



## D7.6 KPI Evolution Report (I to IX) v6

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## Abstract

This is the fifth edition of the Key Performance Indicators (KPIs), KPIs Evolution report, which is mainly based on surveying the pilots about the updates of their experiments.

The report includes updated version of pilots' experiment and associated outcomes and **Impact Assessment KPIs**, as well as the preliminary work with the monitoring tools. Following the vision per pilot, an updated description is reported per Reference Use Case, including primary outcomes and related Impact Assessment KPIs. In this version, an updated overview of the **Operational KPIs** is described. Both Impact Assessment KPIs and Operational KPIs are presented as **descriptors** of the overall **ODIN Experiment Framework**.

These indicators, which include scales and evaluation techniques, were established as part of the WP7 tasks activities in a cooperative and collaborative effort with the pilots.

Furthermore, this report includes updates to the pilot experiment description, such as a new ODIN Pilot incorporation.

## Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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## List of abbreviations

Abbreviation	Explanation
ODIN	"ODIN - Leveraging AI based technology to transform the future of the health care delivery in Leading Hospitals in Europe" - Grant agreement number 101017331
AI	Artificial Intelligence
API	Application Programming Interface
DoA	Description of Action
Dx.x	Deliverable number x(WP number).x(number of the deliverable)
EIP on AHA	European Innovation Partnership on Active and Healthy Ageing
HCP	Health Care Professional
HCW	Health Care Worker
HTA	Health Technology Assessment
IA	Impact Assessment
ICT	Information and Communications Technologies
IoT	Internet of Things
IPJ	Innovative Procurement Journey
IPR	Intellectual Property Rights
KET	Key Enabling Technologies
KER	Key Enabling Resources
KPI(s)	Key Performance Indicator(s)
Mx	Project Month x
NHS	National Healthcare System
R&D&I	Research, Development and Innovation
RUC	Reference Use Case
SME	Small and Medium-sized Enterprises
Tx.x	Task x(WP number).x(number of the task)
UC	Use Case
WP	Work Package

# 1 About this deliverable

This deliverable, in this fifth edition, examines how Key Performance Indicators (KPIs) are effectively used as measurable values to show the evolution from the Operational side and the outcomes from the Impact side of the ODIN experiments pilot per pilot, and how they will evolve from a more general ODIN Project perspective.

Following the improved version of the pilots' experiment, a proper refinement of the Operational KPIs and Impact Assessment KPIs framework is detailed in terms of indicators and metric collection.

This document is linked to the Deliverables 7.1.2 (Pilot Studies Use case definitions and Key Performance Indicators (KPIs)), D7.2, D7.3, D7.4, D7.5 (KPI Evolution Report (I to VI)) and is part of the work done in the different tasks of the Work Package 7 (WP7. ODIN Pilots Design, Deployment, Evaluation and Validation).

Changes in Pilot settings will inevitably reflect a change and evolution in KPIs, as KPIs correctly evaluate how well the experiments are achieving and fulfilling their goals.

## 1.1 Deliverable context

Table 1 - Deliverable context

PROJECT ITEM IN THE DOA	RELATIONSHIP
Project Objectives	This deliverable is framed in the context of WP7 and contributes directly to the impact evaluation framework the ODIN experiments
Exploitable results	The results of this deliverable will be directly exploited by the technical work packages as well as WP2, WP9 and WP10 related to the open calls.
Workplan	The deliverable will be constantly updated according to the DoA. Our partners will be encouraged to provide constant up-to-date inputs regarding the pilot activities. Pilots' progress in this regard will be monitored and documented.
Milestones	This deliverable is linked to the deployment and running Phases
Deliverables	Related deliverables: D2.2, for the blueprint definition of the pilot needs; D2.3 the catalogue of technology, D7.1 the experiment definition and D7.2, D7.3, D7.4, D7.5 (KPI Evolution Report (I to VI) v1, v2, v3, v4)

**Risks**

Due to the changing nature of hospital contexts, some of the conditions outlined here may change over the course of the ODIN project.

## 1.2 Summary of key updates and modifications

In table below are reported the list of changes from D7.6

Table 2 - Changes between D7.5 and D7.6

SECTION	UPDATES/MODIFICATIONS
1	Deliverable context
2	Revised introduction
3	Revised description
4	Introducing new pilot SAS and RUCs
5	SAS description
8	Update of Operational KPI
9	Update of Impact Assessment KPI
10	Conclusions revised
App. A	Fully revised: Pilots descriptions, (ALL) Pilots' experiments definition, (ALL) defined timelines, (ALL) detailed technology, (ALL) primary outcomes (ALL) re-defined KPIs (ALL but MUL) SAS experiments

## 2 Introduction

Due to the Public dissemination level, some information in this document is already included in D7.1.2 Experiment definition.

For readability purposes as a standalone document, this deliverable includes the necessary forewords, concepts, and descriptions previously included in the earlier editions.

As stated in the DoA, the hospital becomes the primary infrastructure leading towards the necessary evolutions of the Industry 4.0. In fact, one out of three hospitals promoted or planned to adopt particular strategies or policies to implement new technological tools in the last five years. Technology is becoming increasingly prevalent in all parts of the hospital, not just for specific functions such as diagnosis and treatment, but also for managing logistical operations and procedures. Clinical algorithms, patient pathways, decision-assist tools, and optimisation techniques could be created using a combination of clinical skill, patient data, environmental resource availability, and the best available research findings. Evidence-Based Medicine (EBM) changed medicine by relying on the core notion that data-driven processes can significantly improve medicine's effectiveness and safety while keeping costs in check.

This Report Series provides a comprehensive overview of the project status, with a detailed measure of the experiments' evolution pilot per pilot.

**This fifth edition includes the pilots' update experiments with the new timelines the related Operational and Impact Assessment KPIs.** The main aim is to demonstrate how these indicators will effectively reflect the evolution of the ODIN experiment framework. For this, a new section, Section 9, has been included about the Impact Assessment KPIs.

Future releases we will also include the KPIs defined in the technical work packages, from WP3. Platform integration, Privacy, Security and Trust + knowledge + cognition to WP6. High Level Ecosystem for AI Operations.

This deliverable offers an up-to-date report of the ODIN Experimental Framework. All pilots have thoroughly revised their experiments upon the performed technology assessment. This version includes a full description of the new pilot SAS.

Overall, this report includes 10 sections and 1 appendix: **sections 1 and 2** provide the abstract and introduction. **Section 3** presents to the reader the framework we build to redefine the use cases (UCs) and defining reference uses cases (RUCs) and how we co-designed the experiments with the Pilots and all the technical partners. **Section 4** introduces the reference use cases. **Section 5, 6 and 7** delve into RUCs describing the phases and the goals and, where available, the KPIs, the involved staff, and the foreseen technology after the tech assessment. **Section 8** shows an overview of the Operational KPIs. **Section 9** presents an introduction to the Impact Assessment KPIs, and **Section 10** resumes the most important points achieved in this deliverable. **Appendix A** shows the tools used in the co-designing process, and reports the Pilots descriptions and the experiments per each RUC they will deploy at the local level.

### 3 The ODIN Experiment framework

This section stems directly from the previous one with slight changes only because we followed the same approach.

The ODIN Experiment framework is a federation of case studies aiming to prove the positive impact of the ODIN Key Enabling Resources (KERs), AI, big data, robots, and IoT, on hospitals safety, quality and cost effectiveness.

The starting point is the research and innovation questions here described as the ODIN challenges, in the table below.

Table 3 - ODIN Challenges

Challenges and ODIN answers
<b>Challenge 1.</b> Financial challenges and hospital productivity Data-driven management will enable pervasive data collection, data analytics, real time in-hospital tracing of devices, workers and patients. This will enable optimisation of clinical and logistic processes while reducing the time required to accomplish common hospital tasks and optimise shared resources. Predictive analytic modelling will reveal ways to break down barriers between departments. eWorkers, eRobots, and eLocation will support this optimisation.
<b>Challenge 2.</b> Increase patient and staff safety Advance process for tracing people and medical tools/instruments will help to prevent exposure to risky areas (e.g., infections, electrocution). In case of infection events, ODIN will contribute to the early detection, monitor and intervention measures. The use of autonomous robots will prevent infections. The use of exoskeletons or lifters together with rehabilitation robots will improve the treatment of the patients, while enhancing working conditions of the professionals.
<b>Challenge 3.</b> Logistics, regulatory standards and energy mandates Tracing the real usage of medical locations and goods (e.g., drugs, furniture, medical devices), as well as the path of objects will help optimising internal/external processes, while ensuring the compliance with regulatory standards, facilitation the data exchange and adaptation to new regulations or digital standards.
<b>Challenge 4.</b> Hospital security ODIN surveillance services will contribute to reducing the risk of violence and theft, with support of small-size robots when personnel are not available (i.e., at night), contributing to avoid Mass Casualty Incidents. The use of robots for drugs/objects transportation will provide for more safety when there is a limited number of staff members. Moreover, the employment of block-chain will help facing emerging security issues, such as cybersecurity.
<b>Challenge 5.</b> Patient satisfaction (value-based healthcare). Health literacy and patient empowerment will start during the stay in the hospital with the use of robotic assistants that motivate and coach patients, preparing them for self-care after discharge, giving information, entertaining, making teleconferences with family.
<b>Challenge 6.</b> Too many avoidable patient days (reducing unneeded hospital stay). The ODIN platform will enable data collection from patient home/residence in the days after of the discharge, with the use of IoT support services, companions and rehabilitation robots, and cyber assistants. According to literature, these solutions contribute to better planning the transitional care models, preventing delay discharge and reducing readmissions.

## Challenges and ODIN answers

**Challenge 7.** Desire for physician integration but very few employed physicians'. Robotic assistants can support healthcare professionals in non-complex tasks (such as food provisioning), internal and external transport of devices and waste and cleaning related tasks. This will free time for staff-patient interactions.

**Challenge 8.** Unhealthy community The coordination with smart cities (in terms of air quality, transportation habits, etc) will contribute to create awareness and training campaigns. In case of patients performing transitional care pathway at home, the IoT sensors and the robotics support will enhance the self-care training.

**Challenge 9.** Poor communication between providers (industry 4.0) A mix of advanced analytical data, tracing devices, people and drugs and targeted interpersonal relations will reduce redundancies in communication and provide optimised communication channels and messages.

**Challenge 10.** Shortages of physician, nurse and well-trained healthcare professionals. The continuous data exchange and processing optimisation contribute the detection of the lack of training of the different types of staff providing mechanisms to apply the needed training mechanisms. The use of ODIN technologies and interactive tools will support staff and process optimisation.

**Challenge 11.** Disaster preparedness. The COVID-19 pandemic demonstrated the vastness of the number of EU hospitals are not prepared to face disasters. In the past 20 years, EU NHSs have reduced the critical beds in their hospitals (average ICU beds per million inhabitants per EU-Nations cut from 10k in 1990 to 3k in 2020[1]) moving the resulting saved budget to investments in non-hospital health services, in response to demographic challenges. While this is a necessity, these changes cannot be left to empirical attempts, but require EBM reasoning, scientific simulations and holistic approaches, supporting systemic responses from different hospital experts (clinical, technical, managerial), who now still work in silos in the majority of EU hospitals.

These challenges are meant to be deployed by the pilots within the following **areas of intervention**:

- Enhanced Hospital Workers (eWorkers)
- Enhanced Robots (eRobots)
- Enhanced Locations (eLocations)

The areas are defined as follows.

- **Enhanced Hospital Workers (eWorkers):** The aim is to look into how to provide appropriate technology to hospital staff (such as nurses, porters, technicians, and doctors) to improve their abilities and support their daily work. Technology will be employed to relieve workers of the weight of their daily tasks, allowing them to focus on the vital jobs that require all of their human abilities. Wearable technologies will be used to improve their 'senses,' increase their 'connectivity,' speed up their reasoning, and improve their physical traits. We will start with nurses and porters, utilising commercial technologies offered by project partners. Through Open Calls, new healthcare employees and technologies (such as virtual and augmented vision) will be added.
- **Enhanced Robots (eRobots):** The aim is to automate hospital processes that no longer require humans or can be improved by automatons. These robots will not necessarily be humanoid and will be used in the form of centrally synchronised swarms with some level of

autonomy. ODIN robots will have advanced perception functions (smell, vision, touch, taste, and hearing), extensive connectivity (with other robots, hospital assets, humans, and medical places), advanced AI reasoning capability (both locally and remotely), and task-performability (wheels, arms, hands, etc.). We will initially focus on the distribution of materials (drugs, food, disposables, consumables, and so on), the management of medical devices (e.g., preparing surgical equipment kits), and the facilitation of hospital processes (human navigation, reception, and patient surveillance) during the project. Other hospital processes will be added through Open Calls.

- **Enhanced Locations (eLocations):** The aim is to instrument medical locations to support hospital activities more proactively. In order to interact with personnel, robots, devices, and other necessary hospital assets securely and effectively, medical places will be improved with sensors (smell, vision, feel, taste, and hearing), technology for communicating with humans (screens, lighting, speakers), and high connection. Furthermore, eLocations will provide real-time data about their underlying technological infrastructures (e.g., power plants, water pipes, air conditioning, medical gases) that are vital for human safety (patients, visitors, and staff), as well as robotics, medical devices, and equipment. Initially, we will concentrate on lower-risk medical settings as part of the study (e.g., reception, diagnostics, laboratories, non-severe patient rooms). Other medical locations will be added through Open Calls.

To understand how the ODIN pilots had to design their experiment to address the challenges we started a co-creation process. In order to achieve a clear UCs definition and an experiment description pilot per pilot the co-creation work has been organised in three methodological steps:

- 1) The Proposition, Thesis, analysis of the UCs
- 2) The Deconstruction, Antithesis (or growing)
- 3) Production, Synthesis of UCs and Reference Use Cases definition

The step 1 was conducted from the beginning of the project during the WP7 meetings and bilateral calls with pilots. The main result of this phase is the template, called “Pilot Journey”, to orient/support the pilots in the preliminary experiment definition of the Step 2.

In the Step 2, from M4 to M7 pilots had to rephrase their own vision about the UCs. For this step different tool have been used:

- A template, from step1, the so-called “Pilot Journey”, administered to all the pilots in order to get their reflections and propositions about their specific needs in relation to each UC
- Focus groups were organised with each UC to discuss their answers to the questionnaires

The results were discussed with all the pilots. Below some excerpts are reported, and the full pilots’ descriptions can be found in Appendix A

These reports highlighted the need to harmonise the experiment descriptions, identifying commonality and stressing specificities.

This led to the Step 3. There were defined three RUCs leveraging on the initial UC description as per DOA and based on the pilots’ inputs to the ODIN UC.

The RUCs are the described in the next section and are the following:

- RUC A Health Services Management, including all the clinical use cases from the DoA, UC3, UC4, UC5;
- RUC B Devices and Facilities Management, including the UC1 and UC2
- RUC C Disaster Preparedness with the UC7

All the subsequent activities were organised following each RUC group to start defining pragmatic constrains, such as: ODIN partner available technology, Open Call challenges, and external factors.

It was chosen to adopt the WHO navigation diagram used in the “WHO list of priority medical devices for management of cardiovascular diseases and diabetes” (2021). In this publication, the priority medical devices that are discussed, selected and presented are organised by clinical units in a health service provision. The navigation diagram in the figure below represents the range of health-related interventions, from pre-hospital activities to highly specialised tertiary hospital-based care. The diagram has been adapted where the phases represent the departments/units required to perform the different tasks of the selected RUC.

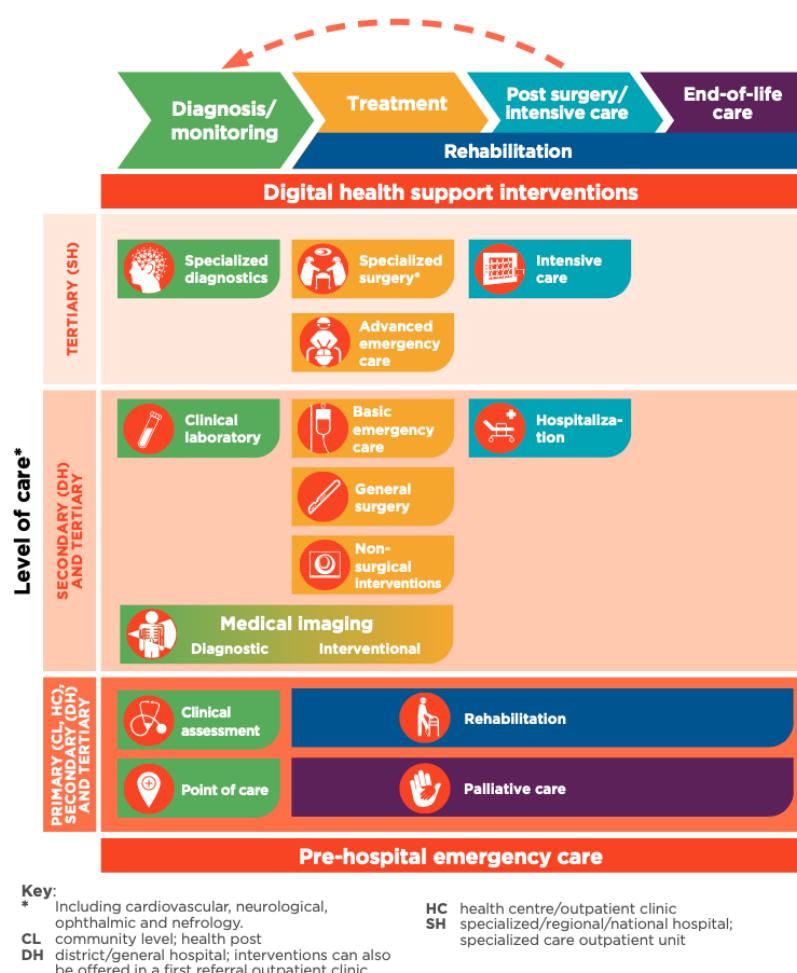


Figure 1 - WHO Navigation Diagram

The phases for each RUC were developed and revised during the workshops, and for each step, the pilots required to specify the Description, Goals / Outcomes, IA KPIs, Technology, and ODIN Contribution, as shown in the pictures below.

The process of KPIs further re-definition is undergoing in the Impact Assessment framework and involves not only the pilots but all the ODIN Partners.

The final goal of this phase is to achieve a **complete framework of indicators (ODIN KPIs journey) from different perspectives: experiment evolution (Operational KPIs), technology deployment (Technical KPIs), impact assessment (IA KPIs).**

## 3.1 ODIN Pilots

So far in the ODIN Experiment framework at M36 includes the pilots described below.

### 3.1.1 Charité - Universitätsmedizin Berlin, Germany (CUB)

Charité University Hospital has 3,000 beds and 14,000 employees. It is distributed over 4 campuses in the city of Berlin. It is one of the largest hospitals in Europe with a strong focus on excellent patient care and research. The aim is to combine patient care, medical research, education to provide best practice for the future of medical services in Europe.

The sleep medicine centre is part of Charité, linked to the department of pneumology. The sleep medicine centre has 10 beds for patient care and 2 beds for research studies. We have about 3,000 sleep studies in the hospital with polysomnography (sleep recording) per year and about 5,000 home sleep studies (with fewer signals recorded) per year. The staff includes pneumologists, neurologists, ENT physicians, cardiologists, engineers, specialised medical technologists, and nurses.

### 3.1.2 Medical University of Lodz, Poland (MUL)

Medical University of Lodz (MUL) is a higher state school having over 70 years-long history. With its 5 faculties, 3 teaching hospitals and 80 clinics, 9,500 students, 1,000 foreign students and approximately 1,600 academics, Medical University of Lodz belongs to the leading Polish medical universities. The University is strongly committed to scientific research in a number of health-related disciplines as well as national and international scientific cooperation. The University is considered a leader in the number of scientific publications and citations among medical schools in Poland. In 2022, MUL ranked 9th among Polish Universities, according to national 'High Schools Ranking Perspectives'. MUL's scientists conduct extensive basic and translational research. The Medical University of Lodz has reached the leading position in various research areas, and particularly in patient adherence and healthy ageing. In acknowledgment of these achievements, the Medication Adherence Research Centre (MARC) was founded in 2020 in MUL, headed by Prof. Przemyslaw Kardas.

MUL makes a substantial contribution to the development of the health care system by promoting modern standards of prophylaxis and treatment, and by building long-lasting cooperation with institutions realizing objectives of public health at regional, national and international levels. Last but not least, MUL is strongly committed to Silver Economy. Being formally recognised as the EIP on AHA Reference Site, MUL plays the key role in facilitation of collaboration between academia and industry, in order to transform the demographic challenge into opportunity. Initiating creation of dedicated businesses clusters, MUL is pioneering and helps boosting the local economy.

With its own complete ecosystem of healthcare services, covering full range of healthcare system levels, from primary health centres to tertiary teaching hospitals, MUL is perfectly well-placed for the purpose of testing and implementation of novel health technologies. Serving over 86,000 patients yearly, MUL is also one of the major local healthcare providers, active in each and every area of modern medicine. This potential will be of particular use within the framework of ODIN project.

### 3.1.3 Hospital Clínico San Carlos, Madrid, Spain (SERMAS)

This pilot is going to take place in Hospital Clínico San Carlos. Three main departments are going to be involved: the Procurement Department, the Cardiovascular Institute and the Innovation Unit.

The Procurement Department is in charge of the supply and logistics distribution of the medical equipment and consumable materials inside the hospital, being a key player in the smooth development of all clinical processes and procedures. This department has transversal action, so the problems we want to tackle affect the performance of the entire hospital.

The Cardiovascular Institute (ICV) represents around 48% of the total hospital's expenditure in medical equipment and consumables. Inside the ICV, the therapeutic areas dedicated to hemodynamic and electrophysiology have high-impact equipment and some of the best-described pathways for consumables provision.

Finally, the Innovation Unit is the hospital team that is part of the ODIN Consortium. It will act as bridge between the ODIN partners and the hospital staff.

### 3.1.4 Università Campus Bio-Medico di Roma, Italy (UCBM)

Università Campus Bio-Medico di Roma (UCBM) is a young, yet rapidly developing, private academic institution, devoted to undergraduate and postgraduate education, advanced research and provision of high-quality healthcare services with the Research Hospital. Established in 1992, today the University runs the School of Medicine and Surgery, the School of Engineering, the School of Science and Technology for Sustainable Development and One Health. In Italy, UCBM has been systematically top ranked for the quality of the education provided to a selected group of students. The institution has increasing:

- i) scientific production per year;
- ii) funding raised from competitive sources in Italy, Europe and worldwide (40+ research projects ongoing);
- iii) technology transfer activities (16 patents families owned/co-owned and 7 spin-off companies from 2015).

An outstanding network of national and international key scientific and educational partners, including 200+ national and international partners, has been continuously developed and consolidated with specific collaboration agreements over the years.

Within UCBM, the Geriatrics Unit conducts research activities in the following areas:

- i) evaluation of the elderly patient health condition, with particular focus on multidimensional evaluation techniques in various disorders or multimorbidity pattern;
- ii) evaluation of respiratory functions, with particular focus on the interpretation of spirometry results in elderly patients; study of diagnosis/prognosis properties of breath volatile organic compounds in the following disorders: heart failure, chronic obstructive bronchitis, obstructive sleep apnoea syndrome, diabetes mellitus, liver diseases;
- iii) development and application of remote telemonitoring systems for patients with chronic diseases;
- iv) pharmacoepidemiologic and epidemiologic geriatric research.

The Unit research activity can make use of a wide range of equipment for functional evaluations. It also has epidemiologic and statistical competences for the designing, planning, execution and analysis of interventional and observational epidemiological studies.

### 3.1.5 The University Medical Center Utrecht, the Netherlands (UMCU)

The University Medical Center Utrecht (UMCU) is one of the leading and largest medical centres in the Netherlands and ranks among the best European academic hospitals in international rankings. The core activity of UMCU is to provide healthcare for which special knowledge is required, provide leading research and offer excellent education to students, medical doctors, researchers and other healthcare providers. UMCU has a strong track record in both pre- and clinical research and forges strong links with companies and scientific institutions across the world.

UMC Utrecht's research focusses on six strategic themes, the ODIN projects fall into the Circulatory Health theme. Healthcare is divided over ten divisions, ODIN falls into the Division Laboratories, Pharmacy and Biomedical Genetics division, where the Central Diagnostic Laboratory is located. CDL's translational subunit ARCADIA (Academic Research for Clinical Applications of DIgnositcs) hosts the Utrecht Patient Oriented Database (UPOD).

Established in 2003, UPOD provides access to the comprehensive and complete electronic health record information of all patients that visited the UMC Utrecht since the 1990's. Overall, 650k individual patients that have been hospitalised were included. UPOD comprises more than 2.4 million individuals, including out-patients. The UPOD group in brief aims to improve clinical diagnostics using routine care data and is involved in efforts to turn the UMC Utrecht into a learning healthcare system.

The UMCU ODIN project members will work in close collaboration with the recently established (2020) UMCU department of Digital Health, which is located in the corporate (permanent) staff.

All projects within the UMCU use case will take place in the strategic theme Circulatory Health. Within this area, UMCU has established a Center for Circulatory Health where a multidisciplinary team sees every patient with a cardiovascular disease. The Circulatory health strategic area includes a long-standing research cohort (Utrecht Cardiovascular Cohort) that already encompasses 13,000+ patients. Combining the Center for Circulatory Health and Utrecht Cardiovascular Cohort efforts has led to the first steps towards transitioning patient care for cardiovascular disease patients into a learning healthcare system. Within this system we are currently developing (clinical decision) support systems. This is where ODIN has its home.

### 3.1.6 Servicio Andaluz de Salud, Andalucía, Spain (SAS)

The project is carried out within the Andalusian Health Service (SAS), which is the main health provider of the Public Health System of Andalusia, the most populated region in Spain, with more than 8.5 million inhabitants in 2023.

The pilot has two use cases that are developed in two of the most important SAS hospitals:

1. Virgen del Rocío University Hospital, a hospital complex located in Seville. It is the hospital with the highest capacity within the Andalusian Health Service and one of the largest in Spain. It has more than 8,000 professionals, 60 operating rooms and more than 1,500 beds.

In this case, the part of the pilot related to the perioperative process will be executed with the collaboration of the General Surgery and Digestive System service, one of the most complex services at the national level.

2. Virgen de las Nieves University Hospital, located in Granada, is another of the most important hospitals of the Andalusian Health Service, with more than 50,000 annual admissions.

In this case, the part to be worked is the TAVI process with the collaboration of the Cardiology service, a top-level service that has been a regional Andalusian reference for the treatment of all cardiovascular diseases in adult and pediatric patients for more than 25 years.

Both hospitals and services and their leaders are national references for the processes that will be addressed with ODIN and have the objective of validating remote patient care to support and enhance the follow-up.

The increase in life expectancy, the prevalence of chronic diseases and the need to ensure the sustainability of the healthcare system, without losing quality and efficiency in care, create the need to generate new organizational and service delivery models.

The solution proposed for implementation, Get Ready®, focuses on patient empowerment through information and education that allows them to take a relevant role and continue working on their care, with guides and guidelines described by their clinical professionals, allowing the care team to monitor these patients throughout the process, in a flexible way and adapted to the needs of each of them, also adding the opportunity to offer greater out-of-hospital continuity of care thanks to remote monitoring.

The use of SaaS, the platform under which the Get Ready® solution is implemented, is a multiplatform cloud-based solution that includes, on the one hand, a web platform that allows healthcare professionals to monitor their patients throughout the process, thus enabling data-based decision making in the management of the patient's clinical condition and, on the other hand, a mobile app that allows the patient to follow the process, the care plan, record their symptoms and constants through questionnaires (PROMS/ PREMS) and access the educational program.

In the proposed use case at HUVR, a comprehensive solution for the digitization of care plans and care processes will be implemented to improve the management of the clinical condition of peri-surgical patients and promote their active participation in their self-care from the diagnosis phase to their post-surgical recovery.

In the proposed use case at HUVN, a comprehensive solution for the digitization of care plans and care processes will be implemented to improve the management of the TAVI patient's and promote the patient's active participation in self-care from the diagnostic phase through to post-procedure recovery.

The implementation will impact in different areas that will be monitored:

- Early detection of complications
- Standardization of the postoperative care plan
- Reduce face-to-face consultations
- Improve patient and professional satisfaction
- Reduce patient stress and anxiety
- Increase active role and patient adherence

- Reduction of cancellation ratio

## 4 Introducing the Reference Use Cases (RUCs)

For a correct execution of the ODIN project, considering the needs of the pilots participating in it, a total of six use cases were defined, which have been explained in detail within the DoA. Considering these and the objectives and categories covered by each of them, in order to optimise the organisation of the project, it has been chosen to introduce Reference Use Cases (RUCs) overarching all the case studies to be included in ODIN. The selected RUCs include three different key aspects of a hospital, providing support to the partners involved and serving as a high-level guide:

- RUC A, about the health services management:
  - o RUC A1 UC3: AI for diagnosis
  - o RUC A2 UC4: Clinical tasks and patient experience
  - o RUC A3 UC5: Clinical workflow
- RUC B, including goods and devices management:
  - o RUC B1 UC1: Aided logistic support
  - o RUC B2 UC2: Clinical engineering and medical locations management
- RUC C, disaster management:
  - o RUC C1 UC7: Disaster preparedness

The figure below shows the RUCs and Use Cases (UCs) distribution per pilot.

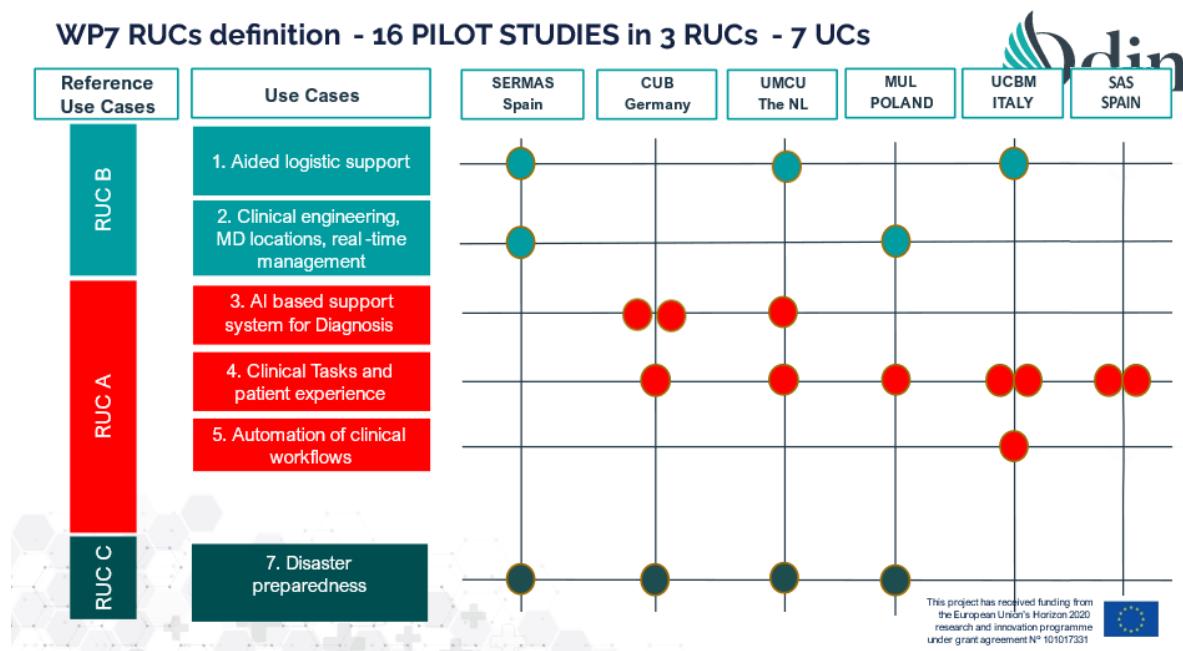


Figure 2 - RUCs - UCs pilots distribution

### 4.1 RUC A

This reference use case encompasses the use cases focused on the clinical oriented activities that the ODIN project will address. Among the use cases, UC4 is considered the most relevant

due to the number of pilots that find it significant, as opposed to the rest of the use cases (UC3, UC5).

On the one hand, the UC3 "AI-based support system for diagnosis", focuses on the use of AI technologies to optimise the personalised search for the diagnostic pathway considered most effective in each case, serving as a support to healthcare professionals in decision-making, considering probabilities as well as the capacity of available diagnostic modalities.

Besides, UC4 "Clinical Tasks and patient experience" is the use case with more pilots involved within the RUC A. It aims to reduce the effort that clinical personnel must exert in therapeutic and diagnostic activities based on ODIN technology. This is intended not only to improve the quality and workflow of clinicians, but also to optimise the comfort perceived by patients during their journey and improve their health conditions.

Likewise, UC5 "Automation of clinical workflows" aims to respond/act against the emerging difficulty within workflows, which often follow processes that are not efficient enough. Therefore, this project, taking advantage of workflows and the collection of data and sources, aims to offer a solution by automating clinical research execution processes in order to reduce possible errors.

To this end, the ODIN project will deploy an AI system to automatically support patients and help healthcare staff to provide optimized lifestyle monitoring.

## 4.2 RUC B

This reference use case, related to the managerial area, covers the first two defined use cases (UC1, UC2). It is focused on the improvement, based on ODIN technologies, of the design, programming and execution of hospital logistics, clinical engineering and the management of medical devices.

The first of these, UC1, defined in the DoA as "Aided logistic support", has been conceived as the entire process of procurement, storage and distribution of different materials in the hospital environment focusing on activities within the hospital environment that are considered redundant (e.g., transport of consumables). UC1 aims to leverage ODIN technology to optimize all these logistic activities, thus improving working conditions, optimizing the working time required by healthcare personnel for certain types of repetitive or risky tasks that do not require their attention, and the efficiency and workflow within the hospital.

In addition, RUC B also includes UC2 "Clinical Engineering, MD locations, real-time management", which focuses on the management of medical devices using ODIN technologies. This is particularly important as the current lack of real-time information exchange is one of the main causes of adverse events in the hospital environment. The correct functioning and adaptation to this use case will allow not only the optimisation of routine activities but also in disaster preparedness, which will be discussed in more detail in RUC C - UC7.

## 4.3 RUC C

This reference use case is focused on the action against possible unforeseen and tragic events that may occur, covering UC7 "Disaster Preparedness". This particular RUC has been introduced to prepare and tackle the multitude of difficulties that hospitals had to face during the pandemic and other catastrophes: terror attacks, natural events, and so on. For this purpose, ODIN approach and KERs will allow, through different simulations, to contribute to hospital resilient management (e.g., crowd management, security infection prevention and control (IPC)) and prepare hospitals for possible future catastrophes, always with the main objective of ensuring safety.

To define the RUC C there have been performed specific workshops and targeted activities with pilots and technical partners. The approach used is similar to the other two and it includes protocols to manage RUC A and RUC B phases during a disaster.

The next sections describe in detail all the RUCs and their sub-UCs.

## 5 RUC A: Health Services Management

### 5.1 ODIN Framework for industry 4.0

The RUC A can be represented as the following process with continuous interactions and feedback from each phase.

The National Health Services strategic planning (<https://www.who.int/activities/supporting-national-health-policies-strategies-plans>), which identifies needs and gaps, along with requests from the territory where the hospital is located, will be used to create the proper **admission screening**, an evaluation of the hospital entry points. This phase feeds the **diagnosis & case study** where patients enter the path of the identification of a disease by examination of the symptoms. The previous phase is necessary to identify the right **treatment** and the subsequent **monitoring and follow-up**.

This reference use case covers aspects related to the exploitation of ODIN technologies for improving execution of clinical tasks and patient overall experience within the hospital ecosystem. Specifically, it consists of the following phases covering all the clinical workflow, as represented in the picture below, from the patient's admission to the follow-up.

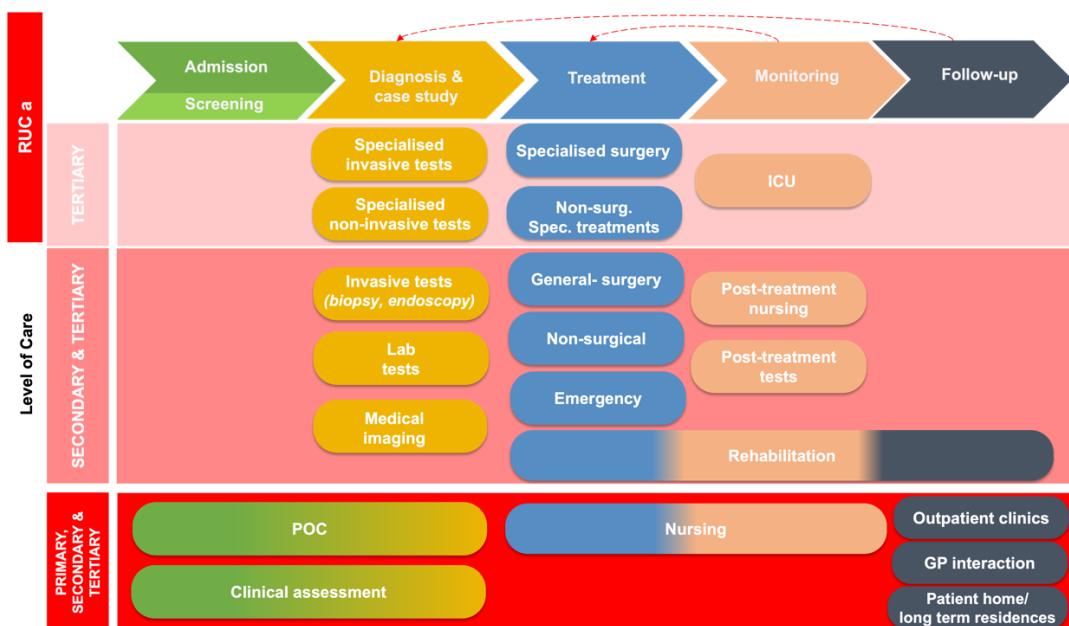


Figure 3 - RUC A Navigation Diagram

### 5.2 RUC A Phases

As reported in Section 4.1 this RUC includes all of the use cases related to clinical (and diagnostic) activities that will be addressed by the ODIN project. Due to the large number of pilots that believe RUC A2 - UC4 to be relevant, it is regarded as the first use case, in contrast to the remainder of the use cases (RUC A1 - UC3, RUC A3 - UC5), which have only been recognised by one pilot.

On the one hand, the RUC A1 - UC3 "AI-based support system for diagnosis" focuses on using AI technologies to optimise the personalised search for the most effective diagnostic pathway in each case, assisting healthcare professionals in decision-making by taking into account probabilities as well as the capacity of available diagnostic modalities.

RUC A2 - UC4 "Clinical Tasks and Patient Experience," on the other hand, is the use case with the most pilots within the RUC A. Based on ODIN technology, it promises to lessen the effort that healthcare workers must exert in therapeutic and diagnostic activities. This is meant not just to improve clinician quality and workflow, but also to maximise patient comfort and improve their health conditions during their travel.

Similarly, RUC A3 - UC5 "Automation of Healthcare Workflows" strives to respond to/address developing challenges within workflows, which frequently follow inefficient processes. As a result, this project intends to provide a solution by automating clinical research execution processes in order to eliminate possible errors by using workflows and data and source collecting.

To this purpose, the ODIN project will implement a robotic component that will automatically support patients and assist healthcare professionals in providing optimal lifestyle monitoring.

Below are presented the phases included in this RUC:

#### **Admission & Screening**

This phase refers to all the activities aiming to properly manage the admission of a patient following preliminary assessment of the clinical status.

#### **Diagnosis & Case Study**

Delivery of the diagnosis as a confirmation/refusal of the preliminary assessment, after patients undergo specialised exams and assessment. This phase ends with the identification and prescription of the treatment.

#### **Treatment**

Execution of the prescribed treatment

#### **Monitoring**

Monitoring of the compliance to the prescribed treatment, correctness and risks. According to the output of this phase, adjustment to the treatment can be introduced.

#### **Follow-up**

This phase refers to the assessment of the short – terms effectiveness of the treatment. This might also stop the treatment or modify it to reach the clinical goal.

## **5.3 RUC A Primary Outcomes**

This reference use case aims at maximising data-driven decisions and supporting execution of clinical tasks through the adoption of ODIN robotic and IoT platforms.

#### **Admission & Screening**

Improving preliminary assessment of the patient's clinical status and optimising the admission process management.

#### **Diagnosis & Case Study**

Optimising Personalised diagnostic pathway.

#### **Treatment**

Supporting execution of treatment with a reduction of workers' stress and workload.

#### **Monitoring**

Implementing a cost-effective monitoring of treatment and generating proper data-driven feedback. During this phase it is necessary to optimise the involvement of the HCW.

#### Follow-up

Optimising assessment of the short –terms effectiveness of the treatment.

## 5.4 RUC A Sub Cases

### 5.4.1 RUC A1 UC3: AI for diagnosis

Diagnostic trajectories in hospitals and medical centres can become difficult, long, expensive and cumbersome for patients. The objective of this use case is to verify if AI and IoT-driven approach is able to improve the diagnostic pathway by (A) Personalising the diagnostic trajectory of patients based on a priori and post priori probabilities and (B) provide integrated capacity management of the full diagnostic supply chain.

RUC A1 is focused on the second phase of RUC A: Diagnosis.

### 5.4.2 RUC A2 UC4: Clinical tasks and patient experience

This use case includes experiments linked to the exploitation of ODIN technologies for enhancing clinical task execution and patient experience across the range within the hospital ecosystem.

### 5.4.3 RUC A3 UC5: Clinical workflow

This UC aims to implement and validate a workflow-driven solution supporting the automation of the clinical research execution processes. It usually covers all the RUC A phases.

## 5.5 Pilots implementing RUC A

Once the reference structure of the RUC A was defined and foreseeable services (RUC A1- A4) were focused on, ODIN pilots described their experiments as a specialisation of these models.

This resulted in the following ODIN RUC A table:

Table 4 - RUC A Pilots implementation

Use Case	Name	Pilot(s)
RUC A1 - UC3	AI for Diagnosis	UMCU
RUC A2 – UC4	Clinical Tasks and Patient Experience	CUB, MUL, UCBM, UMCU, SAS
RUC A3 - UC5	Clinical Workflow	UCBM

Tables below summarises for each pilot the different implementation of RUC A. Appendix A reports the details per pilot.

### 5.5.1 CUB

Table 5 - RUC A - CUB

Use Case	Name	Description	RUC X Phase (s)
RUC A UC 3 & 4	AI Based Support System for Diagnosis & Clinical Tasks and Patient Experience	Validation of Wearables & Automated Scoring of Wearables	Admission & Screening, Diagnosis
RUC A UC 3	AI based support system for Diagnosis	Automated Sleep Scoring of Sleep Studies	Diagnosis
RUC A UC 4	Clinical Tasks and Patient Experience	CERTHbot Receptionist	Admission & Screening, Monitoring

### 5.5.2 MUL

Table 6 - RUC A - MUL

Use Case	Name / Description	RUC A Phase (s)
RUC A2 – UC4	Blood transport Robotic transportation of blood samples from the Emergency Department to the Central Lab	Diagnosis & Case Study phase

### 5.5.3 UCBM

Table 7 - RUC A - UCBM

Use Case	Name	Description	RUC A Phase (s)
RUC A2.1 – UC4	Clinical Tasks and Patient Experience	Monitoring of food assumption to prevent undernutrition	Treatment, Monitoring
RUC A2.2 – UC4	Clinical Tasks and Patient Experience	Rehabilitation to prevent loss of mobility	Treatment, Monitoring

<b>RUC A3 – UC5</b>	Automation of Clinical Workflows	Monitoring of oxygen therapy to prevent hypoxia complications	Monitoring
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## 5.5.4 UMCU

Table 8 - RUC A - UMCU

Use Case	Name	Description	RUC X Phase (s)
RUC A - UC3	AI for Diagnosis	AI tools to improve personalization and efficiency of CVD diagnostic pathways outpatient clinic setting	Diagnosis
RUC A – UC4	Identification of eligible patients for CVD learning	Automatically identify new patients eligible for CVD learning healthcare system	Admission & Screening

## 5.5.5 SAS

Table 9 - RUC A - SAS

Use Case	Name	Description	RUC X Phase (s)
RUC A – UC4	Clinical Tasks and Patient experience	Piloting a tool for digitizing care plans and monitoring patients throughout care processes (TAVI and perioperative pathways).	Monitoring

## 6 RUC B Devices, Goods, Facilities Management

This RUC was created to enable ODIN technologies to contribute to improving the design, scheduling, and execution of Hospital Logistic, Clinical Engineering, and Medical Device management, starting with the description of UC1 in the DoA.

It includes the phases of material procurement, storage, and distribution (medicines, medical and hotel supplies, meals, linens, waste, etc) part of the logistic management and those phases related to the clinical engineering and medical devices management.

All this processes, e.g., order consumables after using them, transport of objects, refill of ward magazines etc; most of the time need duplication of efforts generating additional, and unnecessary load to the hospital workflows, and extra burden to both administrative and healthcare staff.

This reference use case will employ various combinations of eRobots, eWorkers, and eLocations to optimise procedures, improve healthcare operators' working conditions, and improve hospital efficiency and workflow. This is projected to improve the work of personnel who are primarily responsible for hospital logistic processes (e.g., porters, managers), as well as free up time for healthcare workers (e.g., nurses) by removing them from repetitive, time-consuming, and potentially dangerous jobs.

### 6.1 ODIN Framework for industry 4.0 hospital logistic management

By approaching RUC B in a similar manner as RUC A, we can build a workflow, which describes the interactions among the different phases and inputs. As per RUC A, all the phases are interconnected and interdependent on each other. The starting points come from the **Strategic Management Plan** and the gap analysis from the different hospital units. These steps feed the **Planning** phase where the hospital management is in charge to design and develop what is needed by the next phase the **Procurement Stockage**. This last phase is dealing with all the necessary activities to acquire good in the hospital context. The next phase is related to the **Preparation and Delivery** of the acquire good to the final destination / department. Completing this process is the **Real Use Monitoring and Management** in charge of the follow-up steps after the acquisition

The similar navigation schema of the RUC B can be described as the picture below, where instead of having the levels of care there are the different objects managed by the logistics for the RUC B1 or type of the equipment for the RUC B2 as shown in the figures below:

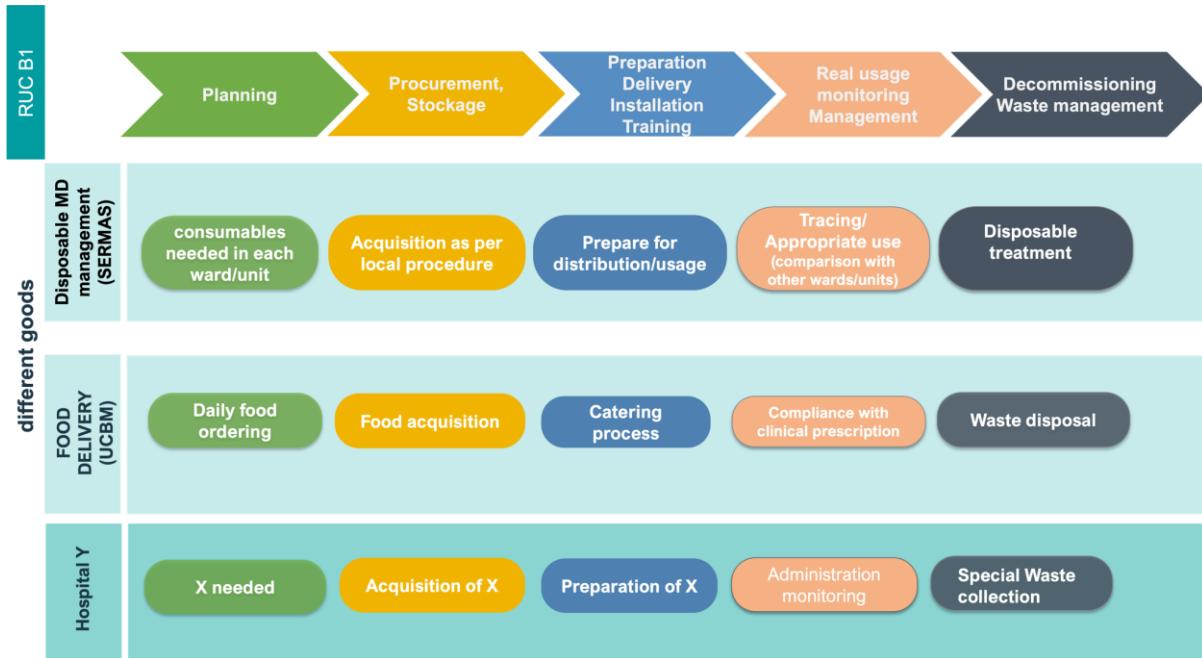


Figure 4 - RUC B1 Navigation Diagram

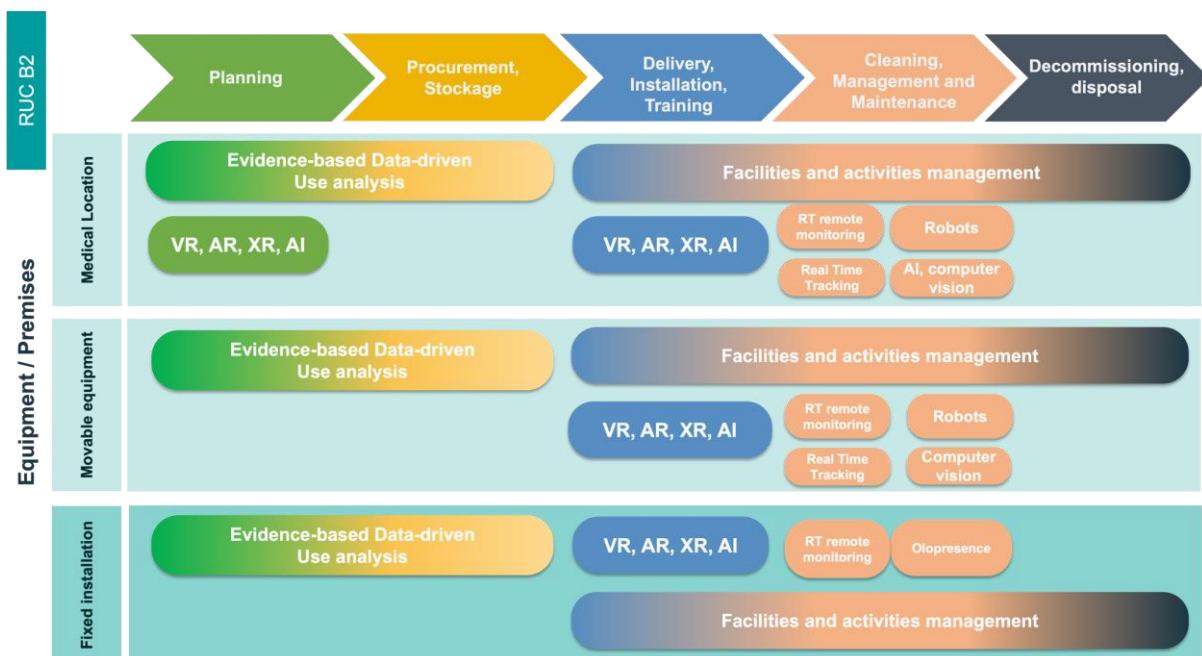


Figure 5 - RUC B2 Navigation Diagram

## 6.2 RUC B Phases

The first two defined use cases are covered in this RUC, which is relevant to the managerial area (RUC B1 - UC1, RUC B2 - UC2). It focuses on improving the design, programming, and execution of hospital logistics, clinical engineering, and medical device management using ODIN technology.

The first of these, RUC B1 - UC1, has been conceptualised as the entire process of procurement, storage, and distribution of various commodities in the hospital environment, with a focus on operations inside the hospital environment that are considered redundant, as specified by the DoA (e.g., transport of consumables).

The other is RUC B2 - UC2 "Clinical Engineering, MD locations, real-time management," which focuses on the management of medical devices employing ODIN technology. This is especially essential because one of the main causes of adverse occurrences in the hospital environment is the current absence of real-time information transmission. The proper functioning and modification to this use case will allow for the optimisation of normal tasks as well as disaster preparedness, which will be covered in further depth in RUC C - UC7.

Here below, the phases of the RUC are briefly described.

### **Planning**

Planning the changes to medical locations and to the electromedical equipment fleet to respond to health needs, based on evidence from needs assessment, current usage, analysis of faults and recalls, maintenance and real-world data (RWD)

### **Procurement, Storage**

Defining a rational process for acquiring and stocking electromedical equipment

### **Delivery, installation, training**

Planning delivery and installation steps which minimise the impact on the hospital processes. Performing effective and customised training to technical staff and healthcare staff

### **Cleaning, management, and maintenance**

Managing the cleaning of spaces, their assignment to departments and operational units, plan and manage their maintenance.

Managing the maintenance of electro-medical devices with a data-driven evidence-based approach

### **Decommissioning, disposal**

Managing the closure of medical locations and the transfers of activities and technology.

Managing the decommissioning and disposal of medical equipment

## 6.3 RUC B Primary Outcomes

This reference use case aims at maximising data-driven decisions and evidence-based management of processes.

### **Planning**

Optimising the whole clinical engineering and medical locations management process

### **Procurement, Storage**

Reducing time and maximising equipment availability

### **Delivery, installation, training**

Innovating the way equipment is delivered and put in place, and the training to technicians and health personnel

### **Cleaning, management, and maintenance**

Optimising medical locations and equipment management and maintenance

### **Decommissioning, disposal**

Optimising closures and transfers

Optimising equipment decommissioning and disposal, in particular for fixed devices (e.g. MRI, CT, Radiology, etc.).

## 6.4 RUC B Sub Cases

### 6.4.1 RUC B1 UC1: Aided logistic support

This use case covers all the aspects about the hospital logistics, excluding patient experience part of RUC A

### 6.4.2 RUC B2 UC2: Clinical engineering and medical locations management

This use case covers aspects related to the exploitation of ODIN technologies for improving the clinical engineering, the management of medical locations and medical equipment.

## 6.5 Pilots implementing RUC B

Having defined, so far, the RUC B and its sub use cases RUC B1 and B2, ODIN pilots described their experiments as a specialisation of these models.

This resulted in the following ODIN RUC B table:

Table 10 - RUC B Pilots implementation

Use Case	Name	Pilot(s)
RUC B1 – UC1	Aided Logistic Support	SERMAS, UCBM, UMCU
RUC B2 – UC2	Clinical engineering, MD locations, real-time management	SERMAS, MUL

Tables below summarises for each pilot the different implementation of RUC A. Full detailed pilots' experiments, where available, are reported in Appendix A.

### 6.5.1 MUL

Table 11 - RUC B - MUL

Use Case	Name / Description	RUC Phase (s)
RUC B2 – UC2	Clinical Engineering and Medical Locations Management	All

### 6.5.2 SERMAS

Table 12 - RUC B - SERMAS

Use Case	Name	Description	RUC B Phase (s)
RUC B1 – UC1	Aided Logistic Support	Monitor the use of consumables	Planning Procurement, Storage
RUC B2 – UC2	Clinical engineering, MD locations, real-time management	Consumable delivery automation	Delivery, installation, training  Decommissioning, disposal

### 6.5.3 UCBM

Table 13 - RUC B - UCBM

Use Case	Name	Description	RUC B Phase (s)
RUC B1 – UC1	Aided Logistic Support	Logistics of food delivery	Preparation, delivery, installation, training  Real usage monitoring Management

### 6.5.4 UMCU

Table 14 - RUC B - UMCU

Use Case	Name	Description	RUC B Phase (s)
RUC B1 – UC1	Aided Logistic Support	Automated delivery of consumables	Delivery, installation, training

## 7 RUC C Disaster Management

The main focus of this particular use case is to mitigate the risk of potential disasters in the future, with a specific emphasis on addressing UC7 "Disaster Preparedness." The COVID-19 pandemic highlighted the many challenges that hospitals faced during a crisis, making it critical to take action to prevent similar difficulties from arising in the future. Disasters can strike at any moment, and hospitals must be ready to respond swiftly and effectively to ensure the safety of patients and staff.

The WHO published a report on a strategic framework for emergency preparedness in 2017. It focuses on the realm of public health and the possible catastrophes that may jeopardize it. The WHO definition of emergency management stresses three paramount pillars, namely:

1. preparedness (i.e., anticipation of).
2. response (having knowledge and tool to respond).
3. resilience (recovery from the impacts of the current emergencies and restore in the short possible time essential services).

The main aims of this framework go beyond strengthening country and community emergency preparedness, but also fostering the prioritization of financial and other resources for emergency response and fast recovery. The WHO enlists 4 main strategic objectives for emergency preparedness, i.e., operational readiness, resilient health system, one health at the human-animal-environment interface (especially for zoonosis), and a whole-of-government, whole-of-society approach. Furthermore, the main areas of work revolve around governance, capacities, and resources.

This is becoming more and more important, as a recent report from the WHO highlighted how COVID-19 had a much more devastating economic impact compared to previous outbreaks.

The Centers of Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH) hierarchy of controls is one of the underlying frameworks for public health response to pandemics. In alignment with other risk-management models, the CDC hierarchy's main tenet is to try to remove the hazard, if that is not possible or sufficient then to focus on reducing the exposition to the hazard, and when this is not possible or sufficient, protect workers and patients with engineering measures, administrative control and PPE. Clearly, removing the hazard is the most effective solution, while accepting the exposition to the hazard, no matter how well protected, is the least effective one. In order to stress this concept, the CDC framework is represented as an upside-down pyramid (see Figure 6). Understanding the CDC pyramid of evidence, helps understanding the rationale behind WHO measures for COVID, and how to better address BME effort towards future pandemics.

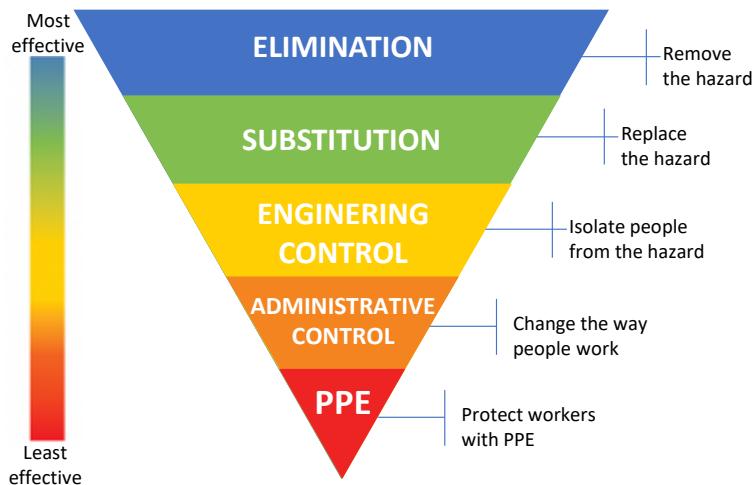


Figure 6 - The CDC NIOSH hierarchy of controls

This model comprises five categories of interventions, presented in order of decreased effectiveness. The CED framework is applied for reducing the risk and controlling the further spread of pandemic/epidemic pathogens within hospital and in community settings.

In a recent study were deepened the best and worst practices to face an healthcare emergency based on the Covid-19 pandemic<sup>1</sup>.

## 7.1 ODIN Framework for industry 4.0 disaster management

The use of ODIN KERs enables the so-called framework to support hospitals' resilient management to mitigate, prepare, respond and restore in case of disasters. In this project, various simulations are going to be conducted, this includes managing crowd control, emergency devices management, enhancing security measures, and providing infection prevention and control support. All of these efforts are geared towards ensuring safety and reducing the impact of potential disasters.

To define this RUC C, starting from the WHO Sendai Framework for Disaster Risk Reduction 2015 – 2030 and highlighting all disaster's dimensions, we conducted targeted workshops and activities with pilots and technical partners. The preliminary results were the characterisations of the different risks and the schematizations of their management. For this, we adapted the WHO navigation model as per the other two use cases having the main difference in mind: the focus on emergency protocols to manage RUC A and RUC B phases during a disaster. The protocols

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<sup>1</sup> Maccaro, A., Audia, C., Stokes, K., Masud, H., Sekalala, S., Pecchia, L., & Piaggio, D. (2023, September). *Pandemic Preparedness: A Scoping Review of Best and Worst Practices from COVID-19*. In *Healthcare* (Vol. 11, No. 18, p. 2572). MDPI.

developed in this section are designed to be practical and effective in mitigating the impact of a disaster and will be a valuable resource for hospitals as they prepare for potential future crises.

RUC C can be described using the following schema:

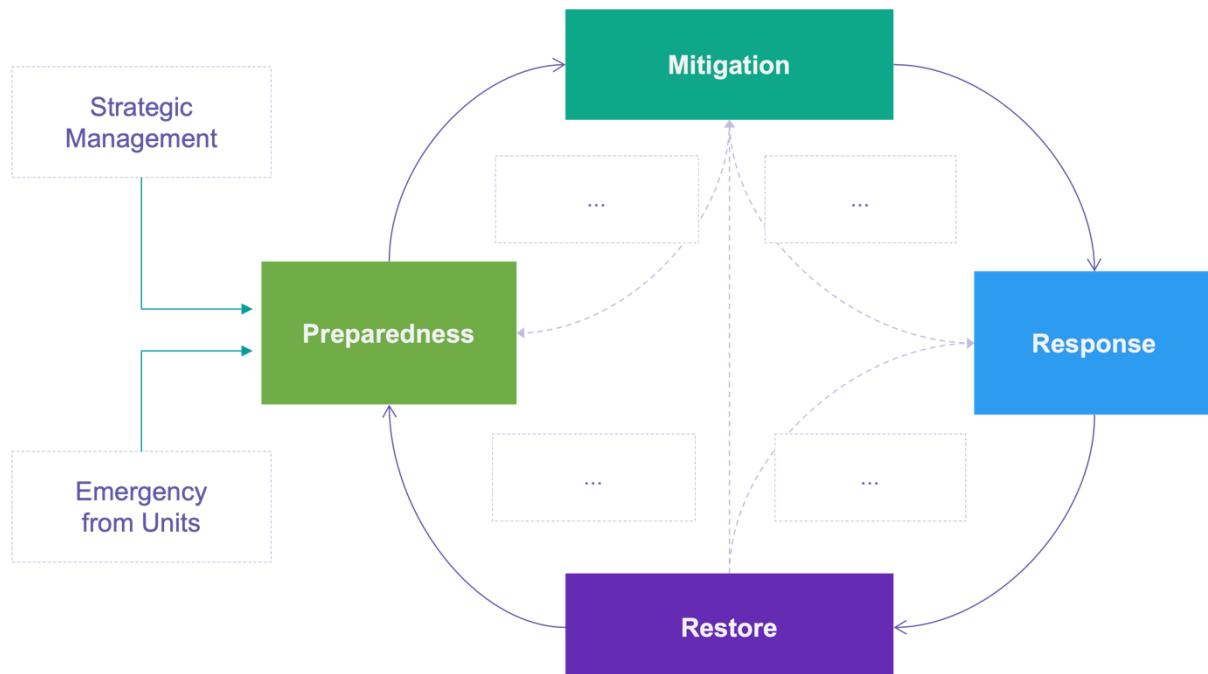


Figure 7 - RUC C Phases workflow

This is to highlight the need to improve the understanding of the different risks in all of their extents and to prepare an adequate disaster management plan.

## 7.2 RUC C Phases

The RUC C infographic provides a visual representation of the disaster preparedness flowchart phases. The aim of this is to help hospitals respond quickly and recover faster from disasters, utilizing state-of-the-art simulations in EBM.

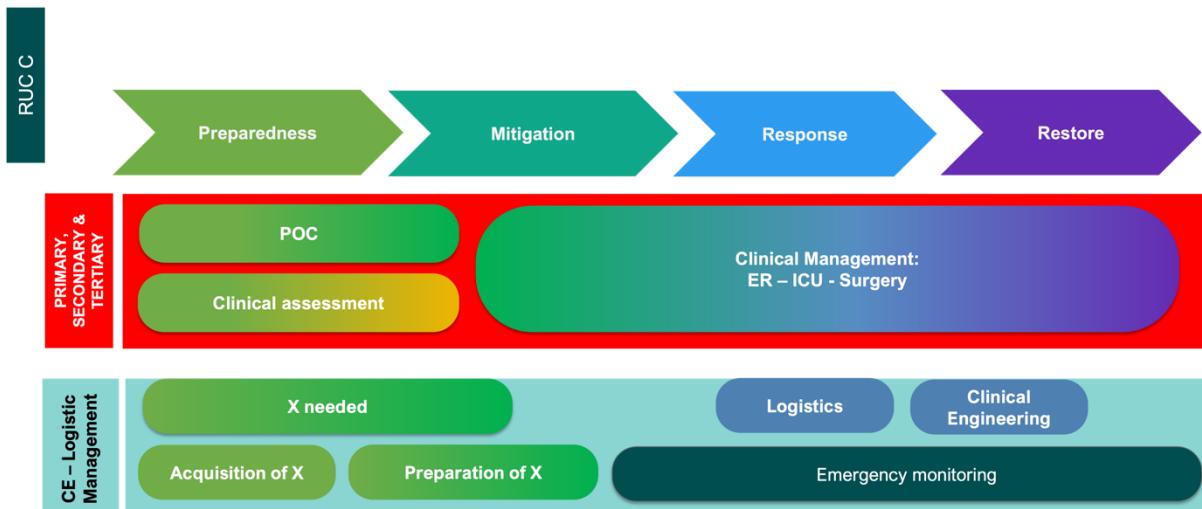


Figure 8 - RUC C Disaster preparedness navigation diagram

This is especially essential because one of the main causes of adverse occurrences in the hospital environment is the current absence of real-time information transmission. The proper functioning and modification to this use case will allow for the optimization of normal tasks as well as disaster preparedness, which will be covered in further depth in RUC C - UC7.

Here briefly described the phases of the RUC.

**Preparedness:** The preparedness phase involves activities aimed at enhancing a hospital's readiness to effectively respond to a disaster. Key components of this phase include:

- Planning and organizing:** Developing comprehensive emergency response plans, establishing command structures, and assigning roles and responsibilities to staff members.
- Training and education:** Conducting regular drills and exercises to ensure staff members are familiar with emergency procedures and protocols. Training sessions can cover various aspects like triage, communication, and evacuation.
- Resource management:** Identifying and procuring essential resources such as medical supplies, equipment, and personnel required during emergencies. Ensuring their availability, maintenance, and adequate stockpiling.

ODIN KER will support data analysis and prediction: AI algorithms can analyse historical data on disasters, patient demographics, and resource utilization to identify patterns and trends. This analysis can help hospitals better understand their vulnerabilities and develop targeted preparedness plans. AI can also facilitate virtual training programs, providing interactive learning experiences to enhance staff readiness. ODIN Platform can assist in optimizing resource allocation by analysing real-time data on person and patient influx, supply levels, and staff availability. This helps ensure efficient utilization of resources during emergencies.

**Mitigation:** Mitigation efforts aim to minimize the impact of potential disasters on the hospital and the community. This phase involves:

- a. Risk assessment: Identifying potential hazards and vulnerabilities specific to the hospital, analysing their potential impact, and developing strategies to reduce risks.
- b. Hazard reduction: Implementing measures to minimize the impact of identified hazards. For example, retrofitting buildings to withstand earthquakes or implementing fire prevention systems.
- c. Public education: Conducting community outreach programs to raise awareness about disaster preparedness and promote individual and community resilience.

ODIN KERs can play a significant role in the mitigation phase by:

- Risk analysis: This analysis can help hospitals identify and prioritize mitigation strategies.
- Predictive analytics: AI algorithm can leverage machine learning techniques to predict the likelihood and impact of specific hazards. This allows hospitals to proactively implement mitigation measures and allocate resources accordingly.
- Early warning systems: AI algorithm can integrate with monitoring systems to detect early signs of potential disasters. For example, AI algorithm can analyse data from sensors to detect anomalies indicating the onset of fires or floods, triggering timely alerts and response actions.

**Response:** The response phase encompasses actions taken during and immediately after a disaster to protect patients, staff, and the facility. Key activities include:

- a. Activation of emergency plans: Initiating the hospital's emergency response plan, establishing incident command, and activating communication systems to facilitate coordination and information sharing.
- b. Triage and medical care: Prioritizing and categorizing patients based on the severity of their injuries or conditions. Providing immediate medical care and initiating treatment as per established protocols.
- c. Resource allocation: Effectively allocating and managing available resources to meet the surge in demand during emergencies. This includes staffing, supplies, equipment, and medications.
- d. Communication and coordination: Establishing clear communication channels with external agencies, neighbouring healthcare facilities, and other stakeholders to exchange critical information and coordinate efforts.

During the response phase, ODIN KERs can provide critical support in robotics and automation: ODIN-powered robots can be deployed for tasks such as disinfection, delivery of supplies, and logistics management, reducing the exposure of healthcare workers to risks and enhancing overall response capabilities.

**Restore:** The restore phase focuses on restoring normal operations and facilitating the recovery process. Key elements of this phase can include:

- a. Facility restoration: Assessing the damage to the hospital infrastructure and initiating repair and restoration efforts.
- b. Patient care continuity: Ensuring continuity of patient care during the recovery phase. This includes resuming routine healthcare services, addressing any backlog of postponed procedures, and supporting ongoing medical needs.

- c. Evaluation and improvement: Conducting a comprehensive evaluation of the hospital's response and recovery efforts. Identifying strengths, weaknesses, and lessons learned to improve future preparedness. Updating emergency plans and protocols based on these findings.

ODIN KERs can support the restoration phase by:

- Data-driven recovery planning: AI algorithms can analyse post-disaster data, patient records, and resource availability to assist in developing recovery plans. This helps hospitals optimize resource allocation and prioritize services during the restoration process.
- Predictive analytics for resource needs: AI can analyse historical and real-time data to predict resource needs during the recovery phase. This allows hospitals to anticipate and address any potential shortages proactively.
- Intelligent scheduling and optimization: AI can optimize scheduling and resource allocation during the recovery phase, considering factors such as patient demand, staff availability, and operational constraints. This ensures efficient utilization of resources and timely restoration of services.
- Knowledge management: AI-powered systems can facilitate the capture and organization of knowledge and lessons learned during the response and recovery phases. This information can be utilized to improve future disaster preparedness efforts.

## 7.3 Pilots implementing RUC C

So far defined the RUC C and its sub use case RUC C1 ODIN pilots described their experiments as a specialization of these models.

This resulted in the following ODIN RUC C table:

Table 15 - RUC C Pilots implementation

Use Case	Name	Pilot(s)
RUC C – UC7	Disaster Preparedness	CUB, SERMAS, UMCU, MUL

Tables below summarizes for each pilot the different implementation of RUC C. Full detailed pilots' experiments are reported in Appendix A.

### 7.3.1 CUB

Table 16 - RUC C - CUB

Use Case	Name	Description	RUC C Phase (s)
RUC C – UC7	Disaster Preparedness	Patient monitoring/ Evacuation	All

## 7.3.2 MUL

Table 17 - RUC C - MUL

Use Case	Name	Description	RUC C Phase (s)
RUC C – UC7	Disaster preparedness	Smart use and proper disinfection of HOSBOT in case of pandemic pathogens	All

## 7.3.3 SERMAS

Table 18 - RUC C - SERMAS

Use Case	Name	Description	RUC C Phase (s)
RUC C – UC7	Disaster preparedness	Evacuation flow optimization/ Control of capacity	Preparedness, Response

## 7.3.4 UMCU

Table 19 - RUC C - UMCU

Use Case	Name	Description	RUC C Phase (s)
RUC C – UC7	Disaster Preparedness	Overview of pathogen carriers for IPD	Preparedness, Mitigation

## 8 Operational KPIs

Operational KPIs (OP KPIs) are essential metrics for measuring the effectiveness of a task execution. Within the ODIN Experiment Framework, we have defined a set of OP KPIs to actively support and track the pilot studies. These indicators are intricately linked to the progression of each pilot and their respective use cases, providing a structured approach to manage the ODIN project and to deliver key insights required for attaining its objectives.

This section first details the materials and methodology employed to define and assess the OP KPIs. It then provides an update on the status on each pilot involved in the project, based on the indicators provided. The Operational KPIs report offers clear information on the current progress of each experiment and the project's trajectory towards achieving its intended results.

### 8.1 Methodology

To determine the most relevant Operational KPIs for each pilot, we initially conducted an in-depth analysis of potential variables, tailored to the specific use cases. This process unfolded in the following stages:

1. General Study of OP KPIs: the initial step involved analyzing each UC and establishing corresponding KPIs within each pilot. The analysis led to a preliminary selection of variables with the potential to serve as indicators for tracking the experiments' progress. These variables were then classified according to the typical phases of a pilot study cycle (i.e., Preparation, Deployment and Running). The results were documented and clarified for easy understanding by the pilots representatives.
2. Pilot Representatives Discussion: Based on the previous documentation, workshops were organized with each pilot representative and relevant partners. These collaborative sessions focused on selecting the KPIs they considered significant for their respective pilot studies.
3. Final Definition of OP KPIs: Incorporating feedback from the previous discussions, the OP KPIs for each pilot were selected, ensuring alignment with their specific UC and phase of the experiment. This process resulted in the identification of 17 global-level OP KPIs and 26 specific OP KPIs.

Subsequently, detailed excel files were prepared for each pilot, incorporating insights from the pilot representatives, timelines of each phase and their current statuses (Figure 9). For every use case and phase, the selected OP KPIs are described along with their explanation and the measurement format. These files are updated and shared monthly with each pilot, enabling effective tracking on their ongoing progress.

TARGETS AND REPORT for the ODIN monitoring and control KPIs									
Pilot name:	From		To:	Reported date					
Name of the responsible person for the report:	Name Responsible 1 Name Responsible 1	Name Responsible 2 Name Responsible 2							
General phase	Explanatory notes	Start date	End date	Status	Measurement unit (LEGEND)	Reported date	Remarks		
Preparation phase	The preparation phase ends when: deployment process is ready to begin, and the preparation KPIs are defined and obtained (LEGEND)								
Deployment phase	The deployment phase ends when: running strategy is defined, end-users are recruited, the technologies deployment completed, pre-testing has been carried out, users are trained and installations have been made (LEGEND)								
Running phase	The running phase ends when: the pilot execution is finalised (LEGEND)								
PREPARATION phase									
Reporting status at:	Operational KPI	Explanatory notes (if needed)	Measurement unit	UC	UCType	RUC	Global ID	Reported date	Reported date
RUC X - UCn								Reported value	Reported value (LEGEND)
Operational KPI name	Explanatorynotes	% and Legend value	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	Number (integer)	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	%	UCn	n	RUC X:Title	Pilot specific		-	
DEPLOYMENT phase									
Reporting status at:	Operational KPI	Explanatory notes	Measurement unit	UC	UCType	RUC	Global ID	Reported date	Reported date
RUC X - UCn								Reported value	Reported value (Legend)
Operational KPI name	Explanatorynotes	% and Legend value	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	Number (integer)	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	%	UCn	n	RUC X:Title	Pilot specific		-	
RUNNING phase									
Reporting status at:	Operational KPI	Explanatory notes	Measurement unit	UC	UCType	RUC	Global ID	Reported date	Reported date
RUC X - UCn								Reported value	Reported value (Legend)
Operational KPI name	Explanatorynotes	% and Legend value	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	Number (integer)	UCn	n	RUC X:Title	Common pilots			
Operational KPI name	Explanatorynotes	%	UCn	n	RUC X:Title	Pilot specific		-	

Figure 9 - OP KPIs monthly report template

### 8.1.1 PowerBI dashboard

Recognizing the need for efficient tracking and visualization of our pilot experiments' progress, we evaluated various analytics tools to find the best fit for our requirements. After a thorough analysis, Microsoft PowerBI was chosen for its robust data preparation capabilities and flexible design options. This analytics solution provides an intuitive and dynamic interface for a detailed overview of the project's status, broken down by individual pilots and specific use cases.

The PowerBI dashboard is deployed using data from the monthly reports. It enables authorized users to delve into the project's details, offering insights into the location, description, and current status of each pilot and use case, including any risks or blockers. Additionally, it tracks the monthly progress of the operational KPIs. Users can navigate through each phase, accessing the monthly reports of each pilot and viewing the cumulative percentage of completion. This setup ensures consistent data capture, simplifying the management and ongoing monitoring of the ODIN project's progress and development.

## 8.2 OP KPIs status

### 8.2.1 General overview

Table 20, presented below, details the current status of each pilot by outlining the completion percentage of each phase and their overall progress. This table illustrates key insights such as the ongoing progression of the preparation and deployment phases and the fact that the running phase is yet start for most pilots.

Table 20 - OP KPIs Pilots General Overview

Pilot	General Overview	Preparation	Deployment	Running
CUB	57.50%	In progress	In progress	In progress
MUL	56.67%	In progress	In progress	Not started
SERMAS	53.67%	Completed	In progress	Not started
UCBM	38.25%	In progress	In progress	Not started
UMCU	43.50%	In progress	In progress	In progress

This information is crucial to easily visualize the status of each pilot, identifying which ones are progressing as expected and which may be facing delays. It allows for the prompt recognition of potential risks, facilitating the development of timely mitigation strategies to ensure that such risks do not affect pilot progress. In line with this, a dedicated screen within the PowerBI dashboard (Figure 10) was designed. It enables the visualization of each pilot's status and the condition of critical KPIs (e.g., ethical approval, study protocol definition). In addition, this screen brings the possibility to users to delve into a detailed analysis of specific UCs as needed.

### ODIN Traffic Lights

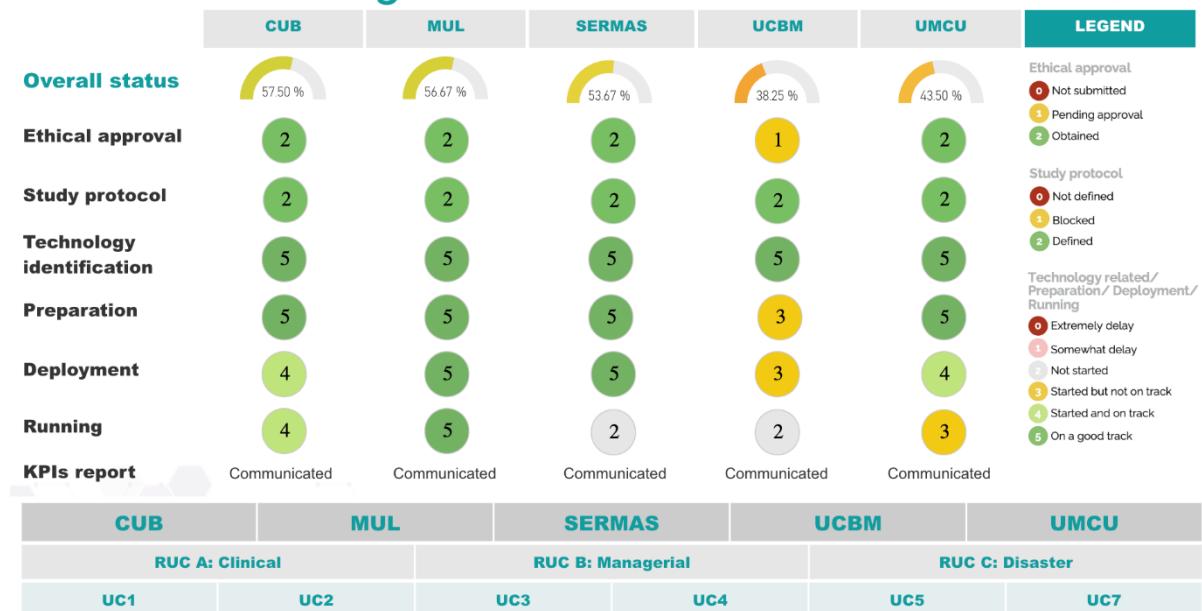


Figure 10 - PowerBI Dashboard Pilots General Overview

## 8.2.2 Pilots Specific Overview

For a more detailed analysis of each pilot, Table 21 showcases the completion status for each pilot experiment, based on their respective use cases. This focused approach allows the extraction of precise insights, such as the completion or significant advancement of the preparation phase for most pilots, signaling their readiness for the next phases.

Table 21 - OP KPIs Pilots Specific Overview

Pilot	UC	Overall UC	Preparation	Deployment	Running
CUB	UC3	50%	100%	50%	0%
	UC3 & UC4	65%	100%	75%	20%
	UC4	58%	75%	100%	0%
	UC7	57%	72%	100%	0%
MUL	UC4	53%	97%	63%	0
	UC2	59%	78%	100%	0
	UC7	58%	100%	75%	0
SERMAS	UC1	48%	100%	44%	0
	UC2	46%	100%	38%	0
	UC7	67%	100%	100%	0
UCBM	UC4.1	40%	92%	29%	0%
	UC4.2	40%	92%	29%	0%
	UC5	40%	92%	29%	0%
	UC1	33%	75%	25%	0%
UMCU	UC3	48%	100%	40%	4%
	UC4	66%	90%	56%	53%
	UC1	21%	63%	0%	0%
	UC7	39%	100%	17%	0%

In congruence as in the general overview, the PowerBI dashboard was configured to provide specific visualizations for a thorough examination of each pilot's progress. It allows users to assess individual pilots in-depth, reviewing the status of their experiments. As illustrated in Figure 11, the dashboard displays the specific pilot's advancement (in this case UMCU pilot). This screen offers insights into the status of each phase, timelines, the current overall completion and the evolution of their OP KPIs, as informed by the data collected from the monthly reports.

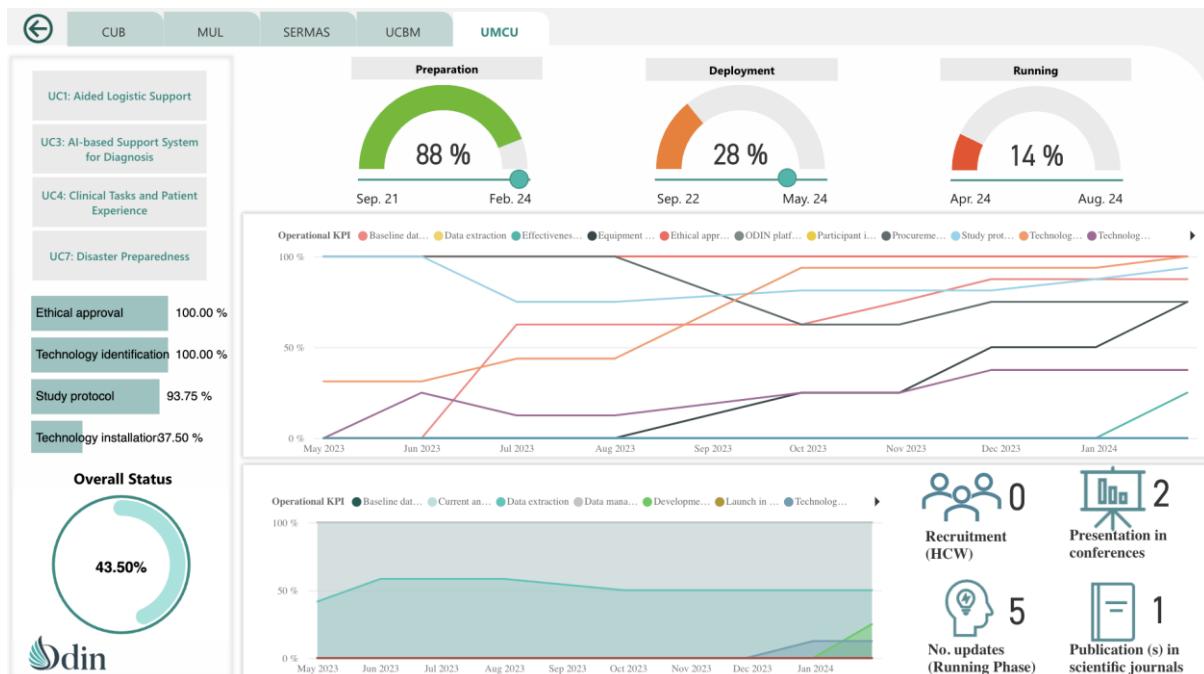


Figure 11 - PowerBI Dashboard UMCU Specific Overview

## 9 Impact Assessment KPIs

Conducting a comprehensive impact assessment is essential for ODIN project, serving as a crucial tool to evaluate methodically the potential effects and outcomes across various dimensions, such as social, economics, and clinical effectiveness.

To effectively convey the results of the ODIN Experiment Framework, a set of KPIs for Impact Assessment (IA KPIs) has been established. These indicators are closely tied to the advancement of pilots and open callers' studies and their associated use cases, facilitating the monitoring of the project's development and providing essential insights to accomplish its objectives. The formulation of these indicators involved collaborative efforts, adopting an open approach with all the pilots and open callers. This collaboration involved the fulfilment of IA tables by each pilot and open caller for each UC of every RUC.

Initially the same guidelines and templates were provided to each pilot. The items used to assess the impact of pilots and open callers' experiments and associated outcomes within ODIN Experiment Framework are:

- Phase: phase in which the pilot/open caller is involved for that use case.  
Example of the RUC A's phases: Admission & Screening, Diagnosis & Case Study, Treatment, Monitoring, Follow-up.
- Descriptor (What): what each pilot/open caller wants to measure, also specifying the unit of measurement.
- How: how each pilot/open caller conducts the measurements, both at T0 (before ODIN platform) and at T1 (after ODIN platform adoption).
- Owner (Who): who has this information, both at T0 (before ODIN platform) and T1 (after ODIN platform adoption)
- Target (Why): the delta of the measurements obtained between T0 (before ODIN platform) and T1 (after ODIN platform adoption)
- Monitoring point (When): when each pilot/open caller performs the measurements, both at T0 (before ODIN platform) and T1 (after ODIN platform adoption).

The IA KPIs formulation was developed through a series of brainstorming sessions involving WP7 leaders and representatives from each pilot or open caller. Each pilot and open caller defined their own KPIs based on their UCs. This approach allowed for a customized and contextually relevant set of metrics to be established, aligning with the specific requirements and objectives outlined in each individual Use Case. The conclusive tables were obtained, serving as the basis from which information will be extracted to evaluate the impact of the introduced technologies.

## 10 Conclusions

In conclusion, this report offers an overview of the ODIN Project's approach, showcasing its progress through various case studies. The project's experimental framework is clearly defined, making it easier to identify and characterize use cases.

This edition primarily updates the experiment status and includes the methodology used to derive the KPIs necessary for managing and tracking each pilot study. It provides insights into the current status of relevant indicators and their display. By offering updates at the pilot level, the project demonstrates its commitment to transparency and continuous improvement.

Overall, the report highlights the evolution of the ODIN Pilots based on their KPIs reports, and the incorporation of a new pilot experiment within the project.

## Appendix A ODIN Pilots experiments

### A.1 ODIN Technology assessment and TRL

This section reports about the technology assessment performed pilot per pilot with the necessary support of the technological partners of ODIN.

The table below reports the technology provider within the ODIN Consortium, which pilot, the name of the technology / service and the TRL.

Table 22 - Pilots technology providers

Partner Name	Pilots	Main Technology Provided	TRL
CERTH	UCBM	CERTHBot robot	TRL6
	CUB	CERTHBot robot	TRL6
	CUB	HAR Tech	TRL 6
	CUB	Resource Federation	TRL 4
	CUB	Data analytics platform	TRL 4
INETUM	SERMAS	Computer vision algorithm.	TRL4
FORTH	SERMAS	AI-based algorithms	TRL4
	UCBM	AI-based algorithms	TRL4
	UCBM	AI-based algorithms	TRL4
	UCBM	AI-based algorithms	TRL5
MYS	SERMAS	RTLS System	TRL6
	MUL	RTLS System	TRL6
	UCBM	RTLS System	TRL6
UMCU	UMCU	RTLS System	TRL 6
	UMCU	AI-based algorithms	TRL 3-4
UCBM	UCBM	TIAGo Robot	TRL 4
	UCBM	Multimodal Interface	TRL 4
	UCBM	Human-Machine Interface (HMI)	TRL6
	MUL	Human-Machine Interface (HMI)	TRL6
	SERMAS	Human-Machine Interface (HMI)	TRL6
	MUL	WASP Component	TRL 7

Partner Name	Pilots	Main Technology Provided	TRL
	SERMAS	WASP Component	TRL 7
	UMCU	WASP Component	TRL 7
THL	UCBM	FMS	TRL5
SSSA	SERMAS	HOSBOT robotic platform	TRL5-6
	UCBM	Transparent Robot-environmental	TRL5-6
	UMCU	HOSBOT robotic platform	TRL5-6
	MUL	HOSBOT robotic platform	TRL5-6
	MUL	Transparent Robot for human interaction	TRL5-6
PHILIPS	CUB	Federated Learning pipeline	TRL 4-5
UPM	UCBM	Streaming channel	TRL 4-5
	SERMAS	Streaming channel	TRL 4-5

In the following sections are reported the descriptions per each and every pilot.

## A.2 CUB - Charité-Universitätsmedizin Berlin, Germany

### A.2.1 Pilot Description

Charité University Hospital, one of Europe's largest hospitals with four campuses in Berlin, hosts the Interdisciplinary Sleep Medicine Centre, which uniquely treats sleep disorders across all age groups. The center features outpatient and inpatient facilities, staffed by various specialists including pneumologists, neurologists, and nurses. Charité aims to integrate patient care, research, and education, staying updated with technological advancements to enhance medical services. ODIN shares this vision of advancing medical care.

The Sleep Medicine Centre focuses on improving organizational, environmental, and economic aspects. Challenges include long waiting lists and time-consuming processes due to limited resources. To address this, they explore new technologies as alternatives to the current gold standard, polysomnography (PSG). Emerging devices offer cost-effectiveness and efficiency, critical amidst an energy crisis and rising costs. Automated sleep scoring using machine learning algorithms further streamlines diagnosis.

Additionally, the center prioritizes disaster preparedness, leveraging technology for enhanced response capabilities. Experimental trials assess new technologies' performance in disaster scenarios. Overall, Charité's Sleep Medicine Centre is committed to innovation and excellence in patient care and disaster management.

#### A.2.1.1 Pilot Experiments

Table 23 - CUB Experiments

Use Case	Name	Description	RUC X Phase (s)
RUC A UC 3	AI Based Support System for Diagnosis	Validation of Wearables & Automated Scoring of Wearables	Diagnosis
RUC A UC 3	AI based support system for Diagnosis	Automated Sleep Scoring of Sleep Studies	Diagnosis
RUC A UC 4	Clinical Tasks and Patient Experience	CERTHbot Receptionist	Admission & Screening
RUC C UC 7	Disaster Preparedness	Patient monitoring/ Evacuation	Monitoring

## A.2.2 RUC A UC 3: Validation of Wearables & Automated Scoring of Wearables

### A.2.2.1 Description (overall and for each phase)

The focus of this use case is on validating new algorithm-based methods for producing sleep metrics that could help diagnose sleep disorders, aiming to overcome the limitations of overnight in-laboratory polysomnography (PSG), the current gold standard. PSG is labor-intensive, time-consuming, and expensive, resulting in long waiting lists and high costs for healthcare systems. The shortage of sleep technicians exacerbates the problem.

Wearable sleep monitor devices offer a solution by being mobile, simple, and lightweight, enabling self-application at home. However, their algorithms require validation against PSG. In pursuit of automated analysis of sleep stages, the data collected from the ring-worn monitors will undergo training in a model, advancing towards accurate diagnosis of sleep disorders. To further refine the process, the data will be tested for federated learning, a collaborative approach that preserves privacy by training models across decentralized devices. This innovative method holds promise for improving diagnostic accuracy while maintaining patient confidentiality and data security, marking a significant step forward in sleep medicine research and patient care.

The initial phase involves conducting two internal experiments to validate different wearable sleep-tracking devices, specifically two studies using finger-worn monitors resembling rings. This initiative aims to enhance diagnostic efficiency while reducing the burden on healthcare personnel and hospital resources.

Figure 12 shows a description of the components and the workflow. This diagram illustrates two use cases: “RUC A UC3 Validation of Wearables & Automated Scoring of Wearables” and “RUC UC3 Automated Sleep Scoring of Sleep Studies”.

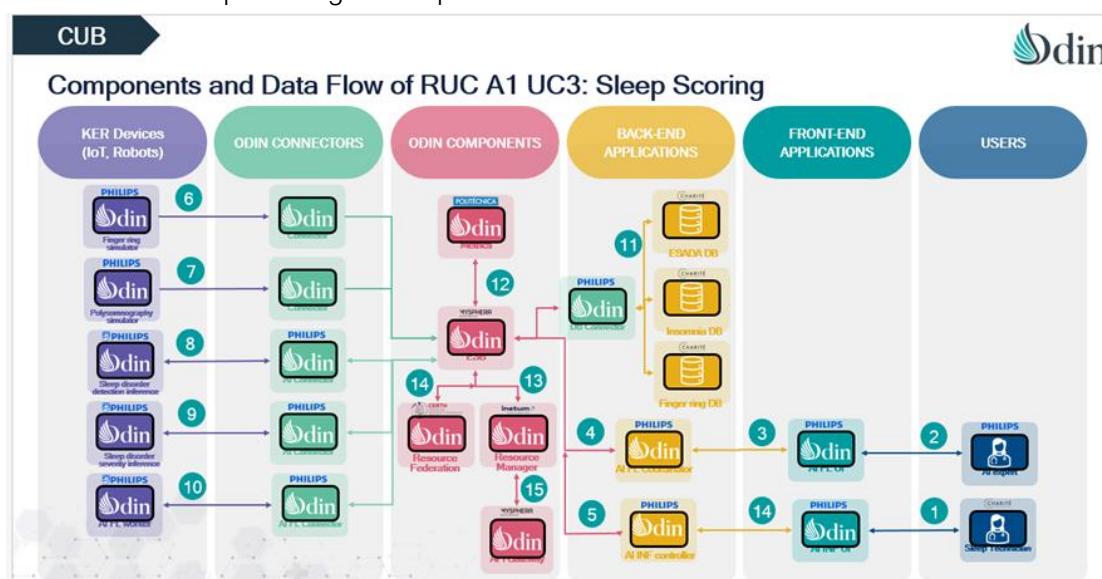


Figure 12 – CUB UML schema for RUC A UC3 regarding sleep scoring

Study 1 focuses on evaluating the diagnostic efficacy of the SleepImage Ring device for obstructive sleep apnea (OSA) in adults, using polysomnography (PSG) as the reference standard. The study aims to validate the device's ability to provide accurate and reliable

measurements of OSA severity compared to PSG across various thresholds of disease severity. The protocol involves simultaneous overnight sleep recordings using PSG and the SleepImage Ring device, supplemented by subjective surveys through questionnaires like the Epworth Sleepiness Scale and the STOP-Bang questionnaire.

In Study 2 the focus is on comparing the measurements and hypnograms obtained from commercial sleep trackers (such as Oura, SleepOn, and Circul) with those obtained from standard polysomnography. The primary endpoints include comparing total sleep time (TST) and wake after sleep onset (WASO) measurements between the sleep trackers and polysomnography, while the secondary endpoints involve comparing the hypnograms produced by both methods. The protocol mirrors Study 1, with simultaneous overnight recordings using PSG and the three commercial sleep trackers for each study participant.

Following these studies, the data collected from the ring-worn monitors will undergo training in a model (federated learning), advancing towards accurate diagnosis of sleep disorders via automatic scoring of sleep metrics.

#### A.2.2.2 Timeline (overall and for each phase)

The experiment started in November 2022 and will end in April 2024 with the following timeline:

- Admission & Screening (Start approx. 1.09.2022):

Patient recruitment started as soon as final ethical approval was given.

- Diagnosis (Start approx. 1.02.2023):

The patient undergoes an overnight recording routine plus self-application of the wearable which is introduced by technical staff.

- Data Sharing & testing model (Start, approx.. 01.12.2024):

Fully anonymise patient recordings and share with partner to test the model with new data once trained. After the model has been trained to score sleep data, test model on unseen sleep recordings to see if they accurately predict sleep metrics.

- Write-up & Dissemination (Start approx. 01.05.2023):

Writing up the final report and disseminating it to all other partners. This will include tying up all loose ends and finalising all aspects of the experiment.

#### A.2.2.3 Technology Definition

IoT: SleepImage Ring, Oura, SleepOn, and Circul – all of which are rings which measure pulse oximetry. They offer so-called sleep trackers in ring format or based on an app-based contactless measurement. By measuring oxygen saturation, breathing rate, movement, pulse and activity, these devices evaluate sleep and breathing with proprietary algorithms and create a hypnogram.

AI: AI Models to predict sleep metrics – Provide a model with the ring dataset in order to teach it specific characteristics of sleep metrics so that when new prospective data comes in, it can accurately and automatically identify the sleep metrics. Once trained, the AI model should be able to predict the sleep metrics without the help of a human if new data is provided.

#### A.2.2.4 Procurement / Acquisition process

Wearable devices: Direct buy

AI Models: Technology partnership already in place

### A.2.2.5 Primary Outcomes (overall and for each phase)

This use case aims to evaluate the diagnostic capabilities of four wearable monitoring devices for sleep disorders in adults. We will use PSG as a standard reference. If the rings' diagnostic abilities are similar to the gold standard PSG, it could be a very helpful alternative for diagnosis. Once confirmed, the pursuit of automated analysis of sleep stages will involve training the data collected from the ring-worn monitors in a model. This step aims to advance towards more accurate diagnosis of sleep disorders by producing sleep metrics. To further refine the process, the data will undergo testing for federated learning techniques, enhancing the overall efficiency producing sleep metrics in order to diagnose sleep disorders.

- Diagnosis

We aim to collect the ring data in a standardised manner in order to produce a clean dataset, which can be easily analysed. Later down the line, this data can be used in a machine learning algorithm with the aim to automatically diagnose future data via federated learning. Thus, providing us with a new, accurate, and automatic method of diagnosing patients which would not be possible without the help from the partners of ODIN.

### A.2.2.6 KPIs

Table 24 - CUB RUC A1 UC3

Phase	KPIs	Measure unit	Tool	Notes
<b>Diagnosis &amp; Case Study</b>	Data collection from both studies	Sleep recordings	Rings, PSG,	
	Automatic scoring of sleep stages	% of sleep stages	Ring data trained in AI model	

#### Diagnosis & Case Study:

Data collection from both studies - Expected outcome: we expect a large clean dataset that measures the constructs of interest.

Automatic scoring of sleep stages – Expected outcome: new prospective ring data can be used to automatically classify sleep stages.

### A.2.2.7 Involved stakeholders

#### Diagnosis:

- Physicians
- Nurses
- Scientific staff

## A.2.3 RUC A UC 3: Automated Sleep Scoring of Sleep Studies

### A.2.3.1 Description

Our collaboration with Philips aims to enhance machine-learning algorithms for the automatic classification of sleep metrics using federated learning techniques. In accordance with our ethics guidelines, we will provide Philips with anonymized sleep apnea data from a European database and insomnia PSG data from a previous clinical trial. After ensuring full anonymization, Philips will employ federated learning to train a model on the provided data, aiming to develop a robust algorithm capable of automatically scoring sleep metrics. This retrospective data training will enable Philips to create an algorithm that can automatically score sleep studies. This innovative approach signifies a significant advancement in leveraging federated learning and technology to improve the diagnosis and management of sleep disorders.

- Diagnosis:

Federated learning to automatically score sleep studies. Philips plan to create an algorithm that can automatically score prospective recordings following the training.

### A.2.3.2 Timeline (overall and for each phase)

The experiment started in August 2022 and will stop in April 2024 with the following timeline:

- Data Sharing (Start approx. 01.08.2023):

Fully anonymise patient recordings and share with partner once the data sharing agreement has been signed.

- Diagnosis (Start approx. 01.12.2023):

After the model has been trained to score sleep data, test model on unseen sleep recordings to see if they accurately predict sleep metrics.

- Write-up & Dissemination (Start approx. 01.05.2023):

Writing up the final report and disseminating it to all other partners. This will include tying up all loose ends and finalising all aspects of the experiment.

### A.2.3.3 Technology definition

AI: AI Models to predict sleep metrics – Provide a model with the large PSG dataset in order to teach it specific characteristics of sleep metrics so that when new prospective data comes in, it can accurately and automatically identify the sleep metrics. Once trained, the AI model should be able to predict the sleep metrics without the help of a human if new data is provided.

### A.2.3.4 Procurement / Acquisition process

AI Models: Technology partnership already in place.

### A.2.3.5 Primary Outcomes (overall and for each phase)

#### Diagnosis

Retrospective data collected by Charité used in a machine learning algorithm could automatically score future sleep data. Thus, providing us with a new, accurate, and automatic method of scoring sleep studies which would not be possible without the help from the partners of ODIN.

### A.2.3.6KPIs

Table 25 - CUB RUC A1 UC3&4

Phase	KPIs	Measure unit	Tool	Notes
Diagnosis & Case Study	Automatic scoring of sleep stages	% of sleep stages	PSG data trained in AI model	

#### Diagnosis & Case Study:

Automatic scoring of sleep stages – Expected outcome: data collected retrospectively can be used to automatically classify sleep stages.

### A.2.3.7Involved stakeholders

#### Diagnosis:

- IT department
- Scientific staff

## A.2.4 RUC A UC 4: CERTHbot Receptionist

### A.2.4.1 Description (overall and for each phase)

Our collaboration with CERTH focuses on optimizing nurses' tasks through the deployment of their robot as a receptionist, primarily guiding patients to their rooms. The planned experiment, spanning several weeks, involves patients interacting with the CERTHbot and providing feedback on its usefulness and likability. While the robot has undergone extensive testing in home environments, its application in hospitals, with long corridors, presents a new challenge. Successful implementation could streamline patient navigation within the hospital, potentially paving the way for further automation in healthcare settings. The interaction between various ODIN components and users is depicted in [Error! Reference source not found.](#).

- Admission & Screening:

This use case tends to focus on the admission of the patient, taking the patient from point A to point B.

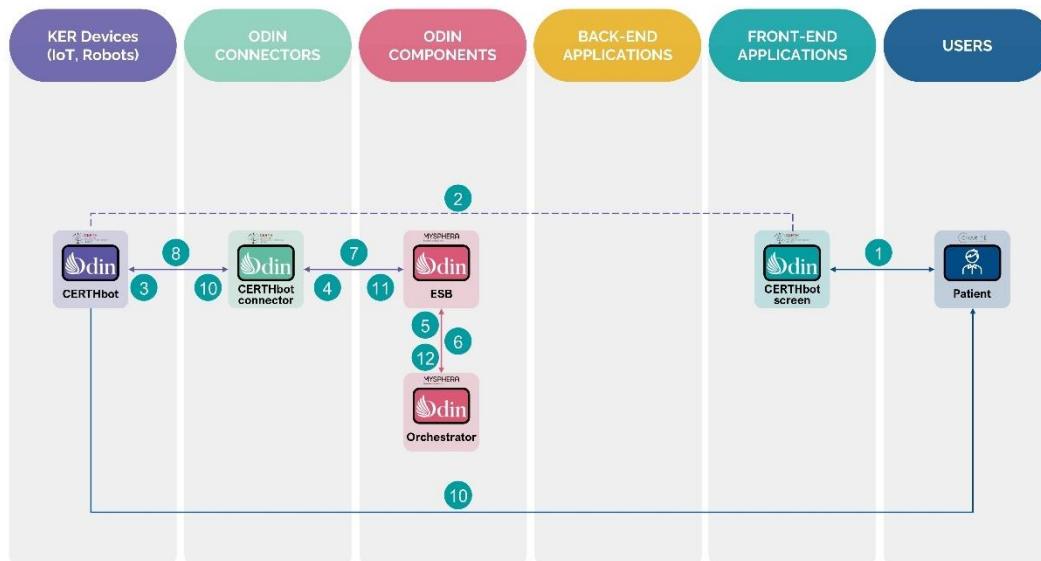


Figure 13 – CUB UML schema for RUC A UC4 regarding robot receptionist

### A.2.4.2 Timeline (overall and for each phase)

The experiment started in January 2024 and will stop in January 2024 with the following timeline:

- Admission & Screening (Start approx. 16.01.2024):

CERTHbot will be present during admission so that it can take the patient immediately from point A to point B.

- Write-up & Dissemination (Approx. 01.02.2024):

Writing up the final report and disseminating it to all other partners. This will include tying up all loose ends and finalising all aspects of the experiment.

### A.2.4.3 Technology definition

Robots: CERTHbot developed and tested by CERTH will be integrated into Charité's sleep laboratory to trial as a receptionist. The robot can learn the hallways and patient wards, so when instructed it can assist the patient to their room.

### A.2.4.4 Procurement / Acquisition process

CERTHbot: Technology partnership already in place

### A.2.4.5 Primary Outcomes (overall and for each phase)

This use case aims to alleviate the workload of nurses and doctors by employing a robot to handle time-consuming tasks, thereby freeing them to focus on more critical responsibilities.

- Admission & Screening:

We aim to display the CERTHbot can take the patient immediately from point A to point B without assistance. Thus, reducing workload whilst completing the task to a high standard.

### A.2.4.6 KPIs

Table 26 - CUB RUC A2 UC4

Phase	KPIs	Measure unit	Tool	Notes
Admission & Screening	Patients taken from the meeting point to the patient ward by a robot	Successful number of trips	Report from patient and nurse	...

#### Admission & Screening:

Patients taken from the meeting point to the patient ward by a robot – Expected outcome: The CERTHbot can successfully take workload from nurses whilst keeping the patient satisfied as an acting receptionist.

### A.2.4.7 Involved stakeholders

#### Admission & Screening:

- Nurses

## A.2.5 RUC C UC 7: Patient Monitoring/Evacuation

### A.2.5.1 Description (overall and for each phase)

Our collaboration with CERTH aims to leverage new technology for enhancing disaster preparedness at Charité, particularly focusing on patient monitoring and evacuation procedures. Currently, the Charité's sleep medicine center lacks automated systems to detect patients remaining in bed, intruders, or successful patient evacuation during emergencies, despite having installed cameras in patient wards. CERTH proposes implementing their automated detection system into a camera placed in our patient ward for trial purposes, aiming to automatically monitor patients, detect intruders, and ensure successful evacuations. The planned experiment will span several weeks and involve workers or consenting patients as trial participants. This could potentially improve disaster management efficiency by facilitating faster evacuations and alerting nurses to intruders. The workflow and components of this use case are depicted in Figure 14.

- Monitoring:

Monitors the patient wards and alerts the staff if any of the following occur: patients remain in their room during an evacuation or whether a patient leaves unexpectedly during a sleep recording / if an intruder enters.

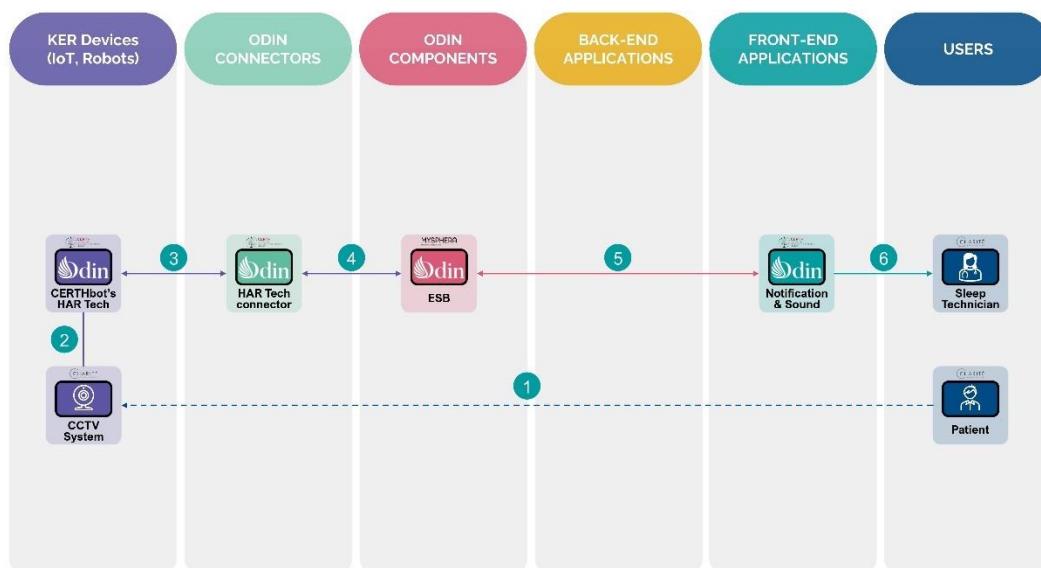


Figure 14 – CUB UML schema for RUC C UC7 regarding patient monitoring and evacuation

### A.2.5.2 Timeline (overall and for each phase)

The experiment started in January 2024 and will stop in January 2024 with the following timeline:

- Monitoring (Start approx. 16.01.2024):

Detection system built into a camera and placed in the patient wards: Monitors the patient wards and alerts the staff if any of the following occur: patients remain in their room during an evacuation or whether a patient leaves unexpectedly during a sleep recording / if an intruder enters.

- Write-up & Dissemination (Start approx. 01.02.2024):

Writing up the final report and disseminating it to all other partners. This will include tying up all loose ends and finalising all aspects of the experiment.

#### A.2.5.3 Technology definition

AI: Detection system built into a camera and placed in the patient wards of the sleep medicine centre to trial as an improved tool for disaster management. It can monitor whether a patient leaves their bed during sleep recording, it can monitor if any intruders enter, and it can also monitor whether a patient has left the ward during evacuation procedures.

#### A.2.5.4 Procurement / Acquisition process

The process of acquisition will be through a procurement process / direct buy / technology partnership already in place / other

Wearable devices: Direct buy

AI Models: Technology partnership already in place

CERTHbot: Technology partnership already in place

#### A.2.5.5 Primary Outcomes (overall and for each phase)

We aim to show that the technology provided by ODIN can help improve disaster preparedness at the Charité. This would be done by installing their software into our cameras, it would indicate whether any patients remain in their room during an evacuation or whether a patient leaves unexpectedly during a sleep recording / if an intruder enters.

- Monitoring:

We aim to show that the detection system integrated into a camera and placed in our patient wards can monitor the patients and alert staff if any of the following occur: patients remain in their room during an evacuation or whether a patient leaves unexpectedly during a sleep recording / if an intruder enters. The overall benefit would be that If this proves useful, it could open avenues for more efficient disaster management (faster evacuation and alerting nurses if an intruder is there).

#### A.2.5.6 KPIs

Table 27 - CUB RUC C UC7

Phase	KPIs	Measure unit	Tool	Notes
Monitoring	Monitored for evacuation/intruder/left the room	Number of successful alerts from the each scenario	CERTHbot technology in the already installed cameras	

Monitoring:

Monitored for evacuation/intruder/left the room – Expected outcome: detection system installed into cameras can successfully recognise if an intruder enters/patient leaves during sleep recording/ patient remains in their ward during evacuation. The technology can then notify staff.

#### A.2.5.7 Involved stakeholders

##### Monitoring:

- Nurses
- Overnight staff

#### A.2.6 ODIN Integration

##### A.2.6.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment

We envision utilizing AI models trained via federated learning to automatically score sleep studies, encompassing both standard recordings and wearable data. The retrospective standard recording data will be anonymized and shared with partners, facilitating the development of AI systems. Similarly, prospective data from wearables will undergo separate model training. These models, trained through federated learning, will help classify sleep disorders by producing sleep metrics, whilst enhancing scoring speed and accuracy for both PSG and wearable recordings. Federated learning will be implemented through the ODIN platform.

Furthermore, our objective includes deploying the CERTHbot as both a receptionist and a camera detection system within the hospital premises. We will initiate the process by ensuring that the medical staff is acquainted with the bot through familiarization sessions and mock testing. Following this phase, the bot will be seamlessly integrated into routine hospital operations. This pilot project is designed to alleviate the workload of medical staff and could potentially serve as a model for other hospital departments, contingent upon successful implementation and favorable patient feedback. Additionally, we aim to deploy the CERTHbot as a receptionist and camera detection system, starting with staff familiarization and mock testing before full integration into regular hospital operations. This pilot project aims to reduce medical staff workload and potentially serve as a template for other hospital departments, pending successful implementation and positive patient feedback.

## A.3 MUL - Medical University of Lodz, Poland

### A.3.1 Pilot Description

Medical University of Lodz (MUL) is a higher state school having over 70 years-long history. With its 5 faculties, 3 teaching hospitals and 80 clinics, 9.500 students, 1.000 foreign students and app. 1600 academics, Medical University of Lodz belongs to the leading Polish medical universities. The University is strongly committed to scientific research in a number of health-related disciplines as well as national and international scientific cooperation. The University is considered a leader in the number of scientific publications and citations among medical schools in Poland. MUL's scientists conduct extensive basic and translational research. The Medical University of Lodz has reached the leading position in various research areas, and particularly in patient adherence and healthy ageing. In acknowledgment of these achievements, the Medication Adherence Research Centre (MARC) was founded in 2020 in MUL, headed by Prof. Przemyslaw Kardas.

MUL makes a substantial contribution to the development of the health care system by promoting modern standards of prophylaxis and treatment, and by building long-lasting cooperation with institutions realizing objectives of public health at regional, national and international levels. Last but not least, MUL is strongly committed to Silver Economy. Being formally recognised as the EIP on AHA Reference Site, MUL plays the key role in facilitation of collaboration between academia and industry, in order to change the demographic challenge into opportunity. Initiating creation of dedicated businesses cluster, MUL plays a role of pioneer and helps boosting of local economy.

With its own complete ecosystem of healthcare services, covering full range of healthcare system levels, from primary health centres to tertiary teaching hospitals, MUL is perfectly well-placed for the purpose of testing and implementation of novel health technologies. Serving over 86.000 patients yearly, MUL is also one of the major local healthcare providers, active in each and every area of modern medicine. This potential will be of particular use within the framework of ODIN project.

The experiments planned within ODIN are directly linked to the current need of the patients served by MUL. With ageing society of Poland, and rising lack of the workforce in the healthcare system, the use of robotic solutions is more than urgent. This has been particularly emphasized by the novel challenges that come with unexpected plague of Covid-19 pandemics, and war in Ukraine that started in the neighbour country in 2022. Introducing to the hospital settings novel IT-based solutions of e-location, and robotic workers is supposed to overcome current bottlenecks, and make the hospital environment more resistant toward such challenges. Moreover, in a longer run, it will also have a positive economic impact on the hospital sustainability.

### A.3.1.1 Pilot Experiments

Table 28 - MUL Experiments

Use Case	Name / Description	RUC Phase (s)
RUC A2 – UC4	Blood transport. Robotic transportation of blood samples from the Emergency Department to the Central Lab	Diagnosis & Case Study phase
RUC B2 – UC2	Clinical Engineering and Medical Locations Management	Diagnosis & Case Study phase

### A.3.2 RUC A2 - UC4: Clinical Tasks and Patient experience

Intervention envisaged by MUL will adopt a principal objective of helping execution of care and diagnostic procedures with robotic transportation of blood samples from the Emergency Department to the Central Lab.

#### A.3.2.1 Description

The clinical scenario that corresponds with this objective is the need to help execution of effortful care and diagnostic procedures in elderly patients, e.g. those supposed to be infected by Clostridium difficile bacteria causing potentially life-threatening gastrointestinal infections, at the teaching hospital Emergency Unit. These procedures belong to the daily tasks of nursing staff. The clinical basis for this is defined by the specific needs of certain clinical specimens (e.g. blood samples), that cannot be carried to the Central Lab with pneumatic post due to their fragility toward shocks. With mobile robotic delivery process, these effortful tasks needing a lot of physical work and staff time will be made easier for nursing staff. Thus, nurses will be less tired, and could be more attentive and focused over higher-level patients' needs, such as e.g. need for social interactions and emotional support in the stressful environment of Emergency Room. In consequence, the use of ODIN technology will have in these patients a positive impact over the quality of life of patients. Enabling elderly patients to be tested, and diagnosed faster, the technology will have a positive effect on their overall wellbeing, as well.

- Admission and Screening phase: there is a need for identification of patients with a need for lab test, particularly those which require fast and safe delivery of the specimen to the Central lab.
- Diagnosis & Case Study phase: Healthcare providers, especially nurses are struggling with a lot of tasks in Emergency Department (ED). It takes a lot of time and effort to carry the fragile specimens from this environment to the Central lab. This is of particular importance in the ED where the cases are acute, and need fast decision making and continuous support. Current gaps include lack of hospital staff (particularly nursing staff), and need for assistance in carrying of fragile samples, just to name the most important ones.
- Treatment phase: Currently healthcare professionals in hospitals must often use their precious time to carry fragile samples to the Central Lab in person. Any help in this activities will enable healthcare professionals especially nurses and paramedics to save their time, and reschedule their valuable time to other duties. Current gaps include acute patients, especially unconscious ones, who need continuous help from healthcare staff at

the ER. There is a need for new solutions supporting healthcare professionals in securing fast and reliable testing of these patients.

- Monitoring phase: Employing robotic solutions is a new idea for Polish hospital staff members. Therefore, there is a need to carefully monitor the performance of this new solution, satisfaction of end-users (nursing staff), safety of the specimens, as well as safety of the other patients in the Emergency Room, in order to secure accumulation of evidence, and better acceptance of similar robotic solutions in future.

### A.3.2.2 Timeline

The experiment started in February 2023, will end in December 2023 with the following timeline:

Experiment Part I: envisaged for the period February-June, 2023 – involves the use of robotic delivery in secure laboratory environment. In this part, all the phases (i.e. Admission and Screening phase, Diagnosis & Case Study phase, Treatment phase and Monitoring phase) will be simulated, and the robotic system will be verified and fine-tuned, in order to get ready for Experiment Part II.

Experiment Part II: Scheduled for the period July - December, 2023 – involves the use of robotic delivery in real Emergency Department environment, without direct contact with patients. In this part, again, all the phases (i.e. Admission and Screening phase, Diagnosis & Case Study phase, Treatment phase and Monitoring phase) will be employed, and the robotic system will be verified and fine-tuned, in order to get ready for Experiment Part III. Particular care will be taken of making it completely safe for both the staff members and the patients.

Experiment Part III: Scheduled for January - February, 2024 – is based on the use of robotic delivery in real Emergency Department environment, with direct contact with patients and staff members. All the phases (i.e. Admission and Screening phase, Diagnosis & Case Study phase, Treatment phase and Monitoring phase) will be included in this Part, and the robotic system will be finally verified regarding its safety and performance, against the pre-set KPIs.

Experiment Part IV: Scheduled for March – December 2024 - This part of the experiment will be dedicated to a multidirectional analysis of data from previous phases to determine optimal methods for implementing both the robot in the hospital space and the patient localization system. The collected data will allow for drawing conclusions that can be utilized in future experiments and will serve as a basis for further development of robotics in the hospital environment.

### A.3.2.3 Technology definition

Overall strategy a cohesive system of screening-execution-monitoring will be secured with the use of relevant digital solutions and interlinked hardware/equipment; robotic carrier (mobile robotic platform provided by Robotnik) equipped with dedicated smart box (provided by SSSA solution) In Figure 15, the relationship between the ODIN components and the workflow is depicted.

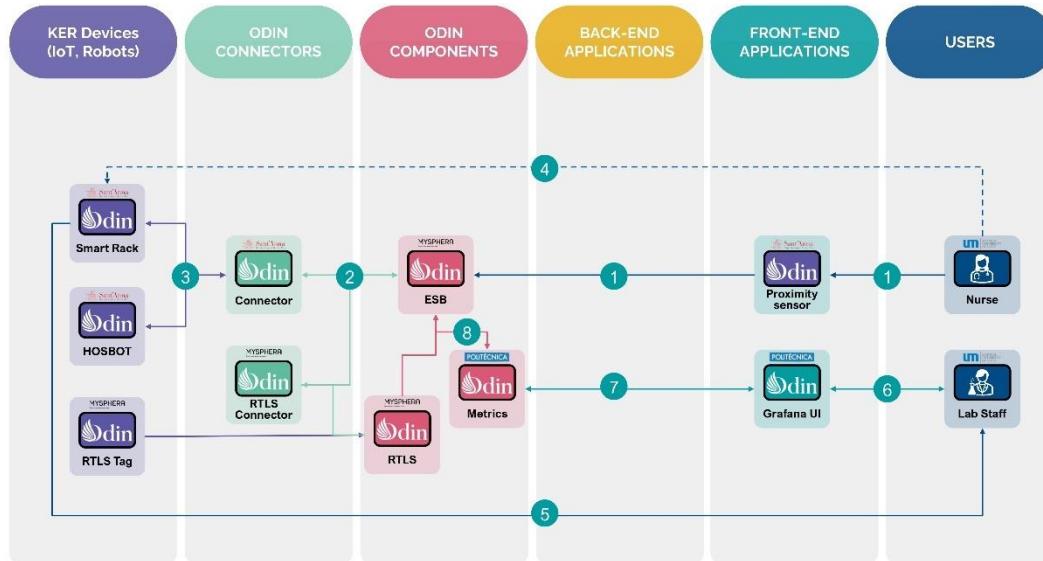


Figure 15 – CUB UML schema for RUC A UC4 regarding blood transportation and RUC C UC7 biohazard material transportation

In details, the experiment will use the following technology:

- Admission and Screening phase: initial screening of the need for specific lab test versus provisional diagnosis (employing HL7/FHIR).
- Diagnosis & Case Study phase: robotic carrier (Robotnik solution) equipped with dedicated smart boxes (SSSA solution); AI component to allow for choosing best path of specimen delivery in potentially crowded environment of Emergency Room
- Treatment phase: same as above
- Monitoring phase: same as above; data storage secured with SQL

#### A.3.2.4 Procurement / Acquisition process

Current view of the process of acquisition of technology looks as follows:

- Robotic carrier (Robotnik solution) is envisaged through technology partnership already in place
- Smart box acquisition (SSSA solution) - as part of the mutual cooperation in the ODIN project, these components, like the robot, will be transported to the location of the experiment (Lodz, Poland). Throughout the duration of the experiment, it will be supervised by SSSA to ensure the highest quality of experiment execution.
- IT hospital infrastructure – will be provided by MUL teaching hospital

#### A.3.2.5 Primary Outcomes

Overall primary outcome of this Use Case is to help nursing staff in execution of time-consuming physical tasks, at the same time improving patient experience and safety in the environment of Emergency Department.

- Diagnosis & Case Study phase: final and sure validation of the advantage of robotic delivery of blood samples to the Central Lab; along with assessment of time necessary to establish correct preliminary diagnosis in the patient.
- Treatment phase: to replace physical work of nursing staff with robotic solutions.
- Monitoring phase: assess HTA parameters describing performance of robotic solutions, and staff-reported parameters assessing end-users' satisfaction.

AI component being enabled by the ODIN technology is supposed to provide an added value to the performance of this RUC, by making the robotic delivery system more efficient and safe.

Data collected in this RUC are of value for the entire ODIN ecosystem, letting the other RUCs benefit from the library of data of real-life use of the robotic delivery.

### A.3.2.6 KPIs

Table 29 - MUL RUC A2 UC4

Phase	KPIs	Measure unit	Tool	Notes
Diagnosis & Case Study	Percentage of successful robot calls	percentage	report from the robot	...
	Total number of effective delivers	number	direct measurement	
	Number of blood samples successfully delivered to the target point.	number	direct measurement	
	Time to transport the blood sample from the collection point to the lab	seconds	direct measurement	
	number of e-robots interventions	number	report from platform	
	number of samples delivered effectively to target point per day	number	direct measurement	
	Percent of effective blood sample deliveries to destination within an acceptable time range	percentage	direct measurement	
	Nursing staff satisfaction	5-point Likert scale	questionnaire	

Overall strategy a battery of various parameters will be traced in order to assess solution feasibility, effectiveness and cost-effectiveness.

- Diagnosis & Case Study phase: The variables of interest include: proxy for effectiveness – e.g. number of e-robots interventions, nursing staff satisfaction parameters; proxy for safety – percentage of safe interventions, without technical/medical complications; unobtrusive performance of robotic delivery in real-world environment of Emergency Room; proxy for costs – nursing staff work time parameters.

### A.3.2.7 Involved stakeholders

Involved staff will include target end-users – i.e. mostly nursing staff; as well as researchers involved in designing and executing the tasks (health scientists, IT specialists, etc.)

- Diagnosis & Case Study phase: Emergency unit staff - mostly nurses, partly – medical doctors, research team, IT department.

### A.3.3 RUC B2 UC2 Clinical Engineering

This MUL reference use case covers aspects related to the exploitation of ODIN technologies for improving the management of medical locations of medical equipment in the busy environment of the Emergency Department of MUL's tertiary teaching hospital.

#### A.3.3.1 Description

Planning: this involves identification of core components of medical equipment which are subject to changing location (e.g. ECHO scanner) and are of potential need of emergency use depending on the conditions ad provisional diagnosis established in a patient admitted to the Emergency Department. This process will be based on evidence from needs assessment of both staff members and the patients, current usage patterns, analysis of faults and recalls, maintenance and real-world data (RWD).

Delivery, installation, training: Currently, the items of medical equipment being used within the Emergency Department are taken to the room where they will be used by the staff members from their current location. Due to the various needs of individual patients, this location is changing in a consequence. Neither their current location, nor the information on the time of their use is currently traced and recorded in the hospital systems.

In order to change this, previously identified core components of medical equipment will be marked with unique digital identifiers, allowing for their tracing. The technology used for this will secure their safe, resisted and unique identification without any negative consequences for their principal role e.g. caused by electromagnetic fields interferences, etc.). With the use of RTLS technology enabled by MYS the most needed devices like ECG and USG will be easily findable in the hospital setting. The gateways placed in regular distances all around the place will be constantly tracing tagged devices using RFID technology. Thanks to this healthcare professionals will be able to find necessary devices within a seconds and use them for the benefit of other patients. Existing infrastructure allowing for in-hospital localisation and navigation will minimise the negative impact of system installation over the performance of the staff in the real-world conditions. Minimal level of technical and healthcare staff training on the system use will be necessary to implement the system.

Cleaning, management, and maintenance: Tagging system applied in order to identify equipment location conforms with relevant cleaning techniques and standards. The use of digitally-enhanced location system will help better adherence to the relevant cleaning procedures (e.g. UV irradiation).

### A.3.3.2 Timeline

The experiment started in April 2023 and will stop in April 2024 with the following timeline:

Experimental Phase I: envisaged for the period April-July, 2023 – involves the configuration of the system, training of the staff, and its pilot verification in living lab environment. In this part, all the phases (i.e. Admission and Screening phase, Diagnosis & Case Study phase, Treatment phase and Monitoring phase) will be simulated, within the lab, and the location system will be verified and fine-tuned, in order to get ready for Experiment Part II.

Experiment Part II: Previously scheduled for the period August-October, 2023, postponed to February 2024 due to delay in ODIN platform deployment – involves the use of equipment location execution in real Emergency Department environment, however, without direct use in patients. In this part, again, the phase Diagnosis & Case Study will be employed, and the location system will be verified and fine-tuned, in order to get ready for Experiment Part III. Particular care will be taken of making it able to work among other pieces of equipment, assuring its safety for both the staff members and other pieces of equipment. This part of experiment is planned to be joined with RUC A HOSBOT deployment simultaneously.

Experiment Part III: Previously scheduled for the period November-December, 2023, now planned for February 2024 – is based on the use of location system use in real Emergency Department environment, for the benefit of patients and staff members. The phase Diagnosis & Case Study will be included in this Part, and the location system will be finally verified regarding its safety and performance, against the pre-set KPIs.

Experiment part IV: Planned for March – December 2024 In this part of the experiment, the research team will focus on analyzing the data obtained during the phase conducted in the hospital environment to better understand the fundamentals of environmental analysis based on the RTLS system. The results obtained will be used to draw conclusions enabling the improvement of the system's performance and the development of medical equipment localization.

### A.3.3.3 Technology definition

Overall strategy a cohesive system of screening-execution-monitoring will be secured with the use of relevant digital solutions and interlinked hardware/equipment; RFID trackers (provided by MySphera - MYS) and interlinked AI-guided ODIN solution (being made available by the consortium partner(s) including CERTH). The identified components as well as the interrelations are shown in the figure below:

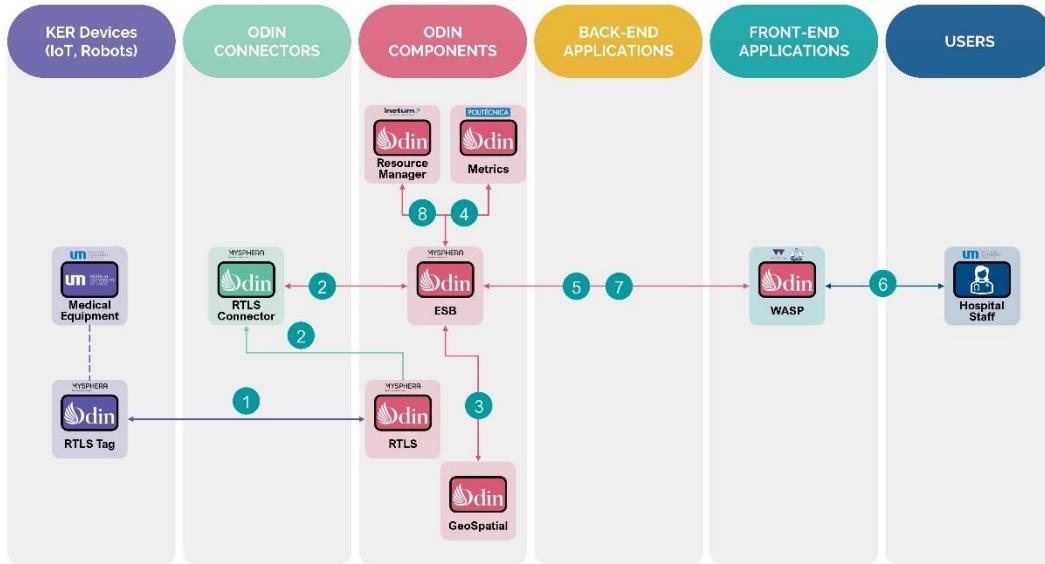


Figure 16 – CUB UML schema for RUC B UC2 regarding medical equipment location

The experiment will use the following technology:

- Diagnosis & Case Study phase: identification of the need to use relevant piece of equipment by medical staff members, which is followed with AI-guided location process showing the staff member where the requested piece of equipment is located, and how to reach it in the fastest way, being informed of the current patient and staff member flow.

#### A.3.3.4 Procurement / Acquisition process

Current view of the process of acquisition of technology looks as follows:

- RFID tagging and localisation system will be made available from MYS for the time of the experiment, it will be used in Lodz, Poland and returned to MYS after the experiment finishes
- ODIN platform access is envisaged through technology partnership already in place
- AI module is envisaged through technology partnership already in place
- IT hospital infrastructure – will be provided by MUL teaching hospital

#### A.3.3.5 Primary Outcomes

This reference use case aims at maximizing data-driven decisions and management of diagnostic and treatment processes in busy environment of Emergency Department, thanks to:

- Optimizing the whole clinical medical locations management process with the use of need-to-solution flow paradigm, starting with the identification of items needing support in their localisation management, through providing operational solution, up to extensive testing and evaluation
- Reducing staff work time, maximizing equipment availability and patient safety.
- Innovating the way the medical equipment is delivered and reused, and the training to technicians and health personnel on the use of the novel system.

- Optimizing equipment cleaning due to shorter time used for location and transportation, and hence, longer time left to e.g. UV irradiation.

AI component being enabled by the ODIN technology is supposed to provide an added value to the performance of this RUC, by making the e-location system more efficient and safer.

Data collected in this RUC are of value for the entire ODIN ecosystem, letting the other RUCs benefit from the library of data of real-life use of the digital location.

### A.3.3.6 KPIs

Table 30 - MUL RUC B2 UC2

Phase	KPIs	Measure unit	Tool	Notes
Diagnosis & Case Study	Total number of interventions	number	direct measurement	...
	Number of interventions per hour	number	direct measurement	
	Time required to locate equipment with the assistance of the localization system	seconds	direct measurement	
	Time saved by the nurse	seconds	direct measurement	
	Percentage of successful localizations	number	direct measurement	
	Percentage of successful localizations within an acceptable time frame defined as below 150 sec.	percentage	direct measurement	
	Number of episodes of discontinuity of monitoring and network contact	percentage	RTLS system internal data	
	Integration quality with the ODIN network, measured by transmitting all information about procedures performed by the robot.	percentage	ODIN platform data	

Phase	KPIs	Measure unit	Tool	Notes
	Clinical staff satisfaction with the use of localization transport	number		questionnaire using a 5-point Likert scale

Overall strategy a battery of various parameters will be traced in order to assess solution feasibility, effectiveness and cost-effectiveness.

- Diagnosis & Case Study phase:

- number of episodes of equipment use with and without the use of digitally-enhanced location.
- average transportation time from ER to Central Lab.
- number of staff members trained in the location system use.
- number of episodes of equipment use with and without the use of digitally-enhanced location.
- equipment delivery time.

#### A.3.3.7 Involved stakeholders

Involved staff will include target end-users – i.e. mostly nursing staff; as well as researchers involved in designing and executing the tasks (health scientists, IT specialists, etc.)

##### Diagnosis & Case Study phase:

- Emergency unit staff - mostly nurses, partly – medical doctors;
- IT department;
- Technical Managers
- Health Managers
- Clinical Engineers

### A.3.4 ODIN Integration

#### A.3.4.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment?

##### RUC A2 UC4

ODIN will enable fast and effective screening of patients who need an intervention due to the analysis of past patient history catalogue, its execution supported by AI component, data collection, retrieval and analysis.

Admission and Screening phase: Because the number of available eRobots is limited, screening of patients who need help in fast blood specimens' delivery at first place will be necessary. That is why screening tests providing information who should receive eRobots help will be necessary. These screening tests will be provided at the point-of-care thanks to ODIN-enabled battery of screening tests.

Diagnosis & Case Study phase: The screening functionality continuously provided at the point-of-care thanks to ODIN-enabled battery of screening tests.

Treatment phase: use of the eRobot in patients with a need for lab tests, identified due to the screening, monitoring the KPI for treatment in 3 moments: before, during and after intervention, allowing for data collection and retrieval; AI module employed for choosing smart path for the robot in changing environment.

Monitoring phase: allowing for performing an effectiveness and cost-effectiveness study.

At the top of these, several added values will come from integration of this RUC with the ODIN environment, e.g.:

- Use of the ODIN platform will allow to provide interactive education and exercise.
- Data collected in ODIN will allow retrospective analysis of the system performance, trouble shooting, and further education of the staff
- Full access to the data on this RUC implementation, secured with ODIN, can serve as a template for other hospital departments, as well as valuable data for other ODIN partners.

##### RUC B2 UC2

ODIN will enable fast and effective screening of patients who need an intervention due to the analysis of past patient history catalogue, its execution supported by AI component, data collection, retrieval and analysis.

Admission and Screening phase: Because the number of certain pieces of equipment is limited, screening of patients who need fast delivery of specific equipment at first place will be necessary. That is why screening tests providing information who should be prioritised to get access to equipment are necessary. These screening tests will be provided at the point-of-care thanks to ODIN-enabled battery of screening tests.

Diagnosis & Case Study phase: The screening functionality continuously provided at the point-of-care thanks to ODIN-enabled battery of screening tests.

Treatment phase: use of the e-location in patients with a need for various tests, interventions etc, identified due to the screening, monitoring the KPI for treatment in 3 moments: before, during and after intervention, allowing for data collection and retrieval; AI module employed for choosing smart path for the localised piece of equipment to be delivered in changing environment.

Monitoring phase: allowing for performing an effectiveness and cost-effectiveness study.

At the top of these, several added values will come from integration of this RUC with the ODIN environment, e.g.:

- Use of the ODIN platform will allow to provide interactive education and exercise.
- Data collected in ODIN will allow retrospective analysis of the system performance, trouble shooting, and further education of the staff
- Full access to the data on this RUC implementation, secured with ODIN, can serve as a template for other hospital departments, as well as valuable data for other ODIN partners.

## A.4 SERMAS - Servicio Madrileño de Salud, Spain

### A.4.1 Pilot Description

This pilot is being implemented at Hospital Clínico San Carlos, an esteemed institution renowned for its healthcare services in the vibrant heart of Madrid. Esteemed for its longstanding tradition of medical excellence, the hospital seamlessly integrates superior clinical care with a steadfast dedication to research and innovation. This initiative encompasses the collaborative efforts of four pivotal departments and the specialized Smart Health Center (SHC): the Procurement Department, the Cardiology Department, the Surveillance and Security Service, and the Innovation Unit.

The **Procurement Department** is instrumental in overseeing the procurement and logistical distribution of medical equipment and supplies, pivotal for the seamless functioning of clinical operations. Its influence is far-reaching, significantly enhancing the hospital's overall efficacy.

The **Cardiology Department**, particularly through the Cardiovascular Institute (ICV), is a cornerstone of the pilot, accounting for a considerable portion of the hospital's expenditure on medical apparatus and supplies.

The **Surveillance and Security Service** ensures the adept management of both human and technical resources, encompassing civil and property security, fire safety, and emergency responses. This service is crucial in managing access points, regulating the movement of individuals, and averting potential incidents.

The **Innovation Unit**, composed of a diverse team of medical and technical experts, spearheads collaboration between the hospital's staff and external entities, propelling forward healthcare innovation. It acts as a bridge between the ODIN partners and the hospital staff, assisting both in the development of the pilot.

The **Smart Health Center (SHC)**, a novel addition dedicated to research, development, and innovation (R&D&I), employs a multidisciplinary approach to harness advanced technologies like data analytics, automation, robotics, and telemedicine. Its mission is to advocate for the 5P model of health (preventive, predictive, participatory, personalized, and population-based) within the Community of Madrid, aiming to create societal health value with a patient-centric focus, supported by cutting-edge technology.

The synergistic efforts of these departments alongside the SHC are key to the successful execution of the pilot, potentially enabling the expansion of these innovations hospital-wide, thereby enhancing both patient care and operational efficiency.

### A.4.1.1 Pilot Experiments

Table 31 - SERMAS Experiments

Use Case	Name	Description	RUC B Phase (s)
RUC B1 - UC1	Aided Logistic Support	Monitor the use of consumables	Planning Procurement Storage
RUC B2 - UC2	Clinical engineering MD locations; real time management	Consumable delivery automation	Delivery, installation, training Decommissioning, disposal
RUC C – UC7	Disaster preparedness	Evacuation flow optimization	All

### A.4.2 RUC B1 UC1

#### A.4.2.1 Description

This use case has as its main objective the development of an artificial intelligence algorithm that can be integrated into the hospital information system. Its purpose is to enable real-time monitoring of consumables used in the hospital and, at the same time, accurately predict future procurement needs. In this initial pilot, the focus will be on a specific consumable related to the Cardiology service: stents. These devices are essential for the treatment of patients with heart diseases, and because the hospital in question is a reference center, it has a very extensive internal catalog. It is important to note that stents have a high cost, making efficient procurement management critical for the hospital.

- Planning:

The consumable acquisition of the different hospital services needs to be planned in advance. Right now, there is no stock management system implemented in the hospital. The prediction of the needed consumables is done based on historic data, but also on the particular demands of each service according to the procedures that are scheduled for the near future. The historic data concerning consumptions and purchases is sent to the Head of Procurement on a monthly basis in the form of excel/txt files.

During RUC B1 UC1, a dashboard powered by AI will be developed to analyse the historic trends, spot seasonal patterns and be able to predict the needs of the hospital.

- Procurement and storage:

The same consumable can be purchased from several different vendors. Which vendor is chosen is many times based solely on the preference of individual clinicians. There is currently no objective metric with which to compare the different vendors. For example, the time that elapses between making an order and the product arriving to the hospital is not recorded. In fact, the entire delivery process is transparent to us.

Furthermore, right now, there is little control over the inventory. The number of units left of each consumable is obtained periodically by counting them by hand. Several persons go through the different storage rooms and count manually the number of items that are stored. Purchase orders are then made in accordance with this counting.

The dashboard will be developed will allow the Procurement Department to compare the performance of the different vendors in a comfortable way. The information about how they work with the hospital will stop being transparent and will start being represented visually. Also, the Head of Department will be able to monitor the number of stents of each type stored in the hospital and where they are located. This will make it easier to distribute stents internally inside the hospital and optimize the procurement, as purchases will only be made when necessary. Also, the reaction time of the Procurement Department will be faster, as the number of stents left can be directly checked by the Head of Procurement at any moment, instead of waiting for the purchase request from the Cardiology Service.

#### A.4.2.2 Timeline

The experiment will stop in August 2024 with the following timeline:

- Collection and processing of data until November 2023.
- Development of AI algorithms until January 2024.
- Development of the user interface of the use case up to February 2024.
- Deployment of the algorithms in the Hospital from March 2024 until April 2024.
- Improvement and validation of AI algorithms until the end of the project.
- At the same time, it is proposed the creation of a dashboard that reflects the results of the algorithm on stent predictions. It is estimated that the start date should be around May 2024 once the AI tool has been validated.

#### A.4.2.3 Technology definition

- Planning:
  1. The first step is predicting the number of units needed for each stent (historical data analysis) for planning the purchases. The data collected are the historical purchases and consumptions of units, composed of:
    - a. Technical aspects of the stents.
    - b. Medical records of the patients that receive the stents (hospitalization episodes, comorbidities, etc.).

For this purpose, AI will be used for the analysis of historical data. At the same time, an interactive dashboard will be necessary (it can be generalised for the logistics RUC B2 - UC2). Also, it will be necessary to have RFID tags on the products to be able to monitor them inside the hospital and gather the information for the dashboard. All the data that will be gathered will feed a data repository that will be accessed by the dashboard.

2. The next step is to conduct a demand analysis. For this, both the same data types and the same technology will be used.
  3. Another step would be to make a query to verify that a certain product is in stock. To do this we will use the dashboard, which will query the data repository and display the result in a clear way.
  4. Alerts will be configured to inform when there is a low number of units for a certain stent type. These alerts will be integrated into the dashboard.
- Procurement and storage:

1. Vendor comparison, selection and optimisation. A section of the dashboard will be designed by the hospital where this step will be analysed (for internal use only). Here, the data regarding the prices, delivery time, errors, etc. will be displayed and studied by the Procurement Department.
2. To monitor in real-time the number of units available across the different storage rooms, a system composed of RFID tags (attached to the stent packages) and sensors will be used. This information will be stored in the data repository and fed to the dashboard.

### Technology description

The experiment will use the following technology:

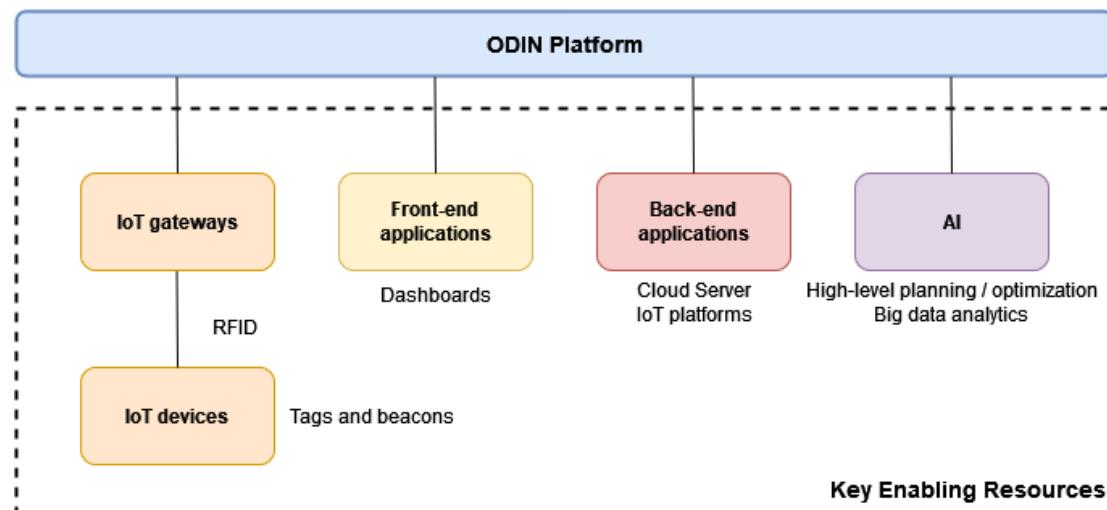


Figure 17 - KERs and components using in SERMAS RUC B1 UC1

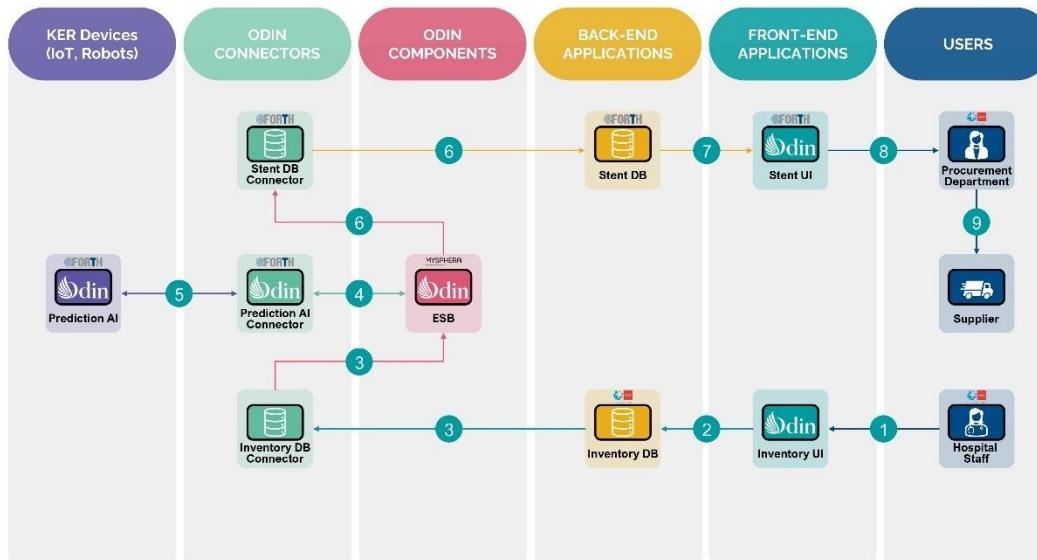


Figure 18 – SERMAS UML schema for RUC B UC1 regarding consumables administration

#### A.4.2.4 Procurement / Acquisition process

A direct procurement process, currently underway, will be made to another ODIN consortium partner (MYS) for the acquisition of RFID tags and IoT gateways.

At the same time, a direct purchase will be made for an Internet installation to support the project in the hospital.

The rest of the technologies used are integrated within the ODIN platform. Therefore, a service is already offered, and no procurement is required.

#### A.4.2.5 Primary Outcomes

Table 32 - SERMAS RUC B1 UC1

Phase	KPIs	Measure unit	Tool	Notes
Planning	Difference between number of consumable units predicted as needed and real needs	[%]	[report from platform]	
Procurement, storage	Vendors' evaluation: <ul style="list-style-type: none"> <li>• Difference in clinical outcomes</li> <li>• Delivery time</li> <li>• Delivery delays</li> <li>• Delivery errors</li> <li>• Costs</li> </ul>	Evaluation metrics: <ul style="list-style-type: none"> <li>• [% of readmissions]</li> <li>• [hours/days]</li> <li>• [%]</li> <li>• [%]</li> <li>• [€]</li> </ul>	[report from platform / dashboard]	
	Number of stents stored in the storage room	[# units]	[report from platform / dashboard]	

This reference use case aims at maximizing data-driven decisions and evidence-based management of processes.

- Planning:

The main goal would be to improve stock management: number of units, time, costs... We want to be able to predict accurately the number of units needed for each stent. It would also be interesting to know, when considering buying a new stent type, if there is already one with the same specifications already in the catalogue, to make the purchase process more efficient.

The ODIN technology will make this phase possible thanks to 1) the AI module necessary to make predictions about the future hospital stent needs and 2) the interactive dashboard that will facilitate information analysis and decision making.

- Procurement and storage:

In terms of procurement, the objective would be to be able to select vendors based on objective metrics: clinical outcomes associated to a certain consumable, number of delays, number of errors, delivery time, cost... It would also be interesting to optimize and homogenize the catalogue of consumables. Having the same item from different brands is not necessary nor efficient.

Concerning storage, the objective would be to have registered how many units are left of each item automatically. That is, to know in real time when new units of a certain consumable are stored in the storage room and when they are retrieved.

In this phase the ODIN technology will be necessary to 1) dump all the information into the dashboard and 2) implement the RFID real-time location system to track the stents.

#### A.4.2.6 KPIs

- Planning:
  - Difference between the number of consumable units predicted as needed and the real needs [%]. This KPI should give us a metric with which to evaluate the performance of the AI algorithm. The predictions of the algorithm need to be at least as good as the current manual method and, if possible, much closer to the real needs of the hospital.
- Procurement, storage:
  - Objective metrics to evaluate the different vendors [scores]: These metrics will allow us to have an objective and quantitative basis from which to compare the different vendors and filter out those with less score. That way, we will be able to reduce the complexity of the Procurement Department catalogue and simplify their day-to-day tasks. Some potential metrics are:
    - Difference in clinical outcomes [% of readmissions]: This KPI will measure the impact each stent model has in the patient prognosis. If the same stent model is available from different vendors, then the model associated with better clinical outcomes should be kept and the rest, discarded. This should be done to both improve the patient care and simplify the stent catalogue.
    - Delivery time [hours/days], delays [%] and errors [%]: Measuring these metrics will allow evaluating the different vendors and selecting the ones who perform the best, resulting in a more efficient procurement process.
    - Costs [€]: Measuring the costs is a key element in deciding which stent vendors should be prioritised, as the Cardiovascular Institute represents around 48% of the total hospital's expenditure in medical equipment and consumables.

Being able to measure the number of stent units stored in each storage room [# units]: Knowing where the different units are stored will allow to see if there is a correct relationship between the stents that are being marked as consumed and the number of units that are really being consumed. It will also help to distribute the stents in a more efficient way.

#### A.4.2.7 Involved stakeholders

The involved stakeholders for this reference use case spans from technical staff to healthcare personnel, clinical engineers, manufacturers and ODIN technical partners.

- Planning:

- Procurement Department: They provide part of the data necessary to develop the algorithm and contribute with their knowledge to the design of the dashboard. They also are responsible for using the dashboard during its implementation. In particular, the Head of Procurement is the person involved in the RUC and the one which will use the dashboard.
- Innovation Unit staff: They gather and anonymize the data from the Procurement Department and the rest of the hospital sources. They process the data and send it to the ODIN Consortium. They act as an intermediary between the Procurement Department and the ODIN Consortium. They will guide the Procurement Department in the use of the dashboard.
- Wardens: They are responsible for counting the number of stents stored in the storage rooms. During the RUC they will check if the number of units available according to the dashboard matches the actual volume stored in each storage room.
- ODIN technical partners (MYS, FORTH): They will provide the necessary technology (AI, dashboard, RFID tags, sensors...) to be able to carry out the RUC. They will also teach the Procurement Department how to use the dashboard.
- Procurement and storage:
  - Procurement Department: They are responsible for using the dashboard during its implementation. They will determine if the predictions made by the algorithm are accurate and if the vendor list can be reduced with the information provided by the dashboard.
  - Innovation Unit staff: They will act as intermediaries between the ODIN Consortium and the Procurement Department. They will guide the Procurement Department in the use of the dashboard and transmit its feedback to the ODIN technical members to adjust the dashboard.
  - Wardens: They check that the number of units available according to the dashboard correspond with the units stored in each storage room. This information will be key to evaluate the performance of the dashboard and adjust it if necessary.
  - Nurses: They will play a similar role to the wardens. They will be the ones taking the stents from the storage rooms and their actions should be displayed in the dashboard.
  - ODIN technical partners (MYS, FORTH): They will provide the necessary technology (AI, dashboard, RFID tags, sensors...) to be able to carry out the RUC. They will also teach the Procurement Department how to use the dashboard.

## A.4.3 RUC B2 UC2

### A.4.3.1 Description

This use case has as objective the use of a robot to automatically transport consumables from the storage room to certain destination. For this pilot, we are going to focus on the same consumable as in RUC B1 UC1 (stents) and have chosen as delivery location the Haemodynamic Room.

- Delivery, installation, training:

At the present moment, stents are both manually retrieved and taken to the room where they will be used. Stents are withdrawn from the storage rooms without this action being registered.

There is no information about the moment a stent leaves the storage room or when it arrives to its destination. There is no control over the item journey inside the hospital.

Although the action of withdrawing stents from the storage room is not recorded, information about which items have been used is indeed registered. That is, if a stent is withdrawn from its shelf and not used, it could be placed back in that shelf or simply kept at the Haemodynamic Room for a later use. However, if the item has been used, that is registered in a database, since that information is used to justify costs and plan procurement.

During RUC B2 UC2, a robot will be installed in the hospital to take care of the stent transport. Thanks to it, it will be possible to monitor the journey of the stent as it moves inside the hospital. Also, the robotic system will feature some sensors to detect if a stent is introduced in the robot or removed from it. That way, we can have a more precise control over the inventory.

- Decommissioning, disposal:

The packaging of the stents that have been used is returned to the storage room, where one person has to manually enter the stent code in a database. This action registers the item as used. Afterwards, the packaging is discarded.

The robotic system will be able to register when an item has been used by placing its package in a special compartment. That way, the decommissioning process can be automated.

#### A.4.3.2 Timeline

The experiment will stop in August 2024 with the following timeline:

- Installation of the IoT environment in the area within the hospital: From February 2023 until March 2023. This phase includes the installation of an internet network and the configuration of a server.
- Robot installation and testing: From March 2024 until April 2024.
- Robot validation: April 2024.
- Staff training: From June 2023 until April 2024.
- Final installation of the IoT environment: From March 2024.
- Hospital implementation: By the end of the project at August 2024.

#### A.4.3.3 Technology definition

- Delivery, installation, training:

1. Autonomous navigation towards the assigned locations. HOSBOT's robotic system is able to autonomously navigate across different rooms to deliver its load to the desired location. It is able to avoid obstacles and react to a dynamic environment.
2. Delivery of consumables with the HOSBOT system or through the smartboxes (as stand-alone units) to the destination point. The full transport system is composed of the robot (which navigates the environment and transports the rest of the components), a rack (which contains the smartboxes and has the interface from which to give instructions to the robot) and the smartboxes (which store the load and detect if an item enters or leaves them). The rack is the component which connects the entire system. It is a structure where the robot can attach itself to and that can store three smartboxes. The rack comes with a tablet that is used to give the robot instructions and interact with the smartboxes.

Finally, the smartboxes are containers which are able to detect when an item is placed or removed thanks to the use of RFID tags. The smartboxes can also be undocked from the robot to allow a worker to manually transport the load.



Figure 19 - SERMAS RUC B2 UC2 technology

3. Real position monitoring through RFID tags and RTLS integrated into the smartboxes. A real-time location system will be used to follow the stents as they travel through the hospital inside the smartboxes thanks to some gateways placed along the trajectory of the robot.
  4. Autonomous navigation and/or manual handling back to the storage room for power charging and consumable management. The user will be able to order the system to navigate back to its charging station and connect itself to it to recharge.
- Decommissioning, disposal
    1. Register used goods. One of the smartboxes will be used to store the packaging of the used stents. Once the smartbox detects that the packaging is introduced (thanks to a RDIF tag) it will send this information to a data repository where the stent will be marked as consumed.
    2. Manually coding and tracking of items (same as above).

The relation between the components described above is depicted below:

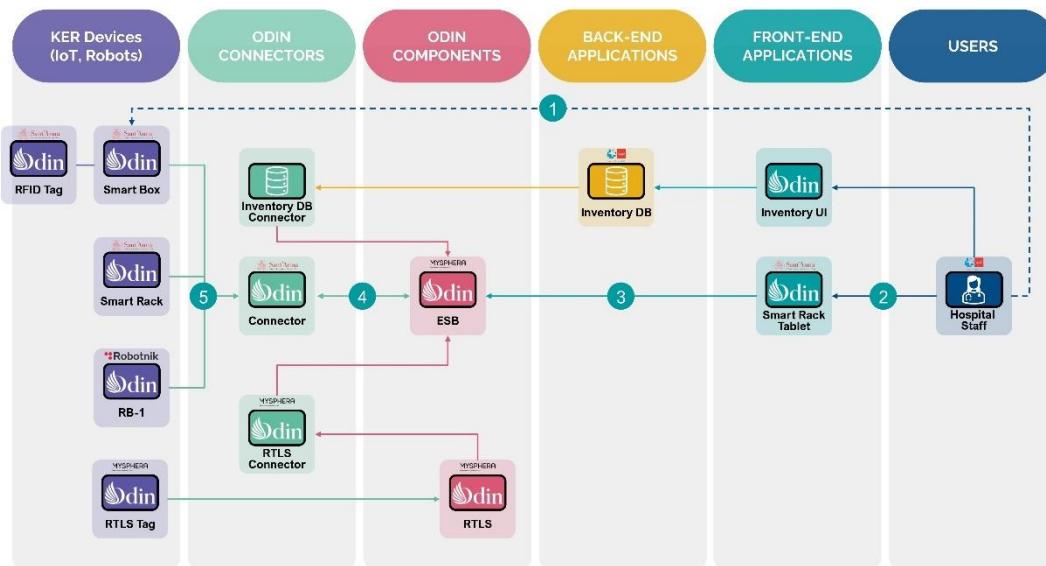


Figure 20 - SERMAS UML schema for RUC B2 UC2 regarding consumables transportation

## Technology description

Here below is described the results of the technology assessment to find the best match between the catalogue and the pilot's needs.

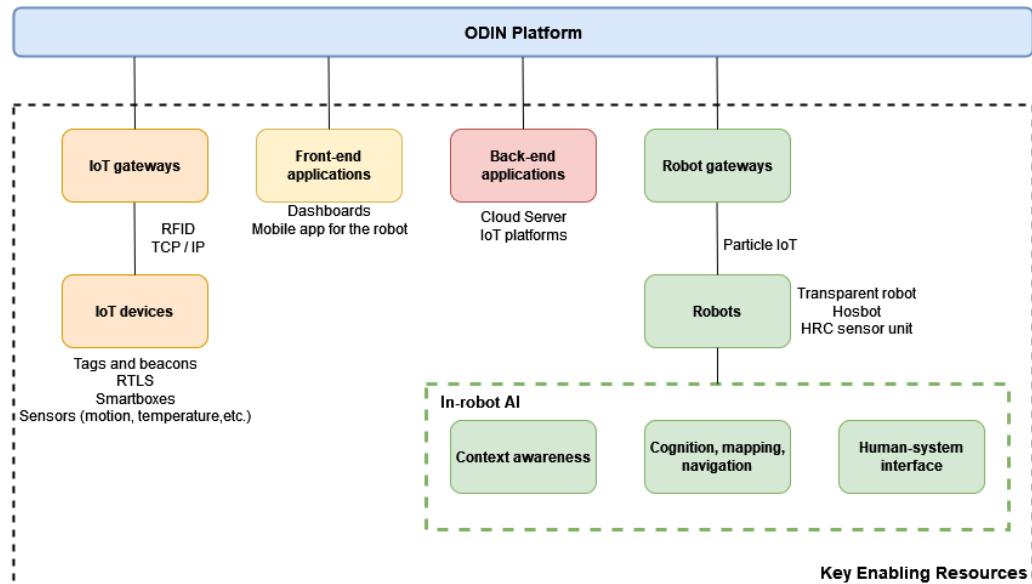


Figure 21 - KERs and components using in SERMAS RUC B2 UC2

### A.4.3.4 Procurement / Acquisition process

A direct procurement process, currently underway, will be made to another ODIN consortium partner for the acquisition of RFID tags and IoT gateways (MYS).

For the robot, funds will be arranged with the consortium member (SSSA) providing the robot for shipment to the hospital.

At the same time, a direct purchase will be made for an Internet installation to support the project in the hospital.

The rest of the technologies used are integrated within the ODIN platform. Therefore, a service is already offered and no procurement is required.

### A.4.3.5 Primary Outcomes

This reference use case aims at maximizing data-driven decisions and evidence-based management of processes.

- Delivery, installation, training:

The goal would be to measure when an item leaves the storage room and when it reaches its destination point. If the item has not been used, we want to know when it is returned to the storage room. This is key to being able to have control over the inventory.

The ODIN technology will facilitate this phase thanks to 1) the RTLS that will track the stents along their journey inside the hospital and 2) the smartbox, which is able to register when the stent is introduced inside it and when it is removed.

- Decommissioning, disposal:

The main goal would be to automatize the process of registering used goods. If possible, avoiding taking their packaging back to the storage room.

The smartboxes will allow us to achieve this goal, as employing one of them specifically for disposing used goods will allow us to identify which items have been used.

#### A.4.3.6 KPIs

Table 33 - SERMAS RUC B2 UC2

Phase	KPIs	Measure unit	Tool	Notes
Delivery, installation, training	Number of stents: <ul style="list-style-type: none"> <li>• Manually retrieved</li> <li>• Units returned to storage room</li> <li>• Units delivered but not used</li> </ul>	<ul style="list-style-type: none"> <li>• [%]</li> <li>• [%] [report from platform / dashboard]</li> <li>• [%]</li> </ul>		
	Delivery performance/time	[mean, median, standard deviation in seconds]		[report from platform / dashboard]
	Level of acceptability from the clinical staff	[score]	[SUS questionnaire]	
Decommissioning, disposal	Monthly time for dismantling and disposal of used stents	[hours]		[report from platform / dashboard]

- Delivery, installation, training:
  - Number of consumable units:
    - 1) Manually retrieved [%]: The percentage of stents that are manually retrieved from the storage room from the total of stents used. This figure will allow us to see if the robotic delivery system is being used by the staff or if they prefer to transport stents the traditional way.

- 2) If not used, returned to the storage room [%]. This KPI will inform us of the percentage of stents that are stored at the Haemodynamic room. It is important because those stents may not be taken into account when planning a new purchase.
- 3) Number of units delivered but not used [%]. This KPI will provide information about the stents that are requested but not used. Looking for patterns among the stent models that are returned without being used might help RUC B1 UC1 objective of simplifying the stent catalogue.
- Delivery performance/time [mean, median, standard deviation in seconds]: These metrics will inform us of the speed of the robot. The delivery time should be as fast as possible (as long as it is safe for the robotic system and the staff) and, ideally, with low variability times.
- Level of acceptability from the clinical staff [score]: This metric gauges the satisfaction level of the clinical staff regarding the system's usability and effectiveness in their workflow. A higher score indicates greater acceptance and ease of use, reflecting positively on the integration of the system into their daily routines.
- Decommissioning, disposal:
  - Monthly time for dismantling and disposal of used stents [hours]. This metric tracks the amount of time dedicated to the dismantling and disposal of used stents on a monthly basis. It provides insights into the efficiency of the disposal process and aids in optimizing resource allocation and workflow management. Ideally, this time should be minimized to ensure smooth operations and reduce the burden on staff involved in the process.

#### A.4.3.7 Involved stakeholders

The involved staff for this reference use case spans from technical staff to healthcare personnel, clinical engineers, manufacturers and ODIN Consortium members.

- Delivery, installation, training:
  1. Procurement Department: The Procurement Department will be able to see (thanks to RUC B1 UC1's dashboard) when a stent has been used and how many units are left. This information will allow them to make more efficient purchases.
  2. Innovation Unit staff: The Innovation Unit will be in charge of supervising the deployment of the robotic transport system, training the staff in its use and addressing the different issues that might appear.
  3. Wardens: They will be responsible for loading with stents and commanding the robotic transport system.
  4. Nurses: They will be responsible for loading with stents and commanding the robotic transport system.
  5. ODIN members: They will supply the technology (MYS, SSSA, INETUM) and train the staff (SSSA) on its use.
- Decommissioning, disposal:
  1. Procurement Department: Same as in the previous phase above.
  2. Innovation Unit staff: Same as in the previous phase.
  3. Wardens: They will be responsible for placing the used items in the corresponding smartbox for the system to register them as used.

4. Nurses: They will be responsible for placing the used items in the corresponding smartbox for the system to register them as used.
5. ODIN members: Same as the previous case.

#### A.4.4 RUC C UC7

##### A.4.4.1 Description

This use case has as objective the use of an image supervision and geographical location system to achieve the automation of current internal processes for managing emergency situations within the scope of the building's Self-Protection plan:

- Improving of the evacuation plan and management of evacuation flows.
- Control of capacity and avoidance of unnecessary crowds.

Due to its strategic location (proximity to the university centre and several of the city's main communication routes) and the hospital complexity in terms of clinical specialties, the hospital is included in the list of critical infrastructures of the city of Madrid (which also includes airports, train stations, the Bank of Spain and the parliamentary headquarters). Critical infrastructure designation will become effective in the next 2 years. Being a critical health infrastructure means, among other things, that safety levels must be optimal to ensure adequate clinical care in the event of catastrophes or disasters such as terrorist attacks, pandemics, fires, landslides, floods, etc.

In addition, the architectural barriers of the Hospital have a negative impact on the vertical evacuation plan. In a peak hour 10.000 people are inside the hospital premises. Current monitoring and communications systems are not robust enough for assuring a fast evacuation.

##### A.4.4.2 Timeline

The experiment will stop in August 2024 with the following timeline:

- By April 2023 the tender for the necessary equipment was completed. In May 2023, the installation of the video surveillance system was completed.
- Development of Artificial Intelligence algorithms related to the detection of people and first tests of these algorithms in the hospital from September 2023 to January 2024.
- Deployment of the algorithms in the hospital from February 2024 to April 2024.
- Deployment of the disaster simulation algorithms from April 2024.

##### A.4.4.3 Technology definition

The installation of a system integration and decision automation platform is proposed for study, which encompasses different necessary security subsystems (CCTV, 3D geolocation, fire detection, public address system, intrusion, etc.) to achieve the indicated objectives. In the market there are different providers, such as DESICO, which has software for the supervision, control and interrelation of the systems necessary for the development of the pilot and which we know for its integration capabilities. It is a highly customizable and scalable system, being able to add own or third-party modules.

As a fundamental part of the security platform, a CCTV system is proposed that uses analytics and artificial intelligence to provide the data to the system, such as those of the AVIGILION brand.

The main characteristics of this system must be:

- Open platform, based on client server architecture.
- Interface oriented to the use of analytics and artificial intelligence.
- Search by appearance: Based on a powerful artificial intelligence engine, and that allows to start an investigation to efficiently locate people, vehicles or objects based on their description thanks to the metadata received from the cameras connected to it.
- Platform ready to work in conjunction with cameras with embedded artificial intelligence and efficiently process events of interest in real time.
- Focus of Attention Interface, which allows a change in the operation in control centres ignoring routine or worthless aspects, to present to the operator what only matters at all times.
- Failsafe architecture that provides a robust system against power or network failures.
- Full integration with third party cameras.
- Unusual motion detection: The analytics will be able to learn how objects in the scene usually behave and allow searches for unusual events.
- Motorized zoom managed from the Video Management System (VMS) software itself.
- Automatic or manual focus from the VMS software itself.
- Independently configurable day focus and night focus with illumination threshold auto focus switching.
- Easy-to-use video management that optimizes the way security professionals manage and interact with high-definition video.
- High-Definition Network Video Recorders (NVR). The proposed system should allow the balancing of cameras between the NVRs in the event of a failure of one of the recording NVRs.

### Geolocation

The integration of 3D geolocation programs would allow us to manage gauges, flows and, through detector arches at the entrances, the system would allow the protection and monitoring of patients and objects using RFID tags or bracelets. Market study pending.

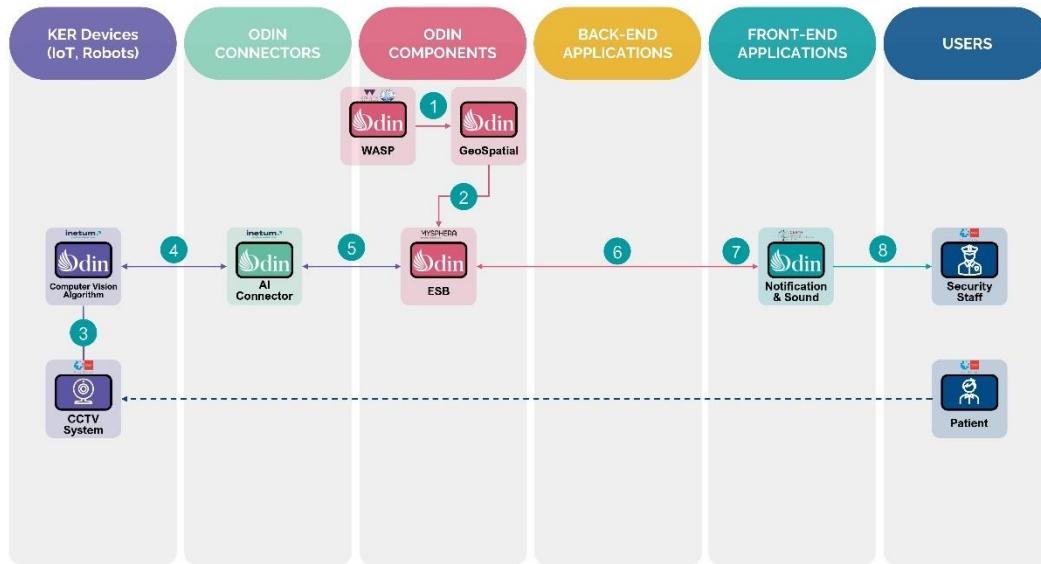


Figure 22 – SERMAS UML schema for RUC C UC7 regarding evacuation plans and disaster preparedness

### Technology description

The experiment will use the following technology:

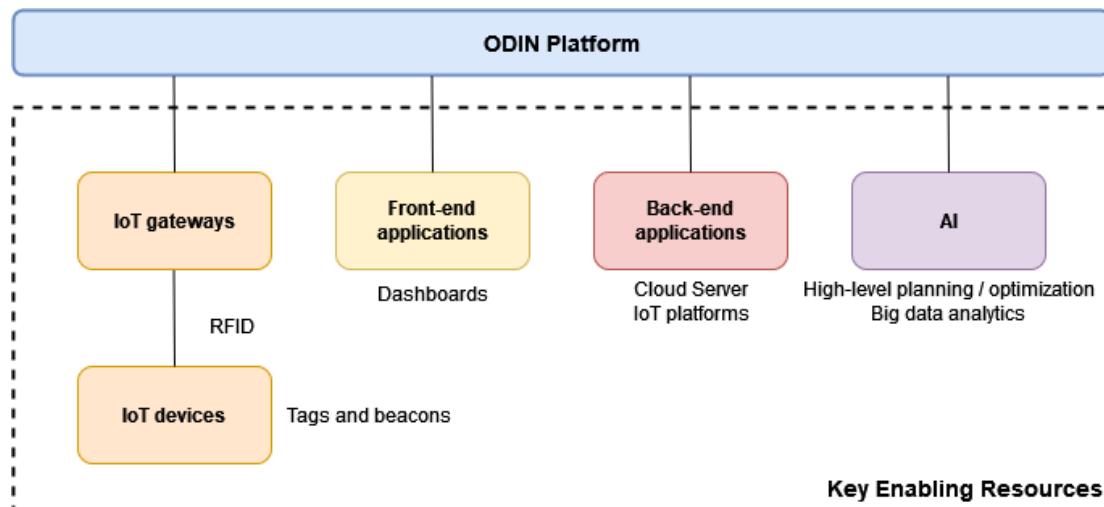


Figure 23 - KERs and components using in SERMAS RUC C UC7

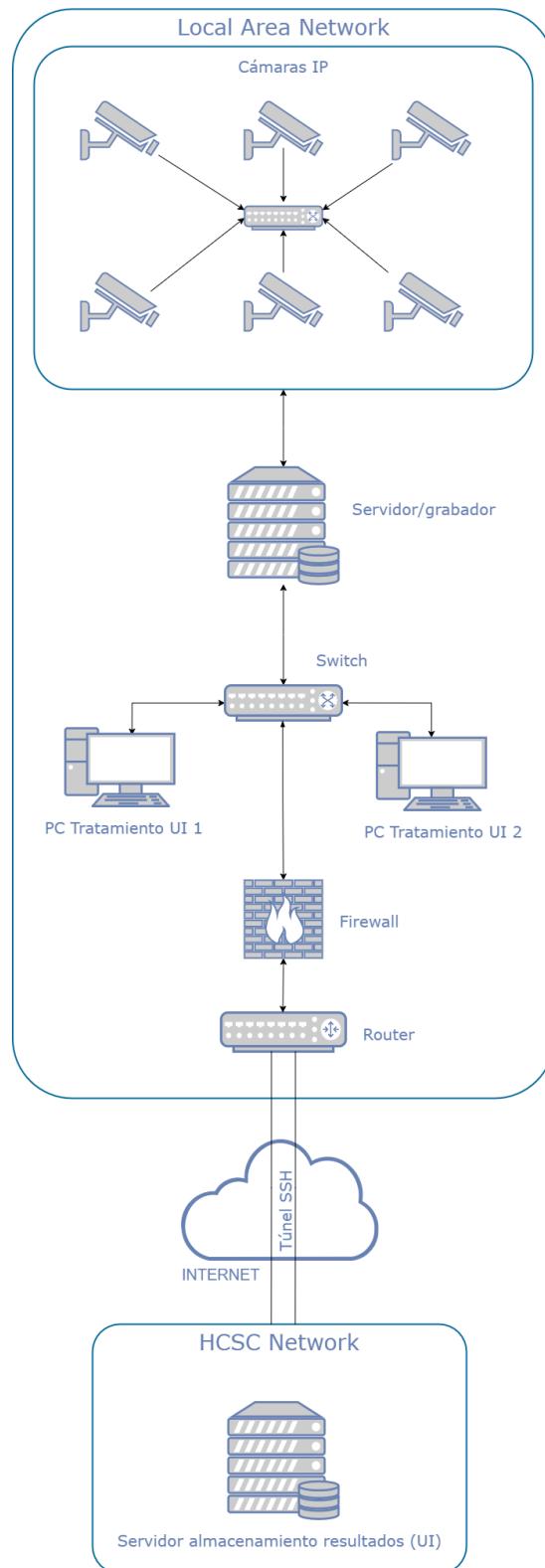


Figure 24 - System architecture in SERMAS RUC C UC7

#### A.4.4.4 Procurement / Acquisition process

A direct procurement process will be made to another ODIN consortium partner (UoW) for the acquisition of Warwick Apollo Semantic Platform (WASP), an ontology that is specific for Medical Locations.

At the same time, a direct purchase will be made for an Internet installation to support the project in the hospital.

A public tender process is underway for the installation and purchase of a CCTV system to monitor the pilot area.

The rest of the technologies used are integrated within the ODIN platform. Therefore, a service is already offered and no procurement is required.

#### A.4.4.5 Primary Outcomes

The main objective of this use case is to improve the Hospital's capacity to react to disasters (natural, technical or human) in terms of its architectural design characteristics, its capacity to monitor the activity carried out inside and its capacity to anticipate such events. Specifically, the aim is to improve the HCSC's current Evacuation Plan.

To this end, the following actions are proposed:

"Real-time monitoring of the flow of people and virtual simulation of the trajectory of this flow in emergency situations":

1. Management of evacuation flows, establishing alternative routes depending on the location of the incident.
2. Capacity control and avoidance of unnecessary crowds: Knowledge of the number of people by delimited sectors and the distance between them.
3. Identification of erratic or accidental movements of people.
4. Control of portable medical equipment.

#### A.4.4.6 KPIs

Table 34 - SERMAS RUC C UC7

Phase	KPIs	Measure unit	Tool	Notes
	Reduction of evacuation time	[%]	[report from platform / dashboard]	
	Identification of new evacuation routes	[# number of routes]	[report from platform / dashboard]	
	Identification of critical points or bottlenecks in evacuation	[# number of points]	[report from platform / dashboard]	
-	Reduction of response time to unusual behaviour of people	[%]	[report from platform / dashboard]	

Response time reduction in emergency situations	[%]	[report from platform / dashboard]
Reduction of the time to locate/move specific equipment	[%]	[report from platform / dashboard]

The expected impact being:

- Reduction of evacuation time [%]. This KPI will allow us to measure the impact that the new evacuation protocol had in terms of the speed.
- Identification of new evacuation routes [# number of routes]. It will give us information about how well the system is able to adapt to a dynamic scenario.
- Identification of critical points or bottlenecks in evacuation [# number of points]. It will be used to compare the different evacuation routes and to see if the system correctly identifies the optimal one.
- Reduction of response time to unusual behaviour of people [%]. This indicator serves to measure the efficiency, in terms of speed, of the response time to these incidents.
- Reduction of response time in emergency situations [%]. This KPI will allow us to measure the impact that the new system has had in terms of the speed in which the security protocol is activated when compared to the current response time.
- Reduction of the time to locate/move specific equipment [%]. This KPI will allow us to measure the impact that the new system has had in terms of the speed in which the equipment is located/moved during an emergency situation when compared to the current time.

The expected result is to have an integrated system that monitors and simulates the flow of people and equipment in emergency situations, thus improving evacuation plans in the event of a disaster and improving evacuation times.

#### A.4.4.7 Involved stakeholders

- Surveillance and Security Service. They will receive the results of the use case as well as having access to the images captured by the security cameras. All of this with the objectives of 1) protecting the integrity of the users and workers during their stay in the hospital facilities, 2) protecting the material goods and values placed at the disposal of the Centre, 3) establishing the human and technical means that allow for immediate intervention in the event of an emergency by the Centre's staff and external assistance in the event of fire.
- Innovation Unit staff. Responsible for the coordination of the different agents involved as well as the management of the purchase and installation of the necessary equipment. They will also be responsible for the implementation of the algorithm provided by the ODIN consortium (INETUM) in order to anonymise the images.
- Property management. Management of the Hospital's fixed assets, property transfer and donation actions, and the management and control of the register of spaces. Responsible for the management of the spaces where the cameras are to be located, including the supply of plans for the project.

- ODIN members. Responsible for supplying the necessary technology (MYS, INETUM) (with the exception of the video surveillance system).

## A.4.5 ODIN Integration

### A.4.5.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment?

In the envisioned integration of the ODIN Key Enabling Resources (KERs) within the Hospital Clínico San Carlos for the specified use cases, there is a strategic plan to employ advanced Artificial Intelligence (AI) models, the HOSBOT robotic system, and Internet of Things (IoT) technology to enhance operational efficiency, inventory management, and disaster response capabilities. The following details the expanded approach for each use case, emphasizing the utilization of these technologies in a third-person perspective.

#### RUC B1 - UC1

The hospital intends to harness AI to scrutinize the utilization patterns of critical medical supplies, with a particular focus on stents. This endeavor involves the analysis of extensive historical usage data to construct sophisticated predictive models. These models are designed to forecast future procurement requisites with high accuracy, facilitating optimal inventory management. To enable interactive data engagement, a bespoke application featuring an intuitive dashboard will be developed. This platform will offer real-time analytics, highlight consumption trends, and provide predictive insights, thereby streamlining procurement processes. The potential integration of IoT in this context could extend to deploying smart sensors across storage facilities, automatically updating inventory levels on the dashboard, and thus enhancing the precision and efficiency of stock monitoring.

#### RUC B2 - UC2

In RUC B2 - UC1, the hospital plans to deploy the HOSBOT, a robotic system tailored for the automated transport of medical supplies, notably stents, from storage areas to specific hospital locales such as surgery rooms. This automation aims to refine logistical workflows, conserve valuable time, and diminish the likelihood of human-induced errors. The HOSBOT will be equipped with advanced sensors to detect the loading and unloading of stents, offering granular control over inventory management. The integration of IoT technologies could also see the implementation of RFID tags to meticulously track the stents' movements within the hospital premises, thus ensuring real-time inventory updates and fostering a seamless logistical operation.

#### RUC C – UC7

The hospital envisions the application of AI models to significantly elevate its preparedness for a range of emergency scenarios, encompassing natural calamities, technical malfunctions, and human-generated crises. By analyzing the architectural nuances of the hospital and overseeing internal activities, AI technologies are expected to aid in formulating more effective evacuation strategies and in preempting potential emergencies. Furthermore, IoT technologies, particularly 3D geolocation solutions, will play a pivotal role in managing crowd dynamics and navigating flows within the hospital infrastructure. The introduction of RFID-enabled detector arches at strategic entry and exit points will facilitate the meticulous tracking of patients and essential medical equipment, ensuring their safety and readiness during emergencies. This comprehensive system aims not only to monitor but also to simulate the movements of individuals and assets in real-time during crisis situations, thus enabling rapid evacuations and enhancing the hospital's overall response to disasters.

Through the strategic application of these cutting-edge technologies across the outlined use cases, the Hospital Clínico San Carlos is poised to establish a new standard in healthcare innovation, markedly improving operational workflows, patient care quality, and safety protocols.

## A.5 UCBM - Università Campus Bio-Medico di Roma, Italy

### A.5.1 Pilot Description

Università Campus Bio-Medico di Roma (UCBM) is a private academic institution, devoted to undergraduate and postgraduate education, advanced research, and third mission. Established in 1992, today the University runs the School of Medicine and Surgery, the School of Engineering, the Science and Technology for Sustainable Development and One Health and hosts PhD course in Bioengineering, Applied Sciences and Intelligent Systems, Integrated Biomedical Sciences and Bioethics, Sustainable Development: Environment, Food and Health and the National PhD in Artificial Intelligence – area: Health and Life Sciences and National PhD in Robotics and Intelligent Machines – area: Robotics and Intelligent Machines for healthcare and wellness of persons. The University hosts 51 multidisciplinary Research Units. An outstanding network of national and international key scientific and educational partners, including 200+ national and international partner, has been continuously developed and consolidated with specific collaboration agreements over the years.

Within UCBM, the Geriatrics Unit conducts research activities in the following areas: i) evaluation of the elderly patient health condition, with particular focus on multidimensional evaluation techniques in various disorders or multimorbidity pattern; ii) evaluation of respiratory functions, with particular focus on the interpretation of spirometry results in elderly patients; study of diagnosis/prognosis properties of breath volatile organic compounds in the following disorders: heart failure, chronic obstructive bronchitis, obstructive sleep apnoea syndrome, diabetes mellitus, liver diseases; iii) development and application of remote telemonitoring systems for patients with chronic diseases; iv) pharmacoepidemiologic and epidemiologic geriatric research.

#### A.5.1.1 Pilot Experiments

With reference to the selected UCs, the planned experiments at UCBM are overviewed in [Error! Reference source not found.31](#).

Table 35 - UCBM Experiments

Use Case	Name	Description	RUC A Phase (s)
RUC A2.1 – UC4	Clinical Tasks and Patient Experience	Monitoring of food assumption to prevent undernutrition	Treatment, Monitoring
RUC A2.2 – UC4	Clinical Tasks and Patient Experience	Rehabilitation to prevent loss of mobility	Treatment, Monitoring
RUC A3 – UC5	Automation of Clinical Workflows	Monitoring of oxygen therapy to prevent hypoxia complications	Monitoring
RUC B1 – UC1	Aided Logistic Support	Logistics of food delivery	Preparation, delivery, installation, training Real usage monitoring Management

## A.5.2 RUC A2.1 UC 4: Clinical Tasks and Patient experience – Monitoring of food assumption to prevent undernutrition

### A.5.2.1 Description

Undernutrition is a highly prevalent condition in older hospitalized patients and associates with an increased risk of prolonged hospitalization and mortality. Inpatients usually present undernutrition, which is promoted by an energy expenditure exceeding energy intake, and/or micronutrient-related undernutrition (i.e. lack of important vitamins and minerals). Nutritional support is effective in improving body weight, fat and fat-free mass, hence a timely recognition of an unbalance between energy expenditure and intake is pivotal to minimize the risks of adverse outcomes. Although there exist formulas to easily predict the energy expenditure of hospitalized patients, the estimation of energy intake requires to quantify food assumption, a burdensome activity for nurses, that is performed only in a selected population, leading to an underestimation of patients at risk for undernutrition.

Furthermore, undernutrition recognizes several causes but one of the most common is dysphagia, a condition that increases the risk of pulmonary aspiration and aspiration pneumonia. Screening is therefore crucial at hospital admission, particularly in older patients.

- Admission and Screening (screening of patients at risk of undernutrition and dysphagia): Acute diseases requiring hospitalization increase the risk of undernutrition, an independent risk factor for morbidity and mortality, particularly in the older and more frail adults. Indeed, these individuals, aside a higher energy expenditure due to the multimorbidity, experience a lower energy intake due to the loss of appetite, dental disorders and cognitive impairment that affect their ability to feed autonomously. One of the most common causes of undernutrition is dysphagia, a difficult swallowing increasing the risk of pulmonary severe complications. Screening of dysphagia and undernutrition is therefore mandatory in all patients at admission and is usually performed by nurses and doctors. Several questionnaires and tests are available in the literature, among which it is worth to cite the 3-oz water swallow test for dysphagia and the Mini Nutritional Assessment for undernutrition. Patients that are considered at risk are then addressed to a specialized evaluation to confirm the diagnosis.
- Diagnosis/Case Studies (diagnosis of undernutrition and dysphagia and diet prescription): Once patients have performed screening tests and result at risk of dysphagia and undernutrition they undergo a specialized assessment which is performed by the nutritionist and speech therapist (or otorhinolaryngologist), respectively. Nutritionists evaluate patient weight and body composition (e.g. bioimpedance analysis or DeXa scan), estimate energy expenditure using predicting formulas (e.g. Harris-Benedict, Angelillo-Moore, etc.) and calculate food intake using food intake diaries. Speech therapists evaluate vocal cords using endoscope and quantify the risk of aspiration using coloured boli. Once the diagnosis has been confirmed, specialists prescribe the treatment, which mainly consists of speech exercises and detailed diet (i.e. calories, consistency, etc.).
- Treatment (meal assumption): Meal is delivered by nurses and healthcare providers and respects the nutritionist and speech therapist indications in terms of consistency and calories. This helps to get the required energy intake and to minimize the risk of pulmonary aspiration.

- Monitoring (compliance with clinical prescription): Nurses and doctors daily overview whether and to which extent patients are feeding, quantifying the food assumption. Errors, as well as no willingness to accomplish the prescription are detailed and reported to the specialist. Patients are motivated to follow their prescription.
- Follow-up (check for improvements in reducing undernutrition): Specialists reassess patients during hospitalization in order to evaluate the goodness of fit to their prescription and patient short-term improvements, if any. This allow to stop the treatment in case the problem is solved or to modify the schedule of exercises or diet to reach the goal.

### A.5.2.2 Timeline

The experiment will start in May 2024 and will stop in June 2024 with the timeline reported in Table 36.

Table 36 - UCBM RUC A2.1 UC4 - Timeline

Task	M37	M38	M39	M40
Preliminary functionality tests in UCBM laboratory				
Tests on healthy subjects at UCBM				
Recruitment of geriatric patients at UCBM				
Experiments on geriatric patients at UCBM				

### A.5.2.3 Technology definition

Within this UC, a mobile robot will reach the patient, recognize her/him, by using a barcode module, and check the consistency with the prescribed daily diet and the delivered meal. TIAGo, CERTHbot and Transparent Robot will be adopted for this UC, together with a Fleet Management System (FMS) module that will select the optimal robot to carry out the task, taking into consideration different factors such as battery level, patient position, distance and type of route. After that, the robot monitors the patients (camera and possibly wearable sensors) to assess the meal consumption in terms of quantities and estimated calories (AI algorithm), also analysing possible coughs events based on saturation measurement (oximeter). The workflow is briefly reported in Figure 25.

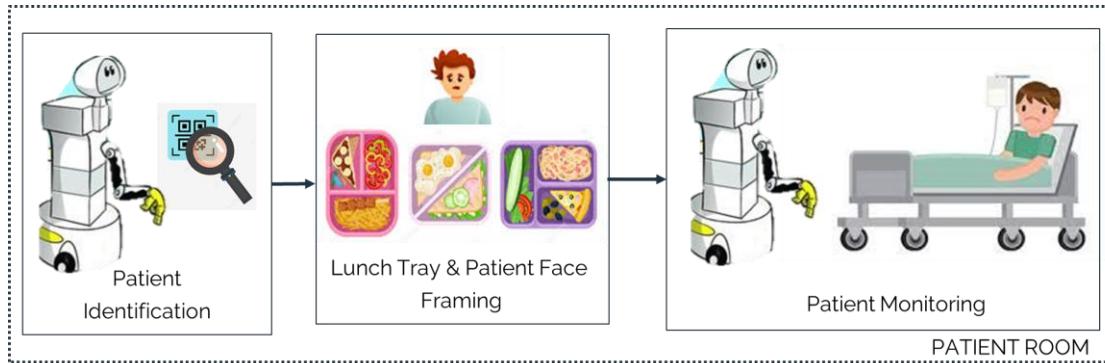


Figure 25 - UCBM RUC A2.1 overview

The various components and their relationship are displayed below:

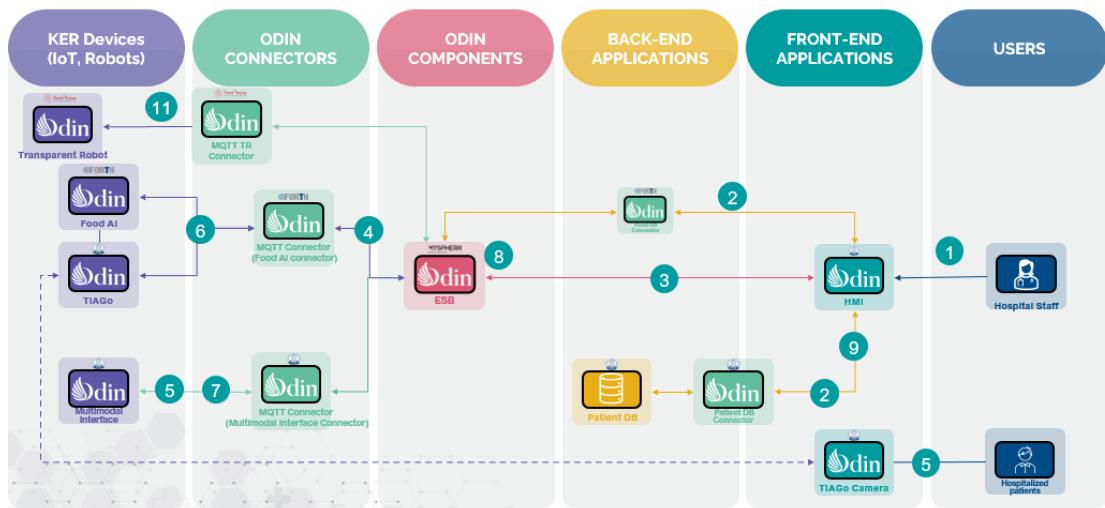


Figure 26 - UCBM UML schema for RUC A UC4 and RUC B UC1 regarding food monitoring and delivery to prevent malnutrition

#### A.5.2.4 Procurement/acquisition process

It is not necessary to acquire any additional technologies.

The technologies for this UC include:

- TIAGo robot: already available at UCBM;
- Human-Machine Interface (HMI): developed by UCBM;
- CERTHbot: already available at CERTH;
- Fleet Management System: developed by TWI;
- Transparent robot: already available at SSSA;
- Multimodal Interface (RGB-D camera, oximeter, Heart Rate and Respiration Rate sensors): developed by UCBM;
- AI modules: developed by FORTH;
- Barcode module for patient/meal matching: developed by UCBM;
- ESB and Orchestrator: developed by MYS.

### A.5.2.5 Primary Outcomes

- Admission and Screening (screening of patients at risk of undernutrition and dysphagia): The goal is to identify patients at risk of dysphagia and undernutrition to refer to a further specialized assessment.
- Diagnosis/Case Studies (diagnosis of undernutrition and dysphagia and diet prescription): The goal is to diagnose dysphagia and undernutrition to allow a timely intervention to minimize complications (e.g. aspiration pneumonia, low of muscle mass, low of exercise capacity, etc.).
- Treatment (meal assumption): The goal is to reach the required energy intake to avoid weight and muscle mass loss, to minimize the risk of aspiration and treat dysphagia. The use of the TIAGO robot is expected to identify problems of undernutrition and avoid complications.
- Monitoring (compliance with clinical prescription): The goal is to verify that patient is following correctly the diet prescribed in order to timely modify the intervention. We aim at monitoring meal assumption that normally is not performed in the normal clinical routine. An accurate monitoring can provide the patient with several benefits and robotic intervention can reduce the time spent by healthcare operators in monitoring patients.
- Follow-up (check for improvements in reducing undernutrition): The goal is to verify the overall efficacy of the treatment for nutrition improvement and swallowing and stop it in case of solution or to redefine the prescription to improve its effectiveness.

### A.5.2.6 KPIs

Only treatment and monitoring phases will be interested by the use of ODIN technologies.

Table 37 - UCBM RUC A2.1 UC4

Phase	KPIs	Measure unit	Tool	Notes
Treatment	Energy intake	[kcal]	TIAGO with AI algorithm	
	Percentage of assumed macronutrients	[%]		
Monitoring	Correctness of head position while eating	[rad]	TIAGO with algorithm for skeleton reconstruction	The patients interact verbally with TIAGO
	Time spent consuming the meal	[min]		
	Number of oxygen desaturation events detected throughout the meal	[#]	Oximeter connected with TIAGO	Indicator of severe aspiration

### A.5.2.7 Involved stakeholders

- Admission and Screening (screening of patients at risk of undernutrition and dysphagia): Doctors and nurses.
- Diagnosis/CASE STUDIES (diagnosis of undernutrition and dysphagia and diet prescription): Nutritionists and speech therapists (or otorhinolaryngologists).
- Treatment (meal assumption and speech exercises): Doctors and nurses.
- Monitoring (compliance with clinical prescription): Doctors and nurses.
- Follow up (check for improvements in reducing undernutrition): Doctors and nurses.

### A.5.3 RUC A2.2 - UC4: Clinical Tasks and Patient experience – Rehabilitation to prevent loss of mobility

#### A.5.3.1 Description

World Health Organization defines rehabilitation as “a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with the environment”. From a general point of view, motor rehabilitation aims at recovering patient motor skills following an injury, trauma and/or pathology and can involve both upper and lower limbs. In case of elderly, rehabilitation aims recovering the highest possible level of self-sufficiency (especially to carry out activities such as eating, dressing, washing, moving from bed to chair, going to the bathroom, checking the function of the bladder and intestine) and avoid loss of mobility.

Moreover, the importance of movement in elderly patients, while not being among the priorities in the acute phase of any disease, should not be underestimated because the restoration of motor functions becomes problematic, complex and sometimes completely impossible. Hospitalized patients may have reduced mobility and potential consequent risks and can strongly benefit from rehabilitation in terms of active mobilization and motor recovery.

Admission and Screening (screening based on risk of reduced mobility): The admission phase is focused on the screening of hospitalized patients with possible long time of reduced mobility and potential consequent risks with the final aim to avoid prolonged bed rest syndromes.

Diagnosis/CASE STUDIES (motor assessment and rehabilitation prescription): The rehabilitation treatment is preceded by an evaluation phase of the patient, which is fundamental for both the therapist/nurse and the patient, as it allows the identification of the treatment to be performed and, at the same time, validated clinical scales are generally administered, in order to assess the state of the patient at the beginning and at the end of the rehabilitation treatment, in order to guarantee a targeted treatment outcome. This phase ends with identification of rehabilitation exercises (bed mobilization, sit-to-stand exercises, bed positioning and repositioning, stand, short walk, ADLs, etc.) and the prescription of the exercises to be performed with passive and/or active mobilization, potentially in an autonomous way.

Treatment (in-hospital rehabilitation): During the rehabilitation treatment, the patient is asked to perform exercises aimed at improving mobility. The recovery of the muscular characteristics from the structural and functional point of view is a long and difficult process, which can last even a few months. For collaborative patients, the treatment is active and the patient is able to (at least partially) autonomously move or support himself/herself, with or without the assistance of a physiotherapist. For uncollaborative patients, the treatment is passive and the presence of the physiotherapist, who guides the execution of the task, is strictly necessary.

Monitoring (monitoring of compliance prescription, correctness, and risks): The aim of this phase is to monitor the patient in performing physical exercises and verify their correctness, compliance with prescription and risks of injuries. During the rehabilitation treatment it is necessary to optimize the involvement of the physiotherapist, who should support the patient's movement only when strictly necessary and, if not, favour the patient's autonomous movement in order to guarantee the maximum effectiveness and autonomy of the treatment. In the worst case, the therapist monitors the subject and encourages him to carry out the assigned motor task correctly.

Follow up (short-term post-rehabilitation assessment): The aim of this phase is the motor assessment and the valuation of benefits of mobilization, in order to evaluate of effectiveness of rehabilitation treatment in short term.

### A.5.3.2 Timeline

The experiment will start in August 2023 and will stop in January 2024 with the timeline reported in Table 38.

Table 38 - UCBM RUC A2.2 UC4 - Timeline

Task	M37	M38	M39
Preliminary functionality tests in UCBM laboratory			
Tests on healthy subjects at UCBM			
Recruitment of geriatric patients at UCBM			
Experiments on geriatric patients at UCBM			

### A.5.3.3 Technology definition

Within this UC, a mobile robot will reach the patient, recognize her/him, by using a barcode module, will retrieve the prescribed physical rehabilitation exercises to be performed and will demonstrate them to the patient. TIAGo, CERTHbot and Transparent Robot will be adopted for this UC, together with a FMS module that will select the optimal robot to carry out the task, taking into consideration different factors such as battery level, patient position, distance and type of route. The selected robot will be able to monitor the patient to assess the motor performance (AI algorithm) and provide support if needed to complete the motor task (only with TIAGo robot). The workflow is briefly reported in Figure 27, and the components and interrelation in Figure 28.

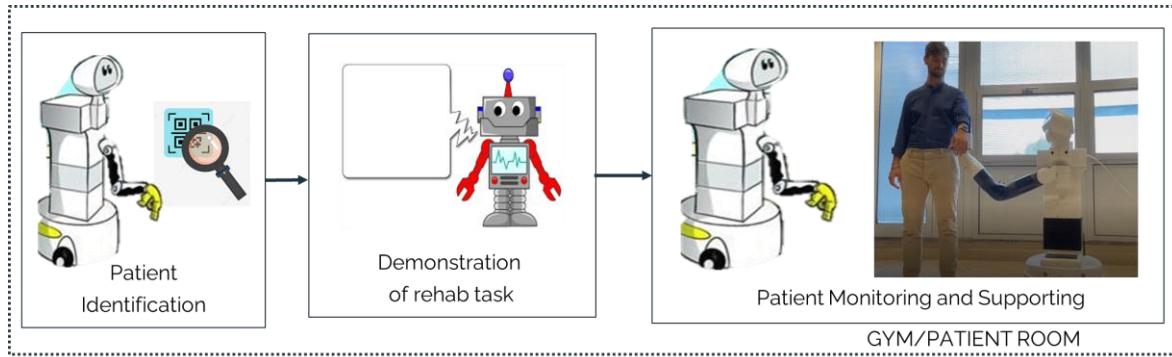


Figure 27 - UCBM RUC A2.2 overview

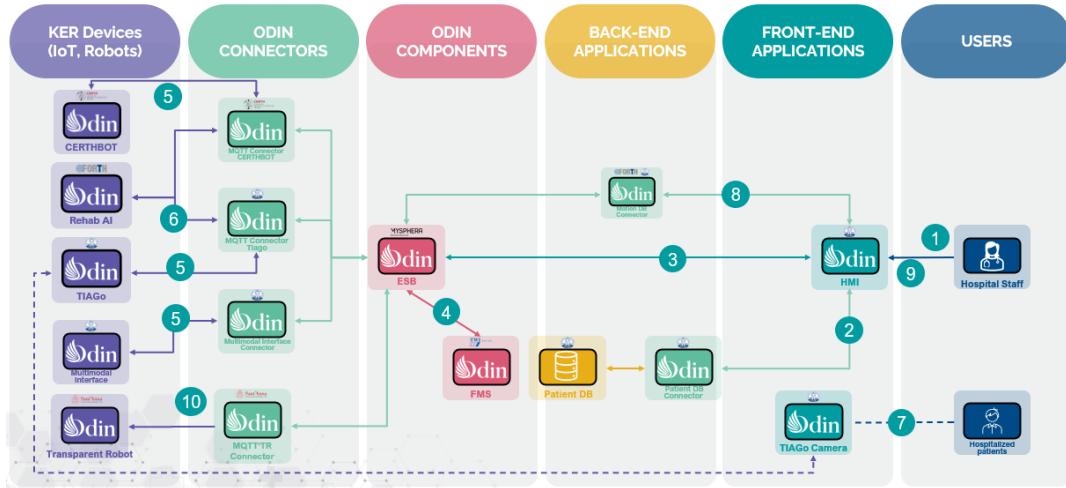


Figure 28 - UCBM UML schema for RUC A UC4 regarding rehabilitation monitoring to prevent loss of mobility

#### A.5.3.4 Procurement / Acquisition process

It is not necessary to acquire any additional technologies.

The technologies for this UC are already available/will be developed within the ODIN consortium.

- TIAGo robot: already available at UCBM;
- HMI: developed by UCBM;
- CERTHbot: already available at CERTH;
- Fleet Management System: developed by TWI;
- Transparent robot: already available at SSSA;
- Multimodal Interface (RGB-D camera, oximeter, Heart Rate and Respiration Rate sensors): developed by UCBM;
- AI modules: developed by FORTH;
- Barcode module for patient/meal matching: developed by UCBM;
- ESB and Orchestrator: developed by MYS.

### A.5.3.5 Primary Outcomes

The objectives of the treatment are many, including certainly the recovery of flexibility and range of motion, the recovery of strength and muscle tone and mass, the reduction of pain, risk of blood clot formation, the improvement of fitness and balance.

- Admission and Screening (screening based on risk of reduced mobility): The goal of this phase is to identify hospitalized patients at risks of mobility loss that require to perform (possibly autonomously) rehabilitation exercises.
- Diagnosis/CASE STUDIES (motor assessment and rehabilitation prescription): The objective of this phase is to collect the greatest number of relevant clinical information, to exclude the presence of contraindications for the rehabilitation treatment, to confirm the initial diagnostic hypothesis, identify risk factors, preserve and possibly improve the original motor functions and avoid loss of exercise capacity in bedridden patients secondary to acute diseases.
- Treatment (in-hospital rehabilitation): The goal of the treatment phase is to improve patients' mobility and reduce consequences of limited mobilization, providing continuous support to rehabilitation with reduced involvements of the clinical staff.
- Monitoring (monitoring of compliance prescription, correctness and risks): The goals of monitoring phase are the continuous assessment of the adherence to the prescription for each task, providing an effective feedback and prompting of the patients to correctly execute the assigned task.
- Follow up (short-term post-rehabilitation assessment): The aim of the follow up phase is to check the motor functions of the patient, to estimate the benefits and the efficacy of rehabilitation in comparison with his/her initial condition.

### A.5.3.6 KPIs

Table 39 - UCBM RUC A2.2 UC4

Phase	KPIs	Measure unit	Tool	Notes
Treatment	Time spent in performing autonomous exercises	[min]	TIAGo	
	Number of vocal robotic interventions	[#]		
	Number of physical robotic interventions	[#]		
Monitoring	Success rate	[%]		
	Execution time	[min]		
	Number of repetitions	[#]	TIAGo	
	Number and type of errors	[#]		

Phase	KPIs	Measure unit	Tool	Notes
	Number of requests to stop the therapy	[#]		
	Number of anomalous movements from the patient	[#]		

#### A.5.3.7 Involved stakeholders

- Admission and Screening (screening based on risk of reduced mobility): Physician and nurses.
- Diagnosis/Case Studies (motor assessment and rehabilitation prescription): Specialist in physiotherapy.
- Treatment (in-hospital rehabilitation): Physiotherapist and nurses.
- Monitoring (monitoring of compliance prescription, correctness and risks): Physician, physiotherapist and nurses.
- Follow up (short-term post-rehabilitation assessment): Specialist in physiotherapy.

#### A.5.4 RUC A3 - UC5: Automation of Clinical Workflows - Monitoring of oxygen therapy to prevent hypoxia complications

##### A.5.4.1 Description

Respiratory failure is a syndrome in which the respiratory system is unable to correctly perform gas exchange: arterial blood oxygenation and carbon dioxide elimination. It is possible to recognize two types of respiratory failure basing on the underpinning mechanism: lung failure, or type I failure, when ventilation, and thus carbon dioxide elimination, is preserved but the impaired lung function leads to hypoxia, and pump failure, or type II failure, when ventilation is impaired (i.e. neurological and/or muscle and/or chest disorders) and hypoxia develops together with hypercapnia. In the first case the therapy is the supplementation of oxygen through different devices according to the severity and patient's characteristics, in the latter ventilation is needed. Hypoxia and hypercapnia are usually symptomatic (i.e. confusion, dyspnea, etc.), however older patients are often asymptomatic or develop geriatric syndromes, like delirium, which are totally nonspecific, delaying the diagnosis and increasing the occurrence of complications.

- Admission and Screening (screening of patients requiring oxygen): Acute respiratory failure is one of the leading causes of hospitalization in geriatric patients, particularly during the COVID-19 pandemic. Hypoxia consists in the lack of arterial blood oxygen to deliver to peripheral tissues for the production of energy and increases the risk of complications, even severe. Symptoms of hypoxia may attract the attention, however older patients may be totally asymptomatic or have nonspecific reactions that can delay the diagnosis and therapy.
- Diagnosis/Case Studies (patient assessment and oxygen therapy prescription): Once the patient is considered at risk of respiratory failure, it is mandatory to confirm the diagnosis and classify the underpinning mechanism to timely start the required treatment, which entails oxygen supplementation in case of lung failure and ventilation in case of pump failure. Furthermore, the diagnosis of respiratory failure compels to search the disease responsible

for the organ failure to start a treatment. Symptoms and signs are pivotal, but additional investigations (e.g. imaging, echocardiography, etc.) help to address the diagnosis.

- Treatment (in-hospital therapy): Once the diagnosis has been confirmed and the type of respiratory failure identified, oxygen therapy or ventilation is prescribed. Prescription is performed by hospital doctors and takes into account several aspects other than blood gas analysis. Oxygen can be supplemented through nasal prongs, venture mask or high-flow nasal cannula and the treatment can be prescribed during the whole day or only during the night according to patient needs.
- Monitoring (monitoring of compliance with prescription and correctness of therapy): Once oxygen therapy has been prescribed, the correctness of the therapy and patient's compliance should be monitored. Indeed, older patients, particularly those with dementia or with hospital-induced delirium, do not perform the therapy correctly and are less compliant, reducing the benefits of the therapy and increasing side-effects. It is therefore mandatory to check that oxygen supplementation is ongoing and that it is performed with the correct device and for the right time to foster healing.
- Follow up (short-term assessment): Oxygen supplementation is not a causative therapy, and its prescription is aimed only at avoiding the risk of developing hypoxia complications until the causative disease has been treated. It is therefore clear that patients should be regularly evaluated to define whether respiratory failure has improved, worsened or resolved to timely stop or increase/decrease the treatment.

#### A.5.4.2 Timeline

The experiment will start in June 2024 and will stop in July 2024 with the timeline reported in Table 40.

Table 40 - UCBM RUC A3 UC5 – Timeline

Task	M37	M38	M39	M40	M41
Preliminary functionality tests in UCBM laboratory					
Tests on healthy subjects at UCBM					
Recruitment of geriatric patients at UCBM					
Recruitment and experiments on geriatric					

patients at UCBM					
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#### A.5.4.3 Technology definition

Within this UC, a mobile robot will reach the patient, recognize her/him, by using a barcode module and check the consistency between the prescribed therapy and the delivered one. TIAGO robot and Transparent robot will be adopted for this UC. The robot will be able to monitor the patients (camera, oximeter and flowmeter) to assess the correctness of the therapy, e.g. in terms of oxygen flow and mask position (AI algorithms). The identification of components is shown in Figure below.

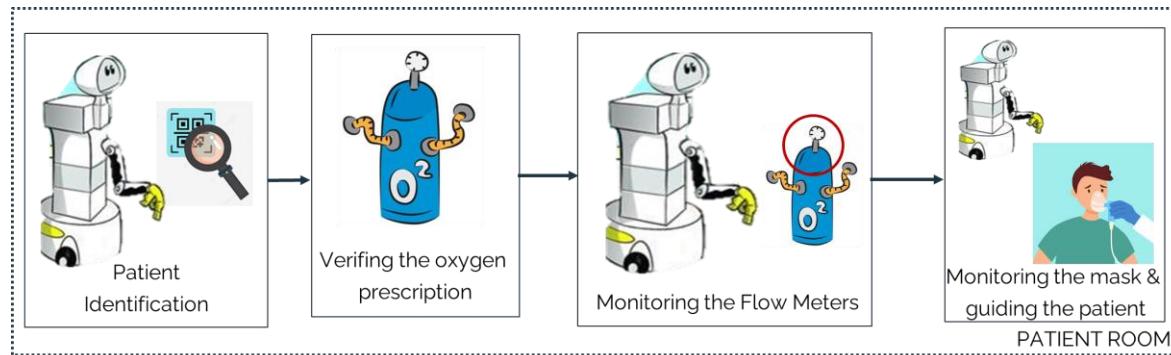


Figure 29 - UCBM RUC A3 overview

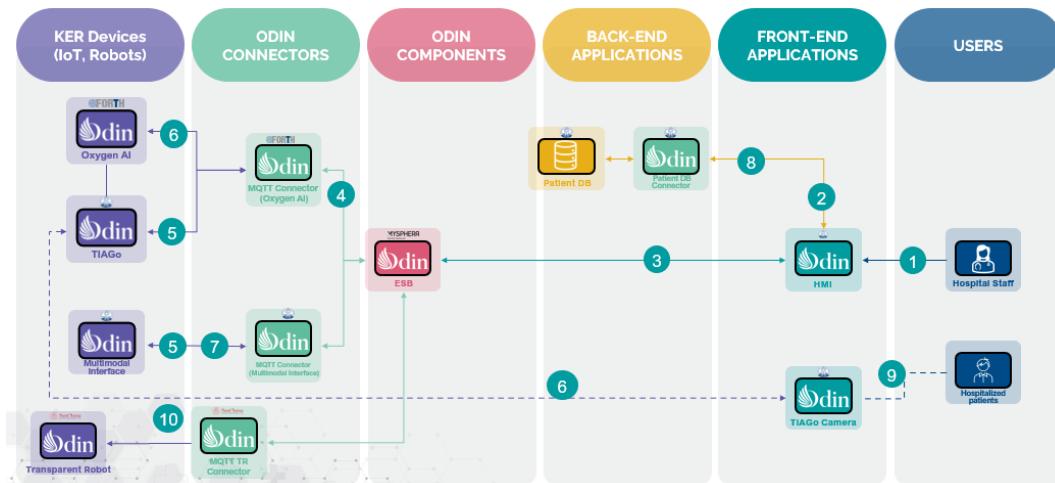


Figure 30 - UCBM UML schema for RUC A3 UC5 regarding oxygen therapy monitoring

#### A.5.4.4 Procurement / Acquisition process

It is not necessary to acquire any additional technologies.

The technologies for this UC are already available/will be developed within the ODIN consortium.

- TIAGo robot: already available at UCBM;
- HMI: developed by UCBM;
- Transparent robot: already available at SSSA;
- Multimodal Interface (RGB-D camera, oximeter, Heart Rate and Respiration Rate sensors): developed by UCBM;
- AI modules: developed by FORTH;
- Barcode module for patient/meal matching: developed by UCBM;
- ESB and Orchestrator: developed by MYS.

#### A.5.4.5 Primary Outcomes

Admission and Screening (screening of patients requiring oxygen):

Prompt identification of patients at risk of respiratory failure.

Diagnosis/Case Studies (patient assessment and oxygen therapy prescription):

Diagnosis of respiratory failure, classification and stratification of severity.

Treatment (in-hospital therapy):

Oxygen supplementation according to patient's needs.

Monitoring (monitoring of compliance with prescription and correctness of therapy):

Prompt identification of scarce compliance to oxygen therapy and/or erroneous supplementation.

Follow-up (short-term assessment):

Identification of patients that have recovered from those who still need oxygen and reassessment of oxygen needs.

#### A.5.4.6 KPIs

Table 41 - UCBM RUC A3 UC5

Phase	KPIs	Measure unit	Tool	Notes
Monitoring	Device correctness	[Boolean]	TIAGo camera	
	Air flow	[l/min]	Flowmeter	
	Fraction of oxygen	[%]		
	Therapy duration	[min]		
	Correct device positioning	[Boolean]	External camera	

Phase	KPIs	Measure unit	Tool	Notes
	Correct therapy duration	[min]		
	Number of robotic interventions	[#]	TIAGo	
	Oxygen saturation	[%]	Oximeter connected with TIAGo	

#### A.5.4.7 Involved stakeholders

- Admission and Screening (screening of patients requiring oxygen): Doctors, nurses and caregivers.
- Diagnosis/CASE Studies (patient assessment and oxygen therapy prescription): Doctors.
- Treatment (in-hospital therapy): Doctors.
- Monitoring (monitoring of compliance with prescription and correctness of therapy): Doctors, nurses and caregivers.
- Follow-up (short-term assessment): Doctors.

#### A.5.5 UCBM RUC B1 – UC1: Aided logistics support – Logistics of food delivery

##### A.5.5.1 Pilot Description

Hospital foodservice is complex and can be considered as one of the most complicated systems in the hospitality sector with many interrelated factors. The layout of hospital wards, often at considerable distances from the kitchen, adds an additional logistics burden, and as a consequence, a long stream of possible delays between production, service, delivery and consumption. The goals of a hospital foodservice are to provide inpatients with nutritious meals that are beneficial for their recovery and health, and also to give them an example of healthy nutrition with menus tailored to patients' specific health conditions. When meals are carefully planned and customized to meet patients' specific needs, and when patients consume what they are served, these goals can be considered as achieved. Meal consumption by inpatients is related to nutritional status and satisfaction with the foodservice, along with other factors such as health status, medical conditions, appetite, the eating environment and dentition. It is widely recognized that food and other aspects of foodservice delivery are important elements in patients' overall perception of their hospital experience and that healthcare teams have a daily commitment to deliver appropriate food to patients. Moreover, among many difficulties that can potentially arise in the phase of meal distribution, the patient-meal match is an issue that can both burden clinical staff and also have negative effect on patients' care and experience.

This UC will address the problem of improving the process of delivering the right meal to the right patients (food delivery process in the following sub-sections) based on the clinical prescription and on the daily special requests.

- Planning (food ordering): Any hospital menu planning and food-based criteria aims to ensure that differing dietary needs are catered for and thus maximizing opportunities to ensure nutritional needs can be achieved. Hospital menu requirements are informed by assessment of local patient population needs which require to be regularly reviewed. The hospital menu typically provide for breakfast, lunch, and evening meal and can include two additional substantial snacks throughout the day. It enables the range of energy and protein requirements of patients to be met i.e. 'nutritionally well' and 'nutritionally vulnerable'. Effective menu planning is essential to meet the dietary and nutritional needs of the hospital population and requires the collection of a wide range of information and input from numerous groups. Before considering menu planning or development of a recipe database, menu planning groups need to consider the wider issues that can affect patient food choice and hence food intakes. Gathering of information about the differing dietary needs of different hospital patient groups can help menu planners develop an appropriate food service that is in a form that is familiar to patients.
- Preparation, delivery, installation, training (food delivery process): Meal distribution represents a repetitive and elementary task that burdens nurses and healthcare workers but is not free of risks. Indeed, the delivery of food to allergic patients can lead to adverse and even severe events, and the delivery of food to patients fasting for a procedure can raise the costs for the healthcare system. Most of the activities related to food delivery must be carried out at least twice a day, to ensure lunch and dinner for each hospitalized patient, as well as breakfast and a possible afternoon snack. Moreover, the perfect synchronization of all the involved resources (not just human: from dieticians to cooks, from drivers to bedside delivery operators) is absolutely necessary. In this context, there are different aspects from a logistic point of view that can be optimized to make a critical service such as that of hospital catering contributing to the improvement of patient health.

Real usage monitoring management (compliance with clinical prescription): The monitoring of food assumption can have different final aims: i) to check for the proper nutrition of patients; ii) to identify compliance with clinical prescription; iii) to identify possible needs of changes of the patients' diet; iv) to identify possible food waste. A wide literature has been produced on all these different topics; anyhow, the focus of the UCBM UC is to compare the diet prescription with the actual delivery of the food. This aspect is also strictly related to the activity carried out within the RUC A2.1 (Monitoring of food assumption to prevent undernutrition) where the aim is to check possible problems of undernutrition.

#### A.5.5.2 Timeline

The experiments will run in parallel to the ones of RUCA2.1 UC4.

#### A.5.5.3 Technology definition

A robotic system will deliver the meal to the patient checking the congruity between patient records on the meal and that on patient bracelet. Moreover, the robotic platform verifies the correspondence between the assigned meal and patient's special requests (allergies, pathologies, daily needs, etc.). The robot is also able to deliver the meal and check the percentage of correct intake by providing alerts (if necessary). The system needs to be equipped with:

- Navigation capabilities to reach the bed of the correct patient;
- Multisensory system and intelligent algorithms for patient recognition;

- AI capabilities to monitor food assumption (shared with UCBM RUC A2.1);
- Communication system to provide alerts to the healthcare staff.

TIAGo robot and Transparent Robot will be used for this UC.

#### A.5.5.4 Procurement / Acquisition process

It is not necessary to acquire any additional technologies.

The technologies for this UC are already available/will be developed in the ODIN consortium.

More in detail, the following hardware/software modules will be adopted for this UC:

- TIAGo robot: already available at UCBM;
- HMI: developed by UCBM;
- CERTHbot: already available at CERTH;
- Fleet Management System: developed by TWI;
- Transparent robot: already available at SSSA;
- Multimodal Interface (RGB-D camera, oximeter, Heart Rate and Respiration Rate sensors): developed by UCBM;
- AI modules: developed by FORTH;
- Barcode module for patient/meal matching: developed by UCBM;
- ESB and Orchestrator: developed by MYS.

#### A.5.5.5 Primary Outcomes

##### Planning (food ordering):

Menu planning groups need to: i) recognize the often complex needs of specific patient populations to be cared for including ‘nutritionally vulnerable’ patients and those on specialised therapeutic diets; ii) provide a choice of foods for individuals who require or would benefit from following a diet based on ‘healthy eating’ principles enabling them to meet their nutritional requirements; iii) ensure provision is made for a choice of foods for individuals with poor appetites or increased requirements to enable them to meet their nutritional requirements; iv) ensure that the dietary needs of individuals who follow diets for cultural or religious reasons are met (e.g. vegetarian diet, vegan diet). It is important to remember that the menu should be reviewed and updated regularly in order to continue to meet the dietary needs of a potentially changing hospital.

##### Preparation, delivery, installation, training (food delivery process):

The objective of this phase of the UC is to introduce technologies to:

- Monitor and support the delivery of the right meal to the right patient (to avoid any issues related to specific prescriptions or diet constraints);
- Improve safety for patients during food assumption (to prevent risky assumption of wrong dangerous food);
- Improve working conditions of the healthcare operators (to reduce the time spent in checking meal-patient correspondence and possibly adopt corrective actions);
- Increase hospital efficiency and workflow (to avoid time loss and inefficiencies due to erroneous meals delivery).

The intervention not only directly impact on patient health but also will soothe the burden for nurses and healthcare workers.

### Real usage monitoring management (compliance with clinical prescription):

The goal of this phase, at least in the UCBM UC, is to verify the compliance of the food assumption with clinical prescription. This is also strictly related with the goals presented in the RUC A2.1 of UCBM, where a timely intervention on undernutrition is targeted. This phase is strictly interwoven with the previous one and technology/KPIs, presented hereafter, will be shared among the two phases.

#### A.5.5.6 KPIs

Table 42 - UCBM RUC B1 UC1

Phase	KPIs	Measure unit	Tool	Notes
<b>Preparation, delivery, installation, training (food delivery process)</b>	Success rate in patient-meal matching	[%]	TIAGo camera	
	Success rate in meal-diet matching	[%]	TIAGo camera	
<b>Real usage monitoring management (compliance with clinical prescription)</b>	Number of warnings detected by robotic platform	[#]	TIAGo and its software module	

#### A.5.5.7 Involved stakeholders

- Preparation, delivery, installation, training (food delivery process): Doctors, nurses.
- Real usage monitoring management (compliance with clinical prescription): Doctors, nurses.

### A.5.6 ODIN Integration

#### A.5.6.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment?

We envisage the use of ODIN KERs as solutions to improve patients' care in three different conditions representative of the clinical practice in the Geriatrics Unit and also to reduce the effort of clinical operators during time-consuming or demanding and wearing tasks.

Robotic solutions will be adopted (TIAGo by UCBM, CERTHbot by CERTH), integrated with AI algorithms developed within the project (food assumption and oxygen therapy monitoring by FORTH) and also supported by IoT (transparent robot by SSSA, environmental cameras by UCBM) and software for the coordination of robots (fleet management system by TWI). All the KERs will be linked to the whole ODIN platform.

Our UCs implementations will serve as a proof of concept for demonstrating technology-aided efficient improvements in the care of geriatric inpatients. The adopted solutions, demonstrated at UCBM, anyhow, will be also possibly generalized and adapted to other hospitals and or to different units and patients in future studies.

## A.6 UMCU - University Medical Centre Utrecht, The Netherlands

### A.6.1 Pilot Description

The University Medical Center Utrecht (UMCU) is a leading medical center in the Netherlands, renowned for its healthcare provision, research output, and educational programs for students, physicians, researchers and other healthcare providers. The UMCU focuses on six strategic teams, with ODIN falling in the Circulatory Health focus. More specifically, the ODIN projects are housed within the Division of Laboratories, Pharmacy, and Biomedical Genetics, particularly in the Central Diagnostic Laboratory's translational subunit 'ARCADIA' (Academic Research for Clinical Applications of DIagnostics). ARCADIA hosts the Utrecht Patient Oriented Database (UPOD), a database established in 2003, containing comprehensive and complete electronic health record (EHR) information of approximately 2.4 million patients that visited the UMCU since the 1990's. The UPOD group aims to improve clinical diagnostics using routine care data and is involved in efforts to turn the UMC Utrecht into a learning healthcare system (LHS). For the ODIN project, the UMCU ODIN project members will collaborate with the recently established (2020) UMCU department of Digital Health, which is located in the corporate staff.

The Circulatory Health theme encompasses the Center for Circulatory Health and the Utrecht Cardiovascular Cohort, already encompassing 13,000+ patients, aiming to transition patient care for cardiovascular disease patients into an LHS. This is where the majority of our ODIN use cases have their home. Our recently added logistics use case is a collaboration between UPOD, the logistics department, and the obstetrics department.

#### A.6.1.1 Pilot Experiments

Table 43 - UMCU Experiments

Use Case	Name	Description	RUC X Phase (s)
RUC A - UC3	AI for Diagnosis	To improve personalization and efficiency of CVD diagnostic pathways outpatient clinic setting	Diagnosis
RUC A – UC4	Identification of eligible patients for CVD learning	Automatically identify new patients eligible for CVD learning healthcare system	Admission & Screening
RUC B – UC1	Aided logistic support	Automatic distribution of medical supplies	Delivery, installation, training
RUC C – UC7	Disaster Preparedness	Overview of pathogen carriers for IPD	Preparedness, Mitigation

## A.6.2 RUC A UC 3: AI for diagnosis

### A.6.2.1 Description (overall and for each phase)

The right treatment starts with the right diagnosis. Diagnostic trajectories can be straightforward, short and inexpensive, but in specialised medical centres can become difficult, long, expensive and cumbersome for patients. Most diagnostic pathways are well defined within protocols, and this implicates simplicity. However, patients that are referred to the UMC Utrecht Cardiovascular health centre (= cardiovascular outpatient clinic) can be referred by general practitioners or other medical specialists in secondary or tertiary care.

Cardiovascular diagnostics can be broad, as atherosclerosis, the underlying culprit disease, can manifest itself in multiple ways. Especially in patients that present with atypical complaints, this can result in a series of diagnostic tests before a diagnosis is given. At the same time, some diagnostics are redundant (e.g. sometimes MRI or angiography can replace CT, yet MRI is more expensive and angiography is more invasive) for some specific patients and diagnostic modalities can replace each other. Furthermore, choices are made based on availability of diagnostic tools. This availability can be in terms of whether or not a specific machine is available in a hospital, but also in terms of whether the agenda indicates availability of the machine within a certain period of time, or even in terms of where the machine is within the hospital. This leads to inefficient diagnostic pathways.

The above culminates into the following conclusion:

in the UMC Utrecht Cardiovascular health centre, diagnostic pathways for complicated diagnostic problems are not Personalised and the location and availability of diagnostic tools are not considered in planning.

For this use case, we want to include patient characteristics, location and availability of the diagnostic devices to make the diagnostic process in the UMC Utrecht Cardiovascular health centre more efficient. We will start with the diagnostic process in patients that visit the cardiovascular surgery department, as these patients vary the most in terms of patient characteristics, diagnostic trajectories and diagnostic modalities used.

- Diagnosis:

Once the patient has been referred to the UMCU cardiovascular surgery department, it is needed to determine what kind of diagnostic tests the patients should undertake. This can be determined by evaluating the patient characteristics (Personalising the diagnostic process). Thereafter, using data on the availability and the location of the medical devices within the hospital, we can make the diagnostic workflow more efficient, as it enables prioritisation within the workflow. For example; if a patient requires both an ECG and an MRI, but the ECG is further away than the MRI and only available in an hour, we could advise the patient to first take the MRI and later-on the ECG.

### A.6.2.2 Timeline (overall and for each phase)

The experiment started in January 2023 and will stop in August 2024.

This experiment takes place in one of the phases only (diagnosis). However, within the experiment we start small and are planning to gradually expand the model.

First, we will build a model to predict the kind of diagnostic test needed solely based on the patient characteristics. Then, we will add the availability of the diagnostic modality to the model, based

on agenda data from the electronic health record (EHR). Thereafter, we will incorporate the location of the modalities by using the data coming from the IoT sensors/tags, enabling us to determine and prioritise the diagnostic workup. At last, we will incorporate alternative pathways, in which some diagnostic modalities are replaced by others, if possible, and if it would make the diagnostic workup more efficient.

#### Preliminary timeline:

- Ethical approval: July 2022
- Description of current and alternative diagnostic pathways: June 2022 – December 2022
- Development of model 1 - 3: February 2024 – June 2024
- Evaluation/validation of the final model: July 2024 – August 2024

#### A.6.2.3 Technology definition

The experiment will use the following technology: IoT (eLocations)

The objective is the optimization of the diagnostic workflow of patients visiting the vascular surgery department. In particular, the idea is to automatically match the diagnostic needs within clinical procedures, the availability and location of diagnostic modalities, such as, echocardiography, MRI and CT scans to identify the optimal (most efficient) workflow of devices usage based on their availability and location in the hospital, for each patient. Considering device locations and diagnostic needs, an automated algorithm should be able to provide the physician of information on the most efficient diagnostic pathway. The different components necessary for optimizing the workflow have been identified, along with their relationships:

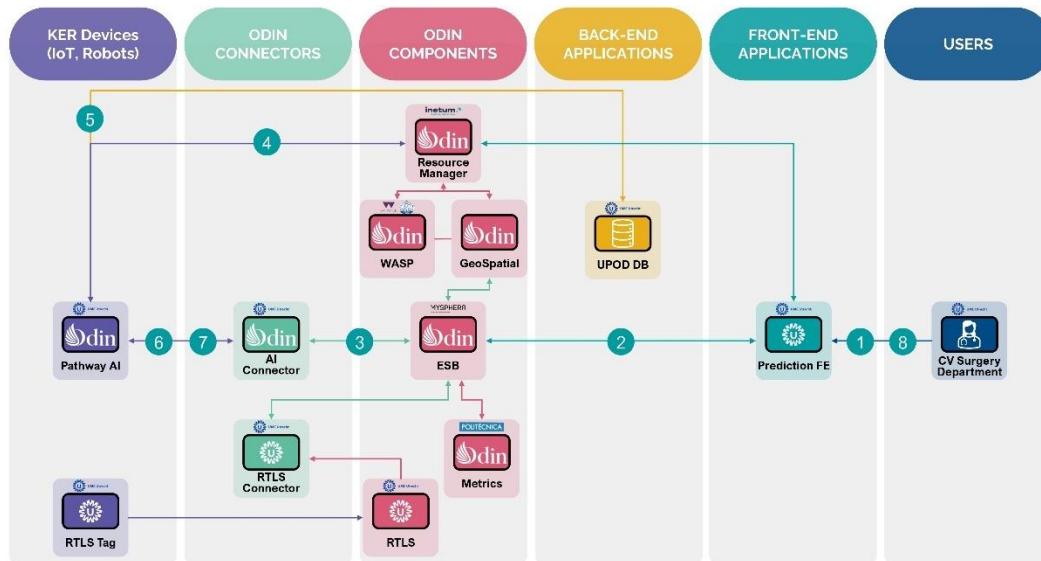


Figure 31 - UMCU UML schema for RUC A UC3 regarding CVD diagnosis pathway

#### A.6.2.4 Procurement / Acquisition process

The experiment will need the following technology to be acquired: sensors, tags, gateways

The process of acquisition will be through a procurement technology partnership already in place. Currently the IT department of the UMCU is establishing a network of sensors, tags and gateways that enabling localisation and availability of medical devices and other modalities. At the moment of writing, several discussion have taken place. This ODIN use case could be used as a clinical use case for the IT department. Therefore, further acquisition will not be needed.

### A.6.2.5 Primary Outcomes

#### Diagnosis:

To make the diagnostic workflow more efficient by;

- (1) Personalising the diagnostic process, and
- (2) including location and availability of the medical devices.

### A.6.2.6 KPIs (for each phase)

Table 44 - UMCU RUCA1 UC3

Phase	KPIs	Measure unit	Tool	Notes
Diagnosis	Time to CEA procedure	[days]	T0: The current number of days until the procedure will be determined based on retrospective data from the electronic health records. The day of the first appointment will be subtracted from the date of the procedure.  T1: After the experiment, the number of days between the first appointment and the day of the procedure will be calculated.	-

#### Diagnosis:

Time to procedure (in days). We expect to decrease the time to the CEA procedure, as by including the location and availability of the devices, we will be able to suggest a more time efficient diagnostic workup/planning. Furthermore, we will also determine the diagnostic tests needed based on patient characteristic, making the diagnostic process more personalised.

### A.6.2.7 Involved stakeholders (overall and for each phase)

#### Diagnosis:

- IT department: The IT department will help us during the experiments by setting up the whole IoT landscape. They will put the sensors/tags on the medical devices needed and provide the data from those devices.
- Datamanagers: The UPOD datamanagers will be involved during the entire process. They will provide us the necessary data from the electronic health records to build the model. In addition, the IT department will send the data from the sensors/tags to the datamanagers.
- Physicians, nurses and administrative staff will be consulted to plot the current diagnostic pathway and underlying assumptions, and, in addition, possible alternative pathways.

### A.6.3 RUC A UC 4: Clinical Tasks and Patient experience

#### A.6.3.1 Description

Cardiovascular risk management has since the Framingham risk score was published been established as the best way to manage cardiovascular risk. The Framingham risk score has since then been updated and refined into cardiovascular risk management guidelines, that each physician needs to follow when treating at-risk patients. These guidelines include measuring blood pressure and BMI, draw blood to perform laboratory testing including lipid levels, assessing cardiovascular history and family history and behavior such as smoking and physical exercise. We know that cardiovascular risk management attainment is generally poor, i.e. not all patients that are entitled to it, get it.

Therefore, the UMCU initiated a cardiovascular learning healthcare system (LHS) to improve uniform assessment and registration of cardiovascular indicators in all patients referred to the UMCU that are entitled to cardiovascular risk management (e.g. for cardiovascular evaluation, either because they are at risk for cardiovascular disease (primary prevention) or because they already got it (secondary prevention). Within this LHS, we regularly assess fields in our electronic health record system where the above risk factors need to be filled in (laboratory results, measurements, etc.). To close the LHS loop, each department received monthly feedback reports consisting of feedback on data quality and completeness so they can improve their cardiovascular risk management attainment and provide better care according to state-of-the-art guidelines that benefit the patients.

However, these reports only include this valuable information for the patients that are included into the LHS. Currently, these patients are manually included into the LHS by medical staff and research nurses. They screen appointments and referral letters in outpatient clinics for diagnoses and measurements that indicate cardiovascular risk. However, this identification method is very time-consuming and has proven to be unsustainable. For example, during the COVID-19 pandemic, inclusion of patients into the LHS stopped completely, as it dropped on the priority list. There was no time or resources left to include patients into the cardiovascular LHS. Additionally, after evaluation we saw that a lot of patients that actually should have been included into the LHS were missed because of time constraints/non-structured data that is not easily visualized in the EHR is needed to identify them. A patient selection based on simple rule-based methodology and

structured data (e.g. appointment codes/billing codes) is will still miss patients and make our cardiovascular risk management suboptimal, which is not right for patients.

Therefore, we would like (1) to develop a patient selection tool for the cardiovascular LHS which includes the appropriate patients based on structured and unstructured routinely available electronic health record data. We then want to (2) provide reports to the treating physicians including visualizations and data quality feedback of the cardiovascular risk profile of their patients in order to close the LHS loop.

#### Screening:

This use case only falls in the screening phase. Patients that visit outpatient clinics for cardiovascular evaluation for the first time will be included in the LHS based on structured and unstructured routine care electronic health record (EHR) data. Of these patients, baseline cardiovascular risk management indicators are extracted from the EHR and the completeness thereof is reported back to physicians through dashboards, aiming to improve the quality of care.

#### A.6.3.2 Timeline (overall and for each phase)

At the moment of writing, we already have developed a patient inclusion system/algorithm. However, this current system is solely based on structured data fields from the EHR (part 1). We have also developed the PowerBI dashboards. Both the inclusion systems and the dashboards are continuously being improved based on feedback we receive from the physicians. In 2023, we are planning an evaluation of this approach. In 2023 we will start incorporating AI into the algorithm (part 2) and this approach will be evaluated in 2024.

##### Part 1:

Development of patient inclusion algorithm without AI: Nov 2021 – Dec 2022 (iterative process)

Development of PowerBI reports (iterative process) departments: Jan 2022 – Feb 2023

Send monthly dashboards to the departments: March 2022 - onwards

Evaluation of the patient inclusion system: November 2023 – June 2024

##### Part 2:

AI model development & evaluation: March 2024 – August 2024

#### A.6.3.3 Technology definition

The experiment will use the following technology for part 2 of this use cases: AI for model development. We will select patient that are eligible for participation in the cardiovascular learning healthcare system, UCC-CVRM, based on structured and unstructured fields of the EHR. Discussions with the participation department have been taking place to agree upon the way to select the patients based on structured data fields in the EHR. These selections will be made based on specific agenda- and appointment codes and diagnosis billing codes. No AI is needed for this part (Part 1).

However, we would like to assess whether we are, using the method described in 'part 1', missing clusters of patients that are at higher cardiovascular risk (Part 2). To assess this, we would like to develop an AI model able to cluster patients based on patient- and clinical characteristics (structured and unstructured (i.e., text) data from the EHR).

Apart for the above, for all selected patients, data on cardiovascular risk indicators will be extracted from the EHR and, to close the LHS feedback loop, dashboards will be developed to provide the departments of information on data quality and completeness.

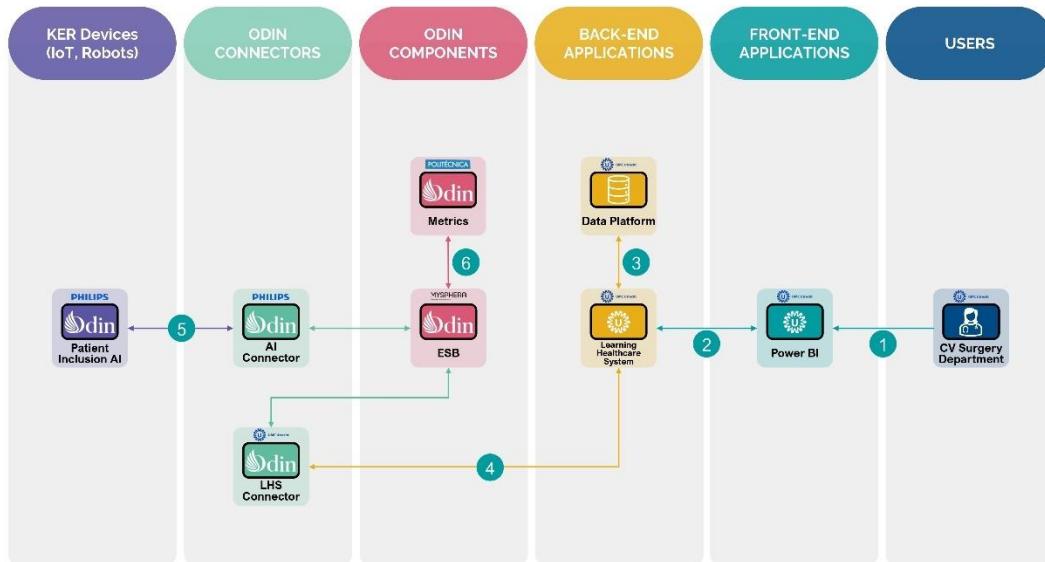


Figure 32. UMCU UML schema for RUC A UC4 regarding CVD patient identification

#### A.6.3.4 Procurement / Acquisition process

PowerBI will be used to create dashboards providing feedback on data quality to the departments. No further acquisition is needed for this. The dashboards are continuously being improved and tailored to match the wishes of the departments (as long as it is within the scope of the UCC-CVR M).

For part 2 of this use case AI models will be developed.

#### A.6.3.5 Primary outcomes (overall and for each phase)

- Admission & screening

We aim to develop a system that is able to identify patients for the cardiovascular LHS, and extract data on cardiovascular risk indicators that, according to (inter)national guidelines, should be assessed regularly in all patients at higher cardiovascular risk. To close the LHS-loop we will provide dashboards on the completeness of specific cardiovascular risk management indicators, to enable improvement of care.

### A.6.3.6 KPI (for each phase)

Phase	KPIs	Measure unit	Tool	Notes
Admission & screening	Number of detected patients at higher cardiovascular risk, eligible for inclusion in the cardiovascular LHS	[mean #]	T0: Mean number of patients invited per month, before 2020. Based on available retrospective cohort data  T1: Mean number of patients at high risk, as identified and included in the cardiovascular LHS using the newly developed algorithm/query based on routine care data from the EHR.	-
Admission & screening	Number of clinicians that find the overviews usable	[%]	T0: Not available  T1: Conducting interviews / focus group discussions with clinicians	

### A.6.3.7 Involved stakeholders (overall and for each phase)

Nurses and doctors of all participating departments of the UMCU are involved. They will need to provide us with the information needed to be able to select the correct patients for the LHS. For example, by pointing us towards structured and unstructured data that are able to identify of patients (-patient groups) that they want us to include into the LHS. This will be an iterative process.

UPOD datamanagers are consulted to help build a script/syntax to select the eligible patients from the EHR.

## A.6.4 RUC B UC 1 : Aided Logistic Support

### A.6.4.1 Description

At the UMC Utrecht, the logistics department's warehouse, located on the hospital's 0 level, is where the logistics staff receives, sorts and fills the stock items. From the warehouse, various carts are filled with 24-hour supplies for the patient rooms. Transporting the carts to the patients' rooms is physically demanding work, so we would like to test whether we can use a robot to transport the carts with the 24-hour supplies from the warehouse to the patients' rooms. This would reduce the amount of physically demanding work for the logistics employee, we would be

able to more efficiently deploy employees, and it would potentially be possible to have a 24/7 operation (i.e., on call in the evenings and at night).

The experiment will be done using the robot called 'HOSBOT' and will be carried out in a mock-up room that is currently being constructed on the 0-layer of the UMC Utrecht. In this mock-up room we can try out the process with the robot without external disturbances. If time allows, and after proving successful in the mock-up, we will pilot the HOSBOT to transport medical supplies to the obstetrics department.

#### **Delivery, installation, training phase**

This use case only tends to fall within this phase, as we're currently solely interested in the robot's ability to deliver the medical supplies to the prespecified location.

#### A.6.4.2 Timeline (overall and for each phase)

Overall: July 2023 – August 2024

Preparation phase: July 2023 – April 2024

Deployment phase: April 2024 - May 2024

Running phase: May 2024 – August 2024

#### A.6.4.3 Technology definition

- Delivery, installation, training

Autonomous navigation towards the assigned locations. HOSBOT's robotic system is able to autonomously navigate across different rooms to deliver its load to the desired location. It is able to avoid obstacles and react to a dynamic environment. The robotic system is composed of the robot (which navigates the environment and transports the rest of the components), a rack (which contains the smartboxes and has the interface from which to give instructions to the robot) and the smartboxes (which store the load and detect if an item enters or leaves them). The rack is the component which connects the entire system. It is a structure where the robot can attach itself to and that can store three smartboxes. The rack comes with a tablet that is used to give the robot instructions and interact with the smartboxes. Finally, the smartboxes are containers which are able to detect when an item is placed or removed thanks to the use of RFID tags. The smartboxes can also be undocked from the robot to allow a worker to manually transport the load.

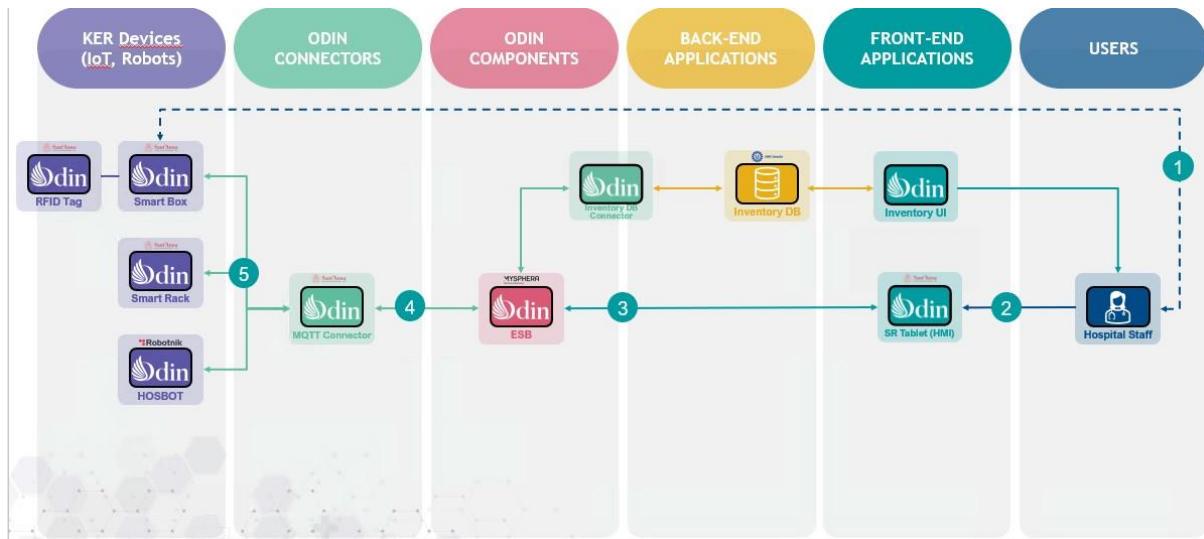


Figure 33 - UMCU UML diagram of the process from the moment a task has been scheduled, RUC B UC1.

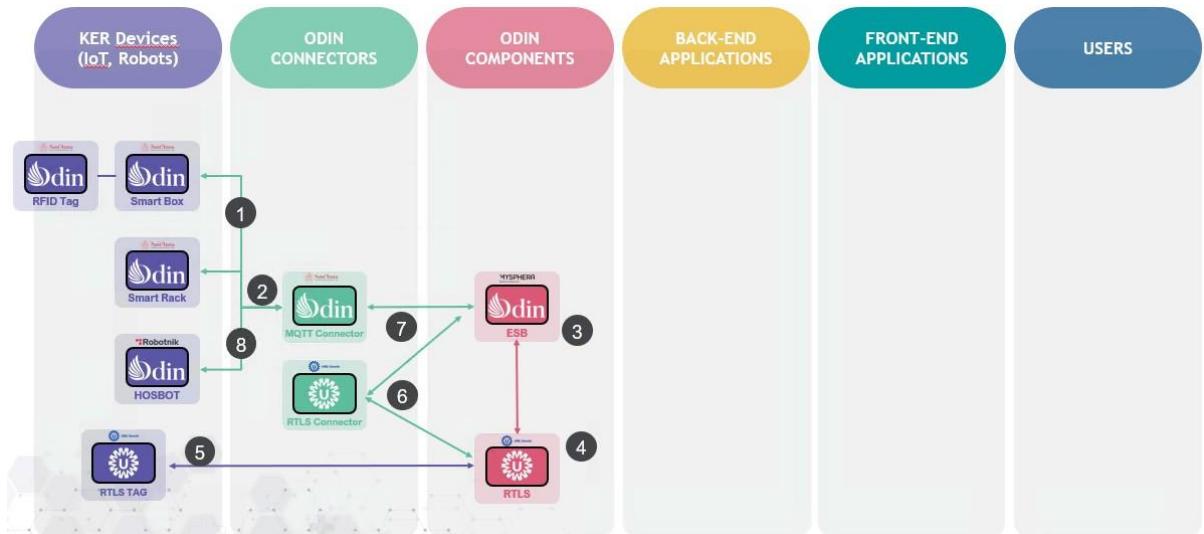


Figure 34 – UMCU UML diagram of the process when the robot module is running out of battery, RUC B UC1.

#### A.6.4.4 Procurement / Acquisition process

Funding agreements have been made with SSSA (consortium partner) to cover the costs of robot transportation to the UMCU and to cover the accommodation costs for the ODIN technical partners involved in the deployment of the experiment in our hospital.

The IoT technology used by the robot will be replaced by UMCU's IoT system, no further procurement is needed for this.

#### A.6.4.5 Primary Outcomes

Reduction of physically demanding work, as, if the robot performs well enough in terms of the number of non-conformities, the robot could replace the work that is physically demanding.

#### A.6.4.6KPI (for each phase)

Phase	KPIs	Measure unit	Tool	Notes
Delivery, installation, training	Number of non-conformities out of 10 attempts	[#]	Count the number of instances, out of 10, in which: I: robot could not find its way (out of 10) II: robot failed to pick up rack (out of 10) III: robot did not identify open space to put rack (out of 10)	We expect 10/10 for T0 (human). we never expect the robot to be as good as a human. We deem 9/10 as sufficiently successful

#### A.6.4.7 Involved stakeholders

- Logistics department: end users of the HOSBOT
- UMCU's IoT department: to provide the sensors / tags necessary for the incorporation in the HOSBOT + explore ways to connect to the ODIN platform
- ODIN members, SSSA: for the supply of the technology and the help with the deployment.

### A.6.5 RUC C UC 7: Disaster Preparedness

#### A.6.5.1 Description

Our infection prevention department currently relies on retrospective reporting and data. During the COVID-19 pandemic, a lot of data has proven to be unavailable and overviews of infected patients as well as pathogen carriers were made manually. Due to covid-19, a lot of attention has been given in the past year to infected patients, yet overviews of pathogen carriers are equally important to the infection prevention department.

The objective of this use case is therefore to provide the infection prevention department with a readily available structured overview of pathogen carriers. This part relates to the 'preparedness' phase of the RUC.

In addition, we will explore the possibility of incorporation an alert system (provided by ODIN partner) when the concentration of a certain pathogen in a specific location of the hospital becomes too high. This part relates to the 'mitigation' phase of the RUC.

#### A.6.5.2 Timeline (overall and for each phase)

Overall: January 2023 – August 2024

Preparation phase: January 2023 – April 2023

Deployment phase: April 2023 – April 2024 (development of the overviews)

Running phase: April 2024 – August 2024 (evaluation of the technology)

### A.6.5.3 Technology definition

We will be using PowerBI/MICORE to create the overviews of pathogen carriers, based on data from the EHR and laboratory system. Furthermore, we will explore the possibility of using ODIN's alert UI to explore whether it is possible to trigger an alarm through the ODIN platform whenever the concentration of a certain pathogen is above a certain safety threshold.

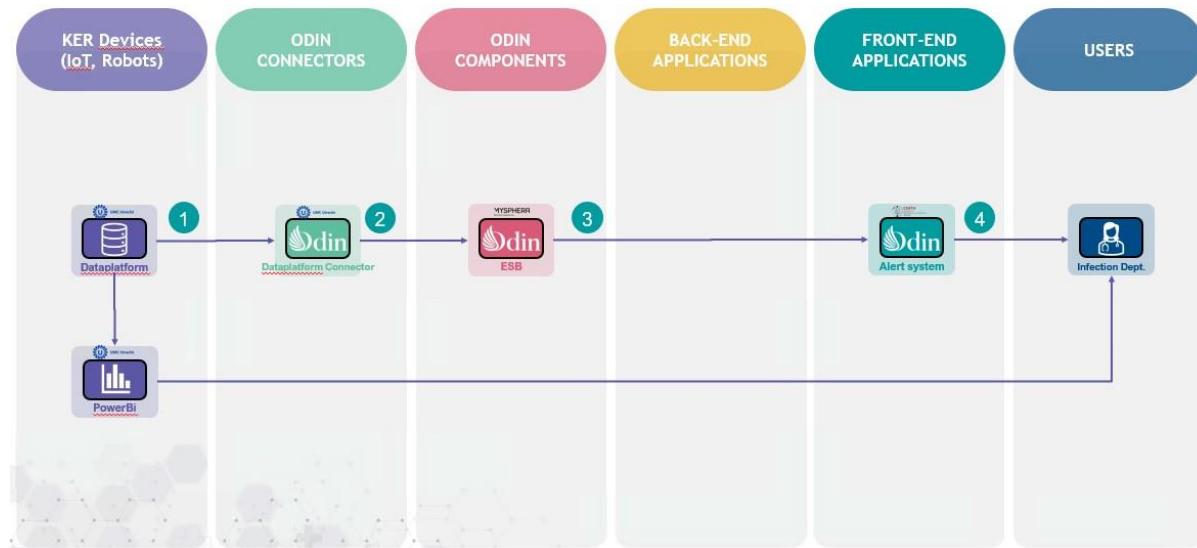


Figure 36. UMCU UML diagram of the data visualization process and alert system when the concentration of a certain pathogen is above threshold.

### A.6.5.4 Procurement / acquisition process

Nothing to be procured. The alert system is being developed within the ODIN consortium

### A.6.5.5 Primary Outcomes

Our goal is to create an overview that is able to support the infection prevention department in tracking pathogen carriers (locate and count) within the hospital, based on already available data in the EHR. The primary outcome is therefore the usability of these overviews.

### A.6.5.6 KPI (for each phase)

Phase	KPIs	Measure unit	Tool	Notes
Preparedness	Usability of the overview	-	Interviews/survey	
Mitigation	Percentage of correct alerts	%	ODIN's Alert UI	

### A.6.5.7 Involved stakeholders (overall and for each phase)

Datamanagers; the UPOD datamanagers will be involved during the entire process. They will provide us the necessary data.

The infection prevention specialist and the microbiology department will be consulted to identify their needs and to provide feedback on the overviews.

ODIN partners will be involved in the part in which we're going to explore the use of the alert system. → mitigation phase only

## A.6.6 ODIN Integration

### A.6.6.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment?

RUC A UC3: The experiment will use the following technology: IoT (eLocations). IoT will be used to find the location of medical devices used for diagnostic purposes within the hospital and check the availability of the device. Using demographic data, clinical data and data on availability of physicians and devices from the electronic health records in combination with the data from the IoT devices we will develop a model that is able to predict the most efficient (and personalized) diagnostic workflow. Our use case implementation can serve as a template for other hospital departments.

RUC A UC4: ODIN will contribute to the development of an integrated patient-inclusion/identification tool that selects and includes all patients that are eligible for the cardiovascular LHS. Leading to a more efficient and inclusive inclusion system compared to the current manual patient inclusion method. Additionally, ODIN will contribute to this use case in the development of the PowerBI dashboards providing the clinicians feedback on data quality of their patients included in the LHS.

RUC B: We will be making use of the HOSBOT, built within the ODIN consortium. We will, however, adapt the HOSBOT slightly, as we will be using UMCU's RTLS system. By doing so, we will be able to demonstrate the ability (or inability) to incorporate IoT systems into the HOSBOT that are already operating in a large hospital.

RUC C: We will be exploring the usability of ODIN alert UI in our experiment.

Furthermore, in most of our use case we will, at least partly, we will be using technology already existing in the UMCU or are under development in the UMCU. Together with our IT department we will explore whether these can be integrated/connected in the ODIN platform. These insights will be very valuable for the ODIN as it would demonstrate how compatible the ODIN platform is in terms of integrating/connecting technology not developed by the ODIN consortium itself. This would be of great interest if the ODIN platform is, at some point in time, to be used in other hospitals with similar IT infrastructures in place as the UMCU.

## A.7 SAS – Servicio Andaluz de Salud, Spain

### A.7.1 Pilot Description

The pilot will be carried out in two different hospitals that belong to the Health Andalucia Service (SAS). Virgen del Rocío University Hospital is the main hospital complex in Andalusia and one of the best in Spain. It is located in Seville and has the highest level of service classification. This hospital covers a basic reference population of more than 500,000 people and an extended population of more than a million and a half inhabitants. Virgen del Rocío University Hospital performs more than 40,000 surgeries per year. In this hospital, the use case involves the deployment of the "Get Ready" platform to accompany the patient during a perioperative process (in this case abdominal wall surgery). On the other hand, the use case to be piloted at Virgen de las Nieves University Hospital involves the deployment of the "Get Ready" platform for patient accompaniment during transcatheter aortic valve implantation, better known as TAVI. Virgen de las Nieves University Hospital, located in Granada, has a reference population of almost 500,000 users. It is a national benchmark in facial surgery and at regional level is a pioneer in the diagnosis and monitoring of seasonal flu, in the development of new assisted reproduction treatments and in treating arrhythmias with 3D imaging.

The increase in life expectancy, the prevalence of chronic diseases and the need to ensure the sustainability of the healthcare system, without losing quality and efficiency in care, create the need to generate new organizational and service delivery models.

The solution proposed for implementation, Get Ready®, focuses on patient empowerment through information and education that allows them to take a relevant role and continue working on their care, with guides and guidelines described by their clinical professionals, allowing the care team to monitor these patients throughout the process, in a flexible way and adapted to the needs of each of them, also adding the opportunity to offer greater out-of-hospital continuity of care thanks to remote monitoring.

The use of SaaS, the platform under which the Get Ready® solution is implemented, is a multiplatform cloud-based solution that includes, on the one hand, a web platform that allows healthcare professionals to monitor their patients throughout the process, thus enabling data-based decision making in the management of the patient's clinical condition and, on the other hand, a mobile app that allows the patient to follow the process, the care plan, record their symptoms and constants through questionnaires (PROMS/ PREMS) and access the educational program.

#### A.7.1.1 Pilot Experiments

Table 45 - SAS Experiments

Use Case	Name	Description	RUC X Phase (s)
RUC A – UC4	Clinical Tasks and Patient experience	Piloting a tool for digitizing care plans and monitoring patients throughout care processes (TAVI and perioperative pathways).	Monitoring

## A.7.2 RUC A2 UC4

### A.7.2.1 Description

- Study 1: Hospital Virgen del Rocío

In the proposed use case at HUVR, a comprehensive solution for the digitization of care plans and care processes will be implemented to improve the management of the clinical condition of peri-surgical patients and promote their active participation in their self-care from the diagnosis phase to their post-surgical recovery.

- Study 2: Hospital Virgen de las Nieves

In the proposed use case at HUVN, a comprehensive solution for the digitization of care plans and care processes will be implemented to improve the management of the TAVI patient's and promote the patient's active participation in self-care from the diagnostic phase through to post-procedure recovery.

#### Aim of the study:

Piloting a tool for digitizing care plans and monitoring patients throughout the perioperative and TAVI process to acquire a better preparation for the procedure that also impact in the experience of the complete process.

#### Hypotheses:

The proper implementation of clinical pathways and perioperative care plans using digital solutions that facilitate the standardization and optimization of processes both in the patient preparation phase and in the recovery phase, through remote monitoring and support of candidate patients.

#### Protocol:

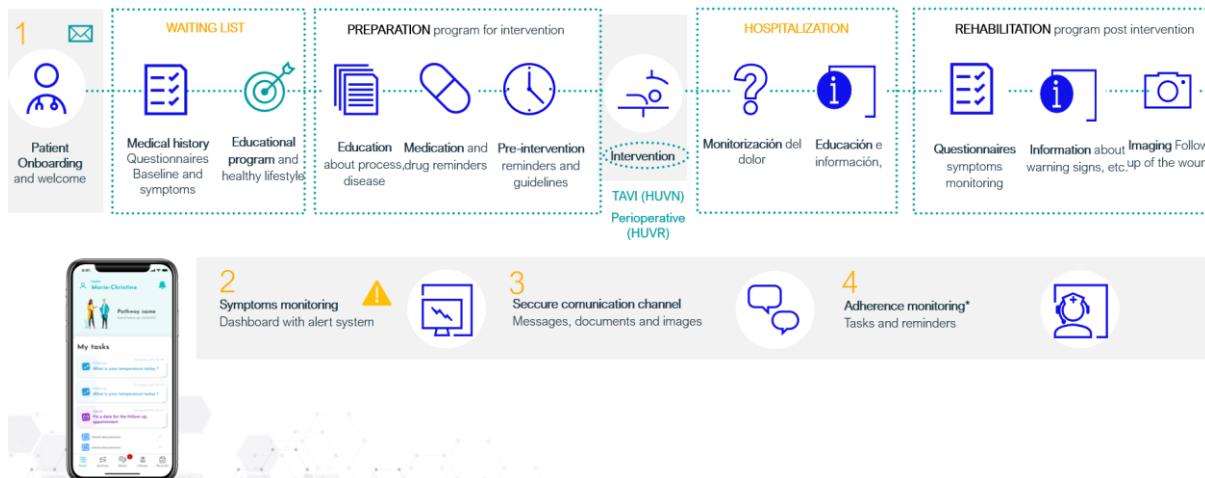


Figure 35 - SAS Protocol scheme

### A.7.2.2 Timeline (overall and for each phase)

#### Process Analysis (VSM):

- Dates: From November 2023 to January 2024
- Status: Completed

#### Content Validation:

- Dates: From January 2024 to March 2024
- Status: On Going

#### Digitalization:

- Dates: From March 2024 to April 2024
- Status: On Going

#### Implementation:

- Dates: April 2024
- Status: To be started

Process Analysis (VSM)	Content Validation	Digitalization	Implementation
✓ Current pathway definition (VSM)	✓ Standard program presentation	<input type="checkbox"/> Program digitalization in the SaaS	✓ Operative Flow definition
✓ Pathway optimization	✓ Standard program review	<input type="checkbox"/> Quality check process	<input type="checkbox"/> Training
✓ New pathway validation	✓ Program adaptation and final validation		<input type="checkbox"/> Program Testing <input type="checkbox"/> Go live with patients <input type="checkbox"/> Data collection and continuos improvement

Figure 36 - SAS phases mapping

#### A.7.2.3 Technology description

This solution is highly flexible and configurable, with the aim of being able to adapt the program to the patient's flow according to the needs of the General Surgery and Digestive System service of the Virgen del Rocío University Hospital and the Cardiology service of the Virgen de las Nieves University Hospital.

SaaS, the platform under which the Get Ready solution is launched, is a cloud-based, multi-platform solution, highly configurable and with multiple customization capabilities. The software includes:

- **Web platform** that allows healthcare professionals to monitor their patients and carry out stability control and monitoring of the patient's clinical evolution through a system for generating alerts based on rules according to the agreed protocol, thus allowing decision making. in managing the clinical condition of the patient patient based on data. Regulated and secure two-way/one-way communication channel with the patient that allows the exchange of messages as well as images and documents.
- **Mobile app** or web platform that allows the patient to follow the program and care plan in which they have been discharged, complete each of the items scheduled over time according to the agreed protocol, record their symptoms and constants through questionnaires (PROMS/ PREMS), and access the educational program.

#### A.7.2.4 Procurement / Acquisition process

The pilot will only require the purchase of licences for the Maela platform, which includes licences for use by both patients and healthcare professionals. In this case, it has been provided by Medtronic.

#### A.7.2.5 Primary Outcomes

Monitoring:

- Piloting a tool for digitizing care plans and monitoring patients throughout the perioperative and TAVI process to acquire a better preparation for the procedure that also impact in the experience of the complete process.
- Reduce in-person consultations: optimizing the protocol through remote support for patients included in the study allows for improved communication between professionals and patients, avoiding unnecessary in-person consultations.
- Improve patient and professional satisfaction: optimization of the protocol and available resources favours improvement in the experience of patients and professionals during the care process
- Increase the patient's active role and adherence to their treatment: better patient education regarding the pathology and its treatment thanks to specific educational programs allows the patient to face their treatment and care with a greater level of empowerment.

#### A.7.2.6 KPIs

Table 46 - SAS RUC A2 UC4

Phase	KPIs	Measure unit	Tool	Notes
Monitoring	Mlevel of information related to the intervention, from question n.9 in the “App patient Experience” questionnaire [score]	Experience questionnaire [score]	Get ready	
Monitoring	patient empowerment and accompaniment from question n.10 in the in the “App patient Experience” questionnaire [score]	Experience questionnaire [score]	Get ready	
Monitoring	patients’ and their family members’ satisfaction through NPS question n.16 in the in the “App patient Experience” questionnaire [score]	NPS score	Get ready	
Monitoring	Number of face-to-face consultations with patients [#]	Number of consultations	Get ready	

#### A.7.2.7 Involved Stakeholders

Monitoring phase:

1. Hospital Universitario Virgen del Rocío: general surgeons and the nursery team
2. Hospital Universitario Virgen de las Nieves: Hemodynamists and the nursery team

### A.7.3 ODIN Integration

#### A.7.3.1 How you envisage the use of ODIN key enabling resources (KERs), e.g., robots, AI, IoT in this experiment?

The connectivity between Get Ready Solution (empowered by Maela) and the ODIN platform will be carried out with a link. It will launch the Maela landing page from the ODIN platform.

Some meetings have been carried out to validate the defined scope, and we are monitoring different phases to achieve the final goal.

1. Authentication system validation
2. End point requisites to set the connectivity.
3. Testing in demo environment
4. Launch in real environment.

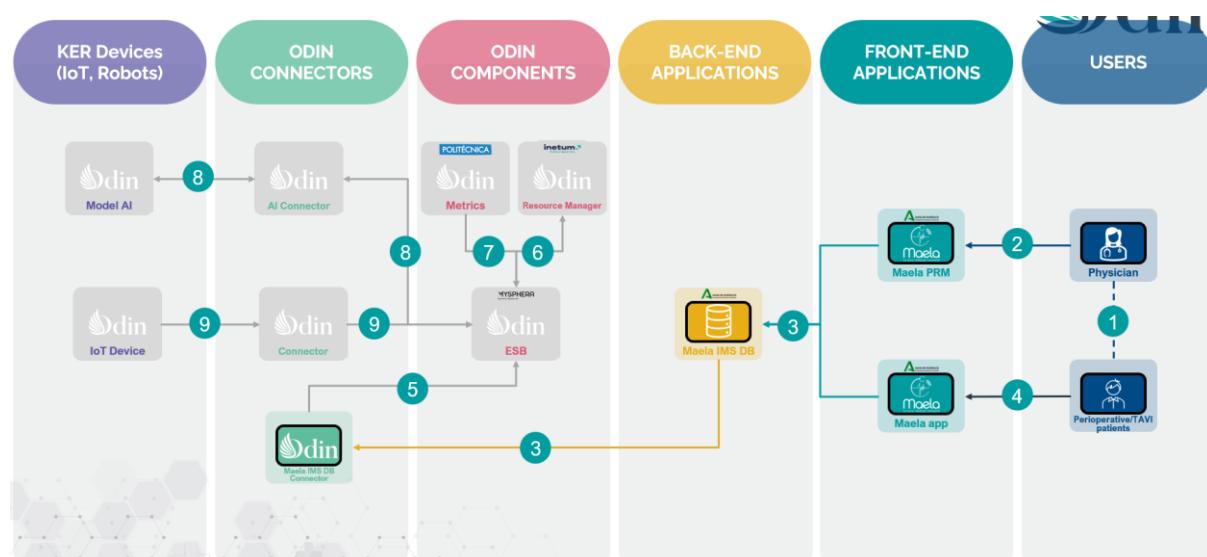


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