot participants' adherence to the pilot research protocol, in the scope of the functionalities enabled by the **SHAPES eCare Platform**.

From a high-level architectural perspective, the **SHAPES eCare** component is depicted as:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

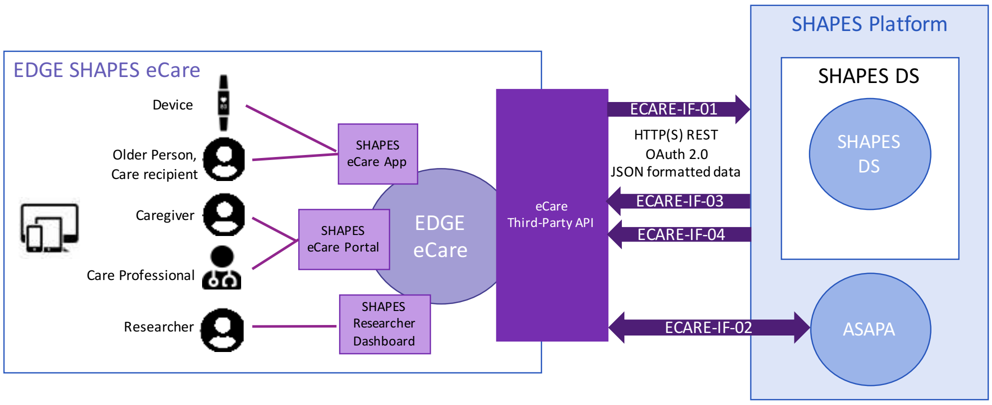


Figure 51 - High-level Architecture of the SHAPES eCare Platform Component for PT1-UC001

The **SHAPES eCare Platform**'s interfaces are detailed in the following table.

Table 18 - SHAPES eCare Platform Interfaces

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
ECARE-IF-01	SHAPES eCare and the SHAPES Platform	SHAPES eCare provides user activity and vitals data collected from the wearable.	**Output**: Activity data (number of steps over time) and vitals (heart rate measurements).
ECARE-IF-02	SHAPES eCare and the ASAPA Module	The ASAPA module provides user authentication in SHAPES. SHAPES eCare uses the same user authentication.	**Output:** username and password. **Input:** If successful, results the user token; if not, returns "not authorised".
ECARE-IF-03	SHAPES Platform and Digital Solutions	SHAPES eCare receives user data and appliances data from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: User data (age; gender), smart plugs data (on/off status, energy consumption).
ECARE-IF-04	SHAPES Platform and Digital Solutions	SHAPES eCare receives reports, alerts and recommendations as a result of user data processing from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: Physical activity reports, sleep quality report, Activity of Daily Living (ADL) alerts and recommendations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Considering the SHAPES eCare Platform architecture and the pilot use case's requirements, the primary functions to be enabled through the **SHAPES eCare App** concern the display of the data collected from the elderly pilot participant's fitness tracker (wearable), the data provided by the SHAPES partner providing the smart home plugs and the data analyses on physical activity, sleep quality and anomaly detection produced by the data analytics SHAPES partners. Similarly, the **SHAPES eCare System** will provide the same primary functions, allowing caregivers to have access to the data of the elderly in their care.

These functions are delivered by the following **eCare Platform** modules:

- **Dashboard**, allowing to display to the user an overview of the key parameters of the eCare monitoring platform (vitals, ambient living, physical activity, sleep, body and nutrition, weather) and provide access to the different functions provided by eCare;
- **Vitals monitoring**, allowing the user to register and view the vital signs (blood pressure, heart rate, temperature, oxygen saturation, respiratory rate and blood glucose) readings from connected devices, visualise them over time (graphical setting) and manually insert measurements, if needed;
- **Physical activity monitoring**, allowing to collect the activity data from fitness trackers and display a physical activity report;
- **Sleep quality monitoring**, allowing to collect the activity data from fitness trackers and display a sleep quality report;
- **Ambient living monitoring**, allowing to display to the user data provided by smart home sensors on the house's ambient living environment, involving the house's air quality parameters, the use of house appliances and lights, the detection of movement and presence, the local weather conditions and outdoor air quality;
- **Notifications**, allowing to present to the user reminders, notifications, alerts or recommendations concerning the vital signs readings, wellbeing data, ambient living data, daily tasks and goals and surveys;
- **Care Plan**, allowing care professionals to establish a personalised care plan for the user, involving vitals monitoring, medication, physical activity, sleep, diet and treatment. It sets individual daily or weekly tasks/goals, personalised reminders, notifications and recommendations concerning the user's vitals and wellbeing data;
- **Devices Management**, allowing the connection with the user's medical, health or smart home devices so as to automatically acquire the user's relevant data;
- **User Information**, allowing the user to configure personal information and the display preferences concerning notifications, reminders and colour code.

As a result, prototyping work is ongoing to adapt the **eCare Platform**'s user interfaces to the pilot use case's needs, considering the mock-up designs and the user feedback received through the co-design phase. Aside from the visual changes detailed in section 3.2.3.2, adaptations have been made so that the **SHAPES eCare App** and the **SHAPES eCare System** display the functionalities associated with the use case and are able to interoperate with other digital solutions supporting the use case:

Table 19 - Adaptations to build the SHAPES eCare Platform for PT1-UC001

Module	Adaptation Work
Dashboard	This module is being adapted in the App to display to the elderly pilot participants the key functionalities of the use case (heart rate monitoring, physical activity monitoring, sleep quality monitoring, appliances monitoring and notifications). The module is also adapted in the Portal to display to the caregiver pilot participants an overview of the monitoring data of the elderly pilot participants' in their care, concerning vitals monitoring, physical activity, sleep quality and appliances monitoring).
Vitals Monitoring	This module is being adapted to display to the pilot participants only heart rate readings and hide other vital signs (blood pressure, temperature, oxygen saturation and respiratory rate) and to enable the manual insertion of heart rate readings (the automatic reading mode is the default active option with the connection to the fitness tracker wearable). The heart rate data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings. In addition, a colour code (green, yellow and red) for each reading allows pilot participants to easily understand whether the displayed reading is within normal, worrisome or abnormal limits.
Physical Activity Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, in order to receive and display the elderly pilot participants' physical activity report. The steps count, active time and sedentary time data are presented for the day, the week and the month periods, using graphics. Further, this module is being adapted to display the pilot participants' physical activity monitoring data (steps count, activity time, sedentary time, heart rate, physical activity intensity in low, moderate and vigorous modes, time duration of each of the intensity modes, exercise and aerobic activity), based on TREE's physical activity report.
Sleep Quality Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, displaying the elderly pilot participants' sleep quality monitoring data presented for the day, the week and the month periods, using graphics and statistics (average, maximum and minimum sleep time duration). The sleep quality monitoring data include sleep quality percentage, time duration of sleep, start and end

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
	time of sleep, light and deep sleep time duration, heart rate, time to fall asleep, number of times awaken, number of times awaken and getting up, time in bed and sleep efficiency percentage, based on TREE's sleep quality report.
Ambient Living Monitoring	This module is being adapted to display to the pilot participants only house appliances monitoring readings and hide other ambient living parameters (house's air quality, movement and presence, local weather conditions and outdoor air quality). Also, this module is being adapted to enable the integration with Omnitor's smart plugs installed at the elderly pilot participants' houses, in order to retrieve and display the devices' identification, on/off status, time duration of the on status and energy consumption.
Notifications	This module is being adapted to display to the pilot participants reminders, notifications, alerts or recommendations concerning heart rate readings, the physical activity and sleep quality information and the data on appliances monitoring. Also, this module is being adapted to enable the integration with VICOM's recommendations system and with TREE's ADL routine detection system. The reminders are automatically checked whenever the associated task is complete and the list of daily tasks to be accomplished is updated.
Care Plan	This module is being adapted to allow caregiver and/or professional carers pilot participants to establish the personalised care plan for the elderly pilot participants, as per the pilot research protocol. It will allow the caregiver and/or professional carers pilot participants to establish individual goals or send personalised recommendations concerning the elderly pilot participants' vital monitoring, physical activity and sleep.
Devices Management	This module is being adapted to enable the connection with the elderly pilot participants' fitness tracker wearable and app, so as to automatically acquire the elderly pilot participants' activity data.
User Information	This module is being adapted to enable the integration with MedSyn's Electronic Health Record (EHR) System, retrieving and displaying only the elderly and the caregivers and/or professional carers pilot participants' fake identification (user ID and email) and password, date of birth and gender.

It is noted that, for the **SHAPES eCare Platform** to function properly, it needs specific user data – the elderly pilot participant's age and gender – that will be provided by the SHAPES partner MedSyn's EHR System.

In addition, the **SHAPES eCare App** will provide a direct link to the SHAPES Front-end App, allowing the user to exit the SHAPES eCare App and access the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

functionalities provided by other SHAPES partners' digital solutions supporting the PT1-UC001 use case. Similarly, the web-based **SHAPES eCare System** will display a modified menu, allowing the caregiver user to directly access the other SHAPES partners' digital solutions.

Furthermore, the web-based **eCare System** has been adapted to build the **SHAPES eCare Researcher Dashboard**, which will allow the CSS team to follow in real-time the progress of the pilot activities they are conducting. The changes being made will enable the CSS team to use a dashboard to supervise whether all elderly pilot participants are complying with the pilot research protocol, using the fitness tracker wearable to monitor their heart rate, physical activity and sleep. The **SHAPES eCare Researcher Dashboard** also includes an adapted menu navigation, allowing the CSS researchers team to directly access the other digital solutions supporting the use case.

Simultaneously, EDGE is completing the user manuals accompanying the three prototypes – the **SHAPES eCare App**, the **SHAPES eCare System** and the **SHAPES Researcher Dashboard** – that support the Phase 3 – *Hands-on Experiments* of the pilot activities, organised by CSS in October 2021. The analysis of the user feedback of the hands-on training with the SHAPES digital solutions, namely concerning the **SHAPES eCare Platform**, will be performed in the following weeks. Based on the received analysis, minor adjustments and corrections will take place so as to ready the **SHAPES eCare Platform** for Phases 4 and 5 of PT1-UC001 piloting activities.

3.2.4 Adaptations for PT2-UC001

The following sections present the adaptations and new developments performed in the **eCare Platform** digital solution, in order to meet the specific requirements of ***PT2-UC001: Remote Monitoring of Key Health Parameters*** and adequately support the use case's pilot activities.

3.2.4.1 Concept and Ideation Stage

In this use case, the targeted audience is the older people (65+ years) living independently and displaying a rather agile physical condition, but requiring information and motivation about the variety of physical activities at their disposal, in order to keep exercising regularly and to prevent loss of vitality and of general fitness. According to Deliverable D2.7 – *SHAPES Personas and Use Cases* [2], the SHAPES persona applicable to PT2-UC001 is Helena (Persona 7). Details on the SHAPES personas are available in Deliverable D2.7.

The use case PT2-UC001 aims to perform the remote monitoring of important health parameters of older individuals with the aim of maintaining or even improving their health status, thanks to preventive health and care measures. To that end, digital

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

technologies are to be deployed, in order to unobtrusively monitor the pilot participants' wellbeing and lifestyle. The involved technologies include a fitness tracker wearable to monitor heart rate, physical activity and sleep quality, as well as a urine monitoring device installed in the toilet bowl to deliver urine and uroflowmetry analyses. Also, dedicated digital solutions will monitor the older individuals' nutrition and water intake. In addition, users will answer a daily wellbeing survey. Moreover, a dedicated solution will allow the monitoring of COVID-19 symptoms. Based on the collected data, data analytics solutions will determine normality patterns and detect emerging anomalies (risky situations) in those patterns, triggering specific notifications, reminders or recommendations to the pilot participants so that appropriate intervention could be carried out.

In order for the **eCare Platform** to properly support the use case PT2-UC001, an analysis of the applicable system specifications (as defined in Deliverable D4.1 – *SHAPES Technological Platform Requirements and Architectu*re [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.3 – *Improving In-Home and Community-based Care - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

Table 20 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	eCare has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	eCare adopts a modular and configurable architecture.
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	eCare follows universal accessibility policies.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCare adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	eCare has its own APIs and adopts interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	eCare delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	eCare has a multilingual interface and eCare adaptations benefitted from SHAPES partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, a dedicated user manual has been created, including relevant instructions on the use of the devices.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	eCare supports health data collection, sharing and processing.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCare complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCare storage is handled in EU Member States.
SPS-033	All classes of users shall be able to review the historical data.	Y	eCare maintains a data repository that includes historical data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	eCare supports fitness trackers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	eCare supports fitness trackers.
SPS-038	Devices recording sleep quality should be supported.	Y	eCare supports fitness trackers allowing to calculate sleep quality data.
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.)	Y	eCare supports medical devices that monitor vital signs.
SPS-042	The SHAPES Platform should support manual data entry.	Y	eCare supports manual data entries.
SPS-043	The SHAPES Platform shall support risk assessment and action plans as part of its data processing of health data.	Y	eCare displays the results of risk assessment data analytics integrated with the platform.
SPS-044	The SHAPES Platform should support use of questionnaires as self-assessment tools.	Y	eCare supports the use of questionnaires as self-assessment tools.
SPS-046	The SHAPES Platform should support reminders.	Y	eCare delivers reminders.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	eCare delivers alerts.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	eCare provides a set of daily tasks for the user.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	eCare delivers motivational notes.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	eCare delivers user friendly dashboards. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	eCare supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data is defined by the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	eCare maintains system access logs for all data.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	eCare offers robust authentication and authorisation features.
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	eCare provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	eCare supports mobile and web-based platforms and devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	eCare provides users with comprehensive feedback.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	eCare supports the creation and personalisation of care plans.
SPS-099	The SHAPES Platform should offer mood self-assessment.	Y	eCare supports the mood self-assessment feature.
SPS-103	More than one mood status should be added per day.	Y	eCare supports several daily readings of the mood status.
SPS-104	The scale for mood assessment should discriminate the numbers from 1 to 10.	Y	eCare supports a scale for mood assessment. Because it is a Likert smiley scale, it only displays 5 levels.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	eCare supports the users' health literacy.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	eCare supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	eCare enables traceability of personal data.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCare is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCare complies with relevant cybersecurity rules for mobile and online services.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	eCare follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	eCare delivers alerts and notifications to its users.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCare offers user friendly and attractive interfaces. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCare offers user friendly interfaces for all users. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCare applies user interfaces resembling other technologies used by the elderly.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	eCare adopts an efficient navigation scheme to facilitate user interaction. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	eCare implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	eCare adopts a data minimisation policy that restricts data processing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	eCare presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	eCare adopts a data minimisation policy that supports storage minimisation.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	eCare complies with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	eCare offers robust authentication and authorisation features.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	eCare implements password-based authentication.
SPS-149	The SHAPES Platform shall support password management.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is defined in the pilot research protocol.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	eCare is a scalable solution in terms of users, services and geographical coverage.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	eCare is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	eCare was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	eCare supports the registration of IoT and medical devices.
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	eCare supports the recognition of connected devices.
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	eCare supports the accessibility features of the access device.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	eCare delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	eCare supports an offline operation mode at the user device.
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	eCare maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	eCare supports service continuity and recovers from network downtime.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	eCare maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	eCare delivers user friendly and intuitive GUI. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	eCare has its own APIs, allowing the exchange of data among digital solutions. eCare was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	eCare is accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	eCare web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	eCare shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	eCare is being adapted to support the exchange of data with SHAPES components.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	eCare shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	eCare shall support the management of notifications among core SHAPES components.
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	eCare shall support SHAPES's single sign-on mechanism, provided via ASAPA.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	eCare offers robust authorisation features for data access.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	eCare API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	eCare implements anonymisation features.
SPS-200	All passwords shall be unique per device and per user.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	eCare adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	eCare adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	eCare adopts robust verification mechanisms for software updates.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	eCare uses the best state-of-the-art encryption techniques to protect data exchange with devices.
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	eCare supports an offline operation mode.
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	eCare allows users to easily delete own data from the device.
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	eCare enables the validation of specific fields of information or data provided by the user or received via the eCare API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

Table 21 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the elderly pilot participant's health and wellbeing parameters.	Y	eCare monitors and displays health and wellbeing parameters based on medical and health devices and self-assessment questionnaires.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R2	Monitor unobtrusively the relevant health and wellbeing parameters of the elderly pilot participant at home.	Y	eCare supports fitness tracker wearables that capture unobtrusively relevant health and wellbeing parameters.
R3	Record the elderly pilot participant's self-perceived state of wellbeing.	Y	eCare registers mood self-assessments using a 5-level Likert smiley scale.
R4	Monitor the elderly pilot participant's daily steps.	Y	eCare collects and displays step data provided by the fitness tracker wearable.
R5	Monitor the elderly pilot participant's physical exercise.	Y	eCare collects activity data from the fitness tracker wearable. eCare displays the results of the physical activity data analytics (including exercise data) integrated with the platform.
R6	Monitor the elderly pilot participant's sleep.	Y	eCare collects data on sleep quality determined via data collected from the fitness tracker wearable. eCare displays the results of the sleep quality data analytics integrated with the platform.
R7	Establish the elderly pilot participant's daily steps goals.	Y	eCare displays information concerning sleep routine and quality to the elderly pilot participant, including those addressing sleep quality goals.
R8	Establish the elderly pilot participant's exercise goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing exercise goals.
R9	Establish the elderly pilot participant's sleep goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing sleep goals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R10	Deliver to the elderly pilot participant reminders on their daily steps goal.	Y	eCare displays reminders on the daily activities to be accomplished by the elderly pilot participant.
R11	Deliver to the elderly pilot participant recommendations on their sleep routine.	Y	eCare displays recommendations to the elderly pilot participant, including those addressing a sleep routine.
R12	Record the elderly pilot participants' responses to pre-defined questionnaires.		eCare registers the elderly pilot participants' answers to pre-defined questionnaires as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).
R13	Create a Researcher Dashboard allowing pilot organisers to follow the progress of the pilot activities and the elderly pilot participants' adherence to the research protocol.	Y	eCare provides an overview of the daily activities performed by the elderly pilot participants, allowing pilot organisers to monitor the pilot activities' progress and the participants' adherence.
R14	Deliver in the Researcher Dashboard a Surveys module allowing the researcher team to view the elderly pilot participants' answers to pre-defined questionnaires.	Y	eCare provides a Surveys module allowing the researcher team to view the elderly pilot participants' answers to pre-defined questionnaires as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).

3.2.4.2 Design and Development Stage

The **eCare Platform** has been redesigned so as to meet the objectives of project brand and the functional requirements of the PT2-UC001, while delivering excellent user experience.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Details on colouring, typography and accessibility guidelines for the adaptations in the user interface are provided in Section 3.2.3.2. Moreover, the **eCare Platform** texts have been translated to the German language, since the pilot use case's leading partner (gewi) operates in Germany and will be recruiting German pilot participants.

Based on the PT2-UC001 use case's requirements and the user experience guidelines, a set of mock-up designs of the **SHAPES eCare App** were created and are presented next.

Figure 52 - SHAPES eCare App for PT2-UC001 – Home Screen

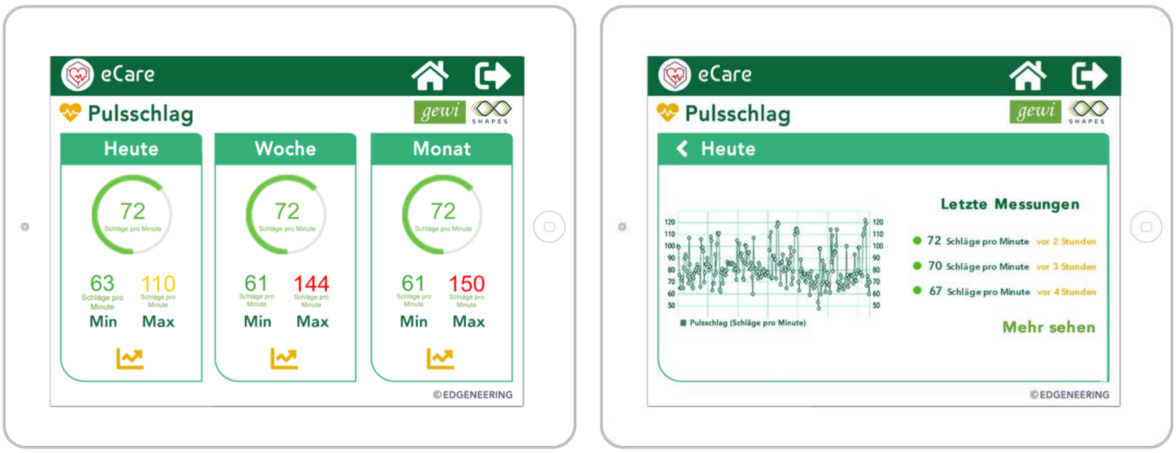


Figure 53 - SHAPES eCare App for PT2-UC001 – Heart Rate Monitoring Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

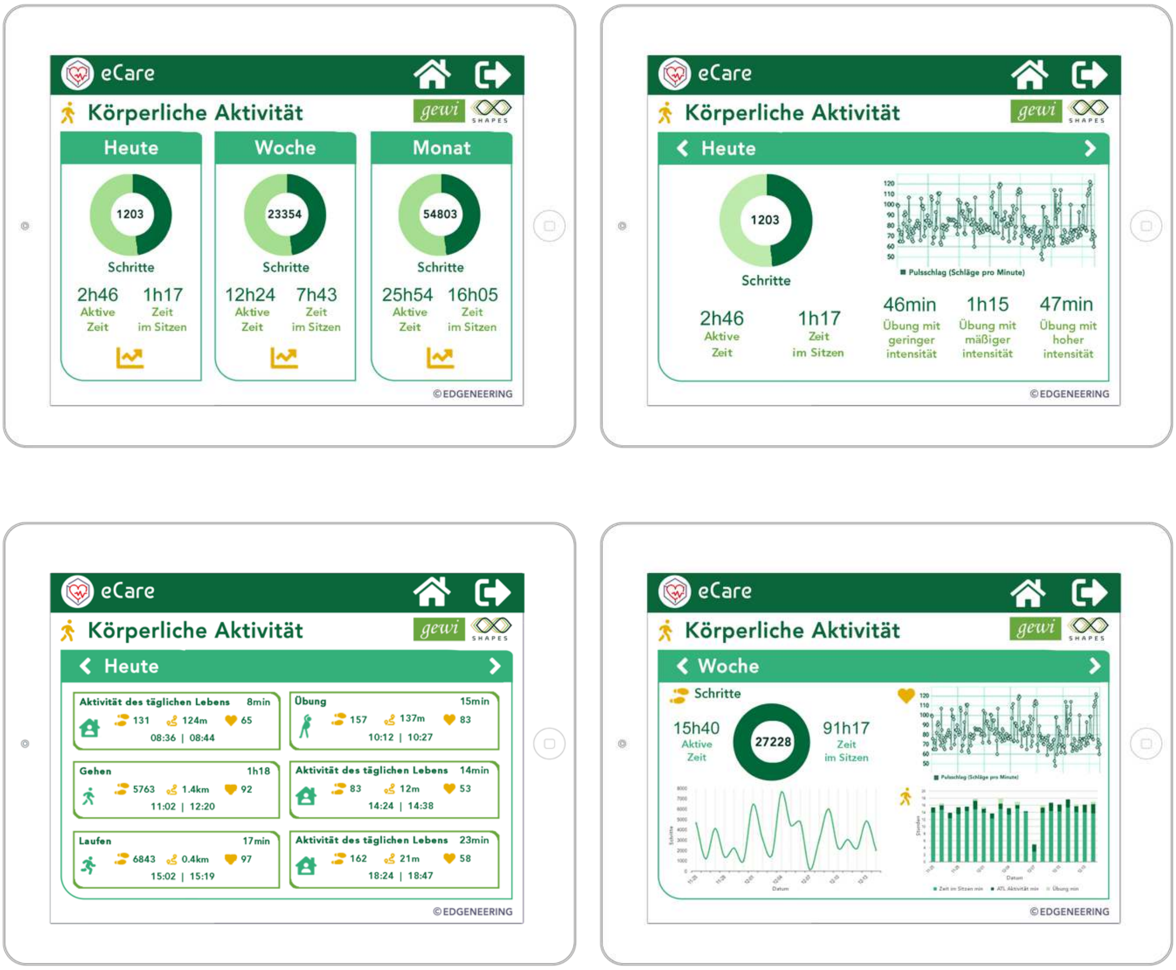


Figure 54 - SHAPES eCare App for PT2-UC001 – Physical Activity Monitoring Screens

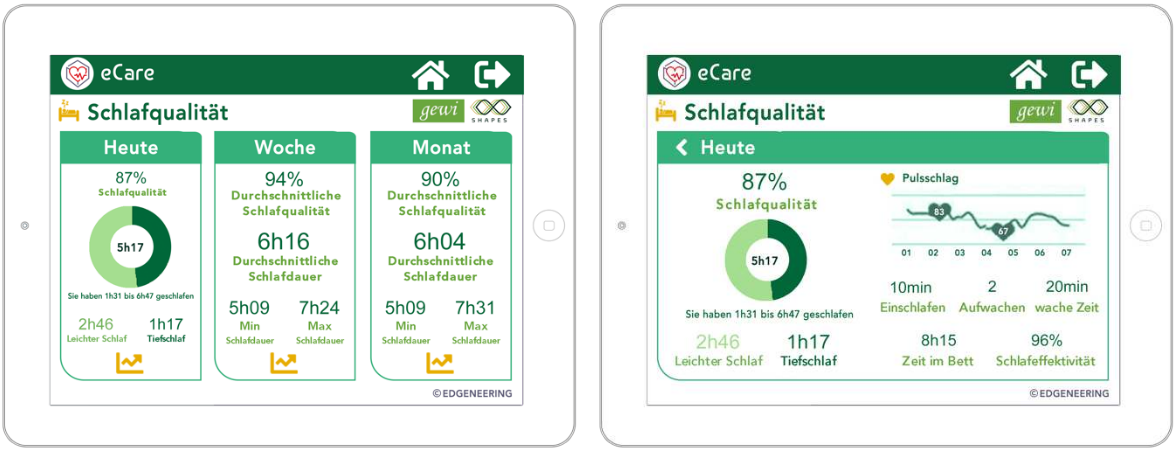


Figure 55 - SHAPES eCare App for PT2-UC001 – Sleep Quality Monitoring Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

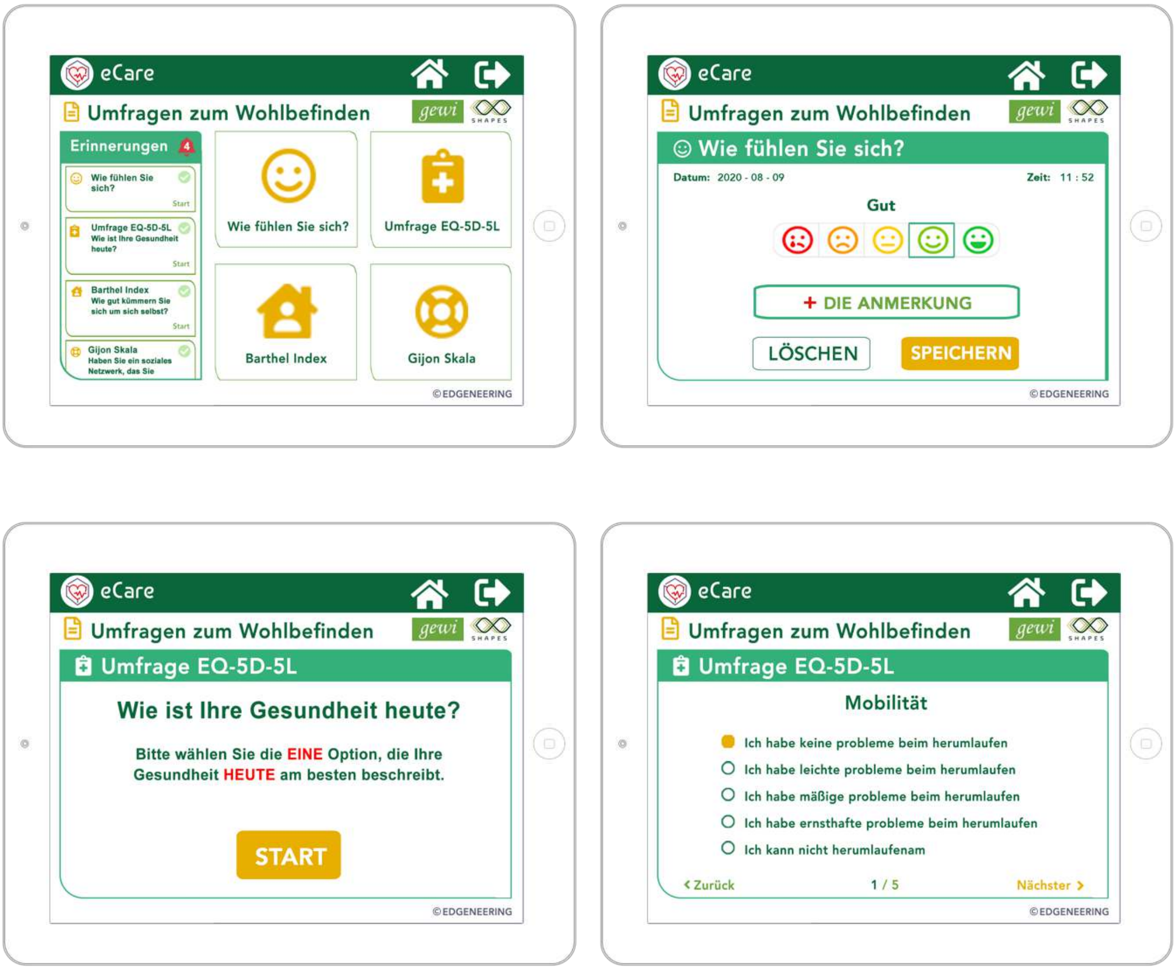


Figure 56 - SHAPES eCare App for PT2-UC001 – Wellbeing Surveys Screens

In June 2021, the mock-up designs were presented by gewi to a set of 9 representatives of the pilot participants, who provided relevant feedback on the understanding of the use case, the layout of the mock-up designs and the interaction enabled by the proposed App. Overall, the collected user feedback on the **SHAPES eCare App** was very constructive, with participants finding the use of icons appropriate, requesting the option to set individual goals and asking for sufficient information to be displayed in order for them to be able to take measurements and interpret their own health data.

In parallel, EDGE pursued the design of mock-ups of the SHAPES eCare Researcher Dashboard for the gewi researchers to follow the pilot participants in PT2-UC001. The **SHAPES eCare Researcher Dashboard** will allow the gewi researchers to monitor in real-time the progress of the pilot activities they are conducting. The changes being made will enable gewi to supervise whether all elderly pilot participants are complying with the pilot research protocol, using the fitness tracker to monitor their heart rate, physical activity and sleep quality. Also, gewi researchers will be able to view the elderly pilot participants' answers to a set of pre-defined questionnaires on wellbeing, quality of life and network support. The **SHAPES eCare Researcher Dashboard** also

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

includes an adapted menu navigation, allowing the gewi team to directly access the other digital solutions supporting the use case. The designs of the SHAPES eCare Researcher Dashboard are presented next.

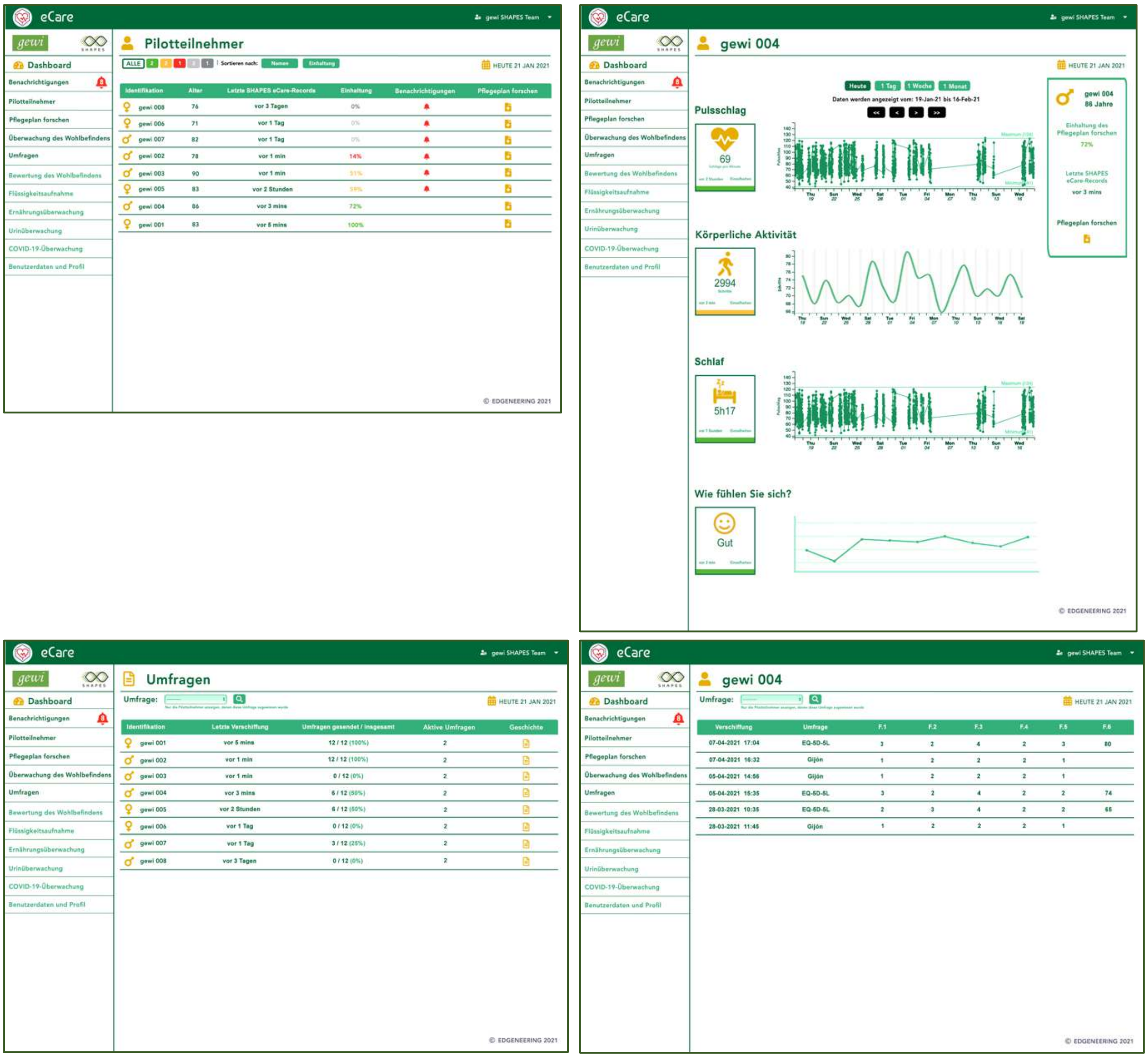


Figure 57 - SHAPES eCare System for gewi Researchers in PT2-UC001

3.2.4.3 *Prototyping and Adaptation Stage*

Following the concept and ideation and design and development stages, the prototyping and adaptation stage focused on the creation of the **SHAPES eCare App** to adequately support the piloting activities of use case PT2-UC001.

The **SHAPES eCare Platform** for PT2-UC001 is responsible for retrieving the data from the connected device (the fitness tracker wearable) and providing a user interface with the elderly pilot participants (the **SHAPES eCare App**). The eCare third-party API allows for the direct exchange of data with the different SHAPES digital solutions supporting this use case, so as to display the most up-to-date information to the user. In addition, the eCare third-party API allows the **SHAPES eCare Platform** to

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

exchange information with the SHAPES Platform, namely the SHAPES Data Lake repository and the SHAPES Authentication module (ASAPA). The web-based **SHAPES eCare System** will be adapted to deliver the **eCare Researcher Dashboard**, enabling gewi to remotely accompany the pilot's progress, providing an overview of the pilot participants' adherence to the pilot research protocol, in the scope of the functionalities enabled by the **SHAPES eCare Platform**.

From a high-level architectural perspective, the **SHAPES eCare** component is depicted as:

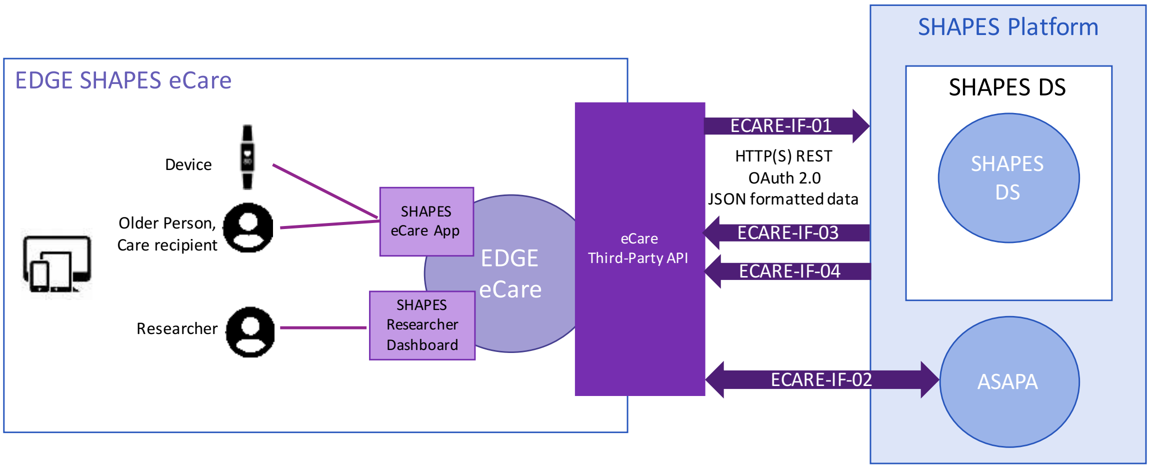


Figure 58 - High-level Architecture of the SHAPES eCare Platform Component for PT2-UC001

The **SHAPES eCare Platform**'s interfaces are detailed in the following table.

Table 22 - SHAPES eCare Platform Interfaces

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
ECARE-IF-01	SHAPES eCare and the SHAPES Platform	SHAPES eCare provides user activity and vitals data collected from the wearable.	**Output**: Activity data (number of steps over time) and vitals (heart rate measurements).
ECARE-IF-02	SHAPES eCare and the ASAPA Module	The ASAPA module provides user authentication in SHAPES. SHAPES eCare uses the same user authentication.	**Output:** username and password. **Input:** If successful, results the user token; if not, returns "not authorised".

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
ECARE-IF-03	SHAPES Platform and Digital Solutions	SHAPES eCare receives user data from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: User data (age; gender).
ECARE-IF-04	SHAPES Platform and Digital Solutions	SHAPES eCare receives reports, alerts and recommendations as a result of user data processing from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: Physical activity report, sleep quality report, ADL alerts and recommendations.

Considering the SHAPES eCare Platform architecture and the pilot use case's requirements, the primary functions to be enabled through the **SHAPES eCare App** concern the display of the data collected from the elderly pilot participants' fitness tracker (wearable) and wellbeing surveys and the data analyses on physical activity, sleep quality and anomaly detection produced by the data analytics SHAPES partners.

These functions are delivered by the following **eCare Platform** modules:

- **Dashboard**, allowing to display to the user an overview of the key parameters of the eCare monitoring platform (vitals, ambient living, physical activity, sleep, body and nutrition, weather) and provide access to the different functions provided by eCare;
- **Vitals monitoring**, allowing the user to register and view the vital signs (blood pressure, heart rate, temperature, oxygen saturation, respiratory rate and blood glucose) readings from connected devices, visualise them over time (graphical setting) and manually insert measurements, if needed;
- **Physical activity monitoring**, allowing to collect the activity data from fitness trackers and display a physical activity report;
- **Sleep quality monitoring**, allowing to collect the activity data from fitness trackers and display a sleep quality report;
- **Wellbeing survey**, allowing to collect the user's daily mood, using a 5-level smile Likert-scale;
- **Notifications**, allowing to present to the user reminders, notifications, alerts or recommendations concerning the vital signs readings, wellbeing data, ambient living data, daily tasks and goals and surveys;
- **Care Plan**, allowing care professionals to establish a personalised care plan for the user, involving vitals monitoring, medication, physical activity, sleep, diet

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

and treatment. It sets individual daily or weekly tasks/goals, personalised reminders, notifications and recommendations concerning the user's vitals and wellbeing data;

- **Devices Management**, allowing the connection with the user's medical, health or smart home devices so as to automatically acquire the user's relevant data;
- **User Information**, allowing the user to configure personal information and the display preferences concerning notifications, reminders and colour code.

As a result, prototyping work is ongoing to adapt the **eCare Platform**'s user interfaces to the pilot use case's needs, considering the mock-up designs and the user feedback received through the co-design phase. Aside from the visual changes detailed in section 3.2.3.2, adaptations have been made so that the **SHAPES eCare App** displays the functionalities associated with the use case and are able to interoperate with other digital solutions supporting the use case:

Table 23 - Adaptations to build the SHAPES eCare Platform for PT2-UC001

Module	Adaptation Work
Dashboard	This module is being adapted in the App to display to the elderly pilot participants a direct access to the key functionalities of the use case (heart rate monitoring, physical activity monitoring, sleep quality monitoring, surveys and notifications).
Vitals Monitoring	This module is being adapted to display only the elderly pilot participants' heart rate readings and hide other vital signs (blood pressure, temperature, oxygen saturation, respiratory rate and blood glucose) and to enable the manual insertion of heart rate readings (the automatic reading mode is active with the connection to the fitness tracker wearable). The heart rate data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings. In addition, a colour code (green, yellow and red) for each reading allows pilot participants to easily understand whether the displayed readings are within normal, worrisome or abnormal limits.
Physical Activity Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, in order to receive and display the elderly pilot participants' physical activity report. The steps count, active time and sedentary time data are presented for the day, the week and the month periods, using graphics. Further, this module is being adapted to display the elderly pilot participants' physical activity monitoring data (steps count, activity time, sedentary time, heart rate, physical activity intensity in low, moderate and vigorous modes, time duration of each of the intensity modes,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
	exercise and aerobic activity), based on TREE's physical activity report.
Sleep Quality Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, receiving and displaying the elderly pilot participants' sleep quality monitoring data presented for the day, the week and the month periods, using graphics and statistics (average, maximum and minimum sleep time duration). The sleep quality monitoring data include sleep quality percentage, time duration of sleep, start and end time of sleep, light and deep sleep time duration, heart rate, time to fall asleep, number of times awaken, number of times awaken and getting up, time in bed and sleep efficiency percentage, based on TREE's sleep quality report.
Wellbeing Survey	This module is being adapted to provide the elderly pilot participants a wellbeing survey to be completed with their mood, by using a simple 5-level smile Likert-scale.
Surveys	This module is being developed to provide to the elderly pilot participants a set of questionnaires on wellbeing, quality of life and network support to be completed at specific timings, as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D-5L, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS). The module is further adapted to enable the researcher team to view the elderly pilot participants' answers to the questionnaires.
Notifications	This module is being adapted to display to the pilot participants reminders, notifications, alerts or recommendations concerning heart rate readings, the physical activity, the sleep quality information and surveys. Also, this module is being adapted to enable the integration with VICOM's recommendations system and with TREE's ADL routine detection system. The reminders are automatically checked whenever the associated task is complete and the list of daily tasks to be accomplished is updated.
Care Plan	This module is being adapted to allow the researcher to insert the applicable research protocol, concerning physical activity and sleep. It will support the identification of individual daily tasks/goals, personalised reminders, notifications and recommendations concerning the elderly pilot participants' vitals monitoring, physical activity and sleep.
Devices Management	This module is being adapted to enable the connection with the elderly pilot participants' fitness tracker wearable and app, so as to automatically acquire the elderly pilot participants' activity data.
User Information	This module is being adapted to enable the integration with SHAPES Platform, retrieving and displaying the pilot

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
	participants' fake identification (user ID and email) and password, date of birth and gender.

In addition, the **SHAPES eCare App** will provide a direct link to the SHAPES Front-end App, allowing the user to exit the SHAPES eCare App and access the other use case functionalities provided by other SHAPES partners' digital solutions supporting the PT2-UC001 use case.

Furthermore, the web-based **eCare System** has been adapted to build the **SHAPES eCare Researcher Dashboard**, which will allow the gewi team to follow in real-time the progress of the pilot activities they are conducting. The changes being made will enable the gewi team to use a dashboard to supervise whether all elderly pilot participants are complying with the pilot research protocol, using the fitness tracker wearable to monitor their heart rate, physical activity and sleep. The **SHAPES eCare Researcher Dashboard** also includes an adapted menu navigation, allowing the gewi team to directly access the other digital solutions supporting the use case.

Simultaneously, EDGE is completing the user manuals accompanying the two prototypes – the **SHAPES eCare App** and the **SHAPES Researcher Dashboard** – that support the Phase 3 – *Hands-on Experiments* of the pilot activities, organised by gewi in October 2021. The analysis of the user feedback of the hands-on training with the SHAPES digital solutions, namely concerning the **SHAPES eCare Platform**, will be performed in the following weeks. Based on the received analysis, minor adjustments and corrections will take place so as to ready the **SHAPES eCare Platform** for Phases 4 and 5 of PT2-UC001 piloting activities.

3.2.5 Adaptations for PT3-UCGeneral

The following sections present the adaptations and new developments performed in the **eCare Platform** digital solution, in order to meet the specific requirements of ***PT3-UCGeneral: Supporting Multimorbid Older Patients*** and adequately support the use case's pilot activities.

3.2.5.1 Concept and Ideation Stage

In this use case, the targeted audience is the older people (65+ years) living at home and suffering from multiple illnesses, such as heart failure, diabetes, hypertension and chronic obstructive pulmonary disease, that lead to the taking of multiple daily medications. According to Deliverable D2.7 – *SHAPES Personas and Use Cases* [2], the SHAPES persona applicable to PT3-UCGeneral is Roberto (Persona 2). Details on this SHAPES persona are available in Deliverable D2.7.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The use case PT3-UCGeneral aims to develop an optimised and personalised approach to the safe and effective use of multiple medicines by older people with multi-morbidity to ensure the best possible health outcomes. Medication should be adjusted, following the review of health parameter monitoring with a goal of optimising and personalising treatment. To that end, digital technologies are to be deployed, namely a set of medical devices, including a blood glucose monitor, a blood pressure monitor, an oxymetre and a body composition scale to monitor blood glucose, blood pressure, oxygen saturation levels, weight and body composition parameters. In addition, users will answer a daily survey aimed at establishing their personalised heart failure (HF) risk level. Moreover, a dedicated solution will allow the monitoring of COVID-19 symptoms. Based on the collected data, data analytics solutions will also determine normality patterns and detect emerging anomalies (risky situations) in those patterns, triggering specific notifications, reminders or recommendations to the pilot participants.

In order for the **eCare Platform** to properly support the use case PT3-UCGeneral, an analysis of the applicable system specifications (as defined in Deliverable D4.1 – *SHAPES Technological Platform Requirements and Architectu*re [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.4 – *Medicine Control and Optimisation - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

Table 24 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	eCare has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	eCare adopts a modular and configurable architecture.

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	eCare follows universal accessibility policies.
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCare adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	eCare has its own APIs and adopts interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	eCare delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	eCare has a multilingual interface and eCare adaptations benefitted from SHAPES partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, a dedicated user manual has been created, including relevant instructions on the use of the devices.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	eCare supports health data collection, sharing and processing.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCare complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCare storage is handled in EU Member States.
SPS-033	All classes of users shall be able to review the historical data.	Y	eCare maintains a data repository that includes historical data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level)	Y	eCare supports medical devices that monitor vital signs.
SPS-042	The SHAPES Platform should support manual data entry.	Y	eCare supports manual data entries.
SPS-043	The SHAPES Platform shall support risk assessment and action plans as part of its data processing of health data.	Y	eCare displays the results of risk assessment data analytics integrated with the platform. For the SHAPES pilot activities, risk assessment of patient data follows the pilot research protocol.
SPS-044	The SHAPES Platform should support use of questionnaires as self-assessment tools.	Y	eCare supports the use of questionnaires as self-assessment tools.
SPS-046	The SHAPES Platform should support reminders.	Y	eCare delivers reminders.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	eCare delivers alerts. For the SHAPES pilot activities, alerts on medical risks and emergencies follow the pilot research protocol.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	eCare provides a set of daily tasks for the user.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	eCare delivers motivational notes.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	eCare delivers user friendly dashboards. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	eCare supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data follows the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	eCare maintains system access logs for all data.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	eCare offers robust authentication and authorisation features.
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	eCare provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	eCare supports mobile and web-based platforms and devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	eCare provides users with comprehensive feedback. The use of a colour code to assist users in understanding measurements is not active as per the pilot's research protocol.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	eCare supports the creation and personalisation of care plans.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	eCare supports the users' health literacy.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	eCare supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	eCare enables traceability of personal data.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCare is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCare complies with relevant cybersecurity rules for mobile and online services.
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	eCare follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	eCare delivers alerts and notifications to its users. For the SHAPES pilot activities, alerts and notifications follow the pilot research protocol.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCare offers user friendly and attractive interfaces. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCare offers user friendly interfaces for all users. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCare applies user interfaces resembling other technologies used by the elderly.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	eCare adopts an efficient navigation scheme to facilitate user interaction. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	eCare implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	eCare adopts a data minimisation policy that restricts data processing.
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	eCare presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	eCare adopts a data minimisation policy that supports storage minimisation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	eCare complies with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	eCare offers robust authentication and authorisation features. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	eCare implements password-based authentication.
SPS-149	The SHAPES Platform shall support password management.	Y	eCare has a password management feature. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	eCare is a scalable solution in terms of users, services and geographical coverage.
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	eCare is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	eCare was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	eCare supports the registration of IoT and medical devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	eCare supports the recognition of connected devices.
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	eCare supports the accessibility features of the access device.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	eCare delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	eCare supports an offline operation mode at the user device.
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	eCare maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	eCare supports service continuity and recovers from network downtime.
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	eCare maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	eCare delivers user friendly and intuitive GUI. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	eCare has its own APIs, allowing the exchange of data among digital solutions. eCare was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	eCare is accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	eCare web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	eCare shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	eCare shall support the exchange of data with SHAPES components.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	eCare shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	eCare shall support the management of notifications among core SHAPES components.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	eCare shall support SHAPES's single sign-on mechanism, provided via ASAPA.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	eCare offers robust authorisation features for data access.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	eCare API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	eCare implements anonymisation features.
SPS-200	All passwords shall be unique per device and per user.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	eCare adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	eCare adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	eCare adopts robust verification mechanisms for software updates.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	eCare uses the best state-of-the-art encryption techniques to protect data exchange with devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	eCare supports an offline operation mode.
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	eCare allows users to easily delete own data from the device.
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	eCare enables the validation of specific fields of information or data provided by the user or received via the eCare API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

Table 25 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the elderly pilot participant's health parameters.	Y	eCare monitors and displays vital signs parameters (blood pressure, heart rate, oxygen saturation levels) based on data collected from medical devices.
R2	Monitor the elderly pilot participant's wellbeing parameters.	Y	eCare monitors and displays wellbeing parameters (weight and body composition parameters) based on data collected from a body composition scale.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R3	Record the elderly pilot participant's self-perceived state of wellbeing for purposes of assessing heart failure (HF) risk.	Y	eCare collects the elderly pilot participants' answers to the VICOM's HF predictor questions for assessing heart failure risk.
R4	Establish the elderly pilot participant's vitals monitoring goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing vitals monitoring goals.
R5	Establish the elderly pilot participant's weight monitoring goals.	Y	eCare displays daily tasks for the pilot participant, including those addressing weight monitoring goals.
R6	Deliver to the elderly pilot participant reminders, notifications and recommendations on their daily monitoring tasks.	Y	eCare displays reminders, notifications and recommendations on the daily monitoring activities to be accomplished by the elderly pilot participant.
R8	Allow the care professional pilot participant to remotely monitor the health and wellbeing parameters of the elderly pilot participants.	Y	eCare displays in the care professional dashboard the health and wellbeing data of the elderly pilot participants.
R9	Allow the care professional pilot participant to remotely monitor the HF risk assessment of the elderly pilot participants.	Y	eCare displays in the care professional dashboard the HF risk assessment of the elderly pilot participants.
R12	Create a Researcher Dashboard allowing pilot organisers to follow the progress of the pilot activities and the elderly pilot participants' adherence to the research protocol.	Y	eCare provides an overview of the daily activities performed by the elderly pilot participants, allowing pilot organisers to monitor the pilot activities' progress and the participants' adherence.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R13	Deliver in the Researcher Dashboard a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires.	Y	eCare provides a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).

3.2.5.2 Design and Development Stage

The **eCare Platform** has been redesigned so as to meet the objectives of project brand and the functional requirements of the PT3-UCGeneral, while delivering excellent user experience.

Details on colouring, typography and accessibility guidelines for the adaptations in the user interface are provided in section 3.2.3.2.

Based on the PT3-UCGeneral use case's requirements and the user experience guidelines, a set of mock-up designs of the **SHAPES eCare App** were created and are presented next.

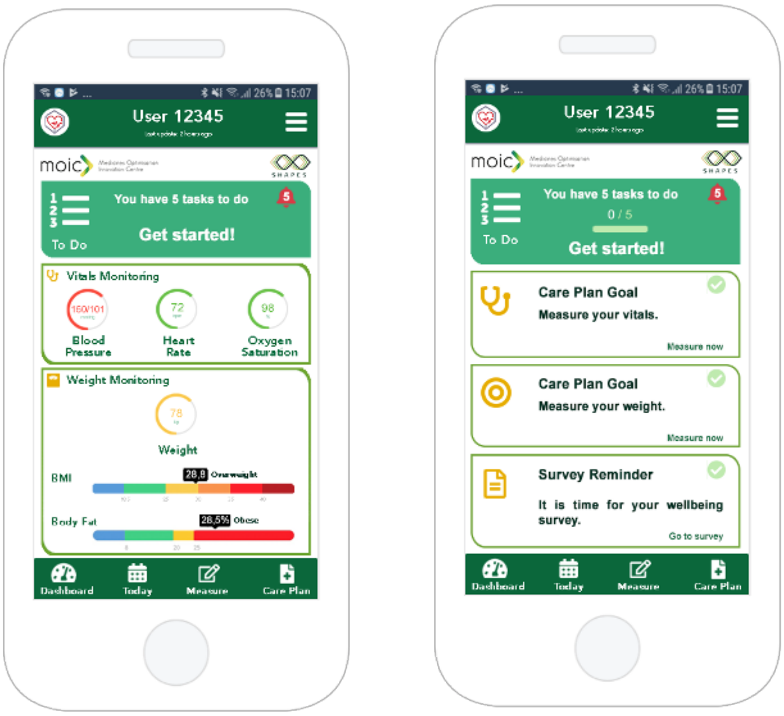


Figure 59 - SHAPES eCare App for PT3-UCGeneral – Dashboard and Today Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

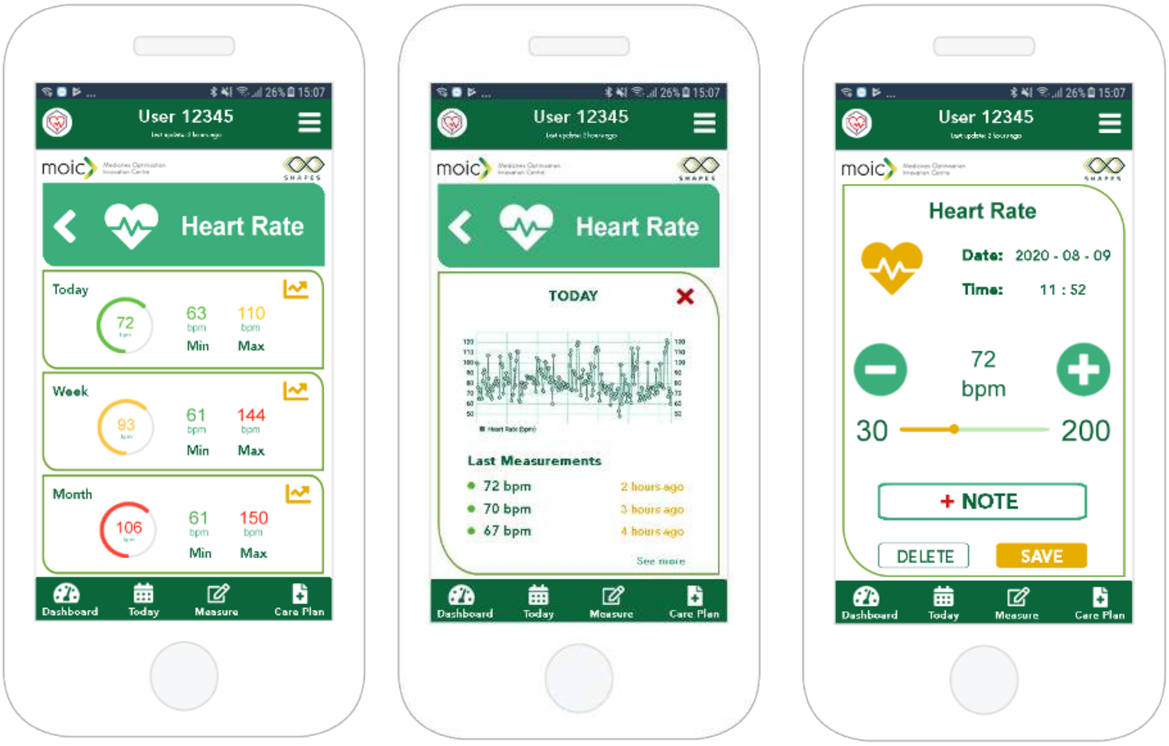


Figure 60 - SHAPES eCare App for PT3-UCGeneral – Heart Rate Screens

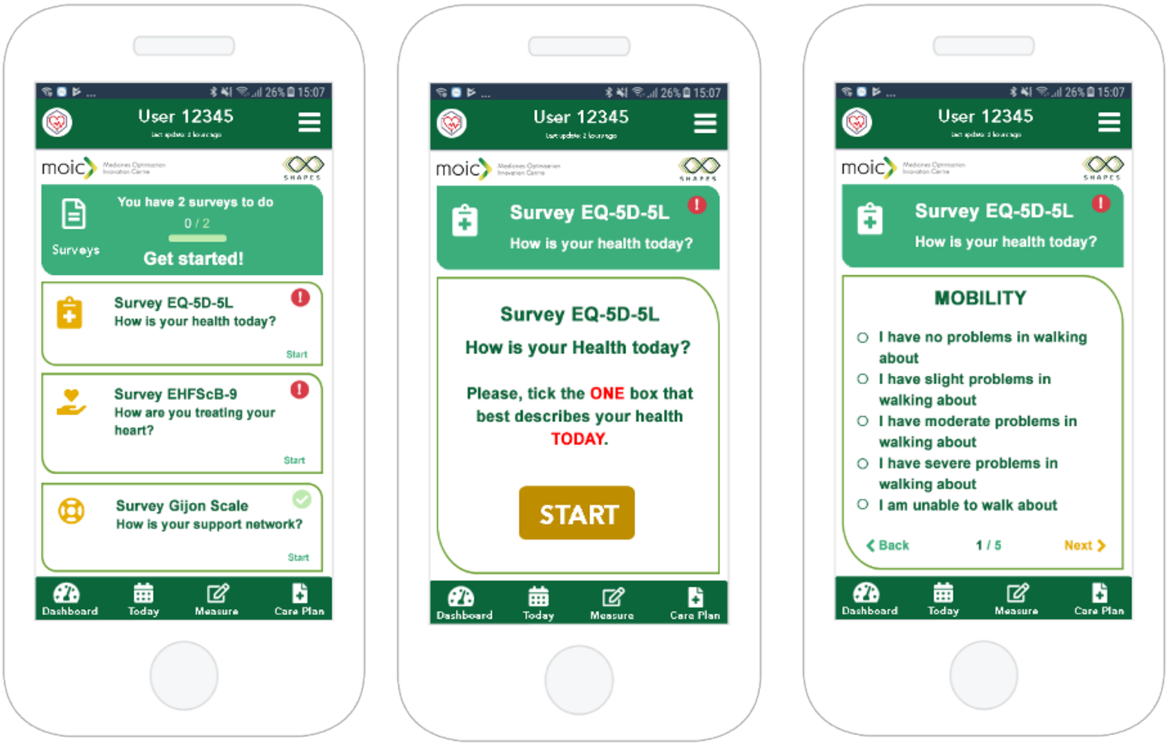


Figure 61 - SHAPES eCare App for PT3-UCGeneral – Surveys Screens

The mock-up designs of the web-based **SHAPES eCare System** for the health and social care professionals participating in the PT3-UCGeneral use case are presented next.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

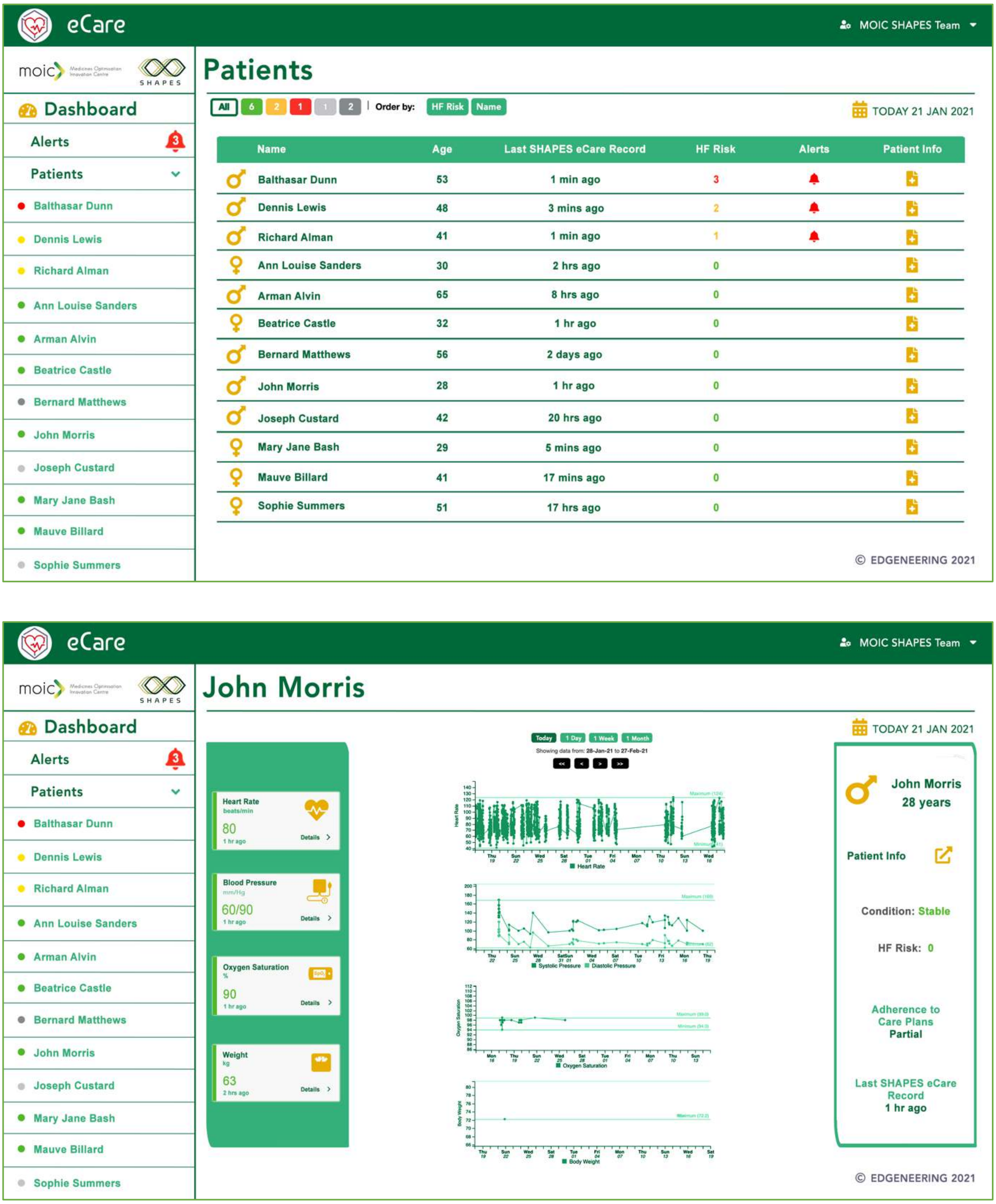


Figure 62 - SHAPES eCare System for PT3-UCGeneral – Patients Screens

The initial mock-up designs were analysed by MOIC and a set of specific requests were made to facilitate the users' navigation, including the concentration on specific tasks, the removal of additional screens and the addition of a single button to access directly the SHAPES Front-end App. Also, it was implemented the rules applicable to the SHAPES pilots concerning the anonymisation of the pilot participants and their authentication in the SHAPES Platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

More importantly, while discussing the capabilities provided by the digital solutions, MOIC became aware that, for legal and ethical purposes, it was not possible to feature specific functions, such as the colour code allowing users to better understand the vitals' measurements (green for normal values, yellow for worrisome values, red for critical values) or the HF risk level, because of the impact they would need to have in the patients' treatment plans. Finally, to avoid disruptions of the patients' treatments, MOIC decided to exclude the participation of professional carers of PT3-UCGeneral pilot activities. This decision also led to the exclusion of the COVID-19 monitoring module, for there was no professional follow-up of reported symptoms. Overall, these decisions eliminated the pilot use case's requirements R8 and R9 and affected the pilot requirements R1, R2 and R3.

A new set of mock-up designs were then created to meet MOIC's requests:

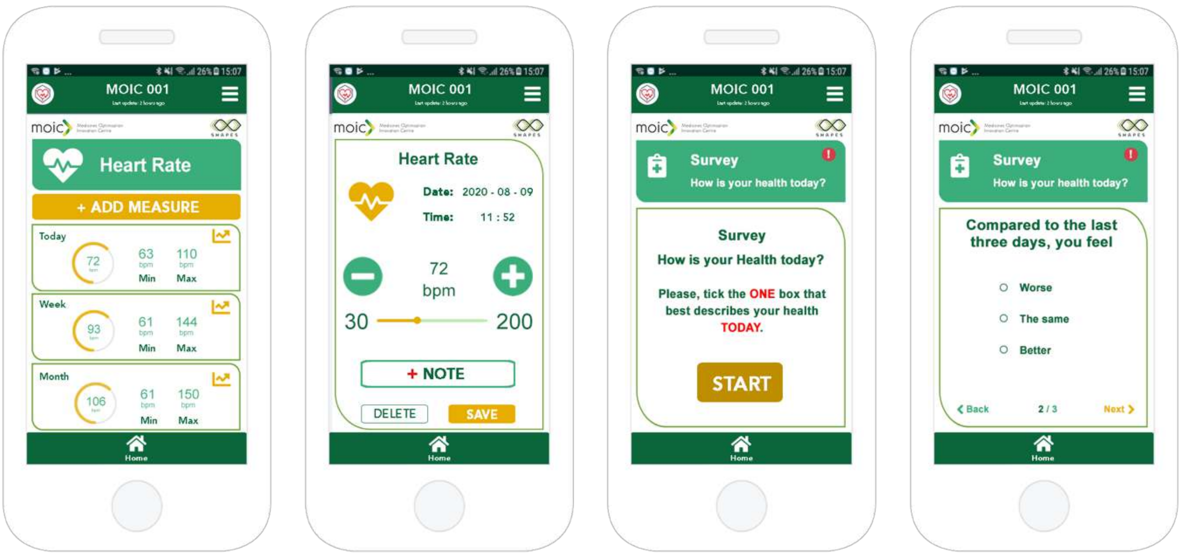


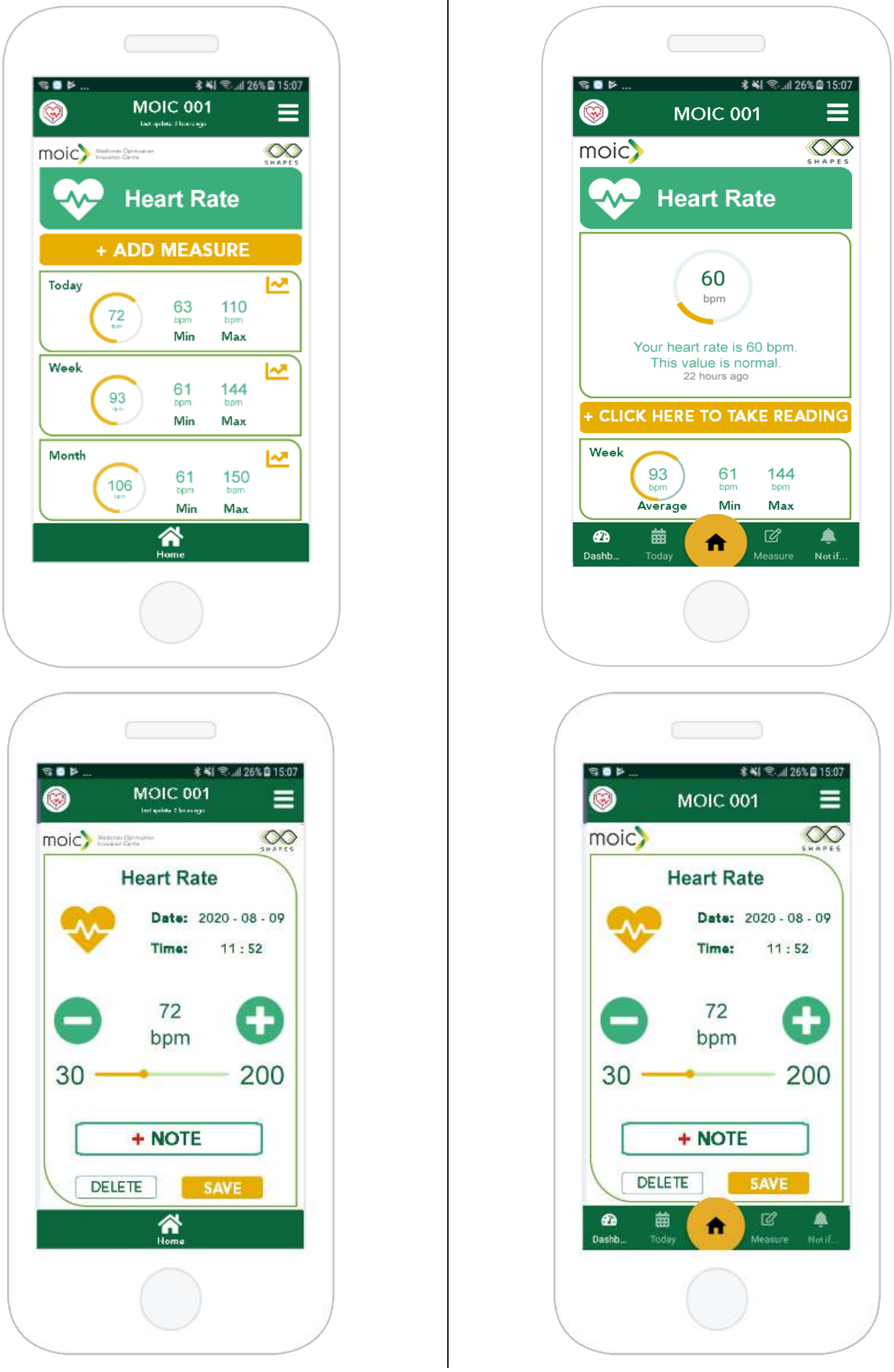
Figure 63 - SHAPES eCare App for PT3-UCGeneral – Reviewed Screens

In April 2021, the mock-up designs were presented by MOIC to a set of 7 representatives of the pilot participants in different Zoom sessions. The user feedback collected during the presentations and interviews observed the ISO standard for multimedia design (ISO14915) and provided relevant insight on how to optimise the design of the SHAPES eCare App: always use the largest size of text possible, keep focus on simple and direct messages or in a single task in each screen and adopt recognisable terminology. In this context, the survey screens were praised, as well as the automated measurements taking. Although there was a firm intention to display sufficient information not to overload the users, it also was clear that users preferred detailed explanations on the significance of the measurements. So, it was suggested to add clickable information buttons to support the interpretation of the measurements. The App was considered useful and beneficial for health improvement, easy to interact with and highly effective to most audiences if dedicated training is provided before-hand.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Following the received user feedback, a new version of the mock-up designs for the **SHAPES eCare App** were developed.

Previous **New**



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

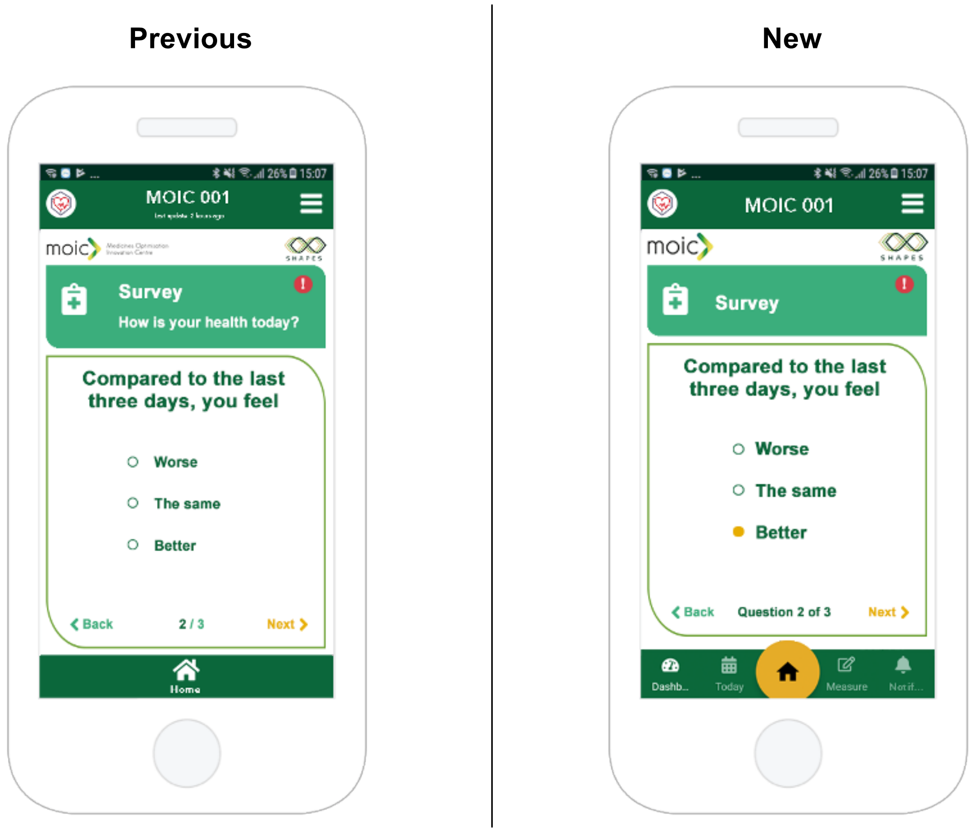


Figure 64 - SHAPES eCare App for PT3-UCGeneral – New Screens with Processed User Feedback

EDGE also created a set of mock-up designs to support the role of MOIC researchers during the piloting activities. A Researcher Dashboard was envisioned to allow MOIC to remotely monitor the piloting activities and understand the level of participants' adherence to the research protocol or plan. The designs are presented next:

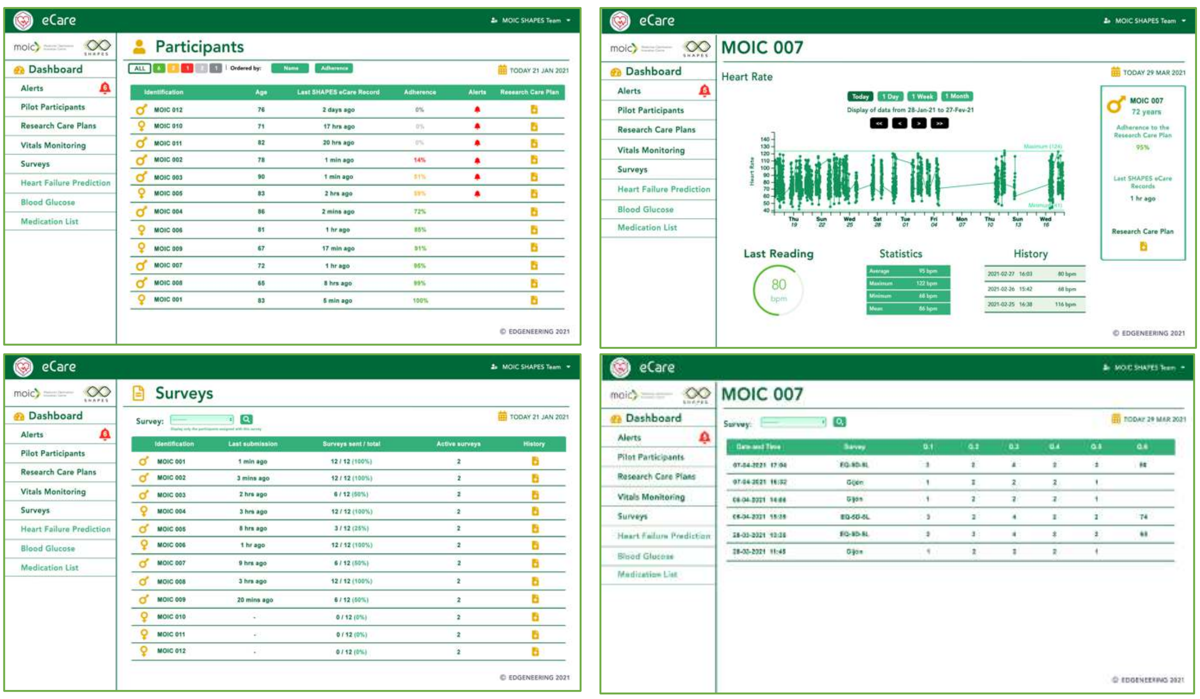


Figure 65 - SHAPES eCare System for MOIC Researchers in PT3-UCGeneral

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.2.5.3 Prototyping and Adaptation Stage

Following the concept and ideation and design and development stages, the prototyping and adaptation stage focused on the creation of the **SHAPES eCare App** and web-based **SHAPES eCare System** to adequately support the piloting activities of use case PT3-UCGeneral.

The **SHAPES eCare Platform** for PT3-UCGeneral is responsible for the collection of the data from the connected devices (the blood pressure monitor, the oxymetre and the body composition scale) and providing user interfaces with the elderly pilot participant (the **SHAPES eCare App**). The eCare third-party API allows for the direct exchange of data with the different SHAPES digital solutions supporting this use case, so as to display the most up-to-date information to the user. In addition, the eCare third-party API allows the **SHAPES eCare Platform** to exchange information with the SHAPES Platform, namely the SHAPES Data Lake repository and the SHAPES Authentication module (ASAPA). The web-based **SHAPES eCare System** will also be adapted to deliver the **eCare Researcher Dashboard**, enabling MOIC to remotely accompany the pilot's progress, providing an overview of the pilot participants' adherence to the pilot research protocol, in the scope of the functionalities enabled by the **SHAPES eCare Platform**.

From a high-level architectural perspective, the **SHAPES eCare** component is depicted as:

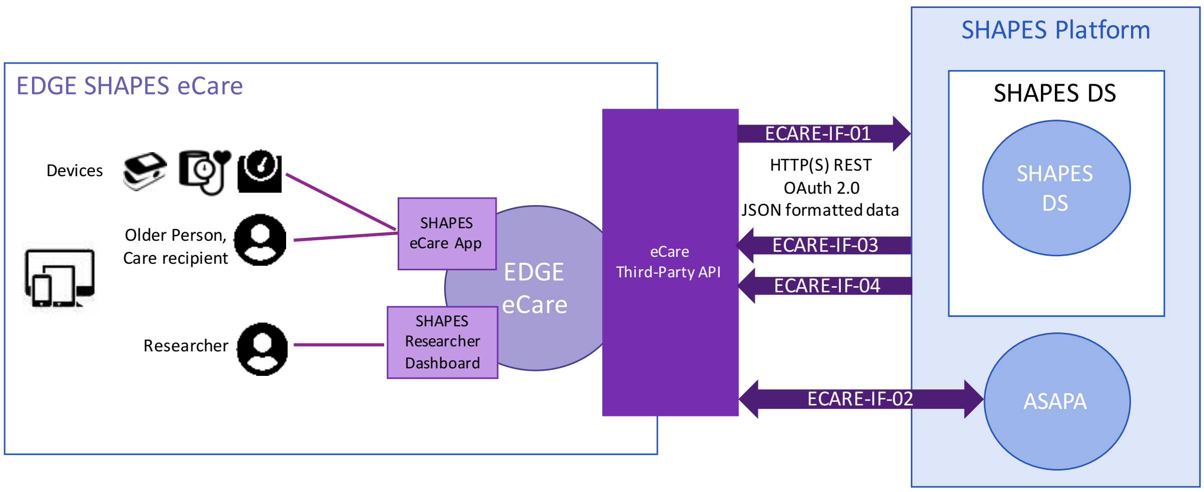


Figure 66 - High-level Architecture of the SHAPES eCare Platform Component for PT3-UCGeneral

The **SHAPES eCare Platform**'s interfaces are detailed in the following table.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 26 - SHAPES eCare Platform Interfaces

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
ECARE-IF-01	SHAPES eCare and the SHAPES Platform	SHAPES eCare provides user vitals and wellbeing data collected from the medical and health devices.	**Output**: Vitals data (blood pressure, heart rate and oxygen saturation measurements) and wellbeing data (weight, body mass index, body fat, visceral fat, skeletal muscle, basal metabolic rate).
ECARE-IF-02	SHAPES eCare and the ASAPA Module	The ASAPA module provides user authentication in SHAPES. SHAPES eCare uses the same user authentication.	**Output:** username and password. **Input:** If successful, results the user token; if not, returns "not authorised".
ECARE-IF-03	SHAPES Platform and Digital Solutions	SHAPES eCare receives user data from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: User data (age; gender).
ECARE-IF-04	SHAPES Platform and Digital Solutions	SHAPES eCare receives alerts and recommendations as a result of user data processing from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: ADL alerts and recommendations.

Considering the SHAPES eCare Platform architecture and the pilot use case's requirements, the primary functions to be enabled through the **SHAPES eCare App** concern the display of the data collected from the elderly pilot participant's medical and health devices (blood pressure monitor, oxymetre, body composition scale) and the recommendations and data analyses on anomaly detection produced by the data analytics SHAPES partners.

These functions are delivered by the following **eCare Platform** modules:

- **Dashboard**, allowing to display to the user an overview of the key parameters of the eCare monitoring platform (vitals, ambient living, physical activity, sleep, body and nutrition, weather) and provide access to the different functions provided by eCare;

- **Vitals monitoring**, allowing the user to register and view the vital signs (blood pressure, heart rate, temperature, oxygen saturation, respiratory rate and blood glucose) readings from connected devices, visualise them over time (graphical setting) and manually insert measurements, if needed;
- **Body and nutrition monitoring**, allowing the user to register and display the weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate parameters from the health device (body composition scale), as well as fluid and food intake, visualise them over time (graphical setting) and manually insert readings, if needed;
- **Today**, allowing to display to the user the list of tasks to be accomplished daily and a progress bar illustrating the number of completed tasks versus the tasks to be completed;
- **Measure**, allowing the user to take readings on vitals, body composition parameters and wellbeing, either automatically or manually, from medical and health devices;
- **Notifications**, allowing to present to the user reminders, notifications or recommendations concerning the concerning the vital signs readings, wellbeing data, ambient living data, daily tasks and goals and surveys;
- **Care Plan**, allowing care professionals to establish a personalised care plan for the user, involving vitals monitoring, medication, physical activity, sleep, diet and treatment. It sets individual daily or weekly tasks/goals, personalised reminders, notifications and recommendations concerning the user's vitals and wellbeing data;
- **Devices Management**, allowing the connection with the user's medical, health or smart home devices so as to automatically acquire the user's relevant data;
- **User Information**, allowing the user to configure personal information and the display preferences concerning notifications, reminders and colour code.

As a result, prototyping work is ongoing to adapt the **eCare Platform**'s user interfaces to the pilot use case's needs, considering the mock-up designs and the user feedback received through the co-design phase. Aside from the visual changes detailed in section 3.2.3.2, adaptations have been made so that the **SHAPES eCare App** displays the functionalities associated with the use case and are able to interoperate with other digital solutions supporting the use case:

Table 27 - Adaptations to build the SHAPES eCare Platform for PT3-UCGeneral

Module	Adaptation Work
Dashboard	This module is being adapted in the App to display to the elderly pilot participants a direct access to the key functionalities of the use case (vitals monitoring, daily tasks, taking measurements, HF predictor survey and notifications).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
Vitals Monitoring	This module is being adapted to display the elderly pilot participants' blood pressure, heart rate and oxygen saturation readings and hide other vital signs (temperature and respiratory rate). It is also enabled the manual insertion of these readings (the automatic reading mode is the default based on the connection to the medical devices). The heart rate data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings.
Body & Nutrition Monitoring	This module is being adapted to display the elderly pilot participants' weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate. The weight and body composition data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings.
Today	This module is being adapted to allow the elderly pilot participants to view the list of daily tasks to be accomplished. As a task is completed, the system updates automatically, marking the task with a checked sign. It is possible for the elderly pilot participants to press the task button and directly access the screen enabling the completion of the task. In addition, a progress bar illustrates the evolution of tasks' completion, clearly highlighting the number of accomplished tasks and the number of tasks still to be completed.
Measure	This module is being adapted to allow the elderly pilot participant to take readings on vitals (blood pressure, heart rate, oxygen saturation levels) and body composition parameters (weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic, using the medical and health devices. Per default, the measures are automatically captured but there is also the feature allowing the elderly pilot participants to enter the readings manually.
HF Predictor Survey	This module is being developed to allow the elderly pilot participants to access and answer the daily HF predictor survey. Also, this module is being adapted to enable the integration with VICOM's HF predictor system.
Surveys	This module is being developed to allow the researcher to collect the elderly pilot participants' responses to a set of pre-defined questionnaires on wellbeing, quality of life and network support, as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D-5L, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).
Notifications	This module is being adapted to display to the pilot participants reminders, notifications, alerts or recommendations concerning heart rate, blood pressure, oxygen saturation,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
	weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate readings, as well as surveys. Also, this module is being adapted to enable the integration with VICOM's HF predictor system and recommendations system and with TREE's ADL routine detection system. The reminders are automatically checked whenever the associated task is complete and the list of daily tasks to be accomplished is updated.
Care Plan	This module is being adapted to allow the researcher to insert the applicable research protocol, concerning vitals and weight monitoring and the response to the HF predictor survey. It will support the identification of individual daily tasks/goals, personalised reminders, notifications and recommendations concerning the elderly user's vitals and weight monitoring and response to the HF predictor survey.
Devices Management	This module is being adapted to enable the connection with the elderly pilot participants' medical and health devices, so as to automatically acquire the elderly pilot participants' vitals and weight monitoring data.
User Information	This module is being adapted to enable the integration with SHAPES Platform, retrieving and displaying the pilot participant's fake identification (user ID and email) and password, date of birth and gender.

In addition, the **SHAPES eCare App** will provide a direct link to the SHAPES Front-end App, allowing the user to exit the SHAPES eCare App and access the other use case functionalities provided by other SHAPES partners' digital solutions supporting the PT3-UCGeneral use case.

Furthermore, the web-based **eCare System** has been adapted to build the **SHAPES eCare Researcher Dashboard**, which will allow the MOIC team to follow in real-time the progress of the pilot activities they are conducting. The changes being made will enable the MOIC team to use a dashboard to supervise whether all elderly pilot participants are complying with the pilot research protocol, using the medical and health devices to monitor their blood pressure, heart rate, oxygen saturation levels, weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate parameters. MOIC will also be able to view the elderly pilot participants' answers to the daily HF predictor survey and to collect their answers to a set of pre-defined questionnaires on wellbeing, quality of life and network support. The **SHAPES eCare Researcher Dashboard** also includes an adapted menu navigation, allowing the MOIC team to directly access the other digital solutions supporting the use case.

Simultaneously, EDGE is completing the user manuals accompanying the two prototypes – the **SHAPES eCare App** and the **SHAPES Researcher Dashboard** – that support the Phase 3 – *Hands-on Experiments* of the pilot activities, organised by

MOIC in October 2021. The analysis of the user feedback of the hands-on training with the SHAPES digital solutions, namely concerning the **SHAPES eCare Platform**, will be performed in the following weeks. Based on the received analysis, minor adjustments and corrections will take place so as to ready the **SHAPES eCare Platform** for Phases 4 and 5 of PT3-UCGeneral piloting activities.

3.2.6 Adaptations for PT3-UC001

The following sections present the adaptations and new developments performed in the **eCare Platform** digital solution, in order to meet the specific requirements of ***PT3-UC001: In-Home Decompensation Prediction for Heart Failure Patients*** and adequately support the use case's pilot activities.

3.2.6.1 Concept and Ideation Stage

In this use case, the targeted audience is the older people (65+ years) living at home independently and suffering from heart failure, an illness that has to be tightly monitored in order to avoid decompensations. In this context, these patients are visited by a caregiver on a regular basis (2-3h a day). When decompensation episodes occur, these patients are normally transferred to hospitals, which incurs in high expenses for the healthcare system, in a loss for the patients' quality of life and an overall decrease of productivity for caring relatives. According to Deliverable D2.7 – *SHAPES Personas and Use Cases* [2], the SHAPES persona applicable to PT3-UC001 is Roberto (Persona 2). Details on this SHAPES persona are available in Deliverable D2.7.

The use case PT3-UC001 aims to develop an optimised and personalised approach to the safe and effective use of medicines by older people with heart failure disease to reduce decompensation episodes and ensure the best possible health outcomes. Medication should be adjusted, following the review of health parameters' monitoring with a goal of optimising and personalising treatment. To that end, digital technologies are to be deployed, namely two medical devices (blood pressure monitor and an oxymetre), one health device (a body composition scale) and one wearable (a fitness tracker), to monitor blood pressure, oxygen saturation levels, weight and body composition parameters, physical activity and sleep quality. In addition, users will answer a daily survey aimed at establishing their personalised heart failure (HF) risk level. Based on the collected data, data analytics solutions will also determine normality patterns and detect emerging anomalies (risky situations) in those patterns, triggering specific notifications, reminders or recommendations to the pilot participants.

In order for the **eCare Platform** to properly support the use case PT3-UC001, an analysis of the applicable system specifications (as defined in Deliverable D4.1 –

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SHAPES Technological Platform Requirements and Architecture [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.4 – *Medicine Control and Optimisation - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

Table 28 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	eCare has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	eCare adopts a modular and configurable architecture.
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	eCare follows universal accessibility policies.
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCare adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	eCare has its own APIs and adopts interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	eCare delivers integrated care features.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	eCare has a multilingual interface and eCare adaptations benefitted from SHAPES partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, a dedicated user manual has been created, including relevant instructions on the use of the devices.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	eCare supports health data collection, sharing and processing.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCare complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCare storage is handled in EU Member States.
SPS-033	All classes of users shall be able to review the historical data.	Y	eCare maintains a data repository that includes historical data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	eCare supports fitness trackers.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	eCare supports fitness trackers.
SPS-038	Devices recording sleep quality should be supported.	Y	eCare supports fitness trackers allowing to calculate sleep quality data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level)	Y	eCare supports medical devices that monitor vital signs.
SPS-042	The SHAPES Platform should support manual data entry.	Y	eCare supports manual data entries.
SPS-043	The SHAPES Platform shall support risk assessment and action plans as part of its data processing of health data.	Y	eCare displays the results of risk assessment data analytics integrated with the platform. For the SHAPES pilot activities, risk assessment of patient data follows the pilot research protocol.
SPS-044	The SHAPES Platform should support use of questionnaires as self-assessment tools.	Y	eCare supports the use of questionnaires as self-assessment tools.
SPS-046	The SHAPES Platform should support reminders.	Y	eCare delivers reminders.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	eCare delivers alerts. For the SHAPES pilot activities, alerts on medical risks and emergencies follow the pilot research protocol.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	eCare provides a set of daily tasks for the user.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	eCare delivers motivational notes.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	eCare delivers user friendly dashboards. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	eCare supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data follows the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	eCare maintains system access logs for all data.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	eCare offers robust authentication and authorisation features.
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	eCare provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	eCare supports mobile and web-based platforms and devices.
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	eCare provides users with comprehensive feedback.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	eCare supports the creation and personalisation of care plans.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	eCare supports the users' health literacy.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	eCare supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	eCare enables traceability of personal data.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCare is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCare complies with relevant cybersecurity rules for mobile and online services.
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	eCare follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	eCare delivers alerts and notifications to its users. For the SHAPES pilot activities, alerts and notifications follow the pilot research protocol.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCare offers user friendly and attractive interfaces. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCare offers user friendly interfaces for all users. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCare applies user interfaces resembling other technologies used by the elderly.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	eCare adopts an efficient navigation scheme to facilitate user interaction. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	eCare implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	eCare adopts a data minimisation policy that restricts data processing.
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	eCare presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	eCare adopts a data minimisation policy that supports storage minimisation.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	eCare complies with GDPR regulations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	eCare offers robust authentication and authorisation features. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	eCare implements password-based authentication.
SPS-149	The SHAPES Platform shall support password management.	Y	eCare has a password management feature. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	eCare is a scalable solution in terms of users, services and geographical coverage.
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	eCare is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	eCare was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	eCare supports the registration of IoT and medical devices.
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	eCare supports the recognition of connected devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	eCare supports the accessibility features of the access device.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	eCare delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	eCare supports an offline operation mode at the user device.
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	eCare maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	eCare supports service continuity and recovers from network downtime.
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	eCare maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	eCare delivers user friendly and intuitive GUI. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	eCare has its own APIs, allowing the exchange of data among digital solutions. eCare was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	eCare is accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	eCare web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	eCare shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	eCare shall support the exchange of data with SHAPES components.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	eCare shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	eCare shall support the management of notifications among core SHAPES components.
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	eCare shall support SHAPES's single sign-on mechanism, provided via ASAPA.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	eCare offers robust authorisation features for data access.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	eCare API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	eCare implements anonymisation features.
SPS-200	All passwords shall be unique per device and per user.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	eCare adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	eCare adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	eCare adopts robust verification mechanisms for software updates.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	eCare uses the best state-of-the-art encryption techniques to protect data exchange with devices.
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	eCare supports an offline operation mode.
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	eCare allows users to easily delete own data from the device.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	eCare enables the validation of specific fields of information or data provided by the user or received via the eCare API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

Table 29 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the elderly pilot participant's health parameters.	Y	eCare monitors and displays vital signs parameters (blood pressure, heart rate, oxygen saturation levels) based on data collected from medical devices.
R2	Monitor the elderly pilot participant's wellbeing parameters.	Y	eCare monitors and displays wellbeing parameters (weight and body composition parameters) based on data collected from a body composition scale.
R3	Monitor unobtrusively the physical activity and sleep quality of the elderly pilot participant at home.	Y	eCare supports fitness tracker wearables that monitor unobtrusively physical activity and sleep quality.
R4	Establish the elderly pilot participant's vitals monitoring goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing vitals monitoring goals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R5	Establish the elderly pilot participant's weight monitoring goals.	Y	eCare displays daily tasks for the pilot participant, including those addressing weight monitoring goals.
R6	Establish the elderly pilot participant's daily steps goals.	Y	eCare displays information concerning sleep routine and quality to the elderly pilot participant, including those addressing sleep quality goals.
R7	Establish the elderly pilot participant's exercise goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing exercise goals.
R8	Establish the elderly pilot participant's sleep goals.	Y	eCare displays daily tasks for the elderly pilot participant, including those addressing sleep goals.
R9	Deliver to the elderly pilot participant reminders, notifications and recommendations on their daily monitoring tasks.	Y	eCare displays reminders, notifications and recommendations on the daily monitoring activities to be accomplished by the elderly pilot participant.
R10	Deliver to the elderly pilot participant reminders on their daily steps goal.	Y	eCare displays reminders on the daily activities to be accomplished by the elderly pilot participant.
R11	Deliver to the elderly pilot participant recommendations on their sleep routine.	Y	eCare displays recommendations to the elderly pilot participant, including those addressing a sleep routine.
R12	Allow the care professional pilot participant to remotely monitor the health and wellbeing parameters of the elderly pilot participants.	Y	eCare displays in the care professional dashboard the health and wellbeing data of the elderly pilot participants.
R13	Allow the care professional pilot participant to remotely monitor the HF risk assessment of the elderly pilot participants.	Y	eCare displays in the care professional dashboard the HF risk assessment of the elderly pilot participants.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R14	Allow the care professional pilot participant to establish the vitals and the weight monitoring goals.	Y	eCare provides a care plan module allowing care professionals to establish specific treatment goals for the elderly pilot participant.
R15	Allow the care professional pilot participant to monitor the elderly pilot participants' adherence to the vitals and the weight monitoring goals.	Y	eCare displays in the care professional dashboard the adherence of the elderly pilot participants to the defined care plan.
R16	Create a Researcher Dashboard allowing pilot organisers to follow the progress of the pilot activities and the elderly pilot participants' adherence to the research protocol.	Y	eCare provides an overview of the daily activities performed by the elderly pilot participants, allowing pilot organisers to monitor the pilot activities' progress and the participants' adherence.
R17	Deliver in the Researcher Dashboard a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires.	Y	eCare provides a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).

3.2.6.2 *Design and Development Stage*

The eCare Platform has been redesigned so as to meet the objectives of project brand and the functional requirements of the PT3-UC001, while delivering excellent user experience.

Details on colouring, typography and accessibility guidelines for the adaptations in the user interface are provided in section 3.2.3.2. Moreover, the **eCare Platform** texts have been translated to the Spanish language, since the pilot use case's leading partner (CH) operates in Spain and will be recruiting Spanish pilot participants.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Based on the PT3-UC001 use case's requirements and the user experience guidelines, a set of mock-up designs of the **SHAPES eCare App** were created and are presented next.

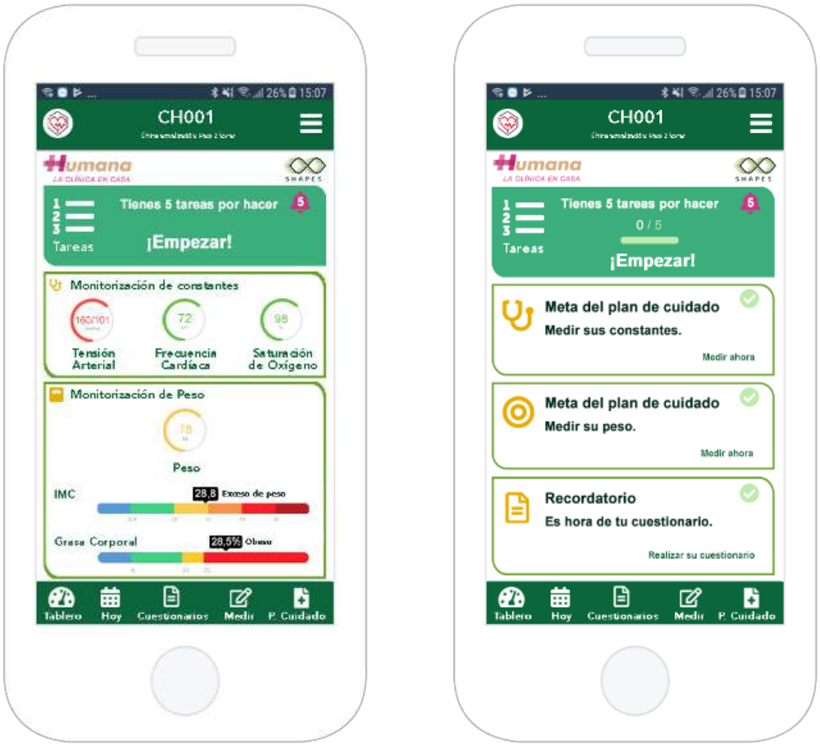


Figure 67 - SHAPES eCare App for PT3-UC001 – Dashboard and Today Screens

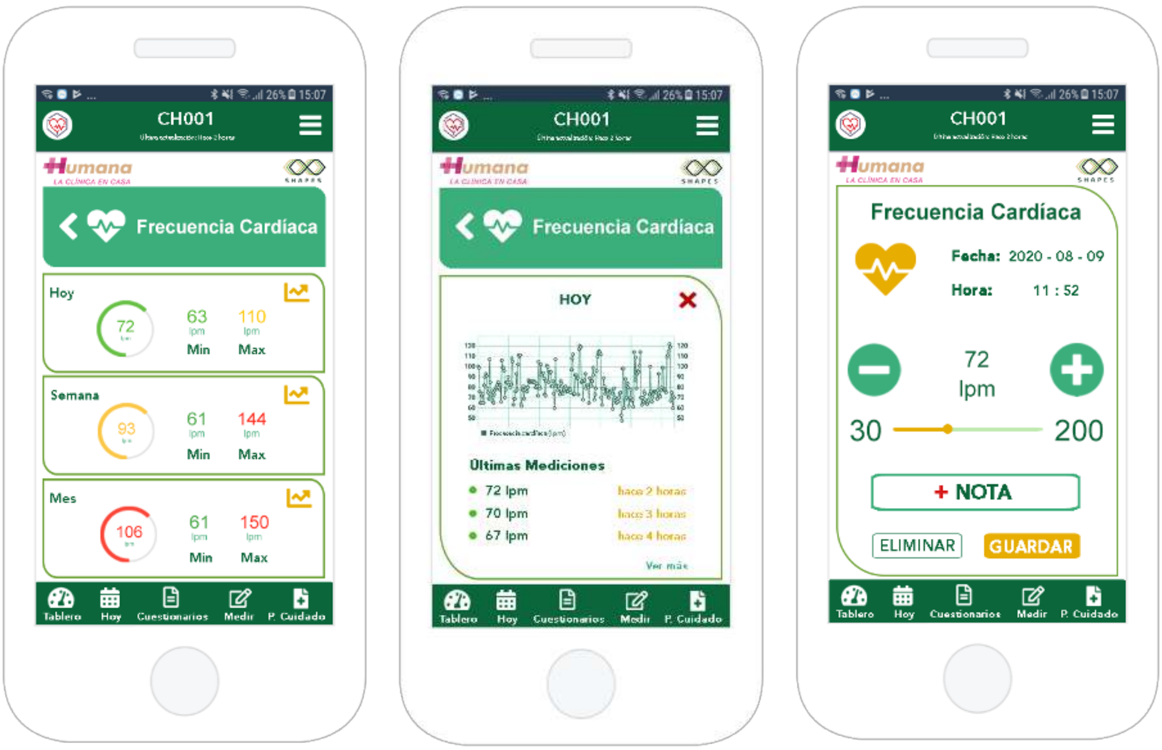


Figure 68 -SHAPES eCare App for PT3-UC001 – Heart Rate Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

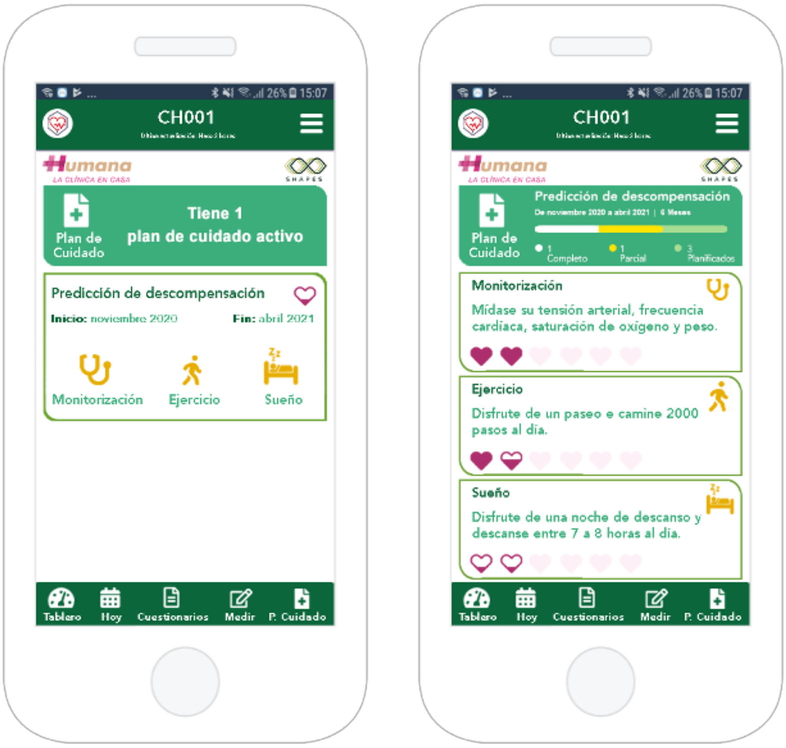


Figure 69 - SHAPES eCare App for PT3-UC001 – Care Plan Screens

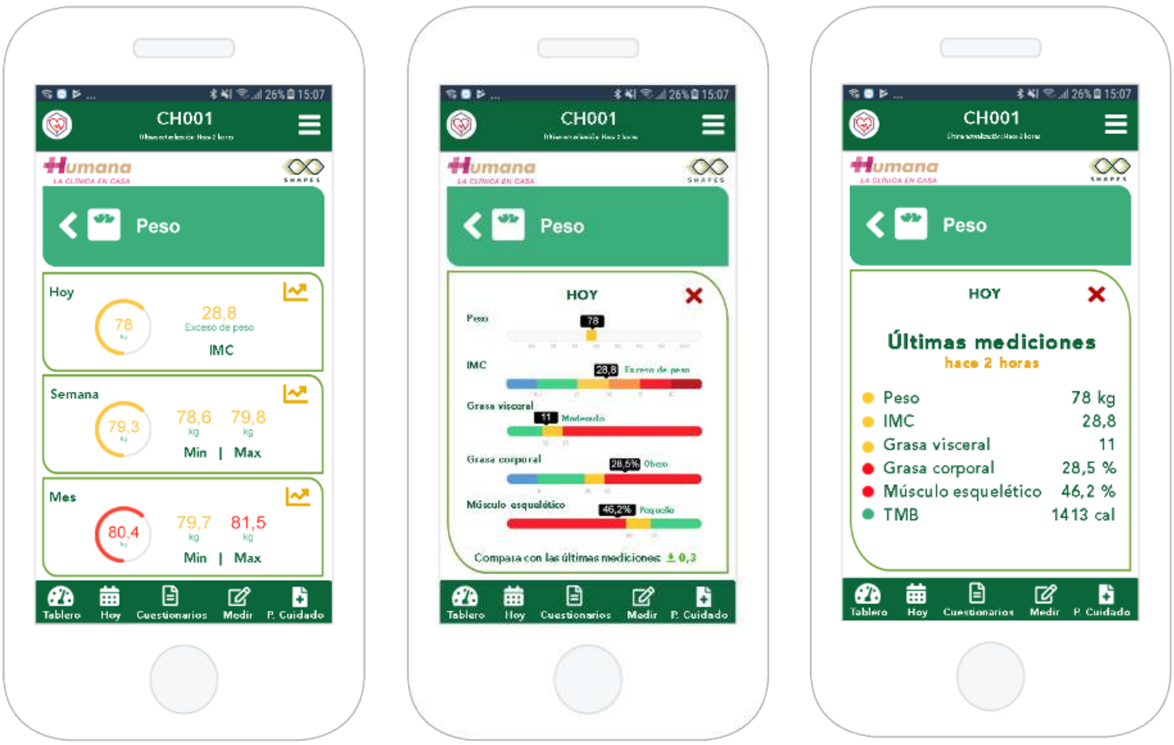


Figure 70 - SHAPES eCare App for PT3-UC001 – Weight Monitoring Screens

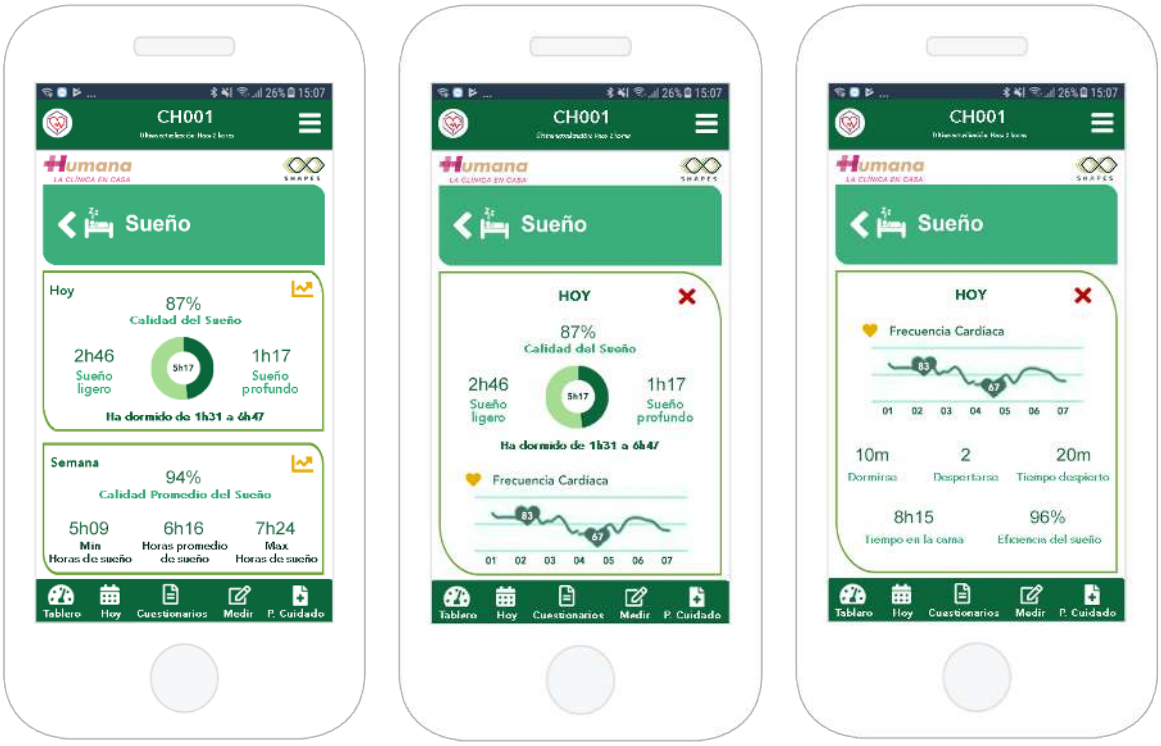
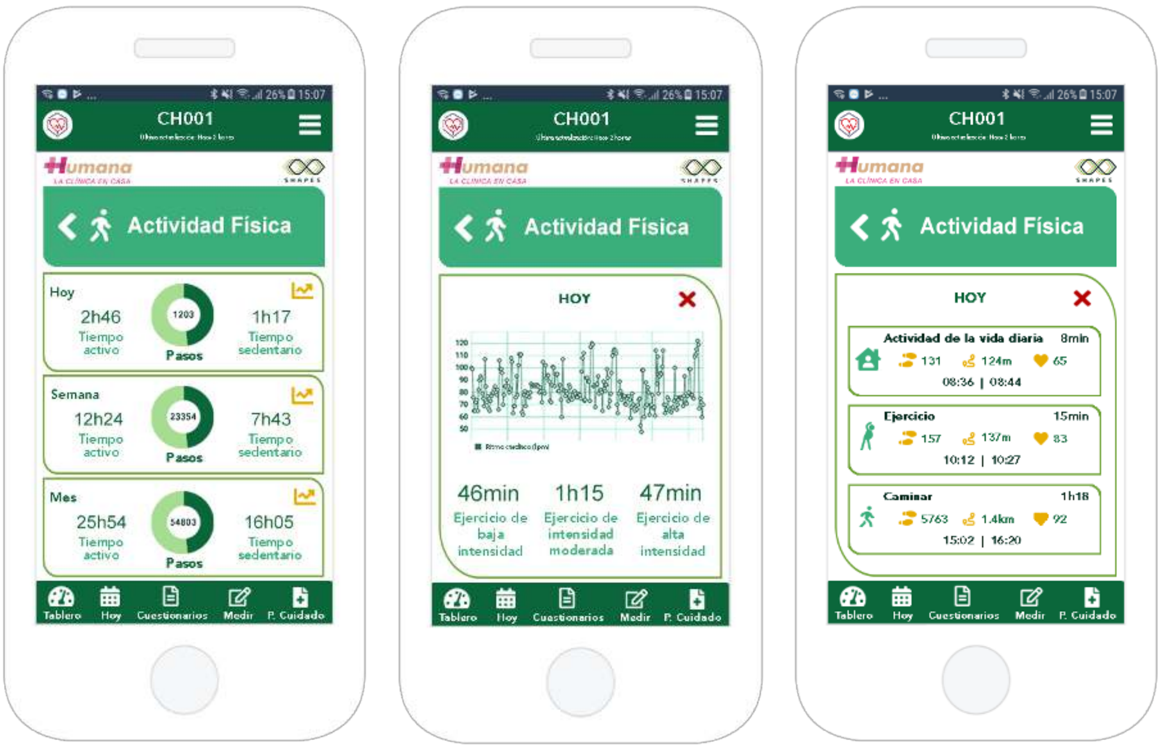


Figure 71 -SHAPES eCare App for PT3-UC001 – Sleep Quality Monitoring Screens



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

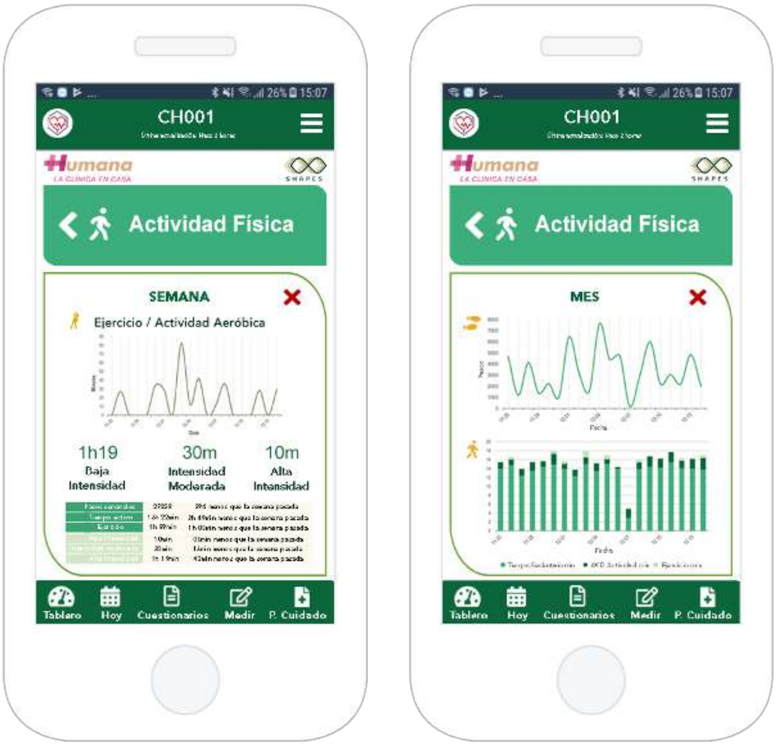


Figure 72 - SHAPES eCare App for PT3-UC001 – Physical Activity Monitoring Screens

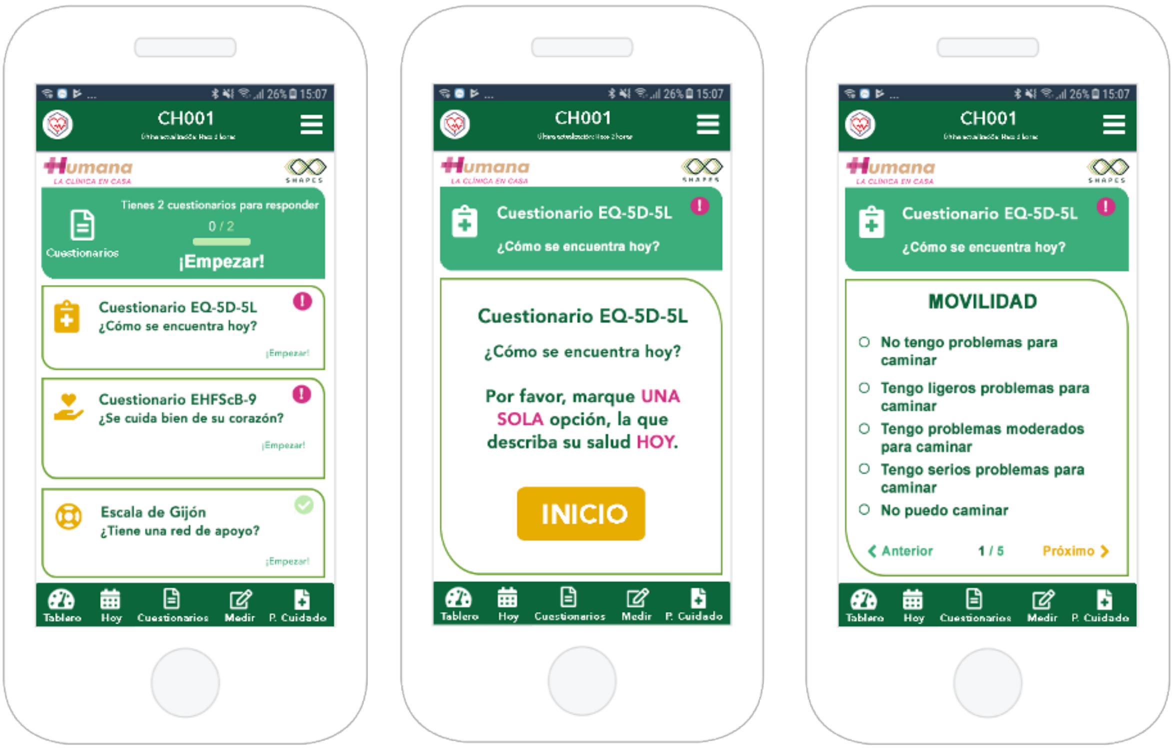
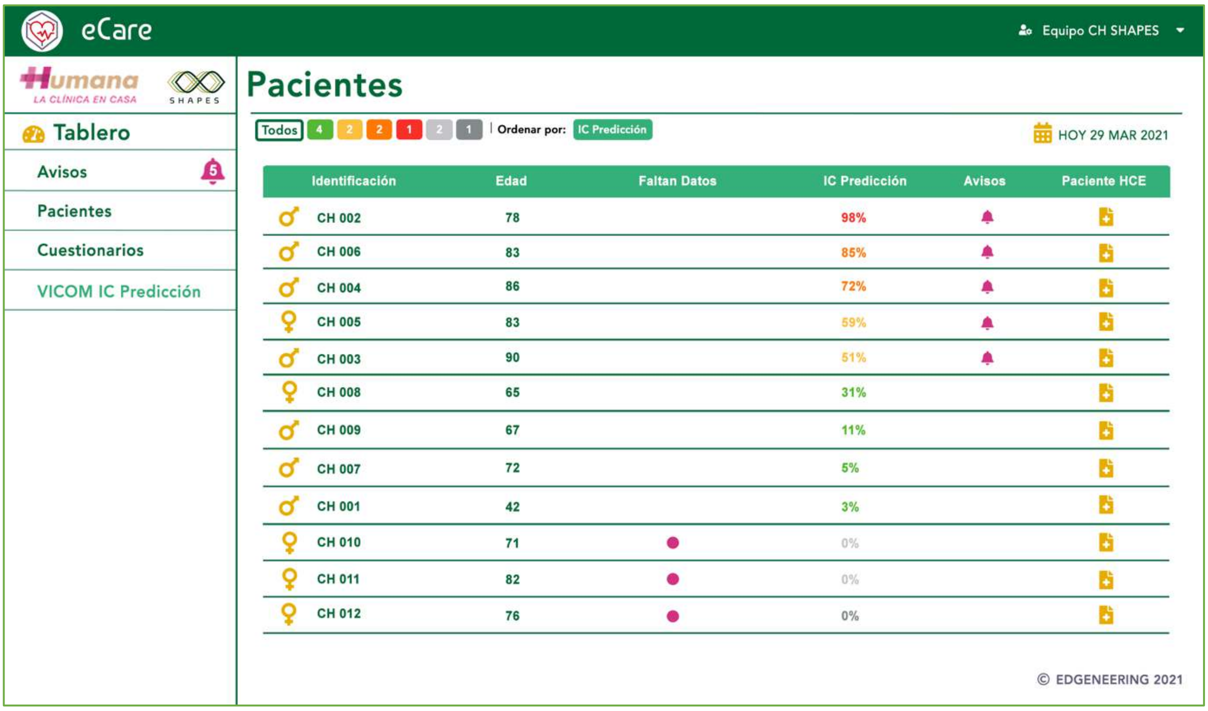


Figure 73 - SHAPES eCare App for PT3-UC001 – Surveys Screens

The mock-up designs of the SHAPES eCare System for the PT3-UC001 use case are presented next.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159



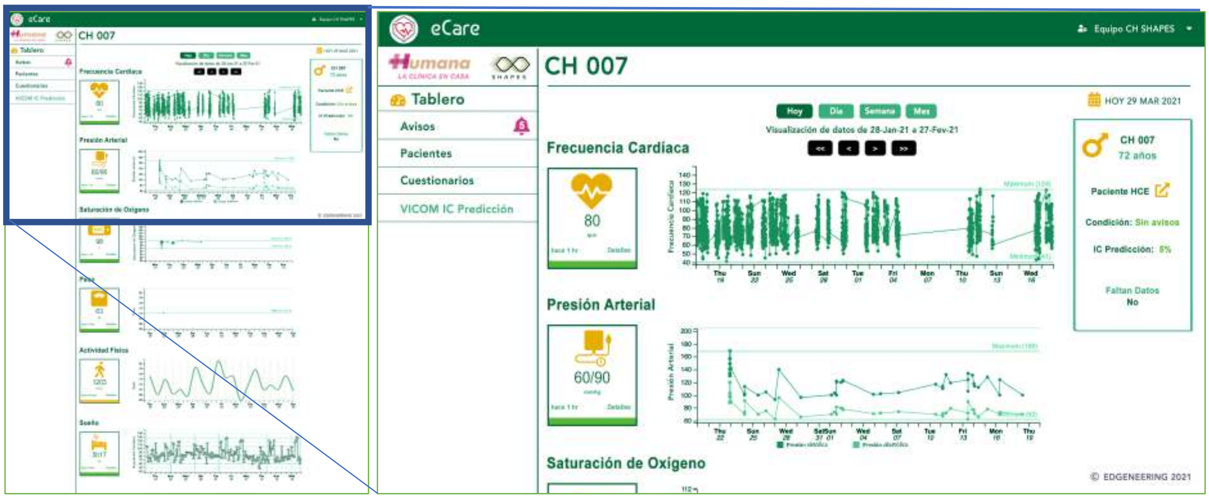


Figure 74 - SHAPES eCare System for PT3-UC001 – Patients Screens

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

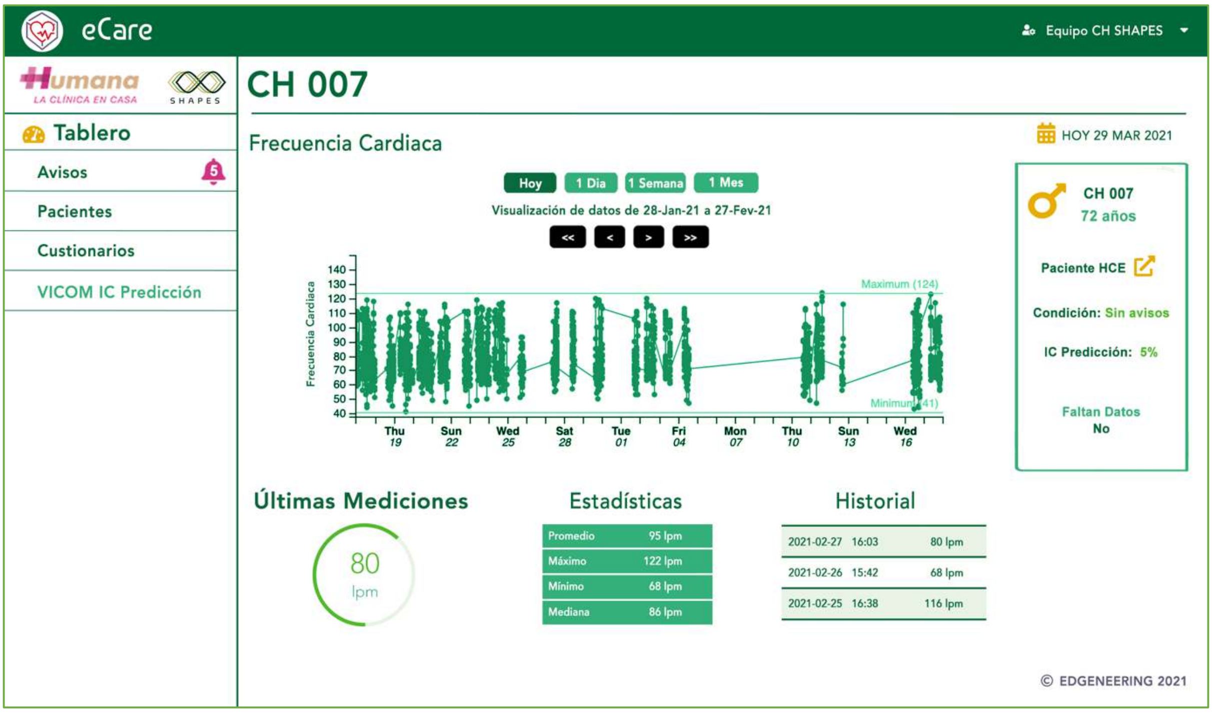


Figure 75 - SHAPES eCare System for PT3-UC001 – Patient Heart Rate Screen

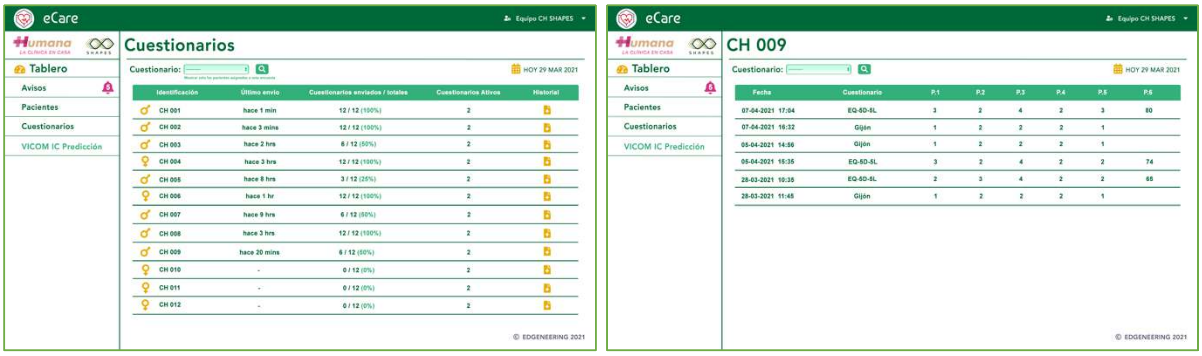


Figure 76 - SHAPES eCare System for PT3-UCGeneral – Questionnaires Screens

In June 2021, the mock-up designs were presented by CH to 4 representatives of the pilot participants. The user feedback collected during the presentations and interviews was very positive about the SHAPES eCare App and Portal and the main recommendation was to always use the largest size of text possible. It was highly appreciated that the App abides to the smartphone's font and display settings selected by the user and that it supports the smartphone's accessibility features. Further, it was deemed very interesting the possibility for the user to turn on/off the colouring code, since some users might become anxious when viewing their readings displayed in yellow, orange or red colours.

In addition, EDGE created a set of mock-up designs for the SHAPES eCare Researcher Dashboard, which has been designed to enable the CH researchers team to accompany the evolution of the piloting activities and assess the level of adherence

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

of pilot participants to the research plan or protocol. The mock-up designs are presented next.

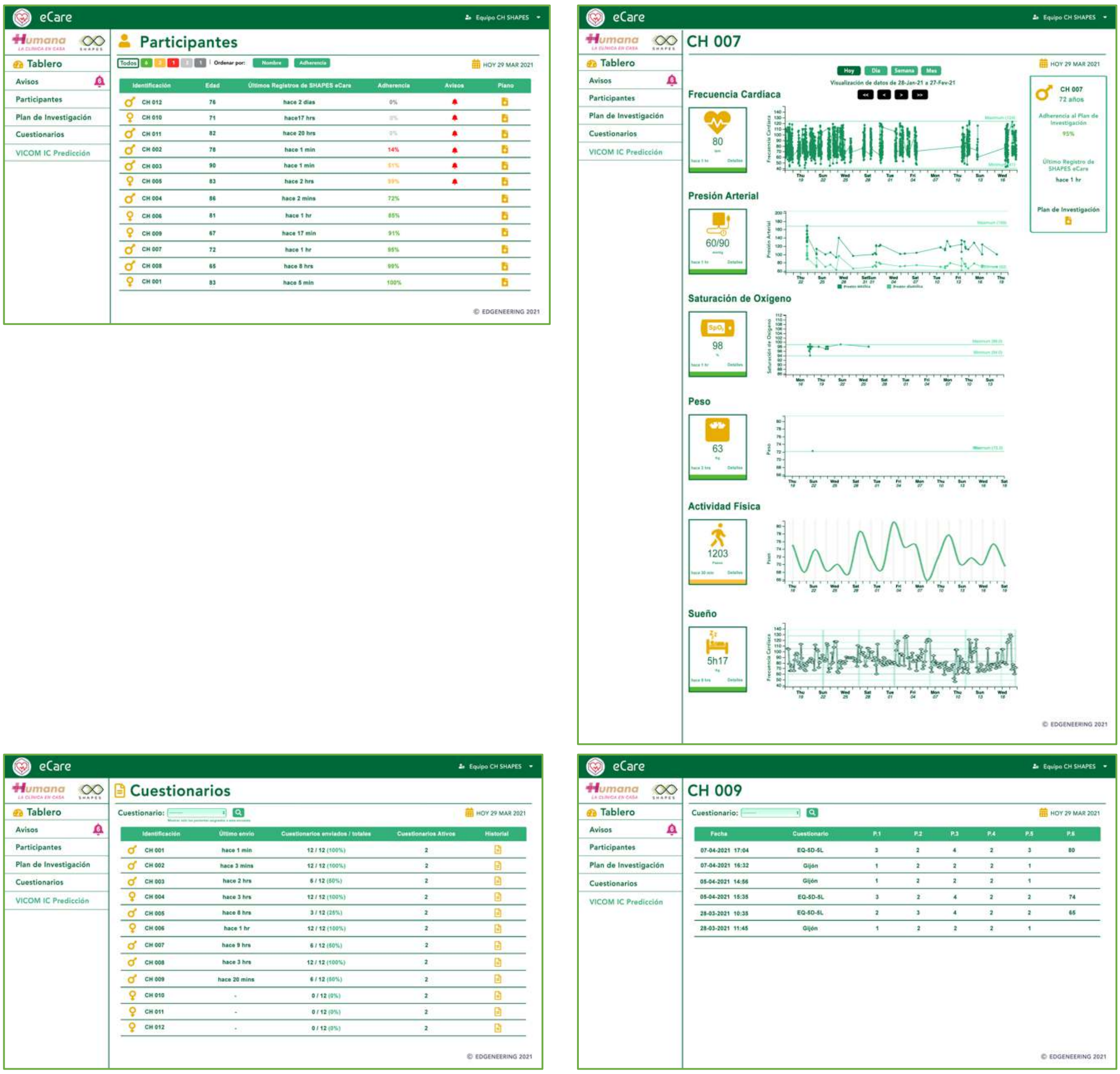


Figure 77 - SHAPES eCare System for CH Researchers in PT3-UC001

3.2.6.3 *Prototyping and Adaptation Stage*

Following the concept and ideation and design and development stages, the prototyping and adaptation stage focused on the creation of the **SHAPES eCare App** and **SHAPES eCare Portal** to adequately support the piloting activities of use case PT3-UC001.

The **SHAPES eCare Platform** for PT3-UC001 is responsible for the collection of the data from the connected devices (the blood pressure monitor, the oxymetre, the body composition scale and the fitness tracker) and providing user interfaces with the elderly pilot participant (the **SHAPES eCare App**) and the caregiver pilot participant (the **SHAPES eCare System**). The eCare third-party API allows for the direct exchange of data with the different SHAPES digital solutions supporting this use case,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

so as to display the most up-to-date information to the user. In addition, the eCare third-party API allows the **SHAPES eCare System** to exchange information with the SHAPES Platform, namely the SHAPES Data Lake repository and the SHAPES Authentication module (ASAPA). The **SHAPES eCare System** will also be adapted to deliver the **eCare Researcher Dashboard**, enabling CH to remotely accompany the pilot's progress, providing an overview of the pilot participants' adherence to the pilot research protocol, in the scope of the functionalities enabled by the **SHAPES eCare Platform**.

From a high-level architectural perspective, the **SHAPES eCare** component is depicted as:

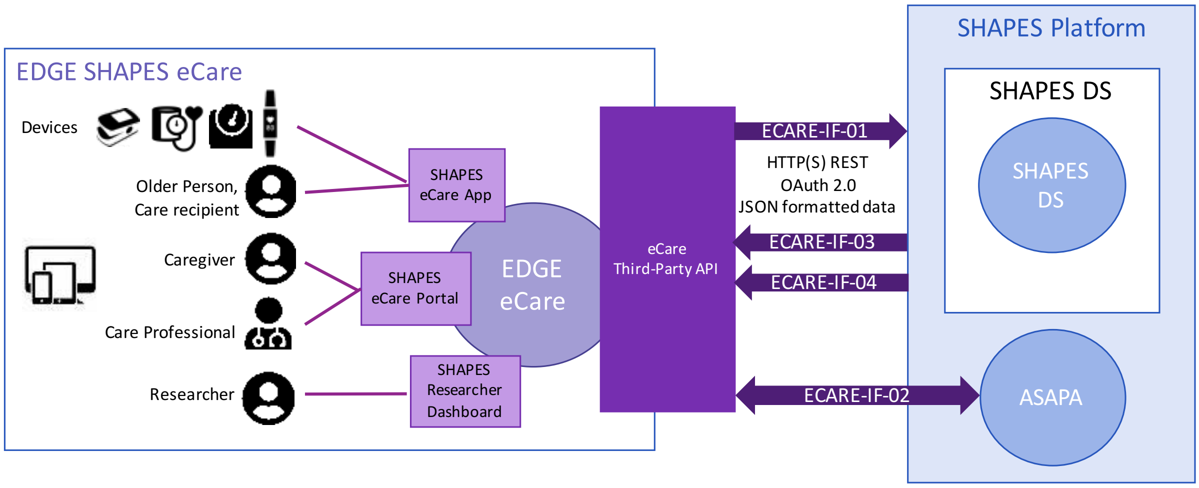


Figure 78 - High-level Architecture of the SHAPES eCare Platform Component for PT3-UC001

The **SHAPES eCare Platform**'s interfaces are detailed in the following table.

Table 30 - SHAPES eCare Platform Interfaces

SHAPES eCare Interfaces			
Interface ID	Involved SHAPES Components	Components Relation	Interface Content
ECARE-IF-01	SHAPES eCare and the SHAPES Platform	SHAPES eCare provides user vitals and wellbeing data collected from the medical and health devices and user activity collected from the wearable.	**Output**: Vitals data (blood pressure, heart rate and oxygen saturation measurements), wellbeing data (weight, body mass index, body fat, visceral fat, skeletal muscle, basal metabolic rate) and activity data (number

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SHAPES eCare Interfaces			
Interface ID	Involved SHAPES Components	Components Relation	Interface Content
			of steps over time) and vitals (heart rate measurements).
ECARE-IF-02	SHAPES eCare and the ASAPA Module	The ASAPA module provides user authentication in SHAPES. SHAPES eCare uses the same user authentication.	**Output:** username and password. **Input:** If successful, results the user token; if not, returns “not authorised”.
ECARE-IF-03	SHAPES Platform and Digital Solutions	SHAPES eCare receives user data from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: User data (age; gender).
ECARE-IF-04	SHAPES Platform and Digital Solutions	SHAPES eCare receives reports, alerts and recommendations as a result of user data processing from SHAPES Digital Solutions, via the SHAPES Platform.	**Input**: Physical activity reports, sleep quality reports, HF prediction risk assessment level, ADL alerts and recommendations.

Considering the SHAPES eCare Platform architecture and the pilot use case’s requirements, the primary functions to be enabled through the **SHAPES eCare App** concern the display of the data collected from the elderly pilot participant’s medical and health devices (blood pressure monitor, oxymetre, body composition scale, fitness tracker) and the recommendations and data analyses on physical activity, sleep quality, anomaly detection and HF prediction risk assessment produced by the data analytics SHAPES partners. Similarly, the **SHAPES eCare System** will provide the same primary functions, allowing caregivers to have access to the data of the elderly in their care.

These functions are delivered by the following **eCare Platform** modules:

- **Dashboard**, allowing to display to the user an overview of the key parameters of the eCare monitoring platform (vitals, ambient living, physical activity, sleep, body and nutrition, weather) and provide access to the different functions provided by eCare;
- **Vitals monitoring**, allowing the user to register and view the vital signs (blood pressure, heart rate, temperature, oxygen saturation, respiratory rate and blood

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

glucose) readings from connected devices, visualise them over time (graphical setting) and manually insert measurements, if needed;
- **Body and nutrition monitoring**, allowing the user to register and display the weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate parameters from the health device (body composition scale), as well as fluid and food intake, visualise them over time (graphical setting) and manually insert readings, if needed;
- **Today**, allowing to display to the elderly user the list of tasks to be accomplished daily and a progress bar illustrating the number of completed tasks versus the tasks to be completed;
- **Measure**, allowing the elderly user to take readings on vitals (blood pressure, heart rate, oxygen saturation levels) and body composition parameters (weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate) either automatically or manually from the medical and health devices;
- **Physical activity monitoring**, allowing to collect the activity data from fitness trackers and display a physical activity report;
- **Sleep quality monitoring**, allowing to collect the activity data from fitness trackers and display a sleep quality report;
- **Surveys**, allowing the researcher to collect the elderly users' response to pre-defined questionnaires on wellbeing, quality of life and network support, as pre-defined in the pilot research protocol;
- **Notifications**, allowing to present to the user reminders, notifications, alerts or recommendations concerning the vital signs readings, wellbeing data, ambient living data, daily tasks and goals and surveys;
- **Care Plan**, allowing care professionals to establish a personalised care plan for the user, involving vitals monitoring, medication, physical activity, sleep, diet and treatment. It sets individual daily or weekly tasks/goals, personalised reminders, notifications and recommendations concerning the user's vitals and wellbeing data;
- **Devices Management**, allowing the connection with the user's medical, health or smart home devices so as to automatically acquire the user's relevant data;
- **User Information**, allowing the user to configure personal information and the display preferences concerning notifications, reminders and colour code.

As a result, prototyping work is ongoing to adapt the **eCare Platform**'s user interfaces to the pilot use case's needs, considering the mock-up designs and the user feedback received through the co-design phase. Aside from the visual changes detailed in section 3.2.3.2, adaptations have been made so that the **SHAPES eCare App** and the **SHAPES eCare System** display the functionalities associated with the use case and are able to interoperate with other digital solutions supporting the use case:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 31 - Adaptations to build the SHAPES eCare Platform for PT3-UCGeneral

Module	Adaptation Work
Dashboard	This module is being adapted in the App and System to display to the elderly pilot participant and to the caregiver/care professional pilot participant the key functionalities of the use case (vitals monitoring, daily tasks, taking measurements, physical activity monitoring, sleep quality monitoring and notifications). In addition, this module is being adapted to include in the System the HF prediction risk assessment, allowing to display to the caregiver/care professional pilot participant the results of VICOM's HF prediction risk assessment (an HF prediction risk percentage).
Vitals Monitoring	This module is being adapted to display to the pilot participants the elderly pilot participants' blood pressure, heart rate and oxygen saturation readings, while hiding other vital signs (temperature and respiratory rate). It is also enabled the manual insertion of these readings (the automatic reading mode is the default based on the connection to the medical devices). The vitals monitoring data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings. Also, the module is being adapted to display the elderly pilot participants' weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate. The weight and body composition data is presented for the day, the week and the month periods, using statistics (average, maximum and minimum readings), graphics and a list of time-stamped readings. In addition, a colour code (green, yellow and red) for each reading allows pilot participants to easily understand whether the displayed readings are within normal, worrisome or abnormal limits.
Today	This module is being adapted to allow the elderly pilot participant to view the list of daily tasks to be accomplished. As a task is completed, the system updates automatically, marking the task with a checked sign. It is possible for the elderly pilot participant to press the task button and directly access the screen enabling the completion of the task. In addition, a progress bar illustrates the evolution of tasks' completion, clearly highlighting the number of accomplished tasks and the number of tasks still to be completed.
Measure	This module is being adapted to allow the elderly pilot participant to take readings on vitals (blood pressure, heart rate, oxygen saturation levels) and body composition parameters (weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic, using the medical and health devices. Per default, the measures are automatically captured but there is also the opportunity for the elderly pilot participant to enter the reading manually.

Module	Adaptation Work
Physical Activity Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, in order to receive and display the elderly pilot participants' physical activity reports. The steps count, active time and sedentary time data are presented for the day, the week and the month periods, using graphics. Further, this module is being adapted to display the elderly pilot participants' physical activity monitoring data (steps count, activity time, sedentary time, heart rate, physical activity intensity in low, moderate and vigorous modes, time duration of each of the intensity modes, exercise and aerobic activity), based on TREE's physical activity report.
Sleep Quality Monitoring	This module is being adapted to enable the sharing of the fitness tracker wearable's activity data and the integration with the data analytics solution provided by TREE, receiving and displaying the elderly pilot participants' sleep quality monitoring data presented for the day, the week and the month periods, using graphics and statistics (average, maximum and minimum sleep time duration). The sleep quality monitoring data include sleep quality percentage, time duration of sleep, start and end time of sleep, light and deep sleep time duration, heart rate, time to fall asleep, number of times awaken, number of times awaken and getting up, time in bed and sleep efficiency percentage, based on TREE's sleep quality report.
Notifications	This module is being adapted to display to the pilot participants reminders, notifications, alerts or recommendations concerning vitals monitoring, the physical activity and sleep quality information and the HF prediction risk assessment (only for the caregiver/care professional pilot participants). Also, this module is being adapted to enable the integration with VICOM's recommendations system and with TREE's ADL routine detection system. The reminders are automatically checked whenever the associated task is complete and the list of daily tasks to be accomplished is updated.
Care Plan	This module is being adapted to allow the caregiver/care professional pilot participants to insert the applicable research protocol, concerning vitals and weight monitoring, physical activity and sleep. It will support the identification of individual daily tasks/goals, personalised reminders, notifications and recommendations concerning the elderly pilot participants' vitals and weight monitoring, physical activity and sleep.
Devices Management	This module is being adapted to enable the connection with the elderly pilot participants' medical and health devices and fitness tracker wearable and app, so as to automatically acquire the elderly pilot participants' vitals and weight monitoring data and activity data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Module	Adaptation Work
User Information	This module is being adapted to enable the integration with SHAPES Platform, retrieving and displaying the pilot participant's fake identification (user ID and email) and password, date of birth and gender.

In addition, the **SHAPES eCare App** will provide a direct link to the SHAPES Front-end App, allowing the user to exit the SHAPES eCare App and access the other use case functionalities provided by other SHAPES partners' digital solutions supporting the PT3-UC001 use case.

Furthermore, the **eCare Portal** has been adapted to build the **SHAPES eCare Researcher Dashboard**, which will allow the CH team to follow in real-time the progress of the pilot activities they are conducting. The changes being made will enable the CH team to use a dashboard to supervise whether all elderly pilot participants are complying with the pilot research protocol, using the medical and health devices to monitor their blood pressure, heart rate, oxygen saturation levels, weight, body mass index, body fat, visceral fat, skeletal muscle and basal metabolic rate parameters, as well as the fitness tracker wearable to monitor activity and sleep. The **SHAPES eCare Researcher Dashboard** also includes an adapted menu navigation, allowing the CH team to directly access the other digital solutions supporting the use case, including own information systems.

Simultaneously, EDGE is completing the user manuals accompanying the three prototypes – the **SHAPES eCare App**, the **SHAPES eCare System** and the **SHAPES Researcher Dashboard** – that support the Phase 3 – *Hands-on Experiments* of the pilot activities, organised by CH in October 2021. The analysis of the user feedback of the hands-on training with the SHAPES digital solutions, namely concerning the **SHAPES eCare Platform**, will be performed in the following weeks. Based on the received analysis, minor adjustments and corrections will take place so as to ready the **SHAPES eCare Platform** for Phases 4 and 5 of PT3-UC001 piloting activities.

3.2.7 Adaptations for PT4-UC001

The following sections present the adaptations and new developments performed in the **eCare Platform** digital solution, in order to meet the specific requirements of ***PT4-UC001: Psycho-social and Cognitive Stimulation Promoting Wellbeing*** and adequately support the use case's pilot activities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.2.7.1 Concept and Ideation Stage

In this use case, the targeted audience is the adults with +50 years healthy and +65 years with frailty conditions (mild chronic conditions or chronic musculoskeletal disorders) living independently, either alone or with their spouse, and being followed by a caregiver/care professional on a regular basis. According to Deliverable D2.7 – *SHAPES Personas and Use Cases* [2], the SHAPES personas applicable to PT4-UC001 are Ernst (Persona 1), Roberto (Persona 2) and Ayesha (Persona 3). Details on these SHAPES personas are available in Deliverable D2.7.

The use case PT4-UC001 aims to foster a combined physical and cognitive intervention – dance – as a means to promote older people's physical and cognitive functioning, positively impacting their psycho-social functioning. Dance integrates a physical component but also requires attention and memory to identify the movements and patterns (cognitive element), while being a ludic and appealing social activity. Ageing is usually associated with losses in several domains of daily functioning, including cognitive functioning, physical functioning and social networks. Preventing these losses, delaying its progression or attempting to revert them is essential to promoting autonomous and independent ageing in place, and long and healthier lives lived with quality. To that end, digital technologies are to be deployed, in order to unobtrusively monitor the elderly pilot participants' dance activity, for dance has the potential to be attractive to older adults and can be adjusted according to individual characteristics (e.g. age, physical limitations, cognitive limitations). The involved technologies include a smart mat and the DanceMove System to provide the choice of music and of dance choreographies, accordingly to the users' (cultural) preferences and characteristics, and to register the users' performance throughout the choreographies. In addition, the eCare Platform displays to the users the data on their dancing performance. Based on the collected data, it is possible to deliver specific notifications, reminders or recommendations to the pilot participants so that appropriate intervention could be carried out.

In order for the **eCare Platform** to properly support the use case PT4-UC001, an analysis of the applicable system specifications (as defined in Deliverable D4.1 – *SHAPES Technological Platform Requirements and Architectur*e [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.5 – *Psycho-social and Cognitive Stimulation Promoting Wellbeing - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 32 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	eCare has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	eCare adopts a modular and configurable architecture.
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	eCare follows universal accessibility policies.
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCare adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	eCare has its own APIs and adopts interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	eCare delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	eCare has a multilingual interface and eCare adaptations benefitted from SHAPES partners' translation skills.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	eCare supports health data collection, sharing and processing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCare complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCare storage is handled in EU Member States.
SPS-033	All classes of users shall be able to review the historical data.	Y	eCare maintains a data repository that includes historical data.
SPS-044	The SHAPES Platform should support use of questionnaires as self-assessment tools.	Y	eCare supports the use of questionnaires as self-assessment tools.
SPS-046	The SHAPES Platform should support reminders.	Y	eCare delivers reminders.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	eCare provides a set of daily tasks for the user.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	eCare delivers motivational notes.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	eCare delivers user friendly dashboards. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	eCare supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data follows the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	eCare maintains system access logs for all data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	eCare offers robust authentication and authorisation features.
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	eCare provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	eCare allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	eCare supports mobile and web-based platforms and devices.
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	eCare provides users with comprehensive feedback.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	eCare supports the creation and personalisation of care plans.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	eCare supports the users' health literacy.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	eCare supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	eCare enables traceability of personal data.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCare is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCare complies with relevant cybersecurity rules for mobile and online services.
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	eCare follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	eCare delivers alerts and notifications to its users. For the SHAPES pilot activities, alerts and notifications follow the pilot research protocol.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCare offers user friendly and attractive interfaces. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCare offers user friendly interfaces for all users. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCare applies user interfaces resembling other technologies used by the elderly.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	eCare adopts an efficient navigation scheme to facilitate user interaction. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	eCare implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	eCare adopts a data minimisation policy that restricts data processing.
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	eCare presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	eCare adopts a data minimisation policy that supports storage minimisation.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	eCare complies with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	eCare complies with GDPR regulations and implements cybersecurity measures to protect data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	eCare offers robust authentication and authorisation features. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	eCare implements password-based authentication.
SPS-149	The SHAPES Platform shall support password management.	Y	eCare has a password management feature. For the SHAPES pilot activities, eCare integrates with the ASAPA module for authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	eCare is a scalable solution in terms of users, services and geographical coverage.
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	eCare is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	eCare was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	eCare supports the registration of devices, including the DanceMove System.
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	eCare supports the recognition of connected devices.
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	eCare supports the accessibility features of the access device.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	eCare delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	eCare supports an offline operation mode at the user device.
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	eCare maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	eCare supports service continuity and recovers from network downtime.
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	eCare maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCare provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	eCare delivers user friendly and intuitive GUI. Adaptations to eCare consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	eCare has its own APIs, allowing the exchange of data among digital solutions. eCare was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	eCare is accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	eCare web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	eCare shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	eCare shall support the exchange of data with SHAPES components.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	eCare shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	eCare shall support the management of notifications among core SHAPES components.
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	eCare shall support SHAPES's single sign-on mechanism, provided via ASAPA.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	eCare offers robust authorisation features for data access.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	eCare API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	eCare implements anonymisation features.
SPS-200	All passwords shall be unique per device and per user.	Y	eCare has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	eCare adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	eCare adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	eCare adopts robust verification mechanisms for software updates.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	eCare uses the best state-of-the-art encryption techniques to protect data exchange with devices.
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	eCare supports an offline operation mode.
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	eCare allows users to easily delete own data from the device.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	eCare enables the validation of specific fields of information or data provided by the user or received via the eCare API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	eCare has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

Table 33 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Deliver the dance sessions performance data to the elderly pilot participant.	Y	eCare displays the dance sessions performance data based on the data provided by the DanceMove system.
R2	Provide an easy-to-use and appealing interface to display the dance sessions performance data to the elderly pilot participant.	Y	eCare presents an easy-to-use and appealing display screens and navigation features.
R3	Establish the elderly pilot participant's dance activity goals.	Y	eCare displays daily tasks for the pilot participant, including those addressing dance activity goals.
R4	Deliver to the elderly pilot participant reminders on their dance activity goals.	Y	eCare displays reminders on the daily activities to be accomplished by the pilot participant.
R5	Allow the care professional pilot participant to establish the dance activity goals.	Y	eCare provides a care plan module allowing care professionals to establish specific treatment goals for the elderly pilot participant.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R6	Allow the care professional pilot participant to monitor the elderly pilot participants' adherence to the dance activity goals.	Y	eCare displays in the care professional dashboard the adherence of the elderly pilot participants to the defined care plan.
R7	Create a Researcher Dashboard allowing pilot organisers to follow the progress of the pilot activities and the elderly pilot participants' adherence to the research protocol.	Y	eCare provides an overview of the daily activities performed by the elderly pilot participants, allowing pilot organisers to monitor the pilot activities' progress and the participants' adherence.
R8	Deliver in the Researcher Dashboard a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires.	Y	eCare provides a Surveys module allowing the researcher team to register the elderly pilot participants' answers to pre-defined questionnaires as per the pilot research protocol (System Usability Scale, EuroQol EQ-5D, Barthel Index, Gijon Socio-Family Assessment Scale and EHFScBS).

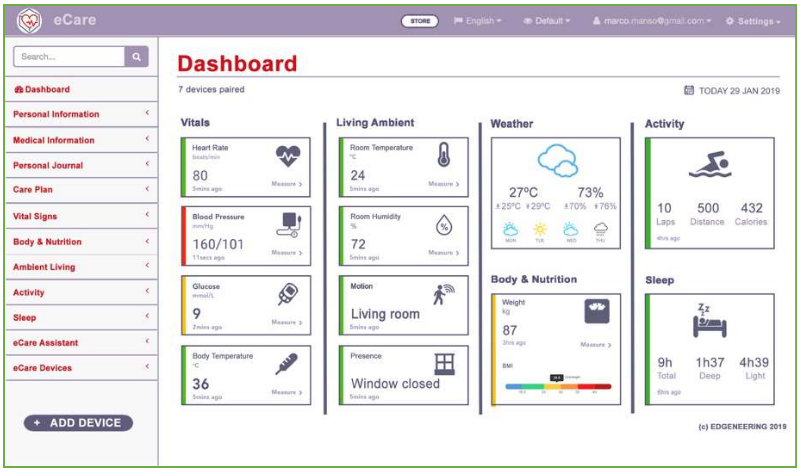
3.2.7.2 Design and Development Stage

The eCare Platform is being redesigned so as to meet the objectives of project brand and the functional requirements of the PT4-UC001, while delivering excellent user experience.

Details on colouring, typography and accessibility guidelines for the adaptations in the user interface are provided in section 3.2.3.2.

Based on the PT4-UC001 use case's requirements and the user experience guidelines, EDGE just started to design an initial set of mock-ups of the **SHAPES eCare System**, exemplified next.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159



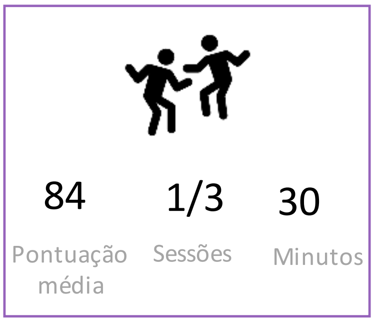


Figure 79 - SHAPES eCare System for PT4-UC001

According to the plan, the mock-up design phase starts in October 2021 and will continue until the end of the year. In this time, EDGE will continue to work with pilot leader UAVR to define and produce the relevant user interface screens adequate to supporting the PT4-UC001 piloting activities.

3.2.7.3 Prototyping and Adaptation Stage

Following the concept and ideation and design and development stages, the prototyping and adaptation stage will be focused on the creation of the **SHAPES eCare System** to adequately support the piloting activities of use case PT4-UC001.

The **SHAPES eCare Platform** for PT4-UC001 is responsible for providing user interfaces to the pilot participants, displaying the dance sessions performance data from the DanceMove system to the elderly pilot participant and the caregiver/care professional pilot participant (the **SHAPES eCare System**). The eCare third-party API allows for the direct exchange of data with the DanceMove system, so as to display the most up-to-date information to the user. In addition, the eCare third-party API allows the **SHAPES eCare Platform** to exchange information with the SHAPES Platform, namely the SHAPES Data Lake repository and the SHAPES Authentication module (ASAPA). The **SHAPES eCare System** will also be adapted to deliver the **eCare Researcher Dashboard**, enabling UAVR to remotely accompany the pilot's progress, providing an overview of the pilot participants' adherence to the pilot research protocol, in the scope of the functionalities enabled by the **SHAPES eCare Platform**.

From a high-level architectural perspective, the **SHAPES eCare** component is depicted as:

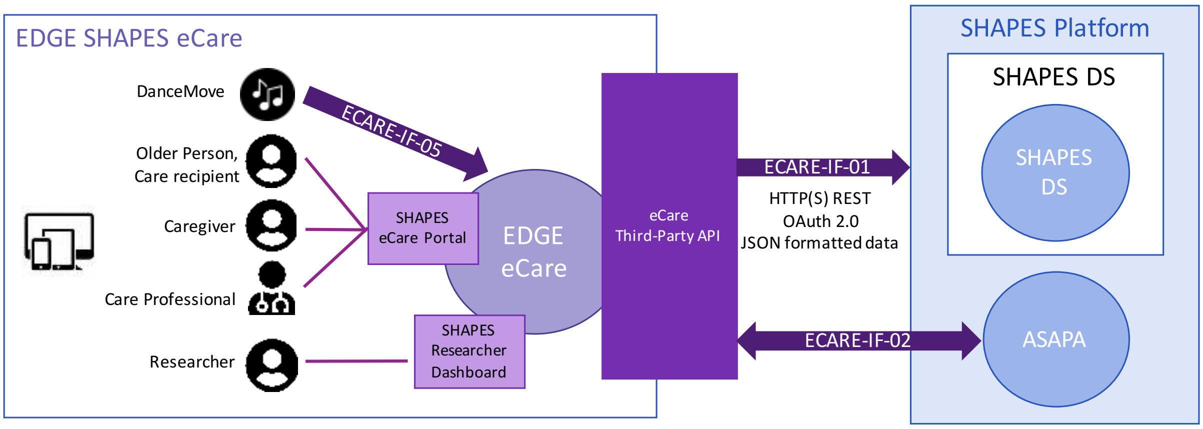


Figure 80 - High-level Architecture of the SHAPES eCare Platform Component for PT4-UC001

The **SHAPES eCare Platform**'s interfaces are detailed in the following table.

Table 34 - SHAPES eCare Platform Interfaces

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
ECARE-IF-01	SHAPES eCare and the SHAPES Platform	SHAPES eCare provides user data and user dance performance data provided by the DanceMove system.	**Output**: User data (age, gender) and user dance performance data (dance session ID, dance list ID, dance difficulty level, dance session start and end times, dance sequence per dance session, interaction type, score, number of right/wrong answers on right, left, front and back, total number of right/wrong answers, dance session average duration, average number of dances per dance session, average score per dance session, total number of dance sessions, number of dance sessions with erratic interaction, average

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SHAPES eCare Interfaces			
Interface ID	**Involved SHAPES Components**	**Components Relation**	**Interface Content**
			score, usage patterns on frequency, duration, number of dances and dances difficulty level).
ECARE-IF-02	SHAPES eCare and the ASAPA Module	The ASAPA module provides user authentication in SHAPES. SHAPES eCare uses the same user authentication.	**Output:** username and password. **Input:** If successful, results the user token; if not, returns "not authorised".
ECARE-IF-05	DanceMove system and SHAPES eCare	SHAPES eCare receives user dance performance data from the DanceMove system.	**Input**: User dance performance data (dance session ID, dance list ID, dance difficulty level, dance session start and end times, dance sequence per dance session, interaction type, score, number of right/wrong answers on right, left, front and back, total number of right/wrong answers, dance session average duration, average number of dances per dance session, average score per dance session, total number of dance sessions, number of dance sessions with erratic interaction, average score, usage patterns on frequency, duration, number of dances and dances difficulty level).

The prototyping and adaptation work performed thus far has been focused on the development of the new interface ECARE-IF-05, aiming to identify the data to be exchanged between the DanceMove System and the SHAPES eCare Platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.3 NOT!FY (OMN)

Omnitor **NOT!FY** is a cloud-based platform currently used to make citizens aware of incoming Total Conversation calls. This can happen in several different ways, e.g. flashing lights. However, NOT!FY is a general alerting platform that can be used for any type of alerting (not limited to Total Conversation).

Omnitor has developed two different versions of NOT!FY, the NOT!FY Smart plug and NOT!FY v1. NOT!FY smart plug consist of a built-in relay that can remotely be switched on/off and offers energy monitoring capability. NOT!FY v1 consists of four exposed relays that external alerting devices can be connected to. This version lacks the energy monitoring capability.

NOT!FY will be able to push energy consumption information to the SHAPES Technological Platform (TP) or other partners in SHAPES. It is possible to see if a device is turned on/off at an abnormal time through energy monitoring. It is also possible to remotely turn on or off the smart plug. As well as providing the user with a general alerting platform that can alert people on incoming calls with e.g. flashing light or tactile vibration.

Table 35 - Summarised Data collected with the NOT!FY Platform

Data Category	Measurements Type	Collection Method
Sensors	Energy monitor for Smart plug	Automated (from connected devices)
Internet Data	Remote activation Settings Device health	Automated (from connected devices)
Data to Industrial Devices	Turning on/off relay	Automated (from connected devices) or manual
Data from Industrial Devices	Energy	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)

Figure 81 - The Two Versions of NOT!FY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.3.1 Technical Specifications

Omnitor's NOT!FY is an IoT device based on either Raspberry Pi or ESP8266. The Raspberry Pi contains four exposed relays but without the capability to monitor energy. The smart plug contains an ESP8266 which is easily deployed. The purpose of NOT!FY is to provide the user with a general alerting platform but at the same time provide raw data to the caregivers.

Almost all "alerting systems" that are relying on relays for on/off can be connected to NOT!FY. NOT!FY also have a configurations list on what units are going to be turned on/off.

Technical specifications for the Smart Plug:

- Wireless IEEE Standards: WiFi 2.4Ghz.
- Voltage Range: 110-240V AC.
- Maximum Current: 16A.
- Max Power: 3500W (resistance load).
- Any household appliances over 2000W are not recommended.

3.3.2 Interfaces and Interoperability

The front-end of the NOT!FY platform is a web interface. The back-end is powered by the NOT!FY server, which supports SQL for inputs and outputs. APIs can be provided for SHAPES TP and SHAPES partners.

Table 36 - Summarised Technical Description of the NOT!FY Platform

General Description	• Omnitor's NOT!FY cloud-based platform with IoT-devices currently used to make citizens aware of incoming. • Total Conversation calls in a number of different ways e.g. flashing lights. However, NOT!FY® is a general alerting. • Platform that can be used for any type of alerting (not limited to Total Conversation).
Features	• Main goal of NOT!FY is to help deaf and hard of hearing people with incoming calls. • Built-in relays can be switched on or off. NOT!FY v1 have 4 exposed relays, NOT!FY Smart plug uses a built-in relay. • NOT!FY Smart plug offers energy monitoring capability. The information can be sent to other systems. • Used together with the eCtouch App to notify (alert) the citizen who are deaf or hard of hearing about an incoming call (e.g. flashing lights, tactile vibration). • NOT!FY can be connected to already installed alerting systems. • NOT!FY is a general notification platform (not limited to eCtouch calls) and consist of a cloud service and IoT devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Application Areas	• Provide a general alerting platform (able to alert people on incoming calls with e.g. flashing light, tactile vibration). • Energy monitoring (monitor connected devices, e.g. microwave, TV, computer and other).
TRL	From TRL7 (NOT!FY v1) From TRL5 (NOT!FY Smart plug)
Data Type	SQL
Inputs	Vendor's who can access NOT!FY, NOT!FY settings
Outputs	Vendor's who can access NOT!FY, Position (IP address), NOT!FY settings
Actions to be performed	• Provide SHAPES TP with information regarding energy consumption, can be used to determine if a device is on or off. • User will be able to remotely turn on or off devices that are connected. • User will be able to alert people with e.g. a flashing light or tactile vibration. • Provide data for third-party concerning energy consumption.
Interface	NOT!FY web interface

3.3.3 Applicable Pilot Themes

In SHAPES, the **NOT!FY Platform** will be adapted to meet the SHAPES user requirements and the pilot specifications associated with the following use cases:

- PT1 – Smart Living Environment for Healthy Ageing at Home.
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

3.3.4 Adaptations for Pilot Use Cases

Some adaptations for PT1-UC001 have been made in order to give the Big Data Companies early access to the NOT!FY Smart pug energy monitoring data. The adaptation consists of a temporary server to POST the data to, and for the Big Data Companies to fetch the data from. This is due to that creating an algorithm takes time, and a temporary solution was necessary.

The next step is to integrate the NOT!FY Smart plug with the SHAPES platform, eCare (EDGE) and eHealthpass (GNOMON).

Adaptations for PT1-UC004 are being discussed. This is to be able to notify the ARI Robot (PAL Robotics) when a user is in an active call. This is due to that the robot should not mistake any conversation as a question to the robot.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.3.4.1 Concept and Ideation Stage

The concept for PT1-UC004 could be done in a couple of ways. The suggested concept would be to have ARI Robot be connected with the NOT!FY server. A modulated version of how the relay command is sent might be needed. Examples will be provided in section 3.3.4.2.

Table 37 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A set of REST API is deployed. Including a temporary server that stores energy monitoring values that the rest of the SHAPES consortium has access to.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	A dedicated user manual already exists for NOT!FY.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	NOT!FY complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All data is stored within EU Member States.
SPS-042	The SHAPES Platform should support manual data entry.	Y	NOT!FY does support manual data entry through the API.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	NOT!FY is designed with privacy by design.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	NOT!FY complies with relevant cybersecurity rules for mobile and online services.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	NOT!FY provides a guide for easy installation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-191	IoT data are sent to Data Lakehouse from Digital Solutions only via the FINoT Platform.	Y	NOT!FY can support the exchange of data with FINoT.

Table 38 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the on/off status of appliances and lights at the home of the elderly pilot participant.	Y	NOT!FY could display on/off status.

3.3.4.2 *Design and Development Stage*

PT1-UC001

In addition to the base functions offered in NOT!FY v1, the development of this solution is able to provide additional functions in form of an energy monitoring capability.

As for now, the current monitoring parameters has been implemented: voltage (V) current (A) Power (P) and time (YYYY-MM-DD-hh.mm.ss). This is however not final, and a re-iteration might be needed based on feedback. For example, if the Big Data Companies or partners prefer that current is displayed in (mA) instead of (A) or both.

PT1-UC004

The following mock-up design is proposed to PAL Robotics. Please note that the grey marked area is eCtouch, which could be read in section 5.10.

The first design. This would be considered the easiest to implement according to Omnitor. This is how eCtouch together with NOT!FY is used by the different county councils in Sweden. A modulation of how the relays worked would be needed. Instead of switching a device on and off, this would be modulated to activate a certain lamp/ item when the user is in a call, and switching off the lamp/ item when the user has hanged up. This however might not be so easy to implement for PAL Robotics.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

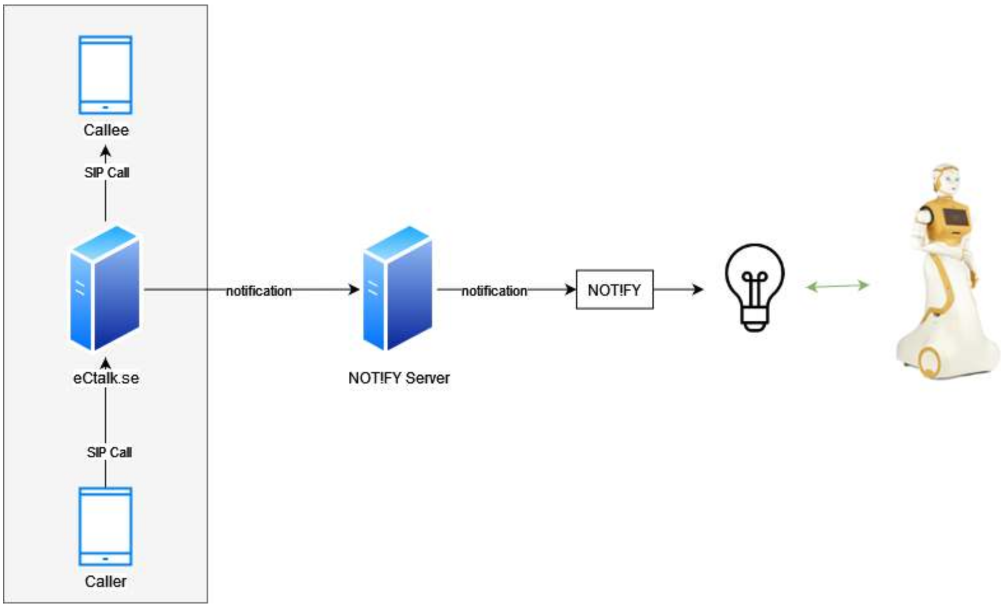


Figure 82 - First Design for Solving NOT!FY with ARI Robot

The second design. Instead of activating the NOT!FY relay, the signal goes directly to the robot informing it that a call is taking place, instead of deactivating the relay a signal could be sent to inform that the call has ended. According to Omnitor, this would be the best route, and also the suggested route.

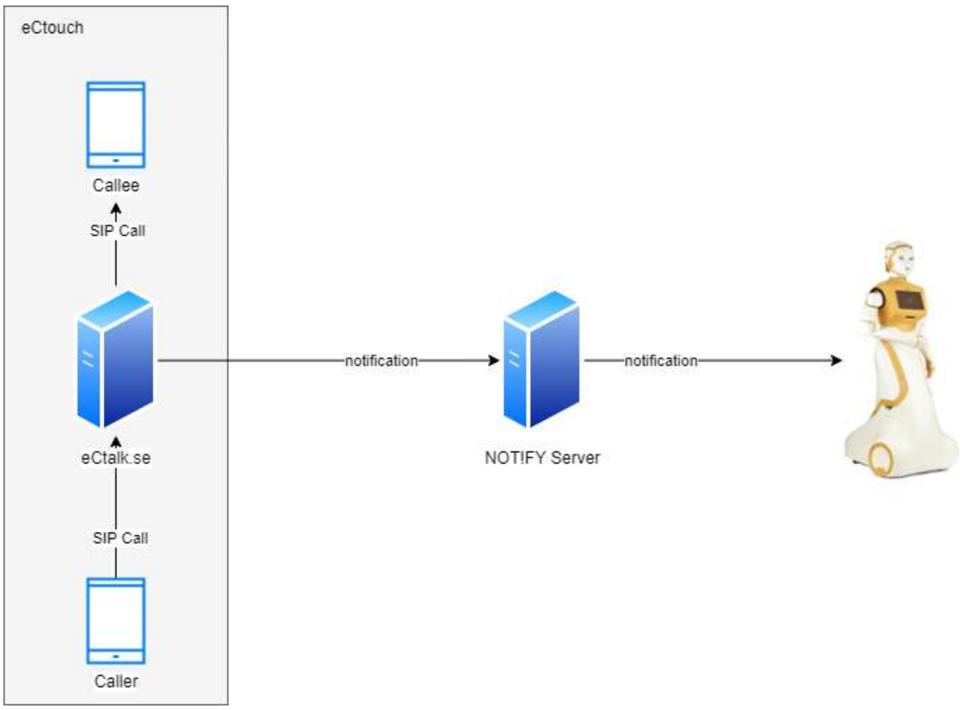


Figure 83 - Second Design for Solving NOT!FY with ARI Robot

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3.3.4.3 Prototyping and Adaptation Stage

Both NOT!FY shares the same base functions, in this term, it's to notifying when an incoming call occurs by activating its relay.

The NOT!FY smart plug have an additional function to monitor energy, as mention above at the moment the following parameters are monitored (voltage, current, power and device temperature) and uploaded to a temporary Omnitor server each 30 - 31 seconds.

Both NOT!FY shares the same admin interface, however, the smart plug's energy monitor part is not included there. The results will probably not be shown by Omnitor and thus might not be implemented. Instead, a solution could be to display the values with the help of the SHAPES Platform, eCare (EDGE), as well as having an API of basic NOT!FY functions are accessible by the partners.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4 Application Suite for Healthy Ageing (Task 5.3)

Europe is ageing: the number of people in Europe aged over 65 will almost double to 151 million in 2060 and the share of those aged over 80 is projected to more than double between 2017 and 2080, from 5.5% to 12.7% [5]. According to Eurostat's 2018 statistics report, good health is not only of value to the individual as a major determinant of quality of life, well-being and social participation, it also contributes to general social and economic growth. In 2017, nearly one fifth (19%) of the EU population was aged +65; the proportion of EU citizens who describe themselves as being in good or very good health has fallen since 2011 and varies greatly across EU Member States: between 82.8% and 43.4%.

The evolution of digitisation of services and eHealth technologies is likely to empower the aged population to gain control of their own health and thereby contributing to the healthy ageing.

In particular, eHealth technologies can increase motivation and awareness and engage the individuals in self-education about their health conditions. In addition, the digital health solutions enable self-management of the condition with the use of IoT medical devices (blood pressure, weight scales, oximeters, glucose meters) and facilitate the remote monitoring and communication with the physicians.

This section describes in detail the Digital Solutions that contribute to the healthy ageing and will be used in the various pilots via the SHAPES Platform.

4.1 eHealthPass Mobile Application (GNO)

eHealthPass is a platform for integrated care that provides its users with an overview of their daily health and care activities, their treatment plan, a self-assessment tool with personalised questionnaires (uses a text-based chatbot) and notifications. Within the treatment plan function, users can control the medication, register vital signs monitoring, manage diet and nutrition and regulate physical activity. Further, due to the interoperability with their healthcare service provider, the user may also book, manage and cancel medical appointments. The platform also includes educational content (e.g., virtual patients, stories and practical video tips) and a discussion forum, and it is able to synchronise with third-party devices (e.g., fitness tracker, heart rate device) and other Apps (e.g., Apple health). The platform supports eHealth standards (HL7 CDA, HL7 FHIR and IHE ITI profiles) and has therefore the capability to connect with existing clinical data repositories, master patient indexes and patient management systems to retrieve and to update user health and medical information. In addition, it connects to openNCP supporting its users to benefit from cross-border access and exchange of health-related data in Europe.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Features:

- Treatment plan;
- Medical history;
- Appointments;
- Questionnaires;
- Video consultation;
- Connection with IoT devices;
- Virtual Community portal;
- Education material and activities;
- Reporting data to national registry (optional for COVID-19).

Application areas:

- Chronic disease management: Diabetes, Chronic pain;
- Teleconsultation;
- Emergency scenarios and unplanned care;
- Medical tourism;
- COVID-19 self-management.

4.1.1 Technical Specifications

eHealthPass front-end is available via smartphone in two platforms, Android and iOS. The backend platform is built around the FHIR leading medical interoperability standards and utilises a fully compatible FHIR server. In addition, a number of IoT devices are integrated either via Bluetooth with the mobile application or via 4G cellular network and cloud services directly with the FHIR server.

4.1.2 Interfaces and Interoperability

The main interface for the user/patient and the caregiver is the mobile application. Additional technical interfaces and APIs are available to third party applications and IoT devices in order to enable exchange of information.

4.1.3 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.
- PT3 – Medicine Control and Optimisation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT5 – Caring for Older Individuals with Neurodegenerative Diseases *(Adaptations for Pilot 5 have not commenced yet).*
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals *(Adaptations for Pilot 7 have not commenced yet).*

4.1.4 Adaptations for PT3-UCGeneral

4.1.4.1 Concept and Ideation Stage

Older individuals tend to have a number of concurrent medical conditions resulting in the need to take a larger number of prescribed medicines to help control these conditions. There is a need to have a personalised approach to the safe and effective use of these medicines to ensure the best possible outcomes from their medicines. Specifically, patients with heart failure (HF) and/or diabetes (DM) must be monitored to avoid decompensations and hyper/hypoglycaemic events. Medication should be adjusted after review of health parameter monitoring with a goal of optimising and personalising treatment.

eHealthPass specifically contributes to this Use Case by providing functionality for a) enabling users to keep track of their medications intake, b) measuring the medication adherence using the relevant questionnaires, c) allowing users to measure and keep record of their blood glucose levels.

Older individual

John is 70 years old and lives with his wife in their own home with a garden. He has some basic activity — short walks outside home and wandering around his home and garden. He can eat, get dressed and have a shower independently. John spends most of his day at home.

John lives with heart failure, diabetes and several other chronic conditions. He is prescribed around 5-10 pills per day, 2-3 of which control his heart failure. He also takes insulin to control is blood glucose levels. He usually takes his medication as prescribed. Once a week he takes a medication before breakfast for his bones. He takes this on a Monday. John and his wife store their medicines in baskets, one for each of them, in the kitchen.

John has recently been discharged from hospital after becoming acutely unwell due to a decompensation event. This was John's third decompensation event in the past year. While in hospital, he was started on a new type of insulin and a new tablet for his blood pressure. John is happy to participate in the PT3-UCGeneral pilot so that he can learn more about managing his conditions and receive some help remembering to take his new tablet. Once John has consented to take part and has been trained on the equipment provided he is keen to see how the devices will help to keep him healthy. He also is trained on the different sections within the SHAPES App where he can view his information. There is a list of his current medication and a calendar display where he can see what medications he is due to take each day.

A typical day during the SHAPES pilot for John proceeds as follows:

- John wakes up at around 8.00am. On Mondays, he takes the pill for his bones and he has to sit upright for 30 minutes before getting up. John's wife sometimes has to remind him to take this particular tablet before he gets up, but when he started the SHAPES pilot he can check his SHAPES App to see what medications he is due to take today.
- At around 8.30am he washes and shaves, weighs himself using the SHAPES weight scale and gets dressed.

Having recently changed his insulin it is important that John monitors his blood glucose before meals to ensure he is using the correct amount of insulin.

- John uses his new SHAPES glucometer to measure his blood glucose level and is able to adjust his insulin himself. He can administer his insulin himself, but sometimes asks for assistance from his wife.
- After administering his insulin, John eats breakfast. Around half an hour after breakfast, John takes his blood pressure using the SHAPES blood pressure monitor, and measures oxygen saturation level and heart rate using the SHAPES pulse oximeter. He was told that the readings will automatically appear in the SHAPES App so he doesn't really pay attention to what each one says just yet. He can check them on his phone later.

Before the pilot, John had not used a blood pressure monitor or a pulse oximeter on himself before. He is familiar with getting his blood pressure taken in clinic and using the monitor he has at home is much the same. When John was in hospital a nurse used a pulse oximeter to monitor his heart rate and the amount of oxygen in his blood so he is familiar with the device and it is quick to use.

Since starting the pilot, John has been answering some questions every day through his phone. John's answers to the questions will help to develop a new technology that might be used in the future by his health care team to review his heart failure and predict decompensation episodes. The questions are easy to complete and are similar to the questions he gets asked when he visits the heart failure clinic. By answering them every day, it increases John's awareness of his own health. When he started the pilot, John chose to answer his daily questions at 11am. This is when he and his wife usually have a coffee together. John could answer these questions alone but he likes having his wife to check his answers with.

- At 11am, John sits down to answer his daily questions. The questions are:

1. Compared to the last 3 days, your legs-feet or any other part of the body are? Less swollen, the same, more swollen
2. Compared to the last 3 days, you feel… worse, the same, better

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3. In the last 3 days, did you take any additional medication without supervision? Yes, no

If there is nothing unusual, the questions stop here. While he is on his phone, John looks at his readings for that day. He looks at his weight, blood pressure, heart rate and oxygen levels every day. He doesn't bother looking at his blood glucose because he saw it earlier when he was working out how much insulin to use.

His weight is important to John as he knows that if his heart failure gets worse, he starts to retain fluid and his weight increases. By using the scales each day, he can track if there are any changes in weight and see how this changes over time. John has a record of what his previous values are for blood pressure, heart rate and oxygen levels. He likes being able to look at these readings and is feeling more confident about what they mean for his health.

Today, he notices that his blood pressure reading looks a little high but doesn't think too much more about it as he is going out for a short walk with his wife to post some letters before lunch.

- At 1pm, again before eating, John measures his blood glucose. His new insulin regimen means he only needs to inject insulin twice a day, which he does before breakfast and dinner. He checks it anyway as he is used to doing this and he has only been using the new insulin for a few weeks.

John spends the rest of the day in the house or out in the garden. He doesn't think about the SHAPES App at all until after dinner.

- At 6pm, John measures his blood glucose again and administers his insulin accordingly.
- He takes his evening medicines.

There is a task list section of the App where he likes to check whether he has any outstanding tasks to complete. It's the same most days but once a week there is an extra survey to answer about his medications.

Local researcher

A researcher will review the SHAPES dashboard regularly to help the participants adhere to the intervention. On this dashboard, they are able to view:

1. The list of participants taking part in the pilot at their site. The dashboard presents participant's unique identification number only. They have a separate list that links identification numbers to the participants' names and contact details.

2. Participants' profiles:

- Baseline demographic data and data required for VICOM HF Predictor.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Medicines list including all treatments, doses and frequencies — editable by researcher.
- History of clinical parameters that require daily monitoring including: blood pressure, weight, oxygen saturation, heart rate, blood glucose.
- History of questionnaire responses.
- History of daily tasks/reminders.
- Dynamic thresholds.
- Use of unscheduled care including hospitalisation details.
- Check how the participant has used the app e.g. how often they log in, what sections of the App do they use most frequently.

As mentioned, eHealthPass facilitates the following activities for the patients:

- Measure blood glucose.
- Complete daily/weekly/monthly/one-off questionnaires.
- Send the data from the clinical devices to the SHAPES App (and automatic upload to SHAPES platform) – blood glucose device.
- View list of medication.
- Daily medication reminders available.

Table 39 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	SHAPES Platform shall support multilingual user interface.	Y	The languages of each pilot and replicated sites are supported.
SPS-029	SHAPES Platform should support health data management (collection, sharing and processing).	Y	eHealthPass supports health data collection and sharing with the health care professionals.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	eHealthPass allows for measuring and monitoring the blood glucose level.
SPS-042	SHAPES should support manual data entry.	Y	User can enter the blood glucose level manually.
SPS-044	SHAPES should support use of questionnaires as self-assessment tools.	Y	Medication adherence questionnaires are available via eHealthPass.
SPS-046	SHAPES should support reminders.	Y	eHealthPass provides a daily medication list for the users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-057	Scheduling of tasks for different users should be supported in SHAPES.	Y	eHealthPass allows the HCP/researchers to schedule specific tasks for the users (care receivers).
SPS-059	User friendly dashboard should be offered to care receivers and care takers.	Y	Mock-up tests were provided and feedback was incorporated to eHealthPass to ensure user friendliness.
SPS-063	SHAPES should offer tutorials on healthy habits.	Y	Tutorials are available via eHealthPass.

Table 40 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-10	Address and improve deficiencies in the adherence to medicines and treatments.	Y	eHealthPass allows the users to register their medication adherence via the MARS questionnaire.
UR-27	Medication adherence monitoring using MARS questionnaire.	Y	Users can answer the MARS questionnaire via eHealthPass.
UR-8	Implement a personalised approach to achieve a safe and effective use of medicines in home.	Y	eHealtPass provides a personalised medication list for each user.
UR-15	Personalised reminders regarding medication (daily list).	Y	eHealthPass provides a daily list of medications that users shall take.
UR-14	Tracking and registration of vital signs and physical measurements. Use sensors and other devices. Record quantifiable health data. Using Health and Wellbeing Apps.	Y	eHealthPass allows users to register and monitor thir blood glucose levels.

4.1.4.2 Design and Development Stage

Currently, the Phase 3 of PT3-UCGeneral is finalised and a functioning prototype of eHealthPass shall be delivered. The prototype is based on the mock-up designs that

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

were initially designed and the feedback that has been received by the pilot site. Main screenshots depicting the functionality that is available are provided below:

1) Provide a personalised medication list per user

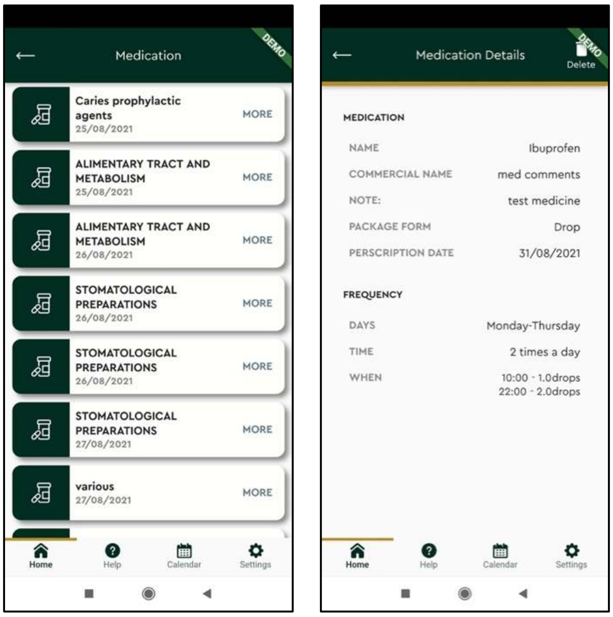


Figure 84 - Medication List

2) Enable users to register their medication adherence via frequently answering the MARS questionnaire.
The screenshots provided demonstrate the questionnaire platform. For testing purposes, a test questionnaire has been added in the Greek language. In the final version of the prototype, the MARS questionnaire will be added and be available for users to answer.

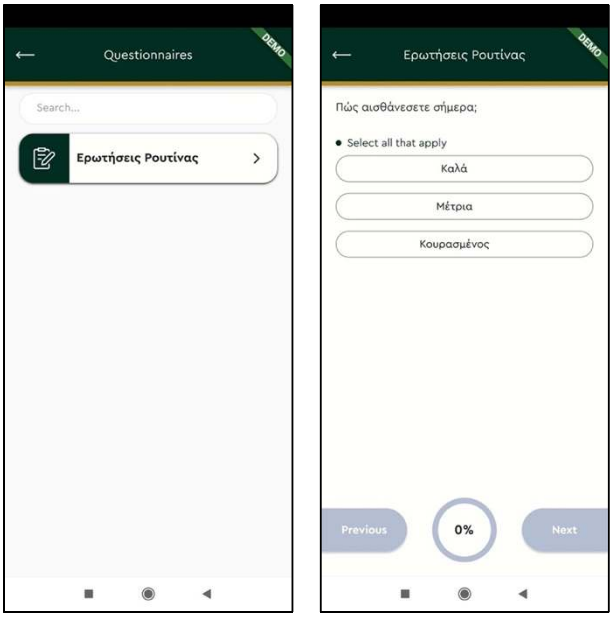


Figure 85 - Questionnaires

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3) Enable users to measure and monitor their blood glucose level by using the connected Roche blood glucose meter device. Alternatively, they can manually log the value of the measurement.

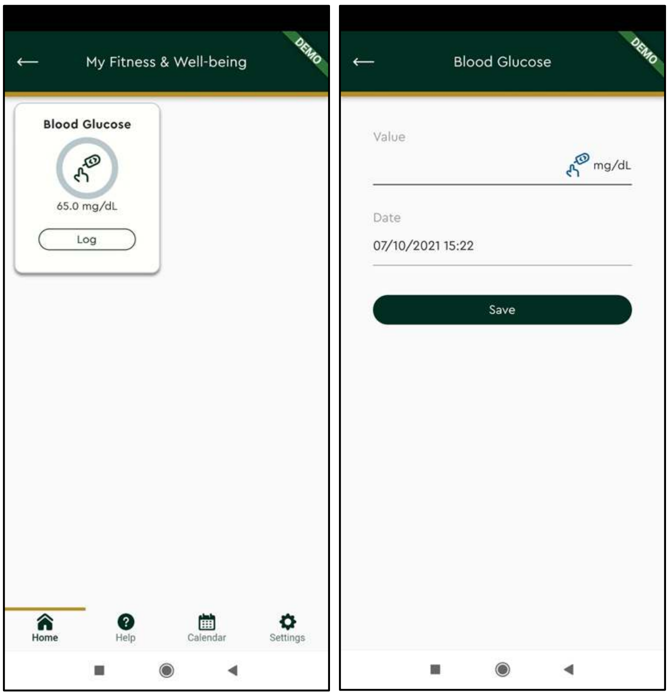


Figure 86 - Blood Glucose Monitoring

4) Provide a daily list of tasks that users shall perform to serve as reminders.
The screenshot provided demonstrate the daily task list. For testing purposes, test activities have been added. In the final version of the prototype, the actual tasks required to be completed by the user will be listed.

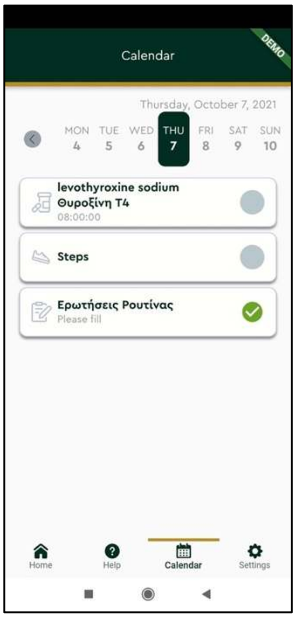


Figure 87 - Daily Tasks

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.1.4.3 Prototyping and Adaptation Stage

In the context of this pilot and use case, eHealthPass has been adapted to include the modules and services that facilitate the following functionality:

- Provide a personalised medication list per user.
- Enable users to register their medication adherence via frequently answering the MARS questionnaire.
- Enable users to measure and monitor their blood glucose level by using the connected Roche blood glucose meter device.
- Provide a daily list of tasks that users shall perform to serve as reminders.

In the context of this pilot, eHealthPass integrates with digital solutions, provided by the SHAPES partners, in order to fulfil the complete list of the Use Case requirements. Specifically, GNOMON are at the stage of integrating with the following partners and digital solutions:

- eHealthPass integrates with TREE's big data analytics platform where it continuously provides the blood glucose measurements for further analysis. To establish communication, the FHIR standard is considered to be utilised along with the FHIR Message Queue component available in the SHAPES Technological platform. Further information about the FHIR and the FHIR MQ is available in Seliverable D4.1 [3].
- eHealthPass integrates with EDGE's eCare solution in order to enable users to perform functionalities provided by the two solutions. Android intents technology is leveraged to establish communication between the solutions.

4.1.5 Adaptations for PT2-UC001

4.1.5.1 Concept and Ideation Stage

Health in old age is of great importance for each and every individual, but also for society. Although health problems and complaints increase with age, old age does not inevitably stand for illness, limitations and the need of care. Individual lifestyles and personal resources, social integration and the level of access to medical and social care greatly impact on the health status, quality of life and well-being of older individuals.

The aim of this use case is the remote monitoring of important health parameters of older individuals with the aim of maintaining or possibly even improving their health status thanks to preventive health and care measures. Wearables, sensors and other devices can enable individuals to remain independent for longer through the provision of specific tips and recommendations. Also, it should be possible to thereby showcase

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

the so-called “feel-good effect” i.e. the power of knowing everything is – relatively speaking – in order. It is expected that recording a stable (good) health status will make older individuals feel safer and thus more secure in pursuing daily activities such as moving around the house or outdoors, engaging with family, friends and the community or committing to further hobbies.

eHealthPass specifically contributes to this Use Case by providing functionality for a) enabling users to register their water intake, b) reporting their COVID-19 symptoms c) listing educational material and information related to COVID-19.

Helena is 93 years old and lives with her cats in her own house with garden. Helena has sometimes bad days in addition to arthritis. On those days, she forgets to drink, falls, and has already started a fire while making tea. These dangerous situations scare her and her daughter. Additionally, she needs motivation and support to keep moving. She takes sleeping pills. Therefore, she is very happy to try the technical devices from the use case PT2-UC001.

Once all the equipment has been installed and Helena has understood how to use it, Helena is curious to see if the technical devices can contribute to improving her general well-being and her feeling of safety and independence in everyday life.

The fitness tracker is very important device for her. As Helena is enthusiastic about the functions that it offers her. During the following nights, her sleeping pattern has been analysed. She presents the recorded results at the next General Practitioner (GP) appointment so that the GP has the possibility to give her very individual recommendations. The GP suggests her to improve her evening routine and recognises that her sleeping time is not optimal. Based on that, she could improve her sleeping patterns which led to reduction of sleeping pills. After a few weeks, she does not longer need sleeping pills to get a good night's sleep. This is a great relief for Helena as she has felt weak from the sleeping pills.

The fitness tracker has also improved her mobility and agility. By counting the steps that she takes every day, she was motivated to reach her step goal and went more often on her walk daily in her neighbourhood. If she did not move sufficiently, the fitness tracker reminded her by notification alert. Overall, this device helped her to establish better routines in her daily life and the tracking of the state of mind day by day via App (smiley scale) showed that she had more happy days and her wellbeing increased. Moreover, Helena also did her exercises for her arthrosis more regularly as she got a reminder of her fitness tracker as well for this purpose. Through this continuity, Helena's pain caused by the arthritis has improved. This gives her a better quality of life and she can do more activities with her grandchildren.

At home, as well as during the tour with her grandchildren to the zoo, Helena took her smart water bottle. Often Helena does not feel thirsty anymore. Especially, when she is excited to do activities with her family and on special occasions. Her smart water

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

bottle can track the water intake and do notifications or flashlights to give her a little hint to drink something. This is good for Helena, because if she is dehydrated, she tends to fall faster and she is very afraid of this.

In addition, a possibility of urinalysis in home-setting is helpful for Helena. Urinalysis can measure many other factors besides water intake. For example, glucose, bilirubin and other parameters that can indicate an infection can be measured in the urine. This is very beneficial for Helena.

A good and varied diet is also very important for Helena's well-being. Monitoring nutrition intake can be very helpful, which can be recorded in a food diary. Helena can also use this app to have suitable meals suggested for her needs. In the beginning, it took Helena a lot of discipline to enter all her meals into the food diary, but Helena got used to it quickly and now entering her meals is part of her routine. Helena likes the food diary very much because she eats more balanced and the app suggests new recipes to her. She enjoys trying these recipes because Helena loves to cook.

Helena and her daughter are very happy that Helena's health can be monitored better. This leads to a general improvement in her well-being, as Helena knows more about her own personal circumstances and her independence is increased. The medical equipment Helena has been provided with will help her to stay longer in her own home.

Table 41 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	SHAPES Platform shall support multilingual user interface.	Y	The languages of each pilot and replicated sites are supported.
SPS-029	SHAPES Platform should support health data management (collection, sharing and processing).	Y	eHealthPass supports health data collection and sharing with the health care professionals.
SPS-037	Devices measuring and/or manually-entering water intake should be supported.	Y	eHealthPass allows users to record their water intake.
SPS-057	Scheduling of tasks for different users should be supported in SHAPES.	Y	eHealthPass allows the HCP/researchers to schedule specific tasks for the users (care receivers).
SPS-059	User friendly dashboard should be offered to care	Y	Mock-up tests were provided and feedback was

	receivers and care takers.		incorporated to eHealthPass to ensure user friendliness.
SPS-063	SHAPES should offer tutorials on healthy habits.	Y	Tutorials are available via eHealthPass.

4.1.5.2 *Design and Development Stage*

Currently, the Phase 3 of PT2-UC001 is finalised and a functioning prototype of eHealthPass shall be delivered. The prototype is based on the mock-up designs that were initially produced and the feedback that has been received by the pilot site. Main screenshots depicting the functionality which is available are provided below.

1) Allow users to record their fluid intake. Fluid includes alcohol, water, milk, coffee, tea, carbonated drink, juice, beer, wine, hard liquor.

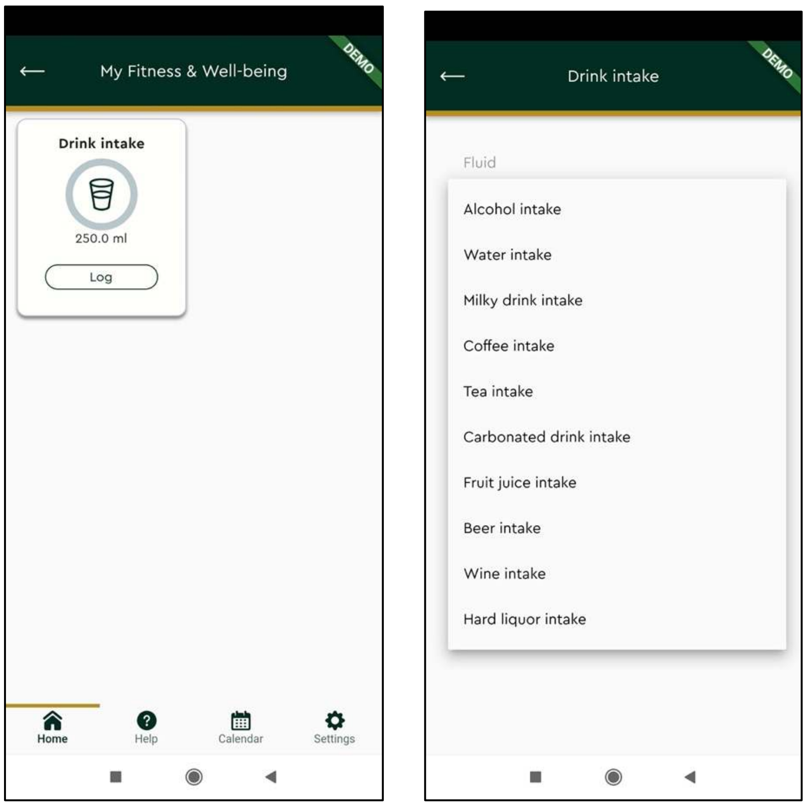


Figure 88 - Drink Intake

2) Functionality related to COVID-19. eHealthPass includes a symptom checker and relevant validated educational material regarding precaution measures against COVID-19.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

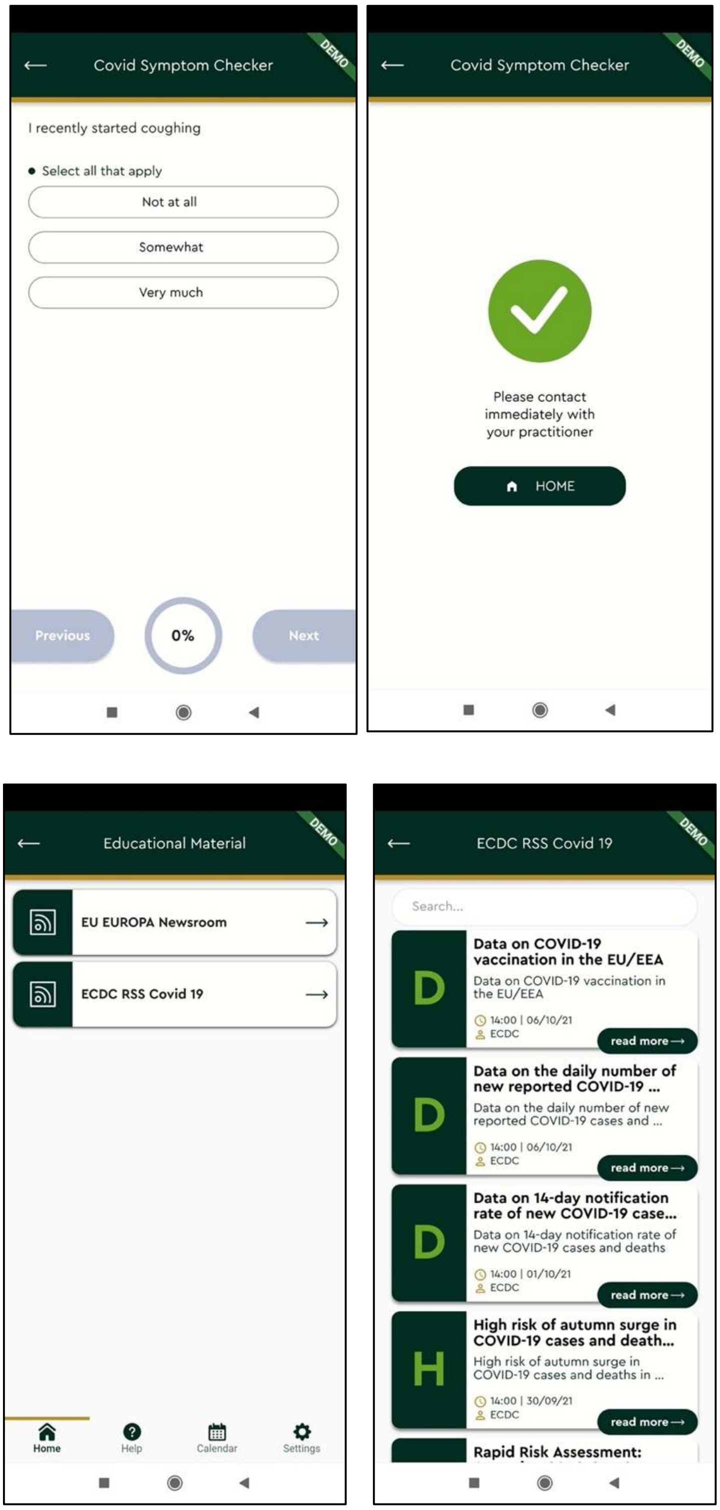


Figure 89 - COVID-19 Functionality

4.1.5.3 *Prototyping and Adaptation Stage*

In the context of this pilot and use case, eHealthPass has been adapted to include the modules and services that facilitate the following functionality:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Allow users to record their fluid intake. Fluid includes alcohol, water, milk, coffee, tea, carbonated drink, juice, beer, wine, hard liquor.
- Functionality related to COVID-19. eHealthPass includes a symptom checker and relevant validated educational material regarding precaution measures against COVID-19.

In the context of this pilot, eHealthPass integrates with digital solutions, provided by the SHAPES partners, in order to fulfil the complete list of the Use Case requirements. Specifically, we are the stage of integrating with the following partner:

- eHealthPass integrates with VICOM prediction and analytics solution where it continuously provides the fluid intake values for further analysis. To establish communication, the FHIR standard is considered to be utilised along with the FHIR Message Queue component available in the SHAPES Technological Platform. Further information about the FHIR and the FHIR MQ is available in the Deliverable D4.1 [3].

4.2 diAnoia Mobile application and diAnoia marketplace online platform (SciFY)

diAnoia is a free smartphone application created by SciFY in collaboration with dementia professionals. It is aimed at the caregivers of people with mild cognitive impairment and at the early stages of dementia. diAnoia offers practical ways to help people with dementia to improve their cognitive functions, their mood, functionality and quality of life. It offers cognitive exercises, ideas for spending quality time together, daily reminders, allows monitoring the frequency of mental stimulation. diAnoia is freely available for Android and iOS in Greek. In Greece, the beneficiaries are estimated to be around 5,500. SciFY will adapt its diAnoia app for people with mild cognitive impairment and early stage dementia. The adaptations will result in offering diAnoia in 4 languages (Greek, English, Spanish and Italian). SciFY will also adapt the code so that the App is easily translated in more languages. SciFY will create a marketplace that will allow experts in dementia to create exercises for people with dementia in various languages. SciFY will then allow diAnoia to use the exercises created in the diAnoia Marketplace.

4.2.1 Technical Specifications

diAnoia runs on mobile phones running Android or iOS operating systems. The application is built using the Ionic hybrid mobile framework.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.2.2 Interfaces and Interoperability

Interface for the diAnoia mobile application: Smartphone
Interface for the diAnoia marketplace online platform; Desktop Computer or Laptop stakeholders.

Family carers and health professionals have in hand an everyday helper that:

- Offers printable cognitive exercises to work on memory, attention skills, in a familiar way for the elderly (paper and pencil).
- Makes exercises more attractive using storytelling: mental stimulation exercises are incorporated into stories that make exercises fun.
- Every day suggests ways to spend quality time together, sending notifications through the smartphone.
- Reminds what is important: key points not to be forgotten.
- Allows to keep track of the exercises performed (history).

4.2.3 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

4.3 Memor-I videogame and Memor-I studio online platform (SciFY)

Responding to the huge need for the creation of electronic games for persons who are blind or have a visual impairment, SciFY has created Memor-i studio. Memor-i Studio is an online platform that allows users to easily create games for educational and recreational purposes, that are suitable for both persons with and without visual impairments. The user just uploads sounds and pictures, and the game is automatically created. Memory is a classic mental stimulation game, and the fact that it can be very easily customised to the interests of the individual, makes it an invaluable tool for achieving learning and mental stimulation objectives. Schools with blind or visually impaired students have already started using it, creating their own games, with the contribution of the children themselves.

Memor-i is currently offered in 2 languages (English and Greek). The platform, initially aimed at people with blindness and visual impairments, has been populated with 30+ games already created by the community. It is used by teachers in the EU, but also promoted by prominent schools in the US.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

SciFY will adapt its platform. The adaptations will allow the use of the platform in 3 languages, easy expansion to other languages, easy creation of new games in many languages. It will also use the SHAPES Platform to suggest related content that is related to the user profile. SciFY will also create tutorials and offer easy-to-use resources for creators. SciFY will create a Memory Marketplace component so that it contributors can offer their games publicly.

4.3.1 Technical Specifications

The videogame works as a desktop application. It needs the Java programming language installed and works in Windows and Linux operating systems. The online platform needs a modern Operating System and browser (Google Chrome, Mozilla Firefox) to work.

4.3.2 Interfaces and Interoperability

Interface: Desktop Computer or Laptop

Stakeholders: The online platform allows users to:

- find free Memor-i games.
- create new Memor-i game (the user uploads sounds and pictures).
- create a 'clone' of the game (make copy of the game and enrich it).
- play against a computer and against another player, online.
- report a game.

The desktop application (videogame) allows the users to play the Memory game. **Interfaces:** Desktop Computer (or Laptop).

4.3.3 Applicable Pilot Themes

- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.4 Talk & Play and Talk & Play Marketplace (SciFY)

Talk and Play is a software application created by SciFY for people with simultaneous speech and motor disabilities (e.g. due to accident and/or cerebral palsy). It allows people with such disabilities to communicate, listen to music, watch movies, and practice to improve their cognitive functions with the help of a computer. It has been designed and developed in cooperation with special occupational therapists to make it very user-friendly.

In Greece, Talk and Play has exceeded 900+ beneficiaries, and is currently being used by most of the key Greek rehabilitation institutions.

SciFY will adapt Talk and Play to suit the SHAPES's objectives. The new Talk and Play (adapted version) will be available in 3 languages (Greek, English and German) and will allow full customisation to the needs of the individual, automatically considering the user's profile. SciFY will create a marketplace component that will allow contributors (occupational therapists, psychologists, speech therapists) to create mental stimulation exercises and new communication cards for Talk and Play.

4.4.1 Technical Specifications

Talk & Play is a desktop application. It works on computers running Windows or Linux operating systems and needs the Java language installed.

Talk & Play marketplace will be an online application. It will require a modern operating system and a modern browser (Google Chrome, Mozilla Firefox).

4.4.2 Interfaces and Interoperability

Interface: Desktop Computer or Laptop.

Talk and Play is fully customisable: an occupational therapist/carer can:

- create multiple profiles.
- customise the interaction mode for each profile (mouse / switch / keyboard).
- create new communication cards and customise the communication module.
- create new variations of the cognitive stimulation games.
- customise the difficulty of the stimulation games.

The user then is able to use the communication cards and the integrated games.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.4.3 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.

4.5 ICSee (SciFY)

ICSee is an application for android smartphones/tablets, which processes the image/video of the device's camera in real time, applies a series of filters and shows on screen a result that is easier to be read or recognised. This way, whoever owns an android smartphone or a tablet, can have a free solution for their problem. The users just point their smartphone/tablet camera towards where they want to have a better view of, and see on their screen a processed, clearer image for them. This way, they have the ability to read a small text (like bills or a restaurant menu, the taximeter fare, a name on a doorbell). ICSee has exceeded 16,500 downloads worldwide.

4.5.1 Technical Specifications

ICSee runs on mobile phones running Android operating system. The application is built using the Java programming language.

4.5.2 Interfaces and Interoperability

Interface: Smartphone

The user holds the phone with the camera directed in the position of the text they would like to read. This can be done either by the user or their caregiver. They then can swipe their finger across the screen to change filters, and their finger on the screen to temporarily freeze the image.

The application offers an audio interface in order to be usable by users who cannot read a text written on a smartphone screen.

4.5.3 Applicable Pilot Themes

- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.6 Integrated Health and Social Care System Long Lasting Memories Care - LLM Care (AUTH)

The Integrated Health and Social Care System Long Lasting Memories Care – LLM Care (www.llmcare.gr) combines state-of-the-art cognitive exercise with physical activity in an advanced assisted living environment and offers an integrated solution for cognitive and physical health, providing effective protection against cognitive decline and, thereby, actively improving the quality of life (Figure 90). The empowerment of older people to improve their mental ability is enabled, while simultaneously boosting their physical well-being. This technological solution coincides with daily monitoring and helps to increase an older persons' overall feeling of safety and self-confidence.

In particular, this service provides a non-pharmaceutical intervention against cognitive deterioration, qualitative results in the specific brain functions, affected by ageing, as well as the psychological state of the participants with a series of scientific contributions in International and European Conferences and Journals. The combination of physical and cognitive exercise reduces the risk of diseases and prolongs the time of independent and autonomous living. It also provides a comprehensive solution that has a direct impact on improving the quality of life of individuals [6], including older people or other vulnerable groups, Intellectual disabilities and Down syndrome, women with breast cancer, Parkinson's disease patients, among others.

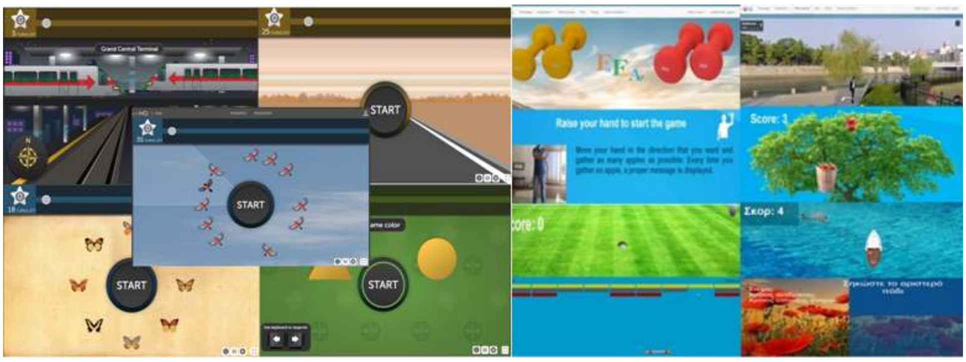


Figure 90 - Interfaces of BrainHQ & webFitForAll

The LLM Care as a certified ICT platform was designed to incorporate two interoperable components:

The Cognitive Training Program, namely **BrainHQ**, is an interactive online environment consisting of cognitive training techniques that are particularly effective. It accelerates and sharpens the visual and hearing process – the brain hearing system. Improvement in the quantity and the quality of what the brain receives through image and sound, leads to a total improvement of thought, focus, observation, and memory, as well. The Cognitive Training System includes six categories with more than 29 effective exercises and hundreds of graded difficulty levels that focus on attention,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

memory, brain speed, people skills, navigation and intelligence. Every exercise is dynamically adapted to the skill level of each trainee in order to produce true cognitive improvements. Concerning the utilisation requirements, a computer/ laptop/ tablet is needed.

The Physical Training Platform webFitForAll, which is an exergaming platform that helps older people physically train and maintain their fitness and well-being, through the use of an innovative, low-cost and widely accepted technology platform, like a motion detection device. The Physical Training System includes exercising protocols, especially designed for older people and vulnerable groups, from experienced scientists specialising in third age and its traits (e.g., dementia). These exercise protocols enhance aerobic capacity, flexibility, balance and strengthening of muscles. In addition, difficulty adjustment based on the trainee's performance aims at the optimal function training. Concerning the utilisation, a computer and motion detection device are required, as well as some basic fitness equipment, such as 1kg or 2kg dumbbells and a mini bike. In addition, a blood pressure monitor is needed to measure pressure and pulses during physical exercise.

4.6.1 Technical Specifications

Cognitive Training System (BrainHQ):

- Operating System: Windows 7 / 8.1 / 10, Mac OS X Catalina (10.5)/ Mojave (10.4).
- Web browsers: Chrome, Firefox, Safari, and Microsoft Edge.
- Internet connection.

Physical Training System (webFitForAll):

- Operating System: Windows 7 / 8.1 / 10 64bit.
- At least 4GB of RAM.
- Internet connection.

4.6.2 Interfaces and Interoperability

Cognitive Training System (BrainHQ)

The cognitive training exercises are delivered through the BrainHQ platform (https://www.brainhq.com/), which is applicable to smartphones, tablets, laptops and computer devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

User's interaction:

1. User logs in the BrainHQ platform with his/her credentials.
2. User selects the training mode; personalised training or selection of preferred exercises:
    - **Personalised training:** User selects the "Start Personal Trainer" button to begin the training. Personalised training includes a daily training session for the user based on his/her unique preferences and performance.
    - **Selection of preferred exercises:** It is recommended that the user spends 10 minutes (1-2 exercises) in each category (Memory, Brain Speed, Attention, People Skills, Intelligence, or Navigation).
3. The user can monitor his/her progress in the "Progress" tab where multiple information with regard to the performance is provided. In specific, the user can track:
    - The days trained;
    - The duration of the training;
    - The levels completed;
    - The percentile overview of each category;
    - Stars Earned: Each time the user completes an exercise level, the total of the earned stars gained in the exercise is presented;
    - The level of BrainAQ: BrainAQ represents user's overall gains from training with BrainHQ. When joining BrainHQ, the user's quotient starts at zero. Each time a new training level is completed, the BrainAQ ticks upward. As user's performance improves, the BrainAQ increases likewise, reflecting the cognitive gains from training.

Physical Training System (webFitForAll)

The physical training exercises are delivered through the webFitForAll (http://www.fitforall.gr/), which is applicable to laptops and computer devices. A motion detection device is also needed to detect body skeletal and recognise gestures/movements in real-time.

User's interaction

1. User logs in to the webFitForAll platform.
2. User is guided by an intuitive interface to connect the controller devices. Once connection is established, the user is transferred to the training session environment.
3. User stands in front of the desktop computer or laptop in a 1.5 m distance from the motion detection device.
4. Auxiliary interfaces offer instructions about the physical tasks to be performed. After reading the instructions, there two options to initiate the physical training; the caregiver can press the start button or the user can rise his/her hand in order to activate the motion detection device.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

A short count-down prepares the user before each physical task. During the physical training the user is able to pause or skip a game at any time by simply touching the screen. Each session has a specific difficulty level. This comprises of two components: the physical exercise intensity component (e.g., more repetitions per exercise), which is the dominant one and the gameplay difficulty (e.g., avoid obstacles during the golf game). Apart from the option of creating/modifying interventions, webFitForAll incorporates a default intervention protocol, tailored to older people, which consists of four difficulty levels.

4.6.3 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.

4.6.4 Adaptations for PT2-UC003

4.6.4.1 Concept and Ideation Stage

Cognitive skills are considered key elements in the daily functioning of older adults, however for some of these cognitive skills (e.g. memory, problem-solving activities or speed processing), decline is inevitable in the process of ageing. This kind of decline undermines older adults' ability to maintain an independent lifestyle. For this purpose, technology assisted solutions might facilitate older adults continued independent living. In this vein, the Integrated Health and Social Care System Long Lasting Memories Care – LLM Care (www.llmcare.gr), which is addressed to adults and integrates both physical and cognitive training through web service technologies aims to maintain older adults' cognitive and physical health status and, thus, improve their overall quality of life.

PT2-UC003 specifically is addressed to older people 65+ with or without neurodegenerative diseases (e.g. dementia, Alzheimer's and Parkinson's disease), with Mild Cognitive Impairment, with chronic and mental disorders (schizophrenia) or with disabilities (e.g. older people, who have communication issues due to movement impairments or difficulties in speech such as tracheostomy combined with mobility limitations, or with movement disabilities). In addition, formal and informal caregivers participate in this UC, in order to facilitate the training session and exploit one of the provided DS themselves. For this reason, Isabella and Marco is the dual persona used in the context of PT2-UC003.

In particular, Isabella is a 75-year-old lady, who lives in a small town in Spain. She is divorced and lives alone in a two-room apartment. She was diagnosed with Alzheimer´s disease two years ago and her illness is in the early to middle stage. Once she got the results of her diagnosis, she started receiving medication and was told to have a check-up every three years. Isabella is already experiencing some health issues regarding the deterioration of her memory. Lately, she started losing her personal belongings and, in particular, she once misplaced her purse and could not find it for a week. The most embarrassing situation happened when she went downtown and could not find her way home, while another time she met with an old friend of hers and could not remember her name. In addition, she recently switched off the electricity by accident in the whole house and the heating was off for two days. Due to these incidents, Isabella started keeping a notebook with the most important information, in order for her to remember where she puts her stuff.

Isabella's son, Marco (46), who lives nearby with his family, visits her every day, does the chores and brings her food. He has a part-time job in a factory and, therefore, he is often tired, worried and frustrated. He started experiencing mood swings, since Isabella started asking repeatedly the same questions. Indeed, there were a couple of times that he raised his voice at her but he felt ashamed and guilty for his impulsiveness. Marco often worries about his mum, especially when he cannot be with her as he is afraid that she might get lost. They also have the help of a field nurse, but only twice a week for a few hours.

It is important for Isabella to maintain her dignity and self-sufficiency, keep herself socially active and stay in home care as long as possible. She is also worried about Marco and wants him to better cope with the caregiving situation. Three months ago, Marco came across the daughter of Mrs. Eleni, an 82-year-old lady, who lives next to Isabella and informed him that her mother started participating in a cognitive and physical training intervention called Integrated Healthcare System Long Lasting Memories Care (LLM Care) that is conducted in the Open Care Centre for older adults in their neighbourhood. Specifically, LLM Care is a certified ICT platform that combines state-of-the-art cognitive exercise with physical activity in an advanced assisted living environment and offers an integrated solution for cognitive and physical health, providing effective protection against cognitive decline and, thereby, actively improving the quality of life. Therefore, Marco considered it a great opportunity for his mother and suggested her to join the team as well.

Isabella was positive about her son's suggestion and joined promptly the training program in the Open Care Centre for older adults. In particular, she attends the training intervention 3-4 times per week, where she interacts for one hour with the cognitive training program BrainHQ and for, one more hour with the physical training program webFitForAll, another 30 minutes with the cognitive exercises from the Talk & Play app, and half an hour more browsing news from the NewSum mobile app. Specifically, BrainHQ includes six categories with more than 29 effective exercises and hundreds of graded difficulty levels that focus on attention, memory, brain speed, people skills, navigation and intelligence. Every exercise is dynamically adapted to the skill level of each trainee in order to produce true cognitive improvements. Isabella finds the software easy and user-friendly and enjoys the fact that she can interact autonomously with several cognitive exercises. Indeed, Isabella considers very important that she is able to choose among the personalised trainer feature that continually measures her performance and serves up the exercises that are right for her and the design of her own program, choosing exercises and workouts that meet her personal interests, mood, and schedule. In addition, webFitForAll incorporates exercise protocols that enhance aerobic capacity, flexibility, balance and strengthening of muscles. Difficulty adjustment is also provided, based on the Isabella's performance and, thus, she feels confident that she will achieve the optimal function training.

Moreover, Talk & Play includes variations of card games in three game categories (Stimulus/reaction, Find similarities, and Time sequence). With Talk & Play, Isabella is able to train her memory and cognitive state while having fun.

Additionally, by reading the news from various news categories with the NewSum mobile app on the tablet that is available in the Open Care Centre, Isabella quickly catches up with the outside world while getting informed.

Isabella is really excited about this venture because many older adults, who suffer from similar health issues, join the LLM Care training program in the Open Care Centre and, therefore, she has the chance to socialise with peers, along with their trainers. Indeed, after 4 weeks of joining the training intervention, Marco has already observed improvements in his mother's cognitive abilities (concentration, observation, and memory) as well as in her physical condition (gait, balance and flexibility). He is really glad that technology keeps his mother busy and focused and considers that the program provides a meaningful workout both to Isabella's brain and body that could potentially offer a greater quality of life.

Table 42 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	LLM Care has its own terms of use and services policy.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	LLM Care has its own privacy policy.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	LLM Care has its own APIs and adopts interoperability standards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	LLM Care delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	LLM Care supports a multilingual interface in both cognitive and physical training components.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	Introductory videos and user manuals, including relevant instructions on the use of the devices, have been developed for LLM Care.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	LLM Care complies with GDPR regulations.
SPS-033	All classes of users shall be able to review the historical data.	Y	LLM Care maintains a data repository that includes historical data, where users can view their previous performance.
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.)	Y	LLM Care protocol supports the monitoring of vital signs, such as users' blood pressure and heart rate.
SPS-042	The SHAPES Platform should support manual data entry.	N	LLM Care supports manual data entries.
SPS-053	SHAPES access devices maybe user friendly	Y	LLM Care provides easy and user-friendly interaction. Usability has already been tested.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	LLM Care provides user friendly dashboards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	LLM Care offers robust authentication and authorisation features.
SPS-080	SHAPES should provide training material for care providers.	Y	LLM Care certified trainers provide the necessary training to care providers before the exploitation of the integrated system. Certificate of training is also provided.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	LLM Care supports access from desktop/laptop/smartp hone and tablet.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	LLM Care supports the creation and personalisation of training intervention plans for each user.
SPS-090	SHAPES should offer means of keeping track of lessons completed.	Y	LLM Care includes the star icon that marks users' completion of levels and exercises.
SPS-098	SHAPES should offer mental exercises for care receivers and care providers.	Y	LLM Care provides essential cognitive training for care receivers. Care providers facilitate and monitor the intervention.
SPS-099	SHAPES should offer mood self-assessment.	Y	LLM Care provides self-assessment of subjective mood. A mood graph/mood history is displayed to represent mood progress over time.
SPS-107	Ability for the caregiver to customise mental exercise difficulty level should be provided.	Y	LLM Care offers the opportunity to caregivers to personalise and customise the cognitive exercise

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
			difficulty level based on users' needs.
SPS-110	SHAPES should support physical exercises.	Y	LLM Care offers a variety of physical exercises.
SPS-112	SHAPES should offer exercises support videos.	Y	LLM Care provides essential support videos for physical exercises.
SPS-128	SHAPES shall support "Privacy by design and by default".		LLM Care implements privacy enhancing technologies, e.g. encryption. anonymisation is performed manually.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	LLM Care complies with relevant cybersecurity rules for mobile and online services.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	LLM Care offers user friendly and attractive interfaces.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	LLM Care offers user friendly interfaces for all users.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	LLM Care applies user interfaces resembling other technologies used by older adults.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	LLM Care adopts an efficient navigation scheme to facilitate user interaction.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	LLM Care implements cybersecurity features to prevent and detect data breaches.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	LLM Care complies with GDPR regulations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	LLM Care complies with GDPR regulations and implements cybersecu rity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	LLM Care complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	LLM Care implements password-based authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	LLM Care is a flexible platform, able to operate at different levels.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	designed with a modular architecture.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	LLM Care delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	LLM Care offers robust authorisation features for data access.
SPS-200	All passwords shall be unique per device and per user.	Y	LLM Care offers unique passwords device and per user.
SPS-202	All software modules should be securely updateable.	Y	LLM Care adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	Updates are performed automatically.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	LLM Care implements encryption features to protect data exchange with devices.

4.6.4.2 Design and Development Stage

Overview

The aim of the mock-ups was to validate the digital solutions deployed in PT2-UC003 and provide technical partners the opportunity to integrate user feedback at an early stage of the technological development process. In particular, the digital solutions for PT2-UC003 underwent a co-design and user-testing process to optimise their usability and acceptability amongst end-users and receive feedback on the design and functionality of the digital solutions respectively.

Method

It is important to mention that PT2-UC003 comprises four different DS: a) the Integrated Health and Social Care System Long Lasting Memories LLM Care, b) Talk and Play Desktop App, c) NewSum & d) Talk and Play Marketplace. However, validation and feedback were sought only on the design and development of Talk & Play Marketplace, which is addressed to formal and informal caregivers, due to the fact that the rest of DS have already been widely explored amongst the relevant target group and have been scientifically validated through evidence-based studies.

The mock-ups were conducted virtually using the Zoom platform. Participants included two formal caregivers, two informal caregivers, three moderators and two technical partners. Eligible individuals were provided with a consent form and a brief information section, where the background and purpose of the study were further explained along with what participants could expect to happen in case they agree to participate in the session.

A PowerPoint presentation was shown to participants, where they were introduced with brief background information about the SHAPES project and its scope along with an overview of the purpose of PT2-UC003 and the included digital solutions. Mock-ups of the DS, in particular visual images of all the types of screens participants are likely to encounter when using the app, were then presented to them. Technical partners were asking questions on the design and layout of the mock-ups during participants' interaction with the mock-up of Talk and Play Marketplace. These questions were predefined and comprised a combination of open and closed questions designed to obtain both general and specific feedback about the mock ups.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.7 Access Earth Platform (AELTD)

Access Earth is a global platform that uses smart and crowd sourced data gathering methods to provide the world with details on the levels of physical accessibility local bars, restaurants, shops and other businesses have.

The Access Earth mobile and progressive web application serves as a crowd sourced data gathering method for users to view and contribute to this growing data set, while the Access Galaxy system uses an AI image classifier to identify accessible assets (e.g. accessible parking spots) within an area from satellite image data. Both systems will be used to target participating partner sites for the gathering of the necessary data for the SHAPES Project.

Recently, COVID-19 related criteria have been added to the platform for users to also view and contribute to social distancing practices being used by these local establishments to keep their workers and customers safe during this global pandemic (details are included in section 1010.7).

This information allows users with accessibility needs or who are immunocompromised the added confidence to engage within their local communities by viewing the information they require before they make their journey.

The information gathered using the Access Earth platform can be deployed and integrated with a live, real-time connection in existing systems through an API or with an interactive plugin for users to view. Alternatively, users can always access the Access Earth application for free on their own personal devices.

4.7.1 Technical Specifications

The Access Earth application is built using the ionic framework to allow for the ease of development and maintenance of the code base for the multi-platform application (iOS, Android, PWA).

The Access Galaxy system takes in satellite image data and passes it through an AI image classifier to identify key points for inclusion into the Access Earth platforms data set.

Access Earth's data is stored on the cloud and can be accessed via APIs, interactive plugin that can be deployed on any website or platform required or through the Access Earth application itself.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.7.2 Interfaces and Interoperability

All stakeholders can either operate as data gathers or data viewers for the information that exists within the Access Earth system. Thus, empowering both caregivers and the cared for agency in viewing and providing insights on their local community.

Users of the application can interact and contribute to the data via their personal devices (iPhone, Android mobile device, or personal computer browser) or through an interactive plugin.

The level of data gathering for each interested pilot site will be determined by all interested pilot leaders.

4.7.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

4.8 Physical Activity Monitoring (UCLM)

This Digital Solution will enable capturing parameters related to physical activity. These parameters will be provided by means of wearable devices such as bracelets or smart bands, equipped with Inertial Measurement Units (IMUs), that measure physical activity of an individual throughout the day. This information is particularly relevant for supervising the recovering process of a person and tracking their general condition. The application areas include tracking recovery process and evolution of diseases with an impact on the physical activity and mobility including gait analysis. It can also provide valuable information for other application such as fall detection.

The system will be collecting data and storing it locally or streaming it through a gateway device to the cloud where it will be stored and processed using different data analytics techniques such as machine learning, to identify patterns and predict the evolution of certain conditions that have an impact in physical state and mobility.

The Physical Activity Monitoring solution currently integrates two different smart bands: the Xiaomi Mi Band 4 and the Mbientlab MetaMotionR MMR.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Off-the-shelf devices and Apps can be found for physical activity and weight management such as those of Fitbit (https://www.fitbit.com/), Apple (https://www.apple.com/es/watch/), Google Fit (https://www.google.com/fit/) or Xiaomi Mi Band (https://www.mi.com/es/mi-smart-band-5/). They all offer a range of functionalities for user engagement, monitoring, reminders for promoting a healthier lifestyle. Most of these commercial solutions offer open APIs, so that third party applications can access the data they collect. So, efforts can be focused on what to do with the data rather than how to collect them. However, a recent study [7] concluded that there is little evidence that wearable devices could improve health outcomes in older adults, although they could improve motivation and physical activity. Current approaches rely on wearable devices as enablers of behavioural change and most studies to date focus on healthy individuals rather than on those already suffering from a chronic condition or multi-morbidity.

This SHAPES digital solution takes this technology a step further, enhancing the facilitating capability of smart bands with the potential functionalities that can be supported by the smart mirror platform and the Phyx.io system (section 4.9). This combination enables more efficient interventions towards physical activities, which will eventually lead to better a health and wellbeing.

Phyx.io (section 4.9) is a platform which automatically manages and monitors many health-related parameters affecting older adults. This is carried out through the commercial MiBand 4 smart band, providing information about the most relevant health parameters. The Phyx.io platform collect and process the following information:

Activities: The activities that the user has carried out in a 24-hour period, among the following ones: asleep state, offline state, walking state and resting state.

Calories: Calories burnt, based on the activity and intensity of carried out activities.

Number of steps: The number of steps taken by the user, automatically tracked.

Heartbeat: The system will automatically and repeatedly record the heart rate indicating the maximum value, the minimum value and the current value.

Sleep quality: It considers two sleep states, as known: light sleep and deep sleep.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 91 - Physical Activity Monitor

The Mi Band 4 smart band records these health parameters and stores them internally. This information is not sent to the Xiaomi cloud as privacy and data protection are major concerns of the smart mirror platform. The information is therefore retrieved through a Bluetooth connection between the Mi Band 4 and the smart mirror, as depicted in Figure 91. A service has been developed to establish a point-to-point connection between the Mi Band 4 smart band and the smart mirror. This service has been built on the Python library Pygatlib (https://github.com/oscaracena/pygattlib). Once the information is retrieved from the smart band, it does not necessarily mean that this has to remain locally, in the smart mirror. It can be sent to a private cloud, from where the Phyx.io system can access it for displaying purposes. Phyx.io has a built-in dashboard, in which such health parameters can be explored, as shown in Figure 92.

Figure 92 - Dashboard Physical Activity Monitor

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

On the other hand, the MetaMotionR sensor (see Figure 93) is employed to supervise the stability during the realisation of the physical exercise, especially for those older adults that exercise alone, in a home environment. This smart band directly provides the 9-DOF information from the IMU sensor integrated through a public API with the computer device hosting the Phyx.io platform.

Figure 93 - Mbientlab MetaMotionR MMR used in the Physical Activity Monitoring Digital Solution

The sensor takes readings of the person movements and can be placed in different parts of the body for different purposes. In the context of physical rehabilitation, it will be used for gait analysis and fall detection. Regarding the fall detection functionality, the sensor is placed at the user's waist, as this is the centre of gravity of the human body. By placing the sensor there, any movement that is likely to cause a loss of balance leading to a fall will be easily detected. This functionality uses de following sensors:

Accelerometer: It measures the acceleration in each of the sensor's axes (x, y, z). It is measured in g(m/s2).

Gyroscope: It measures the angular velocity of each of the axes of the sensor, in◦/s.

Besides these parameters, the sensor provides, by means of an internal algorithm, the absolute orientation of the sensor. This information can be very meaningful for fall detection, as it could indicate whether a user is on the ground. This absolute orientation is also found in all three axes of the sensor, and Euler angles are used as a measure.

The fall detector operates as a service that receives data from an external sensor connected via BLE (Bluetooth Low Energy). The sensor collects data from the user's movements and sends it to the platform. The platform is able to recognise whether the user has suffered a fall. This process is based on a machine learning model, which

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

has been previously trained with an experimental dataset. A Support Vector Machine model has been used as it is the one that has provided the best performance in this type of problems. The training dataset was obtained in our lab performing different activities in a controlled environment, classified into ADLs and falls. From these activities, labelled data were generated and used to train the model to discriminate when a fall occurs. After testing the model, an accuracy of 100% can be reported in controlled environments. The model will be tested under real-world conditions in the pilot sites and use case defined. The Phyx.io platform will therefore act as a gateway, collecting data and determining whether a fall has been detected or not. If a failure is detected, the platform can notify the user's emergency contact via a call service. This enables prompt response to the fall, even in cases of disorientation or loss of consciousness of the victim. Because this solution uses BLE, it is intended to monitor a person in the same environment in which the platform is located, as BLE has a limited range. It is also possible to use coverage extenders if necessary. The system's operation is illustrated in Figure 94.

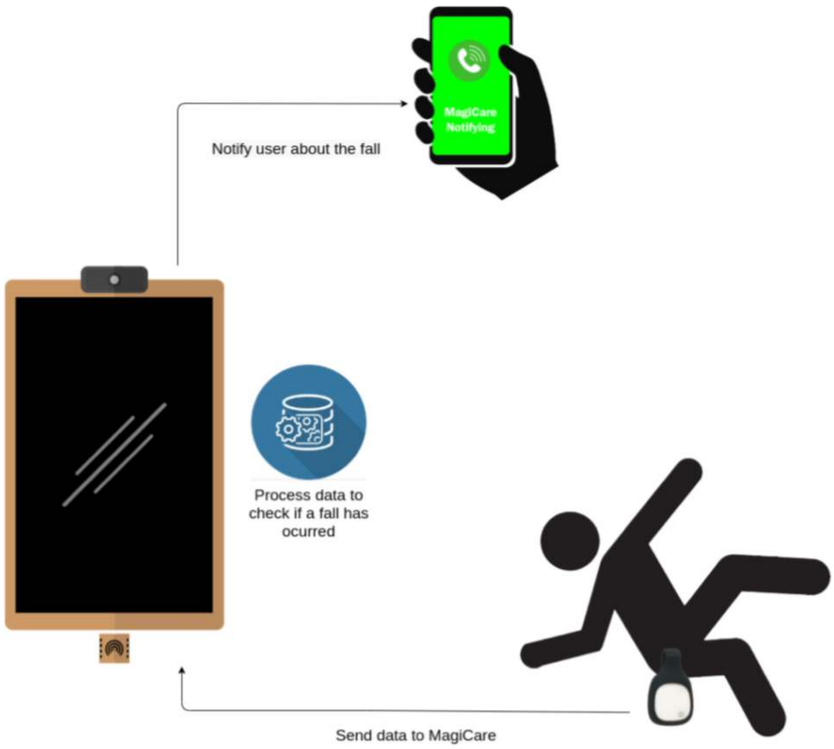


Figure 94 - Fall Detector Functionality of the Physical Activity Monitoring Digital Solution

4.8.1 Technical Specifications

Xiaomi Mi Band 4 features and technical specifications:

- **Functionalities**: Step counting, Heart frequency, Sleep quality, Activity recognition and tracking (running, treadmill, walking, cycling, swimming).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **Autonomy**: Battery lasts 20 days, approximately.
- **Connectivity**: Bluetooth, NFC (Near Field Communication).
- Xiaomi API available (no need to use Xiaomi Cloud).

Mbientlab MetaMotionR MMR:

- **Sensors**: 9-axis IMU (Bosch BMI160 6-axis Accelerometer + Gyroscope, BMM150 3-axis Magnetometer) with environmental sensor (BMP280 Temperature, BMP280 Barometer/Pressure/Altimeter, LTR-329ALS Luminosity/Ambient Light).
- **Battery**: Lithium-ion Rechargeable battery.
- **Memory**: 8MB Memory.
- **Actuators**: Vibrating Coin motor.
- **Connectivity**: Bluetooth Low Energy 4.0, GPIOs, I2C, SPI interfaces.
- Real-time communication is achieved via Bluetooth. Data may also be logged in the 8MB NOR Flash memory, allowing recordings from 2 hours to 48 hours. All data is available in CSV format with a timestamp so it is possible to synchronise multiple devices.
- License free open-source APIs.
- Wearable accessories: wristband, Velcro sleeve, belt clip or body adhesive.

4.8.2 Interfaces and Interoperability

This solution provides an API (back-end) for integration with the SHAPES Platform, so that information can be stored and consumed by other Digital Solutions. An automated registration system is also provided for the user. Information collected by the Mi Band 4 bracelet is stored in a cloud-based Structured Query Language database from which data can be directly retrieved. This information is sent to that dataset whenever the data collector module detects a smart band nearby. The data collected from the smart band and uploaded to the database can be accessed through a Grafana (https://grafana.com/) panel that could run either locally or also in the cloud.

4.8.3 Applicable Pilot Themes

The physical activity monitoring solution will be used in the following pilot themes and use cases of SHAPES:

- PT6 – Physical Rehabilitation at Home.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.8.4 Adaptations for PT6-UC003

This digital solution has been adapted to use case PT6-UC003 so that the MetaMotionR can provide users the functionality that if they suffer a fall during the execution performance, this will be detected and automatically notified. So, the assumption that exercises will be performed in front of the Phyx.io system, in this sense, the fall detection algorithm will be running in parallel.

4.8.4.1 Concept and Ideation Stage

Use case PT6-UC003 is intended to provide a support system for rehabilitation and physical activity exercises. This scenario is supported by the Phyx.io tool and the MetaMotionR band. The Phyx.io tool will supervise the exercise performance, while also offering some functionalities regarding the data visualisation whereas the MetaMotionR band performs real-time fall detection, to ensure the users a safe context for exercise performance. The Mi Band 4 will monitor health and activity parameters during the rehabilitation period.

This digital solution is applicable to Jarda. Jarda (Male) is a 68-year-old man living in the South of Spain. He is a well-educated (14 years of formal education; holds a bachelor's degree), middle-income person. Jarda uses technologies and the internet daily to use the internet to catch up with news, social media, manage his bank account and shop online, normally using his tablet or smartphone. He has affinity with technology and enjoys using some mildly sophisticated devices (e.g., smartwatches).

Four months ago, Jarda suffered a stroke and, as a consequence, he suffers a partial paralysis on the left side. The doctor said there is a great chance for the paralysis to partly disappearing if Jarda performs a set of exercises. He lives alone and, for the moment, he cannot not drive. He lives on the outskirts of a big city, so he decides to use the Phyx.io platform.

The Phyx.io platform runs on a mirror-like interface. This means that there is no need for a complex set up at home. It is just a matter of hanging a mirror in the wall, similarly to a paint or any other decorative element.

Phyx.io will also provide some assistance and collect information about the general feeling of Jarda. The system can also host video conferences with Jarda's therapists who will be following up his evolution. This meeting will take place more often at the beginning.

Jarda wakes up every morning and goes to the living room where the mirror is located. Jarda wakes up the system with a "Hello, mirror". The system wakes up and asks Jarda how he is feelings today. Phyx.io has Jarda's profile along with the exercise routines that he has to follow. Jarda does not have to worry about what exercise has to be done as this is already the responsibility of the system, from the information

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

provided by the therapist. Jarda also feels safe as, if a fall occurs as result of a loss of stability, assistance will be requested.

Today, Jarda is not in the mood for exercising and he is not paying much attention to the exercises. The system correct Jarda and, with some motivational messages, encourages Jarda to follow the indications and performs a more precise execution. After the execution, Phyx.io summarises the session with some information about the time, number of repetitions, accuracy of the exercises, compared against the model. All this information can be accessed, any time, by the therapist to assess the evolution.

Table 43 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	The smart mirror interface provides an easy interaction. Usability has already been tested.
SPS-114	SHAPES should support assisted mobility at home.	Y	The system considers people using walking assistance.
SPS-116	SHAPES should offer fall detection sensing and alerting.	Y	Fall detection is supported.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	The smart mirror interface (magic mirror) is user friendly and attractive.
SPS-135	SHAPES shall offer ease of use interfaces for both healthy and impaired users.	Y	The system considers both type of users.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	Post-processed information is stored (id of activity, for example).

Table 44 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-03	AIM1: Gather information about the physical state of a person measured in terms of his/her activity (number of steps, burnt calories, sleep hours and quality, etc.)	Y	Information is gathered from the different smart bands.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-04	AIM2: Track the evolution of such parameters.	Y	Gathered parameters are stored in a database.
UR-05	AIM3: Provide users with feedback about their daily performance in terms of number of steps, burnt calories, slept hours, etc.	Y	Information is available both in the user dashboard and the smart band.

4.8.4.2 *Design and Development Stage*

The design of the physical activity monitoring solution has been completed. Regarding the assessment of physical activity monitoring, a prototype has been tested by the research team to evaluate the use of the Mi Band 4 during periods of several days, including the recharging periods and the data retrieval. The information collected comprises: the number of steps, the heart rate, the date and time at which the above data was collected and the MAC address corresponding to each smart band, which will be used to identify the band. Different types of walking assistance, namely, the use of a walker, the use of crutches and walking with no assistance, have been considered during the preliminary tests.

Regarding the fall detection, an assessment and performance evaluation tests have been carried out. When analysing a movement, 4 different situations can occur: a true positive (TP) when a fall event has been correctly classified; a true negative (TN) when a non-fall event has been correctly identified; a false positive (FP) when a fall event has been misidentified and a false negative (FN) when a non-fall event has been misclassified. With these four possible outcomes, the performance of the system is evaluated with the following features:

- Sensitivity: Measures the number of positives that are correctly identified.
- Specificity: Measures the number of negatives that are correctly identified.
- Accuracy: Measures the number of events that are correctly identified.

F1: Is the harmonic mean of the precision and recall and is extensively used to measure the quality and performance of a model.

In order to test the algorithm, part of the data previously collected need to be used. Of the 765 measures retrieved from the 17 subjects, the 80% of the data were used to train the system, and the rest were used to test it. The results of the evaluation conclude in a Sensitivity, Specificity, Accuracy and F1 of 100%, classifying all test data in the correct way. It can be observed that all events are correctly classified, which proves that the system is a good and reliable option for detecting falls in real time and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

in an unobtrusive way, but it should be noted that these results, despite being very good, were obtained using exercise data in a stable and controlled environment.

The following table is shown as a comparison between the work of this paper and other studies using Sensitivity, Specificity and Accuracy.

Table 45 - Comparison of Studies using Sensitivity, Specificity and Accuracy

Study	Sensitivity	Specificity	Accuracy
SHAPES fall detection system	100	100	100
SHAPES fall detection system (without orientation)	100	97.7	98.69
[8]	100	100	100
[9]	97.1%	98.3%	97.78%
[10]	97.53%	94.89%	95.55%
[11]	95.8%	86.5%	91.1%
[12]	100%	100%	100%
[13]	100%	96.67%	98.33%

It was expected that orientations could make the difference on fall classification, and as it can be observed in the results, the inclusion of orientations as features increase the Specificity and Accuracy from 97.70% and 98.69% respectively to 100%, recognising all the activities properly.

As it can be observed, some studies as [8] and [12] produce the same performance as the study here presented, with the difference that these systems do not use the orientation, only accelerometer and gyroscope data. In [8] it is used what they named as heading, which is a relative orientation of the user from a vertical plane (but at the end an orientation which is calculated from raw data), explaining the great performance of the system considering it is a Time-Bounded A algorithm. The work of [12], on the other hand, produces a great performance trusting only in accelerometer data, these results can be explained as the result of a great feature selection, and a great performance of neural networks to classify falls.

It can be concluded that orientations can indeed make a difference. The best performing works presented here and in [8] make use of these features. Exceptionally, the work in [7] presents a 100% accuracy solely using accelerometer data, with one main difference, they use a neural network instead of the commonly used machine learning models in fall detection, which seems to perform better in conjunction with the selected features.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.8.4.3 Prototyping and Adaptation Stage

After the initial analysis of the data obtained by the Mi Band 4, it has been discovered that it is incorrectly calculating the number of steps when using a walking aid. This smart band relates the swinging movement of the arms when walking with the steps walked by a person. Therefore, when the arm holds a cane, for example, it makes it difficult to count the person's steps and the resulting information is inaccurate. To overcome such limitation, the accuracy and effectiveness of the Mi Band 4 smart band placed in other parts of the body is being studied, as well as the use of other devices with better performance in terms of step counting.

Regarding the fall detection based on the MetaMotionR smart band, the first prototype has obtained an accuracy of 100%, correctly classifying all movements. However, the testing events were performed in a controlled environment with dictated exercises. The next step involved the deployment of this solution in a real environment during the piloting stages. The system's robustness and accuracy has been evaluated during the period of a week to register and record data. It was detected that the lying-in bed posture was giving rise to a high rate of false positives and, for this reason, improvements are currently being applied to the system to avoid this situation.

4.9 Phyx.io (UCLM)

This solution provides a tool (a physical rehabilitation platform) for monitoring physical rehabilitation processes without the need to rely on direct supervision by the physiotherapist. A system equipped with 3D depth camera analyses the movements made by the user during exercise routines and checks whether they are within the range of movement that can be considered safe. This tool also offers the possibility of capturing information during exercise sessions. In this way, the physiotherapist will be able to analyse the evolution of each patient, making an informed supervision. This system will also be equipped with a videoconference system so that the user and the physiotherapist can interact at any time. The system provides support for the supervision of exercise performance correcting wrong postures as well as tracking of exercise execution (number of repetitions, achievements, time required to complete the exercise).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 95 - Kiosk Version of Phyx.io

The system will offer a version for nursing homes, gyms, or rehabilitation centres, which will take the form of a kiosk where all the hardware will form a single piece. Furthermore, a lighter version will be offered, for which UCLM plan to use the television at home. Additionally, the system can be hosted in a smart mirror.

4.9.1 Technical Specifications

The Phyx.io tool provides a graphical interface for different user roles: therapists and individuals exercising. These interfaces are intended to navigate through the different exercises available both for being prescribed to an individual or to be executed. A graphical interface is also available for the therapist and other professionals involved in the supervision of the condition of a given individual. This dashboard may also incorporate the information retrieved with physical activity monitoring tool described in section 4.8.

The Phyx.io tool incorporates the Microsoft Axure Kinect 3D depth camera, that has the following features:

- 1 Megapixel Depth sensor with wide field.
- 12 Megapixel RGB video camera.
- Matrix with 7 microphones to capture voice and sounds.
- IMU sensor to guide the camera.
- Skeleton joints data provided by their SDK for body tracking.
- System Requirements: Windows® 10 PC or Ubuntu 18.04 LTS with 7th Generation Intel® CoreTM i3 Processor (Dual Core 2.4 GHz with HD620 GPU or faster), USB 3.0 Port, 4 GB RAM. Skeletal/body tracking and other experiences may require more advanced PC hardware.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.9.2 Interfaces and Interoperability

The Phyx.io tool is currently being provided based on a cloud solution. The application is deployed in a VPS and will be available in the domain (already reserved) www.phyx.io. The data collected during the performance of the different routines, as well as the data supporting the routing monitoring, will be available in a cloud-based database. Queries to the database will be supported.

Interoperability of the Phyx.io system is currently being supported for two partner solutions, as it is the video call service of Omnitor and the oroface system of VICOM, for facial rehabilitation purposes. The integration with the Omnitor system is currently achieved based on a REST API interface, whereas with the VICOM solution it is currently supporting the information exchange using JSON.

4.9.3 Applicable Pilot Themes

The Phyx.io tool for physical rehabilitation will be used in the following SHAPES pilot themes:

- PT6 – Physical Rehabilitation at Home.

4.9.4 Adaptations for PT6-UC001, PT6-UC003 and PT6-UC004

This digital solution has been adapted to use case PT6-UC001 so that the orofacial rehabilitation can be provided through the Phyx.io system. Thus, not only the exercises are guided but also the user can benefit from all the functionalities provided by the system (information logging, routine follow-up, direct contact with the therapist). For this particular use case, it is assumed that exercises will be performed in front of the smart mirror so that the user can see his/her face while exercising and receiving corrections and feedback from the Phyx.io system.

For PT6-UC004, adaptions have been made in Phyx.io so that information collected from the smart band can also be integrated into the user profile. In this way, the therapist can track the evolution of the routine performance but also from the information collected from the Mi Band4 (steps, calories, sleep). UCLM implemented a mechanism to associate the band MAC to a user so that when the data are downloaded from the smart band they are also associated to the user profile in Phyx.io.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

4.9.4.1 Concept and Ideation Stage

PT6-UC001 and PT6-UC003 are intended to support the performance of physical rehabilitation (facial and rest of the body). Similarly, PT6-UC004 is also intended to ensure a safe performance (detecting falls) but also tracking information regarding the daily activity and health parameters of users.

The digital solution is applicable to Jarda (male), 68 years old man living in the South of Spain. He is a well-educated (14 years of formal education; holds a bachelor's degree), middle-income person. Jarda uses technologies and the internet on a daily basis to catch up with news, social media, manage his bank account and shop online, normally using his tablet or smartphone. He has affinity with technology and enjoys using some mildly sophisticated devices (e.g. smart watches).

Four months ago, Jarda suffered a stroke and, as a consequence, he has a facial paralysis. The doctor said there is a great chance for the paralysis to partly disappear if Jarda performs a set of orofacial exercises. He lives alone and, for the moment, he cannot not drive. He lives on the outskirts of a big city so he decides to use the Phyx.io platform.

The Phyx.io platform runs on a mirror-like interface. This means that there is no need for a complex set up at home. It is just a matter of hanging a mirror in the wall, similarly to a paint or any other decorative element.

Phyx.io will also provide some assistance and collect information about the general impressions of Jarda. The system can also host video conferences with Jarda's therapists who will be following up his evolution. These meetings will take place more often at the beginning.

Jarda wakes up every morning and goes to the living room where the mirror is located. Jarda wakes up the system with a "Hello, mirror". The system wakes up and asks Jarda how he is feelings today. The system is also equipped with an emotion detection software that will use this answer to run. Phyx.io has Jarda's profile along with the exercise routines that he has to follow. Jarda does not have to worry about what exercise has to be done, as this is already the responsibility of the system, based on the information provided by the therapist.

Today, Jarda is not in the mood for exercising and he is not paying much attention to the exercises. The system corrects Jarda and, with some motivational messages, encourages Jarda to follow the indications and perform a more precise execution. After the execution, Phyx.io summarises the session with some information about the time, number of repetitions, accuracy of the exercises, compared against the model. All this information can be accessed, any time, by the therapist to assess the evolution.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 46 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	The smart mirror interface provides an easy interaction. Usability has already been tested.
SPS-114	SHAPES should support assisted mobility at home.	Y	The system considers people using walking assistance.
SPS-116	SHAPES should offer fall detection sensing and alerting.	Y	Fall detection is supported.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	The smart mirror interface (magic mirror) is user friendly and attractive.
SPS-135	SHAPES shall offer ease of use interfaces for both healthy and impaired users.	Y	The system considers both type of users.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	Post-processed information is stored (id of activity, for example).

Table 47 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
AIM2	Track the realisation of the routine in order to collect data about performance, time, number of corrections.	N	The algorithm is implemented in PC but it is still missing the implementation in the smart mirror.
UR-05	Provide users and therapist/caregivers feedback about the engagement to the rehabilitation plan as well as its performance.	Y	The information is provided through a dashboard.
UR-06	Improve physical condition or the orofacial musculature.	N	Test has not yet been run to assess improvement.
UR-07	Feel that the therapist is nearby, supporting the rehabilitation process, in the	Y	A video call service is provided embedded in phyx.io.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	same way as though the user were at the clinic where the therapist provides support.		
HOW1	The system will guide the user through the realisation of the different routines comprising the rehabilitation plan.	N	The algorithm is implemented in PC but it is still missing the implementation in the smart mirror.

4.9.4.2 Design and Development Stage

For the orofacial system, please refer to section 5.6.

Regarding Phyx.io, the designed has been completed in a PC-based system, so currently efforts are being addressed to migrate the exercise pose tracking to the smart mirror platform, equipped with a Raspberry Pi 4.

4.9.4.3 Prototyping and Adaptation Stage

Regarding Phyx.io, UCLM have run some acceptance evaluation tests. There are different ways to evaluate the system usability such as the System Usability Scale (SUS) [14] or the Post-Study System Usability Questionnaire (PSSUQ) [15]. Nonetheless, applications specifically designed for older adults, such as those thought to be run in ambient assisted living contexts, call for specific frameworks for usability assessment. This is the case of the International Classification of Functioning, Disability and Health Usability Scale (ICF-US) [16]. This scale offers a way to evaluate digital solutions by focusing the designs on the end-user. It allows to retrieve the feedback needed to find barriers and enablers in the mock-up phase, through validated methodologies and procedures.

The ICF-US [16] has two subscales. The ICF-US I enables a general usability assessment, whereas the ICF-US II enables a more detailed assessment, evaluating each component of the design to detect elements that need to be modified (barriers) and good practices (facilitators) to be taken into account in the further design of the solution [17-19]. Depending on the stage of development of the solution, one or both subscales may be chosen. Thus, ICF-US I will be applied for general usability evaluations and ICF-US II will be used to evaluate mock-ups in the early stages of development to find the weaknesses and strengths of the design. Phyx.io will be evaluated using the ICF-US II scale. The ICF-US II is comprised of items that identify the components of a digital solution [16]. Each item can be evaluated as a barrier or enabler, with a maximum value of 3 and a minimum value of -3 or as not applicable (N/A) if it does not respond to the item. By doing so, it is possible to identify the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

components that need to be modified. The ICF-US II is specific to each digital solution, although the structure is common and it is divided into 3 parts:

- Components of the application. In the first part, UCLM evaluate the components that comprise the digital solution.
- Detailed usability. This part takes into account the different interaction functionalities as well as the user interface.
- Overall system evaluation. This last part is composed of a general question about the contact with the system

The Phyx.io evaluation requires an evaluator and an observer. The evaluator assesses the rating of each item through observation and interview. Therefore, the evaluator will base his/her answers on the observation of the user's interaction with the digital solution and on the interview to collect possible reasons why a component is a barrier or to clarify possible doubts about the user's interaction. On the other hand, the observer collects information considered necessary to ensure redundancy without taking any detail for granted. The test has been initially prepared and completed by the professionals dedicate to older adult healthcare. These professionals have a very important role in the Phyx.io system, as they are responsible for the management of their patients within the platform. Assigning exercise routines, monitoring the state of health and physical activity or setting appointments or reminders are some of the tasks that this role can perform within the platform. Thus, the evaluation was conducted involving different professional profiles (physiotherapists, therapists) of the nursing home "El Salvador" SAL. 10 participants were selected with an average age of 36.5, maximum 60 years and minimum 25 years. The assessment is carried out in one of the rooms of the physiotherapy team, in the SAL building. The evaluator conducting the test introduces the Phyx.io platform and provides the user with test credentials for authentication. Then, he/she proposes the healthcare professional to perform the following tasks to evaluate each item of the subscale. The tasks performed by each user are:

- Authenticate on the platform.
- Search something.
- Identify the patients assigned to a professional.
- Explore details of a patient.
- Explore exercises and routines existing in the system.
- Explore exercises and routines assigned to a patient.
- Sort exercises by name and module.
- Create exercises and routines.
- Assign exercises and routines to a patient.
- Delete exercises and routines.
- Delete exercises and routines assigned to a patient.
- Identify the location of the facility to which they belong.
- Edit his/her user details.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Go to the system start.
- Close session.

Once the task has been performed, it could be observed that there were some barriers in the application components. 60% of healthcare professionals experienced problems with the top navigation tabs in tasks such as searching for information on an assigned patient, viewing patient routines and exercises, or even not finding the exact functionality of the component. All of these factors complicated the completion of tasks and the navigation within the application. Consequently, 50% had problems with navigation and, more importantly, they found it difficult to understand which profile they were in, when they were performing the task. On the other hand, the links provided for ordering exercises and routines were perceived as barriers by 40% of users. Tips that were intended to assist users in completing tasks went unnoticed, as 50% did not take them into account. The other evaluated components were not perceived as barriers, although 20% did not find the use of the drop-down menu useful and were also confused with some of the options displayed in the exercise and routine forms.

4.10 ROSA (CH)

ROSA is a combination of inter-communicated technologies for the clinical management of users with heart failure as main condition (patients). The patient has 24/7 contact with a chatbot (virtual nurse) through a chat application. The virtual nurse asks the patient questions to gather data and establish a personalised health plan (frequency of questions, pieces of advice) and launch alerts. The patient may start the conversation (“I do not feel well’, “my blood pressure is high”). The technologies are:

- **Mobile App for patients**: It is a mobile App which serves as interface for instant messaging. The patient can communicate with the virtual nurse and the health professional.
- **Control Panel:** It is a web-based application for the health professional. The health professional can see the health plan of their patients, their alerts and the conversation history. Instant messaging has been embedded in the interface to interrupt the virtual-nurse/patient conversation and intervene (human-in-the-loop). The control panel also includes the database. The algorithm that determines the personalised health plan is in its code.
- **Conversational agent:** it is the chatbot technology.

4.10.1Technical Specifications

- Mobile app for patients: Hybrid application (IONIC v5), currently working on Android and iOS operating systems;
- Control Panel: Application Server, Ruby on rails

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

   - Database: PostgreSQL;
- Conversational agent: Dialogflow (external technology);
- Chat history: Firebase and FireStore (external technology);
- Notifications: OneSignal/Firebase (external technologies);
- Communications: json.

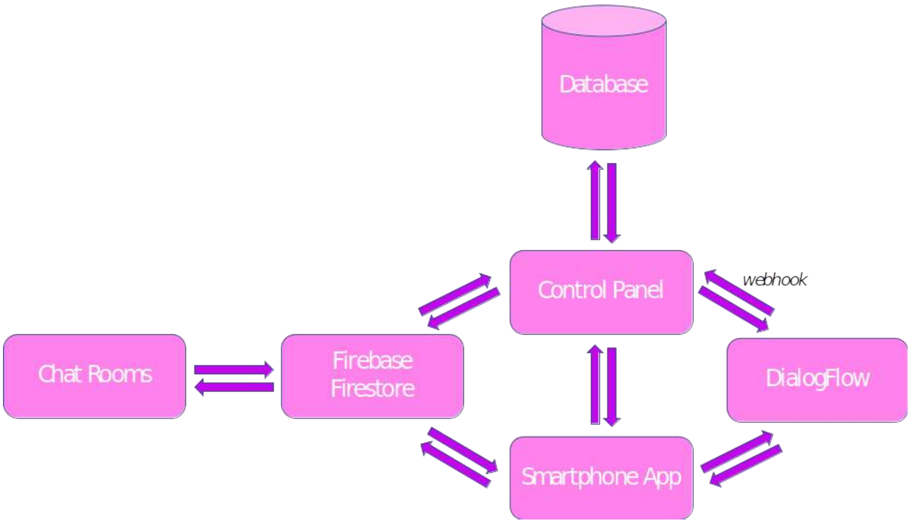


Figure 96 - ROSA's Components and Data Flows

4.10.2 Interfaces and Interoperability

Mobile Application, smartphone:

- Interface for patient interaction with chatbot and health professional, mobile application: Smartphone.

Control Panel, web-based: Browser (preferably Chrome):

- Interface for the health professional interaction with the patient and health plan management system.
- Interface for the system administrator.

Stakeholders: patients, medical doctor, physician, system administrator (to add/delete users, to assign patients with health professionals).

4.10.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for healthy ageing at Home;
- PT2 – Improving In-Home and Community-based Care;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT3 – Medicine Control and Optimisation;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;
- PT5 – Caring for Older Individuals with Neurodegenerative Diseases;
- PT6 – Physical Rehabilitation at Home;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

4.10.4 Adaptations for PT1-UC004

Only the dialog flows will be applied in this case, the control panel will be provided by VICOM (Adilib technology) and the interface will be PAL's robot ARI. The flow of dialogs will be applied to create a conversational agent which assists the older person in obtaining information (reminders) or activating any of the functionalities of the robot. The dialogs will be voice-based through VICOM's text-to-speech technology. The adaptations have started in October 2021.

4.10.4.1 Concept and Ideation Stage

The standard use of ARI (in this use case as a digital assistant) requires that the older person (user) navigates through the options on a touch screen located on the torso of the robot. This approach has two intrinsic barriers: 1) the user needs to get familiarised with the menus and submenus and 2) the user needs to make several clicks to get to the desired functionality. These barriers may become important in people with low e-literacy, which is the case many times among the older persons.

Conversational agents can reduce these barriers contextualising the sentences in order to reach the desire option with fewer selections and providing a more personalised guidance to the user to find the functionality. Two examples below describe the most common scenarios:

- "I want to do a puzzle": puzzle is detected as a specific game implemented in ARI, so the user can access it directly, without going through general menu>games>puzzle.
- "I want to call Maria": call is detected as a functionality with several modes of interaction. In this context, the conversational agent can suggest which one the user prefers ("Would you like to make the call through the front screen or with the back tablet?"). Thus, the user knows which are the call options. After selecting, the context of the conversation keeps 'Maria' as the call receiver and ARI can directly establish the call without asking again.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The applicable persona to the PT1-UC004 use case is Helena:

- Wants to be autonomous.
- Needs to be encouraged to participate in social activities.
- Needs to be supported with more movement and exercises.
- Needs that the daughter does not worry about her.
- Wants to keep old relationships.
- Wants to have always something to do.

The scenario of this case is like a general ‘reminder’ to keep people active and engaged with activities. The user approaches to ARI and, after identification, speaks out what they would like to do. ARI will suggest the options in ARI that match their request and will wait for further input (confirmation, further selection of options, dismissal of options).

Detailed description of the scenarios

Older person

Helena is an 82-year-old woman who lives in her own independently. She has a caregiver but only visits her few days a week (2-3). She is regularly visited by her nephew. She suffers from some chronic conditions, such as vascular insufficiency, atrial fibrillation, advanced cardiovascular disease with thrombosis in her legs and has some trouble walking (she is slow and gets tired). Despite all this, in general terms, her health is good. She likes being autonomous and does not like bothering her family and feeling like she is a burden to them. She likes being busy. However, she spends a lot of time alone and would like a companion that helps her being active and suggests social activities in her neighbourhood.

Helena usually wakes up at 7.00h in the morning. She prepares her breakfast and normally likes to listen to the news and/or would like to know the activities in her area and her scheduled activities. Robot ARI, the digital assistant, approaches to her in the kitchen and a typical scene would be like this:

- ARI: “Would you like to know today’s activities and others in town?”.
- Helena: “Yes, please”.
- ARI: “Today you have a call appointment with Dr. Karina at 11.00h. There is a movie of Gary Grant at the theatre, at 17.00h. There is also a movie of Sofia Loren at 17.00 on TV. You need to buy your MEDICATION. Also, it’s the birthday of your friend Asunción!”. (If preloaded, ARI shows associated pictures on the tablet).
- Helena: “Remind me the Gary Grant movie at 16.00h, please”.
- ARI: “Done, reminder of ‘Gary Grant movie’ set up at 16.00h” (Reminder gift image on the tablet).

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

Helena usually goes to the groceries on her own, and it is a great help telling ARI anytime she finds out she is running out of anything:

- Helena: “ARI, add carrots to the shopping list”.
- ARI: “Sure! Carrots added to the shopping list” (gift image on the Tablet).
- […]
- Helena: “Please ARI, tell me the shopping list”.
- ARI: “Sure! Let me know when you are ready”.
- Helena: “Ready”.
- ARI: “Carrots, ….”, ARI says slowly.

Items of the shopping list can also be added by family/CH, particularly useful for medication that is regularly bought. In this case, they are usually programmed to be reminded on a regular basis (such as a specific medicine once a month).

- ARI: “and remember also to pick up MEDICATION”.

When it is the time of a reminder, ARI approaches to Helena:

- ARI: “Remember you have an appointment ‘Call Dra. Karina’ in 10 minutes”.

ARI has calls and video calls integrated.

- ARI: “Dra. Karina is calling, would you like to answer” (options on screen too).
- Helena: “Yes, please”.
- [video call].

The morning is long, and Helena is bored.

- [In the living room].
- Helena: “ARI, I want to do something”.
- ARI: “Sure! Choose: exercise, dance, tic-tac-toe, chess, stroll, see pictures, call someone, music, …” (options on screen too).
- Helena: “Exercise”.
- ARI: “Good! Please, follow my directions […]” (arm, head exercise).
- Helena: “ARI, call Asunción”.
- ARI: “Do you want to call Asunción Friend or Asunción Neighbour?” (options on the tablet).
- Helena: “Asunción Friend”.
- ARI: “Sure!”, and call starts.

It is recommendable that Helena keeps active. If no interaction (within selected activities - exercise, dance, tic-tac-toe, chess, stroll, pictures, telephone call, music) with the robot has been detected for more than 4 hours and Helena has been at home alone for that time:

- ARI: Hello Helena, how are you doing? Would you like to do something?”
- Helena: Yes/Not today/Later.

If yes, ARI suggests that she chooses one of the activities.

- ARI [16:00]: “Helena, you have Gary Grant movie at 17.00h”.
- Helena: “Got it/Snooze”.

Helena needs to be active; she knows it and she likes being so. However, she sometimes ends up too tired in the evening, she has sometimes fallen at this moment of the day.

- ARI: Helena, I detect you are on the floor. Are you ok?”.
- Helena: “I’m fine thank you/Call FAMILY/CONTACT PERSON please.”.

Family member, informal caregiver, friend, contact

With the App, they can send messages to Helena through the robot and may make video calls.

Clinica Humana

They will have access to the panel to schedule social activities, reminders and pictures.

They will have an App to make video calls.

Table 48 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Phases 2-4 collect feedback from final users and professionals.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	ROSA has its own terms of use and services policy. In the pilots, it is used as a research tool.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	ROSA has its own privacy policy. In the pilots, the use of ROSA will be compliance with GDPR.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	ROSA conversations can be modified.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	ROSA can incorporate any conversation.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	ROSA will include usage documentation and tips while using the technology.
SPS-053	SHAPES access devices may be user friendly	Y	ROSA conversations can be programmed to be fiendly and empathic.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	ROSA conversations are designed to be motivating.
SPS-062	SHAPES should offer social and information space.	Y	ROSA conversations can provide information interesting for the user.
SPS-064	SHAPES should offer info where and how to receive organisational and/or legal support.	Y	ROSA conversations can provide guidance when to contact administrative staff.
SPS-080	SHAPES should provide training material for care providers.	Y	ROSA will include usage documentation.
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	ROSA conversations can mention what was understood so the user can validate.
SPS-122	SHAPES should offer accessibility info in public spaces.	Y	ROSA conversation can incorporate information of general interest.
SPS-123	SHAPES shall offer a choice of multi-cultural avatars to represent users.	Y	ROSA conversation can include different synonyms representing way of

System Specifications	Description	Fulfil (Y/N)	Comments
			speaking of different users.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	ROSA allows direct calling for specific conversations.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	ROSA conversations are modular.

Table 49 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Consider language versatility	User may command using different sentence structures, vocabulary and even constructions which are not 100% correct.	Y	ROSA will incorporate several sentences to express the same user intention. What user says is matched to these sentences and a 100% match is not necessary.
Access to all options with one command	All functionalities should be accessible with one command given at the main page (general menu).	Y	ROSA will allow access to any conversation at any time.
Always confirm action	Any functionality of the robot should be confirmed before activation.	Y	ROSA will incorporate conversations to confirm any action to assure proper understanding.
Skip conversation	ROSA should consider that the conversation could stop at any time without reaching a final point.	Y	ROSA will cancel conversations if there is no activity.
Reset conversation	The user should be able to start the conversation from scratch (erase of context).	Y	ROSA gives access to main menu conversation at any time.
Confirmation of understanding	The user should be always aware of what the system has understood and correct/go backwards if necessary.	Y	ROSA will give information about what it has understood before next action.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

In the upcoming months, PT1-UC004 will continue its technical development and partners will collaborate in the design and development and prototyping and adaptation stages of the process.

4.10.5 Adaptations for PT3-UC001

Only the dialog flows, the mobile app interface and the storage database will be applied in this case, the control panel will be provided by VICOM (Adilib technology).

List of adaptations:

- Heart failure ROSA's questionnaires adapted for the collection of necessary data to perform heart failure decompensation prediction by VICOM's technology.
- Adaptations to the database to include particular data of PT3-UC001 and be able to communicate with VICOM's technology. Adaptations to the database to include TREE analysis.
- Coupling mobile app with eCare App.
- Adaptations of the mobile App to include SHAPES layout and design requirements.
- Modifications of the health care professional dashboard.

4.10.5.1 Concept and Ideation Stage

In PT3-UC001, ROSA is responsible for gathering some of the necessary data for VICOM's decompensation prediction algorithm. The structure of the conversations needs to be changed in order to include the collection of new types of data. In addition, many already existing questions need to be modified to achieve coherence of conversations (e.g., duplication or out of context). Consequently, the database where the data is stored and the dashboard where the health care professional visualises data needs to be restructured. Finally, from the mock-up presentations to older people, it was revealed daily collection of questionnaires (as required by VICOM prediction standard protocol) will not be successful as most participants will reject to do so. Consequently, it was redesigned the protocol and it will now include active participation of the App users to decide when to launch the chatbot regarding these questionnaires.

Some other data needed by VICOM's decompensation prediction algorithm is collected by EDGE's App eCare, which will be also installed in the users' mobile device. The existence of two technologies in the same mobile device may allow their communication with the objective of giving more options to the user when providing data. This way, the user may choose their preferred interaction mode or may access

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

other sections of the SHAPES App easily when not remembering exactly how to go. In particular, the implementations will allow the user to provide vitals data manually in ROSA, and ROSA will take care of providing these data to eCare App. eCare App is the manager of vitals data. Therefore, the user will have three ways to provide data (without intervention, direct transfer from the measuring devices to eCare App), manually in eCare App or manually in ROSA.

The applicable persona for PT3-UC001 is Roberto:

- >65 years (>70 preferred).
- Heart condition.
- Other pathologies (for example diabetes).
- Obese.
- Several medications.
- Smoker.
- He forgets to take blood pressure pills.

The scenario of this use case is an older person who has symptoms which need to be monitored. In addition, the adherence of their medication needs to be regularly checked because symptoms frequency and severity may be related. Even when the older person feels fine, answering questions through the chatbot is not acceptable for them (too much; together with the fact that many are not very attached to new technologies). Therefore, the questions will be launched every week (or other frequency defined between the health care professional and the older person). The older person is also instructed to launch the questionnaires themselves in any day they feel worse. In addition, there is a main set of questions (3) with which the questionnaire starts. If the answers of these questions indicate the person is feeling well, the rest of the questions are not made (thus, reducing the burden of answering the chatbot).

Detailed description of the scenario

Older person (and sometimes caregiver in alternative scenarios)

Roberto is a 70-year-old person, living with his wife. He suffers from heart failure, stage 2-3, and experiences one decompensation a month. He regularly needs to contact Clinica Humana's doctor to adjusts his medication, for example adding a diuretic. He has some activity, basically short walks outside home with scheduled stops, and wandering at home, also along established stretches and stops. He can eat, get dressed and have a shower independently or with little help. For these activities, he has a caregiver who goes 2/3h a day, usually at the same times. The rest of the day, he is most of the time sitting, watching TV and chatting with his wife. He usually takes his medication properly, although sometimes he misses a dose. This routine has

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

actually improved since the pharmacist offered him a pill organiser. He has several chronic conditions for which he takes 5-10 pills, 2-3 of them to control his heart failure.

Roberto wakes up at 8.00. Caregiver comes at 8.30 and assists him in morning activities:

- Wash, bath.
- He weighs himself.
- He gets dressed.
- He has breakfast.
- He takes his medications.
- After half an hour, he takes his blood pressure, O_2 saturation level and heart rate. If values are not normal:
  - Blood pressure: he waits 15 minutes while sitting and takes the measurement again.
  - O_2 saturation/heart rate: He massages his finger and takes the measurement again.

At 10.00h-10.30h, they have usually finished all morning tasks and sit together and chat. Roberto receives a notification in his cell phone. It is the time to answer the questions of his chatbot. They are easy and quick to do, and make him feel at ease because he knows his answers help his doctor to know his state better (in an alternative scenario, it is Roberto's caregiver who has the App, receives the notification and answers the questions).

- Compared to the last 3 days, your legs-feet or any other part of the body are? Less swollen, the same, more.
- Compared to the last 3 days, you feel… worse, the same, better.
- In the last 3 days, did you take any additional medication without supervision? Yes, no.

If there is nothing unusual, the questionnaire finishes here. He also likes to comment with his caregiver while he is answering. Last week, he suffered a decompensation and stayed in hospital for 2 days, and he did not feel like answering the chatbot's questions. Clínica Humana called him to check whether everything was OK, as they could not see any activity. He explained them everything (In an alternative scenario, a caregiver fills missing data on Roberto's behalf through a web-based application).

At 11.00h, he gets a notification in his cell phone. It is a piece of advice from the chatbot:

- "Remember to be active, try to walk 2000 steps a day".

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

He knows, but itis summer and it is very warm lately. Maybe next time he sees his doctor will ask what to do at home instead of waling outside.

Today at 12.00h, he has an appointment with his rheumatologist, his knee arthrosis is not so well lately. He walks to the bus stop, only a 10-minute walk. He wears the bracelet that records his steps. He does not have to think about it too much, just once a week to recharge it. In the visit, the specialist replaces a medication his taking with a new generation drug, apparently more efficient.

At 12.30h, he gets a notification. The chatbot is reminding him a pill. He likes to have this reminder because he cannot eat for an hour after taking the pill, and 12.30h is perfect to have lunch later at his usual time. Another useful reminder is the anticoagulant, the dose of which may change frequently.

Back at home, he remembers that he has been instructed to notify any change in his pharmacological treatment. The chatbot reminds him every week, but the sooner it is notified, the better:

- “Hello, I have changes in my medication”.
- “If I’m not mistaken, you are saying your medication has changed, right? YES/NO”.
- “Yes”.
- “Thanks for letting us know, It is been registered, Clinica Humana will call you”.

In addition to changes in the pharmaceutical treatment, other questions that are regularly asked to the older person to detect that new important events have happened are: hospitalisation (every 14 days) and blood analysis (every 14 days). Roberto has always the possibility to have the initiative to notify them before the reminder.

At 17.00h, he receives a notification on the cell phone. There is a message from the chatbot saying that “no weight has been recorded today”. He does not remember if he did that morning, it happens sometimes. He weighs and decides also to introduce the value manually, as he’s going to watch TV and does not want to bother if everything is ok. He’s usually more tired in the evening and don’t like to have much activity.

- “Hello, I weighed myself”.
- “I see you weighed yourself, how much? In Kg please, for example, 67.9.
- “70.4”.
- “Thank you, it has been registered”. (Alternatively, introduction of values is done through the eCare App or automatically reading from devices).

Because he suffered a decompensation and was hospitalised last week, he usually takes his blood pressure again in the evening.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

Next day, he gets a call from Clínica Humana asking him about the changes regarding his medication.

A few days later, he starts to feel more tired. It happens sometimes. He answers in a chatbot's question that he is feeling worse, and a little longer questionnaire is carried out.

- Could you take walks like previous days? Yes, no.
- Shortness of breath when lying in bed? Yes, no.
- Do you cough or have phlegms? Yes, no.
- Does your medication make you feel bad? Yes, no.
- Urine? Less, the same, more.
- Palpitations? Yes, no.
- Drowsiness? Yes, no.
- MARS questionnaire.

While answering, he realises that he may be going less often to the toilet.

Next day, he receives a call from Clínica Humana, they suggest to add a diuretic to his pharmaceutical treatment, because the new arthritis drug may be retaining body liquids. In addition, they will also visit him on the following day.

Health professionals

The physician has access to a dashboard where they can see:

- Profile of participants, including medical data and pharmacological treatments, collected at baseline.
- Historic evolution of parameters (weight, blood pressure, oxygen level, heart rate, number of steps, answers to questionnaire, hospitalisations, history of warnings).
- Which older person has informed about: changes in medication, use of health care resources, blood analysis.
- Lack of collection of data.
- Warnings: who has presented values out of the normal range or
- The physician can define normal ranges on a personalised manner, as they may depend on the general condition of the older person.

The physician uses the dashboard every day at first hour to:

- Check for availability of updates (medication, use of health care resources, blood analysis) or lack of collection of data
    - Which leads to the task of calling the older person/caregiver to collect data, which is introduced in the system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Reconcile pharmaceutical treatments
  - Which leads to the intervention of changing pharmacological treatments, communication to the respective older person/caregiver and registration in the system.
- Supervision of evolution and warnings
  - Which may lead to any intervention according to the clinics procedure (registered in the internal system of the clinic).

Table 50 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Phases 2-4 collect feedback from final users and professionals.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	ROSA has its own terms of use and services policy. In the pilots, it is used as a research tool.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	ROSA has its own privacy policy. In the pilots, the use of ROSA will be compliance with GDPR.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	ROSA is composed of several modules, not all them needed depending on the scenario.
SPS-017	SHAPES platform shall support its inherent sustainability.	Y	ROSA usage is for the reduction of hospitalisations.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	ROSA has own APIs with interoperability standards.
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	ROSA can put in contact older people, caregivers and professionals. It allows the collection of data from other social/medical services.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	ROSA will include Spanish and German.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	ROSA will include usage documentation and tips while using the technology.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	ROSA collects, shares and processes health data.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	ROSA complies wit GDPR.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	ROSA estores data in health site host.
SPS-040	Medication tracking should be suported.	Y	Medication and adherence to medicines are tracked in ROSA.
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.)	Y	ROSA supports analysis of weight data.
SPS-042	The SHAPES Platform should support manual data entry.	Y	ROSA supports manual entry of health data.
SPS-044	SHAPES should support use of questionnaires as self-assessment tools.	Y	ROSA's chatbot provides questionnaires.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	ROSA provides indicators when values are out of range.
SPS-051	SHAPES should support predictive medicines.	Y	ROSA is designed to prevent decompensations.
SPS-053	SHAPES access devices may be user friendly	Y	ROSA conversations can be programmed to be fiendly and empathic.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-055	Voice and chat interaction should be supported using chatbots.	Y	ROSA offers mobile interface for chat and options for voice interaction.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	ROSA conversations are designed to be motivating.
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.		ROSA professional dashboard allows management of patient profile.
SPS-080	SHAPES should provide training material for care providers.	Y	ROSA will include usage documentation.
SPS-081	SHAPES should provide WEB access from desktop/laptop/smartphone and tablet.	Y	ROSA's professional dashboard can be accessed by web from any device.
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	ROSA conversations can mention what was understood so the user can validate.
SPS-123	SHAPES shall offer a choice of multi-cultural avatars to represent users.	Y	ROSA conversation can include different synonyms representing way of speaking of different users.
SPS-126	SHAPES shall offer traceability of personal data.	Y	Source of data is registered in ROSA's database.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	ROSA is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	ROSA complies with relevant cybersecurity rules.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	Phases 2-4 collects feedback for user-friendly interface.
SPS-136	SHAPES user interface to resemble technologies used	Y	ROSA resembles commonly used

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	by elderly in their every-day-lives.		messaging mobile apps.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	All ROSA app actions can be done with one sentence or two clicks.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	ROSA follows a data minimisation policy by design.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	ROSA follows a data minimisation policy by design.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	ROSA complies with GDPR.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	ROSA complies with GDPR.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	User logins ROSA through a password-based authentication system.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	ROSA consists of several modules.
SPS-160	SHAPES platform shall suport adaptation to needs of care ecosystem.	Y	ROSA can adapt to different questionnaires.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	All interfaces of ROSA are accessible 24/7.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	Activities can be resumed after networks reestablishment.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	ROSA app notifies lost of internet connection.
SPS-166	SHAPES should support self-updates.	Y	ROSA mobile app can be updated automatically.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	ROSA has a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	ROSA comes with a usage guide which includes an installation manual.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	Phases 2-4 collects feedback to reach full self-explanatory GUIs.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	Access to data in ROSA's DB requires authorisation.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	Exchange of medical data between ROSA and other digital solutions is supported by APIs.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	Transferred data is encrypted.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	ROSA has its own terms of use and services policy. In the pilots, it is used as a research tool.

Table 51 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
There will be a protocol to deduce missing data in ROSA database	Because VICOM's predictor needs data for every single day, days in which the questions are not answer will be deduced under the hypothesis the older person feels well.	Y	Data gaps will be compensated while transferring to VICOM HFpred along with protocol ID. Data gaps will not be filled in the database.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
ROSA communication with VICOM's heart failure predictor	ROSA backend sends data that VICOM's heart failure predictor needs to compute the % or decompensation risk.	Y	
ROSA communication with eCare server	Vitals will be stored in ROSA's database (as they are needed for VICOM's prediction). They will be collected from eCare server.	Y	
Rosa communication with VICOM's Adilib	The dialog flow will be programmed in Adilib framework.	Y	
eCare App and ROSA App are embedded in a single App (SHAPES)	User will access the functionalities through a single App (SHAPES App).	Y	
Login through SHAPES platform	User and password are checked through connectivity with SHAPES platform (ASAPA module).	Y	
Answers of questions are sent to ROSA's database	Answers are collected for monitoring by health care professional.	Y	Data is displayed in bar charts in the professionals' dashboard.
App user will be able to launch questionnaires at any time.	The App user will have the option to launch questionnaires at any time.	Y	Both by asking the chat and menu selection.
Healthcare professional will be able to monitor answers	Dashboard will plot history of answers to questionnaires.	Y	Bar charts.
Dashboard: Indicators based on answers	Some answers will be highlighted in the health care professional dashboard.	Y	Using different colours for bars at specific days.
Healthcare professional will be able to introduce data in the dashboard	Healthcare professional will introduce data into the system through the dashboard: medicines, updates of lab tests,	Y	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	medical visits and hospital admissions.		
There will be a protocol to deduce missing data in ROSA database	Because VICOM's predictor needs data for every single day, days in which the questions are not answer will be deduced under the hypothesis the older person feels well.	Y	Data gaps will be compensated while transferring to VICOM HFpred along with protocol ID. Data gaps will not be filled in the database.
ROSA communication with VICOM's heart failure predictor	ROSA backend sends data that VICOM's heart failure predictor needs to compute the % or decompensation risk.	Y	
ROSA communication with eCare server	Vitals will be stored in ROSA's database (as they are needed for VICOM's prediction). They will be collected from eCare server.	Y	

4.10.5.2 *Design and Development Stage*

Mock-ups of ROSA App were prepared for presentations at the phase 2 of the use case. They were displayed in a power point presentation:

Figure 97 - Representation of Mock-ups Shown to Participants of Phase 2 of the Use Case

Feedback given by participants in the presentation were:

Table 52 - User Feedback on PT3-UC001

Topic	Older person (number)	HCP
Do you see yourself chatting with a chatbot?	No (1) Yes (2)	

Topic	Older person (number)	HCP
Would you prefer to type to chatbot or by voice?	Does not know (1) Both (1) Voice (1)	
Would you prefer to read chatbot messages or that chatbot talks?	Chatbot talks. But also to have messages in text if he does not understand (1) Both (1) To read (1)	
Would you prefer the chatbot's voice to be male or female?	Older person (1) Caregiver (2)	
Would you answer daily questions?	Once a week only (2) Yes (1)	Formulation of questions looks OK. May depend on the patient She thinks patients/caregivers will get tired of answering every day after a month. A protocol could be: starting daily questions, then every 2 weeks, then monthly. They could have training.
Any preferred time to answer the questions?	Anytime. But no pressure to answer immediately (1) After 6 pm (1) In the morning (1)	
What days you won't be able to answer the questions?	Many, when I do not feel well (1) If she cannot answer one day, she can do it next day. If there is an emergency	
Who could answer the questions when the usual person is not available?	None (3) If she leaves, she returns the same day. Sleeping in older person's home. (1)	
How many days a month the answer of a daily question will be 'red'?	5 (1) 1 every 3 months (1) 1 every month, swollen legs (1)	
The day you have to answer all the questions, are they too much?	Yes (1) No (2)	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Topic	Older person (number)	HCP
What is the maximum frequency you would like to answer all the 16 questions?	Once a week (2) Once-twice a month (1)	
Would you like the chatbot to tell you any health tips?	Yes (3)	Yes
Would you like to have reminders?	No (2) Yes (1)	In some cases.
What type of reminders?	Medical appointments	Medication. Punctual reminders, not regular most likely. Most useful, mixed with how to take them, for example, before/after meals
Would you like to receive alerts if reminder message is not acknowledged?		No

The key points extracted from the presentations were:

- Low e-literacy but they have smartphone and they feel comfortable with the options they use.
- Would not participate if it triggers anxiety.
- Too much information in App would be stressing.
- There should be no obligations.
- "I'm not gonna use it if I feel bad that day".
- Weekly questions are preferred.
- App should be configurable to user expectations (show/hide, on/off options).
- App should be compatible with Android accessibility configurations (font, size, zoom).
- The protocol for the questionnaires should be adaptable to the user's needs:
  - User may trigger questionnaires just when feeling bad;
  - Buttons in chatbot to trigger questionnaires.

After the mock-up presentations, the ROSA App evolved to include the users' feedback, also represented in the requirements table above. ROSA and eCare Apps have been integrated in the single SHAPES App, with login through the SHAPES platform (Figure 98). In addition, the App layout and colouring have been adapted to SHAPES design (Figure 99). Finally, an option has been added to launch the questionnaires at any time (Figure 100).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 98 - Login and Main Screen of SHAPES App for PT3-UC001 embedding ROSA and eCare Apps

Figure 99 - Look and Feel of ROSA App

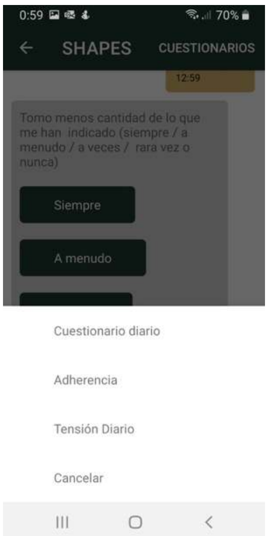


Figure 100 - Option in ROSA App to Launch Questionnaires Manually

4.11DigiRoom (OMN)

Omnitor’s DigiRoom is a digital meeting room based on WebRTC (web-based real-time communications). DigiRoom is a generic meeting room built to be easy to integrate with digital solutions and platforms lacking that functionality. An API is provided to enable smooth integration with DigiRoom. The digital meeting room is encrypted end-to-end.

Figure 101 - DigiRoom Solution by OMN

Table 53 - DigiRoom Data

Data Category	Measurements Type	Collection Method
Internet Data	Room ID/link Settings DigiRoom connection & Calls Connection status	Automated (from connected devices)
Data to Industrial Devices	Can be connected to NOTiFY	Automated (from connected devices) or manual
Data from Industrial Devices	Join other DigiRoom meetings Meetings statistics	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)

4.11.1Technical Specifications

Omnitor DigiRoom is based on WebRTC. WebRTC enables the creation of calls without a dedicated application. It can be run on almost all modern platforms thanks

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

to the widespread adoption of WebRTC. Future enhancements can easily be deployed to all users without their involvement.

Technical requirements for the DigiRoom;

- Relatively modern smartphone/ tablet/ computer.
- A browser that supports WebRTC (any modern browser). The latest version of Chrome, Firefox, or Safari recommended.

4.11.2 Interfaces and Interoperability

Table 54 - Summarised Technical Description of DigiRoom

General Description	• Omnitor DigiRoom is a digital meeting room based on WebRTC. • DigiRoom is a generic meeting room that is built to be easy to integrate with digital solutions and platforms lacking that functionality. • API is provided to enable smooth integration with DigiRoom.
Features	• Integrated into platforms and services that need a digital video meeting room for two participants (could be more). Typical use cases; meetings between doctor-patient, veterinarian-pet owner, customer support-customer. • DigiRoom is a web-based meeting room that supports video, audio, and file sharing (soon chat). The meeting is accessed using a unique link. • No installation is required, only a web browser. It works on Windows 10, iOS, Android and Mac OS. • Built to be easy to integrate - API is provided to make it easy to create meetings.
Application Areas	• Conversation tool • Instruction tool
TRL	From TRL7
Data Type	NoSQL
Inputs	Room start/close
Outputs	Room ID, Room start/close, Feedback
Actions to be performed	• User will be able to generate a link which creates a room where two participants can have a meeting.
Interface	PC, smartphone, tablet

4.11.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

4.11.4 Adaptation to Pilot Use Cases

Some adaptations for PT1 are necessary, this is mainly due to that DigiRoom and ARI Robot (PAL Robotics) have some compatibility issues with accessing the camera.

4.11.4.1 Concept and Ideation Stage

At this stage, no solutions have been reached, troubleshooting has already begun, and further development is needed.

Table 55 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	DigiRoom already has a dedicated user manual with relevant instructions on the use of the service.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	DigiRoom complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	DigiRoom stores all data in a EU Member States.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	DigiRoom supports mobile and web-based platforms and devices.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	DigiRoom is designed with privacy by design.
SPS-131	The SHAPES Platform shall comply with common minimum	Y	DigiRoom complies with relevant

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	cybersecurity rules for mobile and online services.		cybersecurity rules for mobile and online services.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	DigiRoom offers user friendly and attractive interfaces.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	DigiRoom offers user friendly interfaces for all users.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	DigiRoom provides an easy installation.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	DigiRoom is accessible by Android-based mobile devices.

4.11.4.2 Design and Development Stage

This is still an early development stage to solve the issue with the camera and microphone.

4.11.4.3 Prototyping and Adaptation Stage

A prototype where ARI Robot uses its front-touch screen to access a video call has been evaluated. However, as mentioned above where the problem lies within integration with ARI Robot's camera and microphone.

The next step will to be fully integrate ARI Robot with DigiRoom.

4.12 DanceMove (UAVR)

DanceMove is a digital solution that includes a dancing surface and respective software that allows for the personalising of dance choreographies while assesses the performance of the user during the choreography.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

DanceMove is based on the concept of the commercial solution STEPMANIA, which is a free dance and rhythm game for multiple platforms, but it has an adapted interface to meet the expectations and needs of older adults.

DanceMove allows for the choice of the music and the difficulty level in line with users' preferences and characteristics. The user performs a specific movement in a specific sequence and, therefore, requires the users' attention and memory, i.e., DanceMove integrates both a physical and a cognitive component into a ludic and appealing social activity (dancing). It is adaptable to the end-users physical and cognitive functioning, but also their culture and preferences.

To play DanceMove, the user should pay attention to the arrows that scroll upwards on the screen and when they meet a stationary set of target arrows, the player should press the corresponding arrows on their dance mat. The movement of the arrows is defined based on the beat of the song (see Figure 102). The player performance is scored based upon how accurately he can trigger the arrows in time. If the player has an excellent or poor performance, the software triggers motivation messages.

Figure 102 - DanceMove

4.12.1 Technical Specifications

The minimum system requirements are:

- Windows 7; Linux; Mac OS X 10.6+;
- 2GB MB of RAM;
- 700MHz minimum (Multi-core recommended);

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Video card with support for 16-bit colour, 128MB video RAM and OpenGL 2.1 or higher;
- DirectX 9.0 or later (Windows only);
- Sound card;
- Dance mate;
- Internet connection.

4.12.2 Interfaces and Interoperability

DanceMove digital solution includes a dance mat and a software that run on a browser. The data collected during game section feeds the DanceMove Database. The data collected can feed a third-party database enabling the exchange of information. In the scope of SHAPES Project, DanceMove digital solution interoperates with SHAPES platform through eCare. An interchange protocol was developed allowing DanceMove to store data in eCare digital solution and eCare to collect data about users' performance in DanceMove database. The protocol uses HTTP to exchange messages, in a bidirectional way that allows, for example, the users' login and the registration of personal and clinical data. The DanceMove can be accessed via eCare or directly on DanceMove i.e., the user can login on eCare and be directed to DanceMove or login directly on DanceMove.

4.12.3 Applicable Pilot Themes

- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

4.12.4 Adaptations for PT4-UC001

4.12.4.1 Concept and Ideation Stage

This pilot theme focusses on the psycho-social and cognitive stimulation through a technological solution that engages older adults in a ludic activity (dance). The dance intervention can be adjusted according to individual characteristics (e.g., age, physical limitations, cognitive limitations).

The applicable persona(s) are older individuals living in the community including:

1. Active, healthy older adults, satisfactory financial standing and social relationships;
2. Older adults with mild chronic conditions, some reliance on spouses or children;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

3. Older adults with chronic musculoskeletal disorders, risk of isolation.

For the implementation of this use case the user requirements listed in the following table were specified.

Table 56 - Applicable User Requirements

#	User Requirements
UR-02	AIM1: Combine physical and cognitive interventions to promote physical and cognitive functioning through dance with impact in psycho-social functioning.
UR-03	AIM2: Adapt the intervention to end-users physical and cognitive functioning, but also their culture and preferences.
UR-04	AIM3: Captures data regarding users' performance.
UR-05	AIM4: Gain the older individuals' trust and acceptance and provide a good interaction experience.
UR-06	AIM5: Increase the amount of cognitive and physical training of senior participants.
UR-07	HOW1: Conduct dance sessions using DanceMove to promote physical and cognitive training.
UR-08	HOW2: Offer a variability of songs and choreographies that adapt to the different characteristics of the users, whether in physical or cognitive terms and musical and dance preferences.
UR-09	HOW3: Use the DanceMove rug to collect the performance data of the participants' dances.
UR-10	HOW4: Provide an easy-to-use and appealing interface.
UR-11	HOW5: Through a playful activity (dance) increase training.

Table 57 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	The DanceMove login is made by name and pin, or using SHAPES unique ID.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information other than dance performance is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The DanceMove has been designed following accepted cybersecurity paradigms.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	The DanceMove interface development followed the good practices for user interface design within SHAPES digital solutions.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	DanceMove uses feet interaction that can be easier in some types of impairment.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information other than dance performance is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 58 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Interoperability with eCare	DanceMove is integrated and exchanges information with eCare.	Y	The protocol uses HTTP to exchange messages, in a bidirectional way that allows, for example, the users' login and the registration of personal and clinical data.
Internet connection	Computer with internet connection required.	Y	The dance mat connects to the computer via USB and the game runs on a browser.
2GB of RAM	Device with at least 2GB of RAM memory.	Y	To avoid memory overload 2GB is the minimum recommended.

4.12.4.2 Design and Development Stage

The DanceMove interface design process was based in an iterative process where several mock-ups were created and tested. The history of mock-ups and improvement rationale is described below.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

1. Explanation screens

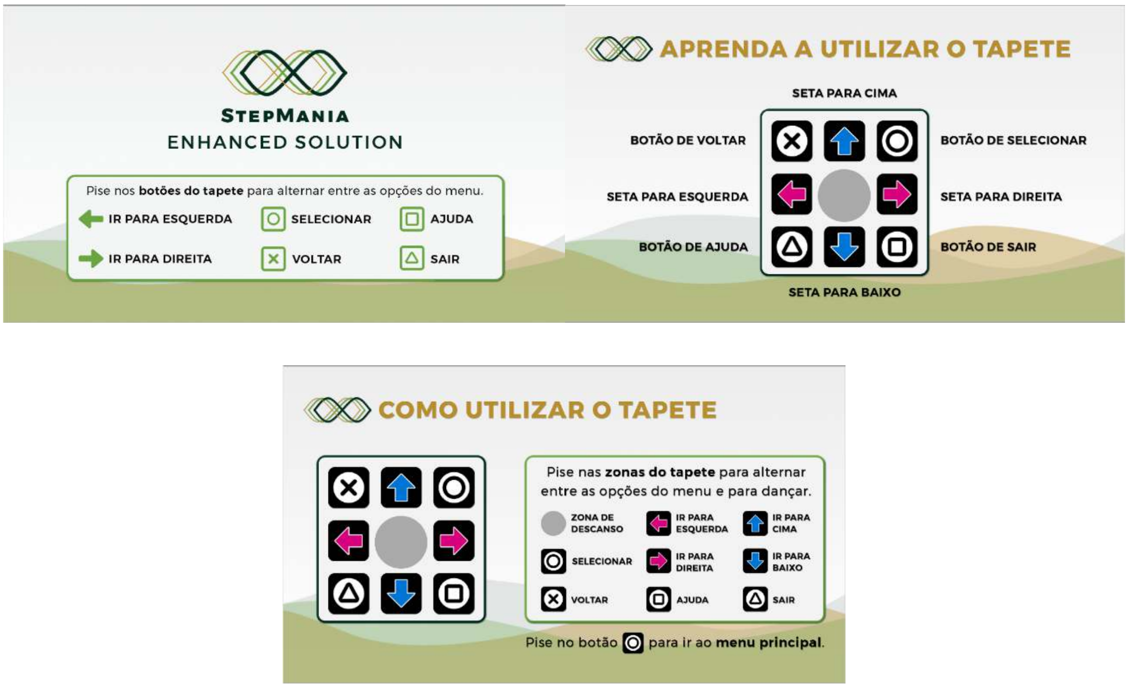


Figure 103 - Explanation Screens

The explanation screens were improved to facilitate the understanding of the buttons. The image of the mat was replicated on the screen for the user to recognise not only the image of the buttons but also their location on the mat (

Figure 103).

2. Music selection

Figure 104 - Music Selection

Initially, the DanceMove had 3 levels of difficulty for each song (easy, medium and difficult), however based on the mock-up tests results, each song was then categorised only in one of the levels (Figure 104).

3. Game

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

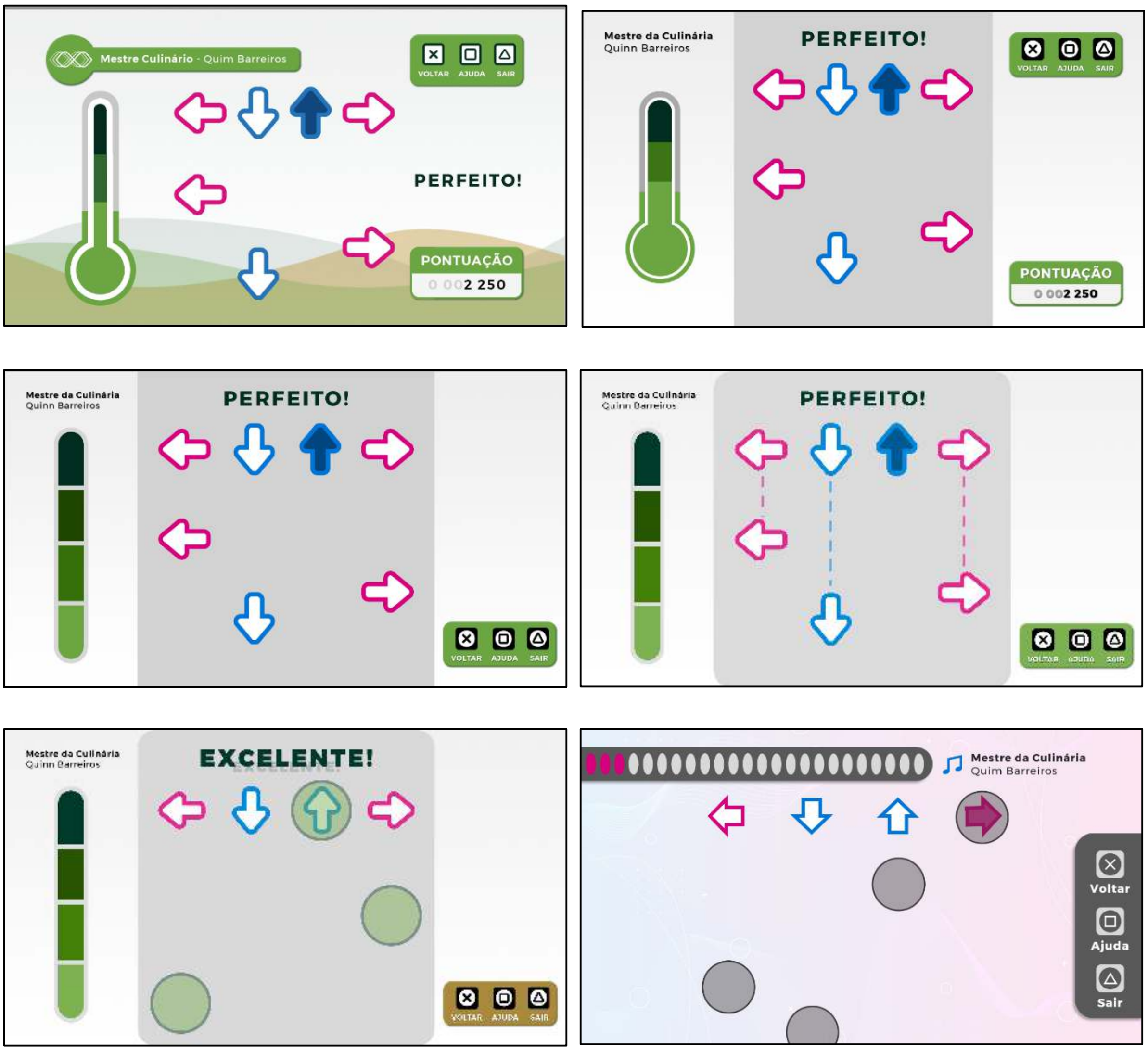


Figure 105 - Game Screens

Regarding the game screens, to facilitate understanding, the background was removed, and a canvas was placed on the playing field so that the user could focus attention only on this field (Figure 105).

The total score was removed from the game screen and placed only at the end of the game. The format of the timer was also changed to one that conveyed the idea of the game's progression (the original looked like a thermometer).

To make it easier, a dashed line was used to indicate the “path” of the arrows.

To improve the understanding of the game, instead of the arrows coming from below and overlapping the arrows on the screen, a neutral symbol (without direction) in this case has been replaced by a circle. The goal was to reduce confusion by the number of arrows that are on the screen at the same time. The tests showed that this was not accurate and that arrows make it easier for the user to know the direction of the arrow they will have to trigger.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

4. Performance and scoring

Figure 106 - Performance and Scoring Screens

The performance was changed from a score to a percentage of correct steps (Figure 106).

In addition to the dance score, it was also included an option to consult the session score.

Motivational messages were added according to the score obtained. For example, message to:

- <50% correct steps – Keep dancing.
- Between 50 and 70% correct steps – Good dance moves.
- >70% correct steps – Congratulations! Excellent dance moves.

A different version Mock-up of the DanceMove interface representing the emulation of the mat on the screen was also created.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Mock-up 1

Figure 107 - Mock-up 1

Mock-up 2

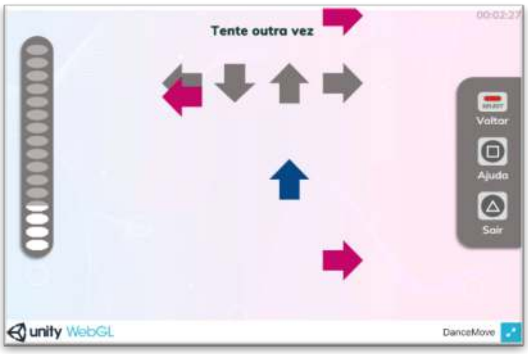


Figure 108 - Mock-up 2

To choose between two interface possibilities that arose from the mock-up phase, UAVR conducted A/B tests with experts on physiotherapy, gerontology and psychology. The primary objective of this study was to assess which of two interfaces better fulfil the objective of performing physical and cognitive training for older persons.

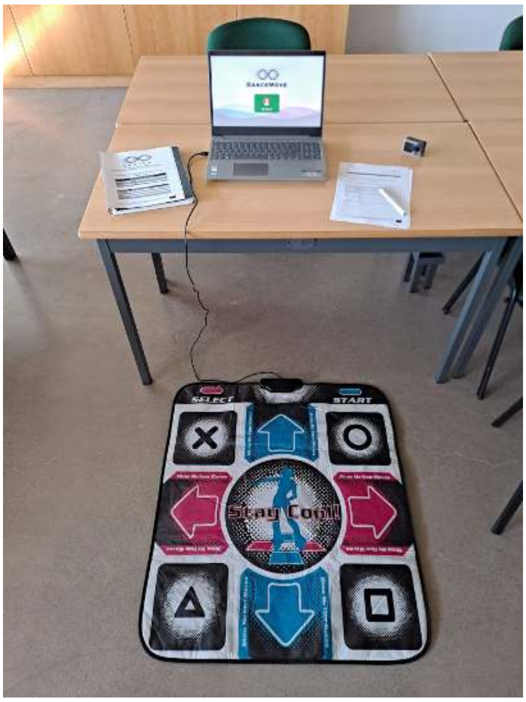


Figure 109 - DanceMove Test Set-up

Figure 110 - DanceMove Test

UAVR conducted tests with 5 participants (two physiotherapists, two gerontologists and one psychologist) and the procedures for each evaluation moment were:

1) Pre-test: the researcher explains the study objectives, clarifies any doubts that the participant may have and request informed consent signature and the filling of the sociodemographic questionnaire.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

2) Test: Throughout the test, the evaluator must encourage the verbalisation of the participant's thoughts, without judgment, there are no right or wrong answers:
   a) Intuitiveness - The evaluator explains the objectives of DanceMove, presents interface number 1 and asks the participant to interact freely (without detailing how the interaction with the mat is made, to evaluate the intuitiveness). After a few moments, when the participant is already satisfied and has already managed to interact satisfactorily, the evaluator presents interface number 2 and asks the participant to repeat the procedure and interact freely. The evaluator must record aspects related to the participant's ease or difficulty in perceiving the interaction mechanism with the interfaces and the time each participant took to understand the interaction mechanism. The order of testing the interfaces should be alternated, i.e., the participant 1 starts with interface number 1, the participant 2 starts with interface number 2, the participant 3 starts with interface number 1, and so on.
   b) Mock-up selection - The evaluator asks the participant to, considering the objectives and the target audience of the system, decide which interface is most appropriate and why. The participant continues to interact freely with the chosen interface.
3) Post-test - The evaluator interviews the participant following the script.

The results showed that the interface from Mock-up 2 was the best fitted to perform physical and cognitive training for older persons. Participants considered that this Mock-up 2 is more challenging from a cognitive point of view and allows for a higher dancing speed. Mock-up 1 was excluded because it limited the maximum speed of the game and therefore the choreography. Also, because there were too many elements on the screen (too much visual noise). During A/B tests, experts recommended some adaptations namely:

- Minimise the risk of falls associated. Place a non-slip net under the rug. It can be a danger on slippery ground.
- It would be good to have bars, a chair with a good support base or to do the exercises against a wall where the person can support if needed. Perhaps the caregiver can be on the other side to provide support also.
- The size of the screen should be large.
- The first few times users must have supervision.

4.12.4.3 Prototyping and Adaptation Stage

The primary parameters to be measured in the DanceMove prototyping and adaptation stage is detailed in the following table. This information is collected in DanceMove and analysed and presented in eCare.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 59 - Parameters to be monitored/measured by DanceMove

#	Parameters to be monitored/measured
UR-12	Number of logins
UR-13	Date of logins
UR-14	Number of correct and wrong dance steps
UR-15	Number of correct and wrong dance steps (front)
UR-16	Number of correct and wrong dance steps (back)
UR-17	Number of correct and wrong dance steps (right)
UR-18	Number of correct and wrong dance steps (left)
UR- 19	Dances performed in each session
UR- 20	Score per dance
UR- 21	Score per session
UR- 22	Type of interaction: continuous or erratic
UR- 23	Total number of sessions;
UR- 24	Average score of the various sessions;
UR- 25	Number of right or wrong answers per session (left, right, front, back, global).
UR- 26	Number of sessions with erratic interaction; • Frequency; • Average duration; • Number of dances; Type of dances selected (difficulty).

The diagram shown in Figure 111 illustrates the data flow in DanceMove. The data is collected using the dance mat, sent to DanceMove that is connected with the eCare. The relation between both is bidirectional and information exchanged includes user data and user performance.

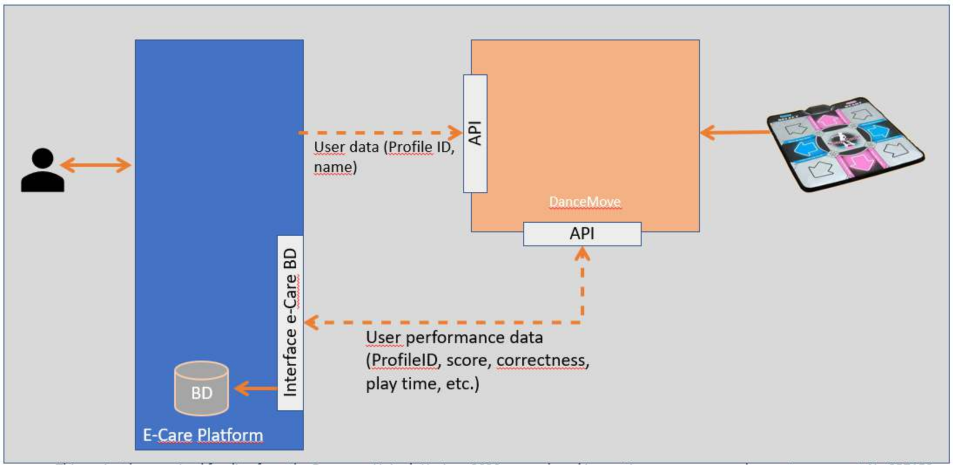


Figure 111 - DanceMove Component Diagram

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The final visual design of the DanceMove interface was inspired on the colours of the dance mat and followed the good practices for user interface design within SHAPES digital solutions as stated in D5.1 – *SHAPES User Experience Design and Guidelines and Evaluation* [4]. Prints of the final graphical user interface are presented in Figure 112.

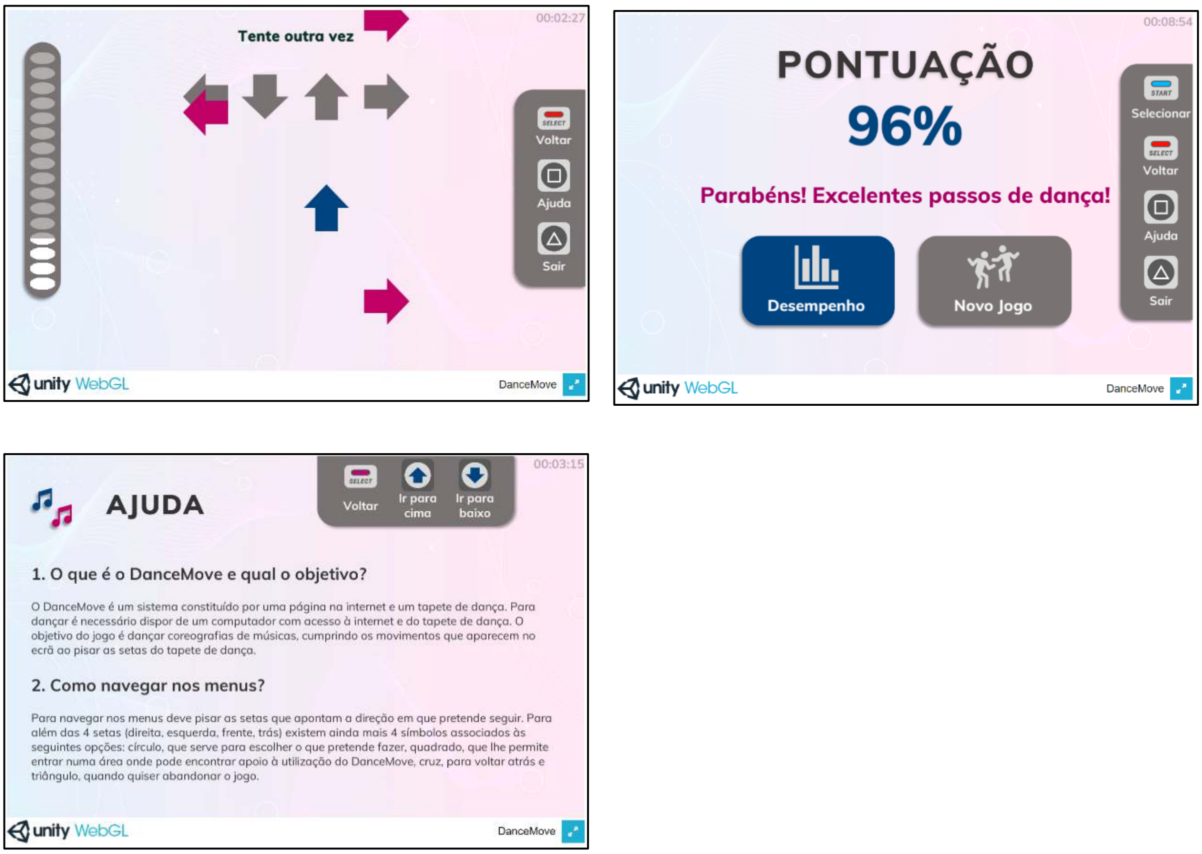


Figure 112 - Final Visual Design of the DanceMove User Interfaces

The diagram in Figure 113 presents the data model for the DanceMove. The involved concepts include:

- Prescription – weekly training plan (example: dancing 3 times a week for 30 min with easy difficulty level).
- Session – dance time performed in the interval between login and logout.
- Dance – set of a song and a choreography.
- Performance – the results of the participants dance, including the correct and incorrect moves.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

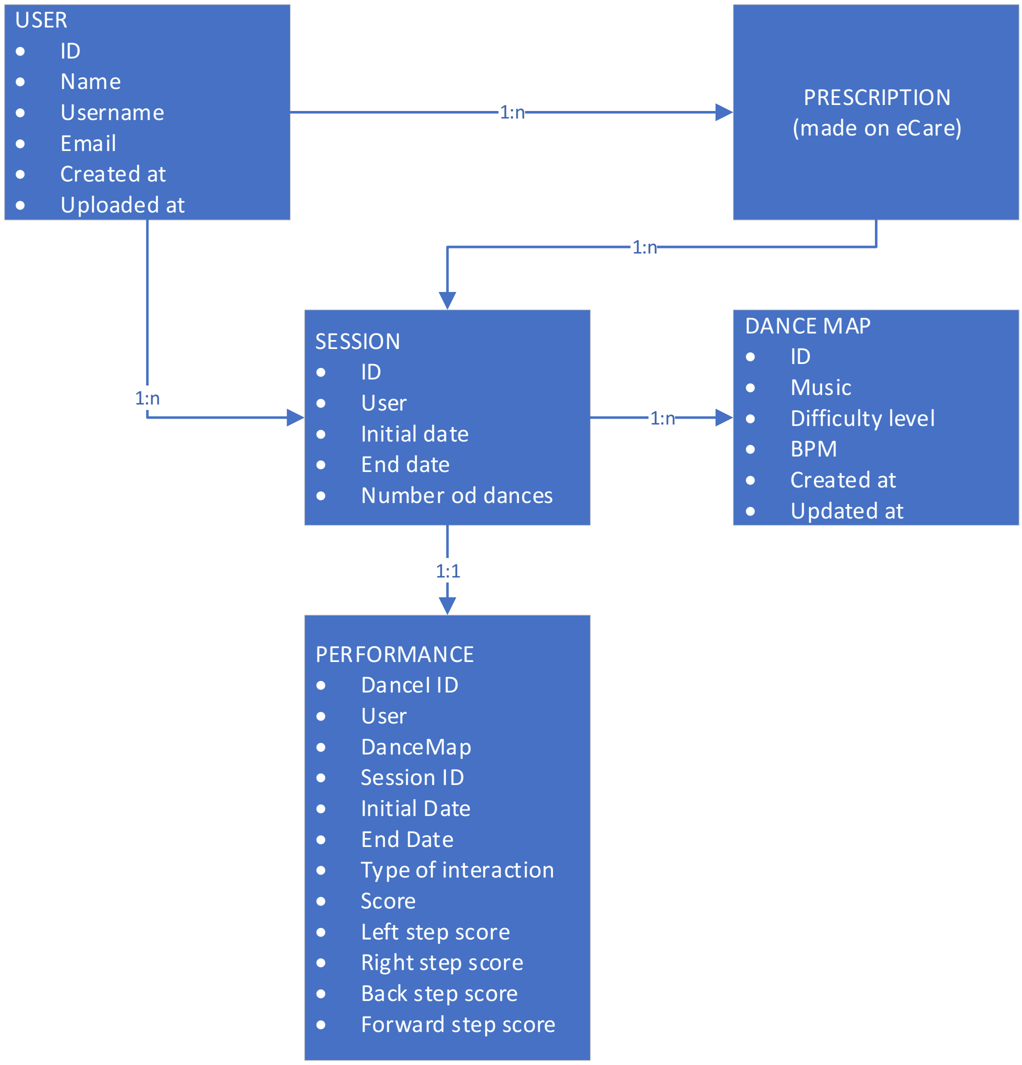
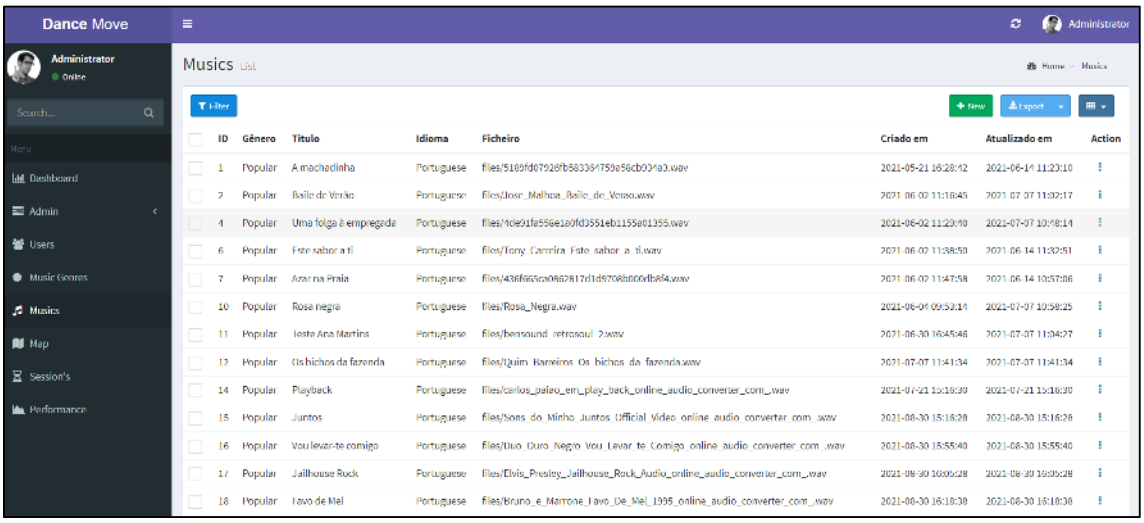


Figure 113 - DanceMove Data Model

Figure 114 present prints of the backoffice of DanceMove.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

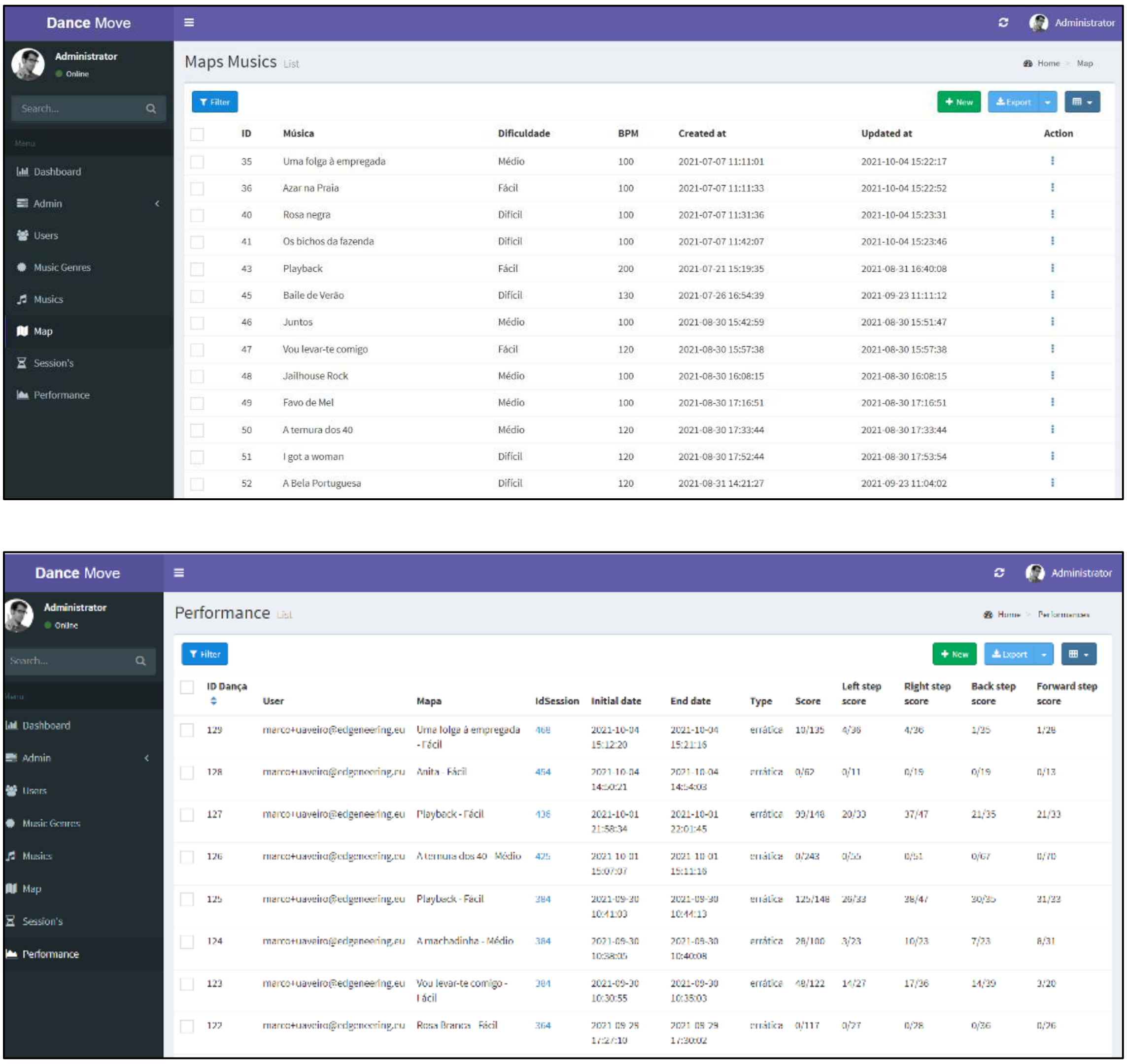


Figure 114 - DanceMove Backoffice

5 Robotics and Assistive Technologies (Task 5.4)

Task 5.4 presents the different digital solutions which are integrated to the robots provided by PAL Robotics and KOMPAÏ within the SHAPES Project. It should be noted that additional solutions may also be integrated later on as the project evolves and if further requirements need to be met.

It is undeniable that the use of robots is gaining importance in the past years, and especially so in the health sector, in order to use personal assistive robots. These types of robots have navigation abilities that, unlike digital assistants, make them possible to approach people, move around the user's apartment or an area and prompt the user to interact with it in a socially engaging way by both verbal and non-verbal behaviours, like this also reducing loneliness. They can serve to remind people to do tasks, play games with them for entertainment or therapeutic purposes; carry out assessments, or monitor them through their cameras in order to detect anomalies. These robots have a set of sensors, such as cameras, to recognise and detect people and objects; map and navigate around an area; speech abilities, and, in the case of a manipulator, the ability to help in physical tasks like fetching objects. All in all, reducing the need of physical human-to-human contact.

In SHAPES, these robots will serve as communication means between other digital solutions such as speech recognition systems, vision-based systems, and the end-user, also adjusting the robot's behaviour and interaction to suit each use case. These solutions are presented from section 5.1 to section 5.10.

5.1 ARI and TIAGo robots (PAL)

PAL Robotics is offering two possible robots to SHAPES, the most suitable one for each use case will be chosen based on the requirements of the pilot sites. In general:

- **TIAGo robot** for manipulation abilities and physical tasks;
- **ARI robot** for cases where no manipulation is needed as it promotes further social interaction.

Integration of SHAPES Digital Solutions onto the robot would be the same for both robots.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

TIAGo (http://pal-robotics.com/robots/tiago/)

Figure 115 - TIAGO robot, from PAL

TIAGo (Figure 115) is provided with a mobile base, a lifting torso, a head, an articulated arm with a dexterous hand. TIAGo has a modular design and can be configured based on our customers' needs. The arm has a large manipulation workspace, being able to reach the ground as well as high shelves. The end effector can be a gripper or a humanoid hand and they can be quickly exchanged or substituted with a third-party development. TIAGo arm can be controlled in effort mode (Sensorless torque control) and if provided with the force/torque sensor it can be controlled with admittance control. The robot's arm has 7 degrees of freedom in total, including the 3 at the wrist. There is an option of 5 fingers underactuated hand or parallel gripper.

The robot can be used to provide a personal robot assistant that helps patients with a wide range of practical tasks, both in hospitals, rehabilitation centres and the patients' own home. The robot can create a semantic map of the apartment to learn more about an object or a location. The robot can handle a set of known and unknown visitors, who will arrive individually at the home entrance and recognise people. The robot can provide general purpose requests of the person inside the apartment or day-care hospital, focusing on interaction as well as manipulation tasks, like fetching simple objects.

ARI Robot (http://pal-robotics.com/robots/ari/)

ARI is a high-performance robotic platform designed for a wide range of multimodal expressive gestures and behaviour, focused on social interaction. Its behaviour can be customised using the easy-to-use web interface provided.

ARI can be integrated with different speech recognisers like this enabling it to interact in many languages, recognise faces, make gestures, and show information/application on the touchscreen on its chest for user interaction and multimedia content, as well as being fitted with a voice and facial recognition system. It can locate itself inside a building and move around while avoiding obstacles in its path.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 116 - ARI robot, from PAL

ARI is provided with a mobile base, torso with an integrated Linux-based tablet, two arms and a head with expressive gaze. It can be manufactured in different colours (e.g. orange, red, blue) and can be configured based on the needs of SHAPES - the touch-screen if needed can be positioned externally or with the option to remove it to facilitate its interaction. ARI's two arms are mainly to promote gesture-based communication.

ARI has navigation capabilities thanks to its Realsense D345 camera on its torso, using feature-based SLAM. ARI is also equipped with RGB-D cameras and microphone array that can be used for vision and audio capabilities.

ARI comes with a comprehensive set of Robotics Operating System (ROS) software and documentation, specifically Ubuntu 18.04 and ROS Melodic, with the option to test the robot on simulation (Gazebo), like the TIAGo robot.

With an integrated NVIDIA Pascal GPU, it is a powerful platform that can be used to develop AI algorithms, and can be equipped with text-to-speech software and human face detection and tracking capabilities, to name a few examples.

As a social robot ARI can serve as a therapeutic assistant at hospitals, care-homes or end-user homes to foster social communication, reduce loneliness, stress, and increase overall user entertainment. It can be connected to other AI systems, such as virtual assistants with robust natural language processing (NLP) systems, emotion and facial recognition systems, to engage in verbal communication and improve human-robot interaction. Thanks to facial recognition, the robot can authenticate the user and provide customised care.

Users can interact with ARI through its tablet, can use it to communicate with friends and family by video calls, and to play games such as cognitive games to improve their cognitive abilities. The caregiver can arrange an agenda for each user and input the user profile into the robot, so that the robot can provide personalised timely reminders -medical appointments, the need to play a specific game, and user-specific activities. ARI can help by creating a map of the user's apartment and locating different objects

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

there, in order for instance to remind the user of their location and guide them around the house, or provide instructions on how to different activities that they may have trouble doing alone assistance in switching on new home devices.

5.1.1 Technical Specifications

TIAGo

- Mobile base has a Differential drive, Max speed of 1 m/s, operates in indoor environments.
- 15 Degrees of Freedom (without end-effectors), 7 DoF on each arm.
- 64 cm diameter footprint.
- 110-145 cm height.
- 3 kg arm payload (without the end-effector).
- 87 cm arm reach (without end-effector).
- WiFi-Bluetooth connectivity.
- 4-5h (1 battery) / 8-10 h (2 batteries) autonomy.
- Sensors:
  - Laser 5.6/10m / 25 m range, rear sonars 3x1 m range.
  - Head RGB-D camera for perception.
  - IMU.
- Audio: 2-microphone array and 1 audio speaker.
- Software: Ubuntu LTS 64-Bits, working on ROS (Robotics Operating System).
- Possible as add-on: different types of end-effectors, touch-screen, wrist sensor.

ARI

- 165 cm height.
- The mobile base with 2 differential drive wheels and 2 caster wheels, with maximum hardware velocity of 1.5 m/s, but due to the constraints of obstacle avoidance, for navigation it has a maximum speed of 0.5 m/s. Indoor environments, specifically flat ground.
- 14 Degrees of freedom (Figure 117): 4 in each arm, 2 mobile base, 2 head, 1 each hand. Motion builder to create new robot motions and gestures to support its speech, touch-screen content and/or LED lights to improve interaction.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

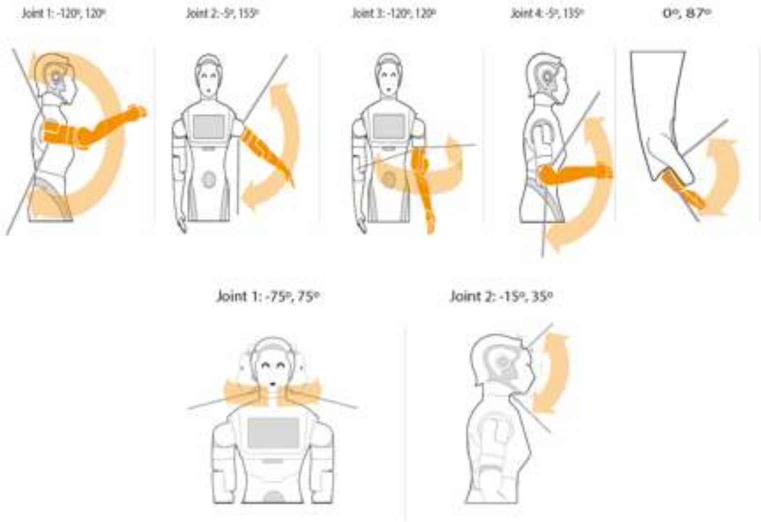


Figure 117 - Degrees of Freedom in the ARI Robot

- Connectivity: WiFi, Bluetooth, Ethernet.
- 0.5 kg arm payload.
- 8-12 h autonomy.
- Cameras:
  - Head RGB camera: especially for perception.
  - Torso RGB-D camera: used for autonomous navigation.
  - Rear stereo-fisheye camera: Currently used for auto-charging behaviour and to be extended for navigation (localisation).
- Audio: 4 microphone array, 2 speakers.
- GPU: NVIDIA Jetson TX2, enabling the deployment of powerful AI algorithms.
- Software: Ubuntu LTS, Robotics Operating System.

Interfaces for interaction:

- Touch-screen: it has incorporated a 10.1’’ touch-screen working on Ubuntu, fixed on the torso. To display data:
  - HTML, CSS, Javascript or other Web Technologies.
  - Pictures loaded robot’s WebGUI.
- LEDs: 2 LED rings on each ear, and 1 at the back. Possible to adjust their intensity, colour.
- LCD animated eyes: at the moment of writing, the eyes move randomly, but could be within scope of project to research how to combine with specific gaze behaviour.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

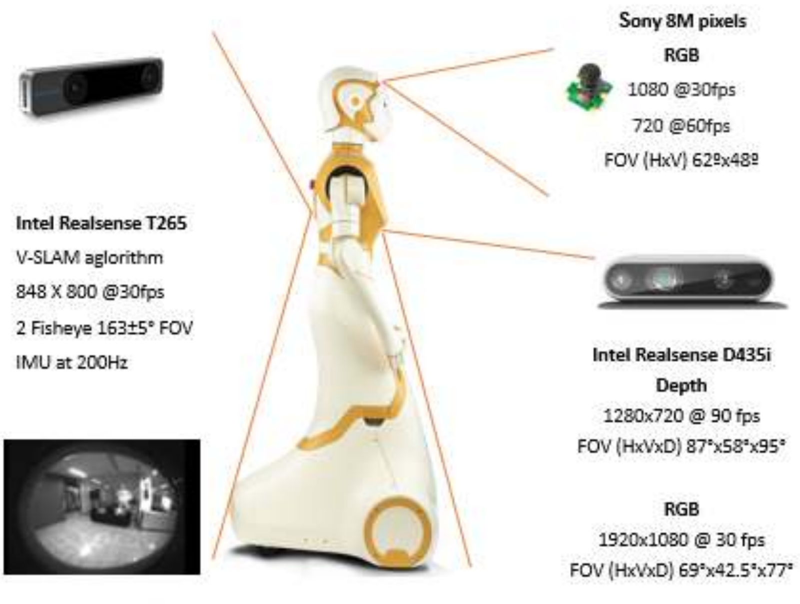


Figure 118 - ARI Robot: Different Components

Set-up and input/output requirements for TIAGo/ARI:

- The robot can set up its own WiFi (access mode) but would need to be connected to an existing WiFi network (Client mode) like this interconnecting with other devices and SHAPES Platform.
- Charging area (room or protected small area).

Existing software implemented (TIAGo/ARI)

- Speech: right now, it is connected to an external TTS/ASR API: Google Speech API, and DeepSpeech. It uses Ubuntu's PulseAudio, with Acapela's TTS, to output speech. Possible to exchange to another speech assistant (e.g. digital solution of SHAPES).
- Auto-charging behaviour.
- Perception: using the head RGB camera, default packages already installed include face recognition using Verilook Face SDK by Neurotechnology, people detection, basic object recognition, augmented reality marker detection.

5.1.2 Interfaces and Interoperability

As the robots are already equipped with some software packages that enable them to perceive people or objects, to autonomously navigate, and to speak, there is no further off-the-shelf software needed. Its behaviour will be programmed for each particular use case and based on the digital solutions that will be integrated in.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Integration with DS

The robots work on ROS and it is possible to code new programs using either Python or C++ as ROS packages. Digital solutions to be integrated onto the robot may be added as ROS nodes, specifying needed ROS messages and actions based on the required input from the sensors and output. For instance, in the case of a digital assistant, it will give as input the sound wave obtained from the robot's microphones (.wav format) and then output from the encapsulated ROS node, the text understood (string format).

The robot also has an extensive REST API so that digital solutions may call its functions externally, enabling the use of other programming languages (e.g. Java, Android).

User interfaces

The functionality of the robot is dependent on the digital solutions to be integrated and the user-case, as it will be adapted to each case in particular. In general, users can interact with ARI/TIAGo through:

- Speech.
- Touch-screen (for ARI).

In the case of ARI, the robot's behaviour can be customised so that it uses a combination of LED lights, gaze behaviour, arm gestures, and touch-screen to provide both verbal and non-verbal interaction behaviour.

The robot can approach the user in question or move around the house/common room using it autonomous navigation abilities.

5.1.3 Applicable Pilot Themes

In bold are the pilot themes that already confirmed the participation of PAL's robots:

- **PT1 – Smart Living Environment for healthy ageing at home;**
- PT2 – Improving In-Home and Community-based Care;
- **PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;**
- PT6 – Physical Rehabilitation at home.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.1.4 Adaptations for PT1-UC004

Based on the requirements of the pilot the ARI robot has been selected. Several adaptations were made to the ARI robot in order to fulfil the needs of PT1-UC004.

A web-based front-end has been completely designed that displays the possible interactions with the robot, and interfaces to connect to the different digital solutions needed, several hardware components have been added, and interfaces using ROS (Robotics Operating System) or Rest to communicate with other digital solutions.

5.1.4.1 Concept and Ideation Stage

Pilot PT1-UC004 is focused on using the ARI robot at individual or sheltered apartments to increase social engagement of older adults, by delivering reminders, suggestions, option to do video calls with caregivers and family, and play games, to name a few examples. For this, the ARI robot will integrate other digital solutions such as Adilib chatbot and wake-up word (VICOM, section 5.8), emotion recognition and fall detection (TREE, sections 5.3, 5.4 and 5.5), Face Recognition (VICOM, section 5.7) with ASAPA (HMU, D4.1), and DigiRoom and eCtouch and (OMN, sections 4.11 and 5.10) for video call.

The applicable SHAPES persona is Helena. Helena is an 82-year-old woman who lives on her own. Her independent lifestyle is supported by the robot ARI, which provides her with assistance in relation to managing reminders and appointments, taking her temperature, managing the shopping list, showing unread messages, and promoting physical activity.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 60 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly	Y	The robot has different interaction modalities such as speech, front touch screen or back tablet.
SPS-128	SHAPES shall support "Privacy by design and by default"	Y	Access to the robot is restricted by SSH.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	A humanoid-shape face, expressive eyes and smooth movement design promotes positive human-robot interaction.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	An additional back android tablet or use of screen-pens for standing and sitting positions in case of video calls.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	The robot has a certain level of autonomous behaviour.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 61 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection	Y	RGB-D camera integrated to detect people.
No code	Face Recognition	Y	RGB-D camera integrated on the head instead of RGB camera for robust verification.
No code	Text-to-speech and speech recognition	N	Microphone and 2 speakers. Speech recognition not yet integrated (Adilib).
No code	Search for person behaviour	Y	Visual navigation system used to build maps and navigate autonomously. For fall detection and delivering reminders.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	Fall Detection and alert system	Y	RGB-D camera integrated for fall detection, Twillio calls integration for voice alerts.
No code	Entertainment games	Y	Rest API provided to communicate games with robot speech, movements.
No code	Video calling system	Y	Back Android tablet added, option to use also front touch-screen.
No code	Personalised reminders and suggestions	N	Mock-up so far, to be added with Adilib skills.
No code	User engagement detection	N	RGB-D camera integrated for face emotion detection.

5.1.4.2 Design and Development Stage

As part of the mock-up, the robot was shown as it spoke with animated gestures, LED effects, eye movement and displaying content on its front touch-screen. New robot gestures were produced for its two arms and head, as well as LED effects (different colours, blink effect, fading effect).

To achieve multi-modality and proactive behaviour, 2 main methods of interaction have been designed:

- Idle behaviour: the older person will approach the robot and ask to begin the interaction using the touchscreen or speech (e.g. "Hello, ARI, can you tell me when my appointment is?").
- Search for user behaviour: robot proactively searches for the user. For this a map of the environment is first produced, clinic personnel then indicate the route of the robot (a list of points to go through), as the robot uses face detection and recognition to find the target person.

As the front-touch screen can be used to display pictures, videos or web-based content, a pilot-specific web-app has been developed as a mock-up, taking into consideration the colours and font size. Example screen where users can select what to do with the robot: games, video call, measure temperature, call or list of events.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Some other mock-ups were shown such as entertainment games, example delivery of a reminder, or physical exercise.

Figure 119 - Mock-up Front-end for PT1-UC004 Menu

Some modifications highlighted during the mock-up interviews were:

- The robot should approach users physically to give reminders, instead of remaining static.
- Non-clinical reminders and suggestions, instead of only delivering medical reminders, e.g. drinking water, social events, hairdresser's appointments, family meetings.
- High preference for video calling instead of phone calling.
- Instead of predefining when the robot will send alerts, option for caregivers to indicate the triggers (e.g. no interaction with the robot, no medication taken, fall detected).
- Menu acquisition for residences, as the main residence of Can Granada prefers to use the robot in common rooms.

5.1.4.3 Prototyping and Adaptation Stage

The ARI robot prototype includes the addition of features needed to evaluate the different requirements of the pilot by:

- Hardware adaptation of the robot.
- Integration of relevant SHAPES digital solutions to endow the robot with advanced abilities: Adlib Chatbot and wake-up word, Face Recognition (VICOM), User engagement and fall detection (TREE).
- Front-end and upgrade of ARI robot features.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Hardware adaptation

A Real Sense RGB-D camera was added to the head of the robot, switching from its original RGB camera, and an external tablet (Android) has been included to be compliant with SHAPES app, mainly eCtouch (OMN). Figure 120 shows the main features integrated on the robot and what kind of hardware component they use.

Figure 120 - Component Architecture of PT1-UC004 and Hardware Components to be used

Integration of SHAPES digital solutions

Figure 121 indicates the high-level integration of the digital solutions. Most of the solutions run locally on the robot, either as ROS nodes or by the robot's Rest API: only Adilib for reminders/follow-ups and speech recognition run externally, as well as the overall SHAPES Platform. Details are included in Deliverable D4.1 [3].

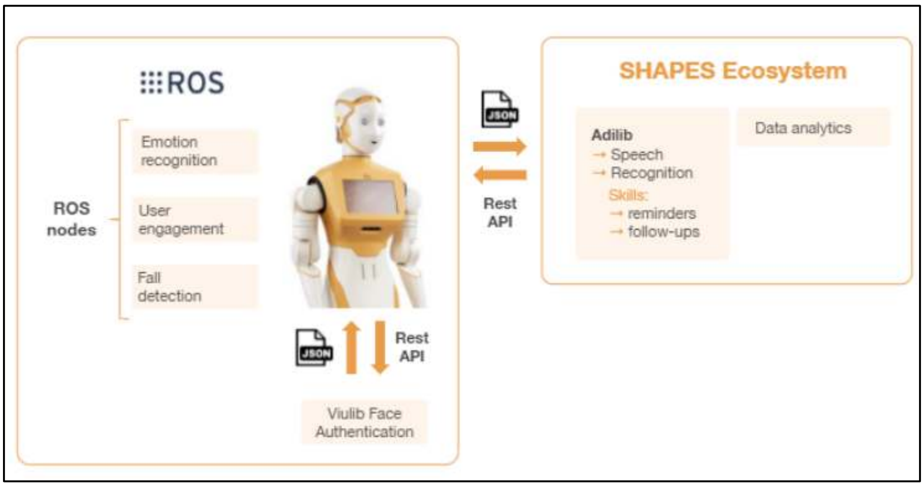


Figure 121 - Software Integration of the Digital Solutions onto the ARI Robot, most of them running as ROS nodes, or else communication done through REST.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Authentication: ASAPA (HMU)

In order to personalise interaction to the user and safe access to user data, the prototype is equipped with SHAPES single-sign-on authentication, consisting of face recognition (VICOM) and username/password based (ASAPA, from HMU).

Integration of the robot with ASAPA is made through the Rest API provided by ASAPA (see Deliverable D4.1 [3]). A web-based front-end is used to retrieve data from the users, visible in Figure 122. In the back-end, it calls the **/auth/login** endpoint. Additional buttons will be added to log out of the system. All the while, the robot provides verbal instructions.

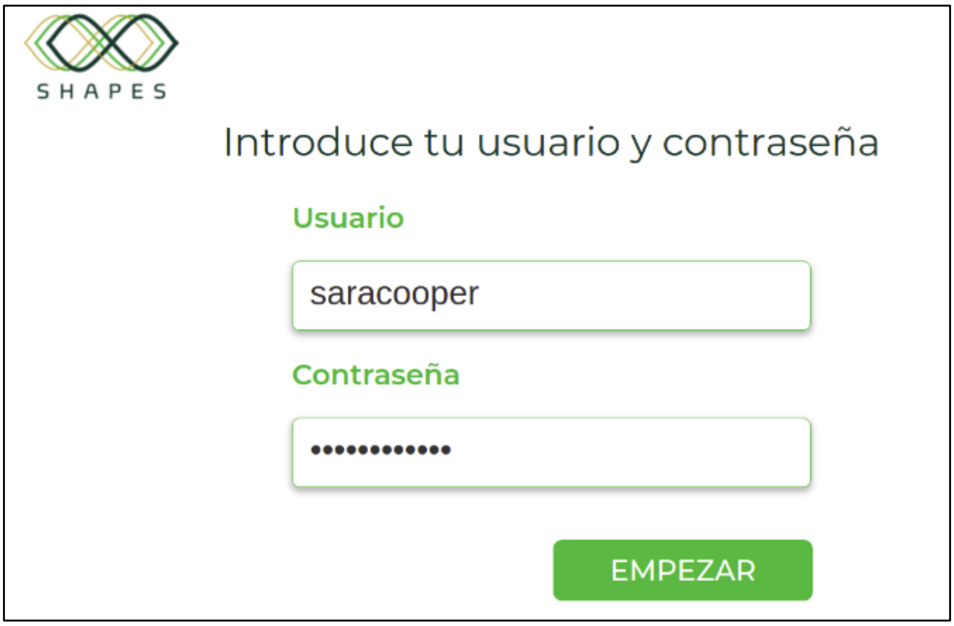


Figure 122 - Login Mock-up Front-end Using the Robot's Front Touchscreen

The received tokens and durations are stored as ROS parameters inside the robot (**/shapes/token** and **/shapes/tokenduration**), and a separate ROS node will be continuously checking for the duration of the token and need of refreshment. While not implemented yet, the robot internally will have the encrypted username/passwords of the SHAPES registered users.

Additional Rest endpoints:

- http://ari-Xc/topic/shapes_login.
- http://ari-Xc/parameters/token.
- http://ari-Xc/parameters/tokenduration.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Authentication: Face Recognition (VICOM)

The Face Recognition relies on the robot's Jetson TX2 for execution of the server and client and uses ARI's Head RGB-D camera (Real Sense) as input. The solution has been integrated through the following steps:

- Wrap the Face Recognition server and client as a ROS package.
- Wrap client calls to recogniser services in ROS topics and services. Specifically, the new Python script does the following:
  - Subscribe to the ROS topic of the robot's Head RGB-D camera (Intel RealSense): */head_front_camera/color/image_raw/compressed*. As a ROS topic, the advantage is that multiple digital solutions can use the same camera without overlapping and can be streamed and processed continuously.
  - Use of CvBridge python package to convert ROS camera topic to OpenCV image, that is processed by the recogniser.
  - Wrap existing recogniser services provided by VICOM in ROS, by mapping them ROS topics and services. Specifically, the following table summarises the new list of ROS topic and endpoints, used in the front-end interface.

Table 62 - Additional ROS Topics and Rest Endpoints for Face Recognition

ROS Topic Name	REST Endpoint	Description
/face	http://ari-Xc/topic/shapes_face	Compressed Image ROS topic outputting the bounding box of the detected faces.
/facecog_detected	http://ari-Xc/topic/shapes_detected	Bool ROS topic returning Trues/False if faces are detected or not.
/facecog_identified	http://ari-Xc/topic/shapes_face_identified	String ROS topic returning name of recognised person; returning empty if not.
/facecog_feedback	http://ari-Xc/topic/shapes_face_feedback	String ROS topic returning feedback "look left", "look right", "look up", "come closer".
/add_new_user	http://ari-Xc/service/shapes_add_user	ROS service with input 'name' that calls service to register new face.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

ROS Topic Name	REST Endpoint	Description
/remove_user	http://ari-Xc/service/shapes_remove_user	ROS service with input 'name' that calls service to remove indicated data.
/identify_person	http://ari-Xc/service/shapes_identify	ROS service to trigger person recognition.
/identify_person_stop	http://ari-Xc/service/shapes_identify_stop	ROS service to stop person recognition.
/verify_person	http://ari-Xc/service/shapes_verify	ROS service to start person verification service.

The server is run directly from the Jetson TX2 that initiates VICOM's FACECOG services. In order to run the client, the docker provided by VICOM has been combined with a ROS Noetic docker, that is executed inside the robot's Jetson TX2.

A web-based front-end has been developed to register new faces and recognise faces as part of the prototype, visible in Figure 123.

For face identification, it indicates the resulting image with the detected face, feedback received ("move backwards") and identified user ("sara"). The robot outputs the feedback using speech every 5 seconds and greets the user ("hello sara"). For this wrapper, the robot's Rest API is used that connects to the ROS topics mentioned previously, as part of the Javascript page, adding new endpoints as required.

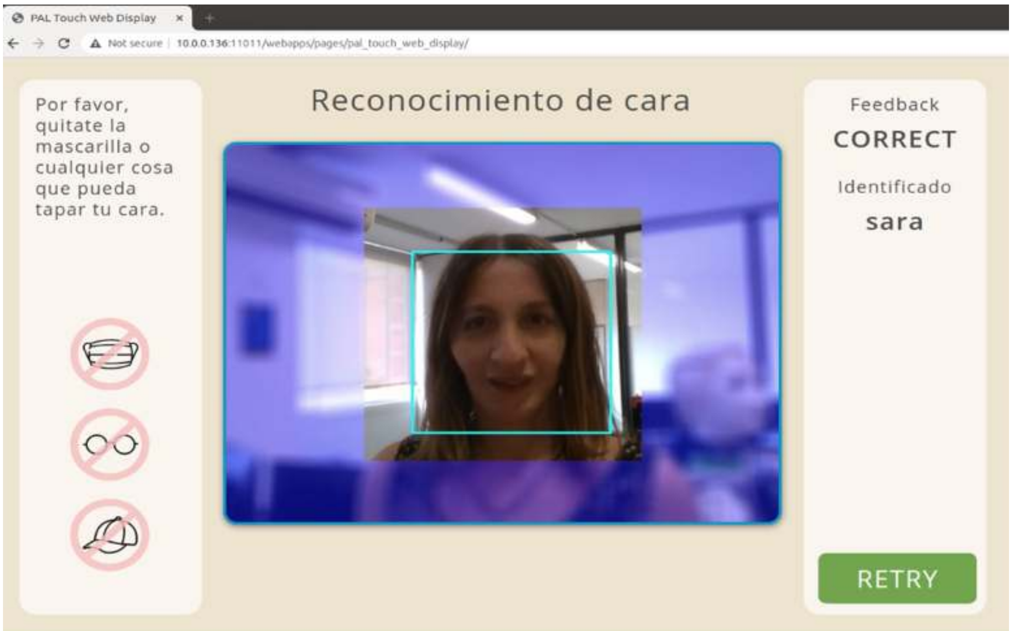


Figure 123 - VICOM's Face Recognition Front-end Displayed on the Robot's Touchscreen

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

For face recognition, the interface has been slightly modified, and follows the next procedure:

1. Users input their username.
2. Recogniser page (as above) is started. Once feedback is "CORRECT", the **/add_new_user** service is called automatically with the given username and the **/identify_person** service is then called to start recogniser.
3. If the recognised person matches the inputted name, the robot considers the process to be successful.

As next step, verification of the user will be added, as well as integration with the ASAPA component to authenticate users with username/password. This includes calling the ASAPA methods once a face is recognised, and internal mapping to encrypted username/password data. See FACECOG's section for further detail.

Feedback from the hands-on training included the possibility for the robot to track the user's face, so it is easier to register people sitting down or of lower stature.

Adlib wake-up word and chatbot (VICOM)

VICOM partner's chatbot (section 5.8), including speech recognition and wake-up word, have been interfaced with the robot to provide speech interaction.

For this, audio samples have been first acquired, with positive ("Hola ARI") and false wake-up words, recorded from the robot's ReSpeaker Mic-Array v2.0, an array of 4-microphones. Several limitations have been observed mainly regarding ambient and internal noise, as the microphone is positioned inside the torso of the robot, that will require additional data gathering to re-train the model.

To run the wake-up server, a ROS package has been developed, that includes:

1. Adlib server (section 5.8): listener of the wake-up word. Once "Hola ARI" wake-up word is detected, it attempts to recognise the speech, and if a Adilib chatbot is connected to it, sends back a response.
2. Wake-up and speech recogniser ROS client node: reads the output from the server and publishes in 2 respective topics to indicate wake-up and text received (Table 63).

Moreover, if the wake-up is detected, it changes the effect of the robot's ear LEDs to blinking.

Additionally, while the robot is listening, an animated icon is seen in all the front-touch screen pages, as seen in Figure 124, using the robot's REST endpoints.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 63 - Additional ROS Topics and Rest Endpoints for Wake-up Word and Chatbot

ROS Topic Name	REST Endpoint	Description
/adilib/wakeup	http://ari-Xc/topic/wakeup	Bool type topic returning True if wake-up is detected.
/adilib/responses	http://ari-Xc/topic/asr_response	String type topic returning speech recognised.

Figure 124 - When the Wake-up Word is Detected, Animation is Shown on the Front-end to Indicate the Robot is Listening

Lastly, integration with Adilib chatbot is done through its WebSocket in Javascript language. The speech recognised using the above procedure is sent to the WebSocket, and the response is fed to the robot's text-to-speech.

People detection, user engagement, fall detection (TREE)

All these solutions use the robot's Head RGB-D camera, as well as the Intel RealSense and, similarly to the Face Recognition, get as input its ROS topic. The solutions have been wrapped as a ROS package and run from the robot's main computer (CPU). They are described in sections 5.3, 5.4 and 5.5. Output is observed in Figure 125.

A list of new ROS topics and endpoints for data transmission are included in Table 64.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 64 - Additional ROS Topics and Rest Endpoints for Fall and People Detection

ROS Topic Name	REST Endpoint	Description
/person_detected	http://ari-Xc/topic/shapes_people	Bool type topic that returns True if any person is detected.
/fall_detected	http://ari-Xc/topic/shapes_fall	Bool type topic that returns True if a fall is detected.

Emotions are retrieved as described in section 5.3.

Figure 125 - Integration of TREE's People Detector, User Engagement and Fall Detector using the Robot's Head RGB-D Camera

For fall detection, the prototype includes a prototype similar to the Search for User behaviour, where the robot navigates to a series of points while attempting to detect people and falls. At each point, the robot looks around, and, if a fall is detected, offers the option to call for help using Twillio technology. If no help is needed or people are found, it returns to the initial position.

Reminders and skills (VICOM)

The goal with this aspect is to deliver reminders and suggestions of medication, anniversaries, etc. Integration with VICOM's Reminders Skill has still not been carried out, although it will be similar to that of the Chatbot (section 5.8). However, a simplified mock-up has been provided where caregivers can introduce desired reminders in a CSV file, loaded onto the robot. Once users log in, the robot randomly selects one of the reminders to give to the user. Moreover, the robot will, at the given time selected, look for the user to deliver the reminder both through touch screen and speech.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Video call (OMN)

The prototype has been adapted to include an Android tablet, where eCtouch (OMN) is installed, to carry out video calls.

From the front touchscreen, users can select to carry out the video call using this solution or else the front-touch screen (DigiRoom). In the case of the latter, users can select who they want to call, and the robot sends an email with the room URL to the respective person using a GMAIL API. Specifically, through the endpoint http://ari-Xc/action/email, indicating addressee, email topic, and text (includes room link).

Next steps will include interfacing eCtouch and DigiRoom with the robot's REST API to trigger its text-to-speech, and DigiRoom with the robot's microphone and cameras.

Games

Three different web-based games are included in the prototype, using robot gestures and speech to motivate users: solitaire, matching pairs, and puzzles. Figure 126 shows examples developed where ARI explains the games and gives feedback and encouragement using its REST API.

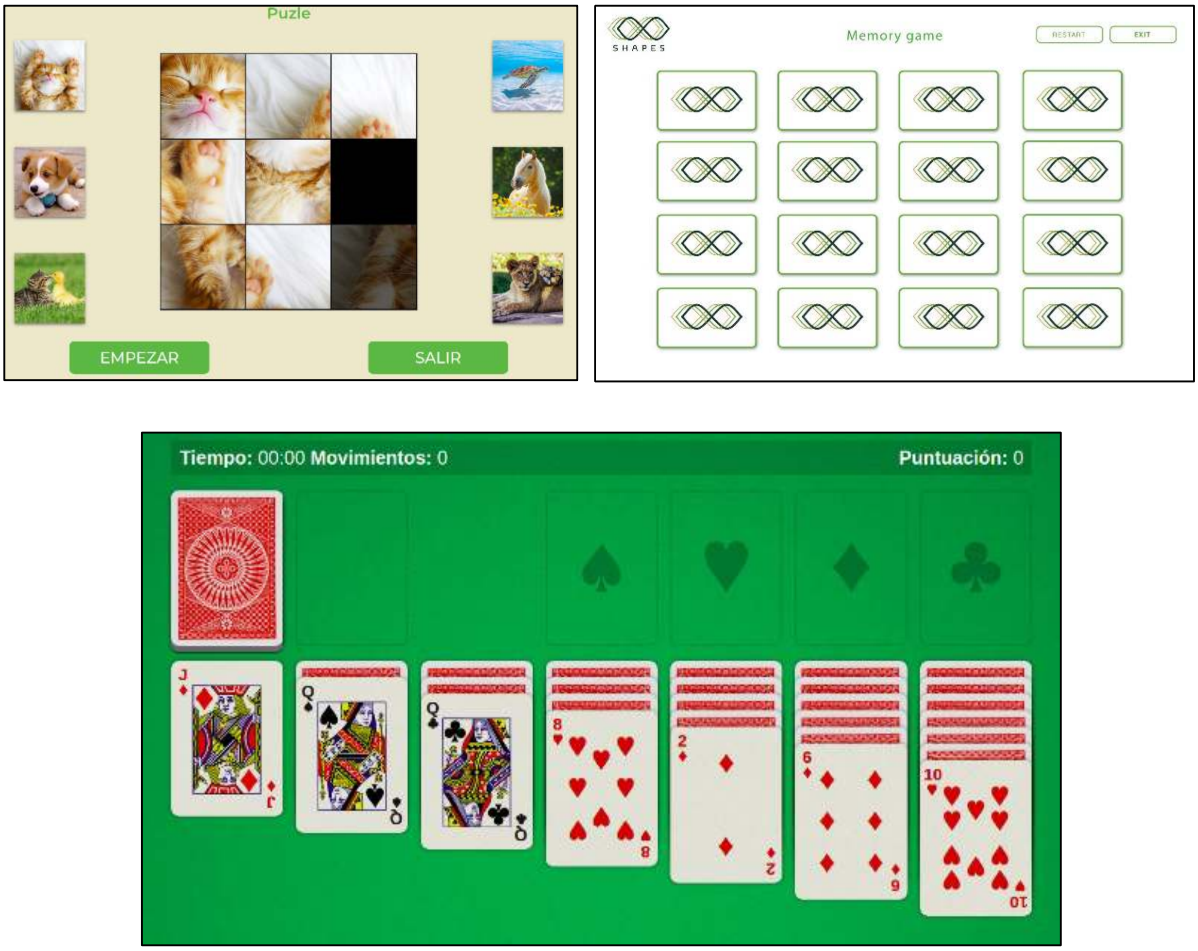


Figure 126 - Entertainment Games like puzzles, matching pairs or solitaire

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.1.5 Adaptations for PT4-UC002

Based on the requirements of the pilot, the ARI robot has been selected. The considerations and adaptations made for PT1-UC004 are also applicable here, specifically the robot interfaces have been adapted to integrate the following digital solutions:

- Face Recognition (VICOM).
- ASAPA (HMU).
- Adilib wake-up word and chatbot (VICOM).
- Memor-i and diAnoia (SciFY).
- User engagement detection (TREE).

Additional adaptations of the prototype are done for SciFY games, described in sections 4.2 and 4.3.

5.1.5.1 Concept and Ideation Stage

Use case PT4-UC002 aims to support old people with dementia in its early stages. The robot will be used at individual psychology sessions, or be placed at the common rooms where end-users can indicate to the robot they want to play the games, at which point the robot will move to a quieter room. The applicable persona are people with early stage dementia, independent or highly dependent. They are frequently visited by caregivers, care partners or family members, who can assist with robot interaction and provide guidance during game directions.

As part of this pilot, the robots will integrate cognitive games developed by SciFY, customised to each user through authentication mechanisms (VICOM, HMU) and be able to get user input from speech interaction and guide the user through the games (Chatbot, Wake-up word). Moreover, based on emotions detected (TREE), the robot will be able to select different games and adapt its behaviour.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 65 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	The robot has different interaction modalities such as speech, front touch screen or back tablet.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	Access to the robot is restricted by SSH
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	A humanoid-shape face, expressive eyes and smooth movement design promotes positive human-robot interaction.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	An additional back android tablet or use of screen-pens for standing and sitting positions.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	The robot has a certain level of autonomous behaviour.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 66 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	For robust user verification, a RGB-D camera like an Intel Real Sense is needed.	Y	Robot's head RGB camera has been switched to a RGB-D camera.
No code	SciFY games diAnoia require Android tablet, users that are sitting down may often prefer to pick up tablet.	Y	Robot offers tablet by turning around.

5.1.5.2 Design and Development Stage

At this stage, similar considerations as to PT1-UC004 apply. Additionally, for SciFY games, several additional considerations were taken for the mock-up phases:

1. diAnoia requires the back Android tablet to play the games, and the games will be printed out.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

2. Memor-i is run as a Java program launched from inside the robot's main computer and displayed on the front touch-screen.
3. Additional games will be adapted from diAnoia that use the front-touch screen, so that users can use speech to select options, and is touch-based.

For both cases, the robot's Rest API will be used to include text-to-speech. In order to select the interface, that is, the front touch-screen or the back Android tablet, a custom HTML5-based web page will be designed where, based on the game selected, the robot will turn around to offer the tablet. Figure 127 shows a mock-up of this interface shown to end-users during Phase 2:

Figure 127 - Game Selection of Interface for the Pilot using the Robot's Touchscreen

Figure 128 shows a mock-up of the position of the back Android tablet that is charged through the robot:

Figure 128 - Preliminary Integration of the Back Android Tablet for the Games

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Lastly, mock-ups of adapted touch-screen games are visible in Figure 129. In this example, a pop-up virtual keyboard shows up on the front touch-screen where users need to introduce a word that begins with the letter B.

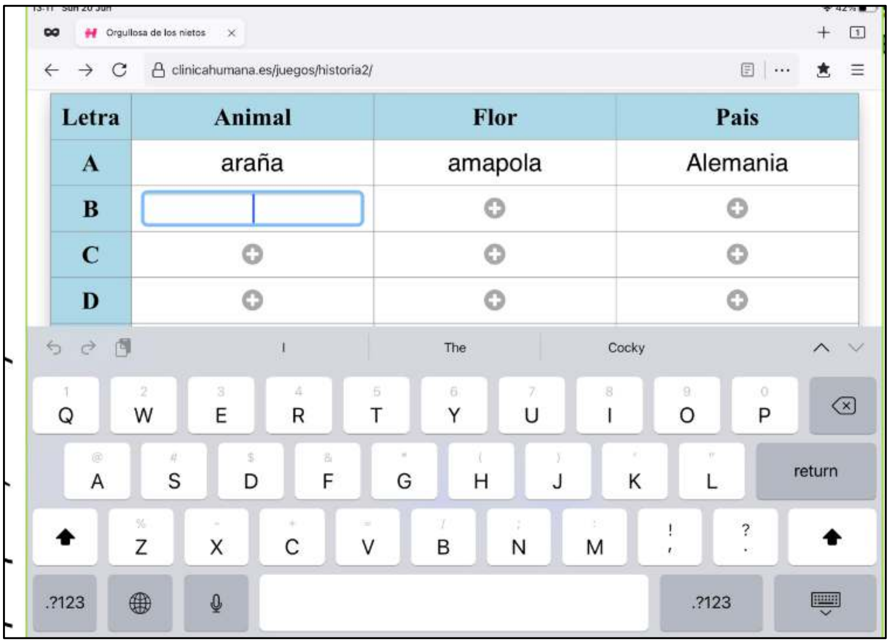


Figure 129 - diAnoia Games Adaptation Mock-up to the Front Touchscreen

5.1.4.4 *Prototyping and Adaptation Stage*

At this stage, similar considerations as to PT1-UC004 apply. Based on the mock-ups, some modifications include projecting ARI front touch-screen output to a PC projector to enlarge the games of the psychologist. This will be done by accessing the web browser of the robot.

Communication with face recogniser, emotion recognition and chatbot is done in the same manner as for PT1-UC004.

5.2 KOMPAÏ-3 Robot (KOM)

KOMPAÏ robotics is offering its last generation of KOMPAÏ-3 robot to SHAPES in its two basic versions: EHPAD version and R&D version. The most suitable one of each user-case will be chosen based on the requirements of the pilot sites. In general:

- EHPAD version robot equipped with its walking assistance bars for physical tasks.
- R&D version for cases where no physical tasks are required.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Integration of SHAPES digital solutions onto the robot would be the same for both robots.

The Kompaï-3 robot is unique of its kind because it was designed with health organisations and only for them. It offers mobility assistance capacity, multiple functions, and numerous development possibilities.

Kompaï-3 robot was designed with two main objectives: to help care professionals in their repetitive daily tasks, but also to help patients, regardless of where they live.

5.2.1 Technical Specifications

Figure 130 gives the main dimensions and volumes of the robot.

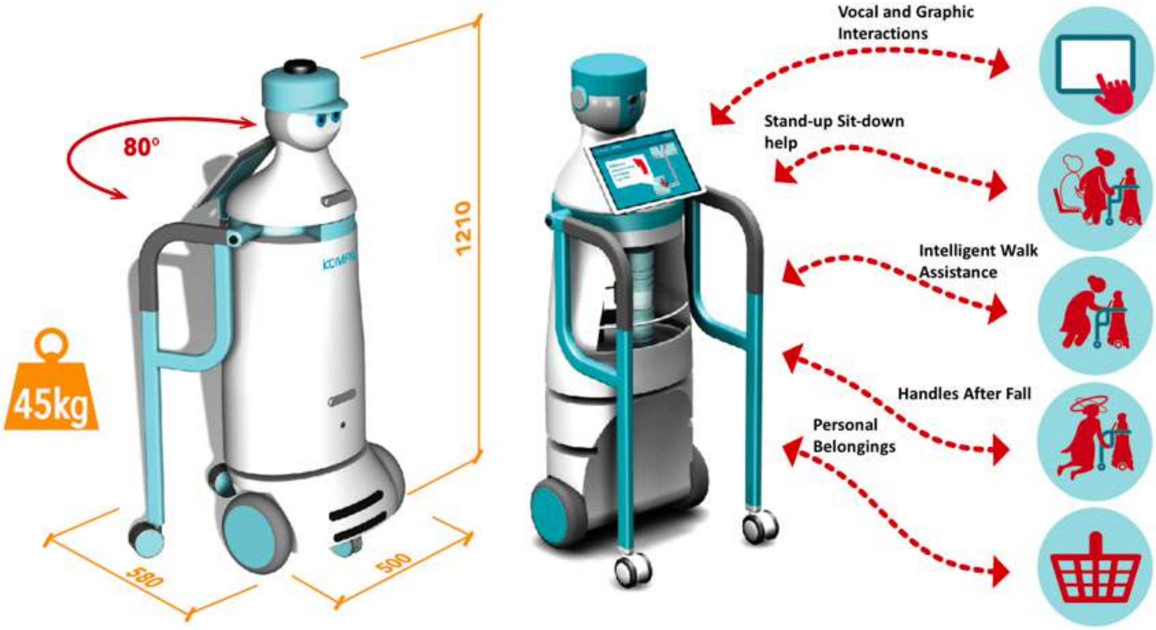


Figure 130 - KOMPAÏ-3 Robot: Dimensions and Volumes

The main robotic components are:

- The rotating laser on the head, ensuring localisation in a pre-recorded map.
- Animated eyes, which can express many emotions, but also give indications such as malfunctions.
- The emergency call button, which can send an SMS or an email to a remote assistance centre.
- The 3D camera, used among others, for obstacle detection.
- The “fisheye” camera, used for taking control of the remote robot.
- The low laser, which completes the 3D camera for obstacle management.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

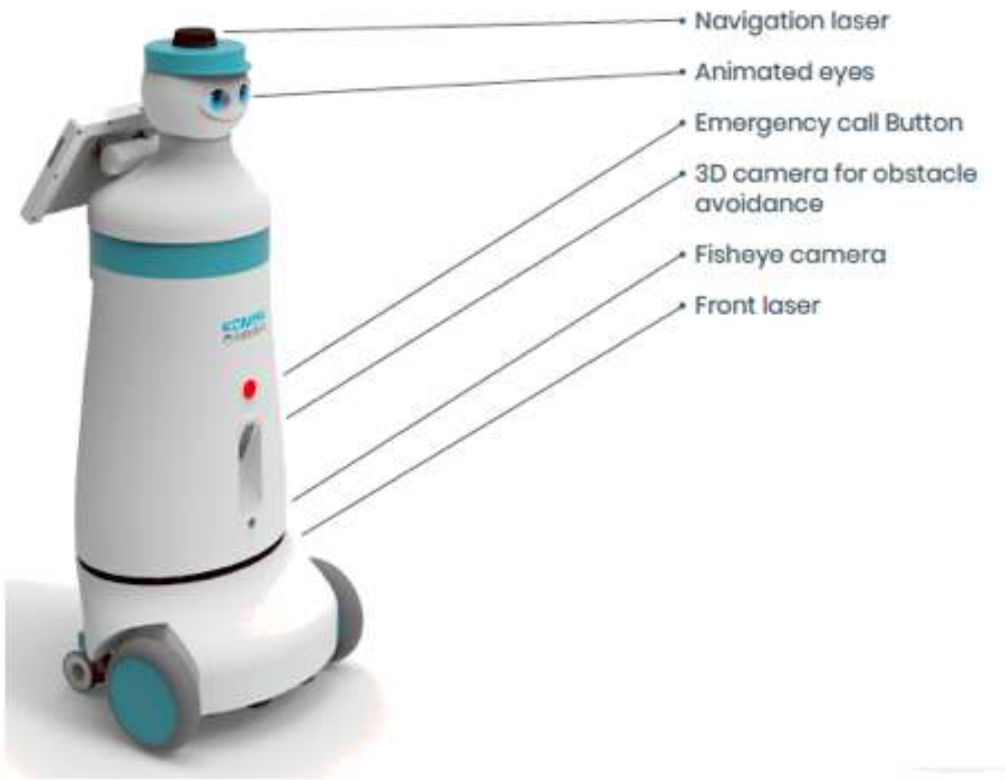


Figure 131 - KOMPAÏ-3 Robot Components

Table 67 - KOMPAÏ-3 Robot Technical Specifications

Functionality	Specifications Use
Cases	• Mobility aid with patented rotary bar • Individual and collective entertainment Animation, logistics, surveillance tours
Speed	From 0 to 2.3 m / s max, l imitated by software
Traction	2 AC motors (2x120W: continuous, 2 x 500W: at start-up)
Direction	By speed differential on the 2 motors
Dimensions	Height x Width x Length = 1210 x 500 x 580 mm
Clearance of obstacles (vertical step)	~ 2cm
Maximum slope	10%
Autonomy	Up to 6 h (depends on the used scenario)
Sensors	
Navigation sensor	2D Laser above the head for mapping and localisation
Obstacle detection	• The 2D laser above the head is used for the detection of high obstacles • A low 2D laser for the detection of low obstacles • A 3D camera that covers the entire front volume of the robot
Hole detection	2 at the front and 2 at the rear
Leg movement detection for walking	2D laser
Remote control assistance	Fisheye camera at the front

Assistance with automatic recharging	an IR locator at 180 ° placed on the docking station
Embedded	
Main controller	• computers NVIDIA Jetson TX2 card under Linux (256 core Pascal GPU @ 1.12GHz, ARMv8 Multi-Processor CPU @ 2GHz, 8GB LPDDR4, 32GB eMMC, WLAN) • Low level controller u PURE and software navigation
Human / Machine	• Tablet Size 13 "Windows 10 • Microphone • Speaker
Communication	• WiFi • 4G
Other	
Eye	• animated Eyes

The Kompaï robot is in accordance with the marking requirements of EC Machinery Directive 2006/42 / CE and ISO 13482-2014, basic standards for this type of product.

The two versions of the Kompaï robot are:

1) **The R&D version**

It is the modular version for all those who wish to customise their robot, whether mechanically or software:

- at the hardware level which through the walking assistance bar allows it to be entrusted with various missions (autonomous product transport, autonomous zone disinfection).
- at the software level thanks to the SDK which is supplied with the robot to develop any on-board or off-board application, in s 'pressing on http requests or URL access.

Figure 132 shows the many possibilities offered to developers:

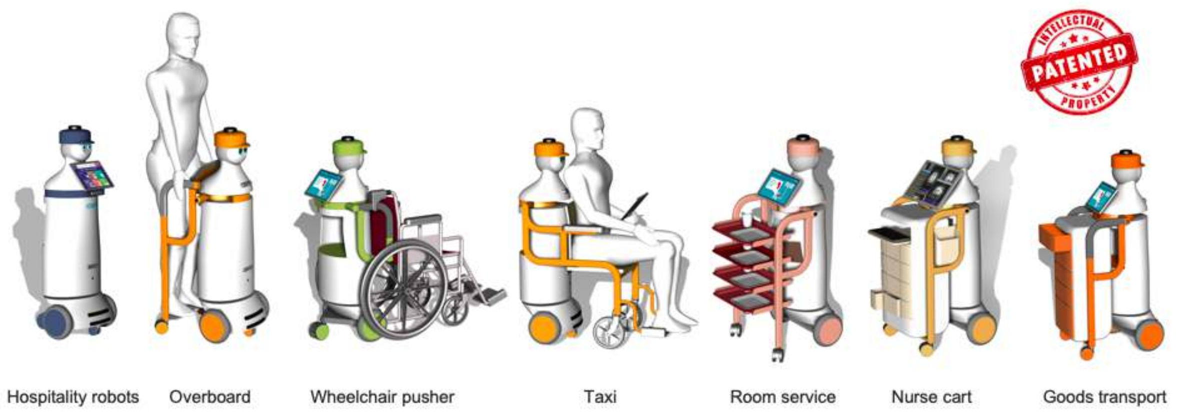


Figure 132 - Different Possibilities Offered to Developers

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Note that the R&D version can be delivered with or without assistance bar.

2) The EHPAD version

The version EHPAD is the same robot, but with application software specific to the needs of establishments.

These are the two basic functions of the EHPAD version:

Figure 133 - Basic Functions of the EHPAD version of Kompaï

- Mobility assistance to residents: Kompaï can be used as an intelligent walker to help residents move around inside the building. It can adapt his speed to that of the user but also to assist him/her vocally and visually throughout his/her journey. Three assistance modes are available:
  - **Free mode:** allows a cognitively autonomous resident with slight physical difficulties to go where he/she wants with the help of the robot. Here the resident controls the speed of the stops as well as the trajectory. The number of steps taken is displayed on the robot to motivate residents to walk more regularly.
  - **Guided mode:** the robot takes the moderately autonomous resident physically and cognitively from a starting point to an ending point by following a trajectory established thanks to a map. It is the caregiver who sets the journey for the resident. The resident therefore has no control over the trajectory, but he/she can manage the speed and stops because the robot adapts to its walking. Like a GPS, the robot indicates the directions to take during the journey.
  - **Exercise mode:** to be used in the presence of a caregiver to do walking exercises. Several trajectories are possible (forward, backward, curves) and must be selected by the healthcare provider. The resident has no control over the trajectory, but he/she manages the speed and the stops

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

because the robot adapts to its walking. The robot encourages users during their exercises.

- Rounds or tours: announcements, surveillance, animation: A tour is defined by a title and a launch time. It is a route from Points of Interest (POIs) to POIs to which the robot must go to take action. They can be:
    - o **Announcements:** information given by hand beforehand by a caregiver.
    - o **Monitoring:** movement detection (ambulation of people), temperature controls, air quality control, doors open. The idea is to patrol to detect possible anomalies and if so, send a screenshot to the guard to warn him/her.
    - o **Activities:** broadcasting videos, music, audio stories, cooking recipes.

Entertainment

The robot can be used to distract residents, individually or collectively.

Figure 134 - Kompaï as Entertainment Robot

- **Individual:** entertainment Kompaï has a touch pad allowing the user to play games, see the weather, see the horoscope, talk to family via Skype, watch photos or videos, listen to music or audio stories. Thanks to facial recognition, it is possible to offer personalised content for each resident. Thus, a resident will only see the horoscope and the photos that concern him/her. This scenario requires upstream work by caregivers to create content specific to each resident.
- **Collective entertainment:** Personalised content is not an obligation. Less personal photos and videos can be made available to all residents for collective use. Distraction sessions can be set up to entertain residents while the meal is being prepared, for example. Kompaï will be able to go around the common room and show videos / photos or read stories to residents. Similarly, collective

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

games can be imagined and developed in partnership with caregivers. Kompaï can help organise quizzes, a Trivial Pursuit, a Bingo and even a gym class. Of course, the presence of another facilitator is essential for this scenario.

Operating interfaces

The EHPAD version, based on so-called "business" software, remains configurable by healthcare personnel, with simple and intuitive interfaces, requiring no IT skills. Figure 135, Figure 136 and Figure 137 are interface examples, while noting that these interfaces are constantly evolving.

Figure 135 - Route Monitoring Interface

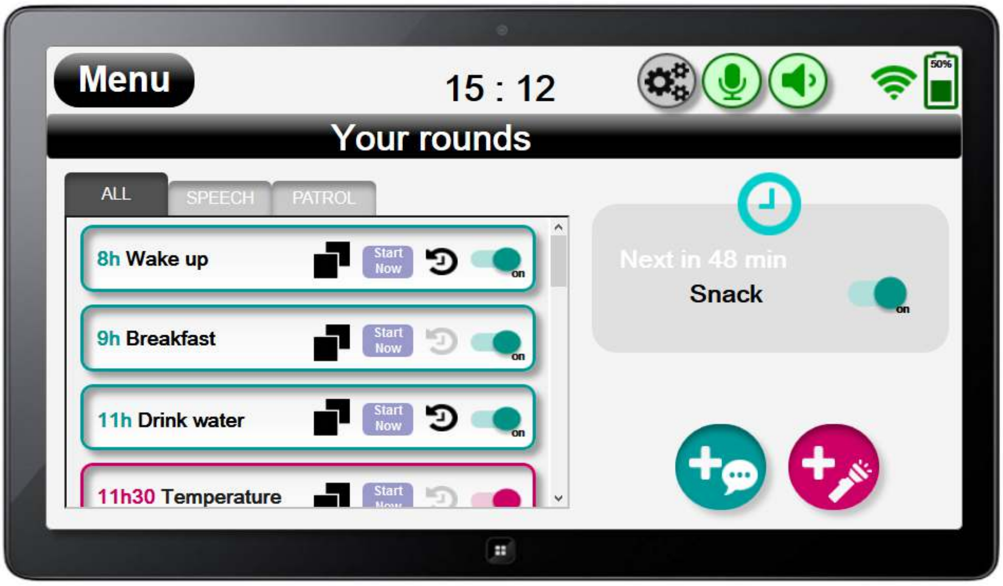


Figure 136 - Route Setting

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 137 - Emergency Stop Interface when the Robot is in Autonomous Mode

5.2.2 Interfaces and Interoperability

Thanks to the Software Development Kit (SDK), the 2 versions (R&D and EHPAD) are customisable, directly by customers or by third parties. The robots are designed to be easily integrated into any ICT architecture, thanks to the use of the latest web technologies. It is important to understand that these web technologies can also work on private local networks, without going through the internet.

All robot functionality is accessible by external applications via http requests. They also have an embedded web server that allows access to internal pages via uniform resource locators (URLs), from any browser (Chrome, Firefox).

The software architecture is summarised in Figure 138:

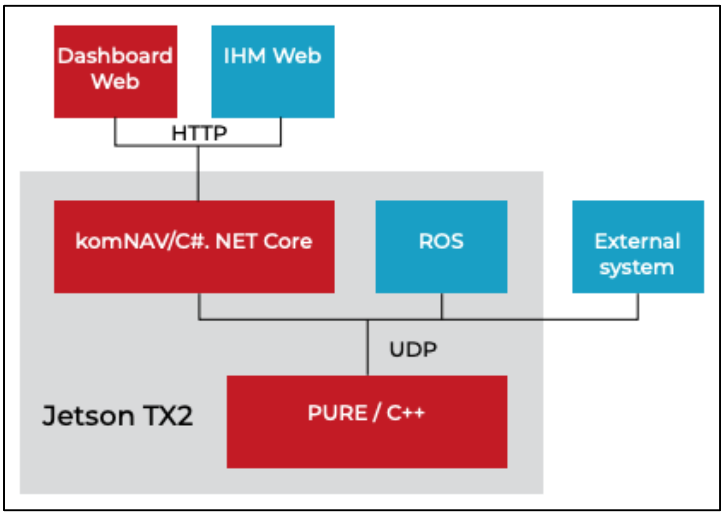


Figure 138 - Software Architecture

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The technical interfaces are in the "Web Dashboard", and the business interfaces in the "Web HMI", the 2 accessible on the tablet equipping the robot (a Microsoft Surface).

It is also possible for developers to control the robot at its lowest level via the PURE UDP API (API provided).

5.2.3 Applicable Pilot Themes

In bold, are those pilot themes that already confirmed the participation of Kompaï's robots:

- **PT1 – Smart Living Environment for healthy ageing at home.**
- **PT2 – Improving In-Home and Community-based Care.**
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.
- **PT6 – Physical Rehabilitation at Home.**

5.3 Sentiment Analysis (TREE)

Non-verbal communication while doing activities is very important since it indicates the predisposition of the interlocutors or intention during a human interaction. A very representative part of this non-verbal communication is facial expression, and mainly, the expression of feelings (joy, sadness). However, the analysis of these sentiments by artificial systems (robots, apps) is complex due to the variability and subjectivity of these expressions. However, Tree Technology (TREE) brings a digital solution for sentiment analysis which can detect the eight most representative facial expressions: joy, fear, disgust, sadness, anger, surprise and contempt.

As input for this digital solution, it needs videos of users interacting with the systems. These videos (or collection of images) must capture users from the front and a distance from the sensor (camera) that allows the visualisation of facial details. This distance depends on the resolution of the camera so it cannot be defined a priori. As a reference, facial expression detection can be optimally performed with 720p resolution cameras from about two meters away.

There are two outputs from this solution: first, a file with information on the most probable facial expression (among 8 possible facial expressions) at each instant of the video (image). On the other hand, another file with temporal consistency (sliding window) of the expression made by the user.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

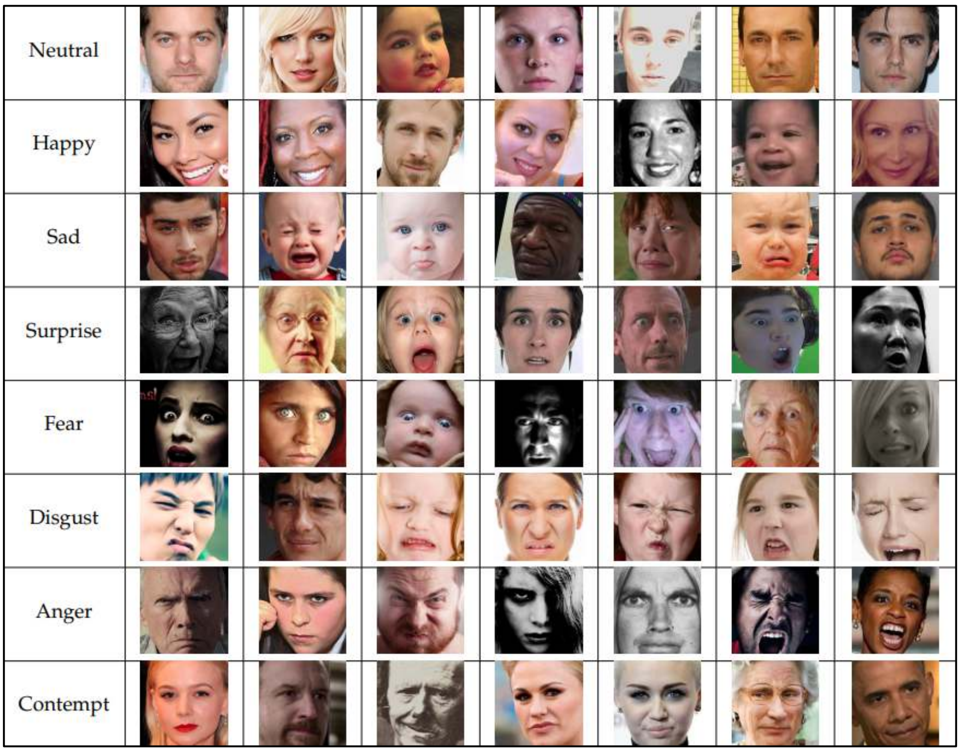


Figure 139 - Sentiments Detected by Sentiment Analysis Digital Solution

5.3.1 Interfaces and Interoperability

Two ways of communicating with the needed Digital Solutions are proposed. In the case of a robotic system, the encapsulation of the sentiment analysis system is performed as a ROS node, connectable by means of specific messages to the sensors (inputs) and the information managers (outputs).

In the case of an application, the system must present an API. This API must define the ingestion of data or how to introduce the images to the module, as well as the dump areas of information (processed data).

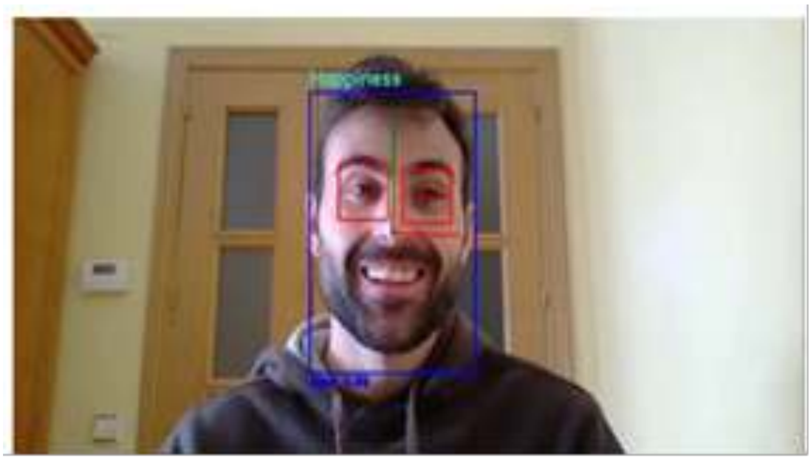


Figure 140 - Sentiment Analysis Solution from TREE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.3.2 Applicable Pilot Themes

Two pilot themes were identified for this Digital Solution:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

5.3.3 Adaptations for PT1-UC004

Two main adaptations were made to this Digital Solution in order to comply with the needs of PT1-UC004. On the one hand, it was taken into account that with age the face and expressions of people tend to change. Therefore, a complete re-training of the models was made to support the sentiment detection of old people. On the other hand, and given that it will share hardware resources with a robot, extensive optimisations were made in order to reduce the central process unit (CPU) consumption of the Digital Solution.

The applicable SHAPES persona is Helena. Helena is an 82-year-old woman who lives on her own. Her independent lifestyle is supported by the robot ARI, which provides her with assistance in relation to managing reminders and appointments, taking her temperature, managing the shopping list, showing unread messages, and promoting physical activity.

5.3.3.1 Concept and Ideation Stage

Use case PT1-UC004 aims to empower the independence of old people. This usually entails assistance to remember appointments, taking the medication, use home devices, or make home exercises. This is supported by the use of a socially assistive robot which, additionally, helps them combat isolation and loneliness.

This is empowered by the robot's capabilities to understand non-verbal communication. In particular, the Digital Solution allows to contextualise the user's interaction with the robot's screen with the sentiment detected from the user's facial expression.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 68 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 69 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection	Y	User detection needed for performing sentiment analysis.
No code	Search for person behaviour	Y	Sentiment analysis performed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.3.3.2 Design and Development Stage

The previously developed system for the detection of perceived feelings is based on public and non-specific data sets of use cases. However, for the various use cases a fit of the deep learning models has been performed with the data available from the various pilots, making the solution more robust to the perceived feelings from end users. These data and additional settings allow the existing solution to be tailored for the age intervals of the users as facial gestures vary with age, as well as the arrangement of the cameras in relation to the users.

As such, this Digital Solution does not provide a user interface, so no mock-ups were considered in the design process.

5.3.3.3 Prototyping and Adaptation Stage

The main functionality of this module is to perform a detection of the feelings perceived on the users' faces while they are interacting with various systems, mainly in the interaction of the users with the various robotic systems within SHAPES.

The functionality and utility of the solution is based in the data coming from the bag files and videos provided by SHAPES's system (e.g. a robot). The solution can be applied to measure the sentiments detected and also the feelings themselves.

All the data extracted from the video is stored in a JSON Line (one for each video) in order to be usable by other partners.

The data flow for this solution is based on the communication between ROS and TREE's code. The workflow goes like this:

- First, the solution receives and extracts image by image from the topic that the user wants from the bag file recorded with the faces of the people.
- Then, with these images, TREE creates a video for the code to process this information (as bag files cannot be processed directly).
- Now, with the video created, TREE can run the code and get metrics from the analysis.
- These metrics give the information needed to know the sentiments that the person has when recording the video and, also, some additional information, such as the engagement or the gaze metrics.

The results are not displayed directly by TREE. Instead, the outputs are shared in the proper format and structure (i.e. a JSON Line file for each video). JSON Line allows to store the information correctly writing all the information of each frame in individual lines. Therefore, every line contains information about the feelings and the metrics for each frame.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

An example can be seen here:


```
[{"frame_number": 0, "frame_timestamp": 0, "attention_fraction": 0.0, "arousal": 0.0, "valence": 0.0, "eyes_closed_fraction": 0.0},
{"frame_number": 30, "frame_timestamp": 2000, "attention_fraction": 0.0, "arousal": 0.623, "valence": 0.596, "eyes_closed_fraction": 0.0},
{"frame_number": 60, "frame_timestamp": 4000, "attention_fraction": 0.267, "arousal": 0.58, "valence": 0.532, "eyes_closed_fraction": 0.0},
{"frame_number": 90, "frame_timestamp": 6000, "attention_fraction": 0.3, "arousal": 0.644, "valence": 0.545, "eyes_closed_fraction": 0.0},
{"frame_number": 120, "frame_timestamp": 8000, "attention_fraction": 0.0, "arousal": 0.656, "valence": 0.464, "eyes_closed_fraction": 0.057},
{"frame_number": 150, "frame_timestamp": 10000, "attention_fraction": 0.0, "arousal": 0.578, "valence": 0.404, "eyes_closed_fraction": 0.073},
{"frame_number": 180, "frame_timestamp": 12000, "attention_fraction": 0.067, "arousal": 0.548, "valence": 0.325, "eyes_closed_fraction": 0.1},
{"frame_number": 210, "frame_timestamp": 14000, "attention_fraction": 0.167, "arousal": 0.617, "valence": 0.44, "eyes_closed_fraction": 0.1},
{"frame_number": 240, "frame_timestamp": 16000, "attention_fraction": 0.0, "arousal": 0.522, "valence": 0.377, "eyes_closed_fraction": 0.163},
{"frame_number": 270, "frame_timestamp": 18000, "attention_fraction": 0.067, "arousal": 0.578, "valence": 0.348, "eyes_closed_fraction": 0.203},
{"frame_number": 300, "frame_timestamp": 20000, "attention_fraction": 0.033, "arousal": 0.483, "valence": 0.323, "eyes_closed_fraction": 0.267},
{"frame_number": 330, "frame_timestamp": 22000, "attention_fraction": 0.2, "arousal": 0.596, "valence": 0.403, "eyes_closed_fraction": 0.277},
{"frame_number": 360, "frame_timestamp": 24000, "attention_fraction": 0.133, "arousal": 0.644, "valence": 0.61, "eyes_closed_fraction": 0.26},
{"frame_number": 390, "frame_timestamp": 26000, "attention_fraction": 0.667, "arousal": 0.606, "valence": 0.952, "eyes_closed_fraction": 0.32},
{"frame_number": 420, "frame_timestamp": 28000, "attention_fraction": 0.5, "arousal": 0.622, "valence": 0.44, "eyes_closed_fraction": 0.323},
{"frame_number": 450, "frame_timestamp": 30000, "attention_fraction": 0.567, "arousal": 0.606, "valence": 0.5, "eyes_closed_fraction": 0.297},
{"frame_number": 480, "frame_timestamp": 32000, "attention_fraction": 0.5, "arousal": 0.619, "valence": 0.38, "eyes_closed_fraction": 0.27},
{"frame_number": 510, "frame_timestamp": 34000, "attention_fraction": 0.0, "arousal": 0.643, "valence": 0.502, "eyes_closed_fraction": 0.27},
{"frame_number": 540, "frame_timestamp": 36000, "attention_fraction": 0.033, "arousal": 0.575, "valence": 0.605, "eyes_closed_fraction": 0.217},
{"frame_number": 570, "frame_timestamp": 38000, "attention_fraction": 0.233, "arousal": 0.591, "valence": 0.591, "eyes_closed_fraction": 0.177}]
```


Figure 141 - Excerpt from a JSON Line

5.3.4 Adaptations for PT4-UC002

The considerations and adaptations made for PT1-UC004 are also applicable here. The applicable SHAPES persona is Isabella. At the time, an activity has been scheduled to be suggested to the user, the robot activates, undocks, and starts searching for the older person within the house. When the robot detects a person, it tells them to approach for face recognition. If the user is detected, the interaction with the robot starts. From then, either the robot reminds the user to start some activities, or the user activates the option to start them by personal initiative. Either way, the user carries out some activities (e.g. games) while the robot evaluates the person's sentiments and emotions.

5.3.4.1 Concept and Ideation Stage

Use case PT4-UC002 aims to support old people with dementia in its early stages. At the appropriate time, decided by a caregiver, the robot will locate the user and inform him/her that it is the moment for playing cognitive games. The user goes to the room where the activity is supposed to take place, and the game takes place.

The activities will be supported by the sentiment analysis Digital Solution. In particular, the user will be offered the possibility to change the activity, if frustration is detected from his/her facial expression.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 70 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 71 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection.	Y	User detection needed for performing sentiment analysis.
No code	Search for person behaviour.	Y	Sentiment analysis performed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.3.4.2 Design and Development Stage

The same considerations in PT1-UC004 apply, and therefore design and development stages have been analogous to what was explained in section 5.3.3.2.

5.3.4.3 Prototyping and Adaptation Stage

The same considerations in PT1-UC004 apply, and therefore prototyping and adaptation have been analogous to what was explained in section 5.3.3.3.

5.4 People Detection and Tracking (TREE)

The detection and monitoring of individuals is a key piece for understanding the various activities and movements of people in certain environments. Naturally, these applications were widely embraced by video-security systems, as they allowed reducing the cost and effort of monitoring intrusions or other types of incidents, and health application as evaluation of performance during physical exercises. However, this technology which is very mature indoors and with favourable lighting conditions, has many applications beyond the detection of these events. For example, the control of patients in healthcare environments, market research (clients).

The Digital Solution proposed aims to detect people and detection of the different performed activities in different supervised areas covert by closed circuit television (CCTV) and/or by integrated cameras in robotic platforms as well as their paths as long as they are visible by cameras. They can be used in video surveillance and Health (detection of daily routines, falls detection, to name some applications).

As input for this digital solution, it needs videos provided by the CCTV or video surveillance system of the facilities or homes.

There are two outputs from this solution. First, the logs of detection of people, and second, the path of each detected person (tracking) (Figure 142).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

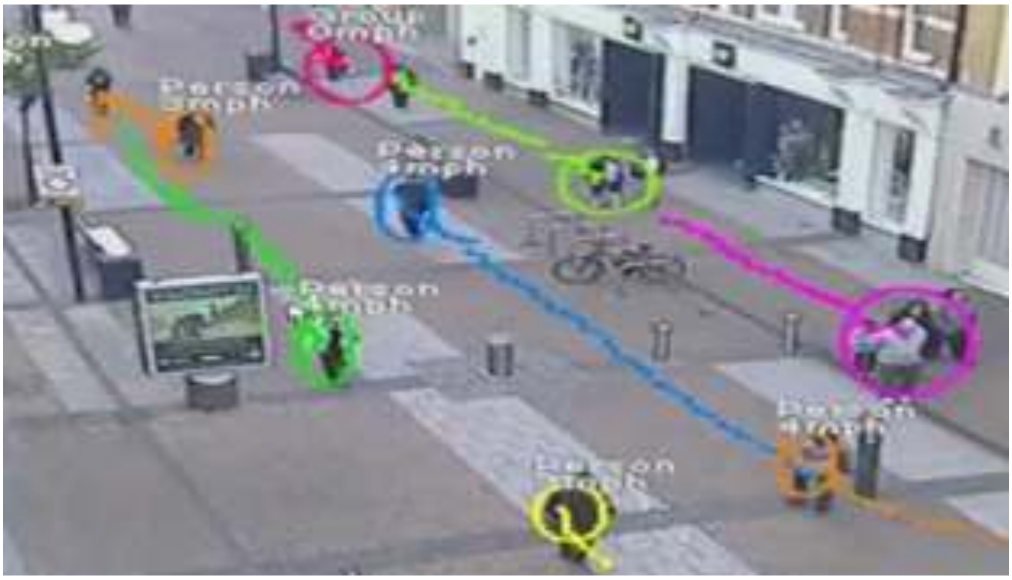


Figure 142 - Example of People Detection and Tracking Solution

5.4.1 Interfaces and Interoperability

For the integration of these monitoring systems within video-surveillance systems, an API will be defined. This API must indicate the way to enter the images into the Digital Solution, as well as the storage areas for detection and monitoring logs of the detected people.

The interoperability is based in the communication between ROS and the Digital Solution. In this case, the workflow goes as follows:

- Since the video is already available from a previous step, it just requires for that video to be an input parameter to run the code of the Digital Solution.
- It is launched the *You Only Look Once* (YOLO) (https://github.com/leggedrobotics/darknet_ros) and get the topic "detection image", which contains all the detections and bounding boxes of the YOLO network.

5.4.2 Applicable Pilot Themes

Two pilot themes were identified for this Digital Solution:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.4.3 Adaptations for PT1-UC004

Two main adaptations were made to this Digital Solution in order to comply with the needs of PT1-UC004. On the one hand, some modifications were made to account for the perspective obtained from the robot's point of view (i.e. height, angle, and field of view of the robot's camera). On the other hand, given that it will share hardware resources with a robot, extensive optimisations were made in order to reduce the CPU consumption of the Digital Solution.

The applicable SHAPES persona is Helena. Helena is an 82-year-old woman who lives on her own. Her independent lifestyle is supported by the robot ARI, which provides her with assistance in relation to managing reminders and appointments, taking her temperature, managing the shopping list, showing unread messages, and promoting physical activity.

5.4.3.1 *Concept and Ideation Stage*

Use case PT1-UC004 aims to empower the independence of old people. This usually entails assistance to remember appointments, taking the medication, use home devices, or make home exercises. This is supported by the use of a socially assistive robot which, additionally, helps them combat isolation and loneliness.

The pilot leverages the robot's capabilities to find and track the user in a complex environment such as his/her own home, which are supported by the people detection and tracking Digital Solution.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 72 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-116	SHAPES should offer fall detection sensing and alerting.	Y	Facial detection is supported.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation"	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 73 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection.	Y	User detection needed for performing tracking.
HOW4/7	In case the robot detects a fall or increased temperature, alert a caregiver or medical personnel.	Y	Requirement supported by implementing fall detection.

5.4.3.2 *Design and Development Stage*

TREE's initial people detection solution has been augmented by the introduction of another detection algorithm, one of the most robust in the state of the art. This approach is referred to as YOLO. This algorithm is a neural network trained for the detection and bounding (by means of enclosing rectangles) of a great number of objects, including people, within images. The initial Digital Solution has been

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

expanded with this approach to allow detection of people at a greater variety of scales than initially supported.

In this case, a retraining of the systems has not been carried out as the proper behaviour of the current model was verified in the preliminary tests.

As such, this Digital Solution does not provide a user interface, so no mock-ups were considered in the design process.

5.4.3.3 Prototyping and Adaptation Stage

The basic functionality of this system is to detect people in the various images that include people and objects, to indicate their position while they are visible by the system's sensors.

The functionality and utility of the solution is based on the bounding boxes detected by TREE's algorithms combined with the approximation of YOLO. The output is going to be the coordinates of these bounding boxes, which will be extracted as topics in ROS. With these topics, we have all the information related to people stored in one place and can be invoked using ROS.

The data flow for this solution is based on the communication between ROS and TREE's code. The workflow goes like this:

- First, the algorithm gets all the bounding boxes from the persons detected in the image.
- Then, with the coordinates of the bounding boxes, the system stores them in ROS topics.
- Finally, the algorithm extracts all the information related to persons in the image and provide them to other modules, such as fall detection.

As the results are not going to be displayed directly by TREE the outputs will be shared in the proper format and structure, i.e. ROS topics. These topics store the information related to person detection and can be shared throughout the project. This information indicates an encompassing rectangle for each of the people present and detected, as well as an estimate of their distance globally.

Also, besides detecting people, fall detection has also been implemented. Fall detection follows the same data flow for people detection and uses bounding boxes from YOLO, as well. In the initial step of this fall detection algorithm, it is extracted the coordinates of the bounding boxes and make some calculations with them. After these computations are done, a flag is activated stating if a person is in a horizontal position and laying on the ground or not.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.4.4 Adaptations for PT4-UC002

The considerations and adaptations made for PT1-UC004 are also applicable here. The applicable SHAPES persona is Isabella. At the time an activity has been scheduled to be suggested to the user, the robot activates, undock, and starts searching for the older person within the house. When the robot detects a person, tells them to approach for face recognition. If the user is detected, the interaction with the robot starts. From then, either the robot reminds the user to start some activities, or the user activates the option to start them by personal initiative. Either way, the user carries out some activities (e.g. games) while the robot evaluates her sentiments and emotions.

5.4.4.1 Concept and Ideation Stage

Use case PT4-UC002 aims to support old people with dementia in its early stages. At the appropriate time, decided by a caregiver, the robot will locate the user and inform him/her that it is the moment for playing cognitive games. The user goes to the room where the activity is supposed to take place, and the game takes place. The process by which the robot locates the user is supported by the people detection and tracking digital solution.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 74 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-116	SHAPES should offer fall detection sensing and alerting.	Y	Facial detection is supported.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum	Y	The Digital Solution has been designed following

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	cybersecurity rules for mobile and online services.		accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 75 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection.	Y	User detection needed for performing tracking.
HOW4/7	In case the robot detects a fall or increased temperature, alert a caregiver or medical personnel.	Y	Requirement supported by implementing fall detection.

5.4.4.2 *Design and Development Stage*

The same considerations in PT1-UC004 apply, and therefore design and development stages have been analogous to what was explained in section 5.4.3.2.

5.4.4.3 *Prototyping and Adaptation Stage*

The same considerations in PT1-UC004 apply, and therefore prototyping and adaptation have been analogous to what was explained in section 5.4.3.3.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.5 User Engagement (TREE)

Knowing if users are engaged during activities or exercises performed at home has always been important for the supervisors of these activities. Currently, through the application of deep learning, one can make an objective quantification of commitment using various metrics. One metric is the attention. The attention is calculated by tracking the direction of the gaze during the activities and evaluate if it disperses outside the screen or area of attention. Other relevant metric is the drowsiness. This metric exploits the EAR (Eye Aspect Ratio) calculation to check when the user has their eyes open or closed, so one can realise if they are asleep or pre-sleep. Finally, the commitment is also relevant. The commitment exploits the valence and excitement metrics by classifying student expressions during class. The excitement represents how happy/angry is the end-user while the valence indicates the interest during the activity. Merging these metrics, a level of real-time engagement while performing an activity is indicated.

The main objective is to study the users' engagement during the execution of different activities or exercises. This exercise is applied to education and health areas.

The inputs required for the digital solution are videos of users interacting with the systems. These videos (or collection of images) must capture users from the front and a distance from the sensor (camera) that allows the visualisation of facial details. This distance depends on the resolution of the camera so it cannot be defined a priori. As a reference, facial expression detection can be optimally performed with 720p resolution cameras from about 2 meters away.

The outputs are three metrics to change how attentive and committed the user is during activities. These metrics are attention, sleepiness and commitment.

5.5.1 Interfaces and Interoperability

Two ways of communicating with the rest of the system are proposed. In the case of a robotic system, the encapsulation of the sentiment analysis system is performed as a ROS node, connectable employing specific messages to the sensors (inputs) and the information managers (outputs).

In the case of an application, the system must present an API. Said API must define the ingestion of data or how to introduce the images to the module, as well as the dump areas of information (processed data/real-time engagement metrics).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.5.2 Applicable Pilot Themes

Two pilot themes were identified for this Digital Solution:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

5.5.3 Adaptations for PT1-UC004

Two main adaptations were made to this Digital Solution in order to comply with the needs of PT1-UC004. On the one hand, it was taken into account that with age the face and expressions of people tend to change. Therefore, a complete re-training of the models was made to understand and support the analysis of user engagement of old people. On the other hand, given that it will share hardware resources with a robot, extensive optimisations were made in order to reduce the CPU consumption of the Digital Solution.

The applicable SHAPES persona is Helena. Helena is an 82-year-old woman who lives on her own. Her independent lifestyle is supported by the robot ARI, which provides her with assistance in relation to managing reminders and appointments, taking her temperature, managing the shopping list, showing unread messages, and promoting physical activity.

5.5.3.1 Concept and Ideation Stage

Use case PT1-UC004 aims to empower the independence of old people. This usually entails assistance to remember appointments, taking the medication, use home devices, or make home exercises. This is supported by the use of a socially assistive robot which, additionally, helps them combat isolation and loneliness through activities and conversation. This is empowered by the detection of the engagement of the user in his/her facial expression, which opens the door to stimulating him by proposing new activities.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 76 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

			the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 77 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection.	Y	User detection needed for performing engagement analysis.
No code	Search for person behaviour.	Y	User engagement analysis performed.

5.5.3.2 Design and Development Stage

This solution is based on the results obtained by the sentiment detection module, as well as two other additional derived metrics. The current digital compromise detection solution has not been updated, as derived metrics do not vary depending on camera layout or user types. However, as described in section 5.3, sentiment detection has

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

been adapted, so that the metrics derived from said detection have already been indirectly modified to improve the robustness of the general machine vision pipeline of digital solutions.

As such, this Digital Solution does not provide a user interface, so no mock-ups were considered in the design process.

5.5.3.3 Prototyping and Adaptation Stage

The basic functionality of this system is to obtain metrics to check if the user is engaged with the system or not. The functionality and utility of the solution needs the face detection algorithm and a module of sentiment analysis, previously explained in section 5.3. This digital solution uses the detection of end-users' face in order to locate the face. Over these detected faces, the module that calculate, check, and weigh the engagement and attention of the person in front of the visual system.

These calculated scores and features are:

- **Attention**: people's attention is calculated keeping in mind a visual zone of interaction for the activities carried out. Ideally, if the camera arrangement and activity are aligned (as is the case of the SHAPES pilots) the solution presents an optimal area of interest in the centre of the user interaction screen and therefore, if the user is attentive to this area of interaction, this implies that his/her attention has been captured. To estimate the attention, it is detected the direction of the user's gaze during interactions with the system. Through a projective process, the intersection points of the vectors that indicate the direction of the gaze can be estimated with the application's viewing plane. This interaction can be grouped into a heat map that will indicate the position most viewed by the user. With this heat map, it is possible to calculate the percentage of time that the user is looking at the interactive application, and therefore, the percentage of the time that he/she is attentive to it.
- **Arousal-Valence** (AV): according to scientific studies, a very important part of understanding a user's commitment, can be measured by AV. This bi-valued metric, with independent terms of variation, is composed of valence and arousal. Valence is positive or negative affectivity, that is, if the experience is being pleasant (e.g. happy, hopeful, satisfactory) or unpleasant (e.g. sad, hopeless, annoying). On the other hand, arousal measures how calming or exciting the information is being processed. It has been shown that the more exciting and enjoyable an activity is, the more its benefits are enhanced (learning, memorisation, motivation).
- **Somnolence**: it can be estimated by looking at the blink rate of people in front of the cameras. These sleepiness detection systems are based on the EAR of the eye. The EAR is calculated by detecting the points that delimit the visible part of the eyeball and therefore its visible surface, being 1 when the eye is

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

completely open and 0 when the eyelids are totally closed. The frequency and opening of the eye make it possible to estimate the level of sleepiness of the users, which directly impacts on his/her commitment to a task.

With these features, the module calculates a global score of engagement of the user during the activities carried out in front of the visual sensors.

The data flow for this solution is based on the communication between ROS and the user engagement code. The workflow goes like this:

- Firstly, the sentiment detection module sends its results as the initial input, as well as the position of the face.
- Then, the detection of the facial points of the people is carried out, mainly for the detection of the eyes and their state.
- With these data, the direction of the gaze is aggregated in the heat map of attention together to the person's EAR is calculated.
- Finally, attention, AV and somnolence values are calculated to be fused and merged into a single engagement metric.
- This final metric is sent as the output.

As the results are not going to be displayed directly by TREE the outputs will be shared in the proper format and structure, i.e. ROS topics. These topics store the information related to calculated engagement score and can be shared throughout different SHAPES's modules.

5.5.4 Adaptations for PT4-UC002

The considerations and adaptations made for PT1-UC004 are also applicable here. The applicable SHAPES persona is Isabella. At the time an activity has been scheduled to be suggested to the user, the robot activates, undock, and starts searching for the older person within the house. When the robot detects a person, tells them to approach for face recognition. If the user is detected, the interaction with the robot starts. From then, either the robot reminds the user to start some activities, or the user activates the option to start them by personal initiative. Either way, the user carries out some activities (e.g. games) while the robot evaluates her sentiments and emotions.

5.5.4.1 Concept and Ideation Stage

Use case PT4-UC002 aims to support old people with dementia in its early stages. At the appropriate time, decided by a caregiver, the robot will locate the user and inform

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

him/her that it is the moment for playing cognitive games. The user goes to the room where the activity is supposed to take place, and the game takes place.

The activities will be supported by the user engagement Digital Solution. In particular, the robot can decide to keep the current game or propose a new one based on the user's attention, somnolence, or AV detected through the robot's cameras.

An analysis of the applicable system specifications and the pilot's use case requirements has been made. The following tables map the applicable ones and how they have been supported within the scope of this use case.

Table 78 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-053	SHAPES access devices may be user friendly.	Y	Facial interfacing contributes to improving the overall user experience.
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial interfacing contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigms.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Facial interfacing maximises user friendliness.
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Facial interfacing contributes to the overall ease of use.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Facial interfacing contributes to minimising the overall user interaction.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 79 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	User detection.	Y	User detection needed for performing engagement analysis.
No code	Search for person behaviour.	Y	User engagement analysis performed.

5.5.4.2 *Design and Development Stage*

The same considerations in PT1-UC004 apply, and therefore design and development stages have been analogous to what was explained in section 5.5.3.2.

5.5.4.3 *Prototyping and Adaptation Stage*

The same considerations in PT1-UC004 apply, and therefore prototyping and adaptation have been analogous to what was explained in section 5.5.3.3.

5.6 *OROFACE - Emotion Detection and Gesture Analysis (VICOM)*

The most representative, “basic” facial expressions (joy, fear, disgust, sadness, anger, surprise and contempt) brought by TREE's digital solution for “sentiment analysis” (see section 5.3) are suitable to check the predisposition of the interlocutors or intention during a human interaction or while using a specific Digital Solution. The digital solution brought by VICOM for “emotion detection and gesture analysis”, OROFACE (Orofacial Gesture Training Tool), focuses on detecting emotions and gestures from facial images beyond the “basic” facial expressions, i.e., more “fine-grained” dimensional emotions, following the Valence-Arousal-Dominance (VAD) model, and other kind of facial gestures that do not necessarily relate to facial emotions, usable for other kind of applications, such as rehabilitation. The VAD model maps emotional states to an orthogonal dimensional space, with measurable distances from one emotion to another. Since dimensional models pose an emotion as real-valued vector in the space, it is likely to account for subtle emotional expressions compared to categorical models which employ a finite number of “basic” emotions. With dimensional VAD models, capturing fine-grained emotions could benefit clinical NLP research, emotion regulation as a psychotherapy research and other works in computational social science fields dealing with subtle emotion recognition.

It relies on multi-tasking of Deep Neural Networks (DNNs), i.e., several facial attributes are estimated from one forward pass of the DNN, which allows the efficient deployment of the digital solution in low-resource devices.

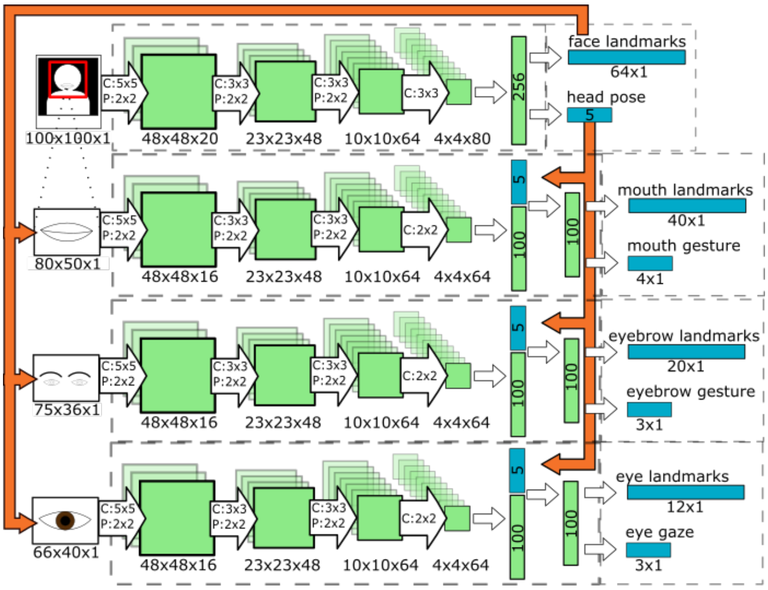


Figure 143 - Depiction of the DNN-based Multi-tasking Approach for Emotion Detection and Gesture Analysis

5.6.1 Interfaces and Interoperability

OROFACE is a module from VICOM's Viulib library (http://www.viulib.org/). It has C++ and Python APIs that allow building apps that would run this functionality locally (i.e., no cloud support required for the calculations).

The C++ API of the library is ready for the following computing platforms:

- Desktop and laptop PCs with Windows, Mac, or Linux operating systems.
- iPhone and Android mobile phones and tablets.
- Embedded systems, such as NVIDIA Jetson boards and the Raspberry Pi 4 board.

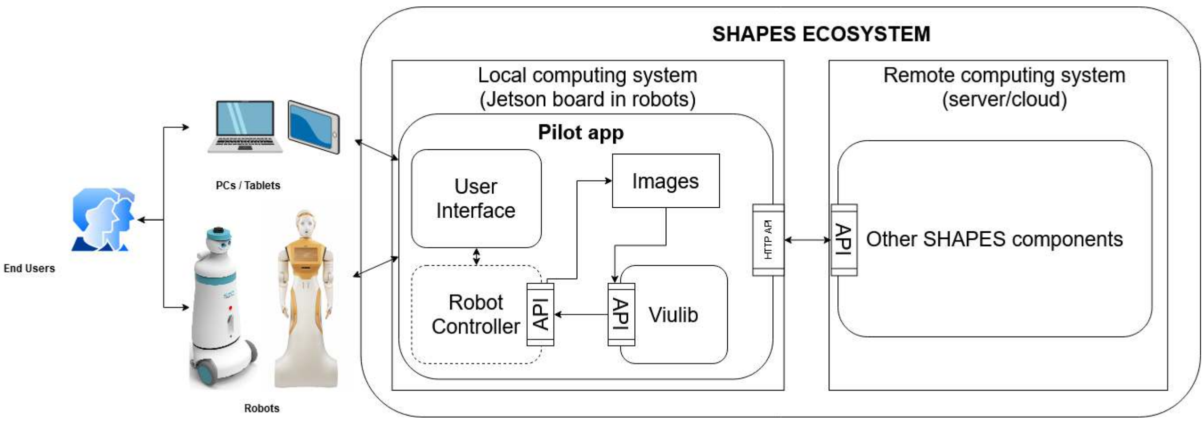


Figure 144 - Proposed Interoperability Mechanisms to Integrate Viulib Modules in the SHAPES Ecosystem

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.6.2 Applicable Pilot Themes

In bold are the pilot themes that confirmed the participation of the Emotion Detection and Gesture Analysis:

- PT2 – Improving In-Home and Community-based Care;
- **PT6 – Physical Rehabilitation at Home;**
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

5.6.3 Adaptations for PT6-UC001

The initial integration in the Phyx.io platform (section 4.9) in the context of PT6-UC001 has already been done. For this pilot, VICOM considered the following 27 orofacial gestures (apart from the "neutral" face), which are the typical ones used by rehabilitation trainers with elderly people: "bite_lower_lip", "bite_upper_lip", "blink", "blow_cheeks", "blow_left_cheek", "blow_right_cheek", "close_eyes", "eyes_left", "eyes_right", "frown", "hide_lower_lip", "hide_upper_lip", "kiss", "kiss_left", "kiss_right", "open_eyes", "open_mouth", "press_lips", "rise_eyebrows", "rise_nose", "show_teeth", "smile", "smile_left", "smile_right", "tongue_forward", "tongue_left", "tongue_right".

Most of these gestures are different from the typical gestures available in facial datasets for emotion and expression recognition (like those used to train OROFACE), including also other which are not related with emotions at all. Therefore, this required us to generate a dataset of many people performing several repetitions of these gestures in front of a camera with uncontrolled "in-the-wild" environmental conditions to train OROFACE. For that we asked for volunteers among the partners of the pilot to perform the gestures as previously shown by the involved rehabilitation trainers.

As explained in the introduction of OROFACE, in principle, it considers a multi-tasking-based approach, which has the advantage of allowing an efficient deployment of the digital solutions in low-resource devices. However, the lack of pre-annotated datasets for these specific gestures adds an additional difficulty as it also requires annotating the facial landmarks apart from the gesture. Thus, to obtain quickly results in this pilot we have simplified this part for the initial version by annotating only the gesture to the associated facial image to train an image classifier.

5.6.3.1 Concept and Ideation Stage

OROFACE (Orofacial Gesture Training Tool) API version 1.0 is designed to analyse in real time facial gestures in the context of orofacial gesture training from facial images captured from a camera in front of the user while performing the gestures.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

It is applicable to anyone that wants to exercise the orofacial musculature to improve overall facial muscle tone, correct tongue posture, decrease muscular tension, and establish a lip seal and nasal breathing pattern. This kind of exercises can benefit people with disorders such as sleep apnoea, bruxism, temporomandibular joint disorder, malocclusion.

The physical therapist or trainer plays a key role, not only prescribing exercise routines but also supervision the evolution, especially under rehabilitation processes. To this end, Phyx.io offers a dashboard view with records over time. The idea is that, even if the Phyx.io system corrects wrong poses or accompany the user during the routine, experts can access later the information generated during the routine. This can help evaluating adherence to the prescribed routine, level of achievement (for example, based on the number of repetitions prescribed and performed), accuracy of the performed exercise measure against the baseline pattern, time.

Figure 145 shows that the performance of orofacial gestures could be quite subtle. In consequence, as it can be observed in the confusion matrix of the trained model shown in Figure 146, during the execution of these gestures there could be moments in which the appearance between different gestures could be similar. Therefore, users should try to perform gestures with the highest expressiveness possible to avoid this problem. Besides, the evaluation should consider the time frames with the obtained maximum intensities for each gesture and ignore the gesture-to-gesture transitions.

Figure 145 - Examples of Reference Orofacial Gesture Images

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

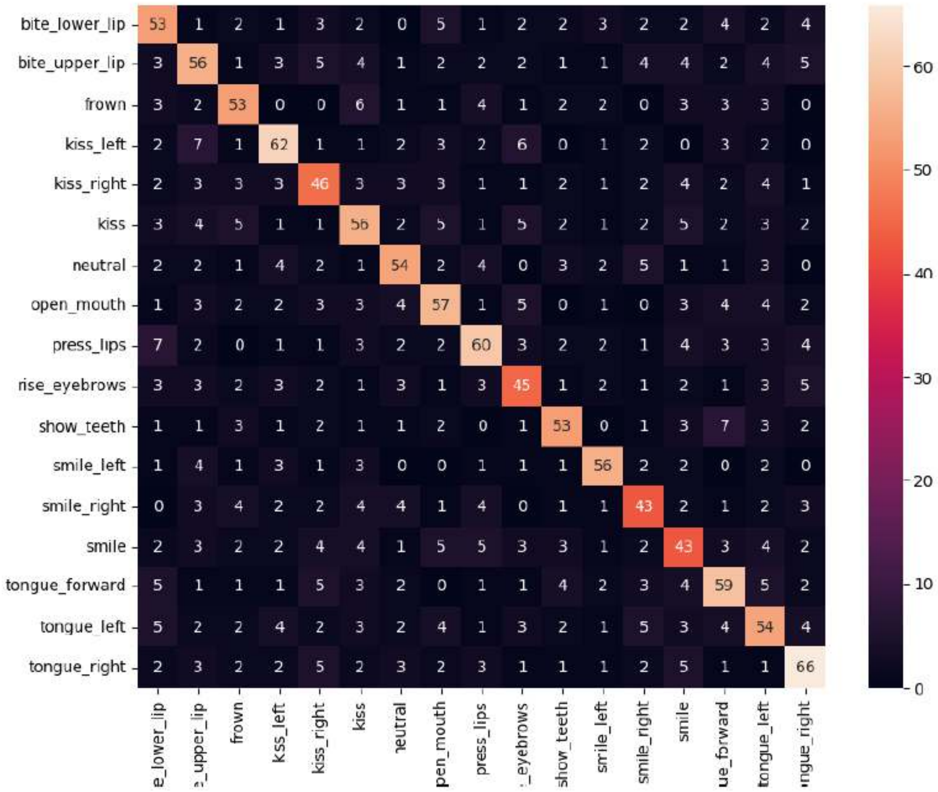


Figure 146 - Confusion Matrix of the Trained Orofacial Gesture Detector

Table 80 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigm.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	The digital solution does not store any data from the user.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Information shared with other DS through the Platform's API.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 81 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Access to camera required	OROFACE needs to access to a camera connected to the device that can provide images from the user while performing the gestures.	Y	The considered platforms accomplish this requirement.
Facial images of at least 100 pixels of width	OROFACE needs to visualise facial images with a size that allows applying gesture recognition techniques.	Y	The camera resolution and the distance of users in front of the camera affects this requirement.
Device with at least ARM64 architecture	The latest version of OROFACE needs at least ARM64-based architecture to work.	Y	The considered platforms accomplish this requirement.
Device with at least 2GB of RAM memory	The latest version of OROFACE requires in the order of 300MB to work. Nevertheless, considering also other elements that normally are needed in the full integration, VICOM suggests this requirement.	Y	The considered platforms accomplish this requirement.
PT6-UC001: Integration in a Raspberry Pi 4	OROFACE needs to be integrated in a Raspberry Pi 4 of the Phyx.io platform.	Y	The Raspberry Pi 4 has sufficient computational resources to run OROFACE.

5.6.3.2 *Design and Development Stage*

OROFACE is integrated in a Raspberry Pi 4 of the Phyx.io platform (section 4.9). It considers three lightweight DNNs to detect the face, the facial key points and the considered facial gestures, respectively. The deployment of these DNNs is optimised for mobile/IoT platforms using MediaPipe and TensorFlowLite for the inference. First, the user's face detection is performed by BlazeFace [20]. This DNN is related in structure to MobileNetV1/V2 [21, 22] and the Single Shot Multibox Detector (SSD) framework [23] and is aimed at effective GPU utilisation in mobile/IoT devices. Its output is used to initialise another DNN [24], which allows inferring a dense 3D mesh representation of the user's face. Thus, based on the localised facial key points, facial images are rotated and rescaled into normalised face patches to minimise the impact

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

of facial image shape and appearance differences that could affect the subsequent gesture recognition stage.

5.6.3.3 Prototyping and Adaptation Stage

In the initial setup for the Phyx.io platform VICOM considered the following 17 gestures for orofacial rehabilitation from the mentioned 27, which we will extend as we advance in the annotation process: “bite_lower_lip”, “bite_upper_lip”, “frown”, “kiss”, “kiss_left”, “kiss_right”, “open_mouth”, “press_lips”, “rise_eyebrows”, “rise_nose”, “show_teeth”, “smile”, “smile_left”, “smile_right”, “tongue_forward”, “tongue_left”, “tongue_right”.

For the normalised facial image classification, VICOM relied on EfficientNet-lite0 [25]. This DNN is the most efficient version of the EfficientNet-lite mobile/IoT friendly image classification models. Its output is a 17-dimension vector of floating-point numbers that go from 0 to 1. This trained model serves as the reference guide for users. Thus, if the user performs one gesture close to the learned reference, the output will be close to 1 for that gesture. This way the system can automatically evaluate how well the user is performing every gesture. Thresholds could be configured to determine whether a user performs sufficiently well the gestures in real time and to analyse the evolution through time.

5.7 FACECOG - Facial Recognition (VICOM)

This digital solution, called FACECOG (Face Recognition Solution for Heterogeneous IoT Platforms), allows recognising user identities, based on their facial images, captured from video-cameras, image files or video files. It relies on a set of DNNs that extract representative and privacy-preserving i-vectors from facial images. The involved image processing stages are the following:

1. Faces “in the wild” are detected in captured images.
2. Facial landmarks from the cropped facial images are detected to estimate the user’s facial shape.
3. Facial image textures are normalised to minimise the impact of environmental and behavioural effects (illumination, image quality, distances from the camera, poses, expressions).
4. Representative and privacy-preserving i-vectors are extracted.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

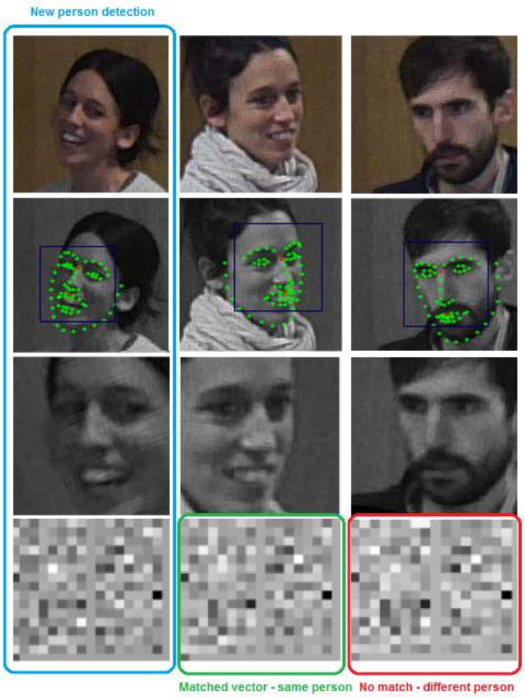


Figure 147 - Examples of the Image Processing Stages (from top to bottom rows: (1) face detection, (2) shape estimation, (3) facial texture normalisation and (4) i-vector extraction)

No facial images are stored, neither during the user registration process, nor during the surveillance/authentication process, only the extracted i-vectors are used. The user's facial images cannot be obtained from the extracted i-vectors, as these i-vectors are constructed by learning facial cues from facial image datasets built without any of the final users involved. Thus, the user's privacy is preserved.

5.7.1 Interfaces and Interoperability

FACECOG is a module from VICOM's Viulib library (http://www.viulib.org/), and therefore it can be integrated in the same way as the digital solution for "emotion detection and gesture analysis", OROFACE, described previously.

5.7.2 Applicable Pilot Themes

In bold are the pilot themes that already confirmed the use of FACECOG:

- **PT1 – Remote In-Home Wellbeing Monitoring and Assessment;**
- **PT2 – Improving In-Home and Community-based Care Monitoring;**
- **PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;**
- PT6 – Physical Rehabilitation at Home;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

5.7.3 Adaptations for PT1-UC001, PT2-UC003 and PT4-UC002

VICOM made some adaptations to FACECOG for all the use cases in SHAPES identified above, because elderly users especially need user-friendly and secure face enrolment and verification mechanisms, as they will probably have reduced interaction capabilities, and might need the assistance of caregivers. Besides, these mechanisms should prevent impostors from accessing sensitive user data (i.e., medical data).

Figure 148 shows the face recognition workflow customised for SHAPES that considers the shared use between the elderly user and the caregiver, with automated feedback to get facial images with the best possible quality.

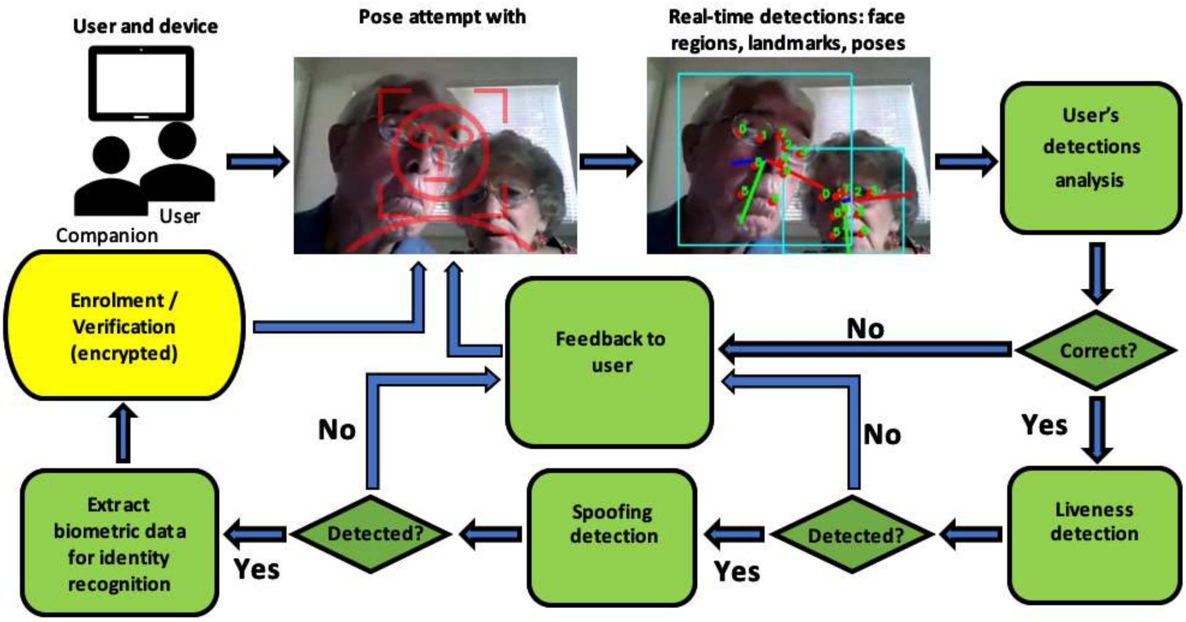


Figure 148 - User Interaction and Recognition Workflow

Additionally, the security of the biometric data has been improved taking into account that in this context: (1) data could be stolen remotely as these are connected to the Internet (to access data and other utilities from the SHAPES Platform in the cloud), (2) users should be able to enrol on one device and authenticate on another, and (3) not only the registered users—who give explicit consent for being uniquely identified—might be detected by the sensing capabilities of edge devices and robots.

FACECOG is deployed locally and not in the cloud. More specifically, in a local hardware platform with sufficient computing capability. In the case of not compliant IoT interaction devices, FACECOG would be deployed in a compliant IoT gateway as a service, and the IoT interaction devices would send queries when required.

The biometric data is stored in the hardware platform where FACECOG is deployed and will never leave it unless somebody steals it. Therefore, to avoid compromising the privacy of users, we have included an encryption mechanism [26], based on fully homomorphic encryption, that allows maintaining the biometric data always encrypted, even during matching operations. This approach requires 4 keys: a public key for encryption, a private key for decryption of the scores, and relinearisation and Galois keys for the matching operations of the encrypted data (Figure 149).

This way, if someone steals the stored biometric data from the hardware platform, it would not be usable without access to the private key required for decryption. This private key should be kept safely in a secure element of the hardware platform like, for example, a Trusted Platform Module (TPM) or a Trusted Execution Environment (TEE). TPMs are normally available in modern computer PC mother boards (since 2016). TEEs are available in Jetson Xavier NX, Jetson AGX Xavier series, and Jetson TX2 series devices.

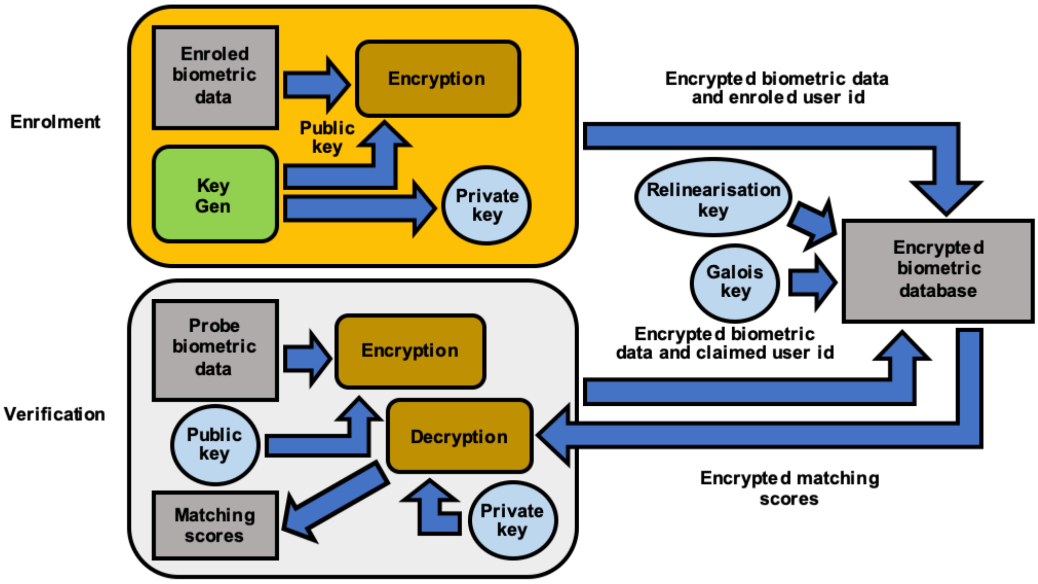


Figure 149 - Secure Face Matching using fully Homomorphic Encryption (Boddeti, 2018)

Read further details about the integration of FACECOG with ASAPA and the front-end in Deliverable D4.3.

5.7.3.1 Concept and Ideation Stage

FACECOG (Face Recognition Solution for Heterogeneous IoT Platforms) API version 1.0 is designed to analyse facial identities in the contexts of user verification and person identification in heterogeneous IoT platforms.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

It can support the user authentication process based on user/password (like ASAPA, explained in Deliverable D4.3) to make it more user-friendly, but also for the recognition of potential users at a distance (e.g., to ask for attention).

FACECOG has been designed to overcome the problem of effectively deploying face recognition algorithms in the high variety of edge devices and robots that could be part of an IoT platform, like SHAPES. Currently, DNNs – which generally have a high computational complexity for devices with limited computational resources – constitute the basis of state-of-the-art face recognition algorithms [27]. In some applications, these should be processed continuously at high-framerate and with low-latency (e.g., robots looking for users or performing surveillance tasks while moving around the house). This means that the DNN inference should be done locally on edge machines, and not on remote servers, as data transference would add a considerable latency in such cases. Moreover, there is an increasing variety of new processors (XPUs: CPUs, GPUs, FPGAs) and DNN inference engines (Intel's OpenVINO, Google's TensorFlow Lite, NVIDIA's TensorRT, Facebook's PyTorch) specifically designed for those processors [28].

Table 82 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-114	SHAPES should support assisted mobility at home.	Y	Facial recognition contributes to assisted care.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigm.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	The Digital Solution has been designed to store only the minimum amount of biometric data for recognition purposes.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	The biometric data is not shared with any other solution, but the responses are shared with other DS through the Platform's API.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-193	Single sign-on mechanism shall be provided by SHAPES Platform.	Y	The digital solution supports the ASAPA component to make the user authentication process more user friendly, it does not replace it.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 83 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Access to camera required	FACECOG needs to access to a camera connected to the device that can provide images from the user while performing the gestures.	Y	The considered platforms accomplish this requirement.
Facial images of at least 60 pixels of width	FACECOG needs to visualise facial images with a size that allows applying identity recognition techniques.	Y	The camera resolution and the distance of users in front of the camera affects this requirement.
Device with at least ARM64 architecture	The latest version of FACECOG needs at least ARM64-based architecture to work.	Y	The considered platforms accomplish this requirement.
Device with at least 2GB of RAM memory	The latest version of FACECOG requires in the order of 300MB to work. Nevertheless, considering also other elements that normally are needed in the full integration, VICOM suggests this requirement.	Y	The considered platforms accomplish this requirement.
PT1-UC001 and PT2-UC003: Integration in a Jetson Nano board	FACECOG needs to be integrated in a Jetson Nano board of FINT's gateway.	Y	The Jetson Nano board has sufficient computational resources to run FACECOG.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
PT4-UC002: Integration in a Jetson TX2 board	FACECOG needs to be integrated in a Jetson TX2 of PAL Robotics' ARI platform.	YES	The Jetson TX2 board has sufficient computational resources to run FACECOG.

5.7.3.2 Design and Development Stage

See Deliverable D4.3 for details about the test cases and validation.

5.7.3.3 Prototyping and Adaptation Stage

See Deliverable D4.3 for details about the deployment options and offered interfaces, test cases and validation.

5.8 Safe Digital Assistant and NLP (VICOM)

This section presents the Chatbot and NLP digital solution, its detailed technical description, the available interfaces, expected use cases, and an illustrative mock-up of two of the main skills: reminders and periodical follow-ups. Although this solution is being included under Task 5.4, it could be included under various tasks.

A chatbot is an interactive solution that can comprehend the end-user intention in natural language, plan the next response according to some domain knowledge and give the appropriate response. They are widely used due to their naturalness and frictionless communication with the end users.

The objective of the DS described here is to provide simple, transversal, modular and customisable solutions to satisfy the demands raised by the SHAPES Consortium, lowering the gap of the technical skills required to build a chatbot as much as possible. To that end, a Skill based approach is selected.

A Skill is a specific functionality of the Chatbot, e.g. weather forecast, which allows to have a customisable "recipe" to adapt to each possible Chatbot, highly reducing the time and effort required to build these systems.

The skills that are identified are listed below, but due to the dynamic nature of the project they could be adjusted, changed or replaced by other ones:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **Reminders**: be able to set different types of reminders by the caregivers (water intake, pill intake, cultural activities) so the system can have the required initiative.
- **Periodic follow-up**: be able to make follow-ups periodically with a sort of pre-defined question types (evolution, scoring 1-5, and so on), setup alarms and register and store this information for further analysis.
- **Forms/Questionnaires**: be able to identify frequent questions and gave them the appropriate answer.
- **FAQs**: define frequently asked questions and their answers.
- **How-to**: gave the assistant the ability to guide the end-users through a procedure of multiple steps.

5.8.1 Technical Specifications

The technical information is summarised in the table below:

Table 84 - Adilib Skills

	Adilib Skills
Goal	Add a certain functionality to the Chatbot
Operating System	Ubuntu
Deploy method	Docker
Hardware requirements	TBD
Web Interface	Yes
HTTP Rest API for Developers	Yes
Connects via	API with Adilib Core
Persistence	MongoDB/Customisable
Data-dump	None/TBD
Requires SHAPES Ecosystem	Yes
Required Info from SHAPES	Bridge user identifiers Store information Skill configuration Personalisation
Interfaces to add External Modules	Customisable (HTTP REST APIs preferred)
Malleability[2]	Very High
Scalability	Vertical

[2] Degree of possible adaptations/adjustments.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

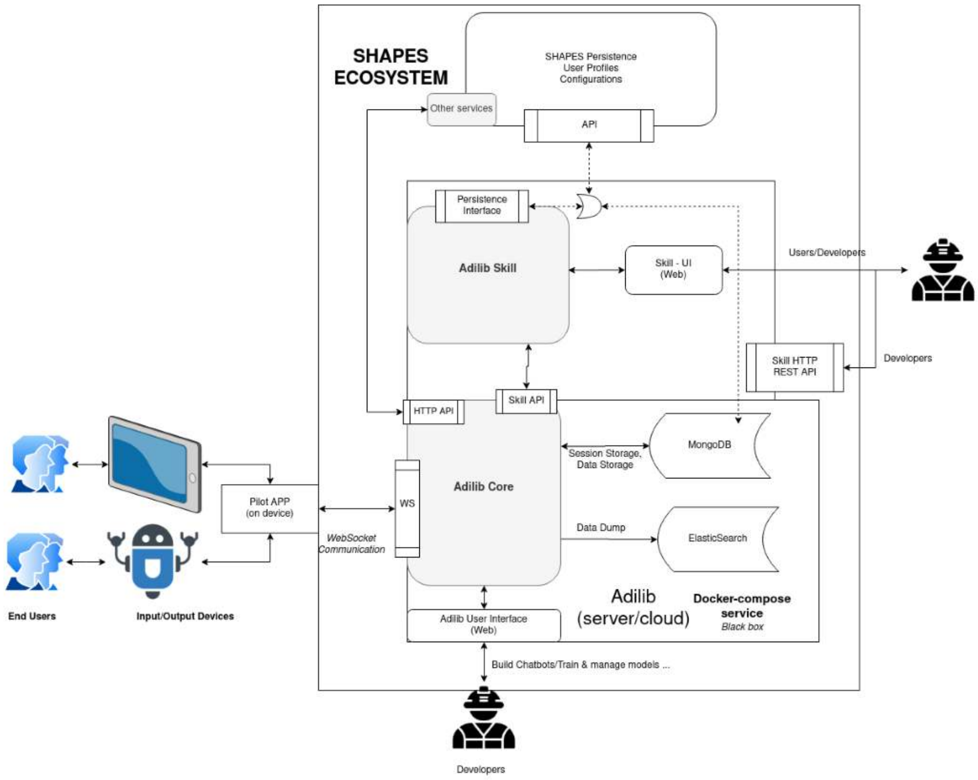


Figure 150 - System Architecture

Overall, both Adilib Core and Adilib Skills work as a black box which communicates using JSON style messages following the REST properties. Note that they need to be installed on a dedicated server, as the module scales vertically for concurrent users (single machine).

The communication with the Chatbot is done via web socket, so any front-end type can interact with the Chatbot. Two persistence layers appear in the Adilib Core, the MongoDB where the dialogue sessions are stored and the ElasticSearch data-dump, where the information of the conversations and dialogues is stored.

The access point by the end-users will be using a custom Front-end/App.

The consumption of other services and Adilib will be done using HTTP REST API protocols, and the communication with the Skills will be handled by an internal Skill API. The whole Adilib Core and Adilib Skill is intended to be a black box.

As each Skill will be customisable for each individual (see Mock-up section), the skills will require to access certain information which can be stored in a MongoDB that each skill has or in other persistence layer in the SHAPES ecosystem. As illustrative example, the following items will be needed:

- **User profile and identifiers**: to determine its channel identifier, assigned follow-ups/reminders, and so on. For example, if a question arrives from “user10” the Chatbot has to retrieve if “user10” has any reminder or pending task.

- **Configurations**: of each skill, reminder types, questions to ask, follow-up templates and so on.

5.8.2 Interfaces and Interoperability

Denoting as "interface" every mechanism that allows external users to gain access/control or modify the behaviour of the Adilib Core/Skills, i.e. having a significant impact on the behaviour of the Chatbots, the following interfaces are identified:

- **WebSocket communication with Adilib**: main communication channel to talk with the Chatbots deployed in production.
- **Adilib User Interface**: this web interface allows to train the main technological modules of the chatbot, define interaction rules, deploy model, open channels such as the WebSocket and so on. This is intended to use by the Chatbot developers, as it requires a deep knowledge on the topic.
- **Skill User Interface**: this web interface allows to modify the behaviour of the skill, adapting and personalising it to each UC and, if it is necessary, to each user. This interface is intended to be used by the UC integrators, the caregivers and non-technical staff. See the Mock-up section for an illustrative example.
- **Skill HTTP REST API**: Optional. This API will be exposed for Skills that could require a programmatic integration with other services so the Skill could be configurable with automatisms.
- **Adilib Chatbot HTTP Client**: The Chatbots have a HTTP REST Client mechanism that allows to interact with external services and middleware to integrate information and knowledge into the Chatbot process. For example, to generate an adequate response for the question "What will the weather be in Sydney tomorrow?" the chatbot will have to communicate with a Weather API and provide it with the right information (location and time).

Voice Layer

The voice layer is the service which grants access to Speech Recognition and Text to Speech synthesis. The languages provided by VICOM are Spanish and English.

To access these services an HTTP REST API/Socket will be made available, integrating the following mechanisms:

- **Recognise**: send and audio file and receive the transcription.
- **Synthesise**: send a text and returns an audio.

Other connection types/custom APIs/Bridges or mechanisms will be determined according to the needs expressed by the different use cases.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.8.3 Applicable Pilot Themes

The summary of the use cases that have demonstrated interest on integrating this DS are:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;
- PT5 – Caring for Older Individuals with Neurodegenerative Diseases;
- PT6 – Physical Rehabilitation at Home.

Note that the goal of VICOM will be to provide as much coverage as possible to the several use cases that have shown interest on digital assistants.

5.8.4 Adaptations to Use Cases

Due to the interest over Adilib of several pilot themes and use cases, the adaptations follow a general-interest principle, i.e., the adaptations and changes are generic enough to satisfy several PT needs at the loss of specificity.

To adjust the Adilib chatbot building platform, the initial version of the proposed skills has been deployed on a remote server.

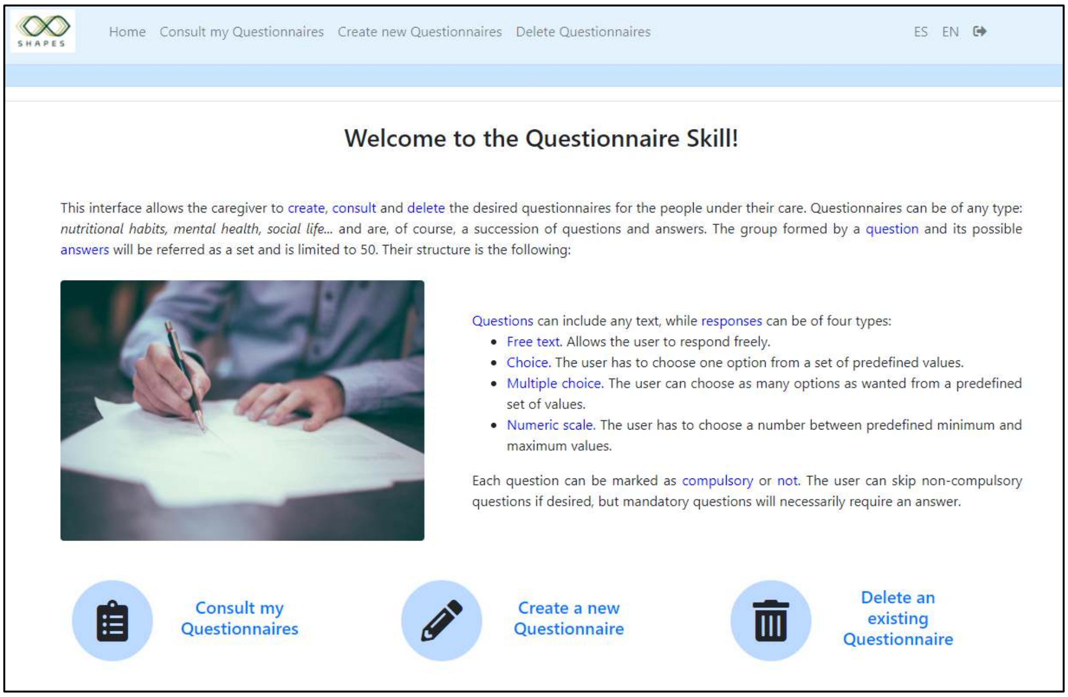


Figure 151 - Questionnaire Skill

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

These skills allow the Assistant administrator to build custom interaction regarding to tutorials, questionnaires, reminders, agenda items, without the need of expert chatbot-building knowledge.

In addition, as the lack of front-end channels was accused by the pilot sites, a web-based assistant has been deployed to perform interactions using modern web browsers (Chrome and Firefox tested).

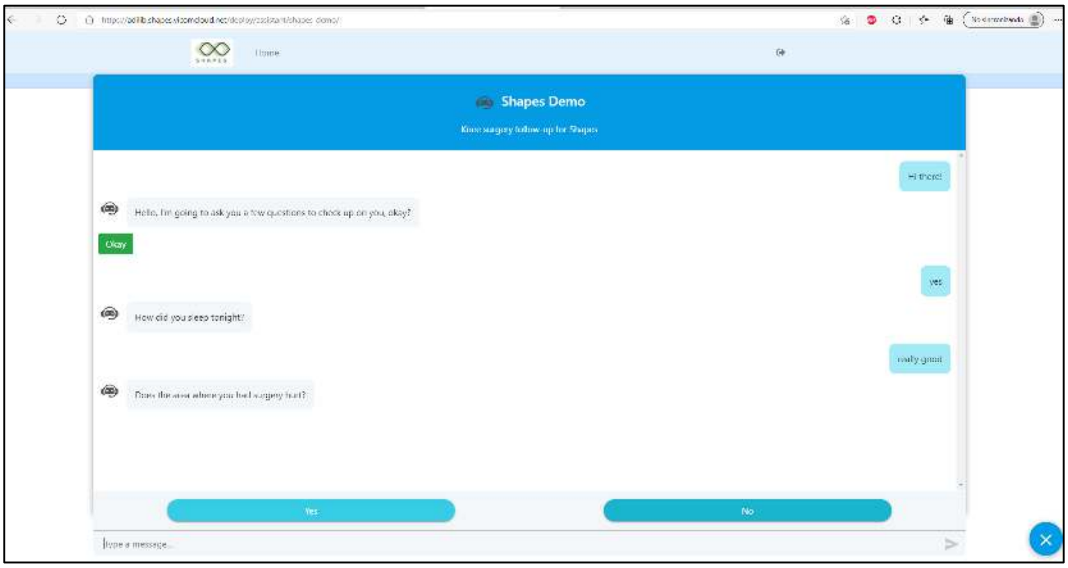


Figure 152 - Web-based Assistant

This web-based interface will allow to consume the assistants using the most common devices such as PCs/Laptops/Smartphones and Tablets.

5.8.4.1 Concept and Ideation Stage

The Adilib Skills have been developed to overcome the barrier of the technical knowledge required to develop the assistants. These skills allow to develop closed-logic interactions (e.g., tutorials) just by filling some web-forms which is easier to achieve than creating complex rules and interactions in Adilib.

It can support the user authentication process based on user/password to make it more user-friendly and integrable in SHAPES.

The Adilib Skills are designed to overcome the problem of effectively deploying on the heterogeneous environment like SHAPES.

In addition, as there is no unified front-end to consume the generated assistants, a web-based interface has been deployed so, after authentication, the users of SHAPES Platform may employ to consume the assistants.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 85 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	The SHAPES Platform shall support a multilingual user interface.	Y	Adilib has a multilingual interface (Spanish, English) and the translation of other language should be done by partners.
SPS-046	SHAPES should support reminders.	Y	Setting reminders is supported in Adilib.
SPS-055	Voice and chat interaction should be supported using chat bots.	Y	Adilib has been created to fulfill this criterion.
SPS-095	SHAPES may support multilingual voice translation.	N	Voice translation is not in the scope of the project. Multilingual Speech to Text is available in Spanish and English.
SPS-105	Communication through an interface showing pictures & words with associated sounds, that users can use to communicate needs/feelings when not able to speak/move adequately should be provided.	Y	Although the chatbot supports text/buttons/image and other data types, the system specification is too *ad hoc* and depends on how the assistant is implemented.
SPS-114	SHAPES should support assisted mobility at home.	Y	Chatbots contributes to assisted care.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The use of the digital assistant requires the authentication and authorisation of the end-user.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	The front-end and interface of each use case is developed by each use case managers, also, the “user friendly” and “attractive” terms differ from each use case to another (e.g. a user-friendly interface for people with hearing impairment is not friendly for other group of users).

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-135	SHAPES shall offer Ease of Use interfaces for both healthy and impaired users.	Y	Chatbots and assistants are user-friendly interfaces, yet are not suitable for some impairment types (deaf, deafblind).
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	The stored information is the one required to ensure GDPR compliance.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	The information of conversations is stored in an elasticsearch database so it can be accessed from the outside.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner, using docker-compose, container image hubs and versioned microservices.

Table 86 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Handle several concurrent users	The number of concurrent users talking to Adilib might reach hundreds at a time.	Y	The server has 128GB of RAM and 64 cores so it can handle multiple several 1-2 thousand connections.
User Management	Adilib and the skills need to handle caregivers and care receivers.	Y	Skills have separated capabilities per each role.
Adaptable to different scenarios	Adilib can be adjusted to each PT.	Y	Skills are customisable within a certain logic.
Availability	Adilib should be accessible by each PT.	Y	It is deployed in a publicly accessible server with the required security measures.
Skills	The UCs require to have an easy way to create custom	Y	The skills are generic to satisfy several UCs in

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	interactions to solve specific tasks.		overall, at expenses of being overly-tailored to specific needs.
Custom Interactions	Some UCs require to have custom and specific interactions with their uses.	Y	Adilib allows to create these interactions using custom dialogue rules. To instantiate these rules a Webinar was presented to the consortium so each PT/UC could employ Adilib to that end.
Front-end	Some UC did not have a front-end available for them. To solve this a generic web-based front-end has been developed for SHAPES.	Y	Web-based, tested currently on PC on Firefox and Chrome.

5.8.4.2 *Design and Development Stage*

See Deliverable D4.3 for details about the test cases and validation.

5.8.4.3 *Prototyping and Adaptation Stage*

See Deliverable D4.3 for details about the deployment options and offered interfaces, test cases and validation.

5.9 NewSum Mobile Application (SciFY)

NewSum automatically summarises information from many sources and combines them in a single text. It gives the main points of all the different information that one would get if one would read all the articles from the sources visited. With the use of artificial intelligence technology, news is summarised, and all repeated information is not duplicated. NewSum is an open source project and is offered for free without ads. The New Sum App will be adapted to incorporate elder-oriented content on local and national news feeds and social networking feeds and interactions.

NewSum is available in English and in Greek.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

5.9.1 Technical Specifications

NewSum runs on mobile phones running Android operating system. The application is built using the Java programming language.

5.9.2 Interfaces and Interoperability

Interface: Smartphone

The user can:

- choose from a plethora of news categories.
- see news, for each category, that were gathered from multiple sources (like news websites, RSS feeds) and summarised by AI.
- click on an article and see the summary.
- see the sources that were used for each news article.
- share the summary on social media.
- select favourite news categories.
- select from which news sources they would like to receive news.

5.9.3 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.

5.10 eCtouch (OMN)

Omnitor eCtouch App for computers, tablets and smartphones. eCtouch is an accessible Total Conversation communication software for Windows, iOS and Android. eCtouch supports assistive technologies such as screen magnifiers, screen readers and Braille devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 153 - eCtouch DS by OMN

Table 87 - eCtouch Data

Data Category	Measurements Type	Collection Method
Internet Data	Contacts Settings SIP registration and calls Connection status	Automated (from connected devices)
Data to Industrial Devices	Can be connected to NOT!FY	Automated (from connected devices) or manual
Data from Industrial Devices	Calls from other SIP-based units	Automated (from connected devices)
Data from Appliances	Home appliances Mobile appliances Service appliances	Automated (from connected devices)

5.10.1Technical Specifications

Omnitor eCtouch uses Voice over Internet Protocol (VoIP) (RFC 3261) to create a call session. During calls, the protocol dynamically allocates Use Datagram Protocol ports for media. The ports range from 35000 and 40000 server sided.

A restrictive firewall rule could be achieved with limitation to communication with Omnitor's SIP server, which is located at a specific Internet Protocol. The ports that are needed for the server are 35000 – 40000 UDP and 5060, 443, 80 Transmission Control Protocol.

In summary, the technical requirements of eCtouch are:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **eCtouch Android**
  Minimum Android 6, 2,3 GHz quad-core processor and 3 GB RAM to handle HD-video.
  The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.
  A built-in speaker and microphone are recommended.
  IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.
- **eCtouch iOS**
  Minimum iOS 13 and higher. The oldest supported hardware is iPad 2017 (gen 5) and iPhone 7.
  The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.
  A built-in speaker and microphone are recommended.
  IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.
- **eCtouch Windows**
  Minimum Intel i3 processor and 2 GB RAM to handle HD-video.
  The camera needs to support a resolution of QVGA, VGA, 720p with 25fps minimum.
  IP network Wi-Fi 802.11b, 802.11g or 3G/4G. At least 1000 kbit/s both upstream and downstream is recommended for good video quality. 2 MBIT/s is required to handle calls with HD video.

5.10.2 Interfaces and Interoperability

Table 88 - Summarised Technical Description of the eCtouch

General Description	• Omnitor eCtouch App for computers, tablets and smartphones, accessible Total Conversation communication software for Windows, iOS and Android • eCtouch support assistive technologies such as screen magnifiers, screen readers and Braille devices.
Features	• Citizens with disabilities (often elderly) that need an accessible remote communication solution. Used at work and home by the citizen with a disability for daily communication with friends, family, colleagues, authorities, customers. • eCtouch is an accessible Total Conversation (Real Time Text, video, audio) App (Windows 10, Android, iOS) for deaf, hard of hearing, deafblind, vision impaired, speech impaired individuals. • Support assistive technology such as screen magnifiers, screen readers, braille devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

	• Follows the Session Initiation Protocol standard and works together with remote interpretation services e.g. for sign language. • Independence and well-being, cost reduction for society – individuals with disabilities are able to work.
Application Areas	• Conversation tool (App)
TRL	From TRL9
Data Type	XML
Inputs	Contacts, App settings
Outputs	Call logs, Chat logs, App settings
Actions to be performed	• Users will be able to contact each other with the eCtouch app. • The user could also add a NOTiFY to their eCtouch which would enable them to have e.g. a flashing light when they have an incoming call.
Interface	PC, smartphone, tablet

5.10.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

5.10.4 Adaptations for PT1-UC004

PT1-UC004 needs some adaptations in order to integrate it with the ARI robot from PAL Robotics. This is to be able to trigger text-to-speech function and to be able to make the robot aware when the user is in a conversation.

5.10.4.1 Concept and Ideation Stage

No solution to trigger text-to-speech function with the robot exists for now. A concept will be proposed soon.

To make the robot aware that the user is having a call could be made through NOT!FY, please see section 3.3.3.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 89 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	eCtouch is built with a common standard such as SIP.
SPS-023	The SHAPES Platform shall support a multilingual user interface.	Y	eCtouch has a multilingual interface (English & Swedish for the moment) and adaptations could be made with help of partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	eCtouch already has a dedicated user manual with relevant instructions on the use of the devices.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	eCtouch complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	eCtouch storage is handled in EU Member States.
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	eCtouch is designed with privacy by design.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	eCtouch complies with relevant cybersecurity rules for mobile and online services.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	eCtouch offers user friendly and attractive interfaces.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	eCtouch offers user-friendly interfaces for all users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	eCtouch applies user interfaces resembling other technologies used by the elderly.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	eCtouch could be installed through Apple store, Google Play, and Microsoft Store.
SPS-173	SHAPES services and applications should be accessible using Android and iOS-based mobile devices.	Y	eCtouch is available by both Android and iOS-based mobile devices.

5.10.4.2 *Design and Development Stage*

At this stage, no visual design has been implemented, a translation to each pilot's native language might be needed.

5.10.4.3 *Prototyping and Adaptation Stage*

A prototype where ARI Robot is integrated with an Android tablet, where eCtouch is installed has been evaluated.

The next step will to be fully integrate ARI Robot so it could trigger text to speech and also alert ARI Robot when the user is in a call.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

6 Decision Support, Risk Assessment and Prediction Services (Task 5.5)

Task 5.5 began with discussions around the different solutions the SHAPES Project will integrate related to Decision Support, Risk Assessment and Predictions, while designing the different project's use cases. In this section, a summary of these different solutions is presented. It is important to stress these Digital Solutions are dependent on the data collected during the project, so this first approach can be modified as the project evolves.

Predictive systems have been used and continue to grow in use in healthcare systems for early identification of patients at high risk (or at the beginning) of suffering an adverse event or disease, allowing for a proactive approach by healthcare staff and patients. They can help predict the onset of diseases and adverse events for patients with long-term diseases, allowing for early treatment and prevention measures that could improve people's health and lower healthcare costs. Risk assessments can be used to determine the likelihood of a patient to contract a particular disease in the future, enabling the patient and medical staff to take measures early on for prevention. Decision support systems use clinical knowledge, patient and other health information to improve healthcare delivery and quality.

In situations of real-time monitoring of older adults, prediction and analytics services can detect abnormal signs, allowing doctors to know when to perform further tests and provide advice and support in relation to the results or even suggest medication.

In the next sections, a set of different Solutions supporting the Decision Support, Risk Assessment and Prediction Services in SHAPES are presented.

6.1 Prediction of Exacerbation/Chest Infection in COPD Patients (TREE)

The Chronic Obstructive Pulmonary Disease (COPD) is a chronic respiratory disease. The diagnosis of the disease is related to the loss of lung function due to an inflammatory process in the airways and lungs. In the initial stages of the disease, symptoms like breathing problems or dyspnoea could appear because of the inflammation of the small airways. The severity of the disease is variable and is associated to the lung function (measured in the expiratory manoeuvre).

This disease is understood as a complex and heterogeneous multisystem disease, with varying levels of progression and activity in different patients. The main risk for COPD patients is linked to exacerbations, understood as instability episodes that

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

contribute to the progression of the disease. These episodes could lead to the hospitalisation of the patient and even death. Some of the stronger efforts to deal with this disease try to predict or anticipate the exacerbations. There are no firm rules or models to predict exacerbations and most of the studies are focused on finding relationships between different groups of variables to avoid the patients decline.

The use of medical devices and home ambient monitoring stations can contribute to a better understanding and control of the disease. At least, the continued monitoring of some parameters allows the control of changes in the development of the disease and facilitates the research of relations between the ambient conditions and the patient status.

6.1.1 Interfaces and Interoperability

This digital solution is close to the research level and the aim is to provide insights to improve the assessment of COPD patients. The scope and usability of the analytical service depends on the advancement and collection of comprehensive patient data. This digital solution works as an analytical service within the Big Data platform, so the response is a collection of outputs to be displayed in the front-end solutions involved in the pilot/use cases. For this reason, there is not an interface and the use case participants do not interact directly with the digital solution.

6.1.2 Applicable Pilot Themes

- PT3 – Medicine Control and Optimisation.

6.1.3 Adaptations for PT3-UCCOPD

This analytical solution focuses on the study of the PT3-UCCOPD - Advanced telemonitoring of patients with COPD in home environment. This use case is dedicated exclusively to the implementation of medical devices to follow up COPD patients. It is planned the deployment of key medical devices for this purpose like pulse oximeters, spirometers and home ambient stations.

The aim in this use case is the assessment of the COPD patients through the data provided by the IoT devices. The main idea is to assess the evolution of the key parameters related to the COPD diagnosis and their relation with the ambient conditions.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The applicable SHAPES persona is Jarda. Jarda's daily routine starts with measurements of blood pressure and SpO_2. After that he also conducts spirometry. Before going to sleep Jarda also puts on his ring-like sensor to monitor SpO_2 thorough the whole night. Data from home environment monitoring are transmitted without any need for user's intervention. The measured data is also being analysed at the COPD predictive tool.

6.1.3.1 *Concept and Ideation Stage*

In COPD patients, as the disease progresses, a few functional parameters can be predictors of morbidity or disease status. The main source to measure the disease progression is linked to the spirometry. A spirometer is a device that measures the volume of air inspired and expired by the lungs and, depending on the quality of the device, can provide several measures and indicators. The simplest method to diagnose pulmonary and airways diseases. The COPD diagnosis is mainly defined for the relation between two measures given by the spirometry, the Force Expiratory Volume in the first second (FEV1) and the Force Volume Capacity (FVC). If the ratio between these two measures (FEV1/FVC) is above 0,7 the patient is affected by COPD. This ratio illustrates the limitations of air flow in patients with COPD and informs about the severity and prognosis of the disease.

The FEV1/FVC is not the only indicator to assess the COPD. The spirometry provides a collection of outputs that are useful for the assessment of the disease and to anticipate exacerbations. The exacerbations are episodes of instability that allow the disease to progress. These episodes could lead to the hospitalisation of the patient and even the death. Some of the stronger efforts to deal with this disease try to predict or anticipate the exacerbations. There are no firm rules or models to predict exacerbations and most of the studies are focused on finding relationships between different groups of variables to avoid the patients decline. A summary of values coming from the spirometry to assess the COPD development and the exacerbation risk:

- **FEV1**: The Force Expiratory Volume in the first second by itself is reported as the primary predictive factor on COPD associated to general physical decline and the main source to set the stages of development of the disease (according to the GOLD scale).
- **SVC - FVC (difference)**: Other important relation between spirometry indicators is based on the air Volume in Slow Expiration manoeuvre (SVC) and the Force Vital Capacity (FVC). The difference between these two values has been described as a marker of air trapping, an early step in the development of obstruction, and it is proposed as a good measure to assess exacerbations.
- **FVC / SVC** (ratio): The second value that relates the two previous measures is the ratio between FVC and SVC. In this case this indicator gives insights to changes in small airways (important in early stages of the disease).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **IC** (inspiratory capacity): The total inspiratory capacity presents a good correlation during COPD exacerbations.
- **IC/TLC** (ratio where TLC = Total Lung Capacity; IC = Inspiratory Capacity): it is also a value that gives good correlation during a COPD exacerbation.
- **FEF 25-75:** An average of volume exhaled between the 25 and 75% of the FVC per second is considered as a valuable measure related to the exacerbations and inflammatory process.

The patient decline in COPD patients is mainly evaluated through the spirometry but other physiological parameters can be helpful in disease assessment. For example, the respiratory rate is clearly correlated (in the admission time) with disease complications like exacerbations that can lead to hospitalisation. A high respiratory rate or dyspnoea (the feeling of not being able to breathe well enough) are referenced as a common consequence of an exacerbation.

But probably a better and more referenced indicator is the oxygen saturation. Oximeter measures is highlighted as good variable to prevent exacerbations. Some studies analyse the evolution of the *n* previous measures to a new one to assess the risk of exacerbations. The stand-alone assessment of oxygen saturation (SpO_2 in pulse oximeter) seems useful as a time series. The retrospective analysis usually refers to 5 prior days of abnormal values to lead an exacerbation. Oxygen saturation can be used as predictor of exacerbations in combination with other physiological parameters like blood pressure, heart rate, lung function (spirometry), weight and temperature.

Some associated factors to COPD studies refer to environmental variables. Out of the direct parameters affected by COPD development, external factors should be taken into account to evaluate the progress of the disease. The relations between the evolution of key parameters and environmental variables are yet a field to explore. There are no consistent cause-effect relationships but there are tendencies or patterns that seems to affect the evolution of COPD patients. Not only pollution and air quality conditions but also climatological factors as well have been referenced as elements to consider in relation with changes in the normal development of the disease.

In terms of air quality, it seems thresholds can be set as bound of condition deterioration in COPD patients. Mainly outdoor, it is important the assessment of the relation between COPD conditions and level of different pollutants. SO_2 and NO_2 concentrations were found to be positively associated with COPD exacerbations. Other studies suggest PM2.5 exposure can induce a worse lung function or airway inflammation. PM10 is associated with increased COPD hospitalisations. However, as was said before, these relations are not conclusive and the COPD prognosis depends on a heterogeneous collection of factors.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The main objective of this solution is the assessment of changes in the disease and to find the main relations between the environmental factors and the COPD key parameters.

Table 90 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	The analytics engine operates over vital signs obtained through medical sensors.
SPS-043	SHAPES shall support risk assessment and action plans as part of its data processing of health data.	Y	Risk assessment and response have been taken into account as part of the operation of the analytics engine.
SPS-118	SHAPES should offer monitoring of home environment.	Y	Non-medical IoT data are included in the analysis.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto Data Lakehouse repository.	Y	IoT is received by the Data Lakehouse using SymbIoTe.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via FINoT platform.	Y	IoT Data is received via FINoT.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

Table 91 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
G01	The system has to comply with ethics requirements (WP8).	Y	The analytics engine is compliant with ethics requirements.
G02	Easy to use (for both older people and professional caregivers).	Y	The analytics engine is transparent to end-users.
G03	Accessibility issues (for older people).	Y	The analytics engine is transparent to end-users.
G04	Privacy and security. GDPR compliant.	Y	The analytics engine is compliant with GDPR.
G05	The system has to comply with platform requirements (WP4).	Y	The analytics engine is compliant with WP4 requirements.
G06	The system has to comply with other requirements (WP3/T3.5).	Y	The analytics engine is compliant with WP3 requirements.
G07	The system is compatible with the chosen 3rd party medical devices (scale, blood pressure monitor etc.).	Y	The analytics engine is compliant with medical devices through connectors.
FO15	App collects all this information from the user and sends it to the FNOL Cloud/SHAPES TP for further processing and analysis.	Y	Information is received by the analytics engine.
SP01	Authentication applies to all types of accesses and users.	Y	Authentication is supported by the SHAPES platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
SP02	Ensuring users' privacy, safety and security.	Y	Privacy and security are supported by the SHAPES platform.
CPV04	Risk of COPD exacerbation per patient.	Y	Analytics contribute to the COPD risk evaluation.

6.1.3.2 Design and Development Stage

The development of this solution is linked to data collection. The analysis proposed is focused on the research of the relations between the two groups of data sources coming from IoT devices. The expected output for this specific use case is to put the basis of a monitoring tool capable to help COPD patient in two ways:

- A better assessment of the key parameters in COPD patients by the professionals.
- Improve the capability to anticipate and prevent episodes of respiratory crisis that imply the decline of the patient.

The focus for this specific use case is the research using IoT data. The guidelines are oriented by state-of-the-art studies but we do not bring solutions developed before SHAPES project for this topic.

6.1.3.3 Prototyping and Adaptation Stage

The input information for the analytical approach proposed is the data coming from the key devices for COPD patients monitoring:

- Spirometers;
- Pulse oximeters;
- Smart inhaler;
- Blood pressure;
- Environmental sensors.

The data provided by these IoT devices gather all the key information necessary for the assessment of the COPD evolution. The specific orientation of PT3-UCCOPD clearly defines the paths of the study and the data requirements.

The specific data flow and components involved for this solution will try to follow the general scheme proposed for other digital solutions in similar case uses. The research orientation of this pilot implies a low definition of the expected outputs. Anyway, a general framework can be easily defined as the devices and components are provided

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

by the partner FNOL. Is only needed a bilateral communication between the provider of data (FNOL) and the partner in charge of the analytics (TREE).

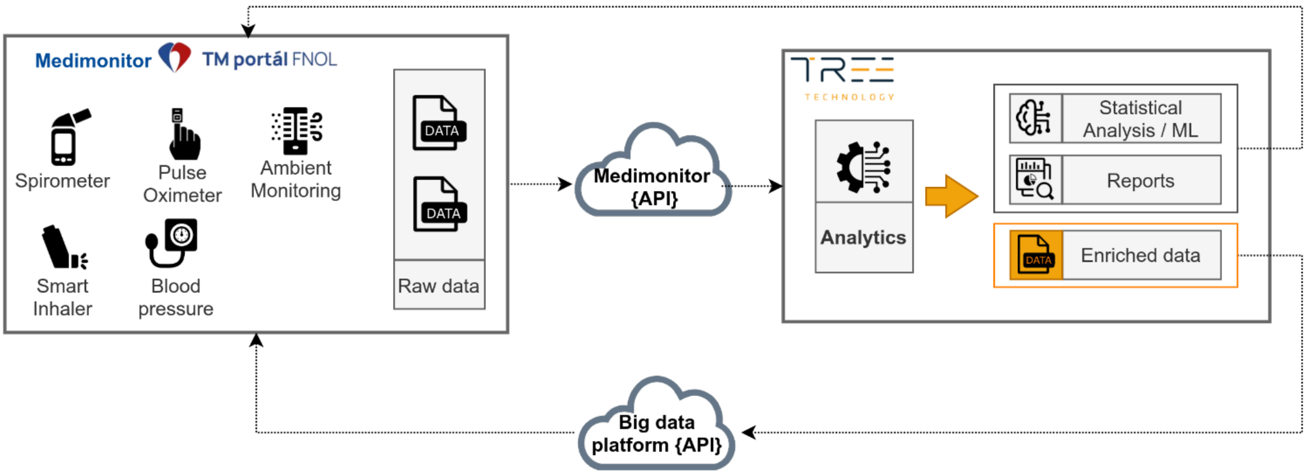


Figure 154 - Data Flow of the Digital Solution

This analytical service is linked to the extraction of insights for better assessment of COPD patients using remote medical devices. There are no interfaces or fixed structures of outputs.

6.2 Vitals Control (TREE)

The use of IoT medical devices allows the remote control of different physiological parameters like blood glucose levels, blood pressure, oxygen saturation, heart rate, weight, etc. Depending on the device, the amount and frequency of data may vary, but in any case, it opens up a range of possibilities for better monitoring the health of patients and increases the analytical possibilities for assessment of different associated pathologies.

From TREE, the interest is in providing solutions for a more personalised approach to improve and enrich the monitoring of patients. The intended solution is linked to the frequency of data updates taken into account the historical data to help, making use of statistics, medical assessment and decision processes. Specifically, the proposal aims to produce dynamic threshold that change over the time, according to the acquisition of new data.

The advantages for the application of this techniques in relation to the monitoring and assessment of the physiological parameters are:

- Simplicity and good sensitivity.
- A personalised approach.
- Comprehensive and visual tool.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

In a real, remote and non-clinical context the application of statistical solutions could help the healthcare professionals to have a better understanding about the evolution and changes in the diseases of their patients.

6.2.1 Interfaces and Interoperability

This digital solution works as an analytical service within the Big Data platform, so the response is a collection of outputs to be displayed in the front-end solutions involved in the pilot/use cases. For this reason, there is not an interface and the use case participants do not interact directly with the digital solution.

6.2.2 Applicable Pilot Themes

- PT3 – Medicine Control and Optimisation.

6.2.3 Adaptations for PT3-UCGeneral

The proposed solution works the same for all the assumptions raised in Pilot Theme 3. As the analytic is a monitoring tool for personalised assessment of the vital signs and other physiological parameters, it is applicable for any time series recorded by the medical devices. The changes over the different use cases depends on the number of medical devices. For the *PT3-UCGeneral - Supporting multimorbid older patients,* the solution can be implemented for the data coming from 4 devices: blood glucose meter, blood pressure monitor, weight scales and pulse oximeter meter.

This solution is designed as a monitoring tool according to the expected frequency of measurements from the medical devices during the pilot. The approach focus is on providing an individualised monitoring tool through the statistical analysis.

The applicable SHAPES persona is Roberto. Roberto uses his new SHAPES glucometer to measure his blood glucose level. He also takes his blood pressure using the SHAPES blood pressure monitor, and measures oxygen saturation level and heart rate using the SHAPES pulse oximeter. He was told that the readings will automatically appear in the SHAPES App so he does not really pay attention to what each one says just yet. He can check them on his phone later. A researcher will review the SHAPES dashboard regularly as well, to help his/her participants adhere to the intervention.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

6.2.3.1 Concept and Ideation Stage

The analytical approach is based on the *Statistical Process Control* methodology as a technique that can be helpful in healthcare monitoring. This methodology is based on the creation of control charts to monitor a process. The approach is focused in learning through the data, with special attention to the variation within the accumulated values over the time. These values can be in a controlled process or out of control when their variation respect to the accumulated measures is too high. When a measure is out of control the causes of the out-of-control should be analysed. In this sense, the causes can be related to an external factor (special cause) such as a human error taking the measures or caused by intrinsic factors to the process (common causes). When a special cause is detected, the measures should be removed to avoid an incorrect performance of the analytic. When the common causes are detected, the professional should analyse the stem of the out-of-control and initiate actions if necessary.

The results provided by this solution are constructed over the original data, giving calculations for the historical data until the last measurement of a vital constant. Specifically, the analytic returns personalised thresholds to monitor the evolution of the measures coming from medical devices. This information it is not intended to replace the use of fixed or theoretical thresholds but is understood as a complementary tool for a better monitoring of patients. The collection of outputs is generated in a daily basis and can be updated every time a new measure is taken.

Table 92 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU	Y	All the data managed by the analytics engine is

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	Member States and other countries considered as GDPR compliant.		stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	The analytics engine operates over vital signs obtained through medical sensors.
SPS-043	SHAPES shall support risk assessment and action plans as part of its data processing of health data.	Y	Risk assessment and response have been taken into account as part of the operation of the analytics engine.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal	Y	The analytics engine continues to operate

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	operation after period of network downtime.		during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

Table 93 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-21	HOW9: Vitals & weight statistical control: dynamic thresholds and out of range control.	Y	The analytics engine re-calculates thresholds as new measurement are available.

6.2.3.2 Design and Development Stage

The Vitals Control solution provides a personalised approach to monitor the different measures coming from the medical devices under a personalised perspective. The aim of the digital solution is to provide a comprehensive, visual, and simple tool to give value to the monitoring process within the Pilot Theme 3 Use Cases 001 and General.

The results provided by this solution are constructed over the original data giving calculations for historical data until the last measurement of a vital constant. Specifically, this digital solution returns dynamic and personalised thresholds to monitor the evolution of the measures coming from medical devices. This information is not intended to replace the use of fixed or theoretical thresholds but is understood as a complementary tool for a better monitoring of patients. The collection of outputs is generated on a daily basis and can be updated every time a new measure is taken. The outcomes generated by this digital solution are going to be displayed by other

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

digital solutions eCare (EDGE) or eHealthPass (Gnomon) for the specific case of the blood glucose monitoring.

The outputs generated by the analytics are explained in the following table.

Table 94 - Vitals Control Outputs

Output Name	Description	Type	Units	Values
timestamp	Timestamp of the recording measure	Datetime	yyyy-mm-dd hh:mm:ss	
measure_value	Measure value (for blood pressure, weight, oxygen saturation, blood glucose)	Numerical (float)	Standard units for each vital	
wr_lcl	Value of the daily intermediate lower control limit	Numerical (float)	Standard units for each vital	
wr_ucl	Value of the daily intermediate upper control limit	Numerical (float)	Standard units for each vital	
lcl	Value of the daily global lower control limit	Numerical (float)	Standard units for each vital	
ucl	Value of the daily global upper control limit	Numerical (float)	Standard units for each vital	
status	Categorisation of the measures respect to the control limits	Categorical		*ic*: in control limits *wr*: out of the intermediate control limits *oc*: out of the global control limits

The structure and organisation of the outputs generated by this analytical solution aim to create control charts that are going to be developed within other digital solutions. These charts include all the information generated over the original series of measurements for the different vitals. An example to illustrate the functionality of Vitals Control is shown in the image below.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

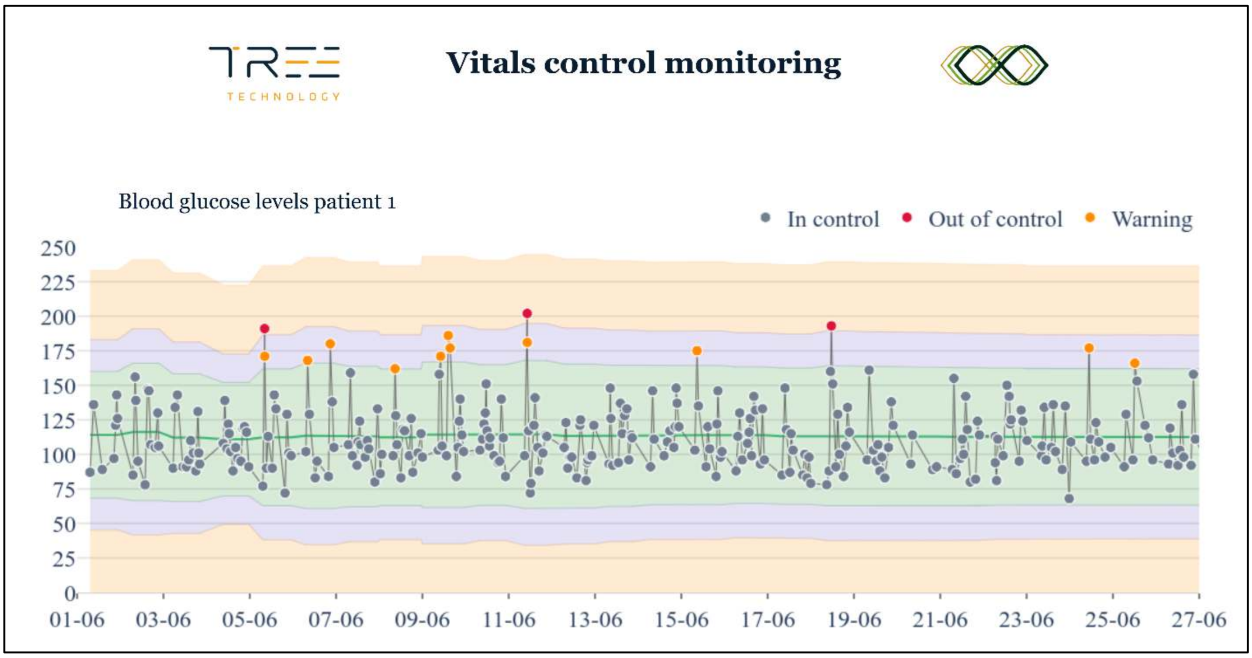


Figure 155 - Example of Vitals Control Visualisation for Blood Glucose Monitoring

These control charts are planned to be part of the professional dashboards for Pilot Theme 3 Use Cases 001 and General.

6.2.3.3 Prototyping and Adaptation Stage

The functionality and utility of the solution is based in the series of data coming from the medical devices. Specifically, the solution can be applied to the measures recorded of blood pressure, weight, heart rate, oxygen saturation and blood glucose. All the vitals monitored are going to be gathered and shared by eCare (EDGE), except the blood glucose concentrations that are provided through eHealthPass (Gnomon).

The specific data flow for this digital solution is quite simple and similar to other analytical solutions provided by TREE. The scheme of the data flow is the following: the data are consumed by TREE from the digital solutions that gather the information, the data goes into the analytical process and the results are shared through the Big Data Platform API with the digital solutions that are going to display the results.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

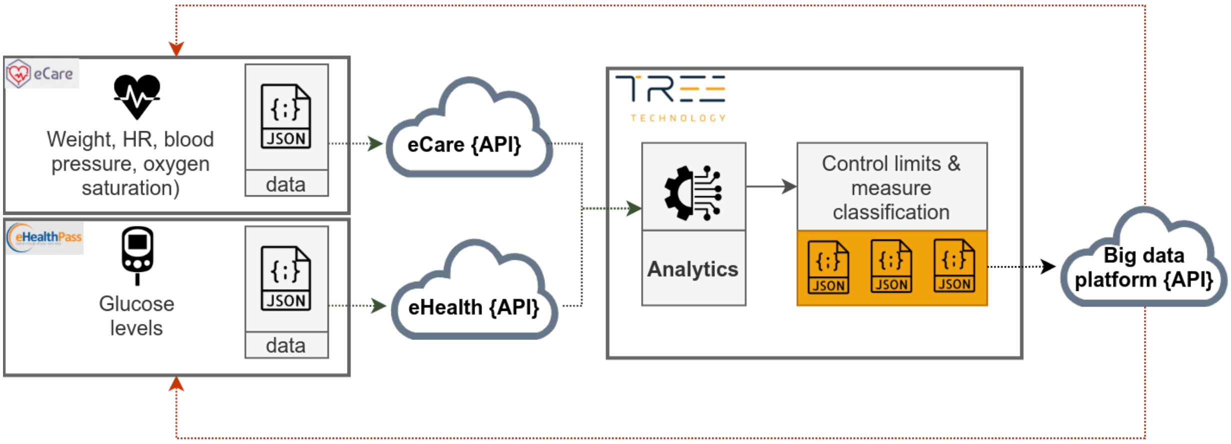


Figure 156 - Specific Component Diagram in Dataflow for Vitals Control

As the results are not going to be displayed directly by TREE, the outputs will be shared in the proper format and structure (json format). An example of the final structure and organisation of the outputs can be easily presented in table format. Although the information is structured and shared in json format, the content included in the files is shown in the next example.

	user_id	timestamp	bg	wr_lcl	wr_ucl	lcl	ucl	status
0	00001	2021-06-01 00:05:00	94	82.614649	117.671066	73.850544	126.43517	ic
1	00001	2021-06-01 09:15:00	97	82.614649	117.671066	73.850544	126.43517	ic
2	00001	2021-06-01 13:55:00	93	82.614649	117.671066	73.850544	126.43517	ic
3	00001	2021-06-01 16:50:00	113	82.614649	117.671066	73.850544	126.43517	ic
4	00001	2021-06-01 19:50:00	90	82.614649	117.671066	73.850544	126.43517	ic

Figure 157 - Sample Vitals Control Output

6.2.4 Adaptations for PT3-UC001

All the analytic development is common for the two use cases in which this solution will be implemented. The only difference between the PT3-UCGeneral and PT3-UC001 use cases is the number of the medical devices used in the use cases. In PT3-UC001, the glucometer will not be deployed but the analytical framework is the same for both use cases.

The applicable SHAPES persona is Roberto, as well as the team of health professionals giving him assistance on a regular basis. In this scenario, health professionals have access to a dashboard where they can see Roberto's historic evolution of parameters (e.g. hours of sleep, weight, blood pressure, oxygen level, heart rate, number of steps).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

6.2.4.1 Concept and Ideation Stage

The development of the analytic tool is the same for the two case uses PT3-UCGeneral and PT3-UC001.

Table 95 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Devices supported.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	Devices supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Devices supported.
SPS-114	SHAPES should support assisted mobility at home.	Y	Mobility tracked and analysed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 96 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
CPV03	Activity analysis dashboard and the corresponding visual analytics.	Y	The analytics engine supports all the visualisations provided by the dashboard.
CPM09	The health professionals can manage the settings related to activity capture and analysis.	Y	All analytics are calculated, so that they can be selected or de-selected at the dashboard at will.

6.2.4.2 Design and Development Stage

Again, the output structure provided for this use case is the same explained in PT3-UCGeneral. For the historical measurements of the medical devices in a daily basis, the values of the control limits and the categorisation of the measures is provided.

6.2.4.3 Prototyping and Adaptation Stage

The functionality of the solution as in the PT3-UC001 is based on the series of data coming from the medical devices. In this case, the solution will be applied to the measures recorded of blood pressure, weight, heart rate and oxygen saturation provided through eCare (EDGE).

The only adaptation of the solution in this use case is linked to the absence of the glucometer. The scheme of the data flow is the same as in the PT3-UCGeneral but Gnomon's components are not deployed for this use case. The data is consumed by TREE from eCare, the data goes into the analytical process and the results are shared through the Big Data Platform API with de digital solution that are going to display the results. In this use case, all information flows within the connection between TREE's components and the EDGE components.

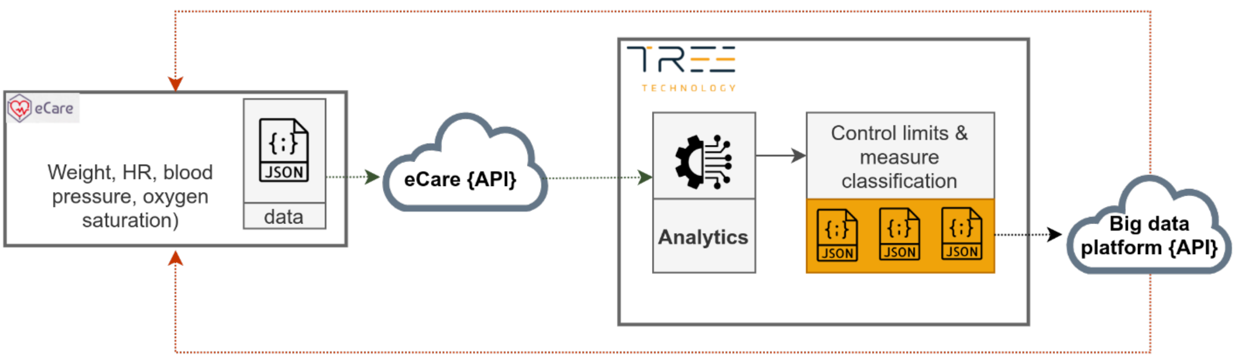


Figure 158 - Specific Component Diagram in Dataflow for Vitals Control in PT3-UC001

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The results will not be shown directly by TREE either, so the data model will be the same as in the PT3-UCGeneral. Format and data structure replicates the model shown for the PT3-UCGeneral.

6.3 Fall Detection using Wearable Data (TREE)

This Digital Solution was originally foreseen as a fall detection system that could be useful in reducing the negative impact when an older person falls. The system would alert caretakers and/or medical staff when an older person has suffered a fall, so that they can take the needed actions. Pilot Theme 6 would make use of such Digital Solution. However, TREE eventually reconsidered the participation in such pilot, so the design of the fall detection system was halted.

6.4 Major Adverse Cardiovascular Events (MACE) Risk Prediction in T2D patients (TREE)

This Digital Solution was originally foreseen as a predictor for major adverse cardiovascular events (MACE) in patients with type 2 diabetes, triggering an alarm when MACE is predicted to occur and the associated level of risk. Use case PT3-UCGeneral could make use of the Digital Solution. However, its use was eventually discarded (the use case's selection fell on the Heart Failure Decompensation Predictive Module by VICOM), so the design of the MACE risk predictor was halted.

6.5 Type 2 Diabetes Patient Assessment and Profiling (TREE)

Type 2 Diabetes is the most common type of diabetes and most often occurs in middle-aged and older adults. The prevalence of Type 2 Diabetes is expected to increase as life expectancy increases. If not treated properly diabetes can cause serious health problems, such as heart disease, stroke.

The use of medical devices in SHAPES allows the assessment of patients on an individualised perspective. Statistical analysis tends to focus on clinical studies with large patient samples. The remote patients control with different diseases in SHAPES focuses on the analysis of individuals and opens the possibility to develop longitudinal analysis.

TREE wants to contribute with new perspectives on the study and follow-up of patients over time without relying on large clinical samples. Patients with type 2 diabetes are a

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

group of special interest within the project and retrospective analysis can be performed in order to create patient profiles and study differences in the control of the disease from one individual to another.

6.5.1 Interfaces and Interoperability

This digital solution is close to the research level and the aim is to provide insights to improve the assessment of Type 2 Diabetes patients. The scope and usability of the analytical service depends on the advancement and collection of comprehensive patient data. This digital solution works as an analytical service within the Big Data platform, so the response is a collection of outputs to be displayed in the front-end solutions involved in the pilot/use cases. For this reason, there is not an interface and the use case participants do not interact directly with the digital solution.

6.5.2 Applicable Pilot Themes

- PT3 – Medicine Control and Optimisation.

6.5.3 Adaptations for PT3-UCGeneral

The general use case of Pilot Theme 3 (*PT3-UCGeneral: Supporting multi-morbid older patients*) is focused in the control of patients with different medical conditions. Particularly, heart failure and diabetes are the two chronical conditions specially interesting in this use case.

The applicable SHAPES persona is Roberto. Roberto uses his new SHAPES glucometer to measure his blood glucose level. He also takes his blood pressure using the SHAPES blood pressure monitor, and measures oxygen saturation level and heart rate using the SHAPES pulse oximeter. He was told that the readings will automatically appear in the SHAPES App so he does not really pay attention to what each one says just yet. He can check them on his phone later. A researcher will review the SHAPES dashboard regularly as well, to help his/her participants adhere to the intervention.

Type 2 diabetes patients will have an important presence in this use case and connected medical devices like glucometer will be deployed. The use of continuous glucose monitoring meters has recently contributed to the study of glucose levels with the intention of predicting hyper / hypoglycaemic episodes, but this kind of devices have not a relevant presence in real-life scenarios. The most common tool for glycaemic control is the use of Self-Monitoring of Blood Glucose (SMBG) devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

These devices have become the main method of blood glucose control and recently they also feature Bluetooth connectivity for an easy access to the data.

Normally, the most important features measured with these devices are related to the pre-prandial (before meals) and postprandial (after meals) blood glucose levels in order to prevent or assess the risk of hypoglycaemic events (mainly during the night) and hyperglycaemia. However, the assessment through SMBG data normally leads changes in medication or a primary control of blood glucose according to fixed values without a deeper analysis of the behaviour of the data. Data collection and subsequent analysis can be a difficult task to carry out due to lack of time and resources. TREE wants to contribute to a better evaluation and study of the SMBG data in the development planned in PT3-UCGeneral.

6.5.3.1 *Concept and Ideation Stage*

Continuous glucose monitoring devices will not be used in SHAPES project so short-term predictions of glucose levels to prevent hypo/hyperglycaemia cannot be performed. However, the use of SMBG devices has not been sufficiently attended in some contexts. The use of this kind of devices with connectivity in the SHAPES Project allows a proper exploration and assessment of the data in order to study relevant differences between patients and add value to the SMBG data.

The general idea is to provide a deeper analysis and extract insights about the different behaviour of the blood glucose data of the diabetes type 2 patients within the PT3-UCGeneral. This analytic proposal is closely related with the solution "Vitals Control" (section 6.2). The aim for this solution is to contribute to a good diabetes control explaining the causes of particular trends and patterns observed in the SMBG data. In this sense, an important question in this solution involves the assessment of the blood glucose levels out of range detected with "Vitals Control".

Prospective and longitudinal analysis of individual data reflects some of the interest in Pilot 3 like make contributions to the better monitoring of patients remotely and in a personalised way. To fulfil these purposes, it is planned to assess the evolution of some key parameters for improve the quality of the glycaemic control:

- *Average/median values of glucose*: The assessment of the average values of glucose by days and week allows a good assessment of the progression of the disease and treatments.
- *Glucose variability*: Is a key parameter for the assessment of the glycaemic control. Informs about the progression of the disease and enriches the analysis of out-of-range values. Sometimes the appearance of out-of-range values is not the most appropriate way to assess the patient status and the use of glucose variability provides better explanations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- *Temporal trends and changes over time*: The general behaviour of the data over the observation period gives a general overview of the evolution of the disease and the effects of different factors like a change in the treatment.
- *High/Low blood glucose indexes:* Retrospective analysis of the evolution of the maximum and minimum values can provide insights about the risk of suffering hypoglycaemia for example.

All the features extracted from the SMBG data will be combined with the medical history in order to provide classifications or profiles of the patients. The main idea is to provide a systematic approach to assess diabetic patients and correctly identify subgroups and profiles.

Table 97 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	The analytics engine operates over vital signs obtained through medical sensors.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-043	SHAPES shall support risk assessment and action. plans as part of its data processing of health data	Y	Risk assessment and response have been taken into account as part of the operation of the analytics engine.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage	Y	The analytics engine notifies the availability of

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	notifications among core SHAPES components.		analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

Table 98 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-21	HOW9: Vitals & weight statistical control: dynamic thresholds and out of range control	Y	The analytics engine re-calculates thresholds as new measurement are available.

6.5.3.2 Design and Development Stage

The development of this solution is linked to the complete data gathering. The analysis proposed is focused on the research of the benefits of a complete assessment of SMBG data. The expected output for this specific service is to put the basis of monitoring tools to help professionals in the control and assessment of type 2 diabetics patients.

There are no interfaces or structures of results planned for this solution. The aim is to contribute to a systematic approach for a better assessment of SMBG data as the most extended and affordable method for glucose control.

6.5.3.3 Prototyping and Adaptation Stage

The most important element for this analytic solution is the data coming from the glucometer. The complete record of the glucose measures for all the diabetic patients is the necessary input for the purposes of this solution. To enrich the analysis and achieve better result in profiling and statistics will be desirable access to sociodemographic data and a part of the medical history data.

6.6 Visual Analytics (VICOM)

Due to the limited time of clinicians to explore data, it is essential to give them intuitive and fast tools to interpret them. In this context, visual analytics (VA) is the science of displaying information through interactive interfaces focused on analytical reasoning

[29]. Analytical reasoning is the ability to detect patterns within the data and to gain deep insights by looking at the representation of large amounts of data. One of the most widespread criteria for classifying the visualisation types is the dimensionality of the visualisation, that is, the number of attributes that allows to show. Univariate visualisation – one dimension – is the simplest form of data analysis and its goal is to gain insight about the distribution, the central tendency and the spread of an attribute. On the other hand, the main objective of the multivariate visualisation – two or more dimensions – is to allow the analysis of the relationship or interaction between attributes.

Thus, VICOM provides a VA tool to explore different metrics that provide the evolution of patients (Figure 159Figure 159), statistical results of patient characteristics and patterns (Figure 160Figure 160).

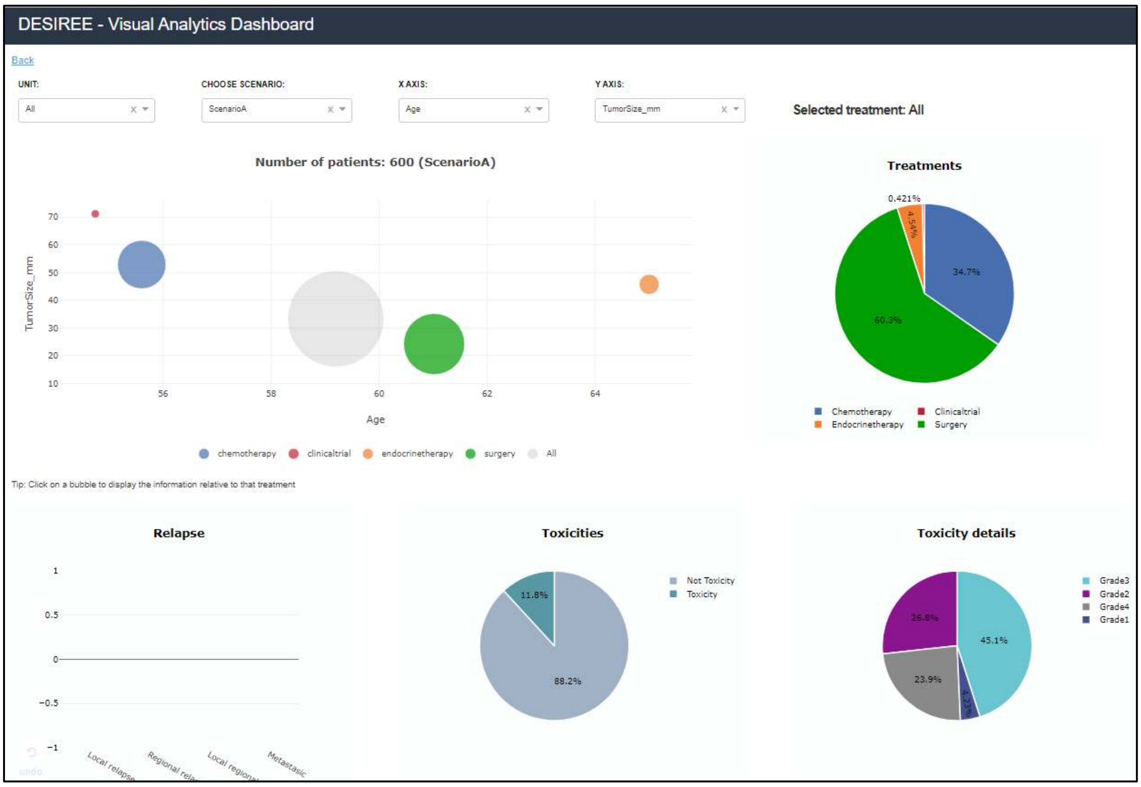


Figure 159 - Visual Analytics for Statistical Results

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 160 - Visual Analytics for Patterns

6.6.1 Interfaces and Interoperability

Two possible approaches are considered to provide the VA service within the global user interface solution. The first option is to implement the VA GUI following the SHAPES (global) web framework approach, achieving a tight integration.

The alternative is to open VA GUI using a URL redirection within the same page, a separate window or tab. In this case, mimicking templates and navigation bars would be required to ensure the user a unified navigation experience.

The initial goal is to achieve a tight integration with the SHAPES web framework.

On the other hand, the following figure presents the interactions of the VA DS with the SHAPES Platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

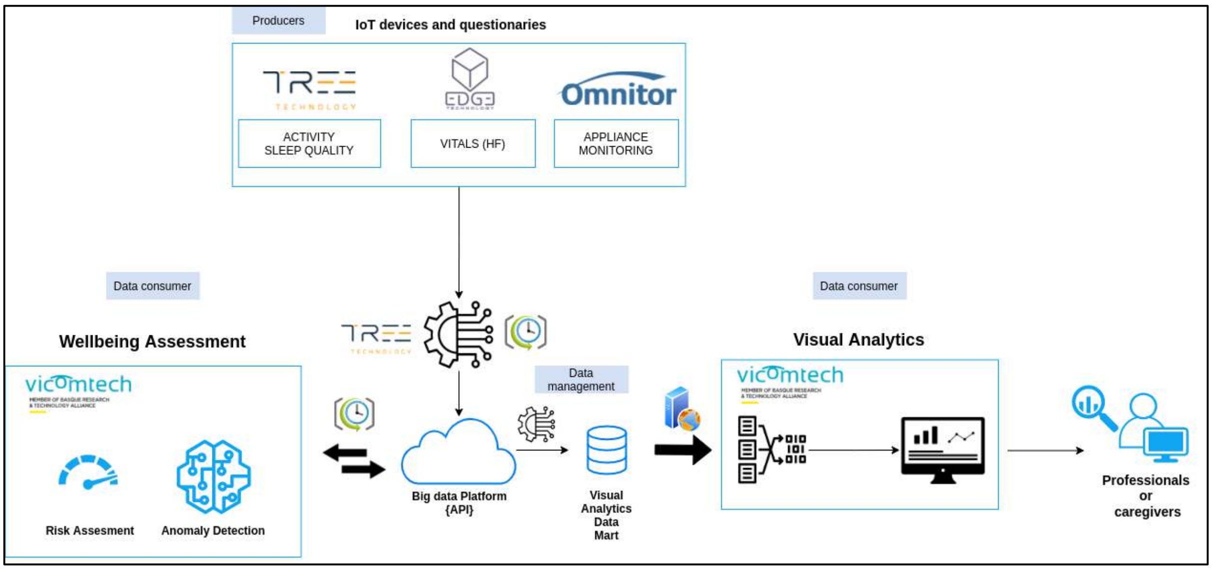


Figure 161 - Visual Analytics Interaction with the SHAPES Platform

6.6.2 Applicable Pilot Themes

- PT1 – Smart Living Environment for healthy ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing;
- PT6 – Physical Rehabilitation at Home;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals

6.6.3 Adaptations for Pilot Themes

In current stage, there is no required adaptation of the visual analytics among the pilots mentioned above, but it would be adapted to user requirements and available data.

6.6.3.1 Concept and Ideation Stage

In order to explore data acquired from different pilot sites, the VA tool provides insights over statistics that can help clinicians, caregivers and researchers on determining which could be best treatments, and actions for different type of users or can support clinical managers and policy makers on determining the best practices for each group of users.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

This module is composed of two different dashboards:

a. A dashboard consisting of five synchronised graphics: main scatter plot that displays a bubble for each treatment/action and faces different selectable variables depending on each use case. Since the current data are of a prospective type, there is not yet charts displaying real prospective data. Different types of charts with these data will be added to the dashboard when retrospective/prospective data are available.
b. A parallel coordinates dashboard that lets the user to explore the multivariate data in order to find out patterns. This visualisation lets the user to select the unit, scenario, user group and the number of axes to display, and the criterion to colour the parallel coordinates lines (usually binary variables) (Figure 160). These criteria are outcomes for the users: anomalies, decompensations. The predetermined axes to be displayed are the ones most correlated with the selected criteria to colour the parallel coordinates lines. It is possible to change the order of the axes and select a range on the axis to highlight (Figure 160).

Table 99 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Python programming language	The Statistical and New Knowledge visualisations (statistical and parallel coordinate dashboards) have been developed using Python. The following libraries have been used: pandas, numpy, matplotlib, plotly and dash.	Y	
JSON format	CWDSS requires to receive the data into JSON format due to the rule engine characteristics. This JSON object needs to follow the structure of key-value, arrays of values cannot be processed by the rule engine.	Y	The regarding partners accepted this requirement.

6.6.3.2 Design and Development Stage

As shown in Figure 159 and Figure 160, there is already a template of the visual analytics dashboard. However, its design would be adapted to SHAPES Platform.

6.6.3.3 Prototyping and Adaptation Stage

The current prototype has fake data and it is still not adapted to a use case from SHAPES.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

6.7 Model-driven Decision Support System (VICOM)

Clinical Practice Guidelines (CPGs) are paper-based documents reporting latest evidence-based recommendations in order to (i) support clinicians during decision making process, (ii) reduce clinical variability, (iii) improve clinical outcomes and (iv) reach a more efficient healthcare service. For their best implementation, Clinical Decision Support Systems (CDSS) are promoted which need from the digital version of the CPGs to be able to reason and provide the recommendations that best fits the studied patients. Nonetheless, this implementation process of transforming the paper-based guidelines into computer interpretable guidelines is tedious for the complexity of the medical language and the variability and complexity of the structuration of the clinical information. Moreover, it is capital to record the made decisions since the compliance of clinicians with the guidelines depends on a number of factors including their own experience and preferences but also patients' preferences.

6.7.1 Interfaces and Interoperability

Taking into account all the identified difficulties for developing a CDSS based on modelled knowledge and independent form big quantities of clinical data, VICOM has developed a tool, named eHST, which provides an intuitive and easy-to-use authoring tool that helps clinicians, along with knowledge engineers in the process of digitalising clinical protocols and maintaining them up-to-date with latest evidence (Figure 162).

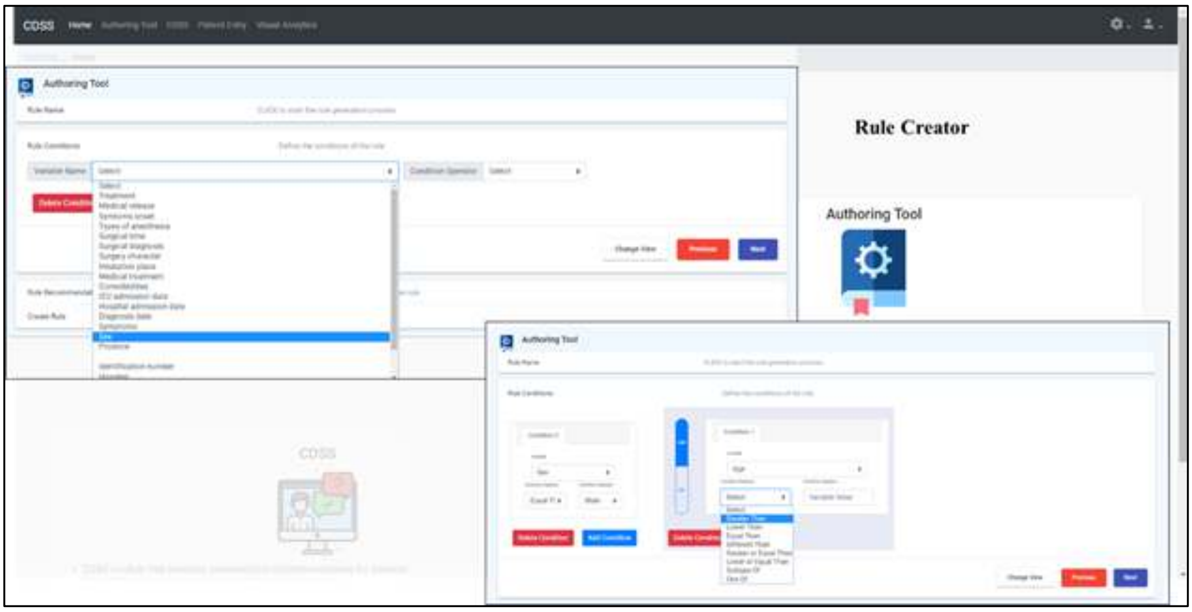


Figure 162 - The Authoring Tool of the eHST by VICOM

Moreover, a rule engine is integrated to make available instantly the formalised rules for any analysed patient.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Finally, a decisional event structure has been formalised too in order to register all made decisions and identify and justify guideline compliance deviations for generating new knowledge in rule form that will cover those gaps in the guidelines and also to study the impact of those decisions through clinical and patient-based outcomes.

6.7.2 Applicable Pilot Themes

In bold are the pilot themes that already confirmed to use the digital solution:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- **PT2 – Improving In-Home and Community-based Care;**
- PT3 – Medicine Control and Optimisation;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

6.7.3 Adaptations for PT2-UC001

In the current stage, no adaptation of the Decision Support solution is required, based on the use case indications. However, the solution will remain attentive and be adjusted to the use case requirements.

6.7.3.1 Concept and Ideation Stage

CDSS generates personalised wellbeing recommendations through the analysis of data obtained via wearable devices and inputs made by users using the developed mobile application. The generated content is sent to a notification system where the Digital Solution is integrated.

CDSS is designed to detect an alteration and send an alert in a recommendation format for the content to have a positive impact on the individual. The aim is to encourage older individuals to maintain healthy habits and help them on their daily basis by advising them when this alteration is produced. To do so, CDSS is composed by a large set of rules that measures:

- **Activity** (steps): measures the number of steps made by the user.
- **Sleep** quality: measures the quality of sleep by analysing different aspects of sleep (duration, number of waking hours, resting).
- **Liquid intake**: measures the amount of liquid taken in one day. It includes water and other types of refreshments.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

These rules play an important role to identify physiological disorders and therefore to supervise the evolution of patients by indicating when there is an anomaly in their activity. Therefore, it allows professionals to evaluate the state of each individual while avoiding the progression of physiological and psychological disorders in older individuals, assuring a good quality of life.

Table 100 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Rules engine will include daily steps data and this module will be supported in the recommendation system.
SPS-037	Devices measuring and/or manually-entering water intake should be supported.	Y	Rules engine will include global liquid intake. This module will be supported in the recommendation system.
SPS-038	Devices recording sleep quality should be supported.	Y	Sleep quality related information should be supported.
SPS-048	SHAPES should offer alerting mechanisms about medical risks.	Y	Alert generated by the system should be displayed.
SPS-114	SHAPES should support assisted mobility at home.	Y	Recommendation system contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Information is shared with other DS through the Platform's API.
SPS-186	FHIR shall be used as a common data model for Medical Data exchange among components of the SHAPES Platform.	Y	Data from no IoT devices will be sent to the FHIR component.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 101 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
JSON format	CWDSS requires to receive the data into JSON format due to the rule engine characteristics. This JSON object needs to follow the structure of key-value, arrays of values cannot be processed by the rule engine.	Y	The regarding partners accepted this requirement.
PT2-UC001: Integration into Notification Systems	CWDSS needs to communicate with the eCare and the eHealthPass notification systems to display the content. The generated recommendations will be sent to those DS' notification systems.	Y	eCare and eHealthPass notification systems will receive and display the CWDSS recommendations.

6.7.3.2 *Design and Development Stage*

The analysis of the user data by the means of rules is done to improve the quality of life of the users. The expected output for this specific service is to generate personalised wellbeing recommendations analysing the data of the user (liquid intake, daily steps) that later will be sent to the user's mobile application.

There are no interfaces or structures of results planned for this solution. The aim is to contribute to generate well-being recommendations based on the gathered data of the users that will later be sent to them.

6.7.3.3 *Prototyping and Adaptation Stage*

The core of this solution are the formalised rules that are used to generate the recommendations. For this, the set of variables that are used to store the gathered data of the user are needed for the evaluation process. The overall process can be visualised in the following schema, where via IoT devices and questionnaires, data about steps, sleep quality or liquid intake is captured. The data is sent to the CWDSS, where the rule engine generates the recommendations, and are sent to the applications (eCare) for their visualisation.

As already mentioned, the main interest and usability of this solution is based on the input information received from the different IoT devices. As shown in Figure 163 - Workflow of the Recommendation Support SystemFigure 163, the data that will be provided to CWDSS when data collection starts are:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

1. Activity(steps) (EDGE, TREE): The activity is measured by the number of steps stored in the Big Data Platform.
2. Sleep quality modules (TREE): the activity and sleep quality data are going to be stored in the Big Data Platform.
3. Liquid intake (Gnomon): the water intake and the rest of liquid measures are going to be stored the in Big Data Platform.

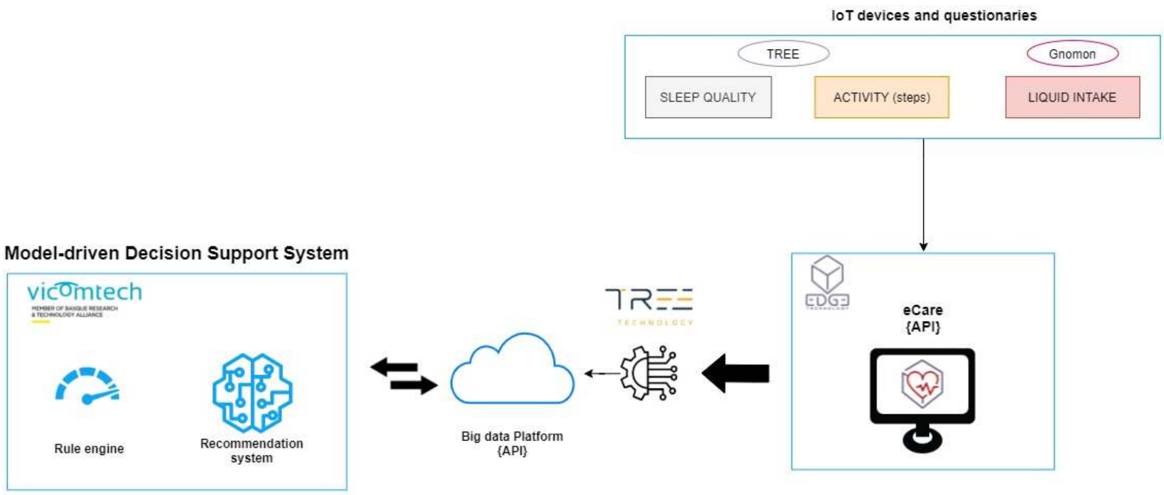


Figure 163 - Workflow of the Recommendation Support System

6.8 Gait Analysis for Motion Quality Assessment in Elderly Population (VICOM)

According to the World Health Organisation, 28-35% of people over 65 years fall each year[3]. One of the biological factors associated with an increased risk of falls is the decline of physical condition, that can be reflected in terms of gait performance loss.

A cost-effective and widely used device to obtain gait-related data is called IMU, a sensor which measures tri-axial acceleration and rotation with an accelerometer and a gyroscope, respectively.

To be able to evaluate and monitor the gait performance meaningful quantitative metrics have to be extracted from the data gathered from one or more IMUs. The gait quality assessment could be integrated in a decision support tool for health care professionals to help prevent further physical impairment.

A literature review has been done in order to identify the metrics that are more relevant to the decreased quality of life and an increased risk of fall. Among the spatiotemporal

[3] WHO Global Report on Falls Prevention in Older Age 2006.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

metrics, the following stand out: stride length, step length, stride speed, double support time and gait asymmetry.

A preliminary data analysis is performed on the data collected from UCLM's case study (section 4.8). The participants are aged over 65 and have three different degrees of mobility: walker-aided, with crutches and without any external aid. Time series longitudinal acceleration and angular speed in the three directions is recorded with a 9-axis IMU (Mtbientlab MetaMotionR) attached to the sagittal plane of the right ankle.

The raw time series data (Figure 164) have to be curated, filtered, and processed to identify the gait cycle phases (stance and swing) and be able to extract previously mentioned metrics. An example of the gait phases identification taken from the literature can be seen in Figure 165. Regarding kinematic metrics, the curated data can also be used to compute joint angles of interest through inverse kinematics with a biomechanical model.

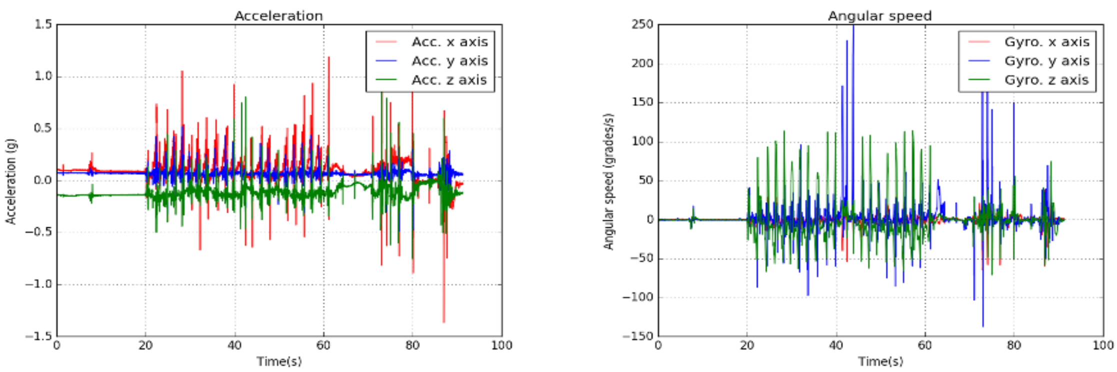


Figure 164 - Raw Tri-axial Acceleration and Angular Speed from IMU in the Ankle

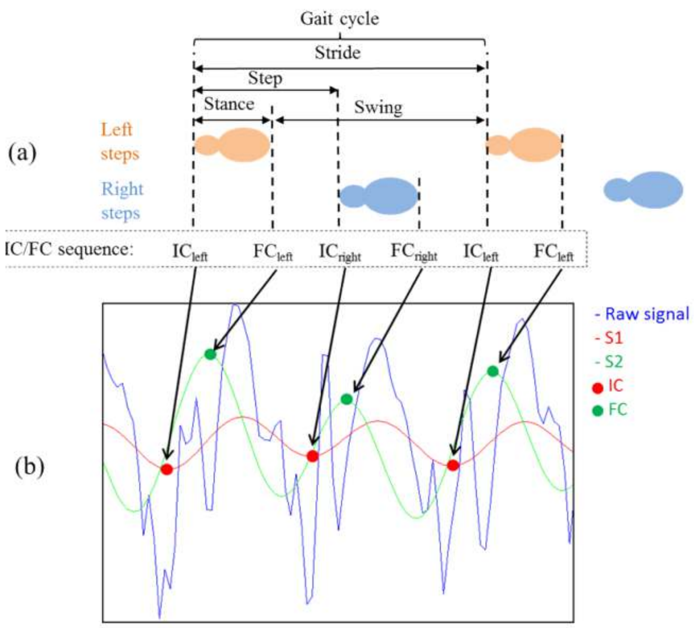


Figure 165 - Gait Cycle Phases Extracted from Raw Acceleration Data from Wearable IMU (del Din et al. [30])

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

6.8.1 Interfaces and Interoperability

This solution will provide an API for integration with the SHAPES Platform where the gait metrics can be displayed and assessed by professionals.

6.8.2 Applicable Pilot Themes

- PT6 – Physical Rehabilitation at Home.

6.8.3 Adaptations for PT6-UC004

In the current stage, no adaptation of this solution for the use case PT6-UC004 is required, but the solution will be adapted to user requirements and available data.

6.8.3.1 Concept and Ideation Stage

The following requirement and specifications are not exhaustive since the concept and ideation stage of the solution are in progress.

The applicable persona(s) will be the health professionals supervising the elder people's health status in a residence or day care centre.

Table 102 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	DS as an open API to be integrated with UCLM DS.
SPS-027	Digital Solutions shall provide usage tutorials and help cards including devices they use.	Y	This DS will provide help cards including metrics definition and interpretability.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Agreement on device and location with partner UCLM.
SPS-152	SHAPES shall use a modular architecture.	Y	This DS designed with modular architecture.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	This DS needs data from another SHAPES component.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	This DS needs data from another SHAPES component
SPS-202	All software modules should be securely updateable.	Y	Updates of this DS will be securely implemented.

Table 103 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Access to wearable motion data API	This solution needs access to the raw acceleration data in order to compute the gait metrics.	Y	Provided by partner UCLM.
JSON format	Both input and output data will be in json format.	Y	Agreement with partner UCLM.
Docker	The deployment of the solution is foreseen to be in a docker container.	Y	Platform compatible with docker deployment.
PT6-UC004: Wearable Motion Monitoring Device	The gait assessment system needs to access the motion data from IMUs after a trial session to be able to compute the gait metrics.	Y	An API will be provided for integration among other solutions.

6.8.3.2 *Design and Development Stage*

No user interface is expected to be developed in this solution. The gait metrics extracted from the wearable data will be integrated via an API into the SHAPES Platform for visualisation and interpretation.

6.8.3.3 *Prototyping and Adaptation Stage*

The Gait analysis solution (Figure 166) will incorporate several modules for data processing needed to extract the target metrics. The I/O module incorporates functions to read, parse and write the data from/to json format. The filtering module allows to eliminate unwanted noise and drift from the sensor's signals, the gait cycle segmentation module processes and analyses the filtered data to identify events like the initial and final foot contact. Finally, the gait metrics module will calculate the desired gait performance metrics that can be stored to disk via the I/O module.

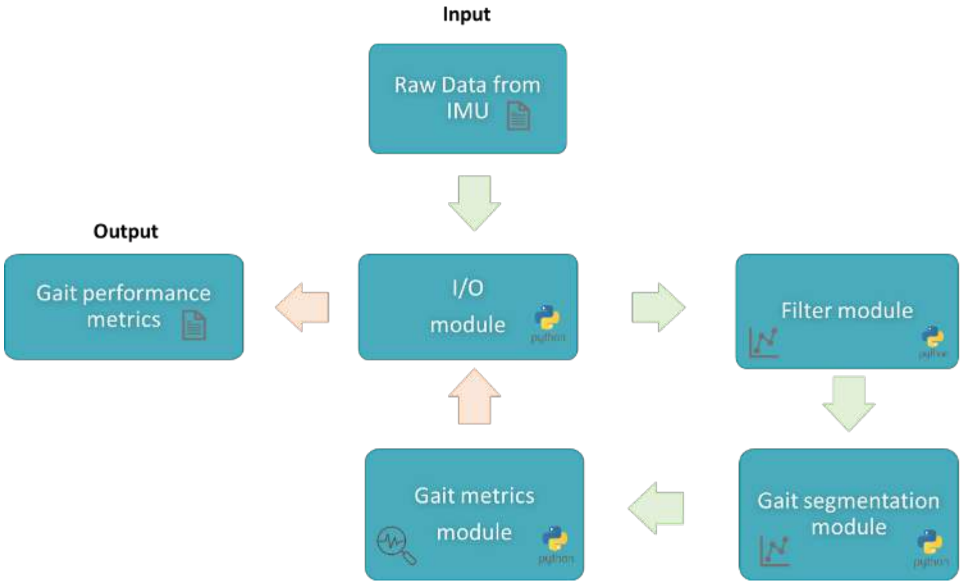


Figure 166 - Workflow of the Gait Analysis Solution

6.9 Heart Failure Decompensation Predictive Module (VICOM)

Heart failure (HF) is a clinical syndrome caused by a structural and/or functional cardiac abnormality. HF patients suffer decompensations, which is defined by Mangini et al. [31] as a clinical syndrome in which a structural or functional change in the heart leads to its inability to eject and/or accommodate blood within physiological pressure levels, thus causing a functional limitation and requiring immediate therapeutic intervention. Hence, decompensations may lead in hospital admissions, which in this study are defined as emergency admissions and hospital admissions, and home interventions. As Ponikowski et al. presented in a paper [32], the prevalence of HF depends on the definition applied, but it is approximately 1-2% of the adults in developed countries, rising to more than 10% among people >70 years of age. Hence, due to the aging population, an increase in the number of HF patients is expected in the future. Therefore, predicting the risk of a patient to suffer a decompensation may prevent admissions and readmissions, improving both patient care and hospital management, which has a high impact on costs and clinical professionals' time. The first step to predict the risk of decompensation is to telemonitor ambulatory patients. Next, we need reliable systems to assess the risk. Most telemedicine systems apply alerts or rule-based systems to detect potential complications of ambulatory patients [33] 34]. But these usually contain large number of false alerts, and hence, these systems are not trustworthy.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Therefore, it is key to use current AI solutions to develop predictive models in this context. VICOM, together with the public health service of Basque Country (Osakidetza), Hospital Universitario de Basurto from Bilbao (Spain) have developed a predictive model based on mobile clinical data of 242 HF patients collected for a period of 44 months [35].

The input for this digital solution is baseline data (i.e., information collected by a clinician when the patient is diagnosed (Table 104), ambulatory patient monitored data (i.e., information collected from three to seven times per week, Table 105 and Table 106), and patients' admissions information (i.e., emergency admissions, hospital admissions, and home care interventions that are associated to HF associated with a patient decompensation).

Table 104 - Baseline Characteristics of the Study Population for HF Predictive Model

Characteristics	Description	Median ± SD/ percentage
Age	The age of the patient (years)	78±10.9
Height	The height of the patient (mm)	162.37±10.34
Sex	The sex of the patient (men/women)	57% men
Smoker	If the patient smoke, did smoke and now do not or never has smoked	15.35% do smoke, 22% did smoke (not now)
LVEF	Left Ventricular Ejection Fraction (%)	42.4±15.21
First Diag	Years since first diagnosis	5.8±7.04
Implanted device	If implanted device (peacemaker, implanted cardioverter defibrillator, cardiac resynchronisation therapy)	22.7%
Need oxygen	If the patient needs oxygen	4.7%
Barthel	Barthel Scale	82.98±15.23
Gijón	Socio-family assessment scale in the elderly that allows the detection of risk situations or social problems.	7.47±2.29
Laboratory		
Urea	Urea (mg/dl)	75.12±37.8
Creatinine	Creatinine (mg/dl)	1.3±0.54
Sodium	Sodium (mEq/L)	140.12±4.14
Potassium	Potassium (g/dl)	4.28±0.74
Haemoglobin	Haemoglobin (g/dl)	13±9.6
Comorbidities		
Rhythm	If sinus rhythm, AF or atrial fluter	Sinus: 37.1%
Atrial Fibrillation	If the patient has atrial fibrillation (AF)	57.4%
Pacemaker	If the patient has a pacemaker	14.5%

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 105 - Ambulatory Patients Monitored Characteristics of the Study Population for HF Predictive Model

Characteristics	Description
SBP	Systolic Blood Pressure (mmHg)
DBP	Diastolic Blood Pressure (mmHg)
O_2Sat	Oxygen Saturation (%)
HR	Heart Rate (bpm)
Weight	Body weight (Kg)

Table 106 - Ambulatory Patients Questionnaire for HF Predictive Model

n	Tag	Question	Possible Answer
1	*Well-being*	Comparing with the previous 3 days, I feel:	B/W/S*
2	*Medication*	Is the medication affecting me well?	Yes/No
3	*New Medication*	During the previous 3 days, did I take any medication without my clinicians' prescription?	Yes/No
4	*Diet and exercise*	Am I following the diet and exercise recommendations provided by my clinician and nurse?	Yes/No
5	*Ankle*	In the last 3 days, my ankles are:	B/W/S*
6	*Walks*	Can I go walking like previous days?	Yes/No
7	*Shortness of breath*	Do I have fatigue or shortness of breath when I lay down in the bed?	Yes/No
8	*Mucus*	Do I notice that I started coughing of with phlegm?	Yes/No

The predictive model obtained is a combination of alerts based on monitoring data and a questionnaire with a Naive Bayes classifier using Bernoulli distribution. This predictive model performs with an AUC= 67%, and reduces the false alerts per patient per year from 28.64 to 7.8. This way the system predicts the risk of admission of ambulatory patients with higher reliability than simple alerts. It provides a risk score from 0 to 100, divided in three terciles: from 0-33% low risk, from 34-66% medium risk, and from 67-100% high risk.

This HF predictive model service will be made available through an API to other SHAPES digital solutions that request the risk score for a patient.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

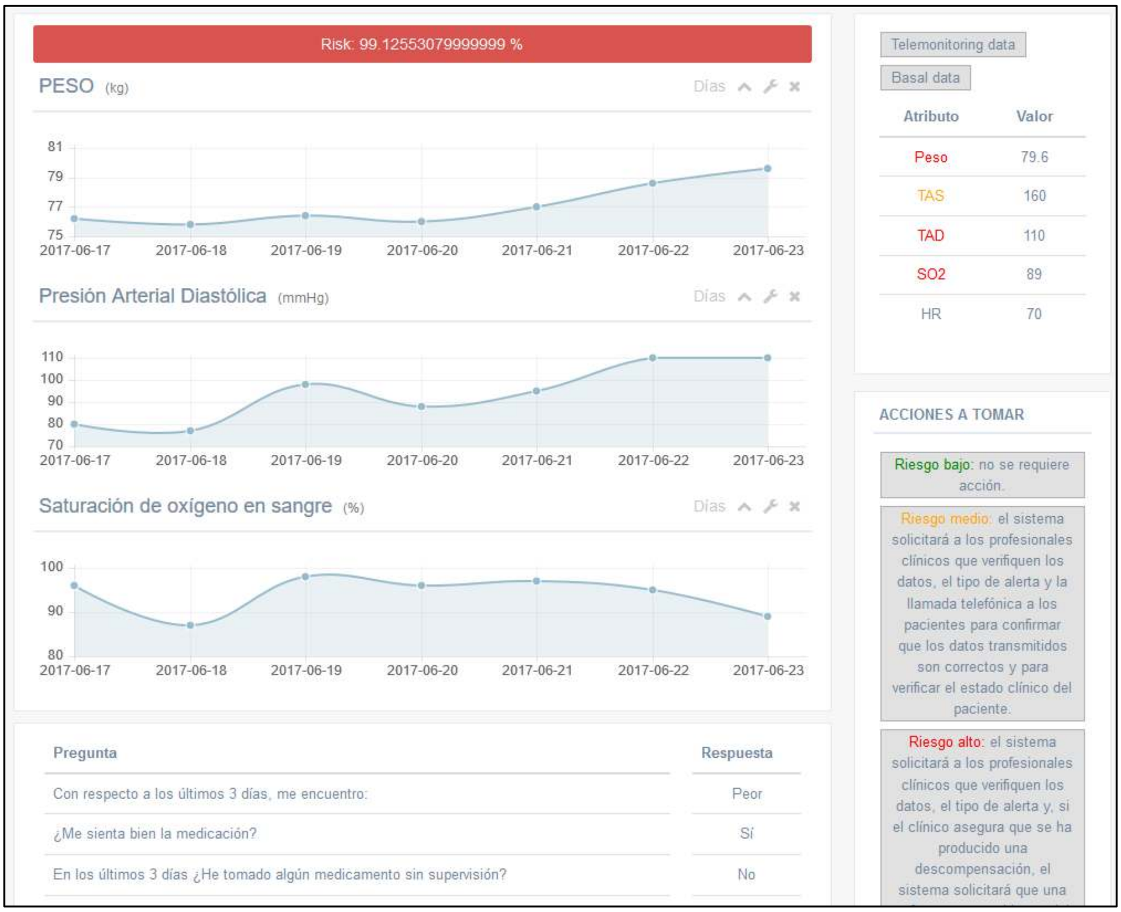


Figure 167 - Visualisation of HF Predictive Models

6.9.1 Applicable Pilot Themes

- PT3 – Medicine Control and Optimisation.

6.9.2 Adaptations for PT3-UC001, PT3-UC001c and PT3-UCGeneral

In PT3-UC001 and PT3-UC001c, the solution will be used as defined. This means that it is a service that collects all the information through a post, performs the calculations that it must do internally, and returns the corresponding risk information.

In PT3-UCGeneral, the information corresponding to the clinical-basal-data information and the hospital admissions or treatments are gathered manually and in a shared folder (two files of csv format) which is read automatically when the post with the daily data is done. For this, the server has been modified so that when an identifier is received in the json of the post (indicating that the call comes from PT3-UCGeneral), it reads the updated files directly from the box and extracts the information corresponding to the patient (whether the patient has been admitted 30 days ago and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

the baseline data). Once the information is collected and processed, all the information is passed to the model for risk estimation.

6.9.2.1 Concept and Ideation Stage

This is a service for estimating the risk of decompensation in patients with heart failure who are monitoring certain information from home. It is a machine learning model that has been trained with a retrospective dataset to detect worsening in these patients. For this, it needs daily measurements of weight, blood oxygen saturation, heart rate, systolic and diastolic blood pressure and an 8-question questionnaire, as well as patient information (whether the patient has been admitted in the last month, baseline data). With this information, it estimates a risk (value between 0 and 1) that indicates the probability of suffering a decompensation in the next 7 days.

Table 107 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-040	Medication tracking should be supported.	Y	HFPred improves the medical tracking by giving the decompensation risk.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	HFPred makes use of the monitored data to make the predictions.
SPS-044	SHAPES should support use of questionnaires as self-assessment tools.	Y	HFPred makes use of questionnaires' data to make the predictions.
SPS-046	SHAPES should support reminders.	Y	In case the risk is not estimated with all the data, it is returned that all data is not used (as a reminder).
SPS-048	SHAPES should offer alerting mechanisms about medical risks & emergencies.	Y	HFPred estimates the risk of decompensation. Moreover, it checks some variables in danger.
SPS-051	SHAPES should support Predictive Medicine	Y	Prediction of risk of health events such as decompensations in patients with heart

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
			failure are supported and applied.
SPS-114	SHAPES should support assisted mobility at home.	Y	The Heart Failure Prediction model contributes to assisted care.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	The Digital Solution has been designed following accepted cybersecurity paradigm.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	Server stored the essential data guaranteeing cybersecurity.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Information shared with other DS through the Platform's API.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	SymbIoTe and FHIR perform mediation only, i.e. matching between data models used by Digital Solutions, but do not take part in exchanging actual data.
SPS-202	All software modules should be securely updateable.	Y	The Digital Solution is updateable in a secure manner.

Table 108 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Daily measurements	It needs at least the 5 days of the measurements of the previous days (7 is preferred) of the variables weight, blood oxygen saturation, heart rate, systolic and diastolic blood pressure. These will be sent in the json of the server ordered with	Y	These are provided by the post.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	the corresponding date (tag: “monitoring_data”).		
Questionnaires	The answers of the questions of the questionnaire. These will be sent in the json of the server (tag: “questionnaire”).	Y	These are provided by the post.
Basal data	The clinical information about the patients. These will be sent in the json of the server (in PT3-UCGeneral is done in another way as it is explained below) (tag: “patient_data”).	Y	These are provided by the post.
Readmission	If the patient has been admitted in the previous 30-days. These will be sent in the json of the server (in PT3-UCGeneral is done in another way as it is explained below) (tag: “readmission”).	Y	These are provided by the post.
Alert thresholds	The specific thresholds of each patient in each variable to trigger it. This is changed in case the patient has usually low/high value in a variable. These will be sent in the json of the server (tag: “alerts”).	Y	These are provided by the post.
PT3-UCGeneral: Basal data	This data is stored in a box shared folder in which MOIC will change a excel file to introduce the patients' data in a secure manner, then the server will read it directly.	Y	These are provided by the box folder.
PT3-UCGeneral: Readmission	This data is stored in a box shared folder in which MOIC will change a excel file to introduce the patients' admissions or treatments information and the server will read and process it to use it.	Y	These are provided by the box folder.
PT3-UCGeneral: Alert thresholds	In this pilot site, the thresholds will be constants, we are not going to modify these so that the default will be used.	N	In this Pilot Use Case, this is not used.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

7 Solutions for Health and Care Service Providers (Task 5.6)

Aside from the obvious benefits for older individuals looking for digital support for an active and healthy ageing and independent living, SHAPES's digital solutions are also important for caregivers and health and care providers, who benefit from the connected SHAPES digital solutions to improve the delivery of health and care to older individuals whenever required, especially for those living in remote locations (e.g., rural areas).

In particular caregivers and health and care service providers can leverage digital solutions in order to:

- remotely monitor the progress of the patients and alleviate the need of unnecessary physical visits;
- create and assign treatment plans to the patients and be alerted automatically when a critical condition occurs;
- schedule and carry out online appointments via the video consultation feature.

In the times of COVID-19, utilising such solutions becomes even more imperative since it can greatly reduce the physical visits to the hospital which increase the risk of infection and also the workload of the healthcare professionals.

This section lists the digital solutions that the caregivers and health and care professionals and service providers will use via the SHAPES Platform.

Some solutions that fit this category were already presented in a previous one. To avoid replicating content, a list of the solutions is presented below, together with the Section in this document where the information is available:

- eCare Platform (section 3.2).
- diAnoia mobile application and diAnoia marketplace online platform (section 4.2).

7.1 eHealthPass – Web Application

eHealthPass web application is used by clinicians and healthcare professionals, allowing them to directly connect with patients, to schedule appointments, to validate monitoring data, to review and update treatments as required and to follow up on patients' activities and progress. eHealthPass web application is used in conjunction with the eHealthPass mobile application which is the interface of the patients.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Features:

- Treatment plan;
- Appointments;
- Questionnaires;
- Medication prescription;
- Video consultation;
- Charts for visualising the patient’s progress;
- Personal notes;
- Virtual Community portal;
- Education material and activities;
- Reporting data to national registry (optional for COVID-19).

Application areas:

- Chronic disease management: Diabetes, Chronic pain;
- Teleconsultation;
- Patient’s remote monitoring;
- Emergency scenarios and unplanned care;
- Medical tourism;
- COVID-19 self-management.

7.1.1 Technical Specifications

eHealthPass web application is available via all popular browsers such as Chrome, Safari and FireFox. The back-end platform is built around the FHIR leading medical interoperability standards and utilises a fully compatible FHIR server. In addition, several IoT devices are integrated either via Bluetooth with the mobile application or via 4G cellular network and cloud services directly with the FHIR server.

7.1.2 Interfaces and Interoperability

The main interface is the web application which is accessible via a browser. This interface is used by the physicians and nurses that monitor the progress of the patients.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

7.1.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT5 – Caring for Older Individuals with Neurodegenerative Diseases *(Adaptations for Pilot 5 have not commenced yet)*.
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals *(Adaptations for Pilot 7 have not commenced yet)*.

7.1.4 Adaptations for PT3-UCGeneral

7.1.4.1 Concept and Ideation Stage

Older individuals tend to have a number of concurrent medical conditions resulting in the need to take a larger number of prescribed medicines to help control these conditions. There is a need to have a personalised approach to the safe and effective use of these medicines to ensure the best possible outcomes from their medicines. Specifically, patients with heart failure and/or diabetes must be monitored to avoid decompensations and hyper/hypoglycaemic events. Medication should be adjusted after review of health parameter monitoring with a goal of optimising and personalising treatment.

In the context of this pilot, the eHealthPass will be used by the local researchers of the pilot site who will supervise the pilot study. A description of the local researcher profile and the actions to be performed is provided below:

Local researcher

A researcher will review the **SHAPES Dashboard** regularly to help the participants adhere to the intervention. On this dashboard, they are able to view:

1. The list of participants taking part in the pilot at their site. The dashboard presents participant's unique identification number only. They have a separate list that links identification numbers to the participants' names and contact details.
2. Participants' profiles:
    - Baseline demographic data and data required for VICOM HF Predictor.
    - Medicines list including all treatments, doses and frequencies – editable by researcher.
    - History of clinical parameters that require daily monitoring including: blood pressure, weight, oxygen saturation, heart rate, blood glucose.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- History of questionnaire responses.
- History of daily tasks/reminders.
- Dynamic thresholds.
- Use of unscheduled care including hospitalisation details.
- Check how the participant has used the app e.g. how often they log in, what sections of the App do they use most frequently.

Table 109 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-023	SHAPES Platform shall support multilingual user interface.	Y	The languages of each pilot and replicated sites are supported.
SPS-029	SHAPES Platform should support health data management (collection, sharing and processing).	Y	eHealthPass supports health data collection and sharing with the health care professionals and local researchers.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	eHealthPass web app displays the values of the blood glucose monitoring and thus allows the HCP to monitor the vital signs of the patients.
SPS-044	SHAPES should support use of questionnaires as self- assessment tools.	Y	Via ehealthPass web app the local researcher can create and assign questionnaires to the users.
SPS-057	Scheduling of tasks for different users should be supported in SHAPES.	Y	Via eHealthPass web app the local researcher can create and assign care plans which include personalised tasks for each user.
SPS-059	User friendly dashboard should be offered to care receivers and care takers.	Y	Mock-up tests were provided and feedback was incorporated to eHealthPass to ensure user friendliness.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 110 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-08	AIM7: Implement a personalised approach to achieve a safe and effective use of medicines in home.	Y	Via eHealthPass web app the local researcher can create a medication list and assign it to each user.
UR-14	HOW1: Tracking and registration of vital signs and physical measurements. Use sensors and other devices. Record quantifiable health data. Using Health and Wellbeing Apps.	Y	Via eHealthPass web app the local researcher can monitor the measurement of the blood glucose.
UR-16	HOW3: Medication adherence tracking via MARS questionnaire.	Y	Via eHealthPass the local researcher can assign the Medication Adherence Report Scale (MARS) questionnaires to the users and evaluate their responses.

7.1.4.2 Design and Development Stage

Currently, the Phase 3 of PT3-UCGeneral is finalised and a functioning prototype of eHealthPass shall be delivered. The focus of Phase is primarily on the mobile application which is used by the patients. However, a first version of the eHealthPass web App, used by the local researchers, is also available. Updated versions will follow during Phase 4 and 5 to meet the exact requirements of the pilot. Main screenshots depicting the functionality that is available are provided below:

1) Manage the patients participating in the pilot
   The users displayed are test users. During the pilot, only pseudonymised data will be available.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

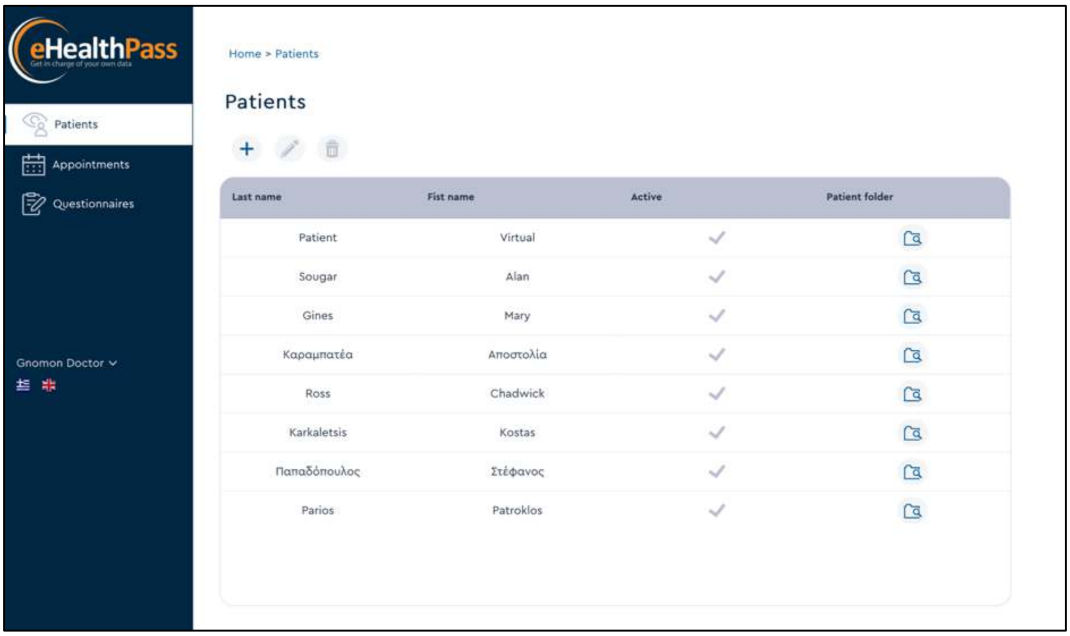
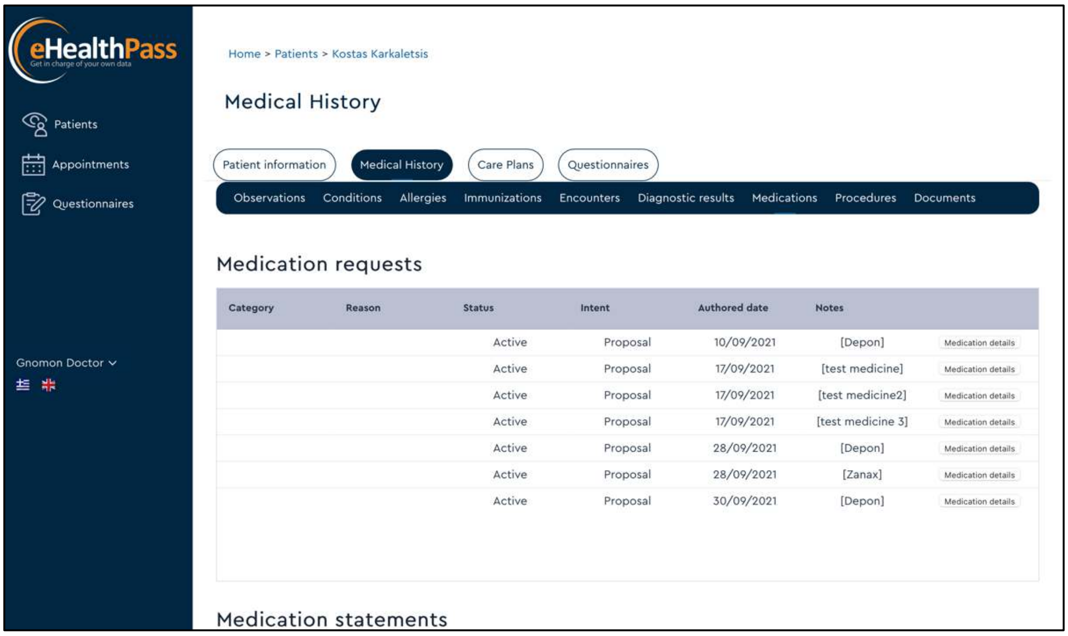


Figure 168 - Patients Screen

2) Provide a personalised medication list per user



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

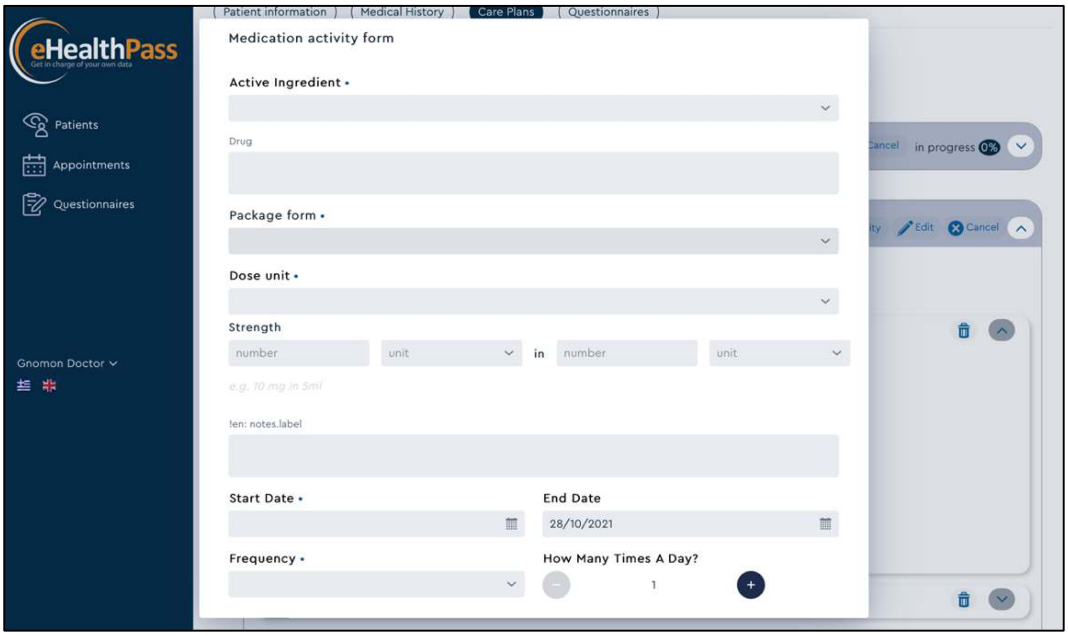
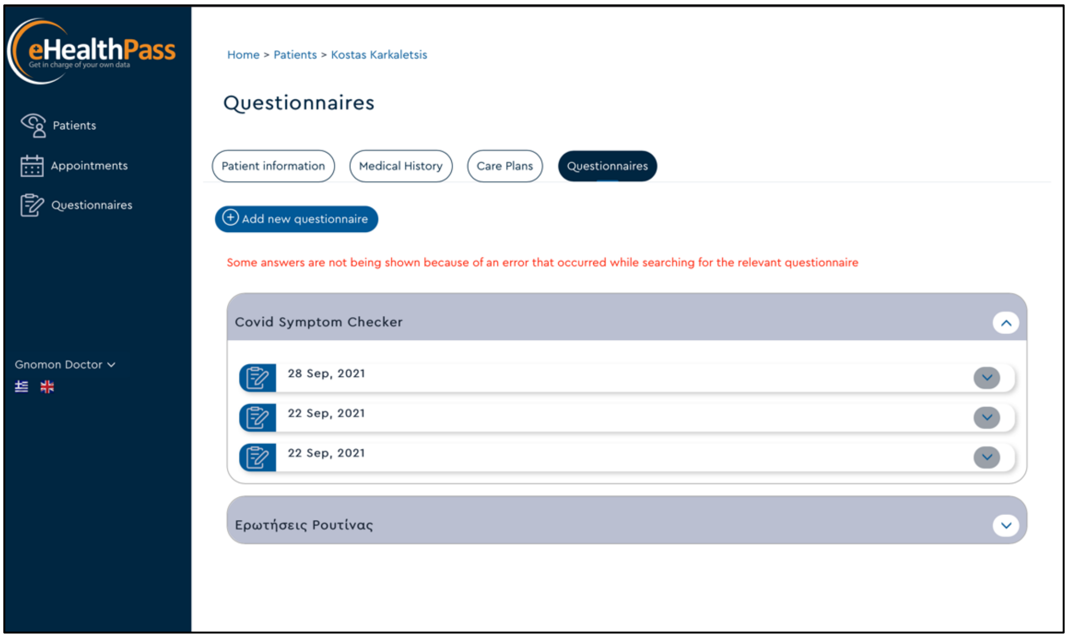


Figure 169 - Medication List

3) Enable users to register their medication adherence via frequently answering the MARS questionnaire.



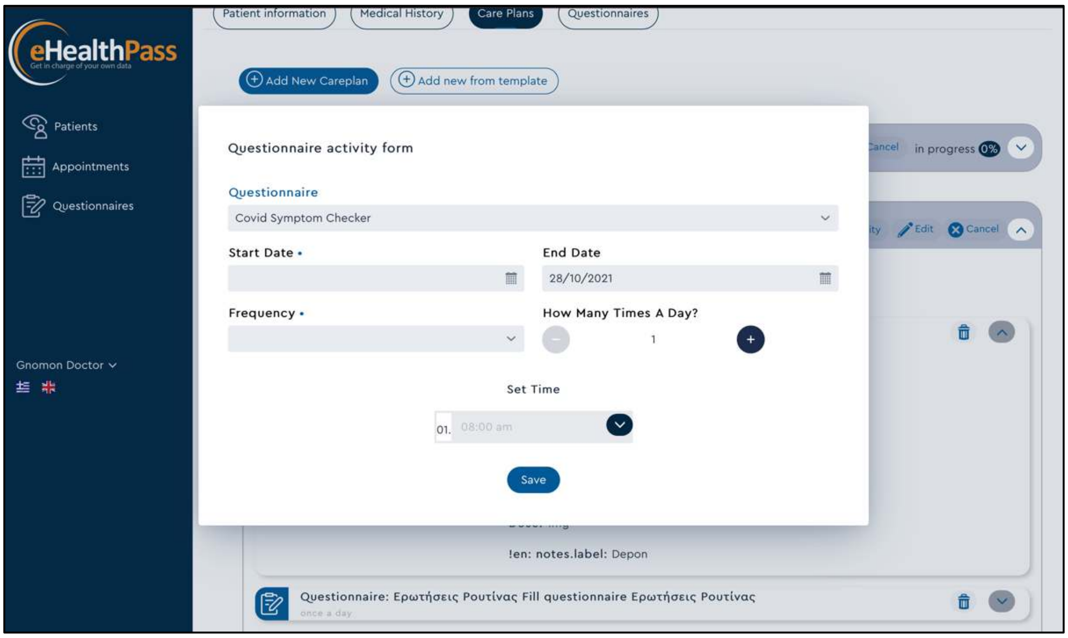


Figure 170 - Questionnaires

4) Scheduling of specific tasks for different users. This is achieved via the care plans where the local researcher can assign different tasks to each user.

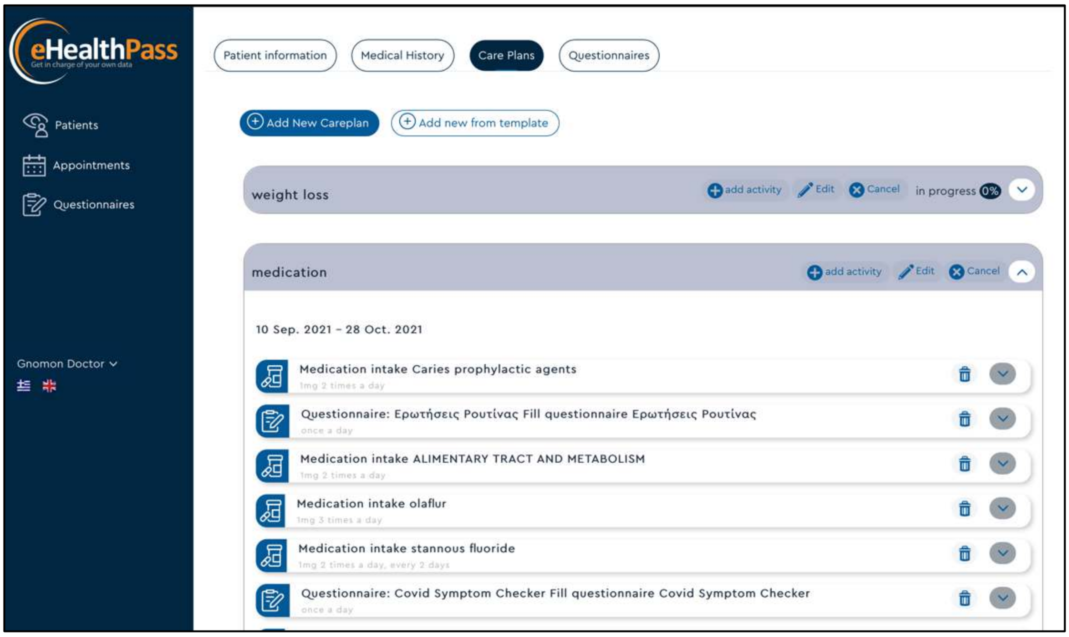


Figure 171 - Tasks Scheduling

7.1.4.3 Prototyping and Adaptation Stage

In the context of this pilot and use case, eHealthPass web App is being adapted to include the modules and services that facilitate the following functionality:

1) Manage the patients participating in the pilot.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

2) Provide a personalised medication list per user.
3) Enable users to register their medication adherence via frequently answering the MARS questionnaire. The local researchers can then observe the responses via the eHealthPass web app.
4) Scheduling of specific tasks for different users. This is achieved via the care plans where the local researcher can assign different tasks to each user.

In the context of this pilot, eHealthPass integrates with digital solutions, provided by the SHAPES partners, in order to fulfil the complete list of the Use Case requirements. Specifically, we are the stage of integrating with the following partners and digital solutions:

1) eHealthPass will be integrated with VICOM's heart failure predictor platform where the local researcher will be able to redirect from eHealthPass web app to the VICOM's platform.
2) eHealthPass will be integrated with EDGE's eCare web App where the local researcher will be able to redirect from eHealthPass web App to EDGE's eCare.
3) eHealthPass will be integrated with TREE's Big Data analytics platform where eHealthPass will be sending the users' blood glucose measurements and TREE will be responding with dynamic thresholds that will then be visualised in eHealthPass web App interface.

7.2 Virtual Patient Scenarios – Mobile Virtual Patients (AUTH)

Virtual Patient Scenarios (VPS) and Mobile Virtual Patients (MVP) have been increasingly used as educational resources in many medical educational institutions. More specifically, they are defined as specific types of computer-based programs that simulate real-life scenarios where learners emulate the roles of health care providers [36]. They combine scientific excellence, modern technologies and the innovative concept of game-based and problem-based learning activities [37] and are considered an innovative approach which may lead to effective outcomes in education [36, 38, 39]. VPS are developed using the OpenLabyrinth (http://vp.med.auth.gr) (Figure 172), an open-source platform for creating and playing virtual patients, while MVP using the Open-Source Framework Drupal (Figure 173). They enable learners to take the role of a health care professional and develop clinical skills including making diagnoses and therapeutic decisions. They are considered effective learning tools that facilitate the transfer of real-life challenges in engaging scenarios which mimic the tensions, distractions and uneven issues that make real-life decisions more difficult. In particular, the methodology followed is to provoke the learner to think through a number of solutions or options in order to move forward in the scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

In this vein, formal caregivers have the opportunity to interact with diverse virtual cases through scenarios and, therefore, familiarise themselves with a range of neurodegenerative diseases (including Alzheimer's, Parkinson's, dementia, stroke) and other chronic diseases (diabetes, heart disease), aiming at enhancing their learning skills with regard to the symptoms, diagnosis and treatment of beneficiaries. To this end, they are considered as being valuable for caregivers in encouraging decision making, reasoning and self-assessment skills.

Figure 172 - VPS's Interface

Figure 173 - MVP's Interface

VPS and MVP can be used in many different learning activities and contain a wide range of features that make them fit for individual purposes.

- **Provision of different learning settings and learning activities**: (a) Large Group Teaching, (b) Small Group Teaching, (c) Self-Directed.
- **Structure of scenario**: they can differ in structure. The three main structures are linear, semi-linear and branched.
- **Enriched with media**: a variety of features are available including multiple nodes and links, avatars, media files, rules, info buttons, counters and skins. All these provided through a user-friendly interface and a visual editor.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **Assessment steps or questions**: free text, multiple choice, list-based questions and others.
- **Interactive scenarios**: they can include different types of interactivity.
- **Disciplines**: they can be used in a wide range of different disciplines and there have been very popular within the medical and healthcare settings.
- **Languages**: they can be developed in many languages.

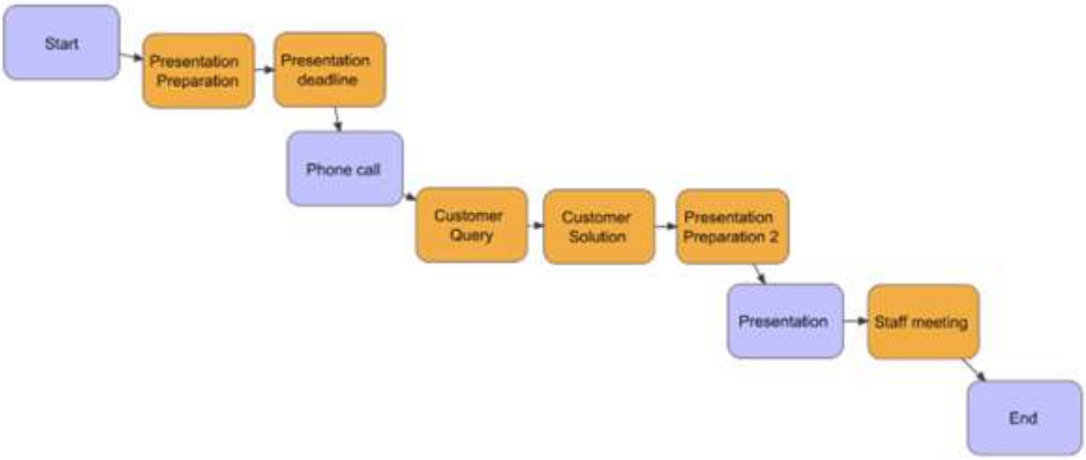


Figure 174 - Simple Scenario Map Showing the Ideal Route Through a Scenario with Key Nodes in Purple and Additional Information Nodes in Amber

7.2.1 Technical Specifications

Virtual Patient Scenarios (VPS) and Mobile Virtual Patients (MVP)

- Disk space

The total amount of disk space needed for the site is not a fixed amount, as it depends on the site itself. The base files for the core software take up about 100 MB on the web server. It is required more space if additional modules or themes are installed, and if media, backups, and other files generated by and uploaded to the site are required. The database also uses disk space, although that is typically not in the same area (and in some cases, not even on the same server) as that used by the site files.

- PHP

PHP 7.2 or higher. PHP must be set up with a minimum memory size of 64MB; if running multiple modules on the site or using memory-intensive PHP-based command-line tools (such as Composer), considerably more memory than that may be needed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Certain PHP extensions are also required; the exact list of required PHP extensions depends on the installation of the core software and which modules are used on site. Generally, hosting service providers have installed all the PHP extensions needed. In self-hosting scenarios or if the site is run on a local computer, there may be error messages during installation if any required PHP extensions are missing. It is still possible to install them and continue.

- Web server

Apache (Recommended). Apache is the most commonly used web server. The core software will work on Apache 2.x hosted on UNIX/Linux, OS X, or Windows that have the Apache mod_rewrite module installed and enabled. The Apache VirtualHost configuration must contain the directive AllowOverride All to allow the .htaccess file to be used.

- PHP

It may temporarily run a local demo site on a local computer using just PHP, without installing web server software.

- Nginx

Nginx is a commonly used web server that focuses on high concurrency, performance and low memory usage. The core software will work on Nginx 1.1 or higher hosted on UNIX/Linux, OS X, or Windows. The ngx_http_rewrite_module must be installed and enabled.

- Microsoft IIS

Microsoft IIS is a web server and set of feature extension modules for use with Microsoft Windows. The core software will work with IIS 5, IIS 6, or IIS 7 if PHP is configured correctly. Because clean URLs are required, it may be needed to use a third-party product. For IIS 7, it may be used the Microsoft URL Rewrite module or a third-party solution.

- Database

Use one of the following databases:

  - MySQL - 5.5.3 (MariaDB 5.5.20, Percona 5.5.8) or higher with an InnoDB-compatible primary storage engine.
  - PostgreSQL - 9.1.2 or higher.
  - SQLite - 3.4.2 or higher. Temporary local demo sites use SQLite, which is distributed as part of PHP and does not require installing separate database software.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.2.2 Interfaces and Interoperability

VPS are developed and delivered through the OpenLabyrinth system (vp.med.auth.gr) that represents an open-source authoring software. VPS are applicable to tablets, laptops and computer devices. **MVP** are developed and delivered through the Open-Source Framework Drupal that represents a free and open-source web content management framework. MVP are applicable to smartphones.

User's interaction

1. User logs in to the Open Labyrinth platform (http://vp.med.auth.gr) or the MVS platform where a list of healthcare-related use case scenarios is available.
2. User selects a VPS/MVP to perform.
3. User interacts with diverse scenarios and familiarises him-/herself with cases that may be confronted with in real-life clinical experience with care receivers.
4. Inside the virtual scenario, the user follows a problem-solving or narrative design scenario where he/she responds to related questions aiming to manoeuver through clinical situations or perform a task. Successful completion of VPS leads to development of essential skills on handling care-receivers' symptoms, diagnosis and treatment.

7.2.3 Applicable Pilot Themes

- PT5 – Caring for Older Individuals with Neurodegenerative Diseases.

7.2.4 Adaptations for PT5-UC004

7.2.4.1 Concept and Ideation Stage

Use Case PT5-UC004 is focused on using VPS and MVP in order to support formal caregivers, healthcare professionals and students of Faculty of Health Sciences in developing decision making, reasoning and training skills in their workplace competency and provide sufficient day care and support to older people with neurodegenerative diseases, including Alzheimer's, Parkinson's disease and mild cognitive impairment.

The applicable SHAPES persona is Daphne. Daphne is a 45-year-old nurse who works the last 6 years in a Nursing Home, in which a Daycare Center for patients with Alzheimer's disease and related dementias (AD/RD) is operating, in an urban area in Greece. Daphne is divorced and lives with her two underage children, 10-year-old daughter, Nefeli, and 7-year-old son Nikola, in the suburbs of Thessaloniki. She also

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

takes care of her 70-year-old mother, who lives one flat downstairs, and suffers from early signs of dementia. Daphne's sister is visiting on the weekends to help with the care of their mother and any potential errands. Daphne does not have much free time, as she has to take care of many patients - her shifts may last up to 10 hours- while she suffers from severe backache and pain on both of her knees, due to long standing and improper lifting and transferring of patients.

Daphne often feels that she lacks in professional readiness and that her care giving skills need improvement, while she is daily confronted with high-stress situations that make her be haunted by anxiety and fear of making a medical error. Additionally, sometimes she fails to appropriately communicate and understand emotions and inner affinity of patients, while she wishes she could better address common needs for AD/RD caregiving, but also better comprehend their unique caregiving needs. Indeed, while surfing on the internet, she found out that fellow colleagues from other countries receive individual training through new technologies that help them identify and manage different symptoms and needs of people with different types of AD/RD. She realises that developing an individual care plan with details on the individuals' unique needs, medications, dietary requirements and restrictions is of utmost importance. Daphne understands that technology could act as an important tool in terms of computerisation patients' health data and communication with her co-workers and she wonders whether new technologies could also help her advance her skills through training.

In this light, the principal of the Day Care Centre, in which Daphne works, introduced a training program aiming at enhancing employees' skills in order to ensure quality care. A training plan can help Day Care operators maintain a highly skilled workforce. Under this perspective, Daphne interacts with the VPS and MVP, which have been increasingly used as educational resources in healthcare education. More specifically, they are defined as specific types of computer-based programs that simulate real-life scenarios where learners emulate the roles of health care providers. VPS and MVP can be deployed as problem-based learning activities and are considered an innovative approach which may lead to effective outcomes in education. In this vein, Daphne has the opportunity to interact with diverse virtual cases through scenarios and therefore familiarise herself with a range of neurodegenerative diseases (including Alzheimer's, Parkinson's, dementia, stroke) and other chronic diseases (diabetes, heart disease), aiming at enhancing her learning skills with regard to symptoms, diagnosis and treatment. Thus, she considers VPS and MVP valuable learning tool for encouraging decision making, reasoning skills, as well as self-assessment.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 111 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	VPS and MVP have their own terms of use and services policy.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	VPS and MVP have their own privacy policy.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	VPS and MVP have their own APIs and adopts interoperability standards.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	Introductory videos and user manuals, including relevant instructions on the use of the devices, have been developed for VPS and MVP.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	VPS and MVP comply with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	VPS and MVP storage is handled in EU Member States.
SPS-053	SHAPES access devices maybe user friendly	Y	VPS and MVP provide easy and user-friendly interaction. Usability has already been tested.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	VPS and MVP provide user friendly dashboards.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	VPS and MVP offer robust authentication and authorisation features.
SPS-081	The SHAPES Platform should provide web access from	Y	VPS and MVP support access from

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	desktop/laptop/smartphone and tablet.		desktop/laptop/smartphone and tablet.
SPS-087	The SHAPES Platform should offer adaptation and personalisation of training intervention plans.	Y	VPS and MVP support the creation and personalisation of training intervention plans for each user.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	VPS and MVP comply with relevant cybersecurity rules for mobile and online services.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	VPS and MVP offer user-friendly and attractive interfaces. Adaptations to VPS and MVP consider the collected user feedback on design mock-ups and prototype.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	VPS and MVP adopt an efficient navigation scheme to facilitate user interaction. Adaptations to VPS and MVP consider the collected user feedback on design mock-ups and prototype.
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	VPS and MVP implement cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	VPS and MVP adopt a data minimisation policy that restricts data processing.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	VPS and MVP comply with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	VPS and MVP comply with GDPR regulations and implements cybersecurity measures to protect data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	VPS and MVP are scalable solutions in terms of users, services and geographical coverage.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	VPS and MVP were designed with a modular architecture.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	VPS and MVP deliver service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	MVP are accessible by Android-based mobile devices.
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	VPS web-based platform does not involve the need for plugins.
SPS-200	Anonymization and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	VPS and MVP implement anonymisation features.
SPS-202	All software modules should be securely updateable.	Y	VPS and MVP adopt secure mechanisms for software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	MVP adopt robust verification mechanisms for software updates.

7.3 Video Call Solution (MedSyn)

Especially in times of a corona pandemic, it can be advantageous for older people to be able to attend the next doctor's appointment not on site but via video consultation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

In addition, there is growing evidence in Germany that the acceptance of video consultations among the elderly population has increased significantly during the COVID-19 Pandemic.

For that reason, older people and care receivers as well as care givers shall be enabled to use a video consultation on a regular basis. To address the needs of elderly persons who live mostly alone and independently or with sporadic supervision in rural or urban environments the system is not only intended to be used between doctors and patients but also between older people and their relatives or care givers for example.

The video consultation of MedicalSyn works with a two-screen display for bi-directional communication. It offers a waiting room and an additional contact form/chat with the option of encrypted transferring of documents. Access to the system will be kept very low-threshold in accordance with security and privacy regulations, to avoid potential barriers right from the beginning.

7.3.1 Technical Specifications

The video consultation is a browser-based application. A concept for different roles and users with different rights and functionalities is implemented but can also be inactivated, if necessary. Same is valid for a login process, which is carried out anonymously via randomly generated Personal Identification Numbers (PINs).

7.3.2 Interfaces and Interoperability

The Video consultation will run in a responsive design for Desktop Computer, Tablet and Smartphone (Android and iOs). There is no App needed.

Possible stakeholders are:

- Older people in general (65+).
- Elderly care receivers.
- Caregivers (family members, friends, Healthcare Professionals).

7.3.3 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home.

Goal: overcoming the fear of digital technologies and easily getting in touch with family and friends while ensuring data protection rights.

7.4 (Patient) Survey System (MedSyn)

To assess the satisfaction related to different digital solutions within pilot themes a digital survey system can be very useful. Moreover, wellbeing assessment via validated questionnaires e.g. addressing quality of life can be implemented regarding the requirements of the use case.

The survey system of MedicalSyn can implement various surveys of interest into an easy to use interface to reach these goals, providing that all necessary licenses for using the questionnaires are existing.

The system offers a personal survey view that lists all available surveys for the user and the specific progress. Surveys can be implemented in different timelines, e.g. in a visit scheme according to an observational study. For each participant, the surveys stored in the system can be selected or deselected according to the time schedule.

7.4.1 Technical Specifications

The survey system is a browser-based application. A concept for different roles and users with different rights and functionalities is implemented but can also be inactivated, if necessary. Data can be exported in different formats to the pilot site.

7.4.2 Interfaces and Interoperability

The survey system will run in a responsive design for Desktop Computer, Tablet and Smartphone (Android and iOs). There is no App needed.

Possible stakeholders are:

- Older people in general (65+).
- Elderly care receivers.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.4.3 Applicable Pilot Themes

- Pilot 1 – Remote In-Home Wellbeing Monitoring and Assessment.

Goal: assessing the satisfaction with digital solutions of interest within the use cases. Calculating a wellbeing assessment score.

7.5 IT Health Care Platform (MedSyn)

The Health Care platform as medical Electronic Data Capture system and Medical DataBase Solutions (MDBS) is a digital Service for medical-clinical care situations and for clinical trials. It was originally developed for the documentation of multiple sclerosis (MS) patient management as an electronic Case Report Form (eCRF).

The eCRF is adaptable to the specific needs of SHAPES:

- Clinical parameters (e.g. patient anamnesis, clinical status, MS relapses).
- Treatments and pre-treatments.
- Previous diseases.
- Clinical investigations/ Clinical tests.
- Laboratory results, automatic analysis of laboratory parameters and alarm functions.
- Medication and concomitant medication.
- Checklist for patients, physicians, and nurses.
- Patient surveys.
- Adverse event notifications (medications).
- User administration and user management (roles and rights).

7.5.1 Technical Specifications

The Health Care Platform is a browser-based application. A concept for different roles and users with different rights and functionalities is implemented but can also be inactivated, if necessary. Data can be exported in different formats to the pilot site.

7.5.2 Interfaces and Interoperability

The Health Care Platform is optimised for Browsers on Desktop Computer. There is no App or other software needed.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Possible stakeholders are:

- Healthcare professionals.

7.5.3 Applicable Pilot Themes

- PT1 – Remote In-Home Wellbeing Monitoring and Assessment.

7.6 Medimonitor (FNOL)

Telemedicine System Medimonitor (Figure 175) is a platform providing remote care assistance and monitoring of patients and it was specially developed for patients diagnosed with chronic heart failure. Medimonitor platform enables to collect patient's health data, vital and physical signs as well as wellbeing and environmental parameters. The overall aim of the platform is to improve quality of patient's life and to empower and support him/her to adopt lifestyle reducing risk of deterioration. All the data and measurements are gathered through smartphones/tablets, sensors and medical devices (e.g. weight scales, blood pressure monitor, oximeter). The platform provides to its users an overview of their daily health status, tasks and treatment plan assigned by medical staff, medication administration and requests, notifications, personalised questionnaires and it also offers the possibility to communicate with the medical staff and to manage medical appointments through video call. Healthcare professionals can remotely monitor the health and wellbeing parameters of their patients, they are able to early identify deterioration signs and to intervene promptly.

The practice enabled screening of common population in the region with the disease; it provides tools for remote control of patients with advanced heart failure (NYHA class III-IV, it means patients that are markedly or severely limited during physical activity) on standard medical therapy (ESC guidelines), before and after heart transplantation. Further it covers population of patients with hemodynamic support (ventricular assist device) before orthotropic heart transplantation or in long-term regimen. Until the service was introduced, there has not been method that would enable to collect relevant data about critical parameters development besides keeping the patient in the hospital. The practice requires only minimum organisational changes in the hospital; its essential parts are under control of clinical staff (cardiologists and nurses) who make use of data (including weight, blood pressure, SpO_2) received from patients at home.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

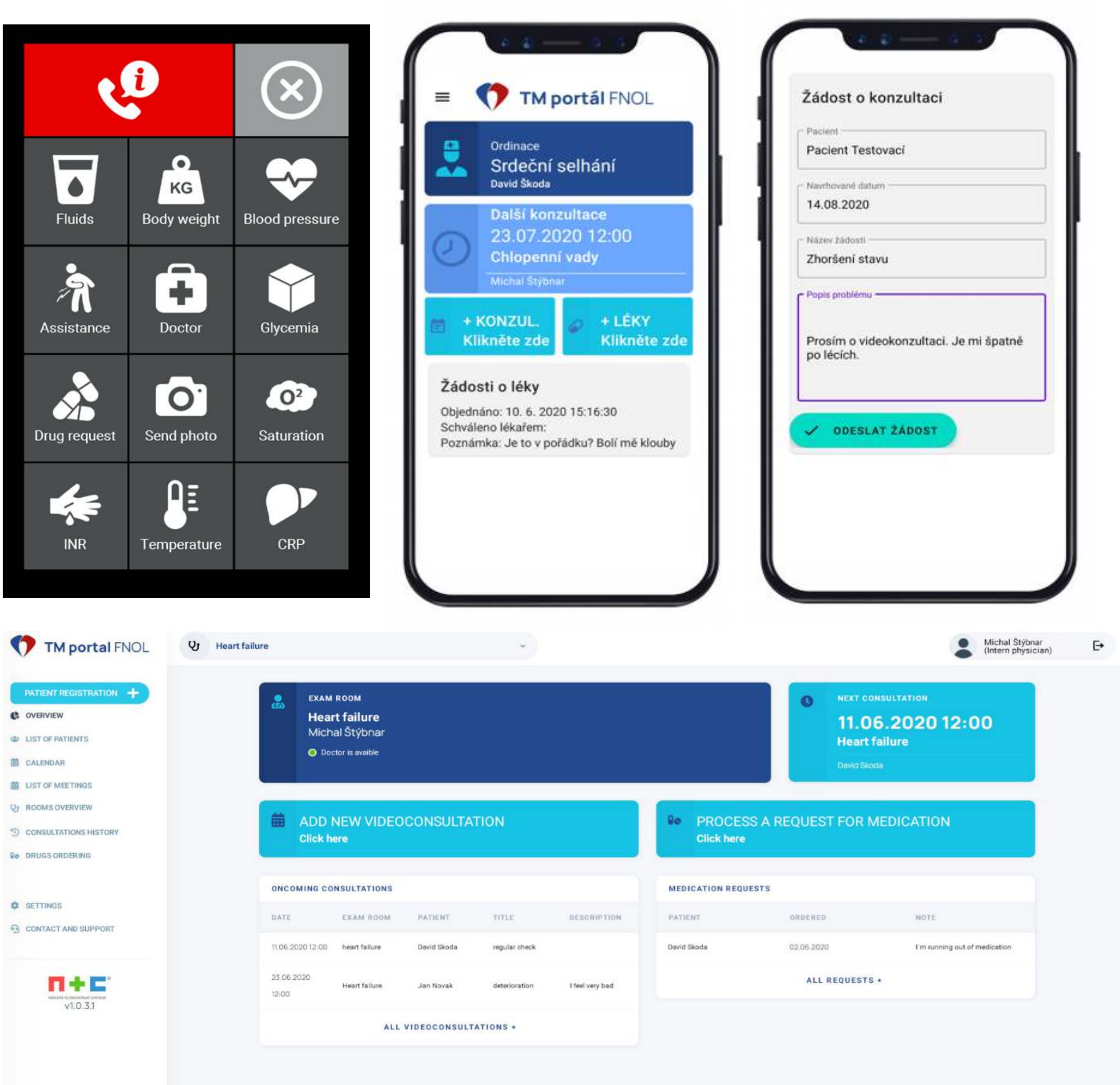


Figure 175 - Medimonitor Solution (from top left: original pre-SHAPES solution, dashboard of the application with updated GUI, request for consult, thin-client interface for medical staff)

The ICT system used for the practice has also several features that enable bidirectional communication between the medical personnel and the patient; including distant ordering of medicaments.

Patients with congestive heart failure can be discharged from the hospital while the data containing their vital signs are still available to the medical staff. If any clinical decision is to be made based on the collected data the patient is called to come to the hospital so the physician can examine the patient properly and, therefore, medical protocols are not compromised. This is due to the fact, that the data collected remotely are not binding and by the local regulations the physician needs to see the patient physically. This practice enables to reduce routine health status check-ups for which the patients must have visited the hospital. Patients are using the telemonitoring

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

system as long as necessary. After that period, the equipment can be transferred to another patient. Therefore, the system also offers an element of sustainability.

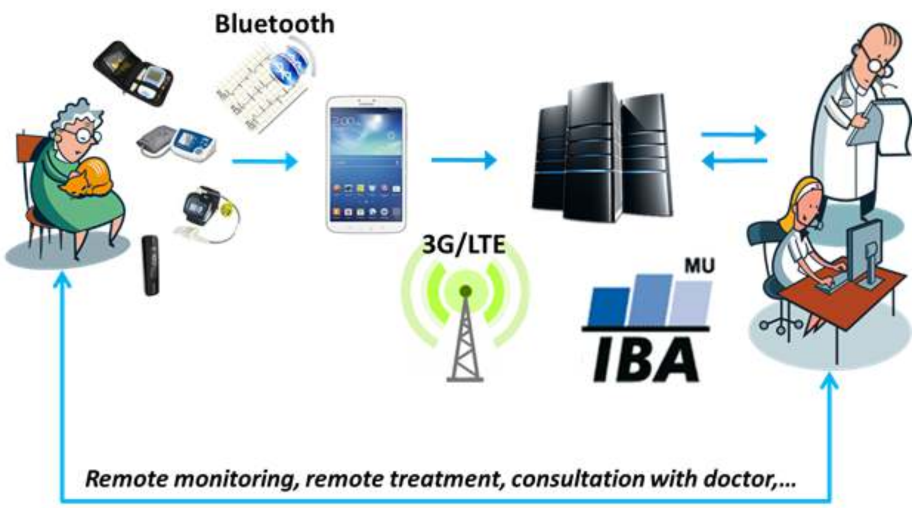


Figure 176 - Medimonitor Solution: Stakeholders, Components and Connectivity

7.6.1 Technical Specifications

HF patients are provided with a smartphone or tablet, blood pressure meter, pulse oximeter, mobile ECG, weight scales, pedometer and are given training to use software application called Medimonitor on the smartphone/tablet. The smartphone or tablet acts as a gateway to upload the vital signs readings daily to the dedicated FNOL telemedicine server. Doctors, specialist nurses and biomedical engineers can access the data through the telehealth portal, so they are able to check the collected data via internet using a web browser with a secure login. The Medimonitor system generates alerts in response to:

- A patient's vital signs readings are outside their threshold parameters. Patients will be contacted by a specialist nurse who will assess the severity of the situation. If the patient's treatment and self-management plan needs adjusting, the cardiologist will contact the patient to make the necessary adjustments and/or invite the patient to attend an unscheduled outpatient appointment.
- If there is missing or incomplete measurement uploads twice in a row – either a biomedical engineer or nurse contacts the patient by telephone, SMS or Medimonitor message and provide additional training in the use of the smartphone or tablet if required.

The scheduled outpatient consultations are enhanced by the availability of the data collected via telemonitoring. These data can be accessed any time by hospital specialists. If patient's symptoms worsen, they are admitted to the outpatient consult or for observation to the hospital.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 112 - Technical Specifications for Medimonitor

Data Category	Measurements Type	Collection Method
Vital signs	Heart rate Blood pressure (diastolic and systolic) Anticoagulation ECG Spirometer	Automated (from connected devices) or Manual
Physical	Height Weight Fluid intake	Automated (from connected devices) or Manual
Health	Medication Medical conditions Symptoms Side effects Pedometer	Manual (fill-in questionnaires)
Lifestyle and Wellbeing	Mood Physical activity	Manual (fill-in questionnaires or everyday tasks)
Ambient Living (in house)	Room humidity Air quality (e.g., PM levels)	Automated (from connected devices)
Environmental (outdoor)	Air quality	Automated (from existing open access databases)

Individuals interact with the **Medimonitor mobile App** that enables an easy manual or automatic collection of health and wellbeing parameters. Automated parameters are collected via health and medical devices and wearables mainly through the Bluetooth connection. In the case of medication adherence, a solution which collects sensor data and collects them onto the memory card is used. Device – pillbox is equipped with the motion sensors and detects the events when the patient took pills from the pillbox. Adherence monitored by the pill administration event will be compared with the lab tests and with the results from the mobile app where the patients confirms that they took their medication. Medication can be also requested with the use of Medimonitor App.

Patients can communicate with the medical staff through video consulting solution which is based on open-source Jitsi platform, which can be replaced by any other online video consulting platform, if needed. Jitsi platform is operated on the hospital servers and every session has its own dedicated and hashed URL link which expires after the meeting. There is also a possibility to lock the virtual room by the password. The session can be also recorded if required.

Also, the app allows individuals to answer to several simple and short questionnaires – Beliefs about Medicine Questionnaire (BMQ), MARS, Quality of Life (QoL) – and feedback forms on symptoms, medication adherence (reminders).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.6.2 Interfaces and Interoperability

Data collection is provided by the mobile application, which is available for Android and iOS devices where data can be transferred through Bluetooth. All mobile devices have either LTE mobile internet connection for data transportation or WiFi connection provided by the patient. Patients borrow the tablet which support the App and with MDM system to provide distant ICT support. In addition to tablet, patient receives portable medical and wellbeing devices defined by each diagnosis (HF, COPD). Patients with chronic heart failure use a personal weight, blood pressure monitor, oximeter, ECG and pedometer for daily measurements. All of these medical devices are certified for medical use (compliant with MDD/MDR) and have built-in wireless transmission using the Bluetooth standard. The data is collected and stored on the hospital servers, from where they are accessible via the so-called Telehealth portal, which is used for access by doctors, medical staff and technicians. In the portal, it is possible to set individual parameters for both measurements and uncompleted tasks, set tasks into the calendar, check measured values, compile questionnaires, display measured values from a long-term perspective, medication settings. With the program for mobile data management it is possible to update the application or solve any technical issues with the App.

Mobile Application, tablet:

- Interface for patient interaction with health professional.

Control Panel, web-based: Browser:

- Interface for the health professional interaction with the patient and health plan management system.
- Interface for the system administrator.

Telehealth portal:

- Based on Microsoft technologies - .NET, SQL server.
- Azure ready (cloud).
- Multitenant.
- Data encryption.

Security:

- Auth 2 protocol for authorisation.
- Encrypted communication between server and device.
- Encrypted data storage on device.
- Mobile Device Management – MobileIron.

Stakeholders: patients, medical doctor, physician, system administrator (to add/delete users, to assign patients with health professionals).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.6.3 Applicable Pilot Themes

- PT3 – Medicine Control and Optimisation.

7.6.4 Adaptations for PT3-UC001c

This digital solution has been adapted to the use case PT3-UC001c which is aimed at advanced telemonitoring of patients with heart failure in home environment using different devices enabling HF patients to be monitored remotely from their homes. Applicable SHAPES persona is Roberto.

Adaptation of the Medimonitor to the aforementioned use case consists of:

- Improved UX – GUI is adapted for the use by elderly patients. Contrast, font size and other features were specifically chosen to compensate typical conditions elderly people might be struggling with.
- Communication protocols with additional medical devices that were not used with the Medimonitor before – mobile ECG and pedometer (on board of smart watch).
- Video consults – a capability that was added to respond to the COVID-19 pandemic and to protect most vulnerable patients while keeping them away from potentially infectious environments.
- Medication and medical aids requests – another new capability of the application that allows patients to stay at home while being able to order both medications and medical aids.
- Questionnaires – application is capable to collect responses to various questionnaires to be able to answer questions related to the quality of life, health condition, user experience/acceptance, beliefs about medication, adherence or any other questions presented in own questionnaires.

7.6.4.1 Concept and Ideation Stage

Main aim of the proposed solution is to provide ability to measure vital signs and other relevant signals or gather answers from specific questionnaires in order to allow patients to stay in their home environment as long as possible while keeping the medical staff informed about the patient's health status. The application is focused on two diagnoses, however, can be easily improved for others as well, either by adding another medical devices with which the App communicates or via additional questionnaires tailored to assess different health conditions. Currently, the App is designed mainly for patients with heart failure or chronic obstructive pulmonary disease.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Relevant persona for this use case is Jan (alternative of Roberto). Jan is 62 years old living in a small town together with his wife. Jan had heart attack when he was 50 and 7 years ago, he was diagnosed with a chronic heart failure. The disease has been progressing over the time. His current status is classified as NYHA III with prognoses towards most advanced stage NYHA IV. Jan was twice hospitalised in the regional hospital specialising in cardiac diseases and during last visit of the outpatient department the cardiologist told him he would probably be indicated for transplantation. Because of his health status, Jan needs to come to see the cardiologist in regional hospital for regular check-ups. However, the commute to the regional hospital is quite long and difficult for him and Jan is always worried to leave his wife alone at home.

Various ICT technologies may help to ease the life to this couple. The technologies may enable longer stay at home without Jan being forced to hospitalisation weeks before the transplantation and Jan would be able to come less often to the regional hospital for regular visits while still being monitored by the medical staff. Healthcare professionals can remotely monitor his health and wellbeing parameters, they are able to early identify deterioration signs and to intervene promptly.

An analysis of the applicable system specifications and the pilot use case requirements has been made. The following tables map the applicable ones and describe how they have been addressed.

Table 113 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	Open API connecting the Medimonitor with TREE and VICOM analytics.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	All relevant medical and non-medical staff have full digital access to the system.
SPS-027	Digital Solutions shall provide usage tutorials and help cards including devices they use.	Y	Animated tutorials to guide the patients how to use the medical devices.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	Application aids data acquisition, transfer to the server and visualisation of analysed data.
SPS-030	SHAPES platform shall comply with private data	Y	Data stored on the server are GDPR compliant, informed consent is

System Specifications	Description	Fulfil (Y/N)	Comments
	protection of the GDPR regulation.		available, retraction of the informed consent is possible.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All of the stored data is located on local server of the University Hospital Olomouc.
SPS-033	All classes of users shall be able to review the historical data.	Y	Every stakeholder in the process is able to see the data back in time.
SPS-034	Data management should be integrated into the patient's dashboard.	Y	Data are accessible from the dashboard.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Smartwatches with available SDKs can be used together with the application.
SPS-040	Medication tracking should be supported.	Y	Notifications available within the App.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	Medical devices with available SDKs are connected to the App.
SPS-042	SHAPES should support manual data entry.	Y	Application allows to manually enter data when Bluetooth is malfunctioning.
SPS-044	SHAPES should support use of questionnaires as self-assessment tools.	Y	Application is using questionnaires.
SPS-046	SHAPES should support reminders.	Y	Medication and task reminders are deployed within the App.
SPS-054	Video conferencing should be supported in SHAPES.	Y	Videoconferencing platform is integrated within the application.
SPS-058	SHAPES may motivate care receiver.	Y	There is a possibility to motivate care receiver via messages.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-065	SHAPES may offer environmental, pollution and weather info, relevant to older population in a given area.	Y	Information on dust particle concentration within home and outside environment provided.
SPS-075	SHAPES should offer possibility to delete access to the platform.	Y	Patient can send a request to delete his /her account via the application.
SPS-076	SHAPES shall offer option to view personal data stored in the platform.	Y	Available in thin-client web platform.
SPS-077	SHAPES shall offer option to edit personal data stored in the platform.	Y	Available in thin-client web platform.
SPS-078	SHAPES shall offer option to request removing own personal info from the platform.	Y	Patient can request removal of his user account through the web platform.
SPS-081	SHAPES should provide WEB access from desktop/laptop/smartphone and tablet.	Y	There is a web-based platform parallel to the mobile application.
SPS-118	SHAPES should offer monitoring of home environment.	Y	Application is able to download data from the environment monitoring sensors.
SPS-128	SHAPES shall support “privacy by design and by default”.	Y	Application employs encryption, anonymisation and/or pseudonymisation.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and on-line services.	Y	Application is compliant with the requirements of local cybersecurity authorities.
SPS-133	SHAPES Digital solutions shall be able to send alerts and notify the caregivers.	Y	Application is providing caregivers with the notification when the measured signals are out of predefined ranges.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Application was developed with the support of UX expert and was tested with the use of focus groups.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Design does not use any complicated navigation routes or gestures. Each functionality is reachable within few simple clicks.
SPS-138	SHAPES shall offer detection of personal data breach.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-139	SHAPES shall support restricting data processing.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-140	SHAPES shall offer info about third parties that have gained access to own private data.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-142	SHAPES shall provide support for "the right to object".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-144	SHAPES shall provide support for "Data protection principles: accuracy".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-145	SHAPES shall provide necessary protection of data.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-146	SHAPES shall offer capability to detect a risk of potential data breach.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-147	SHAPES shall support IAM (identity and access management).	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-148	SHAPES shall implement password based authentication.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-149	SHAPES shall support password management.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Solution is backed-up by the IT department team which is available 24/7 to keep the hospital services operational.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	Data from the devices, questionnaires etc. are stored in the tablet to the point when they are successfully sent to the server.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	Event logging is available.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	User can resume his/her action upon reconnecting to the server. Data downloaded from the medical devices are stored within the tablet and sent to the server as it reconnects.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Notification will pop-up if network unavailable. Measurement still possible. Data will be sent upon reconnection.
SPS-169	SHAPES GUI should use self-explanatory graphical elements linked with respective services.	Y	Application is using pictograms.
SPS-171	SHAPES shall support open and interoperable standards.	Y	Supports FHIR/HL7.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Data transfer to VICOM and TREE.
SPS-173	SHAPES services and application should be accessible using Android and iOS based mobile devices.	Y	Application is available for both platforms.
SPS-186	FHIR shall be used as a common data model for Medical Data exchange among components of the SHAPES platform.	Y	All the collected data are contained within FHIR/HL7 compatible databases.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	All of the private data is being deleted from the data matrix send for analysis.
SPS-200	All passwords shall be unique per device and per user.	Y	Each user is equipped with the unique password.

Table 114 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
G01	The system has to comply with ethics requirements (WP8).	Y	The system fully complies with WP8 requirements.
G02	Easy to use (for both older people and professional caregivers).	Y	UX and GUI experts included in the development stage testing solution on real users.
G03	Accessibility issues (for older people).	Y	Solution tested on real users during the development stage to avoid accessibility issues.
G04	Privacy and security. GDPR compliant.	Y	The system fully complies with GDPR requirements.
G05	The system has to comply with platform requirements (WP4).	Y	The system fully complies with WP4 requirements.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
G06	The system has to comply with other requirements (WP3/T3.5).	Y	The system fully complies with WP3 requirements.
G07	The system is compatible with the chosen 3rd party medical devices (scale, blood pressure monitor etc.).	Y	The system is fully compatible with chosen devices.
FO01	Older people will use an android smartphone or tablet.	Y	If needed, training on how to use Android devices will be provided.
FO02	The app will provide the same information for both smartphone and tablet.	Y	Solution developed and tested on both smartphone and tablet.
FO03	Blood pressure measurement functionality. Manual input.	Y	Blood pressure measurement functionality included.
FO04	Blood pressure measurement functionality. Automatic input (wireless connectivity to blood pressure monitor).	Y	Blood pressure measurement functionality included.
FO05	Weight measurement functionality. Manual input.	Y	Weight measurement functionality included.
FO06	Weight measurement functionality. Automatic input (wireless connectivity to scale).	Y	Weight measurement functionality included.
FO07	Activity measurement functionality. Manual input (wireless connectivity to pedometer).	Y	Activity measurement functionality included.
FO08	Activity measurement functionality. Automatic input (wireless connectivity to pedometer).	Y	Activity measurement functionality included.
FO09	O_2 saturation measurement functionality. Manual input.	Y	O_2 saturation measurement functionality included.
FO10	O_2 saturation measurement functionality. Automatic	Y	O_2 saturation measurement functionality included.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	input (wireless connectivity to pulse-oximeter).		
FO11	ECG measurement functionality. Automatic input (wireless connectivity to ECG).	Y	ECG measurement functionality included.
FO12	Heart rate measurement functionality. Manual input.	Y	Heart rate measurement functionality included.
FO13	Heart rate measurement functionality. Automatic input (wireless connectivity to pulse-oximeter).	Y	Heart rate measurement functionality included.
FO14	Different questionnaires will be presented to the user through the app.	Y	Different questionnaires included.
FO15	App displays reminders & notifications.	Y	Reminders & notifications included.
FO16	App guides the older users through the care plan.	Y	Guide implemented into the App.
FO17	App collects all this information from the user and sends it to the FNOL Cloud/SHAPES TP for further processing and analysis.	Y	Collection functionality implemented.
FO18	Schedule video consults with GPs and specialists.	Y	Video consults included.
SP01	Authentication applies to all types of accesses and users.	Y	Authentication functionality implemented.
SP02	Ensuring users' privacy, safety and security.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
CPA01	Dashboard for alerts (alert manager, health professional can manage the alerts).	Y	Alert dashboard included.
CPA02	History of alerts.	Y	History of alerts included.
CPA03	Alert in case of HF decompensation predicted by VICOM.	Y	VICOM's prediction model included.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
CPA04	Alerts based on older person's data in DB and existing alerts.	Y	Alerts included.
CPA05	Manage push notifications.	Y	Push notifications included.
CPA06	Show reminders for upcoming video consults with GPs and specialists.	Y	Reminders & notifications included.
CPV01	Dashboard for collected data (see data plan).	Y	Dashboard for collected data included.
CPV02	The health professional can define indicators to display in the dashboard, based on collected data (data plan).	Y	Personalised definition of indicators enabled.
CPV03	Visual analytics of the main health parameters retrieved from the users (BPM, O_2, Pulse).	Y	Visual analytics included.
CPV04	Risk of HF decompensation per patient.	Y	Calculation of risk of HF decompensation developed.
CPM01	The health professional can manage patients registration.	Y	Management of patients registration included.
CPM02	The health professional can insert baseline data in DB (see data plan).	Y	Baseline data insertion enabled.
CPM03	The health professional can create and schedule reminders.	Y	Reminders creation enabled.
CPM04	The health professional can create and schedule questionnaires.	Y	Questionnaires creation enabled.
CPM05	The health professional can insert pharmaceutical treatment regime (see data plan).	Y	Pharmaceutical treatment regime insertion enabled.
CPM06	The health professionals can manage the settings related to activity capture and analysis.	Y	Management of settings enabled.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
CPM07	Schedule video consults with patient.	Y	Video consults scheduling included.
DS01	To collect and store data listed in data plan given by health professional.	Y	The system of collection and storage of data developed.
DS02	To collect and store data listed in data plan from devices.	Y	The system of collection and storage of data developed.
GI01	WiFi or 4G connection.	Y	Researchers have to ensure that WiFi or 4G connection is available at participant home.
GI02	Interoperability with SHAPES platform.	N	Interoperability with SHAPES platform not tested yet.

7.6.4.2 *Design and Development Stage*

Figure 177 depicts the first wireframe prototype of the graphical user interface of the telemedicine application developed by FNOL. For the first prototype, it was decided that the design should be landscape oriented and should be designed exclusively for the use with tablets, as the larger screen would allow to accent the needs of the elderly users in an easy manner.

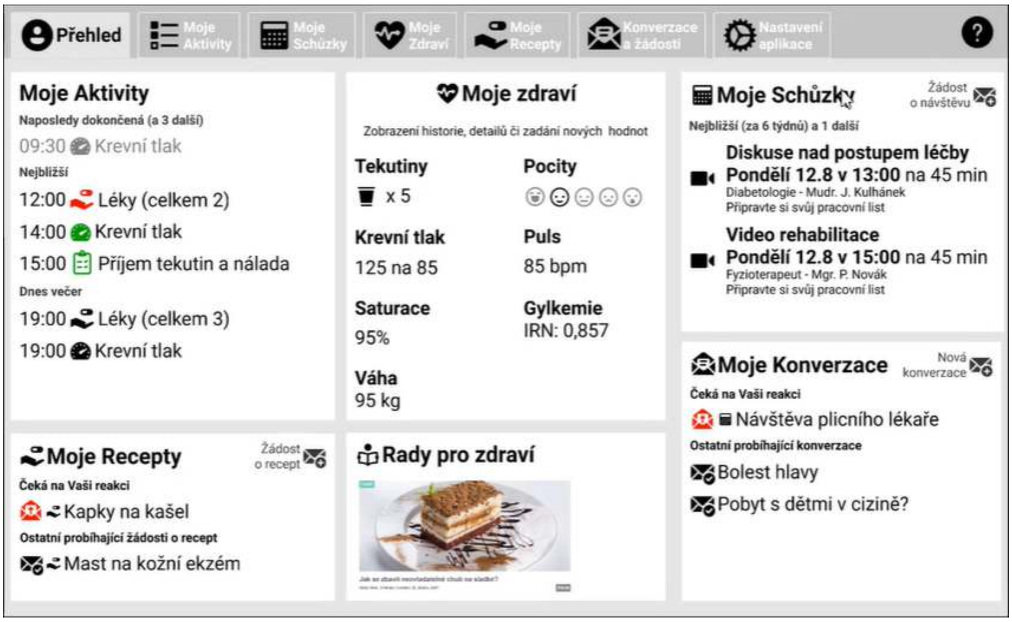


Figure 177 - First Version of the Wireframe Prototype

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Wireframes were presented to the participants in mock-up tests to collect feedback. Based on their feedbacks, the wireframes were adjusted to represent a basis for a preparation of high-resolution graphic user interface models. The users' comments, responses and observed behaviours were analysed and grouped by similar topics. Based on these inputs, the following improvement recommendations were generated:

Acquiring measurements:

- Today's measurements should be in the form of a checklist. Colour differentiation should not be its only attribute.
- During the routine usage of the measuring function, the users would like to skip some of the wizard steps.
- Button for the second step should be described by different wording. Instead of „checked/in order“, it should be used more descriptive „Blood pressure meter working correctly“.
- Wizard can be implemented also by video instructions. The devices where video instructions are most helpful will be identified through practical usage in pilot project.
- It should be possible to initiate measurement or wizard directly from the notification.

Medication list:

- List should be visualised similarly to the today's measurements agenda.

Medication request:

- Instead of a text field it should be possible to choose by a multi-select from the list of available medications. The last item could be „other – please specify“.
- Note for a physician can be omitted.
- The last screen should inform how the ePrescription will be delivered to the patient.

Request for a consultation:

- Multistep dialogue can help the patients to focus on each specific item of the form.
- It is not necessary to give a subject name to the consult, only the reason could be selected from a list.
- It is expected that within the calendar there will be a list of available free time slots as it is typical for the majority of covid-19 test and vaccination reservation systems. This improvement can be fully implemented only after proper update in HMS scheduling capabilities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Upon the completion of the video consultation request, better information how the patient will be notified whether the doctor has accepted it and which time slot he has chosen should be provided.
- It is confusing whether the ordering system is designed for personal or on-line (videoconferencing) visits. But for first generation of the system, only video conference visits will be supported.
- Test users were not sure which side should initiate the call.

Navigation through the application:

- Test users were not able to return to the home screen as they usually ignored the tabs in the headings.

Based on the aforementioned feedbacks, a second version of the wireframe was prepared. This wireframe is shown in the Figure 178.

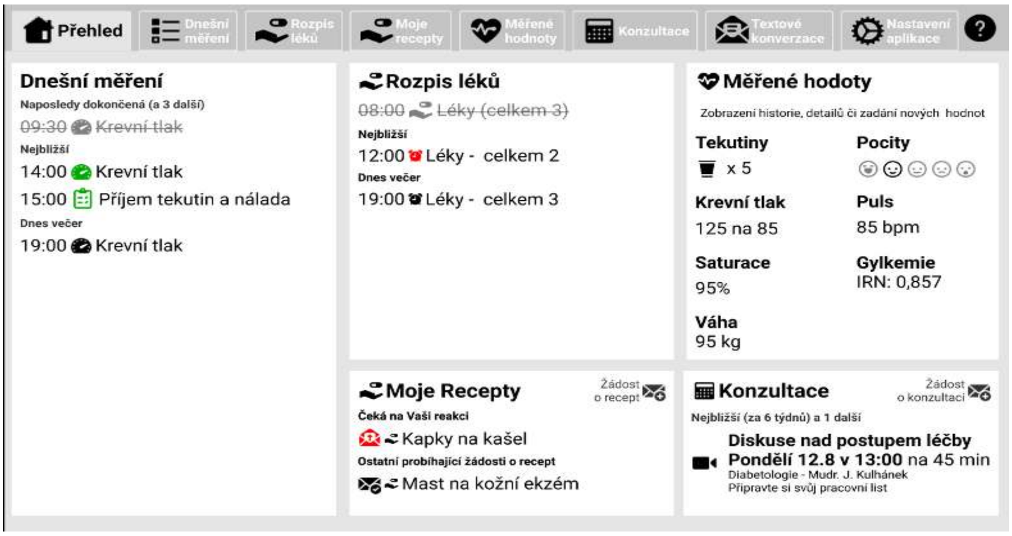


Figure 178 - Second Version of the Wireframe Prototype

From this, a wireframe high-resolution prototype was prepared. This version of the application is depicted in the Figure 179. This version already reflects some of the design requirements imposed by the University Hospital Olomouc graphical manual. Nevertheless, still does not represent the version that will be used for the pilot testing.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

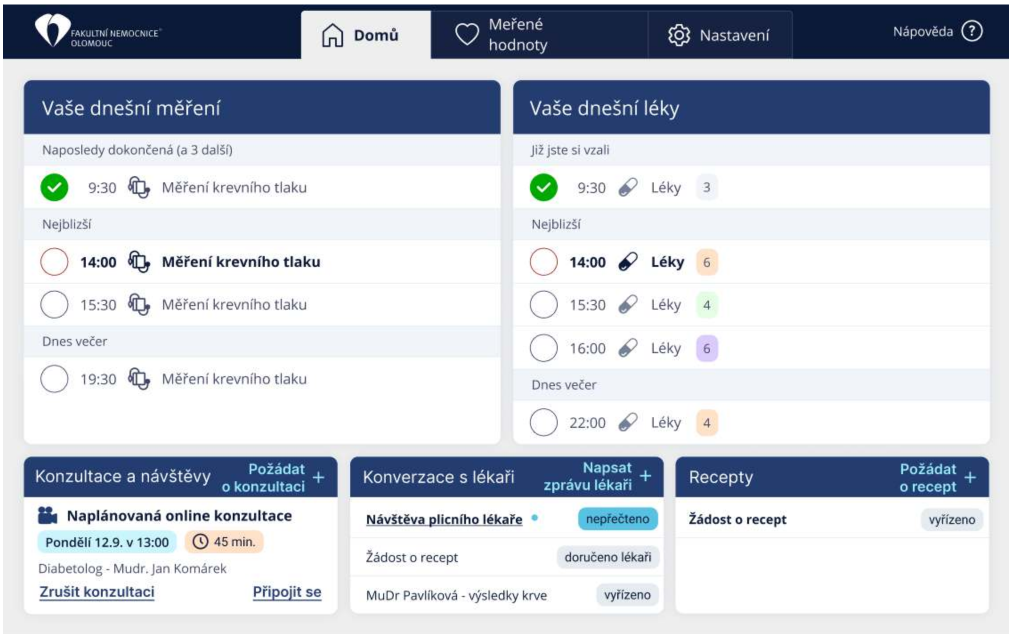


Figure 179 - Dashboard of the First High-resolution Prototype

A thorough feedback collection was conducted and the changes were implemented and prepared for hands-on tests. A brief overview of major outcomes is provided below.

Overview of feedback

Using the feedback collected during the presentations and interviews with participants, the Phase 2 Mock-ups of the SHAPES FNOL component of the PT3-UC001c and PT3-UCCOPD use cases user App were assessed using the ISO Standards for Multimedia Design (ISO 14915).

Suitability for the communication objective *(i.e., suitability of the presentation of the information for achieving the goals of the providers and visitors)*.

In middle-aged and older users, we may encounter the so-called fear-of-computer syndrome. That is, fear that the individual will not be able to master working with a computer. Therapeutic advice that helps people with this syndrome is very well applicable to the general population of elderly users (without a diagnosed syndrome). An important point is, that on the one hand, there should be a clearly designed application, but we should not forget the motivating conversation with the user. For older users who are concerned about working with the tablet, it is advisable to introduce the application and motivate them in person (not just by a brochure or leaflet). This introductory interview can have a major impact on the future use of the application.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 115 - User Feedback on Suitability for Communication

Positive feedback	• Create screens with a small number of elements. • Direct the user's attention to only one task at a time. • Use a contrast sans-serif font. • Use simple design. • Show important information (doctor's reports) with a priority.
Negative feedback	• Do not use icons (or limit their use), respondents often do not understand icons. • The colours used in the application should be justified and in order. Using colour coding with no reason is not recommended, as this confuses users.

Suitability for perception and understanding *(i.e., is the information transmitted easy to understand and can be easily recorded?)*

The clearer and more comprehensible the application, the higher the willingness of users to use the application. This is in line with the Technological Acceptance Model; the assumption that people make more use of technologies for which they perceive benefits and are easily accessible for control (user experience, user interface). The application should suitably combine a pleasant appearance, ease of use, trustworthiness and thus bring an overall positive experience with the application.

Table 116 - User Feedback on Suitability for Perception and Understanding

Positive feedback	• Use one-click confirmation (not double-click). • Use the familiar hospital logo and match the application to the colours that users have associated with this logo (greater credibility). • Create space for the user's "errors", typos, incorrectly selected surgeries, etc. - these user errors must be taken into account by the application and be able to respond to them correctly.
Negative feedback	• Do not use complex gestures to control (do not use a slider or double-click) the application. • Beware of clickable elements too close to each other (seniors have trouble hitting them). • Test the application properly before its release, when the application is launched to the public, do not change it.

Suitability for exploration (*i.e., is the participant able to find the desired information or complete his/her task without any previous knowledge or experience regarding the presentation or structure of the information offered*).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

In majority of cases, the application consists of several predefined scenarios which should guide the user through the whole process and avoid too much of „blind“ exploration. However, also for such a case, the application consists of several navigation elements that can be accessed by ease. Nevertheless, the alternate routes should not be confusing.

Table 117 - User Feedback on Suitability for Exploration

Positive feedback	• Wizards are useful tools to guide the users through the measurement process.
Negative feedback	• Alternative paths to the destination may confuse users, pay increased attention whether they are justified.

Suitability for user motivation *(i.e., a participant must be encouraged to act. By focusing on the needs of the participants, an appealing presentation and goal-oriented guidance, the participant can be motivated)*.

The application should be designed in such a way that patients gain better control over their health condition, thus increasing user adherence, improving health status and thus reducing healthcare costs. Immediate feedback on the deviation in health (fluctuations in weight, pressure) supports early intervention (dietary adjustment, change of drugs, new exercise regimen).

Table 118 - User Feedback on Suitability for User Motivation

Positive feedback	• Create a connection with something that users already know and like to use (e.g., e-prescription). • Present the application as an "extended hand of a doctor", the application complements the contact with the doctor (does not replace it). • The application should include doctor’s feedback for the tasks completed by the patient (it can also be added automatically); then users will understand the application as meaningful.
Negative feedback	• Lower confidence of elderly respondents in the electronic data form (deeper trust in paper notes). • When introducing the application to the public, attention should be paid to possible misinformation, some users expressed uncertainty as to why such an application is being created ("is there a risk of healthcare collapse?").

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

7.6.4.3 *Prototyping and Adaptation Stage*

The following figure demonstrates the system's function and structure based on the used components. The heart of the patient's interface is a tablet connected to medical devices relevant to heart failure patient's condition.

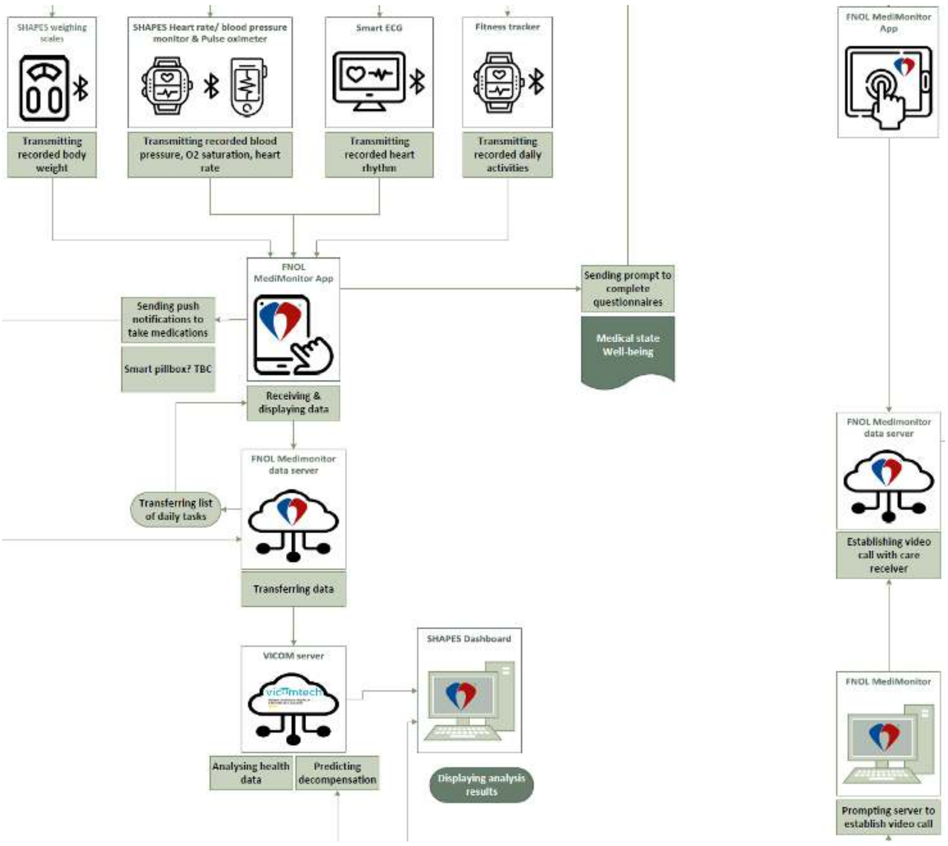


Figure 180 - Medimonitor System Function and Structure

Primary components of the Medimonitor application are:

- Vital sign measurements.
- Medication list.
- Video consults.
- Messaging with medical staff.
- Prescription ordering and medical aid ordering.

Vital signs are measured by the medical devices with Bluetooth capability so the data can be easily transferred to the tablet that works as a nod that collects data from all of the devices available to the patient. These data are then transferred to the server into the MSSQL.

As a part of the digital solution, patient's vital signs and questionnaire responses are being transferred to VICOM, so analysis on these data can be conducted in order to determine the risk of patients' decompensations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.6.5 Adaptations for PT3-UCCOPD

This digital solution has been adapted to the use case PT3-UCCOPD which is aimed at advanced telemonitoring of patients with COPD in home environment using different devices enabling COPD patients to be monitored remotely from their homes. Before, Medimonitor was used only for patients with diagnosed heart failure and the whole solution was transferred to be used for patients with diagnosed COPD as well. Applicable SHAPES persona is Jarda.

Adaptation of the Medimonitor to the aforementioned use case consists of:

- Improved UX – GUI is adapted for the use by elderly patients. Contrast, font size and other features were specifically chosen to compensate typical conditions elderly people might be struggling with.
- Communication protocols with additional medical devices that were not used with the Medimonitor before – spirometer, smart inhaler, ring-like oximeter, home environment monitoring station.
- Video consults – a capability that was added to respond to the COVID-19 pandemic and to protect most vulnerable patients while keeping them away from potentially infectious environments.
- Medication and medical aids requests – another new capability of the application that allows patients to stay at home while being able to order both medications and medical aids.
- Questionnaires – application is capable to collect responses to various questionnaires to be able to answer questions related to the quality of life, health condition, user experience/acceptance, beliefs about medication, adherence or any other questions presented in own questionnaires.

7.6.5.1 Concept and Ideation Stage

Main aim of the proposed solution is to provide ability to measure vital signs and other relevant signals or gather answers from specific questionnaires in order to allow patients to stay in their home environment as long as possible while keeping the medical staff informed about the patient's health status. Application is focused on two diagnoses, however, can be easily improved for others as well, either by adding another medical devices with which the application communicates or via additional questionnaires tailored to assess different health conditions. Currently, the application is designed mainly for patients with heart failure or chronic obstructive pulmonary disease.

Relevant persona for this use case is Jarda. Jarda is older individual living alone in an industrial city with changing air quality. Jarda has severe hypertension and COPD. His COPD exacerbations are possibly linked to the environment as well. Jarda does not like to go to the doctors and avoids hospital stays, therefore, he would be glad if some

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

kind of unobtrusive monitoring of his health status can be employed. Additionally, his son would also welcome it as he often worries about his father health.

Various ICT technologies may help to ease the life to this family. The technologies may enable to keep Jarda's health under control without being worried about further exacerbations and without the need to physically visit a doctor or being admitted to the hospital. Healthcare professionals can remotely monitor his health and wellbeing parameters, they are able to early identify deterioration signs and to intervene promptly.

An analysis of the applicable system specifications and the pilot use case requirements has been made. The following tables map the applicable ones and describe how they have been addressed.

Table 119 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	Open API connecting the Medimonitor with TREE and VICOM analytics.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	All relevant medical and non-medical staff have full digital access to the system.
SPS-027	Digital Solutions shall provide usage tutorials and help cards including devices they use.	Y	Animated tutorials to guide the patients how to use the medical devices.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	Application aids data acquisition, transfer to the server and visualisation of analysed data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Data stored on the server are GDPR compliant, informed consent is available, retraction of the informed consent is possible.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All of the stored data is located on local server of the University Hospital Olomouc.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-033	All classes of users shall be able to review the historical data.	Y	Every stakeholder in the process is able to see the data back in time.
SPS-034	Data management should be integrated into the patient's dashboard.	Y	Data are accessible from the dashboard.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Smartwatches with available SDKs can be used together with the application.
SPS-040	Medication tracking should be supported.	Y	Notifications available within the app.
SPS-041	SHAPES shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.).	Y	Medical devices with available SDKs are connected to the app.
SPS-042	SHAPES should support manual data entry.	Y	Application allows to manually enter data when Bluetooth is malfunctioning.
SPS-044	SHAPES should support use of questionnaires as self-assessment tools.	Y	Application is using questionnaires.
SPS-046	SHAPES should support reminders.	Y	Medication and task reminders are deployed within the application.
SPS-054	Video conferencing should be supported in SHAPES.	Y	Videoconferencing platform is integrated within the application.
SPS-058	SHAPES may motivate care receiver.	Y	There is a possibility to motivate care receiver via messages.
SPS-065	SHAPES may offer environmental, pollution and weather info, relevant to older population in a given area.	Y	Information on dust particle concentration within home and outside environment provided.
SPS-075	SHAPES should offer possibility to delete access to the platform.	Y	Patient can send a request to delete his/her account via the application.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-076	SHAPES shall offer option to view personal data stored in the platform.	Y	Available in thin-client web platform.
SPS-077	SHAPES shall offer option to edit personal data stored in the platform.	Y	Available in thin-client web platform.
SPS-078	SHAPES shall offer option to request removing own personal info from the platform.	Y	Patient can request removal of his/her user account through the web platform.
SPS-081	SHAPES should provide WEB access from desktop/laptop/smartphone and tablet.	Y	There is a web-based platform parallel to the mobile application.
SPS-118	SHAPES should offer monitoring of home environment.	Y	Application can download data from the environment monitoring sensors.
SPS-128	SHAPES shall support “privacy by design and by default”.	Y	Application employs encryption, anonymisation and/or pseudonymisation.
SPS-131	SHAPES shall comply with common minimum cybersecurity rules for mobile and online services.	Y	Application is compliant with the requirements of local cybersecurity authorities.
SPS-133	SHAPES Digital solutions shall be able to send alerts and notify the caregivers.	Y	Application is providing caregivers with the notification when the measured signals are out of predefined ranges.
SPS-134	SHAPES shall offer user friendly and attractive interface.	Y	Application was developed with the support of UX expert and was tested with the use of focus groups.
SPS-137	SHAPES user interfaces shall minimise need for interaction for accessing the required info.	Y	Design does not use any complicated navigation routes or gestures. Each functionality is reachable within few simple clicks.
SPS-138	SHAPES shall offer detection of personal data breach.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-139	SHAPES shall support restricting data processing.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-140	SHAPES shall offer info about third parties that have gained access to own private data.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-142	SHAPES shall provide support for "the right to object".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-144	SHAPES shall provide support for "Data protection principles: accuracy".	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-145	SHAPES shall provide necessary protection of data.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-146	SHAPES shall offer capability to detect a risk of potential data breach.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-147	SHAPES shall support IAM (identity and access management).	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-148	SHAPES shall implement password-based authentication.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-149	SHAPES shall support password management.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
SPS-161	SHAPES shall ensure service continuity and	Y	Solution is backed-up by the IT department team which is available 24/7 to

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	reliability at 98% on 24/7-time bases.		keep the hospital services operational.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	Data from the devices, questionnaires etc. are stored in the tablet to the point when they are successfully sent to the server.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	Event logging is available.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	User can resume his/her action upon reconnecting to the server. Data downloaded from the medical devices are stored within the tablet and sent to the server as it reconnects.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Notification will pop-up if network unavailable. Measurement still possible. Data will be sent upon reconnection.
SPS-169	SHAPES GUI should use self-explanatory graphical elements linked with respective services.	Y	Application is using pictograms.
SPS-171	SHAPES shall support open and interoperable standards.	Y	Supports FHIR/HL7.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Data transfer to VICOM and TREE.
SPS-173	SHAPES services and application should be accessible using Android and iOS based mobile devices.	Y	Application is available for both platforms.
SPS-186	FHIR shall be used as a common data model for Medical Data exchange	Y	All the collected data are contained within FHIR/HL7 compatible databases.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	among components of the SHAPES platform.		
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	All of the private data is being deleted from the data matrix send for analysis.
SPS-200	All passwords shall be unique per device and per user.	Y	Each user is equipped with the unique password.

Table 120 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
G01	The system has to comply with ethics requirements (WP8).	Y	The system fully complies with WP8 requirements.
G02	Easy to use (for both older people and professional caregivers).	Y	UX and GUI experts included in the development stage testing solution on real users.
G03	Accessibility issues (for older people).	Y	Solution tested on real users during the development stage to avoid accessibility issues.
G04	Privacy and security. GDPR compliant.	Y	The system fully complies with GDPR requirements.
G05	The system has to comply with platform requirements (WP4).	Y	The system fully complies with WP4 requirements.
G06	The system has to comply with other requirements (WP3/T3.5).	Y	The system fully complies with WP3 requirements.
G07	The system is compatible with the chosen 3rd party medical devices (scale, blood pressure monitor etc.).	Y	The system is fully compatible with chosen devices.
FO01	Older people will use an android smartphone or tablet.	Y	If needed, training on how to use Android devices will be provided.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
FO02	The app will provide the same information for both smartphone and tablet.	Y	Solution developed and tested on both smartphone and tablet.
FO03	Blood pressure measurement functionality. Manual input.	Y	Blood pressure measurement functionality included.
FO04	Blood pressure measurement functionality. Automatic input (wireless connectivity to blood pressure monitor).	Y	Blood pressure measurement functionality included.
FO05	Measure spirometry. Automatic input (wireless connectivity to spirometer).	Y	Spirometry measurement functionality included.
FO06	Measure medication adherence. Automatic input (wireless connectivity to smart inhaler).	Y	Medication adherence measurement functionality included.
FO07	O_2 saturation measurement functionality. Manual input.	Y	O_2 saturation measurement functionality included.
FO08	O_2 saturation measurement functionality. Automatic input (wireless connectivity to pulse-oximeter).	Y	O_2 saturation measurement functionality included.
FO09	Measure environment parameters (PM2.5 particulate dust matter, temperature, humidity).	Y	Environment parameters measurement functionality included.
FO10	Heart rate measurement functionality. Manual input.	Y	Heart rate measurement functionality included.
FO11	Heart rate measurement functionality. Automatic input (wireless connectivity to pulse-oximeter).	Y	Heart rate measurement functionality included.
FO12	Different questionnaires will be presented to the user through the App.	Y	Different questionnaires included.
FO13	App displays reminders and notifications.	Y	Reminders and notifications included.
FO14	App guides the older users through the care plan.	Y	Guide implemented into the App.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
FO15	App collects all this information from the user and sends it to the FNOL Cloud/SHAPES TP for further processing and analysis.	Y	Collection functionality implemented.
F016	Schedule video consults with GPs and specialists.	Y	Video consults included.
SP01	Authentication applies to all types of accesses and users.	Y	Authentication functionality implemented.
SP02	Ensuring users' privacy, safety and security.	Y	Compliant with data protection manual and requirements of local cybersecurity authorities.
CPA01	Dashboard for alerts (alert manager, health professional can manage the alerts).	Y	Alert dashboard included.
CPA02	History of alerts.	Y	History of alerts included.
CPA03	Alert in case of COPD decompensation predicted by TREE.	Y	TREE's prediction model included.
CPA04	Alerts based on older person's data in DB and existing alerts.	Y	Alerts included.
CPA05	Manage push notifications.	Y	Push notifications included.
CPA06	Show reminders for upcoming video consults with GPs and specialists.	Y	Reminders and notifications included.
CPV01	Dashboard for collected data (see data plan, including interaction frequency from history chat).	Y	Dashboard for collected data included.
CPV02	The health professional can define indicators to display in the dashboard, based on collected data (data plan).	Y	Personalised definition of indicators enabled.
CPV03	Visual analytics of the main health parameters retrieved	Y	Visual analytics included.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
	from the users (BPM, O_2, Pulse).		
CPV04	Risk of COPD exacerbation per patient.	Y	Calculation of risk of COPD decompensation developed.
CPM01	The health professional can manage patients' registration.	Y	Management of patient's registration included.
CPM02	The health professional can insert baseline data in DB (see data plan).	Y	Baseline data insertion enabled.
CPM03	The health professional can create and schedule reminders.	Y	Reminders creation enabled.
CPM04	The health professional can create and schedule questionnaires.	Y	Questionnaires creation enabled.
CPM05	The health professional can insert pharmaceutical treatment regime (see data plan).	Y	Pharmaceutical treatment regime insertion enabled.
CPM06	The health professionals can manage the settings related to activity capture and analysis.	Y	Management of settings enabled.
CPM07	Schedule video consults with GPs and specialists.	Y	Video consults scheduling included.
DS01	To collect and store data listed in data plan given by health professional.	Y	The system of collection and storage of data developed.
DS02	To collect and store data listed in data plan from devices.	Y	The system of collection and storage of data developed.
GI01	WiFi or 4G connection.	Y	Researchers have to ensure that WiFi or 4G connection is available at participant home.
GI02	Interoperability with SHAPES Platform.	N	Interoperability with SHAPES Platform not tested yet.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

7.6.5.2 Design and Development Stage

The same applies as to PT3-UC001c.

7.6.5.3 Prototyping and Adaptation Stage

The following figure demonstrates the system's function and structure based on the used components. The heart of the patient's interface is a tablet connected to medical devices relevant to COPD patient's condition.

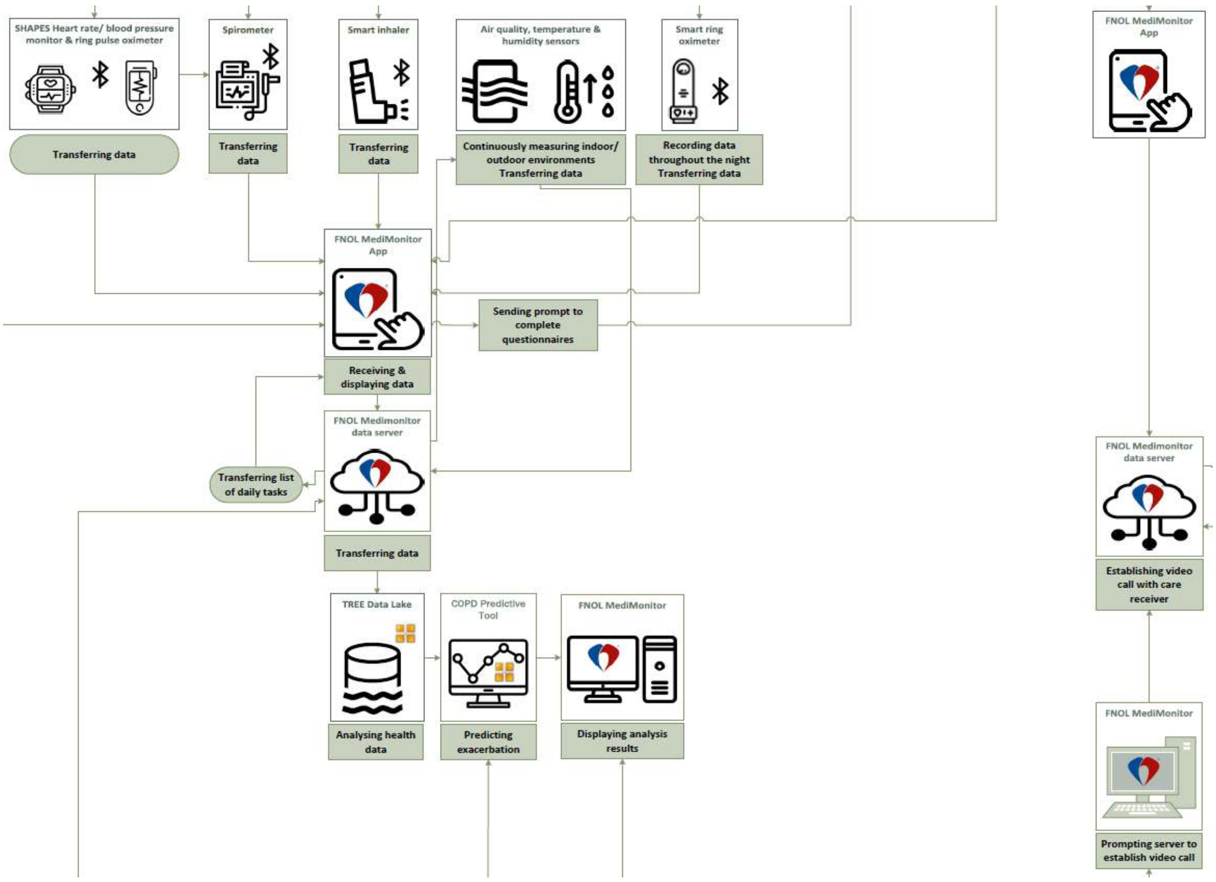


Figure 181 - Medimonitor System Function and Structure

Primary components of the Medimonitor application are:

- Vital sign measurements;
- Environment parameters measurements;
- Medication list;
- Video consults;
- Messaging with medical staff;
- Prescription ordering and medical aid ordering.

Vital signs are measured by the medical devices with Bluetooth capability so the data can be easily transferred to the tablet that works as a nod that collects data from all of

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

the devices available to the patient. These data are then transferred to the server into the MSSQL.

As a part of the digital solution, patient's vital signs and questionnaire responses are being transferred to TREE, so analysis on these data can be conducted in order to determine the risk of patients' decompensations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

8 Lifestyle Management and Wellbeing Assessment Solutions (Task 5.7)

Task 5.7 started with discussions around the different solutions the SHAPES project will integrate related to Lifestyle Management and Wellbeing Assessment Solutions, while designing the different project use cases. These solutions are based on GNO eHealthPass and TREE Wellbeing analytics, enhanced with VICOM eHST and DSS, involving individual models to monitor various health and fitness parameters, provided by wearables, home devices, social activity apps, emotion readers, eHealth sensors, and incorporating intelligent data processing for the recognition of behavioural trends and specific services for personalised guidance on healthy lifestyle and disease prevention. As shown in the Figure 182, each of the partners' contribution is identified within the SHAPES platform, which is composed by 5 main modules of front and back-end elements.

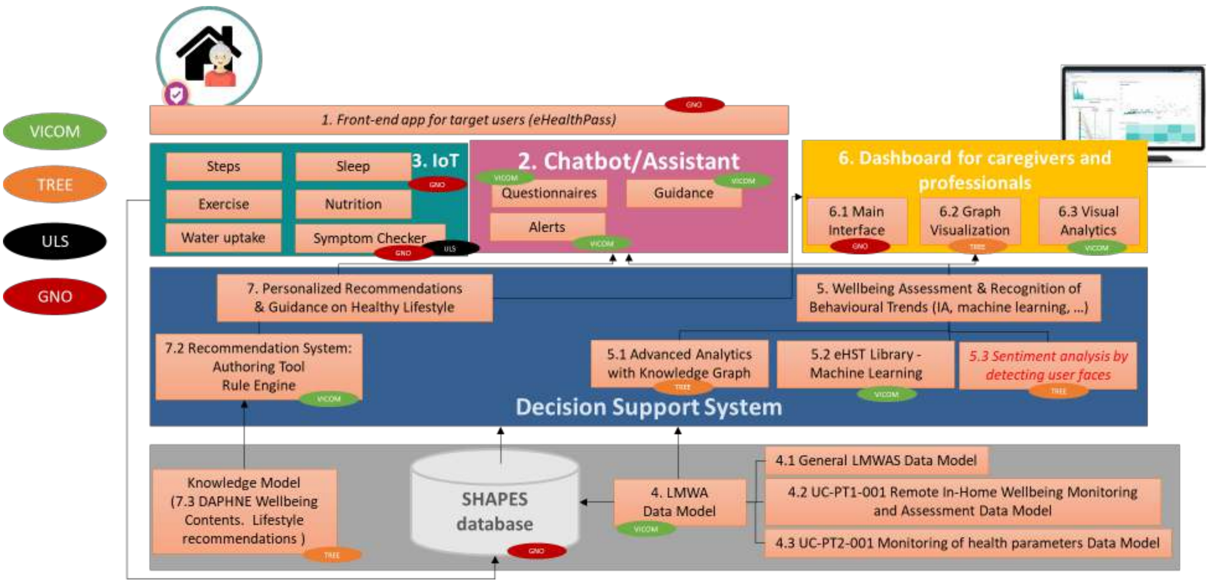


Figure 182 - LMWAS (Lifestyle Management and Wellbeing Assessment Solution) Architecture

In this section, a summary of these different solutions is presented. It is important to stress that these Digital Solutions are dependent on the data collected during the project, so this approach may be modified as the SHAPES Project evolves.

8.1 Anomaly Detection (TREE)

A concern related to active aging and the quality of life of older people is that they can live independently. One of the causes that prevent older people from living independently is mental decline. Diseases such as Alzheimer's or early dementia are related to the progressive decline in the activities of daily living. The IoT devices (smart homes IoTs and wearables) bring the possibility to monitor the behaviour of the elderly in their homes in a non-intrusive way.

The main objective of the analytical work in this topic is to monitor the behaviour of the participants in their activities of daily living, in order to detect anomalies and unusual behaviours. To reach this goal it may be necessary two separate but related works: first, to define the routines or the normal distribution of the activities of daily living and, second, to detect the rare or anomalous behaviours, so the analytic work should be organised in these two stages. To provide the routines and the subsequent detection of anomalies, is important to recognise patterns or streams according to the sensors records. Occupancy's activities are not directly observed, only unstructured data series coming from sensors is provided to understand the occupancy's daily activities.

Many devices can be used for this purpose but the most usual solution is the Smart-Home paradigm understood as the collection of data from a sensor network to monitor presence, operation of appliances or bulbs, etc. According to the organisation of the intended analytic work the main development stages can be described as follows:

- **Activities of Daily Living Definition**: Modelling activities from the raw data coming from the sensor network. The collection of data created by the sensor network should be translated in sequences of operation for the subsequent definition of activities.
- **Anomalies Detection**: Once the activities have been defined, the normal sequences of activities can be inferred taking into account different variables such as duration, hours of occurrence within the day, etc. The definition of these normal sequences allows to detect changes or deviations from the routines or common behaviour.

8.1.1 Interfaces and Interoperability

This digital solution works as an analytical service, so the response should be an output used to fulfil the one of the purposes of the use case, detect anomalies in the ADLs. For this reason, there is not an interface and the participants do not interact with this digital solution.

8.1.2 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

8.1.3 Adaptations for PT1-UC001

The solution proposed is designed for those use cases in which a sensor network is deployed in the home of the participants. Specifically, the development of this solution is linked to the specifications of the *PT1-UC001 - Remote In-Home Wellbeing Monitoring and Assessment,* as a use case that confirms the deployment of a complete sensor network.

It is important to highlight that an important amount of data should be collected before building and implement the models during the pilot. The models are not common for all the participants, and therefore the routines and related anomalies are calculated independently for each participant.

8.1.3.1 Concept and Ideation Stage

Use case PT1-UC001 aims to monitor the lifestyle of participants in order to achieve an early detection of physical or cognitive decline. In this regard, the applicable SHAPES personas are Ernst (P1), Roberto (P2), Ayesha (P3), Isabel and Marco (P4) and Helena (P7).

The motivation of this digital solution is to provide an analytical solution that takes into account the complete data coming from a sensor network. The proposal aims to advance in an analysis that reflects the complexity of the data, avoiding isolated assessments for each sensor.

The main challenge developing a solution for an anomaly detection system in the context of the SHAPES project is not having response or contrast information. That means the approach must be an unsupervised solution. Therefore, this solution provides a first modelling of activities, and in a second phase, a design of the sequences of activities, which is what we call routines. These routines of each participant will be considered as normal behaviour. From normal behaviour, it will be possible to detect statistically significant deviations that can be considered as anomalies. In short, this solution learns from the data what can be considered normal behaviour and enables anomaly detection when events deviate from the normal patterns.

The actions described before are developed following state-of-the-art solutions that try to face the same problem in similar contexts. The main technical approaches tested for these purposes are:

- Clustering techniques: for model activities along the time series provided by the sensor network.
- Markov models: for modelling sequences of activities and anomalies detection.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Fuzzy entropy: as an alternative method to detect anomalies respect to the normal sequences of activities.

The performance of the different techniques should be tested in the piloting phase. The selection of the technical options depends on the number of sensors, type of sensors and the final type of data generated.

Table 121 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Devices supported.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	Devices supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Devices supported.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-114	SHAPES should support assisted mobility at home.	Y	Mobility tracked and analysed.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-143	SHAPES shall provide support for “storage minimisation”.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine’s health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform’s API.
SPS-192	Message Broker shall be employed to manage	Y	The analytics engine notifies the availability of

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	notifications among core SHAPES components.		analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

Table 122 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R1	Monitor the on/off status of appliances and lights at the home of the elderly pilot participant.	Y	Their on/off status is taken into account by the analytics engine.
R2	Monitor the duration of the on status of appliances and lights at the home of the elderly pilot participant.	Y	Their on/off status duration is taken into account by the analytics engine.

8.1.3.2 Design and Development Stage

This digital solution, still under development, aims to define a system for the modelling of activities and the subsequent detection of anomalies from the data generated by the sensor network deployed in the participant houses.

The main ideas of the analytical solution to this topic can be summarised in two phases. First, is to use techniques such as clustering to order and categorise the events observed within the sensor network data, to provide a classification of activities. Once the activities are defined, the detection of anomalies is done over the observed sequences of activities in a daily basis, using techniques such as fuzzy entropy or Markov chains.

The digital solution meets the following characteristics:

- **Multi-sensor data based**: Holistic system taking into account complete data from the sensor network, avoiding standalone analytic solutions from one sensor to another.
- **Unsupervised approach**: The system is developed without previous information like labels or descriptions about the activities performed by the participant or the previous definition of anomalies. Only unsupervised approaches are proposed along the development of the analytical process.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- **Exportable and personalised approach**: It is important to develop a tool capable of adapting to different types of participants. The solution should be computationally light and easily adaptable from one participant to another.

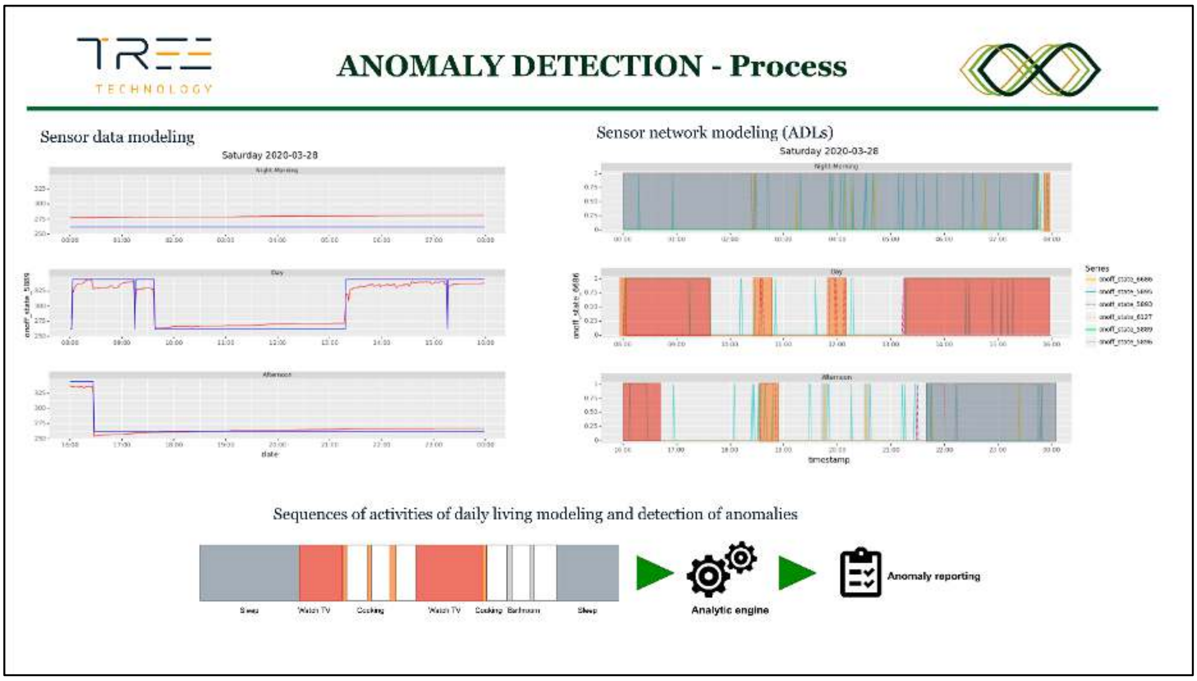


Figure 183 - Visual Example of the Anomaly Detection Process

8.1.3.3 Prototyping and Adaptation Stage

The input information for the proposed solution is the data coming from the sensor network deployed in the participants homes. Specifically, for the Pilot 1 is planned to have smart plugs, smart bulbs, weather stations, activity trackers, in addition to the possibility of having other types of sensors (coming from the open calls for example) to enrich the data.

The specific dataflow and components involved for this solution is similar to other analytical solutions developed by TREE. The intention is to provide a tool to generate results related to the routine and anomaly detection models and share these results with the interested digital solutions. The intention for this specific topic is to integrate results and visual support in the same digital solutions that are going to be in charge of the monitoring tasks of the sensor network.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

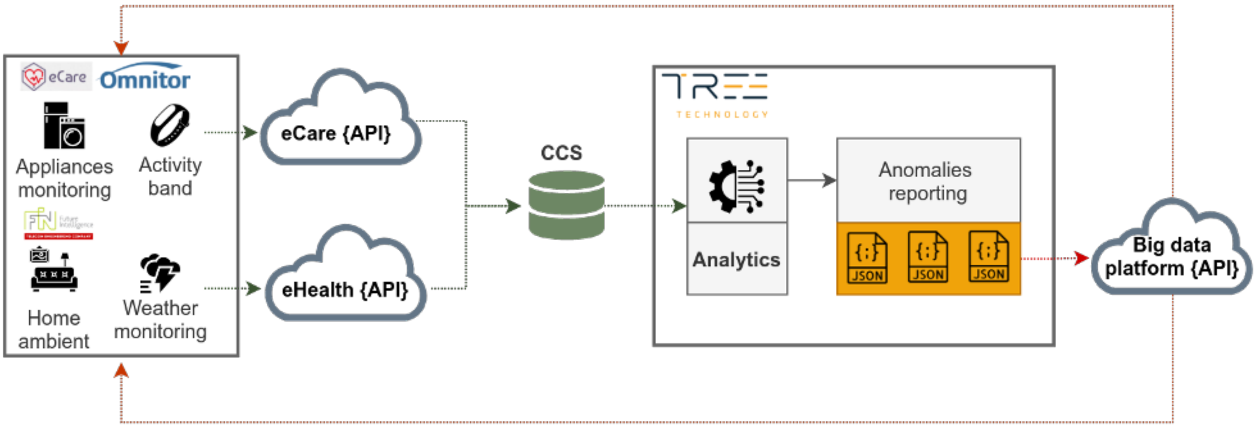


Figure 184 - Data Flow in the Routine and Anomaly Detection Digital Solution

The results generated by this solution will be adjusted to the needs, structure and formats applicable to the pilots/use cases linked to this solution, following the general framework for the SHAPES Project.

8.2 Sleep Quality and Physical Intensity Level (TREE)

Personal wearables/devices allow the collection of different information over physical activity and sleep. Maintaining a healthy lifestyle in terms of physical activity and sleep is important for staying in good health. Reminders to exercise, avoid long sedentary periods, encourage an active lifestyle and try to ensure a good quality of sleep can help older adults attain positive health benefits and ward off diseases.

TREE can provide a solution to analyse and assess the amount and type of physical activity performed by the users. Also, can face an accurate assessment of the sleep quality from wearables data.

The input for this purpose, is the raw information extracted from the wearable devices (Xiaomi Mi Band 3). The raw data provides a collection of features with different degrees of interpretability. Steps and heart rate are the main variables recorded by the devices and all the functionalities of the wearable are based on this real data. Other features extracted from the device provide non-interpretable information related to the activity. In that sense, an important part of the analytical work developed by TREE is focused in the interpretation of this information. The analytical work done can be summarised in three stages:

- Data processing for full human interpretability.
- Analytical proposal for sleep quality assessment.
- Analytical proposal for physical activity assessment.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The main objective in the development of this analytic is to provide a correct and useful assessment of important aspects related to the quality of life of the participants. The results provided are intended to be easily interpretable for participants and professionals.

8.2.1 Interfaces and Interoperability

This digital solution works as an analytical service within the Big Data platform, so the response is a collection of outputs to be displayed in the front-end solutions involved in the pilot/use cases. For this reason, there is not an interface and the participant do not interact directly with the digital solution.

8.2.2 Applicable Pilot Themes

Three pilot themes were identified for this Digital Solution:

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation.

It is important to highlight that the PT2 was the main scenario in which this analytical solution was developed. This is the closest pilot to the purposes related to sleep and physical activity assessment. Within the other pilot themes the analytic solution is not fully usable and only some parts of the outputs will be used for a briefer analysis.

8.2.3 Adaptations for PT1-UC001

Use case PT1-UC001 aims to monitor the lifestyle of participants in order to achieve an early detection of physical or cognitive decline. In this regard, the applicable SHAPES personas are Ernst (P1), Roberto (P2), Ayesha (P3), Isabel and Marco (P4) and Helena (P7).

For this use case, the results generated will follow the schema proposed for PT2-UC001 (section 8.2.4). TREE provides the results to be displayed within the digital solutions that are in charge of data visualisation. For each use case, only the outputs that are of interest according to health professionals involved will be shown. In PT1-UC001, all the outputs generated are likely to be used. The approach fits well for a complete assessment of the wellbeing parameters related to sleep and physical activity.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The changes from one to another use case should be related to the needs agreed by the partners involved. As in this pilot the activity tracker will be used, TREE are able to provide the same collection of outputs provided in PT2-UC001, fully explained in section 8.2.48.2.4.

8.2.3.1 Concept and Ideation Stage

The schema developed for this use case is explained in section 8.2.4.38.2.4. The difference is linked to the usability of the outputs generated by the analytical solution. In the case of PT1-UC001, the results will not be used as input information for alert or recommendation systems. The idea is that data generated can be displayed in the front-end applications.

Table 123 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Devices supported.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	Devices supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Devices supported.
SPS-114	SHAPES should support assisted mobility at home.	Y	Mobility tracked and analysed.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.
SPS-143	SHAPES shall provide support for “storage minimisation”.	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine’s health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime
SPS-165	SHAPES should notify users about technical	Y	Information is supplied by the cloud provider.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
	problems including network downtime.		
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

Table 124 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R3	Monitor the elderly pilot participant's physical activity.	Y	Physical activity is taken into account by the analytics engine.
R6	Monitor the elderly pilot participant's sleep quality.	Y	Sleep quality is taken into account by the analytics engine.
R8	Monitor the elderly pilot participant's heart rate.	Y	Heart rate is taken into account by the analytics engine.

8.2.3.2 Design and Development Stage

The design and development for this use case is explained in the section dedicated to PT2-UC001. The final output for this use case will be linked to the selection of features that the partners and professionals involved want to monitor, study, or visualise.

8.2.3.3 Prototyping and Adaptation Stage

As for the use case PT2-UC001 explained in section 8.2.48.2.4, the necessary source is the raw data from the activity tracker Xiaomi MI Band 3. The analytical proposal is designed to be implemented in all the use cases in which this device will be used and will be desirable to have an evaluation of the sleep quality and the physical activity. These two topics are transversal to the whole project and therefore the analytics are not designed to be linked only to a single use case.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

The specific data flow and the components involved follows the same schema showed in section 8.2.4. The close collaboration with EDGE for this solution is replicated through the use cases with the presence of the Xiaomi MI Band 3.

As was mentioned above, the final selection of outputs for this use case depends on the decision of what features or variables are desirable to monitor, visualise or study during the pilot.

8.2.4 Adaptations for PT2-UC001

This use case is aimed at the remote monitoring of relevant health parameters collected through fitness trackers, smart water bottles, and other smart devices. As such, the relevant SHAPES persona Helena.

This use case has oriented the data model of the analytics. The topic of this use case is the most suitable to develop a complete assessment of physical activity and sleep quality through activity tracker data. Some of the main interests for this use case are linked to activity and exercise measures in order to give alerts or recommendations to the participants.

From the analytical point of view the most important for this use case is to provide a comprehensive assessment of the physical activity performed by a participant. The evaluation of the activity in different intensities and linked to different behavioural aspects is the key action for this use case. As well the sleep quality assessment is an important indicator of wellbeing and a healthy lifestyle.

For this use case, TREE provides the most exhaustive collection of outputs for the sleep quality and physical activity assessment.

8.2.4.1 Concept and Ideation Stage

The main objective for the sleep quality assessment is to provide a reliable measure of sleep quality taking into account the most important descriptors related to the sleep process. From the wearable data, many important variables related with the sleep quality can be inferred. Specifically, time in bed, total sleep time, sleep interruptions, latency and efficiency of sleep allow an accurate assessment of the sleep quality. From these descriptors is also possible to calculate a global quality measure, the Sleep Quality Indicator (SQI), a synthetic and comprehensive value as a general descriptor.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

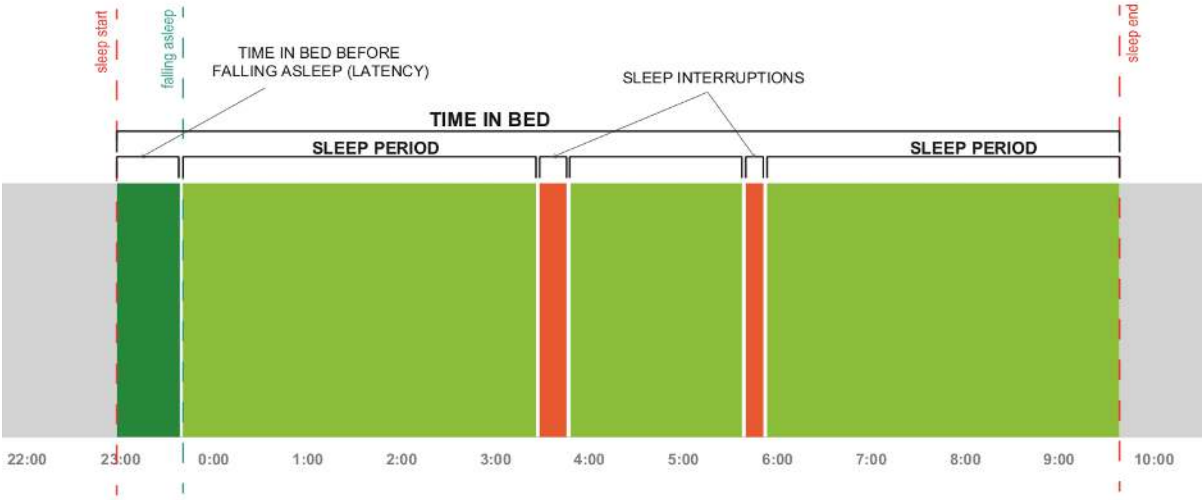


Figure 185 - Elements Involved in the Sleep Process

In relation to the level of physical activity and exercise assessment, it is important to understand that the most trustable information comes from the measurements of steps. That means that from the raw data TREE are able to assess the physical activity that implies movement on the part of a user. In order to provide a solution to assess the physical activity performed by a user wearing the device, TREE can set a diagnosis based in data classification from less to a greater detail. TREE can distinguish three levels:

- In the first and simplest level, it is possible to distinguish between sedentary an active behaviour.
- Within a second level, when a user is active it is possible to distinguish if the participant is active in ADL, if the participant is more constantly active than in the previous case, but without being able to be considered an exercise and when the user is performing exercise.
- In the third level, if the user/participant is performing exercise we are able to distinguish three levels of intensity: light intensity, moderate intensity and intense/vigorous intensity.

The different intensities are calculated over the average cadences (steps per minutes) within the activity blocks or periods, following rules and recommendations from the state of the art. The analytics for the assessment of the physical activity report the amount of time (minutes) under each category. With this approach, TREE are able to provide also the sequences of activities over the days to set a follow up of the routines of the participants.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 125 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Devices supported.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	Devices supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Devices supported.
SPS-114	SHAPES should support assisted mobility at home.	Y	Mobility tracked and analysed.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 126 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
UR-03	The remote monitoring important health and wellbeing parameters of older individuals.	Y	The analytics engine supports the remote monitoring of important health parameters.
UR-12	In case the system monitors unusual data, the informal caregiver/ a predefined person of trust is informed/alerted. Using smart data analytics & predictive algorithms): analysis of anomalies and alert generation based on the data gathered from the different sensors.	Y	Anomalies are detected at the analytics engine.

8.2.4.2 Design and Development Stage

The development of the solution is linked to the process of interpreting the raw data coming from the activity band. The raw data is not fully interpretable, so it is necessary to process data for them to be meaningful. Then, it is necessary to adapt these inputs in order to extract useful information to assess the sleep quality and the physical activity of the participants.

The development stages are:

1. **Raw data processing**: non-labelled data processing for analytic development.
2. **Sleep quality measures calculation**: sleep items calculation for sleep quality assessment.
3. **Summaries of physical activity**: calculations of the amount of physical activity under different categories.

As general framework, the outcomes generated by this digital solution are going to be displayed by eCare App (EDGE) for all the Pilots/Use Cases referenced above. Also, for the PT2-UC001 use case, the information is going to be used as input information for the VICOM's recommendation system. Therefore, TREE does not provide any visualisation or design of its own, but instead integrates the results of that solution within those of other partners involved in the same Pilots/Use cases.

The analytic outcomes to fulfil the assessment of the sleep quality and the physical activity are build following the objectives and the guidelines proposed in the different

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilots/Use cases. A summary of the generated information is shown in the tables below.

For the sleep quality assessment, different descriptors of the sleep process are provided. Additionally, a sleep quality indicator as a global measure that involves the descriptors, is calculated as a summary measure. The collection of outputs for the sleep quality assessment provided by this digital solution.

Table 127 - Sleep Quality Assessment Outputs

Output Name	Description	Type	Units	Values
date	Reference day of sleep assessment. For example, if the sleep process starts at 2021-04-02 23:00, the date will be 2021-02-05.	Date	yyyy-mm-dd	
start_time	Timestamp of the beginning of the sleep process.	Date time	yyyy-mm-dd hh:mm:ss	
latency	Time between bed time and falling asleep.	Numerical	minutes	
in_bed	Total night rest time, that is, minutes between getting into bed and waking up	Numerical (float)	minutes	
sleep_duration	Effective sleep time. Total duration of the sleeping periods.	Numerical (float)	minutes	
sleep_efficiency	Proportion of time in bed where the user has been sleeping.	Numerical (float)	ratio/proportion	0 - 1 (proportion)
n_int_awake	Number of times the user woke up during the night.	Numerical (int)	number of times	
n_int_getup	Number of times the user got out from bed during night.	Numerical (int)	number of times	
int_duration	Total duration of the sleep interruptions.	Numerical	minutes	
sqi	Sleep quality indicator. Summary measure for assessment of sleep quality.	Numerical (float)	ratio/proportion	0 - 1 (percentage)
sleep_disconect	Time when the device is disconnected, not worn or charging during the sleep process.	Numerical	minutes	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

On the physical activity side, to assess the physical activity performed by a participant wearing the activity tracker device this it is possible to set a diagnosis based in a data classification. The scale of time performing each kind of activity is given in minutes and the analytic and the analysis tries to distinguish between different levels of physical activity. Specifically, from the device data a categorisation of activities performed by the participants is build according to the level of effort or intensity of the activities. The behaviour of data allows a comprehensive but complete categorisation of activities such as shown in the table below.

Table 128 - Physical Activity Assessment Outputs

Output Name	Description	Type	Units	Values
date	Reference day of activity	Date	yyyy-mm-dd	
steps	Number of accumulated steps during the day	Numerical (int)	number of steps	Summarises the number of steps taken for a user in a day
sedentary	Minutes in a sedentary behaviour during the day	Numerical	minutes	Amount of time the user is wearing the band and not taken steps.
active	Minutes in active behaviour during the day	Numerical	minutes	Amount of time the user is wearing the band and is taking steps.
adl	Minutes performing activity in ADLs	Numerical	minutes	Amount of time the user is active in ADLs
intermediate	Minutes performing intermediate activity	Numerical	minutes	Amount of time the user is active in intermediate activities (between ADL and Exercise)
exercise	Minutes of physical activity (exercise)	Numerical	minutes	Amount of time the user is performing physical activity / exercise continuously over 10 minutes.
light_exercise	Minutes of physical activity / exercise	Numerical	minutes	Amount of time the user is performing

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Output Name	Description	Type	Units	Values
	in low intensity level			physical activity / exercise in a low intensity level
moderate_exercise	Minutes of physical activity / exercise in a moderate intensity level	Numerical	minutes	Amount of time the user is performing physical activity / exercise in a moderate intensity level
vigorous_int_exer	Minutes of physical activity / exercise in a vigorous intensity level	Numerical	minutes	Amount of time the user is performing physical activity / exercise in a vigorous intensity level
disconnect	Minutes of disconnection during the day	Numerical	minutes	Amount of time the device is disconnected, charging or not being worn by the user.

Although this digital solution is developed to generate information to be displayed by other digital solutions or as an input in other analytical systems. Below, there are examples of the generated outcomes' visualisations.

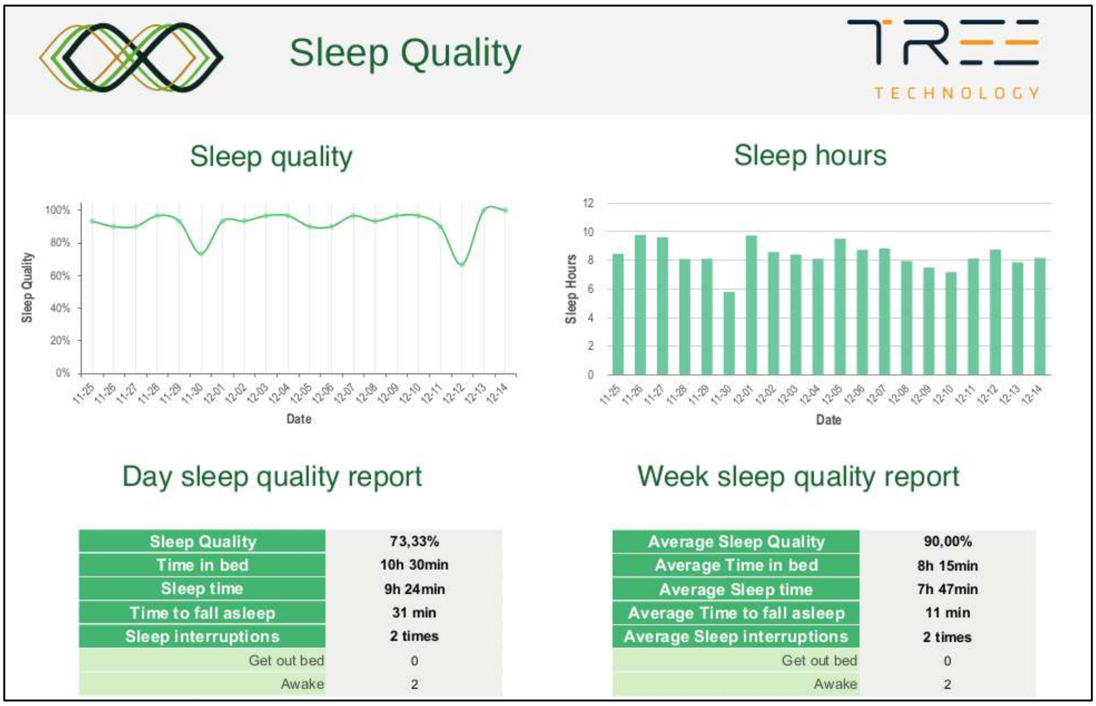


Figure 186 - Visualisation Examples for Sleep Quality Assessment Descriptors

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 187 - Visualisation Examples for Physical Activity Assessment

8.2.4.3 Prototyping and Adaptation Stage

The main source necessary for the correct operation of this digital solution is the raw data from the activity tracker Xiaomi MI Band 3. The data extraction is carried out by EDGE and TREE uses the raw information to set up he analytical tasks. The only mandatory requirement for the success of the analytics is to have all the necessary features to generate the expected results.

The specific data flow for this digital solution almost replicates the common general framework planned on SHAPES. Specifically, the raw data is consumed by TREE through the eCare API. Then the processing and analytical tasks run into the Big Data Platform. At last, the generated outputs are stored in the Big Data Platform to share them via API with the interested partners.

For all the pilots and case uses in which this analytic is going to be applied, the visualisation of the results will be shown to the users by eCare (EDGE), so the outputs will be shared in the proper format and structure for this purpose.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

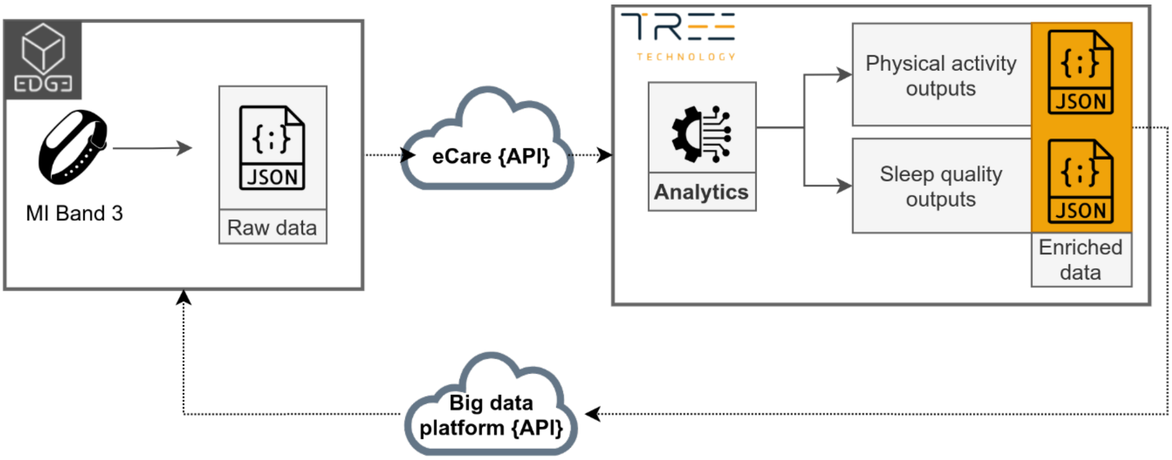


Figure 188 - Specific Component Diagram in Dataflow for Sleep Quality and Physical Intensity Level

As shown in the image above the information (enriched data) generated by this digital solution is going to be shared with the interested partners through the Big Data Platform API. An example of the final structure and organisation of the outputs can be easily presented in table format. Although following the protocol the information is structured and shared in json formats, the content included in the files is shown in the next examples.

Table 129 - Example of the Outputs Generated for Sleep Quality Assessment

	date	start_time	latency	in_bed	sleep_duration	sleep_efficiency	n_int_awake	n_int_getup	int_duration	sqi	sleep_disconnect
5	2019-10-27	2019-10-27 00:38:00	3.0	531.0	515.0	0.969868	3	0	13.0	0.900000	0.0
6	2019-10-28	2019-10-28 00:32:00	14.0	505.0	482.0	0.954455	1	0	9.0	0.966667	0.0
7	2019-10-29	2019-10-29 00:07:00	31.0	611.0	562.0	0.919804	2	0	18.0	0.933333	1.0
8	2019-10-30	2019-10-30 01:11:00	1.0	491.0	484.0	0.985743	1	0	6.0	0.966667	0.0
9	2019-10-31	2019-10-31 01:05:00	6.0	530.0	503.0	0.949057	1	2	21.0	0.900000	0.0
10	2019-11-01	2019-11-01 01:16:00	10.0	522.0	482.0	0.923372	2	1	30.0	0.900000	0.0

Table 130 - Example of the Outputs Generated for Physical Activity Assessment

	date	steps	sedentary	active	adl	intermediate	exercise	light_exercise	moderate_exercise	intense_exercise	disconect
5	2019-10-27	2839	813	109	83	0	26	17	8	0	0
6	2019-10-28	997	851	93	93	0	0	0	0	0	0
7	2019-10-29	831	772	74	74	0	0	0	0	0	1
8	2019-10-30	1968	820	135	135	0	0	0	0	0	0
9	2019-10-31	1660	820	111	111	0	0	0	0	0	0
10	2019-11-01	2920	527	125	94	0	31	19	7	0	296

8.2.5 Adaptations for PT3-UC001

The applicable SHAPES persona is Roberto, as well as the team of health professionals giving him assistance on a regular basis. In this scenario, health professionals can access to a dashboard where they can see Roberto's historic evolution of parameters (e.g. hours of sleep, weight, blood pressure, oxygen level, heart rate, number of steps).

For this use case, the same development is followed. Again, the only adaptation is the selection of outputs that will be used for the purposes and interests of the use case.

Specifically, the participants in this use case are affected by heart failure, so they are not expected to make a significant amount of exercise. The interest is focused on the assessment of the minimal recommendations by the health authorities. The distinction between intensities does not seem necessary and the physical activity assessment will be adjusted to other specifications. The expected use of the analytical outputs is the confirmation of the minimum recommended physical activity in longer periods of time (2-3 days for example).

For the sleep quality assessment, the most important information is the total sleep time and the sleep disturbances. The patients involved in this use case are not expected to get much sleep, but it is important to ensure that they get a sufficient amount from a medical point of view.

8.2.5.1 Concept and Ideation Stage

The same schema developed in PT2-UC001 (section 8.2.48.2.4) is developed for this use case. The main difference is the usability of the outputs generated by the analytical solution. In this case, the results will not be used as input information for alert or recommendation systems. The idea is that data generated can be displayed in the front-end applications.

Again, the same development is followed for this use case. As explained before, the same analytical solution allows to meet different objectives and options to assess the sleep quality and the amount and type of physical activity performed by participants. The analytic solution provides a general framework and allows the display of different parameters in the front-end apps, common or variable along the different use cases. Also provides useful information for the healthcare professionals for deeper assessment within the professional dashboards.

For this use case, the use of the activity tracker allows to monitor the amount of physical activity and the sleep quality for heart failure patients. As explained before, the most important information is related with the assessment of the health recommendations for physical activity and sleep quality.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 131 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-021	SHAPES Platform shall offer open APIs and use interoperability standards.	Y	A REST API is deployed and usable by the rest of the SHAPES consortium.
SPS-022	The SHAPES platform shall facilitate integrated care.	Y	Analytics contribute to the provision of integrated care by health professionals.
SPS-029	SHAPES platform should support health data management (collection, sharing and processing).	Y	The analytics engine deals with the processing of raw health data.
SPS-030	SHAPES platform shall comply with private data protection of the GDPR regulation.	Y	Full compliance with GDPR is achieved.
SPS-031	SHAPES platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	All the data managed by the analytics engine is stored within EU Member States.
SPS-032	Wrist monitors and/or smart watches with emergency function may be supported.	Y	Wearable medical sensors are used to collect data.
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Devices supported.
SPS-036	Devices monitoring daily activity including sports ones should be supported.	Y	Devices supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Devices supported.
SPS-114	SHAPES should support assisted mobility at home.	Y	Mobility tracked and analysed.
SPS-139	SHAPES shall support restricting data processing.	Y	The amount of data used by the analytics engine has been minimised.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	The amount of data used by the analytics engine has been minimised.
SPS-150	SHAPES shall support scaling up its services in terms of geographical coverage.	Y	Geographic scaling is handled by the cloud provider.
SPS-151	SHAPES platform shall be scalable such that to accommodate changing user data storage requirements.	Y	Horizontal and vertical storage scaling is handled by the cloud provider.
SPS-161	SHAPES shall ensure service continuity and reliability at 98% on 24/7 time bases.	Y	Availability is handled by the cloud provider.
SPS-162	SHAPES shall be functional and operational during Internet downtimes.	Y	The analytics engine does not require internet connectivity to operate.
SPS-163	SHAPES should offer capabilities to determine service downtimes of its components.	Y	The analytics engine's health status is offered by the cloud provider.
SPS-164	SHAPES platform and its components should support resuming normal operation after period of network downtime.	Y	The analytics engine continues to operate during and after network downtime.
SPS-165	SHAPES should notify users about technical problems including network downtime.	Y	Information is supplied by the cloud provider.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Analytics are shared with other DS through the platform's API.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	The analytics engine notifies the availability of analytics through the Message Broker.
SPS-197	Data Analytics shall process data excluding private identifiable information.	Y	Analytics are calculated over pseudonymised data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 132 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
CPV03	Activity analysis dashboard and the corresponding visual analytics	Y	The analytics engine supports all the visualisations provided by the dashboard
CPM09	The health professionals can manage the settings related to activity capture and analysis.	Y	All analytics are calculated, so that they can be selected or de-selected at the dashboard at will

8.2.5.2 Design and Development Stage

The design and development for this use case is the same as that explained for the other use cases. The final output for this use case is linked to the common framework accorded for the front-end apps and the final design of the professional dashboards.

8.2.5.3 Prototyping and Adaptation Stage

As for the previous use cases, the necessary source is the raw data from the activity tracker Xiaomi MI Band 3. The analytical proposal is designed to be implemented in all the use cases in which this device will be used and will be desirable to have an evaluation of the sleep quality and the physical activity. These two topics are transversal to the whole project and therefore the analytics are not designed to be linked only to a single use case.

The specific data flow and the components involved follows the same schema showed for the other use cases. The close collaboration with EDGE for this solution is replicated through the use cases with the presence of the Xiaomi MI Band 3.

As mentioned before, the final selection of outputs for this use case will depend on the decision of what features or variables is desirable to monitor, visualise or study during the pilot.

8.3 Wellbeing Assessment (VICOM)

The Constitution of the World Health Organisation, which came into force on April 7, 1948, defined health “as a state of complete physical, mental and social well-being” [40]. Nowadays, three types of definition of health seem to be possible and are used. The first is that health is the absence of any disease or impairment. The second is that

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 857159

health is a state that allows the individual to adequately cope with all demands of daily life (implying also the absence of disease and impairment). The third definition states that health is a state of balance, an equilibrium that an individual has established within himself and between himself/herself and his social and physical environment [41].

In VICOM's perspective, the wellbeing assessment can be studied by the measurement and observation of changes in a previously predefined standard list of different ADLs of the elderly people for an Ambient Assisted Living (AAL).

All measurements collected in SHAPES provide information about lifestyle and wellbeing of older individuals over the time. In this way, it allows not only professionals and caregivers empower elderly people and improve their health monitoring, but also elderly people feel accompanied and secure. In consequence, elderly people reach the three health definitions mentioned before: try to absence of any disease, demands of daily life and balance between social and physical environment.

To meet the need the process, VICOM can develop Artificial Intelligence pipelines based on data extraction and anomaly detection about lifestyle and wellbeing of older individuals by information over the time which is received.

Raw information collected from wearable devices is processed in a previous step. It contains information about older individuals' activity, sleep quality, liquid intake, vitals and appliance monitoring over the time. Once pre-processed, Artificial Intelligence algorithms receive as input these data and give as result the anomalies found and the improvements over the time of older individuals called time series.

As previously mentioned, time series received by Artificial Intelligence Algorithms are not raw data but rather pre-processed data of older individuals from Big Data Platform. The pipeline includes a job which will be launch obtaining the results and metrics necessaries to carry out the anomaly detection process. For this, different temporal abstraction methods will be used to see whether the patient "normal" pattern is being changed over time or differs from the standard pattern. After the anomalies are detected, all the results are represented in a Wellbeing Assessment interface to facilitate the quality of patients monitoring by physicians and caregivers. The phases in the process can be summarised as:

- Phase 1: Data loading and Wellbeing Assessment pipeline
  - Raw data wearables are consumed by TREE through the eCare API and processing in the Big Data Platform consecutively, Wellbeing Assessment pipeline is launched:
    - GET request to the data from Big Data Platform API.
    - Apply the Artificial Intelligence anomaly detection model.
    - POST request to Big Data Platform API for saving anomaly detection results.
    - Anomaly detection interface updating.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Phase 2: Final users access to Wellbeing Assessment results
  - Professionals and caregivers want to know about a patient state.
  - Filter by patient of interest.
  - The query is processed and extracted the anomaly results stored in Big Data Platform.
  - The anomalies are showed in Wellbeing Assessment interfaces to healthcare professionals.

8.3.1 Interfaces and Interoperability

As shown in Figure 189, different graphs are created for the visualisation of these anomalies, most of them giving the option to see the evolution of each variable in time, and the capacity of adding variables to the graph to compare differences and similarities, as is shown in graph a) and b). This representation gives a better understanding of the behaviour and tend of the anomaly (see c) as an example) and the consequences of these irregularities, as shown in graph d).

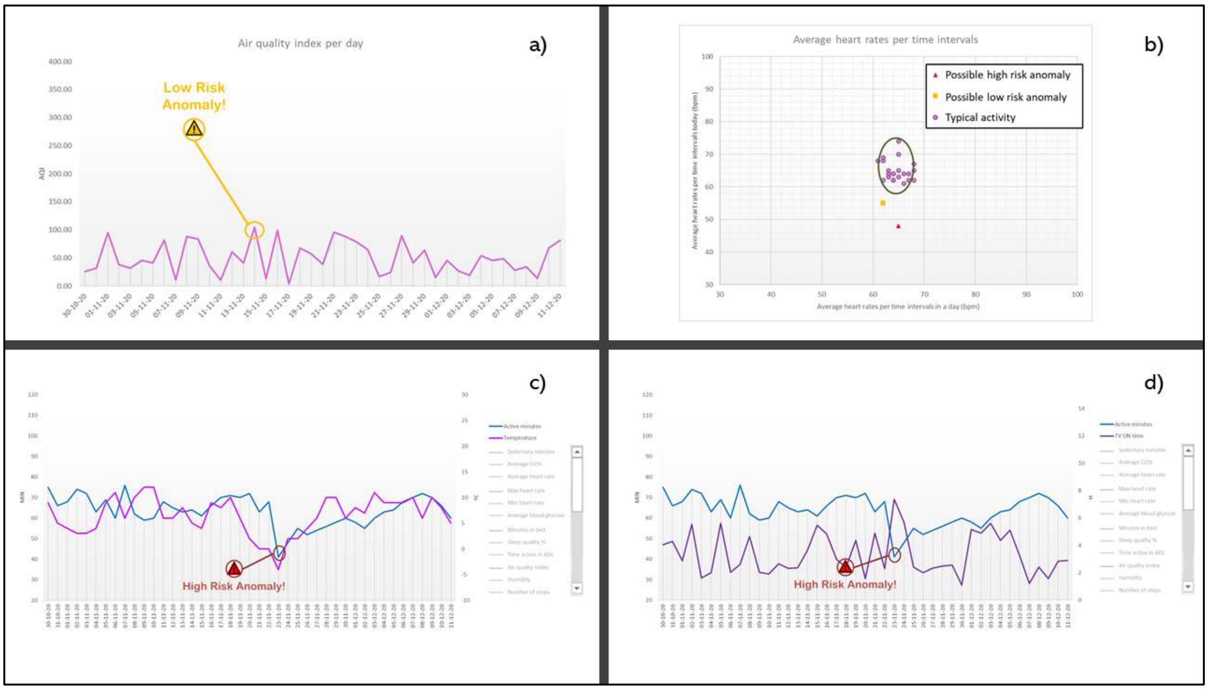


Figure 189 - Graphical Representation of Anomalies in Individual's Daily Activities

This solution displays the results in a Wellbeing Assessment Dashboard. This allows the analysis at user and population levels, by presenting visually the detected anomalies and to prevent future risks in individuals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

8.3.2 Applicable Pilot Themes

In bold are the pilot themes that confirmed the participation of this solution:

- **PT1 – Smart Living Environment for Healthy Ageing at Home;**
- PT2 – Improving In-Home and Community-based Care;
- PT5 – Caring for Older Individuals with Neurodegenerative Diseases;
- PT6 – Physical Rehabilitation at Home;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

8.3.3 Adaptations for PT1-UC001

In the current stage, there is no required adaptation of the Wellbeing Assessment solution. Currently, VICOM is analysing the data source received from Omnitor and TREE to start developing the anomaly detection model according to the pilot requirements.

8.3.3.1 Concept and Ideation Stage

The digital solution, called Wellbeing Assessment, allows the detection of anomalies in the daily activities of older individuals, by developing an Unsupervised Machine Learning (ML) system. The objective of this method is aiding professionals and caregivers to early detect impairments and deterioration. The system incorporates different functionalities:

- Giving a risk value to each of the individuals to detect health conditions and priorities.
- Creating alerts for low- and high-risk anomalies, for detecting irregularities and limiting or preventing its worsening.
- Comparing a detected anomaly with other individual's attributes in time.
- Analysing and prevent the development of any complications.

When working with clinical data and wearables, one of the most important things to take into account is the data variability depending on individual conditions. Moreover, the collection of wearable devices can also be changeable due to the different routines depending on physical mobility. Due to this, anomalies or outliers vary from person to person. However, some ranges have been stablished by physicians taking in account sex, age and diagnostics in order to improve the anomaly detection results. However, **unsupervised methods** try to find anomalies and is not necessarily have a label about normal/abnormal measurement. In this project, both anomaly detection strategies are used. Firstly, unsupervised methods give anomalous results and,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

secondly, analyse these anomalies and check whether they are out of range depending on the elderly person and his or her clinical history.

Commonly used unsupervised methods for this purpose are decision trees, recurrent neural networks, and clustering methods. The most used in each case are Isolation Forests, LSTM and K-Means. At the end, VICOM will choose the model which performs better.

In our solution, no individual data is stored, as the Wellbeing Assessment solution procedure is to analyse the data collected by the questionnaires and wearables to send the anomaly when the system detects that an irregularity occurs. As noted above, this is because the Wellbeing Assessment solution pipeline is connected to the Big Data Platform for making GET/POST requests. These requests return the detected anomalies stored previously and it is not necessary to have a dedicated data storage for anomaly detection.

Table 133 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-035	Devices counting steps as part of daily activity monitoring should be supported.	Y	Wellbeing assessment will include daily steps data and this module will be supported.
SPS-038	Devices recording sleep quality should be supported.	Y	Sleep quality related information should be supported.
SPS-043	SHAPES shall support risk assessment and action plans as part of its data processing of health data.	Y	The wellbeing assessment system for anomaly detection and risk prediction will be displayed.
SPS-114	SHAPES should support assisted mobility at home.	Y	Wellbeing and risk assessment system contributes to assisted care.
SPS-128	SHAPES shall support "Privacy by design and by default".	Y	No information is stored.
SPS-143	SHAPES shall provide support for "storage minimisation".	Y	No information is stored.
SPS-172	SHAPES shall support exchanging information among Digital Solutions.	Y	Information is shared with other DS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
			through the Platform's API.
SPS-186	FHIR shall be used as a common data model for Medical Data exchange among components of the SHAPES Platform.	Y	Data from no IoT devices will be sent to the FHIR component.
SPS-191	IoT data are send to the Data Lake from Digital Solutions only via FINoT platform.	Y	Data from IoT devices will use FINoT.

Table 134 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
JSON format	Wellbeing Assessment requires to receive the data into json format due to the solution characteristics.	Y	The regarding partners accepted this requirement.
Data request	Wellbeing Assessment requires access to Big Data Platform for making GET requests for launch pipeline process.	Y	In process to address it with partners.
REST requests	Wellbeing Assessment requires access to Big Data Platform for making REST requests to store anomalies detection results.	Y	In process to address it with partners.
Volume	Wellbeing Assessment requires store of huge data volume in Big Data Platform.	Y	Depends on Big Data Platform requirements.
Pipelines	Wellbeing Assessment requires launch the pipeline process from SHAPES Platform's stored data.	Y	The regarding partners accepted this requirement.
Users Interaction	Wellbeing Assessment shall receive the user's anomaly detection queries from front-end.	Y	The regarding partners accepted this requirement.
Available	Wellbeing Assessment shall be available.	Y	The regarding partners accepted this requirement. In process to address it with partners (regular maintenance).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
Scalable algorithms	Wellbeing Assessment algorithms shall be adaptable and scalable if variables change.	Y	The regarding partners accepted this requirement.
Data protection	Wellbeing Assessment shall use SHAPES platform requirements about private data protection (GDPR regulation).	Y	In process to address it with partners. Depends on Big Data Platform requirements.
Failure notification	Wellbeing Assessment shall send to the SHAPES Platform requirements about technical problems of data availability.	Y	In process to address it with partners. Depends on Big Data Platform requirements.
Handler error	Wellbeing Assessment shall have an error handling strategy created for the pipeline stage.	Y	The regarding partners accepted this requirement.
PT1-UC001: Total or partial integration in notification systems	Wellbeing Assessment needs to be integrated totally or partially in a notification system.	Y	Wellbeing assessment requires an interface for display purposes.

8.3.3.2 Design and Development Stage

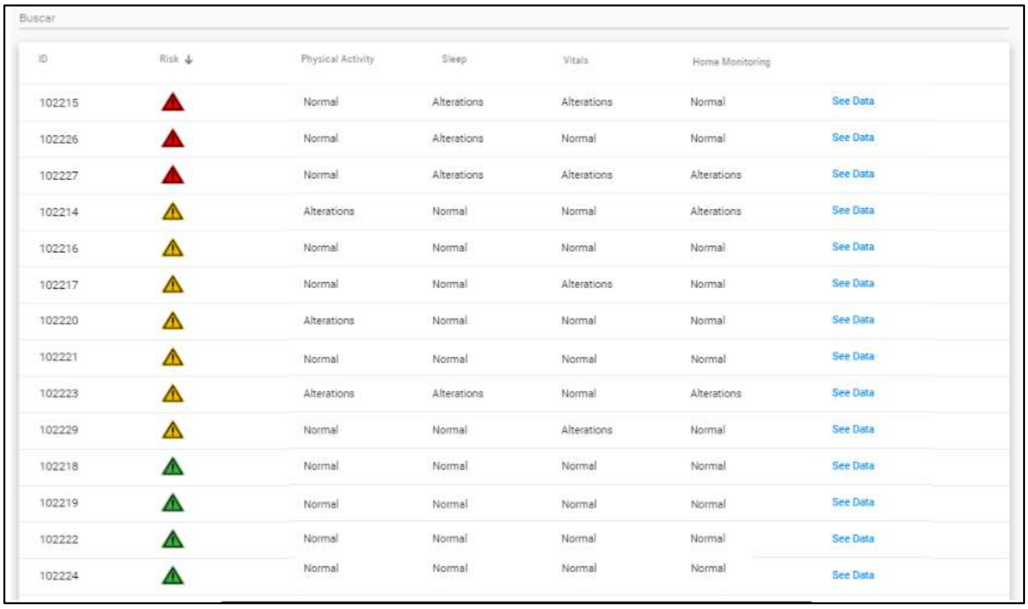
The development of the Wellbeing Assessment solution is directly linked and dependent of data collection. Figure 190 shows the design in which the Wellbeing Assessment modules will be displayed. This visualisation allows caregivers and professionals to identify the level of risk by users and attributes in parallel. As shown in Figure 190, Wellbeing Assessment presents a list of users with their respective risk level, determined in three colours: red (high risk), yellow (medium risk), green (no risk). Notice that the high risk and yellow risk are determined by the number of irregularities in the analysed attributes, as shown in Figure 191.

This design is created with the objective to benefit caregivers and professionals to efficiently identify the physical and cognitive state of individuals in short- and long-term:

- **Short-term evaluation**: Professionals can access the daily data of users to identify any possible anomaly on a determined day. Some information can be used for generating recommendations to send to the user in order to stimulate a regular activity (for more information see section 6.7).
- **Long-term evaluation**: Professionals can observe the evolution of a detected attribute anomaly in time and predict the risk of worsening. In contrast, they

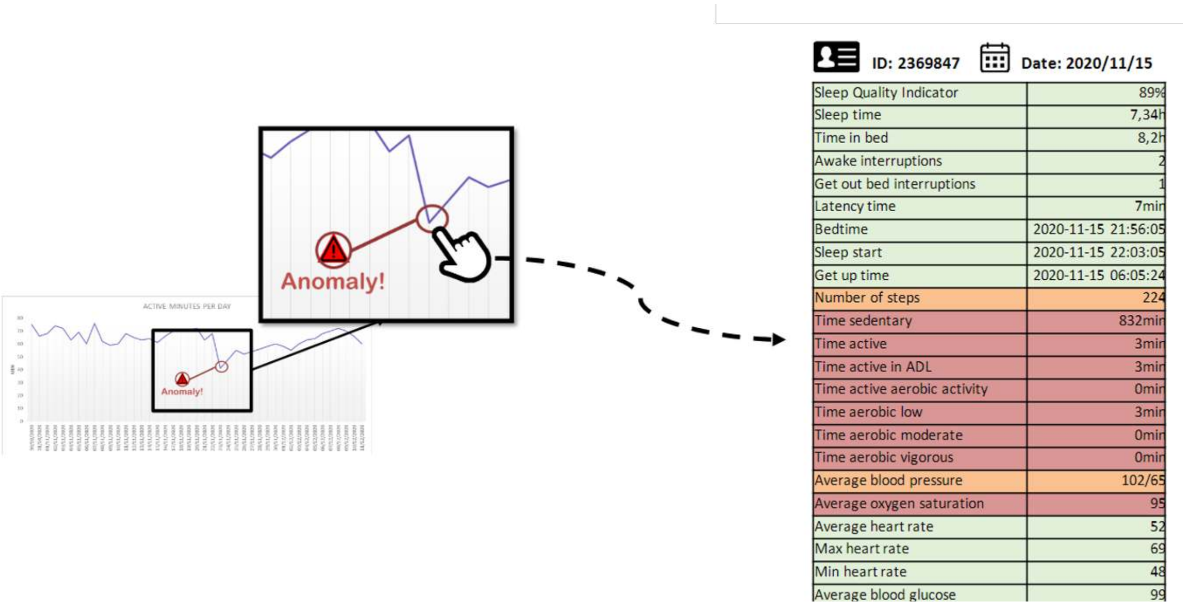
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

may observe the improvement of a condition in time when the respective anomaly is treated.



ID	Risk	Physical Activity	Sleep	Vitals	Home Monitoring	
102215		Normal	Alterations	Alterations	Normal	See Data
102226		Normal	Alterations	Normal	Normal	See Data
102227		Normal	Alterations	Alterations	Alterations	See Data
102214		Alterations	Normal	Normal	Alterations	See Data
102216		Normal	Normal	Normal	Normal	See Data
102217		Normal	Normal	Alterations	Normal	See Data
102220		Alterations	Normal	Normal	Normal	See Data
102221		Normal	Normal	Normal	Normal	See Data
102223		Alterations	Alterations	Normal	Alterations	See Data
102229		Normal	Normal	Alterations	Normal	See Data
102218		Normal	Normal	Normal	Normal	See Data
102219		Normal	Normal	Normal	Normal	See Data
102222		Normal	Normal	Normal	Normal	See Data
102224		Normal	Normal	Normal	Normal	See Data

Figure 190 - Design of General Risk Type List of Individuals



Sleep Quality Indicator	89%
Sleep time	7,34h
Time in bed	8,2h
Awake interruptions	2
Get out bed interruptions	1
Latency time	7min
Bedtime	2020-11-15 21:56:05
Sleep start	2020-11-15 22:03:05
Get up time	2020-11-15 06:05:24
Number of steps	224
Time sedentary	832min
Time active	3min
Time active in ADL	3min
Time active aerobic activity	0min
Time aerobic low	3min
Time aerobic moderate	0min
Time aerobic vigorous	0min
Average blood pressure	102/65
Average oxygen saturation	95
Average heart rate	52
Max heart rate	69
Min heart rate	48
Average blood glucose	99

Figure 191 - Design of Individual Risk by Attributes in a Day

8.3.3.3 Prototyping and Adaptation Stage

The main interest and usability of this solution is based on the input information received from the different IoT devices. As shown in Figure 192, the data that will be provided to VICOM when data collection starts are:

- Activity (steps) (EDGE, TREE): The activity is measured by the number of steps stored in the Big Data Platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Sleep quality modules (TREE): the activity and sleep quality data are going to be stored in the Big Data Platform.
- Heart rate vitals from eCare (EDGE): vitals monitoring is going to be stored the in Big Data Platform.
- Appliance Monitoring (Omnitor): on/off and duration of the state monitoring is going to be stored the in Big Data Platform.

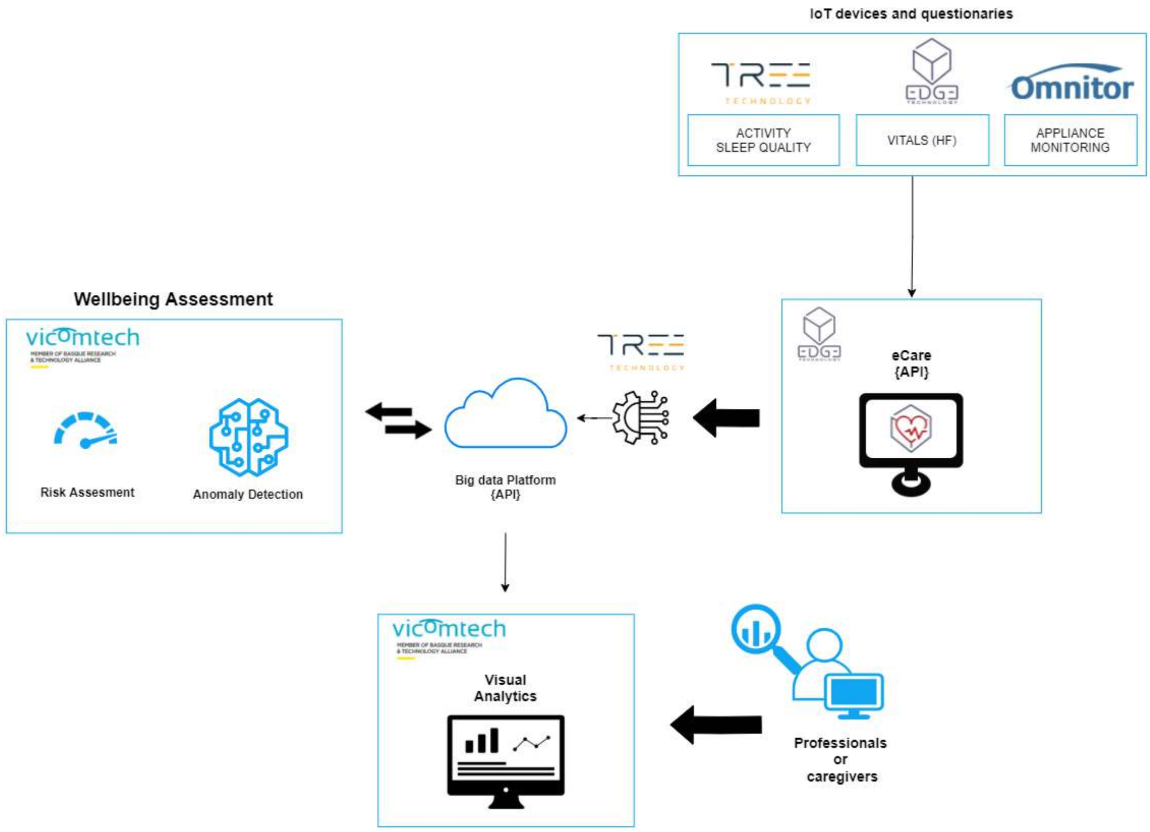


Figure 192 - Workflow of the Wellbeing Assessment Solution

As discussed above, raw data which comes from the three sources are submitted to analytics process and stored in the Big Data Platform. Then, data are requested and anomalies detected by Wellbeing Assessment. The results of this process are stored in the Big Data Platform. According to requirements described before, VICOM will try to implement final users' needs. As a result, professionals and caregivers can request these results for analysing patients' state and well-being improvement from the Wellbeing Assessment interface.

9 Security Assessment as a Service (Task 5.8)

The Security Assessment as a Service (SAaaS) component is an authentication/Authorisation framework for SHAPES. It continuously monitors the underlying network and detects existing and newly introduced network-enabled entities. It periodically assesses them against well-known vulnerabilities and certifies them against a CVSS score concerning their level of security (how vulnerable they are). These entities are assigned to the connectivity-appropriate network, according to their security level (Common Vulnerability Scoring System or CVSS score). After the assessment and certification of those entities, they are authenticated and authorised. This is achieved by utilising the Authentication, Security and Privacy Assurance (ASaPA) component, developed in Task 4.6.

In more detail, the SAaaS component:

- Monitors the underlying network in real-time.
- Is aware of the exiting network-enabled entities.
- Detects the newly introduced network-enabled entities.
- Performs initial and periodical vulnerability assessments on each entity.
- Certifies each entity against a CVSS score deriving from the vulnerability assessment.
- Each entity is assigned to a connectivity-appropriate network (VLAN or slice).
- Certified entities are authenticated and authorised.

9.1 Technical Specifications

SAaaS runs on any Linux-based platform and it is available to be deployed from the cloud. SAaaS monitors the underlying network in real-time for any existing or newly introduced devices utilising a software defined network (SDN) infrastructure on top of the legacy networks. These devices will be temporally separated in a neutral network environment (VLAN) with limited connectivity, where SAaaS tests and assesses the devices. Security assessment is conducted using the OpenVas open source platform, which additionally certifies the devices in accordance to a standardised CVSS. Afterwards, certified devices are assigned to a privilege appropriate VLAN where authentication and authorisation takes place (ASaPA).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

9.1.1 Interfaces and Interoperability

SAaaS has a single interface (SAaaS.I.10) which communicates with ASaPA.I.10. This is required to decide if a device or service is allowed and secure to enter the SHAPES network.

9.1.2 Applicable Pilot Themes

SAaaS is a SHAPES component, co-operating with ASaPA, required in most use cases that include a device/service requesting access to the internal network of SHAPES Platform. Thus, SAaaS could be used in any pilot that includes devices or services requesting access.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

10 COVID-19 Response Digital Solutions

With the aim to support the needs of present times, SHAPES partners gathered additional effort to develop digital solutions aimed at supporting the response to the worldwide COVID-19 pandemic. The different solutions to enrich the SHAPES ecosystem are detailed in the following sections.

It should be noted that, throughout the past year, the fight against COVID-19 has become reinforced with robust vaccination campaigns. As a result, the need to adjust the SHAPES pilots and associated use cases to include the SHAPES COVID-19 Response digital solutions has evolved and most pilot sites have opted not to include them in the panoply of digital solutions supporting the piloting activity.

10.1 ONE System – Observation of National Epidemics (EDGE)

ONE is EDGE's response to COVID-19, by providing a digital system allowing healthcare organisations and healthcare authorities to manage the progression of epidemics (specifically COVID-19) relying on citizens using Apps for reporting and sharing their health and wellbeing parameters.

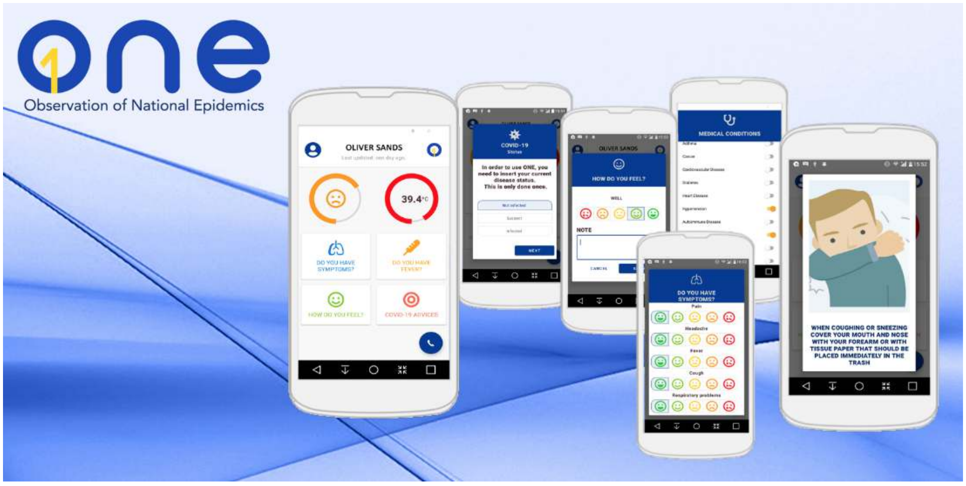


Figure 193 - EDGE's ONE System

The **ONE** App allows citizens to insert their COVID-19 status (subject to validation by authorities), existing medical conditions and, on a periodic basis (e.g., once or twice per day), symptoms (e.g., cough intensity), health and wellbeing parameters (e.g., temperature) associated with the disease. The inserted information, after user consent, is sent to the **ONE** Server platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

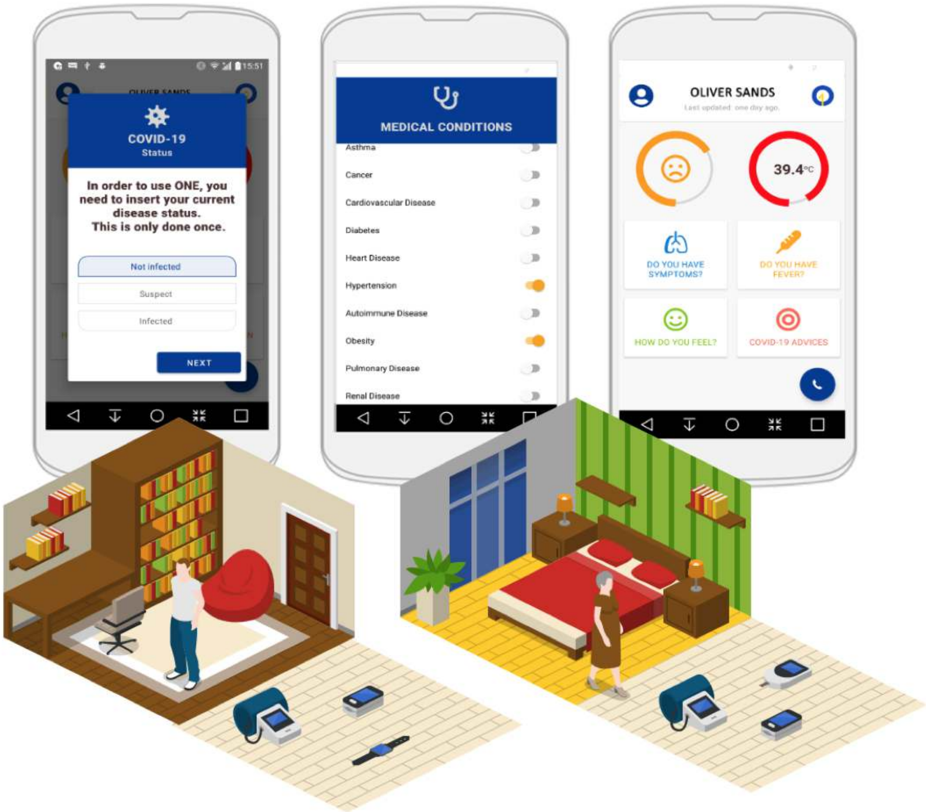


Figure 194 - ONE App for Individuals at Home Environments

Table 135 - ONE Health and Wellbeing Data

Data Category	Measurements Type	Collection Method
Vital signs	Body temperature Heart rate Oxygen saturation	Automated (from connected devices) or Manual
Health	Medical conditions	Manual (fill-in questionnaires)
Symptoms	Fever Respiratory problems Cough Pain Headache Tiredness	Manual (fill-in questionnaires)
Wellbeing	How do you feel?	Manual (fill-in questionnaires)

Upon the patients' explicit consent, the data is shared with the healthcare professionals (care team) responsible for accompanying the patients, allowing them to remotely view the (self)reported health and wellbeing parameters, easily update the patients' health and wellbeing status during domiciliary visits or following telemedicine consults or phone calls, follow the evolution of the patients' condition and to act promptly if needed (e.g., adjustment of medication, change of treatment, immediate phone contact).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Through the **ONE System**, healthcare professionals are able to easily and efficiently monitor in a remote way the health and wellbeing parameters of a large number of patients under their care (significant high scalability is given to the one-to-many monitoring healthcare model), by means of intuitive dashboards and rich visualisation tools that highlight localised risks of relapse or hospitalisation, being aware of their condition at all times and receiving notifications or alerts in case any patient symptoms become severe and their condition worsens, thus warranting the patient's immediate hospitalisation.

ONE provides user friendly dashboards for health and care professionals, supporting large scale management and awareness of patient's health and wellbeing, clearly outlining situations requiring attention. **ONE** provides detailed information for carers concerning the patients' parameters evolution.

Figure 195 - ONE System for Healthcare Professionals at Point-of-Care

Moreover, **ONE** provides tools for decision-makers concerning overall statistical data, trends and identification of clusters. The **ONE System** brings important insights for decision-makers that need to develop situational awareness concerning the progress of the COVID-19 disease and its impact on the population. Statistics (e.g., confirmed and deaths: total, rate over time, age distribution), correlation data (e.g., symptoms, medical conditions and wellbeing deterioration), trends and geospatial intelligence concerning the evolution of the COVID-19 pandemic are made available, leveraging on the vast amounts of data (the COVID-19 knowledge base) collected. **ONE** data services are thus able to generate statistical, stratification and clustering analyses adequate for strategic decision-making, signalling successful patient management options and identifying measures for the effective prevention and control of the COVID-19 contagion and the protection of the population. The data accessible to decision-makers is anonymised, protecting the privacy of individuals and the confidentiality of medical information. Decision-makers are able to access the data and visualise it through user-friendly data analytics and intuitive dashboards.

Data quality and security are also key concerns of the **ONE System** that uses advanced technologies to ensure an efficient access to trustworthy data. **ONE** deals

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

with a high degree of personal and sensitive information pertaining to individuals, thus it is critical that high standards for security and privacy (fully adopting GDPR) are implemented, resulting in a highly trusted platform among its users and stakeholders. **ONE** adopts a privacy-by-design scheme to guarantee full compliance with EU and national legislation and regulations (e.g. GDPR) on data privacy, especially in regard to the use of personal and/or sensitive data. Likewise, security-by-design principles is assumed not only for the **ONE System** itself and security mechanisms, but also for the communication channels with external sources and components.

For any patient data to be sent, shared or anyway exchanged with the healthcare professional, it is required that the individual authorises, consents and enables the so-called data transfer. **Strict authentication, authorisation, and accounting security measures** are in place in the **ONE System** to guarantee the safeguard of the users' privacy and the protection of all personal data. Robust authentication mechanisms and secure access protocols are adopted and strong end-to-end encryption (e.g., transport layer encryption SSL/TLS) is used. Individuals or patients always retain the power to individually grant access to the different elements of their reported health and wellbeing information to healthcare professionals, thus remaining in control of their own data. Individuals have the option to delete all their data and their account with the **ONE System**, effectively leaving the System, in full compliance with GDPR's article 17 *Right to be forgotten*. The **ONE System** records in a secure log system all actions involving the data and information held within, that is, all access, creation, modification, archival and deletion actions concerning the System's data, including the identification of the user responsible for the action. Data access management is based on an Attribute-based Access Control (ABAC) approach, enabling finer grained data access control and a system better fitted to operational efficiency.

10.1.1 Interfaces and Interoperability

The **ONE System** includes an Application Programming Interface (API) that supports the interoperability of the System with third-party applications or software. Following a pre-defined data model, the **ONE** API enables the exportation of anonymised data collected by the **ONE System** to third-party applications or software. The **ONE System** may also be extended to import data provided by external applications and devices.

Table 136 - Summarised Technical Description of the ONE System

General Description	Big data platform presenting the patients' symptoms and wellbeing data captured by health devices and wearables to support the monitoring of a population being treated at home and under active surveillance (quarantine for the diagnosed or suspected of being infected with a specific disease), in an epidemic scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Features	• Gathering and presentation of the patient's o **temperature** information, based on data captured by thermometers and oxymeters (automatic or manual input); o **symptoms** and **wellbeing** information, based on data provided by the individual in the eCare App (questionnaire). • Early detection of the deterioration of the patient's health and wellbeing conditions; • Statistics on the evolution of the patient's health and wellbeing conditions; • Remote monitoring of patient condition by healthcare professionals (workload reduction; faster action); • Delivery of recommendations.
Application Areas	• Remote monitoring of symptoms and wellbeing conditions of COVID-19 patients; • Patient empowerment (manage own care plan and adoption of preventative behaviours); • Management and control of the epidemic evolution and impact in population.
TRL	From TRL4 to TRL7
Data Type	JSON format. Used standards: • Openmhealth (https://www.openmhealth.org). EDGE extensions for specific fields.
Inputs	HTTP(S) REST, JSON messages.
Outputs	HTTP(S) REST, JSON messages.
Actions to be performed	**Older individuals** use the ONE App or the ONE Portal to insert information to the ONE Platform. **Professional and informal caregivers** use the ONE Portal to insert information to the ONE Platform. Compatible **smart devices** (e.g., thermometer) provide automatic information to the ONE Platform.
Interface	ONE App: Smartphone ONE System (front-end): Web browser ONE System (back-end): API for third-parties to access ONE information (using HTTP(S) REST) ONE Platform: API for third-party systems (e.g., data analytics) to insert automatic information in ONE (using HTTP(S) REST)

10.1.2 Applicable Pilot Themes

In SHAPES, the **ONE System** will be adapted to a specific eCare COVID-19 module that will meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1 – Smart Living Environment for Active Ageing at Home;

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

Figure 196 - Application of the ONE System in SHAPES Pilot Themes

10.1.3 Adaptations for PT3-UCGeneral

The following sections present the adaptations and new developments performed in the **ONE System** digital solution, in order to meet the specific requirements of ***PT3-UCGeneral: Supporting Multimorbid Older Patients*** and adequately support the use case's pilot activities.

10.1.3.1 Concept and Ideation Stage

In this use case, the targeted audience is the older people (65+ years) living at home and suffering from multiple illnesses, such as heart failure, diabetes, hypertension and chronic obstructive pulmonary disease, that lead to the taking of multiple daily medications. According to Deliverable D2.7 – *SHAPES Personas and Use Cases* [2], the SHAPES persona applicable to PT3-UCGeneral is Roberto (P2). Details on this SHAPES persona are available in Deliverable D2.7.

The use case PT3-UCGeneral aims to develop an optimised and personalised approach to the safe and effective use of multiple medicines by older people with multi-morbidity to ensure the best possible health outcomes. In addition, older people will use a dedicated solution to monitor COVID-19 symptoms. Based on the collected data, data analytics solutions will also determine normality patterns and detect emerging

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

anomalies (risky situations) in those patterns, triggering specific notifications, reminders or recommendations to the pilot participants.

In order for the **ONE System** to properly support the use case PT3-UCGeneral, an analysis of the applicable system specifications (as defined in Deliverable D4.1 – *SHAPES Technological Platform Requirements and Architectu*re [3]) and of the pilot's use case requirements (to be presented in Deliverable D6.4 – *Medicine Control and Optimisation - Pilot Activities Report*) was conducted. The following tables map the system specifications and pilot use case requirements applicable to the **eCare Platform**, within the scope of its support to this use case.

Table 137 - Applicable System Specifications

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-001	The SHAPES Platform shall adopt a customer logic (B2C and B2B) in its design and development.	Y	Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.
SPS-002	The SHAPES Platform shall have its own Terms of Use and Services Policy.	Y	ONE has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.
SPS-003	The SHAPES Platform shall have its own Privacy Policy, observing applicable regulations, including the GDPR.	Y	ONE has its own privacy policy. For the SHAPES pilot activities, the privacy policy is defined by the pilot research protocol.
SPS-005	The SHAPES Platform shall be modular and configurable.	Y	ONE adopts a modular and configurable architecture.
SPS-018	The SHAPES Platform shall comply with universal accessibility policies.	Y	ONE follows universal accessibility policies.
SPS-019	The SHAPES Platform shall be based on common and open standards.	Y	ONE adopts common and open standards.
SPS-021	The SHAPES Platform shall offer open APIs and use interoperability standards.	Y	ONE has its own APIs and adopts interoperability standards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-022	The SHAPES Platform shall facilitate integrated care.	Y	ONE delivers integrated care features.
SPS-023	The SHAPES Platform shall support multilingual user interface.	Y	ONE has a multilingual interface and ONE adaptations benefit from SHAPES partners' translation skills.
SPS-027	Digital Solutions shall provide usage tutorials and help cards, including on the devices they use.	Y	ONE provides a welcome guide. For the SHAPES pilot activities, a dedicated user manual has been created, including relevant instructions on the use of the devices.
SPS-029	The SHAPES Platform should support health data management (collection, sharing and processing).	Y	ONE supports health data collection, sharing and processing.
SPS-030	The SHAPES Platform shall comply with private data protection of the GDPR regulation.	Y	ONE complies with GDPR regulations.
SPS-031	The SHAPES Platform shall ensure that private data is stored only within EU Member States and other countries considered as GDPR compliant.	Y	ONE storage is handled in EU Member States.
SPS-033	All classes of users shall be able to review the historical data.	Y	ONE maintains a data repository that includes historical data.
SPS-041	The SHAPES Platform shall support monitoring of vital signs (weight, temperature, blood pressure, blood glucose, bio impedance, heart rate, blood oxygen level, etc.)	Y	ONE supports medical devices that monitor vital signs.
SPS-042	The SHAPES Platform should support manual data entry.	Y	ONE supports manual data entries.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-044	The SHAPES Platform should support use of questionnaires as self-assessment tools.	Y	ONE supports the use of questionnaires as self-assessment tools.
SPS-046	The SHAPES Platform should support reminders.	Y	ONE delivers reminders.
SPS-048	The SHAPES Platform should offer alerting mechanisms about medical risks and emergencies.	Y	ONE delivers alerts. For the SHAPES pilot activities, alerts on medical risks and emergencies follow the pilot research protocol.
SPS-057	Scheduling of tasks for different users should be supported in the SHAPES Platform.	Y	ONE provides a set of daily tasks for the user.
SPS-058	The SHAPES Platform may motivate care receivers.	Y	ONE delivers motivational notes.
SPS-059	User friendly dashboards should be offered to care receivers and care takers.	Y	ONE delivers user friendly dashboards. Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.
SPS-060	Management of patient profile data should be supported in the SHAPES Platform.	Y	ONE supports the management of patient profiles. For the SHAPES pilot activities, the management of patient profile data follows the pilot research protocol.
SPS-072	The SHAPES Platform should keep logs of access to personal data.	Y	ONE maintains system access logs for all data.
SPS-073	The SHAPES Platform should support authorisation management to data.	Y	ONE offers robust authentication and authorisation features.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-075	The SHAPES Platform should offer the possibility to delete access to the platform.	Y	ONE provides an opt-out feature to users. For the SHAPES pilot activities, access to eCare is defined by the pilot research protocol.
SPS-076	The SHAPES Platform shall offer an option to view personal data stored in the platform.	Y	ONE allows users to access, edit and delete own personal data.
SPS-077	The SHAPES Platform shall offer the option to edit personal data stored in the platform.	Y	ONE allows users to access, edit and delete own personal data.
SPS-078	The SHAPES Platform shall offer option to request removing own personal info from the platform.	Y	ONE allows users to access, edit and delete own personal data.
SPS-081	The SHAPES Platform should provide web access from desktop/laptop/smartphone and tablet.	Y	eCare supports mobile and web-based platforms and devices.
SPS-086	The SHAPES Platform shall offer comprehensive feedback.	Y	ONE provides users with comprehensive feedback. The use of a colour code to assist users in understanding measurements is not active as per the pilot's research protocol.
SPS-113	The SHAPES Platform should support health literacy (maintaining good healthy diet).	Y	ONE supports the users' health literacy.
SPS-125	The SHAPES Platform shall support requesting, obtaining and storing user consent.	Y	ONE supports user consent features. For the SHAPES pilot activities, user consent is based on the pilot research protocol.
SPS-126	The SHAPES Platform shall offer traceability of personal data.	Y	ONE enables traceability of personal data.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-128	The SHAPES Platform shall support "Privacy by design and by default".	Y	ONE is designed with privacy by design and by default guidelines.
SPS-131	The SHAPES Platform shall comply with common minimum cybersecurity rules for mobile and online services.	Y	ONE complies with relevant cybersecurity rules for mobile and online services.
SPS-132	The SHAPES Platform shall comply with WCAG 2.1 Standards and Universal Design principles in designing and implementing processes.	Y	ONE follows guidelines on WCAG 2.1 standards and Universal Design principles.
SPS-133	SHAPES digital solutions shall be able to send alerts and notify care givers.	Y	ONE delivers alerts and notifications to its users. For the SHAPES pilot activities, alerts and notifications follow the pilot research protocol.
SPS-134	The SHAPES Platform shall offer user friendly and attractive interfaces.	Y	ONE offers user friendly and attractive interfaces. Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.
SPS-135	The SHAPES Platform shall offer ease-of-use interfaces for both healthy and impaired users.	Y	ONE offers user friendly interfaces for all users. Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.
SPS-136	The SHAPES Platform's user interface should resemble technologies used by the elderly in their everyday lives.	Y	ONE applies user interfaces resembling other technologies used by the elderly.
SPS-137	The SHAPES Platform's user interfaces shall minimise the need for interaction for accessing the required info.	Y	ONE adopts an efficient navigation scheme to facilitate user interaction. Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-138	The SHAPES Platform shall offer detection of personal data breach.	Y	ONE implements cybersecurity features to prevent and detect data breaches.
SPS-139	The SHAPES Platform shall support restricting data processing.	Y	ONE adopts a data minimisation policy that restricts data processing.
SPS-142	The SHAPES Platform shall provide support for "the right to object".	Y	ONE presents user consent features that include account deletion. For the SHAPES pilot activities, user participation rights are defined in the pilot research protocol.
SPS-143	The SHAPES Platform shall provide support for "storage minimisation".	Y	ONE adopts a data minimisation policy that supports storage minimisation.
SPS-144	The SHAPES Platform shall provide support for "Data protection principles: accuracy".	Y	ONE complies with GDPR regulations.
SPS-145	The SHAPES Platform shall provide the necessary protection of data.	Y	ONE complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-146	The SHAPES Platform shall offer capability to detect a risk of potential data breach.	Y	ONE complies with GDPR regulations and implements cybersecurity measures to protect data.
SPS-147	The SHAPES Platform shall support IAM (identity and access management).	Y	ONE offers robust authentication and authorisation features. For the SHAPES pilot activities, ONE integrates with the ASAPA module for authentication.
SPS-148	The SHAPES Platform shall implement password-based authentication.	Y	ONE implements password-based authentication.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-149	The SHAPES Platform shall support password management.	Y	ONE has a password management feature. For the SHAPES pilot activities, ONE integrates with the ASAPA module for authentication.
SPS-150	The SHAPES Platform shall support scaling up its services in terms of geographical coverage.	Y	ONE is a scalable solution in terms of users, services and geographical coverage.
SPS-151	The SHAPES Platform shall be scalable in order to accommodate changing user data storage requirements.	Y	ONE is a scalable solution concerning data storage requirements.
SPS-152	The SHAPES Platform shall use a modular architecture.	Y	ONE was designed with a modular architecture.
SPS-156	The SHAPES Platform shall support registration of devices.	Y	ONE supports the registration of IoT and medical devices.
SPS-157	The SHAPES Platform shall support recognition of connected devices.	Y	ONE supports the recognition of connected devices.
SPS-158	The SHAPES Platform's user interface shall support automatic adaptation to visual capabilities of the access device.	Y	ONE supports the accessibility features of the access device.
SPS-161	The SHAPES Platform shall ensure service continuity and reliability at 98% on 24/7-time basis.	Y	ONE delivers service reliability and continuity at 98%. For the SHAPES pilot activities, support services are provided as defined in the pilot research protocol.
SPS-162	The SHAPES Platform shall be functional and operational during Internet downtimes.	Y	ONE supports an offline operation mode at the user device.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-163	The SHAPES Platform should offer capabilities to determine service downtimes of its components.	Y	ONE maintains a system log.
SPS-164	The SHAPES Platform and its components should support resuming normal operation after period of network downtime.	Y	ONE supports service continuity and recovers from network downtime.
SPS-167	The SHAPES Platform should support collecting performance logs for improving its service quality.	Y	ONE maintains a system log.
SPS-168	The SHAPES Platform should provide tools to simplify the installation of solutions.	Y	ONE provides a welcome guide. For the SHAPES pilot activities, the installation of solutions is defined by the pilot research protocol.
SPS-169	The SHAPES Platform's GUI should use self-explanatory graphical elements linked with respective services.	Y	ONE delivers user friendly and intuitive GUI. Adaptations to ONE consider the collected user feedback on design mock-ups and prototype.
SPS-172	The SHAPES Platform shall support exchanging information among Digital Solutions.	Y	ONE has its own APIs, allowing the exchange of data among digital solutions. ONE was adapted to exchange information with the SHAPES Platform and other digital solutions.
SPS-173	SHAPES services and applications should be accessible using Android and iOS based mobile devices.	Y	ONE is accessible by Android-based mobile devices.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-181	The SHAPES Platform's accessibility via web browsers shall exclude plugins considered insecure.	Y	ONE web-based platform does not involve the need for plugins.
SPS-188	SymbIoTe interoperability mechanisms shall be used for exchange of IoT data among SHAPES components.	Y	ONE shall support SymbIoTe exchange mechanisms.
SPS-190	IoT data processed by the core Analytics Engine shall be pre-loaded onto the Data Lakehouse repository.	Y	ONE shall support the exchange of data with SHAPES components.
SPS-191	IoT data are send to Data Lakehouse from Digital Solutions only via the FINoT platform.	Y	ONE shall support the exchange of data with SymbIoTe and the FINoT platform.
SPS-192	Message Broker shall be employed to manage notifications among core SHAPES components.	Y	ONE shall support the management of notifications among core SHAPES components.
SPS-193	A single sign-on mechanism shall be provided by the SHAPES Platform.	Y	ONE shall support SHAPES's single sign-on mechanism, provided via ASAPA.
SPS-194	Authorisation to access user data shall be managed by components where the data has been stored and/or acquired.	Y	ONE offers robust authorisation features for data access.
SPS-198	Exchange of both IoT and Medical Data between Digital Solutions shall be done by direct messaging between them.	Y	ONE API supports the exchange of IoT and medical data between digital solutions.
SPS-200	Anonymisation and scrambling mechanisms shall be employed by relevant SHAPES components.	Y	ONE implements anonymisation features.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

System Specifications	Description	Fulfil (Y/N)	Comments
SPS-200	All passwords shall be unique per device and per user.	Y	ONE has a password management feature. For the SHAPES pilot activities, password management is performed by the ASAPA module.
SPS-202	All software modules should be securely updateable.	Y	ONE adopts secure mechanisms for software updates.
SPS-203	Automatic and periodic mechanisms should be used for software updates.	Y	ONE adopts automatic mechanisms for periodic software updates.
SPS-204	The digital solutions should verify the authenticity and integrity of software updates.	Y	ONE adopts robust verification mechanisms for software updates.
SPS-208	Personal data stored and/or transiting between a device and a service shall be protected with best practice cryptography.	Y	ONE uses the best state-of-the-art encryption techniques to protect data exchange with devices.
SPS-209	Resilience should be built in to consumer IoT devices and services, taking into account the possibility of outages of data networks and power.	Y	ONE supports an offline operation mode.
SPS-210	The user shall be provided with functionality allowing user data to be erased from the device in a simple manner.	Y	ONE allows users to easily delete own data from the device.
SPS-212	The digital solutions shall validate data input via user interfaces and/or transferred via APIs.	Y	ONE enables the validation of specific fields of information or data provided by the user or received via the ONE API.
SPS-213	The manufacturer shall inform users with clear and transparent info about what data is processed, how it is being used and for what purposes.	Y	ONE has its own terms of use and services policy. For the SHAPES pilot activities, the terms of use and services policy is defined by the pilot research protocol.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 138 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
R7	Record and monitor the elderly pilot participant's COVID-19 symptoms.	Y	ONE provides a COVID-19 monitoring module allowing the elderly pilot participant to register daily their COVID-19 symptoms. ONE monitors and displays COVID-19 symptoms (fever, cough, tiredness, pain, headaches, respiratory distress, loss of smell, loss of taste) based on user feedback.
R10	Allow the care professional pilot participant to establish the vitals, the weight and the COVID-19 symptoms monitoring goals.	Y	ONE provides a care plan module allowing care professionals to establish specific treatment goals for the elderly pilot participant.
R11	Allow the care professional pilot participant to monitor the elderly pilot participants' adherence to the vitals, the weight and the COVID-19 symptoms monitoring goals.	Y	ONE displays in the care professional dashboard the adherence of the elderly pilot participants to the defined care plan.

10.1.3.2 Design and Development Stage

The ONE System has been redesigned so as to meet the objectives of project brand and the functional requirements of the PT3-UCGeneral, while delivering excellent user experience.

Details on colouring, typography and accessibility guidelines for the adaptations in the user interface are provided in section 3.2.3.2.

Based on the PT3-UCGeneral use case's requirements and the user experience guidelines, a set of mock-up designs of the **ONE System** were created and are presented next.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

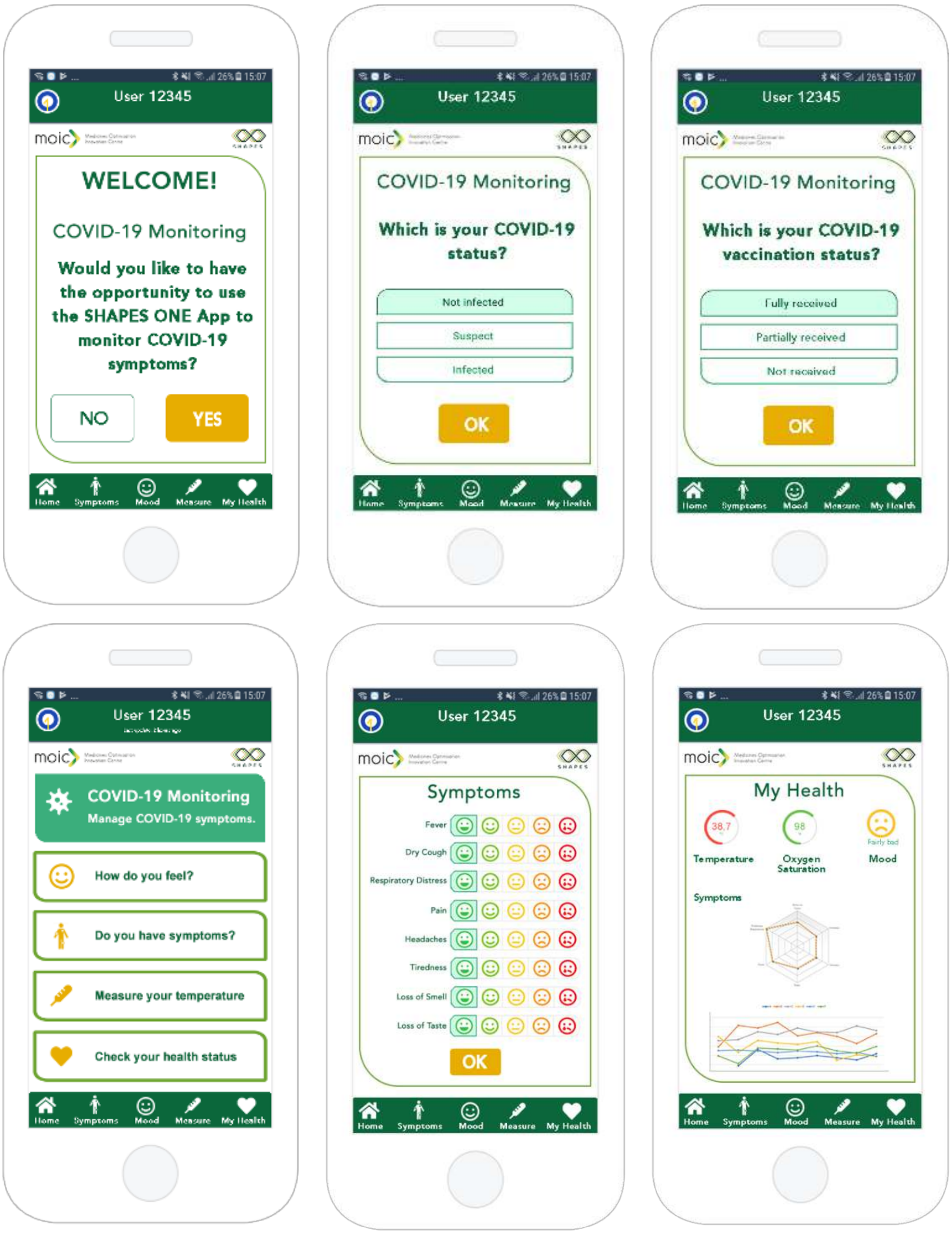
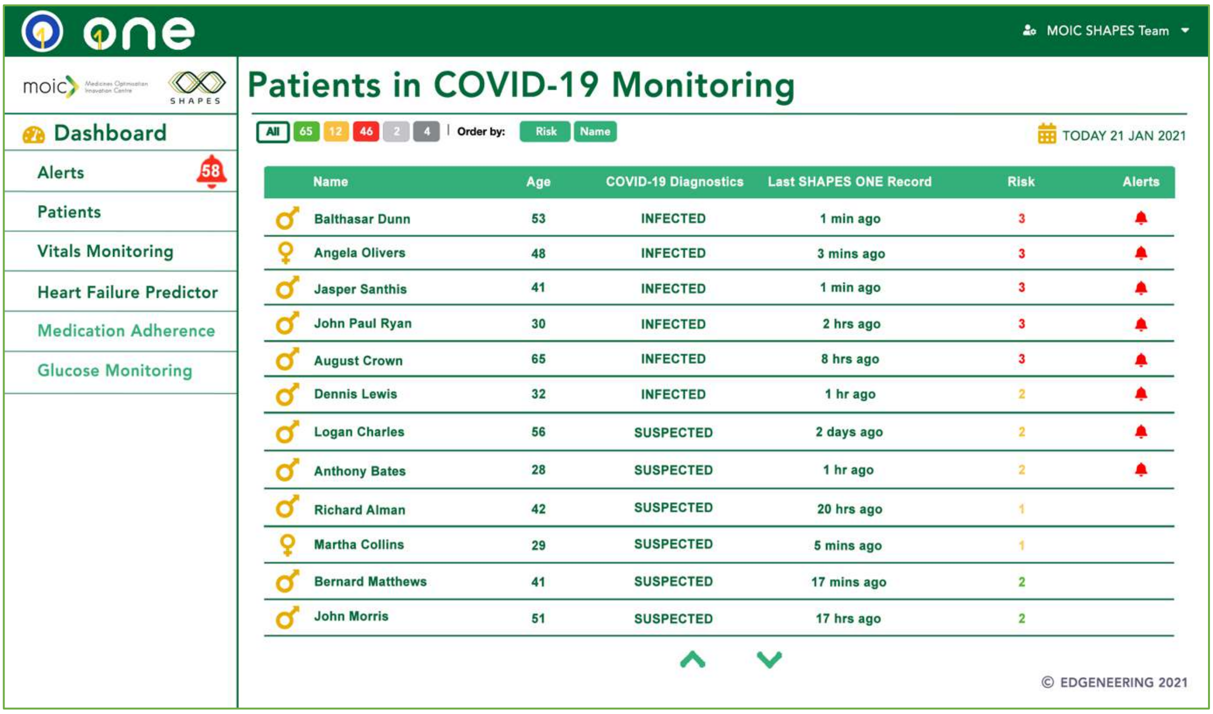


Figure 197 - SHAPES ONE for PT3-UCGeneral – COVID-19 Monitoring Screens

The mock-up designs of the SHAPES ONE System for the PT3-UCGeneral use case are presented next.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159



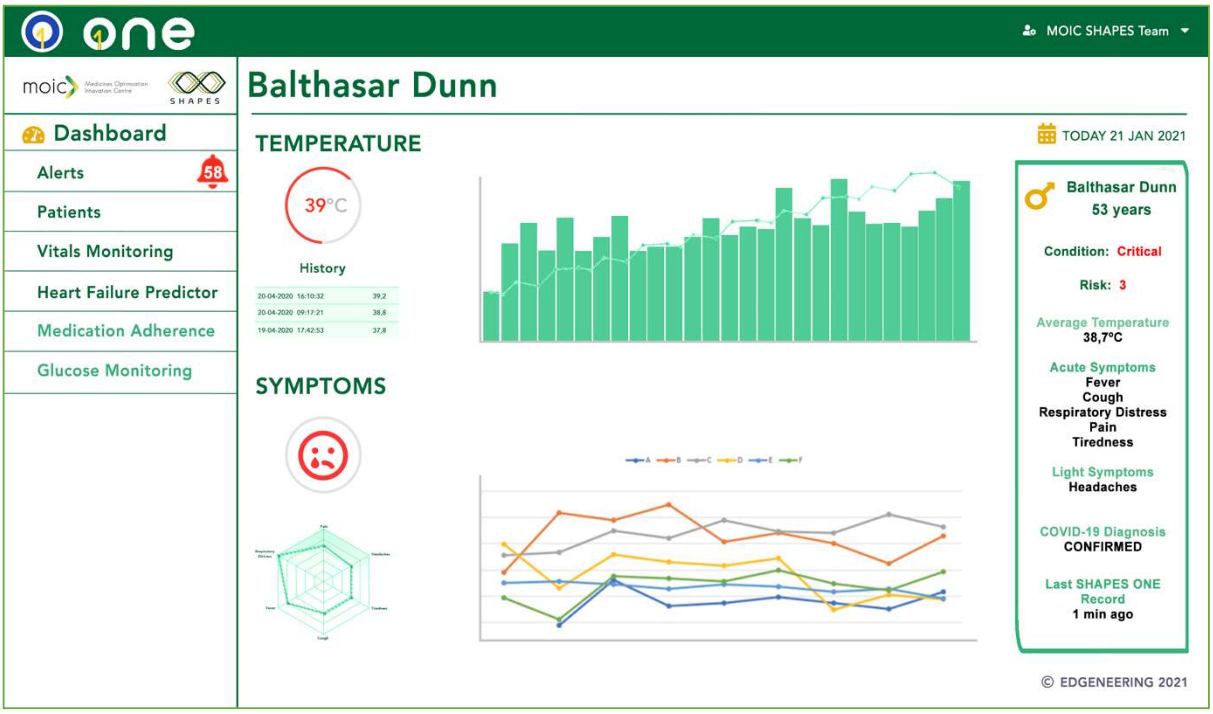


Figure 198 - SHAPES ONE System for PT3-UCGeneral – COVID-19 Patients Screens

The initial mock-up designs were analysed by MOIC and a set of specific requests were made to facilitate the users' navigation, including the concentration on specific tasks, the removal of additional screens and the addition of a single button to access directly the SHAPES Front-end App. Also, it was implemented the rules applicable to the SHAPES pilots concerning the anonymisation of the pilot participants and their authentication in the SHAPES Platform.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

More importantly, while discussing the capabilities provided by the digital solutions, MOIC became aware that, to avoid disruptions of the patients' treatments, professional carers should not participate in PT3-UCGeneral pilot activities. This decision led to the exclusion of the COVID-19 monitoring module, for there was no professional follow-up of reported COVID-19 symptoms. Overall, these decisions eliminated the pilot use case's requirements R7, R10 and R11.

10.2COVIDshield (GNO)

COVIDshield is a post lockdown solution to manage patients in quarantine, chronic disease patients and the general public during and after the pandemic. Patient management is done using wearables, International Patient Summary data and shared care plan data to identify (using Machine Learning algorithms) relevant digital biomarkers that aid the treatment process.

In particular, COVIDshield covers the following COVID-19 related scenarios:

- Reporting epidemic data and managing patient remotely.
- EU cross border scenario & eHDSI National Contact Point (NCP) Integration.
- COVID-19 and Chronic diseases management.
- Emergency and unplanned care.

The functionality is centered around the following pillars:

A. Case Detection and COV containment

- Advanced privacy by design including GPS contact tracing enablement, detailed patient consent and revocation, automated audit logs, standard based data portability and GDPR Compliance.
- Automated clinical, quality of life and personalised smart questionnaire on COVID-19 symptoms.
- Automated reporting to COVID-19 registries based on international HL7 FHIR resources.

B. COVID-19 Patient Self-management

- Personalised Treatment Plans assigned by the doctors.
- Automated reminders, alerts and to-dos.
- IoT and medical devices connectivity, automated measurements collection.
- Personalised Care and education information.
- Panic Button features for emergency and COVID-19 request for testing.
- Validated Questionnaires and PROMS.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

- Educational material to increase awareness and motivation.

C. Remote patient monitoring

- First encounter (visit or remote visit) support.
- Treatment plans among patients-doctor.
- Video consultation and chat tools integrated for direct communication.
- Appointment management for regular and online visits.
- Integration with e-Prescription system if existing.
- Remote monitoring of the patients' progress via real-time analytics and visualisations.
- Automatic detection of medical conditions and alerts notifications.
- Automatic patient clustering based on the risk and their condition as well as discovery of digital biomarkers using Machine learning algorithms.

D. Interoperability

- Leading healthcare interoperability standards to ensure frictionless exchange of medical data.
- Compliance with International Patient Summary Specifications (CEN PrEN17269).
- HL7 FHIR messaging and document sharing by design.
- IHE profiles for Cross Enterprise Document Sharing (XDS) architecture in place to ensure seamless exchange of health documents across Healthcare Information Systems (HIS, LIS, RIS).
- Compliance with IHE MHD integration profile for document sharing via mobile applications.
- Integration with National or Regional e-Prescription systems and Personal or other Electronic Health Records (PHR/EHR) if existing.

E. Safe Cross-border travelling via

- A European Vaccination card to record upcoming EU regulation for upcoming travelling guidelines and prove conformance to EU and other countries relevant legislation.
- Full patient summary with COVID-19 related data to be displayed at an unplanned care, compliant with the EU eHealth Digital Service Infrastructure (eHDSI) openNCP for cross border health care.

10.2.1 Applicable Pilot Themes

- PT2 – Improving In-Home and Community-based Care.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

10.2.2 Adaptations for PT2-UC001

COVIDShield functionality has been merged with the main eHealthPass mobile application. Therefore, the features provided and adaptations performed are reported in section 4.1.5.

10.3 RAPID (VICOM)

The following description of RAPID for COVID-19 solution explained below has been considered by VICOM to be out of scope for the SHAPES use Cases.

RAPID is a contacts traceability app that makes a log of the contacts made by the user through the day. It has a centralised and non-anonymous architecture that allows the analysis of the contacts maintained. While activated, the application detects nearby devices (that have the app installed) and sends the information to a server every 4 hours (as long as there is an Internet connection).

Regarding the contact tracking developed within the app, smartphone's Bluetooth Low Energy (BLE) service is used to scan for nearby devices identified by a universally unique identifier UUID. It advertises and searches for users' *PublicKeys* also working as a background App. Whenever a contact is detected both *PublicKeys*, timestamp and RSSI (signal strength) are saved into an internal database with the contact information and then transferred to the RAPID server. The personal data stored in the Rapid database is the following: email address, nickname, contacts trace, health status and the answers to a risk assessment questionnaire composed by two questions (Are you part of the vulnerable population? (Yes/No); Are you in close contact with anyone part of the vulnerable population? (Yes/No)).

For a safe user registration assessment into RAPID, Keycloack authentication system is used, which grants the needed usage rights. Moreover, all state-of-the-art cybersecurity measures have been implemented both at smartphone and server and the application has been developed GDPR compliant, being the consent signed once the app is installed in the users' device. Actually, there is no iOS App available, but the Android version will be offered through Google play in a short period of time and the application is being validated in VICOM as part of their quality and security policies.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Apart from the described, RAPID also provides several additional features:

- The user can update the health status when changes are detected.
- It updates the potential risk in relation to the vulnerable population.
- The app can scan QRs for Locations (Meeting rooms, office...) and shows the number of devices and the last scanned QR.

Within Shapes, Rapid could be applied for several functions:

- To log the contacts made in a nursing home or in-home care.
- To support the creation and the implementation of preventive policies at healthcare institutions.
- To facilitate the management of health issues related to persons with positive COVID-19 test.

10.3.1 Applicable Pilot Themes

In SHAPES, **Rapid System** will be adapted to a specific COVID-19 module that will meet the SHAPES user requirements and the pilot specifications associated with the following pilot themes:

- PT1 – Smart Living Environment for Active Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT3 – Medicine Control and Optimisation;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

10.4Robotics (PAL)

Two issues are addressed by PAL Robotics solutions:

- The contamination rates of the medical and front-line personnel fighting directly with COVID-19, by automating some front-line activities and reducing their social interactions, providing a safer environment and support for the ones directly facing a risk of contamination due to the need of social interaction.
- Provide emotional support to isolated users through entertainment and facilitating remote communication with medical personnel and family.

Secondly, due to COVID-19, an enormous amount of personal protective equipment (PPE) is needed in hospitals to protect medical staff against the virus. Doctors and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

nurses have to wear gowns, face masks, gloves and face shields to be able to attempt patients that are suffering the virus, as well as family visitors.

Figure 199 - Personal Protective Equipment

Robots can visit patients without risk of infection, increasing staff acceptability of the robots, and saving an enormous number of PPEs as well the time for its disinfection.

Overall, they can help reduce infection rates and provide better attention and care.

ARI and TIAGo robots, already described in section 5.1, could be used for a range of roles targeting COVID-19 based on their skills, in order to reduce infection rates, provide better attention and care and for emotional support:

Receptionist

- Welcome, carry out administrative procedures in common areas or receive visitors to an elderly person's home, including triage by providing an initial health assessment.
- Provide information on COVID-19 symptoms, hospital centres that are close-by to the user, as well as reminders (e.g. to take specific parameters, appointment reminders).
- Enforce protective measurements: remind users to keep social distance, to wear masks or apply gel, as example.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Figure 200 - Robot as Receptionist

Entertainment and engagement with community

ARI/TIAGo can provide emotional support to users isolated due to COVID-19 by providing entertainment and promoting remote social interaction with caregivers/medical personnel as well as family and friends.

Figure 201 - ARI/TIAGo for Entertainment and Engagement with Community

Some tasks that the robot could be adapted to do for entertainment are:

- Play songs requested by the user, or personalised to each person.
- Play games using a mixture of touchscreen and speech (TicTacToe, solitaire), as well as motivate upper-limb physical exercise (ARI) through imitating gestures.
- Provide daily news.

Through the robot's calling functionality and touchscreen, the nurse can enter the room or connect with the end-users virtually. Moreover, another critical situation in this context is the impossibility of family visits. The isolation and stress situations for both, patient and family, has increased with the COVID-19 pandemic. The contact with family has been restricted to "end-life" situations. However, with this functionality on

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

the robot, the contact between family and patient could increase drastically being more frequent during the hospitalisation or confinement at home.

COVID-19 Health Monitoring

The robots can monitor the health status of the users through a variety of ways and alert medical personnel, either at individual apartments or to new visitors to a common room/apartment to screen for potential COVID-19 infected users.

- Temperature screening with a **thermal camera** that can be added to either of the robots.
- **COVID-19 health assessments**: by asking a series of questions to detect potential symptoms.

The robots can then notify medical personnel or family members through SMS or phone call, informing about results and other dynamic information.

Figure 202 - Robot Supporting COVID-19 Health Monitoring

SHAPES integration

Integration of additional Digital Solutions

The robotic system may be substantially improved by a combination of digital solutions of SHAPES Platform. Examples include, but are not limited to:

- Virtual assistant ROSA (CH).
- Speech recognition and face recognition system (VICOM).
- Emotion recognition, fall detection (TREE).

TREE's emotion recognition system can be used by the robot to detect mood and approach users to initiate interaction, including answering questions and addressing doubts regarding their health. Fall detection would be another means of monitoring users that are isolated and alerting medical personnel through SMS/call.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

VICOM's and CH's systems would be used for improved speech interaction and interconnection with the medical system and VICOM's face recognition for uniquely identifying each user and linking health measurements with the right person.

Additional development

Additional hardware to be integrated:

- Thermal camera.

Additional software development:

- Design of new games based on pilot site requirements.
- Video-call functionality.
- Any desired adaptation to COVID-19 assessments or monitoring specific to the use case.

10.4.1 Applicable Pilot Themes

Any of these functionalities can be integrated in a set of SHAPES pilot themes:

- PT1 – Smart Living Environment for Active Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT4 – Psycho-social and Cognitive Stimulation Promoting Wellbeing.

10.4.2 Adaptations for PT1-UC004 and PT4-UC002

In both pilot use cases, the ARI robot is required to measure temperature and alert caregivers if it is too high, to detect potential COVID-19 users. For this, several hardware and software adaptations have been made.

10.4.2.1 Concept and Ideation Stage

Additionally to what is described in section 5.1, the robot should, as part of this pilot, measure temperatures using a thermal camera to older adults living alone or in sheltered apartments. As such, there is an additional pilot/use case requirement included in the following table.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Table 139 - Applicable Pilot/Use Case Requirements

Pilot/Use Case Requirements	Description	Fulfil (Y/N)	Comments
No code	Temperature monitoring and alert system.	Y	Thermal camera added to the robot system integrated (Twillio calls, GMAIL).

10.4.2.2 Design and Development Stage

A web-based interface has been developed that measures the temperature of the person once it verifies it is inside the silhouette. If temperature is too high, the robot offers the option to send a voice alert using Twillio. Based on mock-up feedback, this option will be also extended to email. Temperature is stored in Celsius degrees alongside its accuracy (Figure 203).

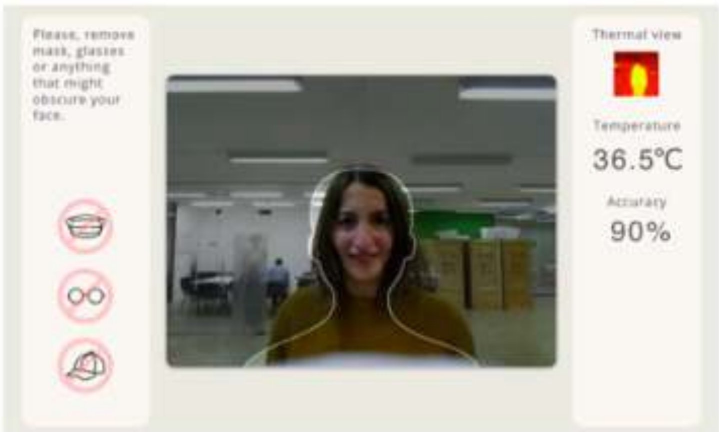


Figure 203 - Temperature Monitoring Interface: if high temperature is detected, pop-up appears to ask if the user wants to send a voice alert

10.4.2.3 Prototyping and Adaptation Stage

A thermal camera has also been added to provide temperature monitoring (COVID-19 solution) on the head of the robot, as indicated in section 5.1.4.3, and uses the Head RGB-D camera for visual feedback of the face. New Rest endpoints have been added:

- http://ari-Xc/topic/temperature -> custom ROS msgs including Temperature (celsius) and accuracy (float).
- http://ari-Xc/topic/head_front_camera -> head RGB-D camera stream.
- http://ari-Xc/topic/thermal_rgb_debug -> thermal camera output image.

As next step, and based on hands-on training feedback, this data will be sent through REST to eCare (section 3.2) to monitor temperature progress.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

10.5 Robotics for COVID-19 Response Support (KOM)

The outbreak of COVID-19 has continued to seriously affect the daily lives of citizens and the economies of every country around the globe. To prevent the spread of the virus KOMPAI offers 2 optional modules on the robots that will be used in SHAPES: a module for the disinfection of areas (rooms, common rooms) and a wireless temperature measurement module.

Disinfection module

This module consists of transforming the Kompaï robot into a disinfection robot. Thanks to the walking assistance bar, this module is plugged into the standard robot in plug and play mode. Kompaï offer two disinfection technologies for this module:

UV-C technology

This technology, proven for decades, can destroy 99.99% of pathogens by exposing surfaces to be disinfected to radiation for a period of time.

Disinfection capability of the proposed module: 13 min to disinfect a room of 20 square meter.

Spraying of EC approved chemicals product

This system consists of spraying a chemical product through a nebuliser. This product complies with European standards and is widely used in crisis situations such as COVID-19. Compared to the UV system above, it is suitable for large surfaces and also faster since it is enough to spray and continue on its way. to disinfect an area of 20 square meters it takes less than a minute. Same as the UV technology, this disinfection system can destroy 99.99% of pathogens.

The usage scenario for this disinfection option is as follows:

- Mapping of the area (rooms, corridors) to be disinfected. This mapping is performed by driving manually the robot through the area to be disinfected),
- Construction of the robot path (a set of predefined points of interest) covering the complete disinfection of the area. This construction is made by a dedicated algorithm considering the embedded disinfection capability and the size of this area.
- Automatic disinfection task. This task consists of making the robot navigate autonomously through this path while stopping at each point of interest for the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

time necessary to ensure the disinfection of each elementary for the UV technology.

Body Temperature Measurement

To answer this function, Kompaï proposes to add a thermal camera module on the KOMPAÏ robot for non-contact body temperature measurement. This assessment may be used:

- as part of an initial check at entry points (of hospitals, nursing homes) to identify and triage people who may have elevated temperatures, and
- continued monitoring inside nursing homes, hospitals, during robot patrol.

Additionally, new features must be integrated in the robot such as:

- Person identification via facial recognition. It is very important that the robot authenticates the user, so that the measured temperature is affected to the right person.
- Integrate Speech-enabled ROSA in the robot so that ROSA can inform person having high temperature to take the necessary preventive measures (keep distance form others, get in contact with doctors).

10.5.1 Applicable Pilot Themes

In SHAPES, these plug-and-play functions will be adapted to a specific COVID-19 module that will meet the pilot specifications associated with the following pilot themes:

- PT1 – Smart Living Environment for Active Ageing at Home;
- PT2 – Improving In-Home and Community-based Care.

10.6Symptom Checker (ULS)

The Ulster University's COVID-19 symptom checker application can be executed on an Android smartphone or tablet. This provides a portable electronic tool that can be used by people with varying levels of digital experience. The App provides various functionalities and features as follows.

Primarily the app is a COVID-19 symptom checker. Demographic information including the user's age and gender, and involvement in the general flu vaccine

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

programme are collected. The user is then presented with a series of COVID-19 symptom check questions, for example whether they have a new continuous cough or are experiencing a loss of smell. The presence of any of these symptoms triggers additional questions related to symptoms, comorbidities and risk factors. These may include whether the user has problems with their immune system, is experiencing difficulties carrying out their normal routine or is having breathing difficulties. The advice is tailored according to the severity of the symptoms and risk factors, and can range from instructions for self-isolation, booking a COVID-19 diagnostic test or seeking immediate care. These instructions are currently tailored for the Northern Ireland context and are based on guidelines from HSCNI. The App provides immediate feedback providing actionable advice that may encourage an individual to seek early medical intervention. A number of screen shots of the App are provided in Figure 204 204.

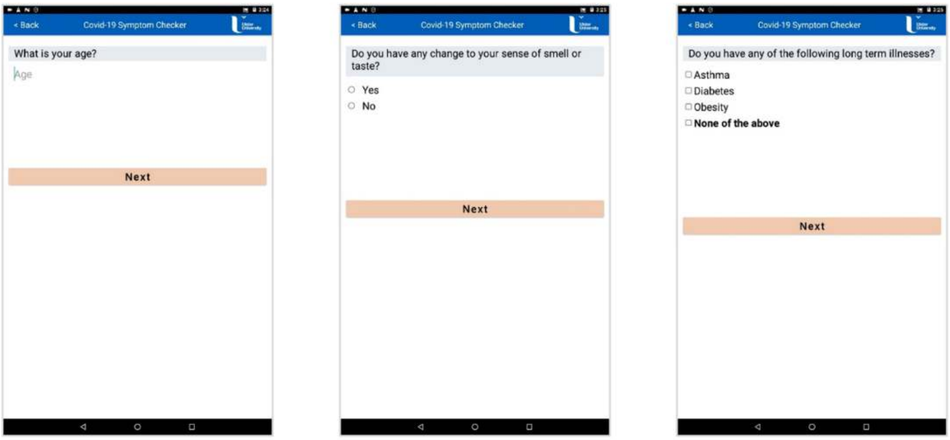


Figure 204 - Selection of Screen Shots taken during Interaction with App

As the symptom checking functionality is available offline the user is not dependent on having a reliable Internet connection and, therefore, the App can be used at any time of the day and in any location.

Demographic information can be stored in the App so as to increase the efficiency of user interactions.

The App also records user interactions and events and subsequently this data can be used to derive usage patterns.

10.6.1Technical Specifications

The App is currently a standalone Android based app, however it is easily extensible to support communications with web services, for example using the HTTP protocol and JavaScript Object Notation (JSON) documents. This could allow for multiplatform

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

support of the app and could support cloud-based algorithm logic. The current symptom checking functionality is based on a probability/rule-based algorithm.

10.6.2 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT3 – Medicine Control and Optimisation.

10.7 AccessEarth (AELTD)

Access Earth are building the world's largest database of accessibility information through crowd sourcing and deep tech data collection technologies. Part of Access Earths role within the SHAPES platform is to provide insights into the accessible landscape for designated pilot sites while also providing this information to participants in an intuitive and interactive manner.

Due to the global pandemic of COVID-19, how businesses, restaurants, shops and other venues operate, with regards to their social distancing procedures, can be a barrier to entry for those within the SHAPES project scope. In essence, COVID-19 information is now accessibility information and therefore falls under the remit of data to be gathered by the Access Earth data gathering tool.

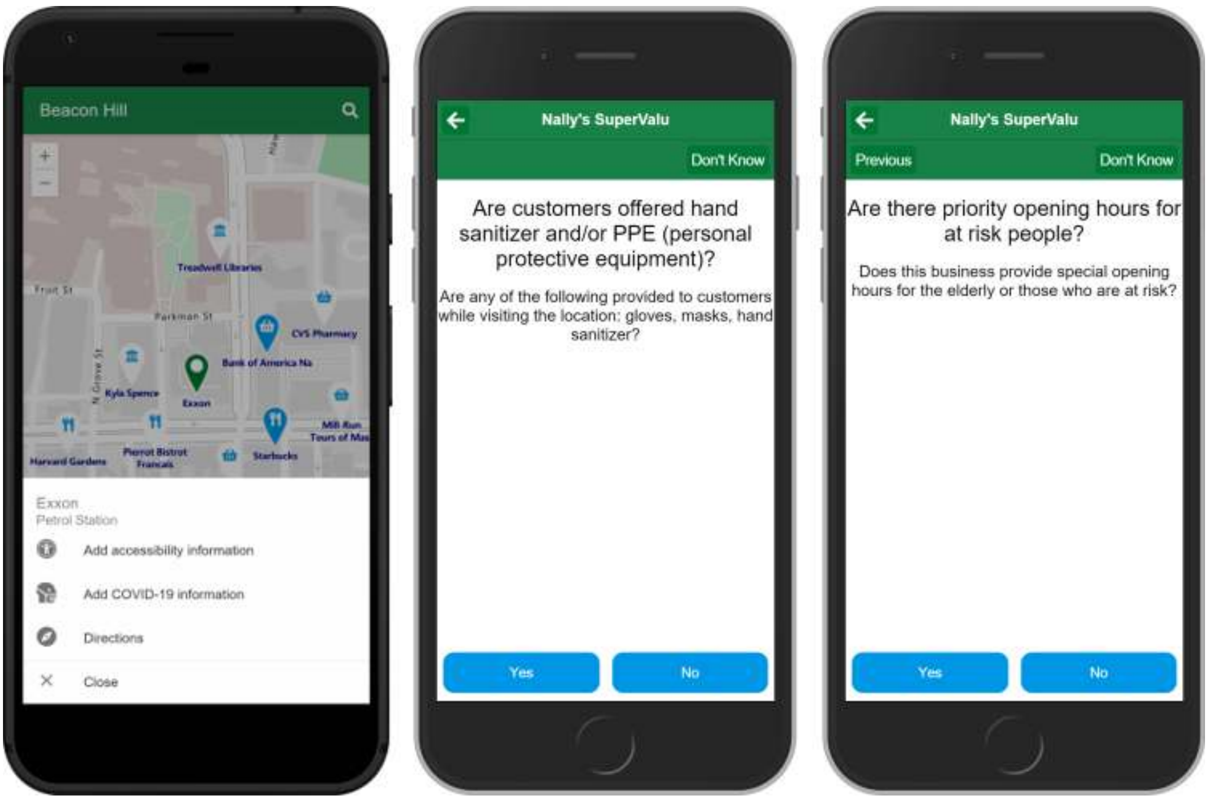


Figure 205 - Access Earth Digital Solution for COVID-19 Response

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

App Integration

Thanks to the modular manner in which the Access Earth data gathering tool has been designed, adding social distancing criteria to complement the already existing accessibility criteria was able to be integrated seamlessly, from the user's perspective, without requiring an extensive UI layout redesign.

The app now shows accessibility information and COVID-19 information options when selecting a desired location and will prompt the user to begin answering questions if a desired spot does not have one or both of the criteria already answered.

This data is then fed directly into the Access Earth platforms database, ready for further adaption with the standard plugin/API integration offerings provided by Access Earth.

10.7.1 Applicable Pilot Themes

- PT1 – Smart Living Environment for Healthy Ageing at Home;
- PT2 – Improving In-Home and Community-based Care;
- PT7 – Cross-border Health Data Exchange Supporting Mobility and Accessibility for Older Individuals.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

11 SHAPES Front-end App

Proposed by EDGENEERING, the **SHAPES Front-end App** is a new development in the SHAPES project and it is designed to function as an archetype, to be used by all pilot use cases, as a single access point to the SHAPES Digital Solutions ecosystem.

Indeed, as described in the previous chapters of this document, SHAPES does gather a wide plethora of digital solutions developed by different partners with the common goal of improving the quality of life of older individuals, while maintaining and extending their independence and autonomy at home settings. To allow the pilot use cases to benefit of the largest possible number of digital solutions, the **SHAPES Front-end App** provides an artificial mechanism to deliver a simple user interface and a centralised access to all the SHAPES digital solutions supporting each pilot use case.

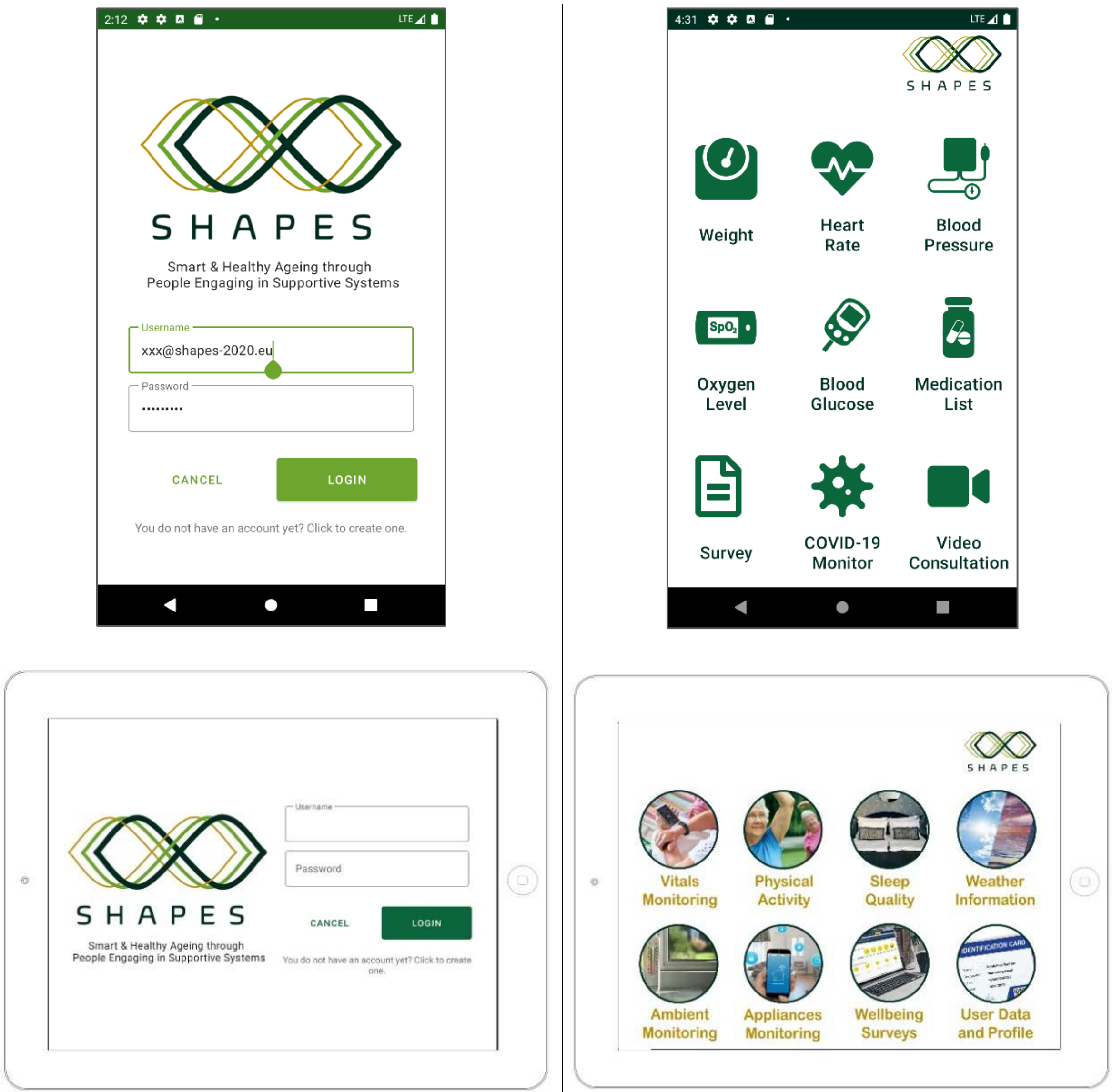
As a simple user interface providing a centralised access to the SHAPES Platform, the **SHAPES Front-end App** provides the login screen and a menu screen, which displays, as buttons, the different features/functionality of the digital solutions supporting the use case. These features are represented by illustrative images or icons and, by clicking on the buttons, users launch the feature/functionality provided by a specific SHAPES digital solution they need to interact with, following the pilot use case's research protocol. The login screen makes use of the SHAPES Single Sign-On (SSO) mechanism (see Deliverable D4.1 – *SHAPES Technological Platform (TP) Requirements and Architecture* [3]) to authenticate the user in the SHAPES Platform. The authentication process is based on a pseudonymised user identification and password and it may include user-friendly biometric accesses, such as face recognition and fingerprinting. Following the user's successful authentication, the **SHAPES Front-end App** grants access to the different SHAPES Digital Solutions installed in the device and the user can benefit from their many functionalities.

Overall, this simplistic approach aims to meet the specific characteristics of the targeted users by the SHAPES pilot use cases – older people – that are likely to have low technological skills and experience difficulty using novel technologies in their smartphones or tablets. With the **SHAPES Front-end App**, older individuals may find in one easy-to-use interface all the digital solutions they have to interact with for the purposes of the pilot use case they are involved with. Also, they only need to identify and authenticate themselves once in the SHAPES Platform to access all SHAPES digital solutions installed in the device, instead of having to identify and authenticate themselves in each of the digital solutions supporting the pilot use case. As a user-friendly approach, the **SHAPES Front-end App** intends to reduce any interaction challenges displayed by users and to enable higher levels of user acceptance.

The design of **SHAPES Front-end App** follows the visual identity and branding of the SHAPES project, namely its logo and colour theme. Also, similarly to the design of the SHAPES project's official website, it was considered the use of images to identify the

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

specific pilot use case's features/functionalities provided by specific SHAPES digital solutions. Alternatively, the screen used icons to identify those features. Below, it is provided the **SHAPES Front-end App** snapshots of its two screens, with the two display alternatives (images and icons) presented to the SHAPES partners.



Authentication Screen:
User Password Authentication

Main screen providing centralised access to key functions provided by different SHAPES Digital Solutions.

Figure 206 - SHAPES Front-end App: Snapshots

The **SHAPES Front-end App** runs on Android devices above Android 5.0 (API 21). The open source code of the **SHAPES Front-end App** is available in GitHub (https://github.com/SHAPES-H2020/Front-end-App), allowing the collaborative development by technical SHAPES partners and ensuring the right connection to Digital Solutions and specific functionalities is implemented, as they support SHAPES piloting activities. As a result, the second screen of the SHAPES Front-end App is adapted to meet the specific requirements of each pilot use case. Several meetings between EDGE and the SHAPES partners organising the pilot use cases were held to ensure that the selected final designs would meet the pilot use case organisers' requirements and expectations. The following figures present a set of mock-up designs and reflect the adaptations already implemented in for several of the pilot use cases being prepared.

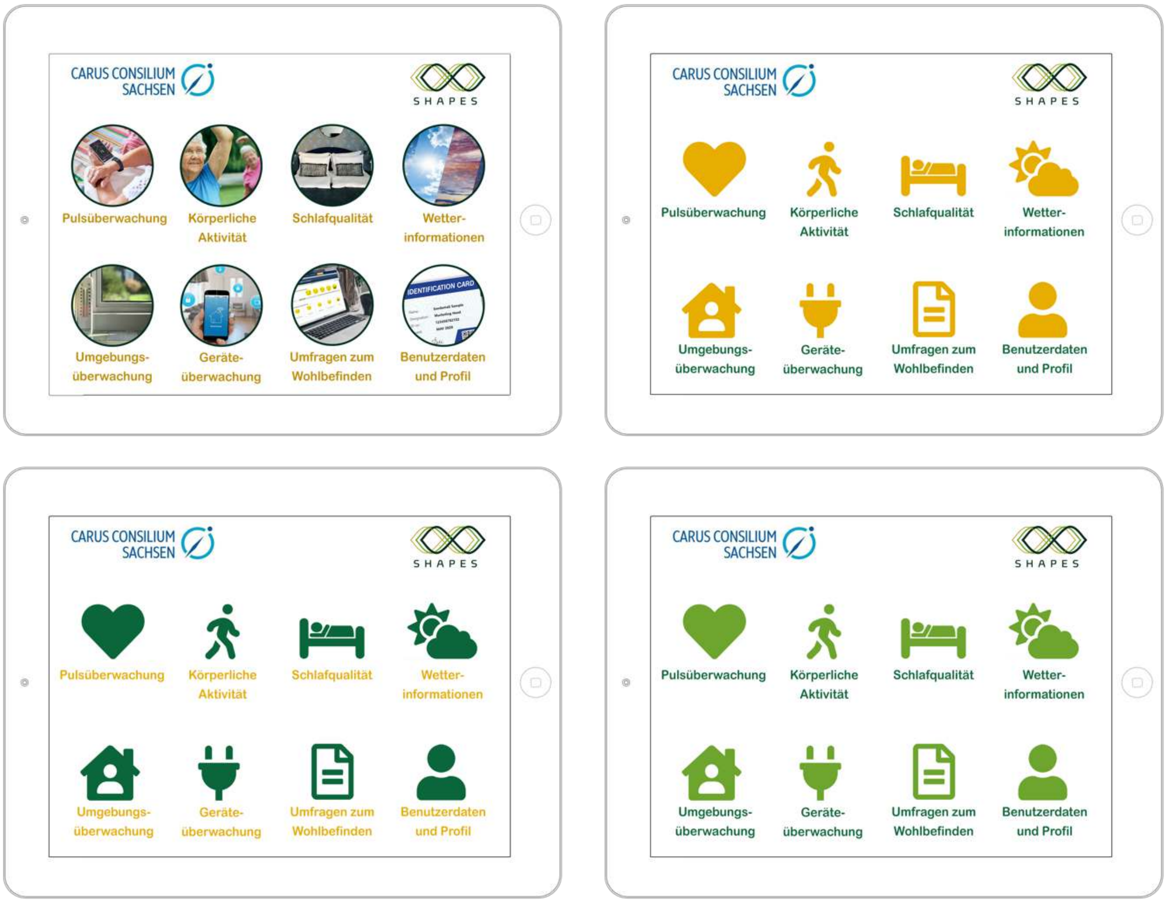


Figure 207 - SHAPES Front-end App for PT1-UC001

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

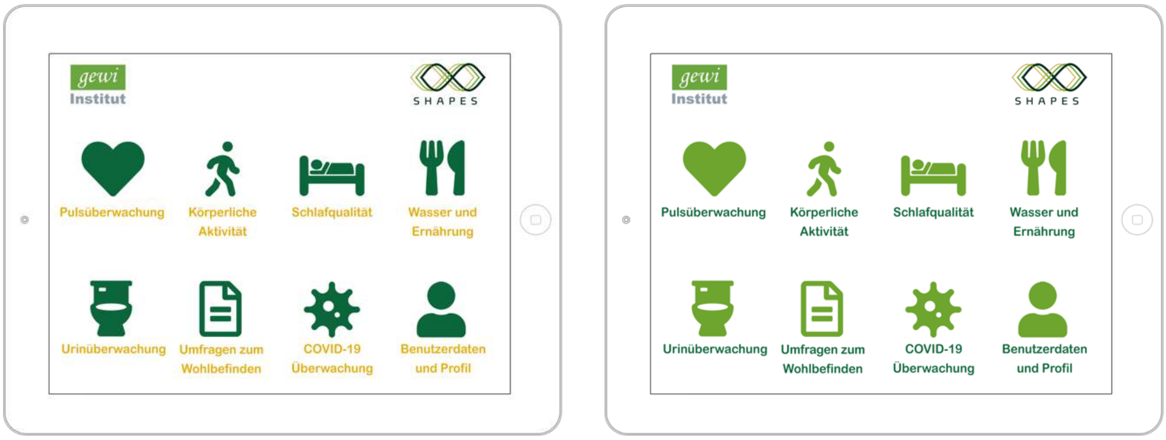


Figure 208 - SHAPES Front-end App for PT2-UC001

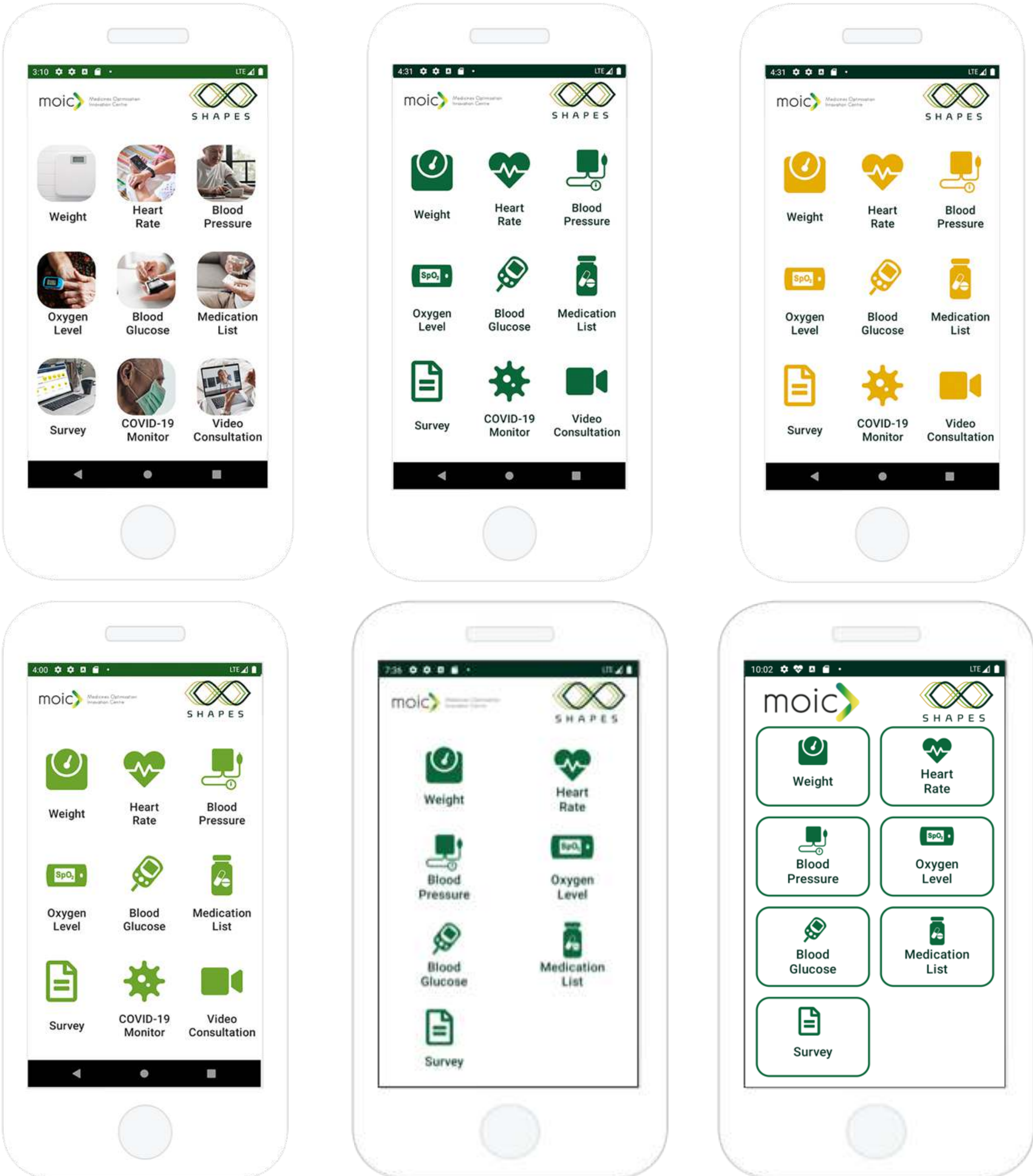


Figure 209 - SHAPES Front-end App for PT3-UCGeneral

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

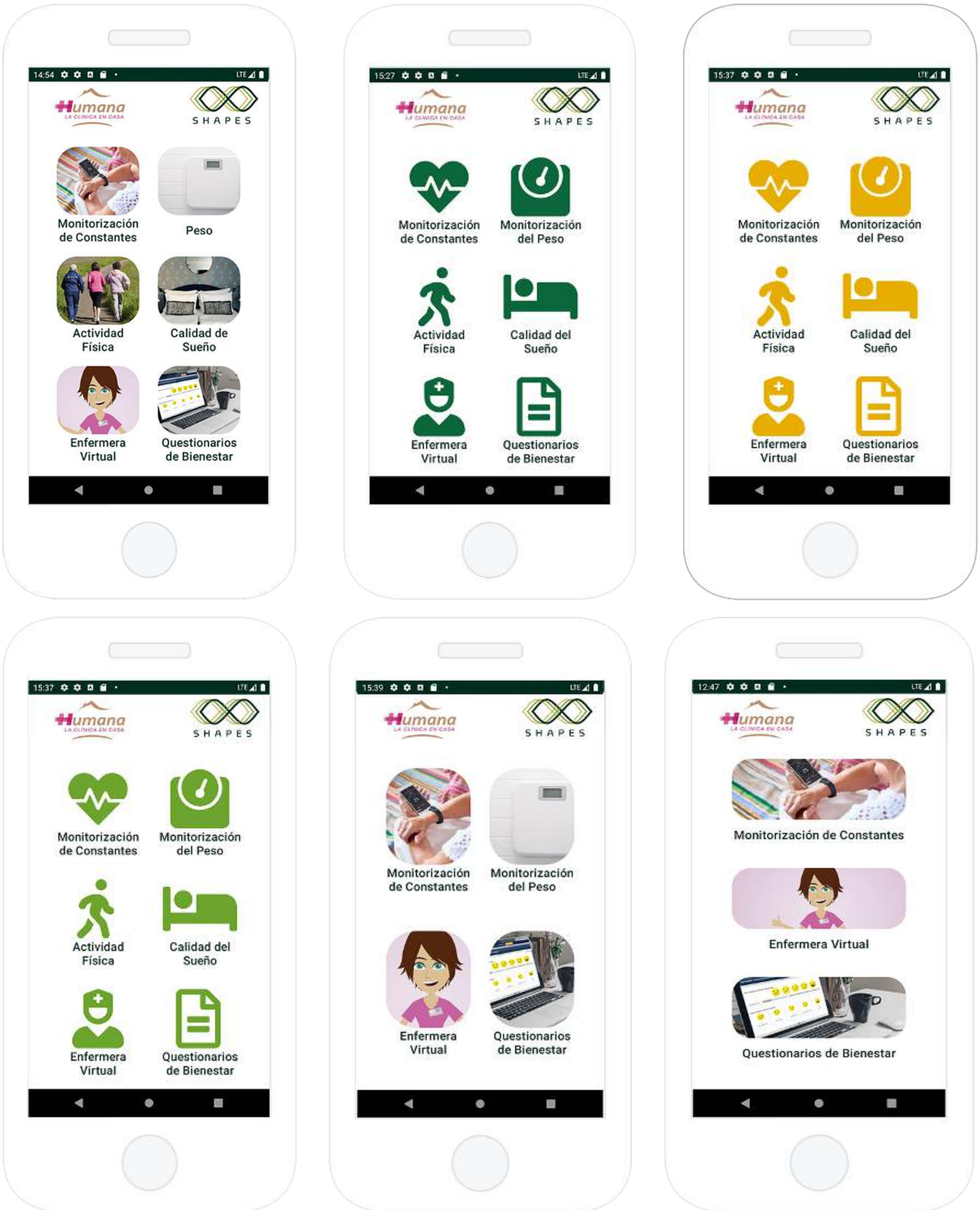


Figure 210 - SHAPES Front-end App for PT3-UC001

12 Conclusion

This report constitutes the intermediate result of the seven tasks currently active in WP5: T5.2 - Solutions for SHAPES Intelligent Living and Care Environment, T5.3 - Applications Suite for Healthy Ageing, T5.4 - Robotics and Assistive Technologies, T5.5 - Decision Support and Risk Assessment and Prediction Services, T5.6 - Solutions for Health and Care Service Providers, T5.7 - Lifestyle Management and Wellbeing Assessment Solution and T5.8 - Security Assessment As a Service. It presents the panoply of Digital Solutions brought by the partners to the SHAPES ecosystem to support the execution of a large-scale piloting campaign that aims to validate the added-value and impact of digital solutions for the improvement of older people's quality of life and for the optimisation of efficiencies in the delivery of health and care across Europe. The SHAPES Digital Solutions will not only support the SHAPES project's seven pilot themes and associated use cases but also be a key element in the SHAPES's strategy to exploit the project's results and shape the market into trusting, accepting and adopting innovative digital solutions for independent living and active and healthy ageing.

The initial descriptions of the SHAPES partners' digital solutions to be deployed in SHAPES pilots have been updated with the description of the thorough work conducted to adapt each digital solution to meet the SPHINX specifications and adequately provide support to the project's piloting activities. This alignment has been developed through a truly co-design and co-development effort that joined end-users and technical partners in the identification of the right features and capabilities to meet the different needs and expectations of SHAPES stakeholders as they take part in the SHAPES endeavour.

This deliverable will be further updated in month 36 or October 2022, with the new version (D5.4 – *SHAPES Digital Solutions V3*) focusing on the achievements and outcomes of WP5 tasks in the upcoming twelve months (from month 25 or November 2021 to month 36 or October 2022), as the SHAPES piloting campaign attains its full deployment across Europe and a valuable body of knowledge and evidence becomes available to assess the impact of SHAPES digital solutions in sustaining and extending healthy and independent living for older individuals who are facing permanently or temporarily reduced functionality and capabilities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

13 Ethical Requirements Check

The focus of this compliance check is on the ethical requirements defined in D8.4 – *SHAPES Ethical Framework* [42] and having impact on the SHAPES solution (technology and related digital services, user processes and support, governance-, business- and ecosystem models). In the left column, there are ethical issues identified and discussed in D8.4 (corresponding D8.4 subsection in parenthesis). For this deliverable, relevant requirements have been identified. For the requirements not relevant for the deliverable, N/A was entered in the right-hand column.

Table 140 - Compliance Check on Ethical Requirements

Ethical issue (corresponding number of D8.4 subsection)	How we have taken this into account in this deliverable (if relevant)
Fundamental Rights (3.1)	Fundamental Rights have been considered in the SHAPES System Specifications, namely those applicable to the SHAPES Digital Solutions, and in the design and development of the Digital Solutions brought to SHAPES.
Biomedical Ethics and Ethics of Care (3.2)	Biomedical Ethics and Ethics of Care were considered in the design and development of the Digital Solutions brought to SHAPES.
CRPD and supported decision-making (3.3)	SHAPES Digital Solutions aim to support older individuals, including those experiencing disabilities, to retain their right to make decisions and live independently. Accessibility features are observed in the design and development of the Digital Solutions brought to SHAPES.
Capabilities approach (3.4)	SHAPES Digital Solutions aim to support older individuals to live independently, enjoying an active and healthy life. Promoting their internal capabilities and active agency is observed in the design and development of the Digital Solutions brought to SHAPES.
Sustainable Development and CSR (4.1)	SHAPES Digital Solutions aim to support older individuals to live independently and enjoy active and healthy life. Using a co-creation process, the promotion of good health, wellbeing and education is observed in the development of the Digital Solutions brought to SHAPES.
Customer logic approach (4.2)	Customer-centric business logic has been a reference for the design and development of the Digital Solutions brought to SHAPES.
Artificial intelligence (4.3)	Artificial Intelligence is addressed by the SHAPES Digital Solutions involving data analytics (sections 6 and 8) and chatbot (section 4.10).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

Ethical issue (corresponding number of D8.4 subsection)	How we have taken this into account in this deliverable (if relevant)
Digital transformation (4.4)	Digital transformation goals are met by the SHAPES Digital Solutions, specifically addressing the use of digital tools for citizen empowerment and for person-centred care, in compliance with data protection rules.
Privacy and data protection (5)	Privacy and data protection are considered in the SHAPES System Specifications, being applicable to the SHAPES Digital Solutions, and in the design and development of the Digital Solutions brought to SHAPES.
Cyber security and resilience (6)	Cyber security and resilience are considered in the SHAPES System Specifications, being applicable to the SHAPES Digital Solutions, and in the design and development of the Digital Solutions brought to SHAPES.
Digital inclusion (7.1)	The SHAPES co-creation process, actively involving users, namely older individuals, in the design and development of the Digital Solutions brought to SHAPES are indicative of how the digital inclusion principles have been duly considered by the SHAPES Digital Solutions.
The moral division of labour (7.2)	SHAPES Digital Solutions support citizen empowerment and person-centred care, thus fostering the conditions to enable older individuals to be better informed and make informed responsible choices concerning their own health and care.
Caregivers and welfare technology (7.4)	The SHAPES co-creation process, actively involving users, namely caregivers and professional carers, in the design and development of the Digital Solutions brought to SHAPES are indicative of how the impact of welfare technology in the health and care working community has been duly considered by the SHAPES Digital Solutions.
Movement of caregivers across Europe (7.4)	The movement of caregivers across Europe is considered by the SHAPES Digital Solutions, as they address the caregivers' perspective, supporting health literacy, training and education, reducing workload and facilitating the reconciliation of family and care responsibilities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

14 References

[1] SHAPES Consortium (2020). D5.2 – SHAPES Digital Solutions V1. October 2020.

[2] SHAPES Consortium (2021). D2.7 – SHAPES Personas and Use Cases V3. June 2021.

[3] SHAPES Consortium (2020). D4.1 – SHAPES Technological Platform Requirements and Architecture. October 2020.

[4] SHAPES Consortium (2020). D5.1 – SHAPES User Experience Design and Guidelines. July 2020.

[5] Eurostat. (2019) Ageing Europe - 2019 edition. Looking at the lives of older people in the EU. Luxembourg: Publications Office of the European Union.

[6] Bamidis, PD., Fissler, P., Papageorgiou, SG., Zilidou, V., Konstantinidis, EI., Billis, AS., Romanopoulou, E., Karagianni, M., Beratis, I., Tsapanou, A., Tsilikopoulou, G. Gains in cognition through combined cognitive and physical training: the role of training dosage and severity of neurocognitive disorder. Frontiers in Aging Neuroscience, 7, 152 (2015).

[7] Jo, A.; Coronel, B.D.; Coakes, C.E.; Mainous III, A.G. Is there a benefit to patients using wearable devices such as Fitbit or health apps on mobiles? A systematic review. The American Journal of Medicine, 2019,132, 1394–1400.

[8] De Cillisy, F., De Simioy, F., Guidoy, F., Incalzi, R.A., Setolay, R., 2015. Fall-detection solution for mobile platforms using accelerometer and gyroscope data, in: Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS, pp. 3727–3730.

[9] Wu, F., Zhao, H., Zhao, Y., Zhong, H., 2015. Development of a wearable-sensor-based fall detection system. International Journal of Telemedicine and Applications 2015. doi:10.1155/2015/576364.

[10] Tsinganos, P., Skodras, A., 2017. A smartphone-based fall detection system for the elderly. International Symposium on Image and Signal Processing and Analysis, ISPA, 53–58doi:10.1109/ISPA.2017.8073568.

[11] De Quadros, T., Lazzaretti, A.E., Schneider, F.K., 2018. A Movement Decomposition and Machine Learning-Based Fall Detection System Using Wrist Wearable Device. IEEE Sensors Journal 18, 5082–5089. doi:10.1109/JSEN.2018.2829815.

[12] Abbate, S., Avvenuti, M., Bonatesta, F., Cola, G., Corsini, P., Vecchio, A., 2012. A smartphone-based fall detection system. Pervasive and Mobile Computing 8, 883–899.

[13] Kwolek, B., Kepski, M., 2014. Human fall detection on embedded platform using depth maps and wireless accelerometer. Computer Methods and Programs in Biomedicine 117, 489–501.

[14] Lewis, J.R. Psychometric evaluation of the PSSUQ using data from five years of usability studies. International Journal of Human-Computer Interaction2002,14, 463–488.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

[15] Bangor, A.; Kortum, P.T.; Miller, J.T. An empirical evaluation of the system usability scale. Intl. Journal of Human–ComputerInteraction2008,24, 574–594.

[16] Martins, A.I.; Queirós, A.; Silva, A.G.; Rocha, N.P. ICF based Usability Scale: evaluating usability according to the evaluators' perspective about the users' performance. Proceedings of the 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion, 2016, pp. 378–383.

[17] Martins, A.I.; Queirós, A.; Cerqueira, M.; Rocha, N.; Teixeira, A. The international classification of functioning, disability and health as a conceptual model for the evaluation of environmental factors. Procedia Computer Science 2012, 14, 293–300.

[18] Martins, A.I.; Queirós, A.; Rocha, N.P. Validation of a usability assessment instrument according to the evaluators' perspective about the users' performance. Universal Access in the Information Society, 2020, 19, 515–525.

[19] Martins, A.I.; Rosa, A.F.; Queirós, A.; Silva, A.; Rocha, N.P. Definition and validation of the ICF–usability scale. Procedia Computer Science, 2015, 67, 132–139.

[20] Bazarevsky, V., Kartynnik, Y., Vakunov, A., Raveendran, K., Grundmann, M. (2019) "BlazeFace: Sub-millisecond neural face detection on mobile GPUs." CoRR abs/1907.05047.

[21] Howard, A.G., Zhu, M., Chen, B., Kalenichenko, D., Wang, W., Weyand, T., Andreetto, M., Adam, H. (2017) "MobileNets: Efficient convolutional neural networks for mobile vision applications." CoRR abs/1704.04861.

[22] Sandler, M., Howard, A.G., Zhu, M., Zhmoginov, A., Chen, L. (2018) "MobileNetV2: Inverted residuals and linear bottlenecks." Proc. CVPR, pp. 4510–4520.

[23] Liu, W., Anguelov, D., Erhan, D., Szegedy, C., Reed, S.E., Fu, C., Berg, A.C. (2016) "SSD: Single shot multiBox detector." Proc. ECCV, LNCS, Vol. 9905, pp. 21–37.

[24] Kartynnik, Y., Ablavatski, A., Grishchenko, I., Grundmann, M. (2019) "Real-time facial surface geometry from monocular video on mobile GPUs." CoRR abs/1907.06724.

[25] Tan, M., Le, Q.V. (2019) "EfficientNet: Rethinking model scaling for convolutional neural networks." Proc. ICML, PMLR, Vol. 97, pp. 6105–6114.

[26] Boddeti, V. N. (2018) "Secure face matching using fully homomorphic encryption." Proc. BTAS, pp. 1-10.

[27] Kortli, Y., Jridi, M., Al Falou, A., Atri, M. (2020) "Face recognition systems: A survey." Sensors, Vol. 20, 342.

[28] Reddi, V.J., Kanter, D., Mattson, P., et al. (2020) "MLPerf mobile inference benchmark." CoRR abs/2012.02328.

[29] R. May, P. Hanrahan, D. A. Keim, B. Shneiderman, and S. Card. The state of visual analytics: Views on what visual analytics is and where it is going. 2010 IEEE Symposium on Visual Analytics Science and Technology, 2010, pp. 257–259.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159

[30] Del Din S, Hickey A, Ladha C et al. Instrumented gait assessment with a single wearable: an introductory tutorial [version 1; peer review: 1 approved, 1 approved with reservations]. F1000 Research 2016, 5:2323 (https://doi.org/10.12688/f1000research.9591.1).

[31] S. Mangini, P. V. Pires, F. G. M. Braga, and F. Bacal. Decompensated heart failure. Einstein, vol. 11, no. 3, pp. 383–391, 2013.

[32] P. Ponikowski, A. A. Voors, S. D. Anker et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: the task force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) developed with the special contribution of the Heart Failure Association (HFA) of the ESC. European Heart Journal, vol. 37, no. 27, pp. 2129–2200, 2016.

[33] W. T. Abraham, S. Compton, G. Haas et al. Intrathoracic impedance vs daily weight monitoring for predicting worsening heart failure events: results of the Fluid Accumulation Status Trial (FAST). Congestive Heart Failure, vol. 17, no. 2, pp. 51–55, 2011.

[34] I. C. Gyllensten, A. G. Bonomi, K. M. Goode et al. Early indication of decompensated heart failure in patients on home-telemonitoring: a comparison of prediction algorithms based on daily weight and noninvasive transthoracic bio-impedance. JMIR Medical Informatics, vol. 4, no. 1, p. e3, 2016.

[35] N. Larburu, A. Artetxe, V. Escolar, A. Lozano, y J. Kerexeta. Artificial Intelligence to Prevent Mobile Heart Failure Patients Decompensation in Real Time: Monitoring-Based Predictive Model», Mobile Information Systems, 2018.

[36] Kononowicz A, Zary N, Edelbring S, Corral J, Heg I. 2015. Virtual patients - what are we talking about? A framework to classify the meanings of the term in healthcare education. BMC medical education 15:11. Online available from: http://www.biomedcentral.com/1472-6920/15/11.

[37] Wood DF. Problem based learning. BMJ. 2003;326(7384):328–330.

[38] Hamdy H, Al-Moslih A, Tavarnesi G, Laus A. Virtual patients in problem-based learning. Medical education. 2017 Apr 10;5(51):557-8.

[39] Dafli E, Fountoukidis I, Hatzisevastou-Loukidou C, Bamidis PD. Curricular integration of virtual patients: a unifying perspective of medical teachers and students. BMC medical education 2019; 19(1), 416.

[40] World Health Organisation. (1946). *Constitution*. July. http://apps.who.int/iris/bitstream/handle/10665/121457/em_rc42_cwho_en.pdf.

[41] Jimenez Diaz, C. (1961). The paths of medicine. Revista Medica de Chile, *89*, 539–548. http://www.ncbi.nlm.nih.gov/pubmed/14451823.

[42] SHAPES Consortium (2021). D8.4 – SHAPES Ethical Framework. May 2021.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 857159