DELIVERABLE

Project title: **LetItFlow: Active Distributed Workflow System for elderly**

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D.2.2 – Change management process and scenario based design and technology survey

Revision: 1.0

Main Authors:

Bica Simona Mihaela (SIVECO)
Victor Carmocanu (SIVECO)
Julien Paduraru (SIVECO)
Pedro A. Ruiz (INTEGRASYS)
Florina Antochi (UHB)
Athena Mergeani (UHB)
Patricia Fernandez Riejos (HUVM)
Enrique Melguizo Madrid (HUVM)
Valentin Gattol (AIT)
Ben Loke (NOLDUS)

Revised by:

Valentin Gattol (AIT)
Ben Loke (NOLDUS)
Otilia Bularca (SIVECO)

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11.0	14.07.2015	Simona Bica, Otilia Bularca	SIVECO	Final version of the deliverable.

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ABBREVIATIONS

UHB – University Emergency Hospital Bucharest
HUVM – University Hospital Virgen Macarena Seville
UCD – User Centred Design
BPM – Business Process Management
HMI – Human Machine Interface
ICT - Information and communications technology
R&D – Research and Development
UC – Use Case
HW – Hardware
SW - Software
ICU - Intensive Care Unit
FOCG – Fisa de Observatie Clinica Generala (ROmanian)
LETAPP – (LET) *Let*ItFlow + (APP) *App*lication
LETSIM – (LET) *Let*ItFlow + (SIM) *Sim*ulation
LETRAIN - (LET) *Let*ItFlow + (TRAIN) *Train*ing
LETCRITICAL – (LET) *Let*ItFlow + *Critical*
ADVIA – Laboratory analyzer (Clinical Chemistry System)
IgA – Immunoglobulins (IgA antibodies)
IgG - Immunoglobulins (IgG antibodies)
IgM - Immunoglobulins (IgM antibodies)
Pros, Cons – The pros and cons of matter

1. EXECUTIVE SUMMARY

The deliverable **D.2.2 - Change management process and scenario based design and technology survey** represents a natural continuation of the first stage of LetItFlow project – the collection and analysis of real demands and user requirements. The collection and analysis of user needs was the first stage of the implementation of the LetItFlow project and is detailed in the deliverable **D.2.1 – User needs and requirements**.

The stage of collection and analysis of user requirements (depicted in D.2.1) was designed to identify the needs of the key users involved in the project, based on the analysis of working procedures, work processes and workflows and on the collection of relevant data regarding the user requirements.

The current deliverable covers all the aspects and findings related to *Task 2.2 Define scenarios and use cases* and *Task 2.3 Technology survey*, as presented in the Description of Work of the LetItFlow project. *Task 2.2* is focused on the analysis and modeling of relevant data collected in real contexts of use (normal situations, critical situations/emergencies and change management situations) and includes the following activities:

- Evaluation of criteria triggering change management situations with high impact over the orderly activities
- Evaluation of criteria with low impact over the elderly activities
- Evaluation of information sources reliability related to change management healthcare critical areas, with special attention to cooperation in the distributed environment and interactions between different actors and age categories, in order to ensure support and knowledge transfer.

Task 2.3 focuses on technology survey. Based on the real needs and user requirements and in conjunction with the scenarios definition, this task explores different existing state of the art solutions and tools that could be applied in the LetItFlow project.

Considering the above mentioned aspects for Task 2.2, the current deliverable explores in section **4. Defining the scenarios and use cases description** the most relevant scenarios based on the analysis of *workflows of the processes* and *tasks management*, specific for the daily activity of the Neurology Department (UHB) and of the Automated Laboratory of Biochemistry – SAR (HUVM). The selected Scenarios were then formalized into specific Use-Cases using an Agile methodology and UCD (user centered design) concepts and principles.

Considering the above mentioned aspects for Task 2.3, the section **5.Technology survey** of the current deliverable presents a compilation of state of the art technologies in different research areas related to the LetItFlow project (hospital and laboratory workflows solutions/platforms, task management solutions, simulations, communication and interoperability, BPM, HMI, methods and tools, sensors and devices, software development).

The following chapters of this document will explore the relevant aspects concerning:

- The general approach used in defining scenarios and use-cases (methods, techniques, concepts, principles)
- The definition of relevant scenarios (analysis, selection, design, structure)
- The description of use-cases
- The similarities and particularities in the approaches for UHB and HUVM

- The technology survey
- The conclusions of the change management process and scenario based design and technology survey stage – Summary and outlook.

2. INTRODUCTION

2.1. Scope and objectives of the deliverable

The deliverable is the second report of the **WP2. Requirements analysis and system design** of the LetItFlow project, resulted from the accomplishment of *Task 2.2 Define scenarios and use cases* and *Task 2.3 Technology survey*.

One purpose of this deliverable, corresponding to Task 2.2, is to define the relevant scenarios and use cases for the Neurology Department of UHB and for the Automated Laboratory of Biochemistry General (SAR) of HUVM, based on the results obtained within Task 2.1 Collection and analysis of user needs. In this context, we present an innovative approach that will be used in the LetItFlow implementation – applying a mix of methods and techniques from Agile and UCD methodologies in software development.

Other purpose of this deliverable, corresponding to Task 2.3, is to explore different state of the art solutions related to the research area of the project that are likely to be applied in the design of the technical solution of LetItFlow, in order to base the correct conceptualization of future architecture in the next stage of the project – T2.4 System Architecture design.

2.2 Structure of the deliverable

The report is structured in six chapters.

Chapter 1. Executive summary – Presents a short description of relevant characteristics of the current stage of the project

Chapter 2. Introduction – Presents a summary regarding the purpose and objectives of the deliverable and its structure.

Chapter 3. General approach – Presents the significant aspects regarding the methodology applied in defining scenarios and use-cases (methods, techniques, concepts, principles).

Chapter 4. Defining the scenarios and use cases description – Presents in detail the relevant scenarios based on the analysis of *processes workflows* and *tasks management*, specific for daily activity of the Neurology Department (UHB) and of the Automated Laboratory of Biochemistry – SAR (HUVM), the selected workflows and tasks being resulted from the first stage of the project – collection and analysis of user needs.

In this chapter are also detailed the specific use-cases based on the selected scenarios. Moreover this chapter provide a comparison between UHB and HUVM considering similarities and particularities of the approach–and presents the common functionalities of the technical solution (commonalities) for the two hospitals and the specific functionalities of the technical solution (particularities) for the two hospitals.

Chapter 5. Technology survey – Presents a compilation of state of the art technologies (solutions, methods, tools, and infrastructure) in the different research areas related to the LetItFlow project.

Chapter 6. Summary and outlook - Presents the conclusions of the change management process and scenario based design and technology survey stage.

Annexes – Includes examples of specific working procedures and protocols, relevant for this stage of the project (in a scanned original format).

Bibliography – Includes the list of bibliographical references that have been used during this research stage.

3. GENERAL APPROACH

This deliverable complies with the objectives of the LetItFlow project – *change management* (training and support in unpredictable situations, appliance of new techniques or if new equipment or software applications is being used) and *use of efficient ICT solutions* (alert/alarm, notification, warning, localization) in assisting and guiding elderly medical personnel in the workplace.

To define the relevant scenarios and use-cases we have used the following techniques:

- The workflow processes analysis
- A standardized methodology – Agile
- The User-Centred Design (UCD) method and principles.

By using the above-mentioned approach the deliverable identifies the most relevant scenarios based on *the analysis of process workflows*, i.e. daily activities of Neurology Department (UHB) and Automated Laboratory of Biochemistry – SAR (HUVM). The selected Scenarios are then formalized into specific Use-Cases, through Agile methodology and UCD (user centered design) concepts and principles.

Applying the mix of methods and principles from Agile and UCD in software development – an innovative approach

Agile methodology for software development and the User-Centered Design (UCD) are iterative approaches to software development which increase the chances to implement successful ICT projects.

Agile methodology for software development presumes a number of iterative and incremental software development steps that involve people (actors), situations, communication and the ability to adapt to change.

UCD represents a design process based on specific methods and principles, focusing on user research, user interface design and usability evaluation.

Integrating Agile development and UCD approach represents a comprehensive and explicit systems implementation methodology.

This approach of exploring the benefits of integrating workflow analysis, Agile methodology and UCD was chosen in accordance with the features and the objectives of the LetItFlow project.

The *Agile software development methodology* is appropriate for the ICT projects specific to the R&D field, because in the R&D field, for clarifying the complexes situations to confront with, and solve different requirements might be necessary to use an iterative process/algorithm.

Moreover, pursuing Agile principles “allow effective handling of day to day problems that occur in an academic research setting and enable small research teams to engage in multiple projects with increased levels of synergy”. (16, Agile for Research Teams).

The Agile methodology could be applied in research projects at three conceptual levels: Practice (Implementation), Management and Infrastructure.

Agile Practices might explore Daily SCRUM, Weekly Planning Meetings and Daily Task Management; Agile Management might explore Agile Scheduling and Risk Management; Agile Infrastructure might be related to the Project Sharing, Templates and Knowledge Sharing16Thus, using *UCD methods and principles* is appropriate in approaching specific objectives of the LetItFlow project and the target group – nurses, orderlies and laboratory technicians, aged 50 and above from UHB and HUVM.

Being a user-driven (as opposed to a technology-driven) approach, the UCD approach presumes the involvement of users from the start and in all stages of product / service development in an iterative manner. As such it is capable of accounting for the individual needs of our target group and adapting the solutions continuously based on user feedback. Considering the specific of our target group, we'll create and will adapt continuously the design of the user interface, from the perspective of older adults acting under stress, almost all the time at their working place.

Applying the UCD approach (based on the results of an iterative process and on the feed-back of users) in the implementation of the LetItFlow project, we intend to obtain an increased efficiency of the staff, an increased usability, user satisfaction and comfort.

Usually, software development projects include four types of work activities in the execution/implementation phase that are needed to deliver a functional and operational ICT system:

- Research / Analysis (requirements engineering)
- Design (software engineering or technical design)
- Programming / Development
- Testing.

After requirements (technical specifications) and design, the software will be programmed and finally tested.

During the implementation of LetItFlow solution, the Agile methodology will be applied as an iterative and incremental model, being an alternative to the sequential project life-cycle model (i.e. the Waterfall model).

"In this model the overall life-cycle of the project is composed of several iterations, each iteration being a self-contained mini project where all the work activities (requirements, design, development and testing) are performed concurrently. The goal of iteration is to release an integrated, tested and partially complete but working system, which is then validated and improved in the next iteration."(8, Pirkka Rannikko).

Using this approach, the system "is built incrementally by adding new features and functionality over several iterations rather than having all of them in place after the first iteration."(9, Larman C.)

Analyzing the workflows of processes specific for the activity of UHB and HUVM, we have acquired the specific daily tasks for the elderly nurses, orderlies and laboratory technicians. These tasks represent the foundation of the Task Management application, component of LETAPP, LETSIM and LETTRAIN.

Using the concepts, principles, practices and methods of Agile methodology during the analysis/research stage, the user stories (story description) were defined and then formalized into scenarios.

This deliverable presents the way to apply practices and methods of Agile within the research/analysis stage of the LetItFlow project, where defining the relevant scenarios (user stories) and use-cases.

The user stories represent a requirements engineering tool in Agile projects. They are short written descriptions of features and findings used to reveal needs and requirements and details referring each feature, presented in a structured form.

User stories can be documented on paper, in a standardized format, or in an appropriate software tool.

The result of applying these approaches is presented in the section **4. Defining the scenarios and use cases description** of the current document.

4. DEFINING THE SCENARIOS AND USE CASES DESCRIPTION

4.1 Scenarios

4.1.1. Scenarios applying to the University Emergency Hospital Bucharest (UHB)

This section aims at presenting the selection of ***real situations/cases*** applying to the Neurology Department within the University Emergency Hospital Bucharest which ensured in the basis for defining Scenarios and Use-Cases.

The identified Scenarios are furthermore formalized into Use-Cases as presented in the section ***4.2. Use Cases Description***.

Based on the collection of relevant data and the requirements analysis inside of the University Emergency Hospital Bucharest, the following scenarios emerged.

The workflow analysis has explored the following relevant aspects:

- *The situation*
- *The context (including relevant data regarding the ambience/work space, human actors and the assumptions)*
- *Story description (relevant steps of the workflow)*
- *Which applications – functionalities – tasks – items should be implemented in LetItFlow (including user benefits and innovation)*.

The features specific to the above-mentioned aspects are represented in the structure of the proposed scenarios. We have chosen for the selected scenarios an appropriate template for representing the best the above mentioned features and findings, a template intelligible and comfortable both for the writers and the readers.

The proposed template for Scenarios is the following:

Scenario Title	
Submitted by	
Domain	
Picture [optional]	
Scene description	<Situation>, <Story description>
User benefits	
Assumptions [from	

Context]	
Ambience categories addressed [from Context]	
Human actors [from Context]	
Key HW elements	
Key SW elements	
Innovation	
Interactions [relations with other Scenarios]	

Table 1. Template for SCENARIOS

	Scenario 1
Scenario Title	**Staff training (Change Management)**
Domain	**Hospital – Neurology Department**
Scene description	**Putting into practice new procedures, new work techniques, new operating modes and new maneuvers** The nurses and orderlies from the Neurology Department get together in the lecture room where the new work procedures, protocols, techniques and operating modes are presented. Aside from presentation/course, the staff will receive written instructions. After the course/training is over, an evaluation test regarding the procedures/techniques described during the course is taken by the personnel. Thus, the degree of assimilating new info is checked. After assessing theoretical knowledge, the nurses take the next step in the laboratory or a dedicated room/location in order to practice the newly introduces procedures, work techniques, operating modes and maneuvers. Certain situations when nurses or orderly might need support are most likely to appear. For instance, a nurse forgets one particular step to be followed when applying a procedure. She is encouraged to ask for help to a colleague that has been trained for the same procedure or technique. Another way of reaching the missing element is to use the specific features offered by LETTRAIN.
User benefits	Knowing exactly what it must to do in each situation, the nurse and orderly will act efficiently according the procedure or protocol in their daily activity

Assumptions	– Training becomes more efficient Management of the training sessions is done more easily. – Learning process is less stressful (user-friendly) and simplified.
Human actors	Medical staff
Key HW elements	Tablets, mobile devices
Key SW elements	– Applications that enhance the learning process. – Applications that provide support for scheduling, maintaining and providing detailed electronic course support.
Innovation	– Electronic training applications (LETTRAIN) – Increase training efficiency – Simplification of the learning process.
Interactions	Scenario 2, Scenario 4

Table 2. Scenario 1. Staff training (Change Management)

Scenario 2

Scenario Title	**Alert/alarm in case of emergency/critical situation**
Domain	**Hospital – Neurology Department**
Scene description	**Major emergency:** e.g. seizures, stroke, transient ischemic attack, cardiac arrest. **Medium/minor emergency:** e.g. acute hypertensive episodes (hypertension / hypertensive spike), vertiginous syndrome, palpitations. The patient is found fallen on the floor, in his room or in the waiting room, in front of one of the laboratories/offices, in the hospital ward. The nurse responsible for that room or the nurse from the laboratory/office calls/alerts *a colleague (nurse) or directly a neurologist*, either by direct contact (face to face) by going to the Nurses Office, by using her personal mobile phone, or, if the patient was found in his room, by using the alarm system/device, located at any bed in the patients' room. If it is necessary, the nurse calls *another colleague (orderly)* to move up the patient and place him in bed, in a safe position. To inform a colleague about the emergency, the nurse uses her mobile phone, or the nurse is looking for an available colleague in the department (the nurses might be in other rooms for the daily activities, or they are in other departments with the patients that need to be guided/guarded). In most of the cases, the mobile phone is being used, due to a vital emergency where the response time needs to be

	short in order to avoid complications. The nurse and her colleague perform the first aid to the patient and furthermore they call/alert the neurologist on duty, by phone or directly (face to face), but the response time might be quite long due to the fact that the physician might not be in the department – in this case the neurologist on duty is contacted on his mobile phone. Once the neurologist on duty has arrived and the patient is stabilized, the nurse responsible for the room actively participates in supportive maneuvers requested by the physician (e.g. sampling tests, orotracheal suctioning, announcing a stretcher bearer to transport the patient for a specific examination determinated by the specific emergency***).*** The nurse or the orderly that shall need support in the emergency / critical situation will use the specific features offered by LETALARM by accessing mobile devices.
User benefits	– Managing the emergencies and critical situations in an optimal way. – Support for unexpected situations. – Optimizing the time of response in case of emergencies/critical situations.
Assumptions	The unexpected situations or emergencies can be controlled more strictly.
Human actors	Nurse, Orderly, neurologist, emergency doctor ICU (Intensive Care Unit), stretcher bearer
Key HW elements	Tablet/smart watch, smart bracelet and sensors to alert/alarm/notify and localize designated medical staff.
Key SW elements	– Application to localize medical staff. – Application to alert/alarm/notify medical staff.
Innovation	– Increase events awareness. – Lower time costs. – Increase medical staff efficiency. – Minimize panic and stress situations.
Interactions	Scenario 3, Scenario 4, Scenario 1

Table 3. Scenario 2. Alert/alarm in case of emergency/critical situation

Scenario 3

Scenario Title	**Monitoring the health status of nurses and orderlies**
Domain	**Hospital – Neurology Department**
Scene description	**Emergencies created/produced by health problems (health status) of nurses/orderlies during their daily activity**

The scenario is similar in both nurse and orderly/sister cases. Also, in this case, there might appear medium/minor and major emergencies.

For example, the nurse/orderly may present a slight hypoglycemia or a hypoglycemic coma, which is a major emergency, i.e. life-threatening.

Similarly, we will refer to a minor emergency in the case of symptomatic hypertensive episodes/hypertensive spikes (*headache/ cephalalgia and slightly vertigo*) and to a major emergency, life-threatening, like *stroke* and *myocardial infarction*.

The orderly/the nurse which is in close vicinity of the nurse/orderly which presents the previously specified symptoms performs the first aid placing her coworker in a safe position and further she calls a nurse (*any available nurse that is closest to the place where the incident took place*), either by direct contact (face to face) by going to the Nurses Office or using her personal mobile phone, or, if the orderly/nurse was in one of the patients' rooms performing her daily tasks, by using the alarm system/device, situated at any bed in the patients' room.

A nurse (*any available nurse that is closest to the place where the incident took place*), accompanied by a neurologist, being in his work shift, which is close to the place where the orderly/nurse in difficulty is located, provides first aid by *measuring vital constants* (heart rate, blood pressure, oxygen saturation and blood glucose measurement).

Based on the initial evaluation/examination one of the next steps will be taken: to continue the examination in the Guard Room (Emergency Room Arrival), requiring the transport of the nurse/orderly in that location, or to continue her caring in the Neurology Department. Also, in the case of a non-neurologic emergency, the physician with the necessary specialty will be called.

While the nurse/orderly receives specialized medical care, another colleague will take over her work responsibilities.

The nurse or the orderly that shall need support in the emergency / critical situation generated by health problems will use the specific features offered by LETALARM and LETCRITICAL by using mobile devices.

	LETAPP will provide also the LOCALIZATION of nurses and orderlies, belonging to the target group. The person (nurse/orderly) who takes over the responsibilities of the nurse/orderly in difficulty will access LETAPP in order to be informed about the performed activities of her colleague until the moment of the emergency. LETAPP includes the check-lists of the planned activities for the patients for any category of personnel (Treatment Plan for the nurses and Daily Program/Schedule for the orderlies).
User benefits	– Lower stress level at work – Managing the emergencies and critical situations in an optimal way – Control of panic situations – Increase confidence – Increase work efficiency – Optimizing the time of response in case of emergencies/critical situations.
Assumptions	– Increase work efficiency and personal confidence – Increase teamwork and self-awareness – Control of personal treatment plan and daily program under stress.
Human actors	Nurse , orderly, neurologist, physician with the necessary specialty, stretcher bearer
Key HW elements	Tablet, smart watch, smart bracelet
Key SW elements	– Application for locating nurse/orderly (for optimum time response) – Application for monitoring the health status – Application for alert/alarm.
Innovation	– Decrease occurrence of critical situations – Increase medical staff confidence.
Interactions	Scenario 2

Table 4. Scenario 3. Monitoring the health for of nurses and orderlies with health issues

	Scenario 4
Scenario Title	**Monitoring nurses and orderlies/sisters daily activity**
Domain	**Hospital – Neurology Department**
Scene description	**Daily activity for nurse in hospital ward** Nurses begin their daily activity at 7.00 a.m. takes over the activity (patients and their problems) from the nurse from the previous shift.

This process consists of taking notes about the last events (from the former shift) both verbal and written. This procedure might take 10 to 15 minutes.

Once this activity is done around 7:10 – 7:15 a.m. the Medical Guard Report is being prepared together with the manager nurse. Drawing up the Medical Guard Report might last 10 to 15 minutes.

After the Medical Guard Report is finished the nurse starts her daily activity in the hospital ward; she takes notes from the Patient's Chart / General Clinical History, FOCG – Fisa de Observatie Clinica Generala, in Romanian) about the daily treatment of the patient and about sampling the blood tests for each patient. Each nurse is responsible for a given number of rooms in the department.

After collecting all the needed data, the nurse starts preparing tickets for sampling the blood tests for each patient.

Once the nurses responsible for every room have finished the tickets for sampling the blood tests for each patient, the daily tasks are distributed for every nurse as following: measuring and registering patient's temperature, sampling the biological tests which were prescribed by the neurologist on the medical visit on the previous day and preparing the solutions that are to be administrated to the patients.

Nurses *administrate the oral medication*, some drugs having fixed hours for administration (e.g. In Parkinson's disease, L-Dopa must be administrated sometimes every 3 hours).

Nurses *feed the patients with nasogastric tube*.

Nurses *prepare the patients for special investigations/examinations* (which require a peripheral venous catheter or administration of a specific treatment (injecting with a specific treatment)).

Nurses *go into patient's room to mount the I.V. infusion and administer injection treatment at a scheduled hour*, *as well as for performing personal hygiene to the patients that have orotracheal intubation probe, nasogastric probe or urinary probe* (in this case difficulties might appear due to the fact that it might require supplementary materials for changing the probe and the nurse might announce/notify another colleague) or *for treating/dressing the patient's bedsores*.

Once the medical problems of the current day are solved *the electronic retour of medication to the pharmacy* takes place (in case of a new diagnostic, death and need to supplement medication etc.) Then the drugs *are transported (physically delivered) to the hospital' pharmacy located on the first floor* (this task usually involves long waiting periods of time for the elevator and also at the pharmacy because the pharmacy serves all the hospital's departments which also have to deliver and or pick up medication. A lot of time is wasted during this task and all this time the nurse is missing from the department. Nurses *administer intravenous injections, intramuscular injections, subcutaneous injections, perfusions and*

	also sample biological tests whenever needed. Nurses *transport/deliver the biological samples at the hospital's laboratory located on the second floor* as many times as needed. This task is time consuming and assumes being away from the department. Nurses *pick up the medication previously prescribed in electronic format from the hospital's pharmacy located on the first floor, as many times as it is needed* (task with long waiting times at the elevator and at the pharmacy; the pharmacy serves all the hospital' departments and it is possible to wait for a long time, until the other departments deliver and pick up their medication). This task is time consuming and assumes being away from the department Nurses *monitor/follow continuously on their monitors the vital functions/signs of the patients hospitalized in the Emergency Neurovascular and Acute Neurological Care Unit*. Nurses *washes the patients with orotracheal intubation probe whenever needed*. Nurses *mount nasogastric probes and urinary catheters to the patients whenever needed*. Nurses *decontaminate and prepare the instruments for sterilization*. Nurses *measure and note the blood pressure of each patient at the physician's indication*. After 12 hours of activity, the shift changes and all the above activities continue running. The person (nurse/orderly) who takes over the responsibilities of the nurse/orderly during the shift change will access LETAPP in order to be informed about the performed activities of her colleague until the moment of the shift change by using mobile devices. Using LETAPP the specific tasks and issues could be remitted between the nurses/orderlies from the two shifts. LETAPP includes the check-lists of the planned activities for the patients for any category of personnel (Treatment Plan for the nurses and Daily Program/Schedule for the orderlies).
User benefits	– Simplify daily schedule – Increase general awareness – Increase confidence Increase work efficiency.
Assumptions	– Daily tasks (workflows) become easy to follow and complete – Optimal design and implementation of tasks management – Control of personal treatment plan and daily program.
Human actors	Nurses, orderlies
Key HW elements	Tablet or smart watch

Key SW elements	– Applications for task management (workflow processes) – Applications to schedule, maintain and provide detailed check lists for medical staff.
Innovation	– Lower time costs Increase medical staff efficiency.
Interactions	Scenario 1, Scenario 2

Table 5. Scenario 4. Monitoring nurses and orderlies/sisters daily activity

4.1.2. Scenarios applying to the University Hospital Virgen Macarena (HUVM)

Based on the collection of relevant data and the requirements analysis inside of the University Hospital Virgen Macarena (Automated Laboratory of Biochemistry General (SAR)), the following scenarios resulted.

We have chosen the same template for Scenarios like the one used for UHB (see ***4.1.1. Scenarios applying to the Emergency University Hospital Bucharest (UHB)***).

Scenario Title	
Submitted by	
Domain	
Picture [optional]	
Scene description	<Situation>, <Story description>
User benefits	
Assumptions [from Context]	
Ambience categories addressed [from Context]	
Human actors [from Context]	
Key HW elements	
Key SW elements	

Innovation	
Interactions [relations with other Scenarios]	

Table 6. Template for SCENARIOS

	Scenario 5
Scenario Title	**Starting the day - quality controls check**
Domain	**Laboratory**
Scene description	Mary arrives at the hospital at 7:55. From the locker room, she gets her uniform, takes the electronic identity card and is about to begin an intense day of work. She registers in the LetItFlow application with her credentials. Hereafter, this specific application is named LETAPP. The LETAPP reminds her that she must first check the levels of different reagents that she is going to need for that day. She starts auto analyzers, checks the levels of different ancillary reagents and liquids of the system. Also, she begins to review the different reagents needed for that day. At the end of the previous day, their colleagues left one of these reagents with low level so she is forced to fill them up. This issue may delay her workday, but today Mary is in good mood. LETAPP reminds her to take out the controls from the refrigerator. The reminder is showed in the screen and a sound and vibration signal are emitted to get the attention of the operator. She goes to the cold room to take the reagent needed for that day. While the reagent is reaching the right temperature (in 10 minutes) she reviews the other reagents: the rest of them are stable. She also takes out of the refrigerator the controls needed to monitor the analytical techniques in that day. She checks in LETAPP that she has stabilized the reagents and that she has taken out the controls (a *check box* like interface is shown in the application). Then, she introduces the reagent in the auto analyzer and proceeds to apply all the necessary controls for the analytical techniques of the day. Applies the controls on the monitor, enters them manually into the sample carousel of auto analyzer and boots the instrument which starts analyzing the job. She marks on the LETAPP that controls are requested and it reminds her that the labeling of urine samples is the next task, so, while the controls are in the auto analyzer, she has to label the urine

samples before performing tests on them.

Meanwhile the auto analyzer has finished its job and the results need to be compared with the ones of the previous day. Similar values are expected, but today, the creatinine levels are outside the normal range. In the last weeks this has happened often, so she suspects that the analyzer is failing to provide accurate results. Today also the cholesterol has slightly moved outside the normal range. Consequently, the nurse decides to repeat the cholesterol check and to directly calibrate the creatinine instead of checking it again. Before taking this decision, the nurse informs the manager about the situation and argues that from her experience repeating the checks over again would be in vain as the values are very different compared to the reference and that the best decision to take would be calibrating the creatinine and retake the test for the cholesterol. She marks down in the LETAPP that she has checked the controls and adds an alarm that informs about the checks that have failed. The system gives her the option of regain control or calibrate. So, she indicates in the LETAPP that she is going to repeat cholesterol control and calibrate the creatinine.

She calibrates the creatinine and she also decides to take some new controls to recheck the technique in order to accumulate no more delays in that day.

She introduces the calibrators in the analyzer and schedules the new calibration and control of the analytical technique that has failed. Meanwhile, she introduces the urine samples in the analyzer.

When she ends this task, she checks with joy that the scheduled cholesterol control is now within the expected values.

So, she re-checks in the LETAPP that the cholesterol control is now successful.

After 5 minutes she checks that the creatinine calibration has been successful. The analyzer is ready to work.

She marks in the LETAPP that the creatinine has been calibrated, and the results are now relevant. She marks in the LETAPP that all the regulatory controls are now compliant.

Once she checks this, she marks in the LETAPP that the auto analyzer is ready to analyze the samples of the day.

User benefits

- Control work order.
- Control of laboratory incidents.
- Control of quality controls and analytical calibrations.

Assumptions

Schedule can be controlled more strictly.

The quality controls of analytical techniques can be adequately managed, achieving a better control of the laboratory as well as the determination of deviations thereof and/or systematic errors or not systematic errors.

	Control about the incidents and/or breakdowns more frequent in the laboratory.
Human actors	Laboratory technician
Key HW elements	Tablet or smart watch for the control of the schedule and the order of work in the clinical laboratory.
Key SW elements	Applications to control the daily tasks of the technician. Applications for monitoring the quality controls of the analytical laboratory with alarms in case of deviation.
Innovation	Strict control of the laboratory technician tasks in the right order. Control of the laboratory processes. Monitor the quality controls which are the most sensitive analytical techniques, the techniques that raise more problems and the techniques that need to be calibrated and are controlled more often.
Interactions	Scenario 2

Table 7. Scenario 5. Starting the day - quality controls check

	Scenario 6
Scenario Title	**Sample processing and reviewing of results**
Domain	**Laboratory**
Scene description	Once the chain of robotic laboratory has started, the tubes begin to enter for their analysis on different analyzers depending on the test that they have requested and the worklist. Mary takes a coffee break at 11:30. When the analyzer finishes the job for all the tubes to the system notes down the data results into the computer system middleware to be reviewed by Mary. The LETAPP warns about the estimated time for the first review of the results. Mary reviews the results in the computer system and she notices that Calcium has altered/ far from normal values. Therefore, Mary suspects that the reagents are in bad condition despite that early in the morning the controls came out correctly. She records the problem in the LETAPP in order to be send as an incident to the other partners throughout the day. Mary informs the manager and they both agree to replace the reagent. Mary is forced to stop the analyzer and thus to delay some steps of the automated chain of actions. Once the analyzer has stopped Mary extracts the Calcium reagent

and replaces it.

Following the procedure, first, she must perform calibration of the analyzer for calcium and then, she places calibrators and new controls in the analyzer. If the calibration is correct, the analyzer will connect to the chain to continue processing patient samples. If it is not correct, it would be possible to continue working with this analyzer but without this technique and outside the chain in which two other analyzers are included. This decision depends on the workload of the day.

The nurse goes to the refrigerator and takes a new reagent. When this reagent gets the correct temperature, she introduces it in the analyzer.

She registers in the LETAPP that she has introduced a new Calcium reagent in analyzer A. Consequently, this action will be reflected in the stock of laboratory reagents.

She applies for the calibration and control of Calcium to verify that this reagent is in perfect condition and after 10 minutes the result shows that everything is in order so the analyzer is reconnected to the chain and everything returns to normal.

She marks in the LETAPP that the new reagent has returned optimal results to the first control and the analyzer has been reconnected.

While the chain is processing chain tubes, Mary is still reviewing the results of different samples that are being processed.

Then, a result of glucose and other of calcium with high pathological levels are detected with several patients. Therefore she decides to repeat samples in order to check them. Then she verifies that the glucose result is not wrong but the calcium result is due to a mistake of the analyzer.

She registers in the LETAPP that she has repeated the sample 15897 and 16587 so the supervisor will be able to check easily that these samples have been repeated and one of the results is true while the other was due to a mistake of the analyzer.

Mid-morning Mary detects an alarm from analyzer B indicating a problem. She goes to the monitor of the analyzer and notices that there is an error in the analytical module. Mary remembers that this error occurs sometimes, so she decides to call for technician. The first thing to do is disconnect the analyzer from the chain. In order to not delay anymore the tasks she disconnects it and calls for the technician. Also, Mary informs the manager about this failure.

Within thirty minutes the technician comes to the laboratory and solves the problem in about 15 minutes. Mary may now reconnect the Analyzer to the chain (one hour has lasted since the detection of the problem).

She marks in the LETAPP that the fault has been resolved and she is

	now able to continue working normally.
User benefits	– Control work order. – Control of the effects of laboratory results. – Control of incidents and / or Troubleshooting to laboratory analyzers. – Stock control laboratory reagents.
Assumptions	– Working hours can be controlled more strictly. – The incidents on the analytical results can be recorded with a clearly order, detecting systematic errors due to accumulation of errors. – Control on the incidents and / or breakdowns more frequent in the laboratory. – Control of stock of laboratory reagents.
Human actors	Laboratory technician
Key HW elements	Tablet or smart watch to control the schedule and order of work in the clinical laboratory, as well as control over stock reagent, incidents with analyzers and / or analytical results.
Key SW elements	– Applications to control the daily tasks of the technician. – Applications for monitoring laboratory analytical results with alarms in case of deviation. – Applications for controlling stock of laboratory reagents. – Applications to the functions of each job – Applications with the working procedure regarding calibration, control and daily work with the analyzer.
Innovation	– Strict control of laboratory technician work in the proper order. – Control on laboratory processes. – Control on the incidents and / or breakdowns to the analyzers. – Control of the analytical results from the laboratory in order to monitor which are the analytical techniques most sensitive that give more problems and incidents. – Control on the stock of laboratory reagents.
Interactions	Scenario 1, Scenario 3

Table 8. Scenario 6. Sample processing and reviewing of results

	Scenario 7
Scenario Title	**Replenishment of reagents in the analyzer. O'Sullivan test**
Domain	**Laboratory**
Scene description	At 14:00 the LETAPP reminds Mary that it is time to replenish the reagents. This task is usually done at this time of day because sufficient specific reagents are needed in the machines in order to process all analytics scheduled for afternoon.

	At that time, Mary checks that the samples in the analyzers have been processed and therefore she stops the analyzers. She proceeds to disconnect the analyzer from the chain and marks on the tablet that the analyzer was set offline. She checks in the monitor of the analyzer ADVIA the reagents that are needed to replenish samples this afternoon. She checks that these are IgA, IgG and IgM immunoglobulin. She collects the reagents from the refrigerator, records on the tablet that she has left the camera and she has taken out the reagents, and then, she proceeds introducing them in the analyzers. All this time she also is checking for insertion mistakes considering batches of R1 and R2. They are correctly inserted. She reads barcodes of reagents and checks on the analyzer's screen that everything is correct. After entering the specific reagents in the analyzers, the LETAPP notifies that there are spare reagents samples that need to be analyzed during the rest of the day. Also the tablet reminds her to process the O'Sullivan test samples which have arrived today. Approximately 25-30 samples per day are manually inserted into the analyzer. The analyzer processes them and then, it reconnects to the chain. Mary marks in the LETAPP that O'Sullivan samples have been processed along with the reagents introduced this afternoon and the auto analyzers have been reconnected to the chain. The laboratory continues its usual activity. .
User benefits	– Control work order. – Stock control laboratory reagents. – Control of the tasks assigned to each job.
Assumptions	– Working hours can be controlled more strictly. – Control of stock specific laboratory reagents.
Human actors	Laboratory technicians
Key HW elements	Tablet or smart watch to control the schedule and order of work in the clinical laboratory, as well as control over stock of reagents.
Key SW elements	– Applications to control the daily tasks of the technician. – Applications for controlling stock of laboratory reagents.
Innovation	– Strict control of manufactured laboratory technician in the proper order. – Control on laboratory processes. – Control on the stock of laboratory reagents.
Interactions	Scenario 2.

Table 9. Scenario 7. Replenishment of reagents in the analyzer. O'Sullivan test

Scenario 8

Scenario Title	**Final day process - serum bank**
Domain	**Laboratory**
Scene description	After all the tubes of the day have been processed, at 19.00 o'clock the LETAPP sends an alert with the message that the general and specific reagents could have been used up throughout the day and they need to be refilled in order to ensure that the analyzer has enough reagents to process all analytical work in the next day. Mary reviews all levels of wash liquid analyzers, all liquids from the system and resets them to optimal levels. Also, she checks the reactants that have been consumed in the monitor. Then, she takes those that are necessary from the cold room. She marks in the LETAPP which have spare liquid in the system, and in the same way also marks that some reagents have been taken from laboratory stock and have been introduced to the analyzers. At 19:30 the LETAPP alerts her on her final task before ending the workday. Thus, Mary washes the analyzers and puts the tubes samples analyzed throughout the day in the serum bank. The tubes are placed in their corresponding sample trays and the trays are placed in the refrigerator. Mary programs the position of the trays in shelves of the refrigerator with the computer system. The trays are manually assigned to the Sample Manager of the serum bank with its position. She goes to the refrigerator and opens it with her electronic card, reads the barcode of the serum bank trays with the code reader and enters them into the refrigerator. Note that this refrigerator is not the same with the cold room; it is a specific refrigerator for serum bank. In the cold room there are not serum samples. The LETAPP records the position of the trays and assigns the position of tubes in the serum bank, which have been introduced by Mary. Mary checks in the LETAPP that the tubes have been stored in the serum bank and, then, the final process of the day. Then, she disconnects analyzers and ends her day of work.
User benefits	– Control work order. – Control of laboratory incidents. – Stock control laboratory reagents.

	– Serum bank control.
Assumptions	– Strict control of laboratory technician work in the proper order. – Control on laboratory processes. – Control on the impact and / or breakdowns to the analyzers. – Serum bank control.
Human actors	Laboratory technicians.
Key HW elements	Tablet or smart watch to control the schedule and order of work in the clinical laboratory, as well as control over serum bank of the laboratory.
Key SW elements	– Applications to control the daily tasks of the technician. – Applications for controlling of serum bank.
Innovation	– Strict control of manufactured laboratory technician in the proper order. – Control on laboratory processes. – Control on the impact and / or breakdowns to the analyzers. – Control tubes of serum bank laboratory. Location of the tubes and the staff that handle them more accurate.
Interactions	Scenario 2.

Table 10. Scenario 8. Final day process - serum bank

4.2. Use Cases Description

4.2.1. Use cases description - University Emergency Hospital Bucharest (UHB)

Based on the above-mentioned scenarios for the University Emergency Hospital of Bucharest the following use cases resulted. It is important to mention that, considering the similarities resulting from the workflow analysis, the studied situations and the major requirements of the users (operators) - alert/alarm notification, warning, localization - are similar for UHB and HUVM.

We have chosen for the representative use cases an appropriate template for representing the best the required features and findings of the technical solution.

The proposed template for use cases is the following:

USE CASE NAME	
Primary actor	
Scope	Describe what is being modeled
Level	
Goal/ Description	
Trigger	

Assumptions/ preconditions	
Minimal guarantees	
Success guarantee	
Steps/Main success scenario	
Extensions	
Variations	
Non-deliverables	
Non-functional requirements	
Issues	

Table 11. Template for Use Cases

UC 1:

Use case name	**Send alarm**
Primary actor	Nurse/Orderly
Scope	**Sending the alarm in emergency cases to different actors**
Level	Subfunction use case
Goal/	The operator is able to send an alarm to:
Description	– Instructor/managers – All the team members – Operators nearby – Individual colleagues
Trigger	It is an emergency case and the user needs to send an alarm to receive help. The user clicks on the alarm button placed the main menu of the LETAPP.
Assumptions/	Prioritization of this message with respect to one another

preconditions	User is registered and logged in the system
Minimal guarantees	The user sends an alarm.
Success guarantee	The user sends the alarm.
Steps/Main success scenario	1. The user selects the person or group who will receive the alarm.The user writes the information about the alarm (brief description, text or voice)The user clicks on the button to send it
Extensions	N/A
Variations	N/A

Table 12. UC - Send alarm

UC 2:

Use case name	**User Login**
Primary actor	Nurse /Orderly
Scope	**The access in the application's workspace based on authentication means of unique credentials**
Level	Subfunction use case
Goal/ Description	The goal is to get access to the application's workspace. This access must be unique and secure for each user registered in the application. The workspace assigned to each user will be independent so that the information will be specifically addressed to the registered user.
Trigger	Workday begins. The user clicks on the icon of the desired application (specific for the alert, training etc.) in the tablet/mobile device.
Assumptions/ preconditions	User has to registered n database correctly
Minimal guarantees	The user gets access to the application workspace.
Success guarantee	The user gets access to the application workspace.
Steps/Main success scenario	1. The user starts the application on the tablet. 2. The user enters his/her username. 3. The user enters his/her password. 4. The user clicks the button for choosing the desired application
Extensions	1. If the application fails during the boot, the user will force restart of the application. If it fails again, the user will contact the technician for support.

2. If the credentials are not correct, the user will contact the administrator of the application for the request of new credentials.

Table 13. UC – User Login

UC 3:

Use case name	**Main Menu**
Primary actor	Nurse/Orderly
Scope	**The main menu of the application**
Level	Sub function use case
Goal/ Description	The main goal is to provide a menu that allows users access to all assigned functionalities of the application.
Trigger	The user completes the login process
Assumptions/ preconditions	User is registered and logged in the system Tasks and its associated content have been assigned to operators in the database. Mobile application bound to smart phone
Minimal guarantees	The menu is visible to the user.
Success guarantee	The user accesses the menu.
Extensions	N/A
Variations	N/A

Table 14. UC- Main Menu

UC 4:

Use case name	**Workflow management**
Primary actor	Head Nurse/Orderly
Scope	**The management of the workflow on the server side**
Level	Overall management functionalities for the supervisor.
Goal/	This use case includes several sub-use cases that will be detailed in the architecture, when the information model is specified. It encloses

Description	registration/modification/removal of tasks, users, validation of assigned workflow, visualization of task status and access to information for further analysis
Trigger	The supervisor logins in the system with its credentials
Assumptions/ preconditions	The user must have access to the management tool
Minimal guarantees	Validations of assigned workflow and access to task status is mandatory
Success guarantee	All functionalities should be available for the supervisor.
Steps/Main success scenario	The user gets into the management system. A screen with all functionalities is available for the supervisor.

Table 15. UC - Workflow management

UC5:

Use case name	**Task Menu**
Primary actor	Nurse/Orderly
Scope	**The task menu for content associated with a task**
Level	Subfunction use case
Goal/ Description	The main goal is to provide a menu to allow access to the associated content for a task like the subtask list or detailed information about the task (methods).
Trigger	The user clicks on a task.
Assumptions/ preconditions	User is registered and logged in the system Tasks and its associated content are assigned to operators in the database. Associated content to the task is in the database
Minimal guarantees	The task menu is shown to the user.
Success guarantee	The task menu is accessed by the user.

Table 16. UC - Task Menu

UC6:

Use case name	**Reception of an alarm**
Primary actor	Nurse/Orderly
Scope	**The reception of an alarm created by a colleague in emergency cases and redistributed by the system. Includes also the reply of the user.**
Level	Subfunction use case
Goal/ Description	The main goal is to allow users to receive and answer alarms. The basic information refers to the position of the operators that generates the alarm and to the text/voice message. The operator will be able to indicate whether he/she is available to respond to the alarm or not. The same interface also shows the number of colleagues that have already confirmed that they can help.
Trigger	This interface is triggered by an alarm sent from other colleagues.
Assumptions/ preconditions	The user is logged and the application is running.
Minimal guarantees	The user shall be able to receive an alarm and to reply it.
Success guarantee	The user receives an alarm and to replies to it.
Steps/Main success scenario	1. The application informs the user that an alarm has been generated by producing sound and vibration. 2. The user accesses the application and reads the alarms. 3. The user replies to the alarm.

Table 17. UC Reception of an alarm

UC7:

Use case name	**Insert of new task**
Primary actor	Nurse/Orderly
Scope	**The insertion of a new task in the database**
Level	Sub function use case
Goal/ Description	The user shall be able to add new tasks, and add it to the task list (displayed in the main menu) in the correct position. The user will select a task from a predefined list, or insert manually a new task(not in the database)

Trigger	An unplanned event needs to be added. The user touches the clickable icon for creating a new task in the main menu.
Assumptions/ preconditions	User is registered and logged in the system
Minimal guarantees	The user defines a new task.
Success guarantee	The user creates a new task.
Steps/Main success scenario	1. The user chooses one kind of task from the predefined list of task.The user saves the task by clicking on the button.
Extensions	N/A
Variations	1. The user makes sure that the task has not been registered previously.The user inserts the name of the taskThe user inserts a brief description of the task.The user sets the estimated duration of the task.The user defines the patient who needs the task (if it has a patient associated)The user inserts the department assigned to the task (if applicable).The user saves the task by clicking on the button.

Table 18. UC - Insert of new task

UC8:

Use case name	**Modification of the state of a task**
Primary actor	Nurse/Orderly
Scope	**The modification of the state of an assigned task**
Level	User goal use case
Goal/ Description	The user shall be able to update the status of each assigned task within the workspace throughout the workday
Trigger	The user starts, finishes or pauses with the activity related with a task. The user touches the clickable icon that indicates the status of the task from the main screen menu. Selecting this icon will open the “confirmed task” screen.
Assumptions/ preconditions	User is registered and logged in the system User is assigned to tasks Tasks are assigned to operators
Minimal guarantees	The user updates the status of a task.
Success guarantee	The user updates the status of a task.
Steps/Main success	The user selects the new status of the task in order to save the value on

scenario	the server.
Extensions	If there is no wireless connection available, then it is not possible to update the status of a task on the server.
Variations	It is possible for the user to choose a status: started, suspended, resumed or completed.

Table 19. UC - Modification of the state of a task

UC9:

Use case name	**Subtask List**
Primary actor	Nurse/Orderly
Scope	**Visualization of the subtask list for a task**
Level	Sub function use case
Goal/	The goal is to visualize the subtask list associated to a task.
Description	The elements of the list can be marked as completed.
Trigger	The user selects a task in the menu and click on subtask list.
Assumptions/ preconditions	User is registered and logged in the system User has tasks assigned. One Task has associated subtasks.
Minimal guarantees	The user shall be able to access the subtask list.
Success guarantee	The user shall be able to successfully access the subtask list.
Steps/Main success scenario	The user clicks the task to mark it “complete”.

Table 20. UC - Subtask List

UC10:

Use case name	**Staff training in case of change management**
Primary actor	Nurse/Orderly
Scope	**Training staff for new procedures and techniques**
Level	Summary use case level

Goal/ Description	The objective is to perform a simulation where the user could interact with different situations leading to a better understanding of how the staff should react, based on a specific guideline.
Trigger	Start of training
Assumptions/ preconditions	The user must have access to the learning tool.
Minimal guarantees	The implementation/simulation of realistic scenarios.
Success guarantee	The implementation/simulation of realistic scenarios.
Steps/Main success scenario	1. The user boots the learning toolThe user interacts with the learning tool in performing different requests and completes the application.

Table 21. UC - Staff training in case of change management

4.2.2. Use case description - University Hospital Virgen Macarena (HUVM)

Based on the above-mentioned scenarios applying to the University Hospital Virgen Macarena (Automated Laboratory of Biochemistry General (SAR)) the following use cases emerged.

We have chosen the same template for use cases like the one used for UHB (see ***4.2.1. Use cases description - Emergency University Hospital Bucharest (UHB)***).

The proposed template for use cases is the following:

USE CASE NAME	
Primary actor	
Scope	Describe what is being modeled
Level	
Goal/ Description	
Trigger	
Assumptions/ preconditions	
Minimal guarantees	
Success guarantee	
Steps/Main success scenario	
Extensions	

Variations	
Non-deliverables	
Non-functional requirements	
Issues	
Remarks	

Table 22. Template for Use Cases

UC 11:

Use case name	**User Login**
Primary actor	Laboratory technician
Scope	**The access based on authentication by credential for each user to the application workspace**
Level	Subfunction use case
Goal/ Description	The goal is to get access to application's workspace. This access must be unique and secure for each user registered in the application. The workspace for each user will be independent so that the information provided from the application to be specifically addressed to the registered user.
Trigger	Beginning of a workday for the user. The user clicks on the specific icon of the desired application in the tablet.
Assumptions/ preconditions	User has to be registered in database correctly
Minimal guarantees	The user gets access to the application workspace.
Success guarantee	The user gets access to the application workspace.
Steps/Main success scenario	1. The user starts the application on the tablet. 2. The user enters his/her username. 3. The user enters his/her password. 4. The user clicks on the button for choosing the desired application.
Extensions	If the application fails during the boot, the user will force restart of the application. If it fails again, the user will contact the technician for help/repair If the credentials are not correct, the user will contact the administrator of the application to the request new credentials.

Table 23. UC - User Login

Figure 1: Mockup of *Login* screen.

UC12:

Use case name	**Main Menu**
Primary actor	Laboratory technician
Scope	**The main menu of the application**
Level	Sub-function use case
Goal	The main goal is to provide a menu that grants users to access all functionalities of the application.
Description	
Trigger	The user completes the login process
Assumptions/ preconditions	User is registered and logged in the system Tasks and its associated content have been assigned to operators in the database. Mobile application bound to smart-phone
Minimal guarantees	The menu is visible to user.
Success guarantee	The menu is visible to user.

Table 24. UC - Main Menu

Figure 2: Mockup of *Main Menu* screen.

UC13:

Use case name	**Task Menu**
Primary actor	Laboratory technician
Scope	**The task menu for associated content for a task**
Level	Subfunction use case
Goal/ Description	The main goal is to provide a menu to allow access the associated content of a task like the subtask list or detailed information about the task (methods).
Trigger	The user clicks on a task.
Assumptions/ preconditions	User is registered and logged into the system Tasks and its associated content have been assigned to operators in the database. Associated content is assigned to the tasks is in the database
Minimal guarantees	The task menu is visible to the user.
Success guarantee	The task menu is visible to the user.

Table 25. UC - Task Menu

Figure 3: Mockup of *Task Menu* screen.

UC 14:

Use case name	**Subtask List**
Primary actor	Laboratory technician
Scope	**Visualization of the subtask list for a task**
Level	Subfunction use case
Goal/	The goal is to visualize the subtask list associated to a task.
Description	The elements of the list can be marked in function of their status (completed, in work etc.)
Trigger	The user selects a task in the menu and clicks on the subtask list.
Assumptions/ preconditions	User is registered and logged in the system Task has associated subtasks.
Minimal guarantees	The user shall be able to access to the subtask list.
Success guarantee	The user shall be able to access to the subtask list.
Steps/Main success scenario	The user clicks on the task to mark it as “completed”.

Table 26. UC - Subtask List

Figure 4: Mockup of *Subtask List* screen.

UC 15:

Use case name	**Modification of the state of a task**
Primary actor	Laboratory technician
Scope	**The modification of the state of a task assigned**
Level	User goal use case
Goal/Description Description	The user shall be able to modify the status of each task assigned into the application throughout the workday
Trigger	The user starts, finishes or pauses with the activities related with a task. The user touches the clickable icon that indicates the status of the task from the main screen menu. Selecting this icon will open the “confirmed task” screen/window.
Assumptions/ preconditions	User is registered and logged in the system User has tasks assigned Tasks are assigned to operators
Minimal guarantees	The user changes the status of a task.
Success guarantee	The user changes the status of a task.
Steps/Main success scenario	The user selects the new status of the task in order to save the value on the server.
Extensions	If there is no wireless connection available, then it is not possible to modify the status of a task on the server.

Variations	It is possible that the user may choose in the first instance one type of status: started, suspended, resumed or completed.

Table 27. UC - Modification of the state of a task

Figure 5: Mockup of *Modification of the state of a task* screen.

UC 16:

Use case name	**Insert of new task**
Primary actor	Laboratory technician
Scope	**The insertion of a new task in the database**
Level	Sub-function use case
Goal/Description Description	The user shall be able to add new tasks, and add them to the task list (displayed in the main menu) in the correct position. The user will select from a predefined list of tasks, or will insert a new task, which is not registered previously in the database.
Trigger	A not planned event needs to be added. The user touches the clickable icon for create a new task in the main menu.
Assumptions/ preconditions	User is registered and logged in the system
Minimal guarantees	The user creates a new task in the database.
Success	The user creates a new task in the database.

guarantee	
Steps/Main success scenario	1. The user chooses one kind of task from the predefined list of task.The user saves the task by clicking on the button.
Extensions	N/A
Variations	1. The user makes sure that the task has not been registered previously.The user inserts the name of the taskThe user inserts a brief description of the task.The user sets the estimated duration of the task.The user defines the patient who needs the task (if it has a patient associated)The user inserts the department assigned to the task (if it is applicable).The user checks if the task is planned or not.The user saves the task by clicking on the button.

Table 28. UC - Insert of new task

Figure 6: Mockup of *Insert New Task* screen.

UC 17:

Use case name	**Send alarm**
Primary actor	Laboratory technician
Scope	**The sending of an alarm in emergency cases to different actors**
Level	Subfunction use case
Goal/Description	The operator is able to send an alarm to:
Description	– Instructor/manager(s) – All the team members

	– Operator nearby – Individual colleagues
Trigger	It is an emergency case and the user needs to send an alarm for get help. The user clicks on alarm button in the main menu.
Assumptions/ preconditions	Prioritization of this message with respect to other ones User is registered and logged in the system
Minimal guarantees	The user sends an alarm.
Success guarantee	The user sends an alarm.
Steps/Main success scenario	1. The user selects the person or group who will receive the alarm.The user writes the information about the alarm (brief description, text or voice)The user clicks on the button to send it.
Extensions	N/A
Variations	N/A

Table 29. UC - Send alarm

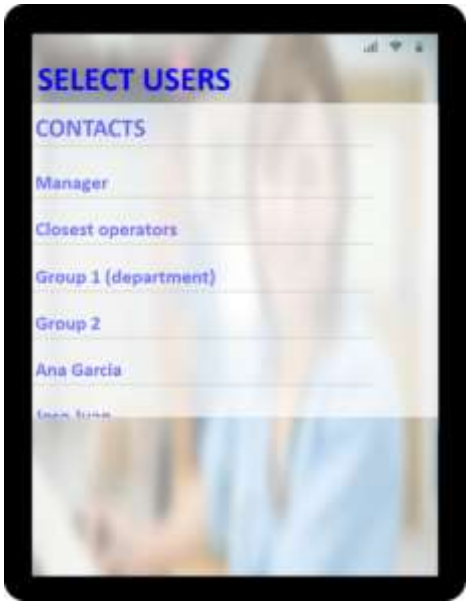

Figure 7: Mockup of *Send Alarm* screen.

UC 18:

Use case name	**Sending a message**

Primary actor	Laboratory technician
Scope	**Sending a message to a colleague**
Level	Subfunction use case
Goal/ Description	The objective is to use a secure messaging application that helps medical staff to coordinate care and collaborate on cases and efficiently manage communication over the continuum of care. It allows connecting to other colleagues, asking for supports or providing information. The application would support text/voice/images. Contacts/operators are provided by the users' database. It allows individual and group communication.
Trigger	The user needs to communicate something to a colleague. The user clicks on the messaging button from the main menu.
Assumptions/ preconditions	User is registered and logged on in the system
Minimal guarantees	The user sends a message correctly.
Success guarantee	The user sends a message correctly.

Table 30. UC - Sending a message

UC19:

Use case name	**Receiving an alarm or notification**
Primary actor	Laboratory technician
Scope	**The receiving of an alarm notification created by a colleague in emergency cases and redistributed by the system. Includes also the possibility of replying to the notified.**
Level	Subfunction use case
Goal/ Description	The main goal is to allow users to receive and respond to r alarm notifications. The basic information is the position of the operators that generates the alarm, and the text/voice message. The operator will be able to indicate whether he/she is available to assist the alarm and in the same interface also shows the number of colleagues that already confirmed that can they can help.
Trigger	This interface is triggered by an alarm sent from other colleagues.
Assumptions/ preconditions	The user is logged and the application is running.
Minimal guarantees	The user shall be able to receive an alarm notification and to reply it.

Success guarantee	The user receives an alarm notification and to replies to it.
Steps/Main success scenario	The application informs user that an alarm has been generated producing sound and vibration.The user opens the application and reads the details of the alarm notification. 2. The user replies to the alarm notification.

Table 31. UC - Receiving an alarm notification

Figure 8: Mockup of *Reception of an alarm* screen.

UC 20:

Use case name	**Receiving a message**
Primary actor	Laboratory technician
Scope	**Receiving of a message from a colleague**
Level	Subfunction use case
Goal/ Description	The objective is to use a secure messaging application that helps medical staff to coordinate care and collaborate on cases and efficiently manage communication over the continuum of care. It allows connecting to other colleagues, asking for support or providing information. The application supports text/voice/images. Contacts/operators are provided by the users' database. It allows individual and group communication.
Trigger	The messaging application receives a message.

Assumptions/ preconditions	User is registered and logged in the system. The application is running
Minimal guarantees	The user shall be able to read the message received.
Success guarantee	The user shall be able to read the message received.
Steps/Main success scenario	1. The messaging application informs the user of the new message received using the vibration (no sound). 2. The user uses the scroll access for displaying and reading the message.

Table 32. UC - Reception of a message

UC 21:

Use case name	**Workflow management**
Primary actor	Laboratory supervisor
Scope	**The management of the workflow in the data base**
Level	Overall management functionalities for the supervisor.
Goal/ Description	This use case includes several sub-use cases that will be detailed in the architecture, when the information model is specified. It encloses registration/modification/removal of tasks, users, validation of assigned workflow, visualization of task status and access to information for further analysis.
Trigger	The supervisor logins in the system with its credentials.
Assumptions/ preconditions	The user must to have access to the management tool
Minimal guarantees	At least validations of assigned workflow and access to task status are mandatory.
Success guarantee	All functionalities should be available to the supervisor.
Steps/Main success scenario	The user gets into the management system. An screen where all functionalities are available for supervisor

Table 33. UC - Workflow management

UC 22:

Use case name	**Laboratory workflow simulation**

Primary actor	Laboratory supervisor
Scope	**The simulation of the laboratory workflow**
Level	It is a modelling and simulator functionality that allows the estimation of performance of the tasks (time and resources) and parameterization of a scenario to simulate different configuration.
Goal/ Description	The objective is to perform a simulation of the work space based on algorithms/models like Petri nets or Yawl for the clinical laboratory workflow. The goal is to estimate the human resources consumption, the response time in case of incidents and the impact of different scenarios over the laboratory workday.
Trigger	The simulation application would be used on demand.
Assumptions/ preconditions	The user must to have access to the simulation tool
Minimal guarantees	The simulation of realistic scenarios. The minimal result is estimating the time elapsed in different tasks for a specific configuration of resources (human and machine).
Success guarantee	The simulation of realistic scenarios. The minimal result is estimating the time elapsed in different tasks for a specific configuration of resources (human and machine).
Steps/Main success scenario	1. The user boots the simulation tool.The user defines the variables of the simulation and starts it.

Table 34. UC - Laboratory workflow simulation

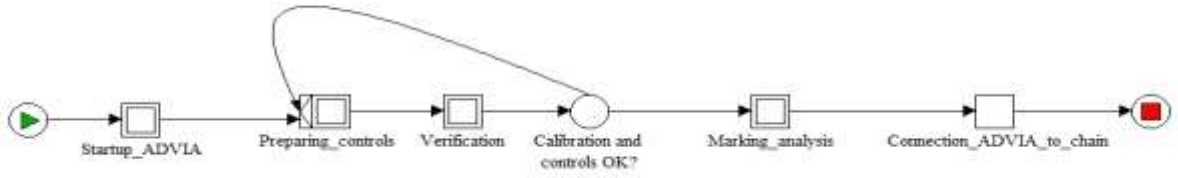

Figure 9: Mockup of the *Workflow simulation* diagram.

4.3 UHB and HUVM - Similarities and particularities in the scenarios

According to the previous sections we identify infer the following desired features from / for both hospitals:

- Change management: The complexity of adopting and implementing of new procedures, protocols and/or handling new specific equipment, especially for elderly persons, or new technicians
- The assignment of task to operators and the control of task status is an arduous and time consuming activity
- Improving the learning curve of new technicians
- Managing complex workflows
- Managing human errors.

We envisage that the following functionalities should be implemented in LetItFlow project:

- **LETAPP:** Development of the smart device application (tablet, Smartphone, smart watch) to support technicians, nurses and operators in their workdays. It is a kind of *check list* application that helps operators minimizing typical errors in their daily routines.
- **LETALARM:** Alarm system enriched with operator localization.
- **LETCRITICAL:** Detection of critical situation in operators (for instance, when a nurse feels bad). It is based on vital signal monitoring.
- **LETSIM:** Development of a simulation tool that focuses in the laboratory workflow.
- **LETTRAIN:** Training the staff involved in LetItFlow project in case of change management, when it must be put into practice new procedures, new work techniques, new operating modes or new maneuvres.

The previous functionalities can be shared among both hospitals and they make use of a common architecture/design for each scenario:

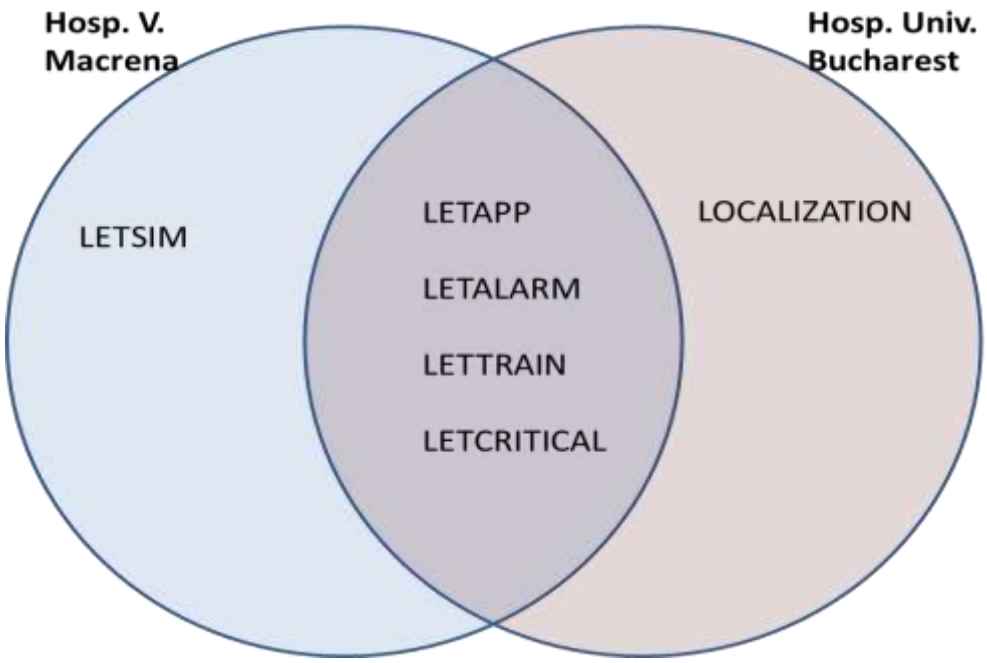

Figure 10 Common functionalities between both hospitals

In Figure 10, we may observe that in both hospitals will share common functionalities. The main difference is that at UHB there is no need for simulation (LETSIM) and at HUVM there is no need for localization.

These commonalities will be considered to specify a common architecture, although the implementation and instantiation of such architecture would be slightly different for both end users. Those commonalities will also help select a common technology platform (hardware and software) and uniform methods.

5. TECHNOLOGY SURVEY

In this section we will describe the state of the art of different technologies, methods or tools related to the LetItFlow project. Each topic in this chapter is structured in three subsections:

- *Background:* Explanations of the scope of said technology, method or tool
- *State of the art and practice:* Description of the most relevant and innovative products/solutions, tools, methods, projects
- *Applying the approach in LetItFlow project:* a preliminary analysis of how the described technologies, solutions, methods and tools can be applied in the LetItFlow project.

5.1. Workflow analysis methods and tools

5.1.1. Background

In a competitive healthcare market, hospitals and clinical laboratories have to focus on ways of streamlining their processes in order to deliver high quality work while at the same time reducing costs.

Moreover, increasing pressure is being put on hospitals and clinical laboratories to work in the most efficient way. Consequently, there is a need for technological support in controlling and monitoring these processes and workflow technology is potentially an interesting tool for achieving this end.

The workflow analysis approach was applied in both hospitals within the surveys of specific processes workflows for daily activity.

The result of using the workflow analysis in the LetItFlow project is presented in the following section ***5.1.3. Applying the approach in LetItFlow project***.

5.1.3. State of the art and practice

Two tools have been studied for this end. A brief description of each of them and an enumeration of pros and cons are included in next paragraphs.

YAWL

YAWL (Yet Another Workflow Language) is a workflow language based on workflow patterns. The language is supported by a software system that includes an execution engine, a graphical editor and a worklist handler. The system is available as Open source software under the LGPL license.

YAWL offers some features really interesting:

- YAWL offers comprehensive support for the control-flow patterns. It is a process specification language for capturing control-flow dependencies.

- Tasks in YAWL can be mapped to human participants, Web Services, external applications or to Java classes.
- YAWL offers support for dynamic workflow through the Worklets approach. Workflows can thus evolve over time to meet new and changing requirements.
- YAWL's architecture is Service-oriented and hence one can replace existing components with one's own or extend the environment with newly developed components.
- The YAWL environments supports the automated generation of forms. This is particularly useful for rapid prototyping purposes.

YAWL has been used to model and simulate clinical workflows. The case studyYAWL4Health is about the diagnostic part of the gynecological oncology healthcare process. The process consists of around 325 activities and involves patients visiting the gynecological oncology outpatient clinic of the AMC hospital. The gynecological oncology process studied has been translated into a YAWL model, as seen in next figure.

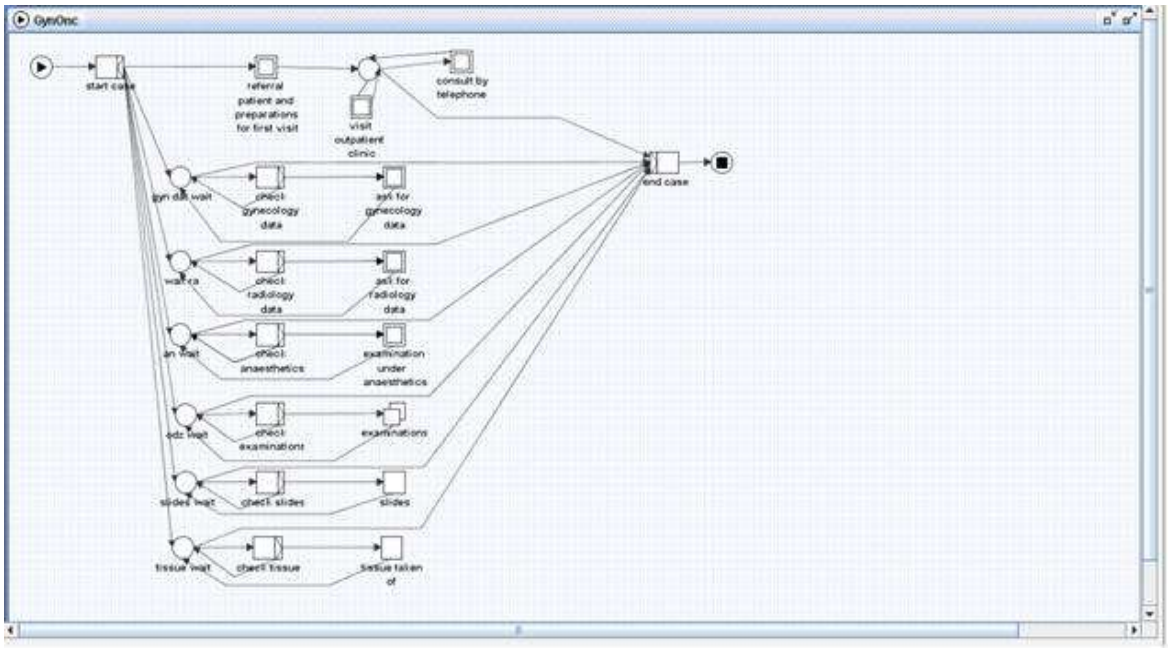

Figure 11. A screenshot of the gynecological oncology process modeled with YAWL

Summarizing, YAWL is a potent workflow language really interesting for clinical workflow modeling. The feature of the human task allocation and the exchange of information with Web Services and external application are really useful from this project point of view.

Pros

- Includes a workspace with an execution engine, a graphical editor and a worklist handler.
- Human task allocation and exchange information with external application
- Provides a unified interface for worklist services based on web services standards
- Successful projects in medical workflow (see YAWL4Health)
- YAWL system comes with a default worklist service that supports several types of human task allocation and handling.
- Open source license

Cons

- Complex tool.

GreatSPN

GreatSPN is a workflow simulator based on extended Petri Nets.

Basic Petri nets (usually referred to as place-transition nets) were used to create models for clinical guidelines due to the fact that they are easy to learn and that the diagrams are easy to understand. Petri nets are based on graph theory, and thus can be defined mathematically. The simplest Petri net modeling tools have some level of simulation capability, which really helps in verifying that the model captures what was expected. However Basic Petri nets cannot model every aspect of clinical processes. For example, they do not handle time, rules, data, or complex control-flow sequences well. This tool is interesting for this application since it is based on *Generalized Stochastic Petri Nets and their colored extension: Stochastic Well-formed Nets* that is an extension of Petri Nets that solve the limitations mentioned.

GreatSPN approach also allows for performance analysis and resource allocation optimization. The general data model of the GreatSPN editor is a compositional model where each component is Petri net node, or an automaton. Components can then be combined into a larger model using *algebra,* a software element for the composition of Petri Nets which is also part of GreatSPN.

Model design (depicted in the central part of the window) is a fully interactive where the modeler draws places, transitions, arcs, and the other model elements by a point-and-click approach. Drawn models can be tested interactively, to better understand the model behavior, and to identify the invariants.

The GUI allows drawing the models graphically, using the Petri net formalism:

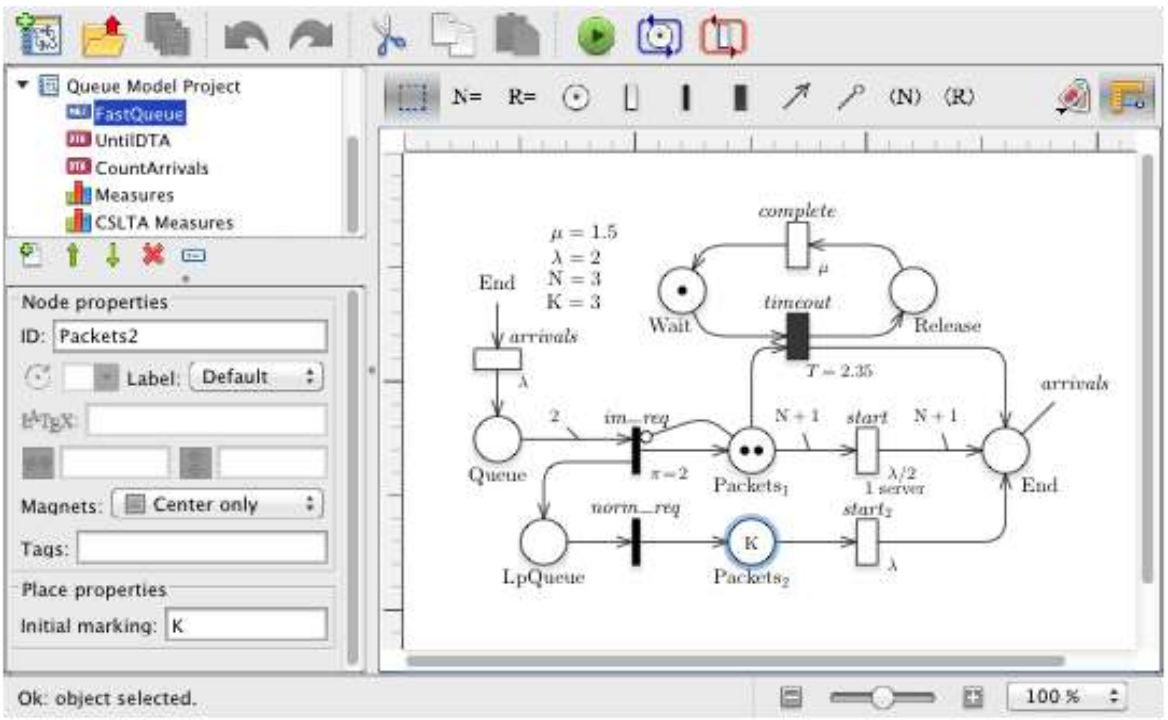

Figure 12. GreatSPN screenshot showing a Petri Net model

The tool allows invariant visualization (namely P-semiflows and T-semiflows) which characterize the behavior of the model, while interactive simulation allows the user to play with the model, activating its transitions to simulate one behavior of the system and observe the result.

Once a model has been drawn, performance indices can be computed on it using a collection of numerical solvers. A batch of indices can be specified through the GUI, which invokes the solvers, performs the computation and shows the results interactively. The following figure shows the interface for the specification of performance indices on a Petri net model.

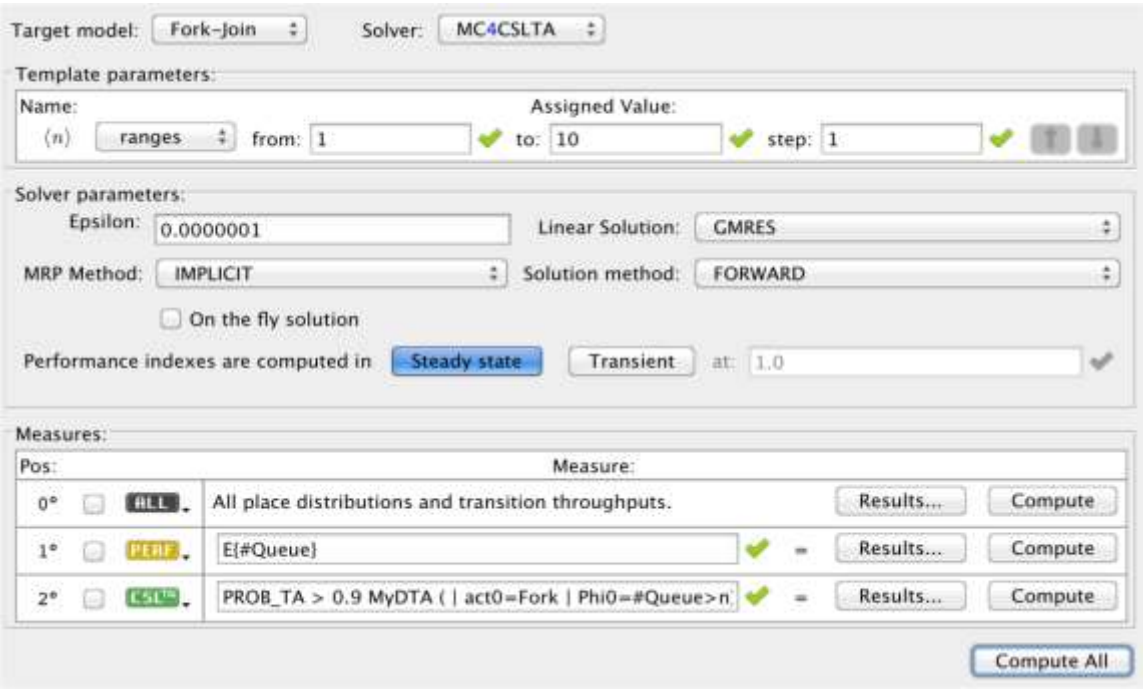

Figure 13. GreatSPN interface for configuration of tasks

However, GreatSPN does not still have implemented all features of Colored Petri Nets, which makes it less suited for use it in this scenario.

Pros

- Easy to implement nets
- Ease the visualization of the complex processes in laboratory medical workflows.

Cons

- Beta version. Some features of the Colored Petri Nets are not implemented yet.

5.1.3. Applying the approach in LetItFlow project

Within the LetItFlow project the idea is to develop *a simulation tool* useful for the study of the workflow optimization inside health environments and *specific software applications* designated to implement the needs and requirements of the end-users (elderly medical staff – nurses, orderlies and laboratory technicians over 50 years).

The workflow analysis approach was applied in both hospitals during our research of specific daily processes workflows.

The most relevant workflows for the Neurology Department of UHB have been selected considering the proceedings (acting and reacting) in *normal and emergency/critical situations for specific locations*, when the members of target group need for support.

The most relevant workflows for the Automated Biochemistry Laboratory (SAR) of HUVM have been selected considering the proceedings (acting and reacting) in *key and sensitive situations and moments* of the daily activity in the laboratory, when the members of target group need for support.

Considering the above-mentioned concerned *operational and procedural* aspects have been analyzed the following situations:

Neurology Department of UHB:

1. Normal work conditions and emergencies in EEG Laboratory, Laboratory of ultrasound, Laboratory of clinical studies, Video EEG Laboratory (Polysomnography Laboratory)
2. Emergency created/produced by health problems of nurses/orderlies during their daily activity
3. Unpredicted emergency/critical situation in the ward / room
4. Monitoring nurses and orderlies daily activity *(Task Management; Defining the Treatment Plan and the Daily Program/Schedule)*
5. Emergency that could arise while patient is transported by an orderly/sister to be investigated / for a consultation outside the ward (inter-departmental)
6. Learning about new work techniques, new work procedures, new operating modes (equipment, devices), new maneuvers (*Change Management*).

Automated Biochemistry Laboratory – SAR of HUVM:

1. Starting the day – Quality Control
2. Sample processing and review of results
3. Replenishment of reagents on the analyzer. Test O'Sullivan
4. End of the working day – Serum Bank.

During the analysis, the representative Scenarios have been chosen and they were then formalized into specific Use-Cases, using the Agile methodology and UCD (user centered design) concepts and principles, as presented in the preceding sections.

The workflow analysis explored the following relevant aspects:

- *The situation*
- *The context*
- *Story description (relevant steps of the workflow)*
- *Which applications – functionalities – tasks – items should be implemented in LetItFlow.*

The features specific to the above-mentioned aspects are represented in the structure of the proposed scenarios.

The simulation tool of LetItFlow solution shall fulfill all the following functionalities:

- Evaluation of the workflow performance
- Detection of bottle necks
- Impact of different scenarios over the laboratory workday
- Assessment of the consequences of changes/incidents (technical or human failures).

The simulation tool will be applied in the Automated Biochemistry Laboratory - SAR of HUVM.

Based on the workflow processes analysis in the Neurology Department of UHB, the functionalities of LetItFlow solution that are to be achieved are disposed in:

- Implement a check list / task management application to support nurses and orderlies in their daily work activity
- Implement an alarm/alert application, including the facility of localization
- Implement a specific application for detection of critical situations, based on vital signs monitoring
- Implement a specific tool designated to assist the operators in learning process.

This survey is the start point of the development of the above-mentioned tools and applications. In the next deliverables more details will be exposed.

5.2. Approach in software development

5.2.1 Background

Engineering methodologies have been around for a long time. They've not been noticeable for being terribly successful. They are even less noted for being popular. The most frequent criticism of these methodologies is that they are bureaucratic. There's so much stuff to do to follow the methodology that the whole pace of development slows down.

Agile methodologies developed as a reaction to these methodologies. For many people the appeal of these agile methodologies is their reaction to the bureaucracy of the engineering methodologies. These new methods attempt a useful compromise between no process and too much process, providing just enough process to gain a reasonable payoff.

The result of all of this is that Agile methods have some significant changes in emphasis from engineering methods. The most immediate difference is that they are less document-oriented, usually emphasizing a smaller amount of documentation for a given task. In many ways they are rather code-oriented: following a route that says that the key part of documentation is source code.

Agile is a set of values, not a process or method. Organizations do not do Agile—they either are Agile, or they aren't. Every organization takes a different approach to being Agile and, as a result, multiple methods have emerged under the Agile umbrella. However, they all stay true to the Agile Manifesto. These values are described by using the SCRUM delivery methodology (see also below).

A good source providing an overview of Agile with recommended resources has been given by: *The Seapine Agile Expedition by Jeff Amfahr, Alan Bustamante, and Paula Rome*. They describe the following:

"Agile delivery methodologies are defined processes for delivering software in an agile manner. They all value close collaboration with the customer and incrementally delivering quality software based on prioritized business value and in the shortest timeframe possible:

- Scrum, which was formalized by Ken Schwaber and Jeff Sutherland in the mid 1990s, is one of the more popular Agile delivery methods. One of Scrum's strengths is that it is a well-defined and extensively documented delivery methodology. Recommended resources:
  - Agile Project Management with Scrumby Ken Schwaber
  - Agile Software Development with Scrum by Ken Schwaber and Mike Beedle
  - Scrum.org(www.scrum.org)
  - Scrum Alliance(www.scrumalliance.org)
  - *The Definitive Guide to Scrum: The Rules of the Game, Ken Schwaber and Jeff Sutherland, July 2013, http://www.scrumguides.org/docs/scrumguide/v1/scrum-guide-us.pdf*
- Extreme Programming (XP) was created by Kent Beck and is similar to Scrum in that it emphasizes short, iterative, and incremental development cycles, short feedback loops, close customer collaboration, and work prioritized by highest business value. XP puts an extra emphasis on engineering practices that help improve code or product quality, such as:
  - Test-Driven Development
  - Pair Programming
  - Continuous Integration
  - Refactoring

  These engineering practices also provide a perfect complement to Scrum's more widely known and adopted delivery methods. XP operates on the following values:
  - 1. Simplicity
  - 2. Communication
  - 3. Feedback
  - 4. Respect
  - 5. Courage

  Recommended resources:
  - Extreme Programming Explained: Embrace Change by Kent Beck and Cynthia Andres
  - Planning Extreme Programming by Kent Beck and Martin Fowler
- Feature-Driven Development (FDD) was created by Jeff De Luca in the late 1990s and, like XP and Scrum, is focused on delivering customer value by identifying and delivering the features with the highest business value first, in an iterative and incremental fashion. FDD is a model-driven Agile process that puts emphasis on first identifying the problem domain using Unified Modeling Language (UML®), then digging into feature development on an iterative and incremental basis. Because FDD is model driven, it has additional roles such as Class Owner to support the modeling function.

  FDD emphasizes the following activities as part of its process:
  - Develop an overall model
  - Build a features list
  - Plan by feature
  - Design by feature
  - Build by feature

  Recommended resources:
  - Java Modeling in Color with UML by Peter Coad, Erick Lefebvre, and Jeff De Luca
  - A Practical Guide to Feature Driven Development by Stephen Palmer and Mac Felsing

- Feature Driven Development (www.featuredrivendevelopment.com).”

5.2.2 State of the art and practice

Recently, iterative methods have been gaining popularity especially in the field of software engineering but also in several other domains. Their positive influence to working efficiency and productivity are widely recognised but they are quite rarely utilised in the development of real physical applications.

The development of methodologies to build solutions by repeatedly identifying bottlenecks and posting constraints to solve them are typically performed by software, hardware and mechanics, where hardware includes computational and electronic components and structures.

On the other hand, the utilisation of modern methodologies to optimize the quality/time relation (such as Agile methods) in development of cyber-physical systems has been mostly limited to methods and practices for embedded software development. A quite typical impression is that these methods cannot be utilised in more rigid field of hardware and mechanics design and the embedded software development just adapts to the limitations and restrictions of the hardware and mechanics parts.

However, hardware and software development processes are more and more interlinked due to the increasing complexity of electronic devices for instance through virtualisation (Cawley et al. “Lean/agile software development methodologies in regulated environments – state of the art”, Lean Enterprise Software and Systems, 2010.).

It is possible to see that iterative methods have a lot of potential, not only to the development of embedded software but also to the whole range of design approaches present in systems like the proposal in LetItFlow.

It may be true that the agile methodologies, such as Scrum or Extreme Programming, do not fit straight and completely into development for this project, which is understandable because they originally are developed purely for software engineering. However, the ideas and the framework behind these methods, the Agile philosophy (proposed in Kent et al. (2001). "Manifesto for Agile Software Development". Agile Alliance), can still be adapted and used in wider selection of topics.

5.2.3 Applying the approach in LetItFlow project

The approach of exploring the benefits of integrating workflow analysis, Agile methodology and UCD was chosen in accordance with the specific and the objectives of the LetItFlow project.

During the implementation of LetItFlow solution, the Agile methodology will be used as an iterative and incremental model, considered as one alternative to the sequential model applied in software development.

Due to the use of Agile and UCD (User-Centered Design) methodologies for LetItFlow project we will need to have a more open-minded attitude, because combining these two methodologies cannot be achieved through a dogmatic attitude.

Agile does not mandate how to define concepts or overall design direction, but it is a great way to execute on solid design research, software development and well laid plans.

UCD needs to be flexible enough to respond to the reality on the ground when the implementation team encounters issues that mandate a different design solution.

The benefits from integrating Agile and UCD methods were presented in 2010 by Anthony Colfelt in a suggestive work with the following findings: “Document only what is needed to get the message across and co-locate if at all possible, because cross-disciplinary collaboration and face to face communication are vital. Working a sprint ahead of the development team is helpful in allowing the design team enough time to test and iterate.”

If these rules of engagement are followed, the two approaches can work very well together. By following the previous rules of engagement we believe that we will succeed in working with the innovative combination of Agile and UCD (User-Centered Design) in developing specific applications and tools of LetItFlow.

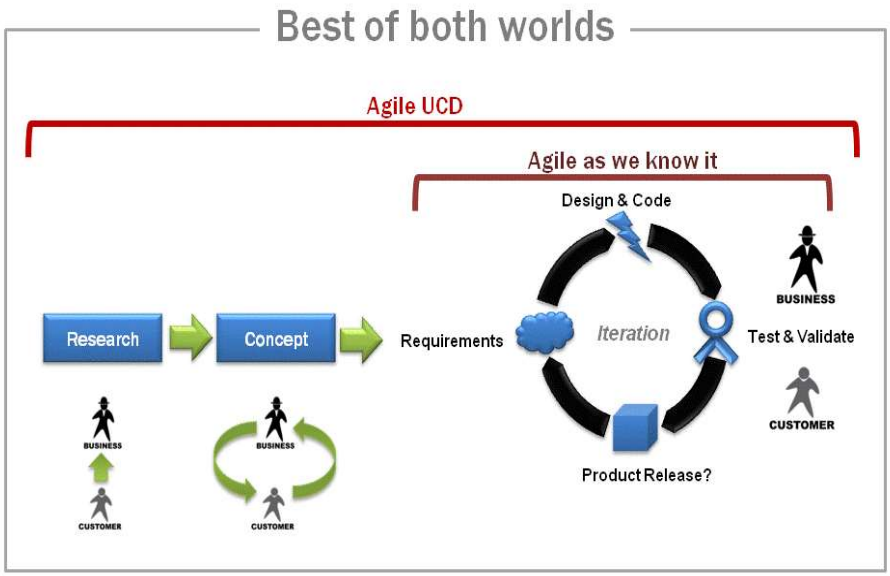

Figure 14. Integrating Agile and UCD in LetItFlow project (11, Colfelt A.)

5.3 Approach in user - centered design (UCD)

In section 5.3 we describe our general approach of involving users in the design process of the LetItFlow service development.

5.3.1 Background

User-centered design (UCD) is an approach in the design of products and services that has continuously evolved over the past decades. The goal of user-centered design is to design products that are easy to use and fit the specific needs and wants of its intended users (Vredenburg et al. 2001). The process has emerged from traditional software development approaches to explicitly account for the perspective of the user and to avoid getting lost in solving technical challenges first (Lowdermilk 2013). The main idea is to involve users from the start and in all stages of product / service development in an iterative manner: to move from a technology-driven approach to a user-driven approach (Vredenburg et al. 2001). User-centered design is not

only about understanding the users of a system but also requires an understanding of the tasks that users will perform with the system and of the environment in which the system will be used (Stone et al. 2005).

5.3.2 State of the art and practice

The current state of the art in user-centered design approaches is described in the ISO standard 9241-210 (International·Organization·for·Standardization, 2010). The goal and purpose of ISO standard 9241-210 is to provide information to relevant stakeholders that can be used in structuring the design process to account for user needs and wants in an effective and timely manner.

It proposes the following six UCD principles (p.9):

Principle #1: The design is based upon explicit understanding of users, tasks, and environments.

Principle #2: Users are involved throughout design and development.

Principle #3: The design is driven and refined by user-centered evaluation.

Principle #4: The process is iterative.

Principle #5: The design addresses the whole user experience.

Principle #6: The design team includes multidisciplinary skills and perspectives.

Based on these principles, ISO 9241-210 defines the following essential design activities:

- Understand and specify the context of use
- Specify the user requirements
- Produce design solutions
- Evaluate designs against requirements

The first activity, understanding and specifying the context of use, involves identifying users and tasks, and describing the environment. Thus, relevant questions to investigate are: Who are the primary and secondary users of the system? What are typical tasks and what are the goals associated with the use of the system? What are characteristics of the social and physical environment?

The second activity, specifying the user requirements, involves elaborating and structuring the information gained from the first activity. Thus, relevant questions to investigate are: What are the specific needs of the primary and secondary users of the systems? What are the specific needs associated with a task or with the use of the system in general? What are the specific needs derived from jointly considering the user and the social and physical environment he / she operates in?

The third activity, producing design solutions, involves designing solutions that fulfill the specific needs of the intended users. It involves generating concepts and sketches, producing mockups and various prototypes of the proposed solution / interaction with the system, which should all account for the specific needs identified and specified in the first two activities.

The fourth activity, evaluating the designs against the requirements, involves continuous evaluations throughout the development of the solutions. These evaluations can be based on feedback from real end users (in a lab or field setting) or from experts (people with extensive knowledge in user-centered design and related domains such as human factors, ergonomics, human-computer interaction, psychology).

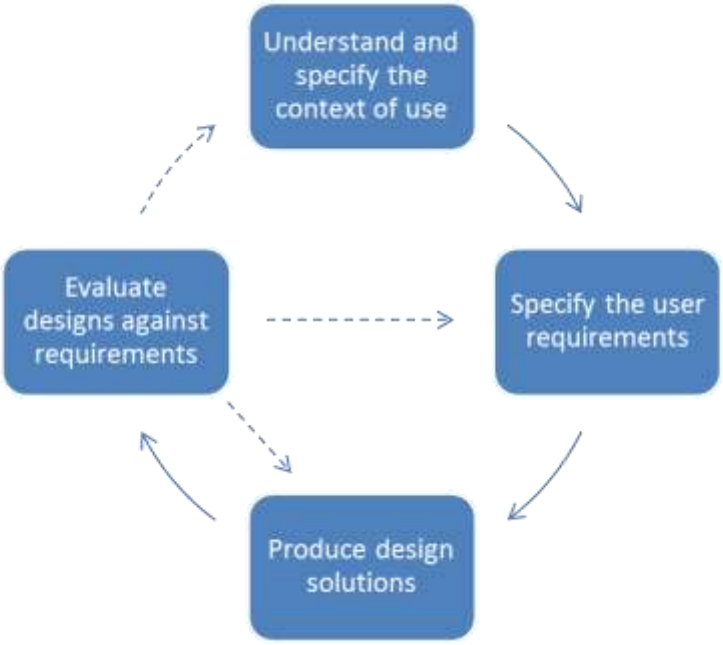

Figure 15. Essential user-centered design activities. Dashed arrows represent potential iterations based on user feedback (adapted from ISO 9241-210, Figure 1).

As shown by the dashed arrows in Figure 12, the user-centered design approach explicitly allows for feedback loops to the previous activities. Evaluations are conducted at different stages of the project and can lead to a reassessment and adaptations of the context of use, specific requirements, and the design solutions. This iterative aspect is crucial when user feedback is to be considered in the design and development process.

7.3.3 Applying the approach in LetItFlow project

¡Error! No se encuentra el origen de la referencia. gives an overview of the tasks that are part of the user-centered design approach in LetItFlow. In it the tasks are mapped to the four essential design activities according to ISO 9241-210 (see previous section). Each column represents an activity.

As part of **the first design activity**, understanding and specifying the context of use, we started with T2.1 Collection and Analysis of User Needs. The goal of this task was to get a first understanding of our target group (i.e., older health-care professionals: nurses, orderlies, lab technicians) and the context they work in, for which we employed a mix of methods including workflow analysis, questionnaires / evaluation forms, and semi-structured interviews (see D2.1). T6.1 Functional Market Analysis (scheduled for M6-M12) is another task that falls under this activity. The goal of this task is to investigate the commercial viability of the planned solutions, overall market conditions, and other macro context factors. Interviews, surveys, and possibly focus groups with various stakeholders (e.g., health-care providers, providers of BPM systems, hospital managers, & health care professionals) are among the employed methods for this task.

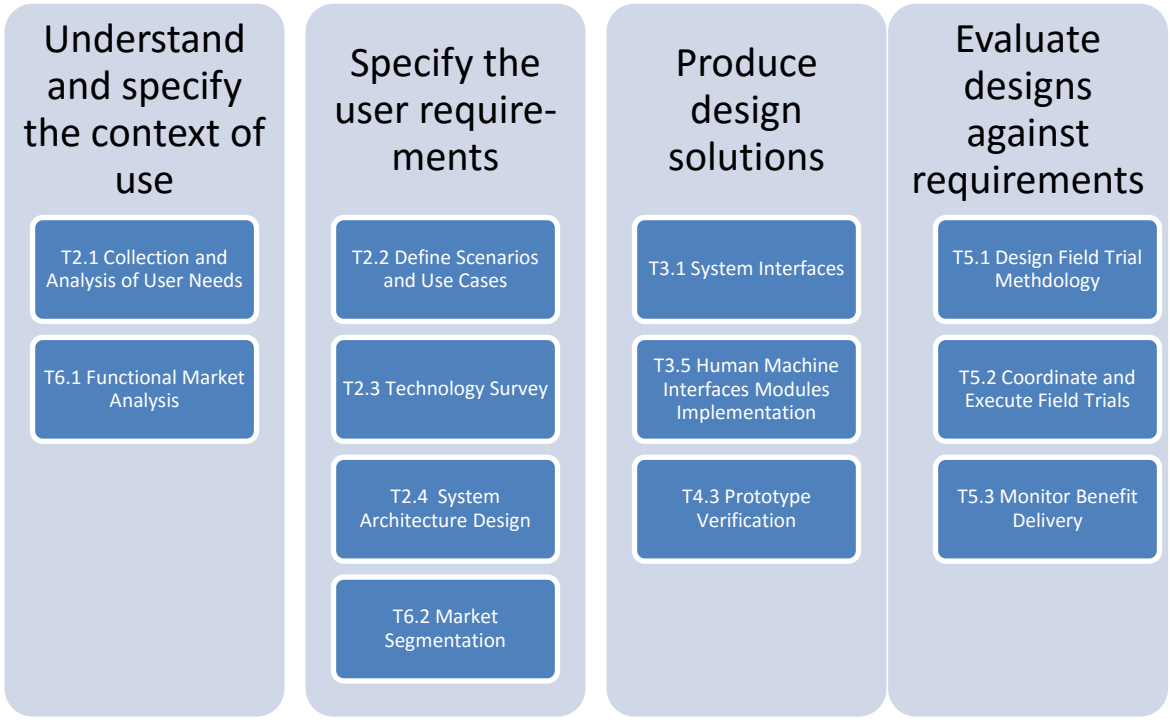

Figure 16. Essential user-centered design activities and tasks. Columns represent the activities with the tasks mapped to them.

The insights gained from both T2.1 Collection and Analysis of User Needs and T6.1 Functional Market Analysis serve as input for **the second design activity**: specifying the user requirements. T2.2 Define Scenarios and Use Cases and T2.3 Technology Survey are both reported in this deliverable (D2.2). The goal of T2.2 was to follow up on the insights gained from the T2.1 Collection and Analysis of User Needs (see D2.1) by devising scenarios and use cases that address relevant needs of our target group (see Chapters 4 & 5). The goal of T2.3 was to give an overview of the state of the art in technologies and methods (see current chapter with its subsections on workflow analysis; software development; user-centered design; communication & interoperability; training, human behavior, & cognitive factors). T2.4 System Architecture design is based on T2.1, T2.2, and T2.3. The goal of T2.4 is to develop an architecture for the proposed solutions that supports workflow and process improvements and emphasizes communication and interoperability. T6.2 Market Segmentation (scheduled for M12-M18) builds on the results from T6.1 Functional Market Analysis (to be covered in D6.1, M12). The goal of T6.2 is to propose a market segmentation of potential end-users for the developed solutions within LetItFlow.

As part of the **third activity**, producing design solutions, efforts will focus on translating the specific requirements from the previous user-centered design activity into design solutions. T3.1 System Interfaces will build on the architecture defined in T2.4. Tangible results from this task include mock-ups of user interfaces and a common development environment that meets the requirements of the modules by the partners involved. T3.5 Human Machine Interfaces Modules Implementation will be dedicated to the design and implementation of personalized interfaces as specified in the system architecture. T4.3 Prototype verification will focus on both a technical and functional assessment of the proposed solutions. This task includes verification of the preliminary and final prototype and will serve as an important in-between step in the user-centered design process. Initial feedback from end-users will provide a basis for adaptations and future developments of the system.

To address specifically the needs of older nurses in the development of the solutions (e.g., the user interfaces), we will further draw on guidelines and best practices in “designing for the elderly” (see Campbell, 2015, http://www.smashingmagazine.com/2015/02/05/designing-digital-

technology-for-the-elderly), taking into account important limitations faced by our target group such as impaired vision and hearing, a decline of motor skills and memory, and idiosyncrasies in attention and decision-making. Important recommendations are summarized in the Table 35 below.

Vision and hearing	Motor skills and memory	Attention and decision-making
• Font sizes of at least 16 pixels • Possibility to have users adjust font size • High contrast ratios • Avoid blue for important interface elements • Provide subtitles when video or audio content is essential	• Buttons on touch interfaces at least 9.6 millimeters diagonally • Buttons to be clicked with a mouse at least 11 millimeters diagonally • Avoid devices with small screens • Reminders/alerts for common tasks and actions • Clear feedback on task progress • Avoid feature overload	• Allow for enough time in interactions (careful with inactivity warnings, etc.) • Allow older people to focus on one thing at a time (avoid multi-tasking) • Older people value the opinion of experts in their decision-making

Table 35. Important recommendations and best practices when "designing for the elderly" (adapted from Campbell, 2015).

Finally, as part of the **fourth activity**, evaluating the designs against the requirements, the goal is to receive detailed feedback from our target group (i.e., older health-care professionals: nurses, orderlies, lab technicians). T5.1 Design Field Trial Methodology is dedicated to the design of a comprehensive evaluation plan for the solutions developed within LetItFlow that will take into account ethics, operationalization / measurement, criteria for selection of users, resource planning, etc. Building on this comprehensive planning, the evaluations will be performed in T5.2 Coordinate and Execute Field Trials at the two main trial sites in Romania (i.e., University Emergency Hospital Bucharest) and Spain (i.e., University Hospital Virgen Macarena). The goal of T5.3 Monitor Benefit Delivery is to further analyze the results from the field trials (T5.2) to derive guidelines and make suggestions for the subsequent development of the LetItFlow system.

5.4 Communication and interoperability

5.4.1 Background

One of the objectives of LetItFlow is to offer an interoperable platform. During a first analysis of the computing and communication infrastructure need for our use case, we discovered that we are dealing with close system and proprietary solutions that hinder the integration of LetItFlow with existing IT infrastructure. Our intention is to facilitate the integration of our solution with the rest if IT infrastructure in hospitals. For this purpose we plan to design an open architecture based on standards and with open interfaces to ease the interoperability of the solution. It is important to note that we do not aim to research in new communication, network or application protocols but just ensure that our solution could be combined with other Healthcare system at minimum effort.

5.4.2 State of the art and practice

The interoperability can be understood from different levels as described in the next figure. The figure is based on the interoperability layers defined in the SECRICOM project.

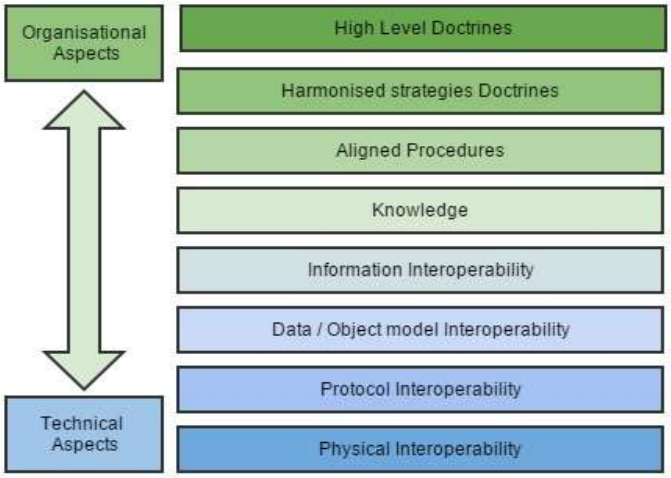

Figure 17. Layers of the Interoperability

In this domain the interoperability will be considered from a data exchange point of view. This implies that the common aspect will be the data exchange and the proposition of common requirements compatibles with the health domain.

Considering the distributed and mobile nature of our application, wireless communication is needed. Different technologies can be considered at different level of communication stack, such as 802.15.4, 802.11.x, Bluetooth (at low level), IP, TCP/UDP (networking level). At higher level, we enhance the interoperability by using standard protocols for information exchange, such as *Advanced Message Queuing Protocol* (AMQP), common and open Information Model and SOA based solution.

5.4.2.1. Communication protocols

This subsection includes an analysis of the most relevant wireless communication technologies. Four main requirements guide the selection of the technology: (i) Interoperability (based on standard), (ii) compliance with Hospital environment (for instance to avoid electromagnetic interference with equipment), (iii) low economic cost and (iv) to provide the adequate quality of services for the considered applications (in terms of bandwidth, easy to maintain or range). Based on these requirements, the most relevant technologies are described:

802.11n

The 802.11n is based on 802.11 and features Multiple-input multiple-output MIMO, 40 MHz channels, WLAN and Enhanced power management capabilities with regards to 802.11x. The technical features are the 2.4/5 GHz frequency bands, the 7.2 – 600 .Mbit/s data rate and the OFDM modulation. The typical range is between 10 - 70 meters.

The network protocol on top is Wi-Fi and the network topologies supported are star and peer to peer.

This technology offers the followings pros and cons:

Pros

- High data rate.
- 5 GHz mode
- Ease to implement a network.
- NLOS.
- Long range.

Cons

- High interferences in the bands of interest (2.4 GHz) due
- High power consumption.

802.15.4

The 802.15.4 is a standard that specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). The standard allows a low-cost, low-speed ubiquitous communication between devices.

The main features of this standard are that it is based on direct sequence spread spectrum (DSSS) techniques, the low power consumption and the fully acknowledged protocol for transfer reliability.

The following figure shows the frequency band and the data rate of this standard.

PHY (MHz)	Frequency band (MHz)	Spreading parameters		Data parameters		
		Chip rate (kchip/s)	Modulation	Bit rate (kb/s)	Symbol rate (ksymbol/s)	Symbols
868/915	868–868.6	300	BPSK	20	20	Binary
	902–928	600	BPSK	40	40	Binary
868/915 (optional)	868–868.6	400	ASK	250	12.5	20-bit PSSS
	902–928	1600	ASK	250	50	5-bit PSSS
868/915 (optional)	868–868.6	400	O-QPSK	100	25	16-ary Orthogonal
	902–928	1000	O-QPSK	250	62.5	16-ary Orthogonal
2450	2400–2483.5	2000	O-QPSK	250	62.5	16-ary Orthogonal

Figure 18. PHY technologies and data rates

The typical range is 10-75 meters. The network protocols are Zigbee, Wireless HART, ISA - SP100, IETF IPv6 – LoWPAN and the network topologies supported are star and peer to peer.

This technology offers the followings pros and cons:

Pros

- Low cost.
- Low power.
- Ease to implement a network.
- NLOS.
- Long range.
- Security.
- Many solutions in the market

Cons

- High risk of interferences due to de bands of interest (2.4 GHz or 868 MHz).
- Low data rate.

802.15.4a, UWB

IEEE 802.15.4a (formally called IEEE 802.15.4a-2007) is an amendment to IEEE 802.15.4 specifying that additional physical layers (PHYs) be added to the original standard. IEEE 802.15.4a specifies two additional PHYs using ultra-wideband (UWB) and chirp spread spectrum (CSS). The UWB PHY is designated frequencies in three ranges: below 1 GHz, between 3 and 5 GHz, and between 6 and 10 GHz.

A variety of well-known and more established wireless communication technologies (e.g., OFDM, DS-CDMA) can be used for UWB transmission.

The typical range is approximately 10 meters.

This technology offers the followings pros and cons:

Pros

- Wide Bandwidth
- Low average power spectral density
- High temporal resolution
- High information transmission capacity
- Higher data-rate
- Immunity to multi-path fading

Cons

- Short operating ranges
- Interference with other licensed, “narrowband” systems.
- Little mature (little standardization)
- No final commercial products

Bluetooth

Bluetooth is an IEEE 802.15.1 specification (Class 1). The main features are the Low power consumption, with a short range and the three classes.

It operates in the 2.4 GHz band (74 channels) with a data rate of 1 Mb/s – 24 Mb/s.

The typical range is between 1-100 meters (Transmission power of 1 mW – 100 mW).

The topology supported is Ad-hoc only for very small networks (<8 nodes)

This technology offers the followings pros and cons:

Pros

- Security

Cons

- Wake-up delays are typically around three seconds
- Few solutions in the market

IrDA

IrDA transceivers communicate with infrared pulses (samples) in a cone that extends minimum 15 degrees half angle off center. The main features are WPAN, the very low error rate and the need of Line-Of-Sight (LOS).

The data rate is 2.4 kbit/s - 1 Gbit/s (usually includes some redundancy for error detection or correction). The wavelength is 850-900 nm. The range is between 0.2 up to few meters and the topology supported is star or mesh.

The protocols are indicates in the following schema:

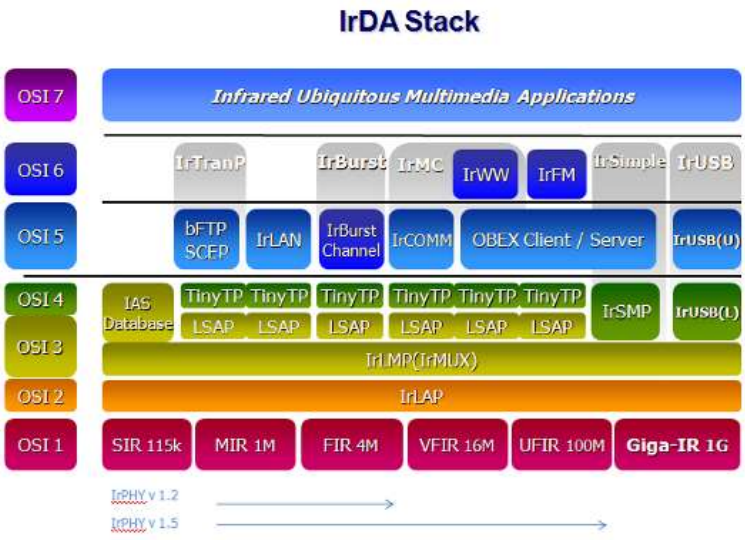

Figure 19. IrDA stack protocol

This technology offers the followings pros and cons:

Pros

- IrDA Data is secure. Data being transmitted via infrared is very difficult to intercept or hack because it is directional.
- Is relatively free from regulation. Infrared frequencies are just below the visible light on the electromagnetic scale so there is no restriction on anyone who wants to use them.
- Avoid signal conflicts.
- No antenna.
- Low cost.
- Low power.

Cons

- Required line of sight.
- Interferences due to the light.
- Short range.

VLC

Visible light communication (VLC) is a data communication medium using visible light between 400 THz (780 nm) and 800 THz (375 nm). It uses a vast unregulated and free light spectrum. It is considered to be a solution for overcoming the crowded radio spectrum for wireless communication systems.

The specification of VLC is included in IEEE 802.15.7

VLC operates with a data rate of 4.8 kbps and a very long range (up to 2 km) and with the topology peer-to-peer.

This technology offers the followings pros and cons:

Pros

- Communication without light flickering
- Use Lights on everywhere, indoor/outdoor
- No EMI/EMS, No damages for human's health
- Easy to make shielding area by blocking light/signals
- No conflict with Radio-restricted areas

Cons

- NLOS.
- Interferences due to the visible light.
- No available solutions in the market.

A resumed comparison between technologies is included in the next table:

	802.11	802.15.4	802.15.4.a	Bluetooth	IrDA	VLC
Range	50-100 meters	10-100 meters	10-100 meters	10 – 100 meters	up to 2 meters	up to 2 km
Operating Frequency	2.4 and 5 GHz	868 MHz (EU), 900-928 MHz (NA), 2.4 GHz (worldwide)	3-10 Ghz	2.4 GHz	Infrared spectrum	Visible light spectrum.
Complexity	High	Low	High	High	Low	High
Power consumption	High	Very low	Very low	Medium	Low	Low
Topology	Point to hub	Ad-hoc, peer to peer, star, or mesh	Ad-hoc, peer to peer, star, or mesh	Ad-hoc, very small networks	Ad-hoc, very small networks	Peer to peer
Security	128 AES plus application layer security	-	AES block cipher (CTR, counter mode)	64 and 128 bit encryption	-	-
Cost	Low	Low	High	Low	Low	High

Table 36. Comparison among wireless technologies

The final selection will be done in the architecture specification. Initially, the most promising candidates are WiFi for medium range communication and Bluetooth for short range.

5.4.2.2. N-Linx middleware

The N-Linx Software Development Kit (SDK) is a set of development tools, develop by Noldus, which allow software engineers to create inter-process and cross-language communication services. It offers a flexible and scalable communication platform for communication between systems, in particular with Noldus products.

The strength of N-Linx is standardization - standardization of the APIs in different programming languages and standardization of the messages that you exchange between applications.

This SDK includes the binaries and header files for programming N-Linx into your application, sample projects for a quick start up and extended technical documentation.

Three often employed use cases of N-Linx are:

Client Server

As a client application you make a remote request call and receive the result. For example: you can retrieve a list of sessions from an application. The call is made using a direct exchange type targeting one specific application in the network, the server. The targeting is based on the routing key.

Sending notifications

You have a change in your application and want to inform all interested applications in the network of your modification. In this case you broadcast a notification using a fanout exchange and every application that is listening on the notification exchange/channel receives this update.

Broadcast live data

Your application produced live data, for example eye tracking position data. You can broadcast this live data in the network using a fanout exchange. Every application that is interested can listen on this channel/exchange and receive the live data.

Architecture

N-Linx is an interprocess and cross platform communication library which has been built on top of RabbitMQ and TCP network protocols. It is a small layer but the main purpose of N-Linx is standardization. First it offers out-of-the-box an easy accessible and standardized API in C, C++, C# and Java and with the potential to support numerous other programming languages. Second, N-Linx standardizes the messages and data which are exchanged between applications by means of contracts (Figure 20, blue blocks).

The N-Linx library is composed of a base module and a Thrift module (https://Thrift.apache.org/). The Thrift module extends the base module with a full RPC-like framework. The main difference between both modules is that the Thrift module adds type safety, versioning of interfaces and a boilerplate server framework. Both modules support the exchanges and communication patterns as described above.

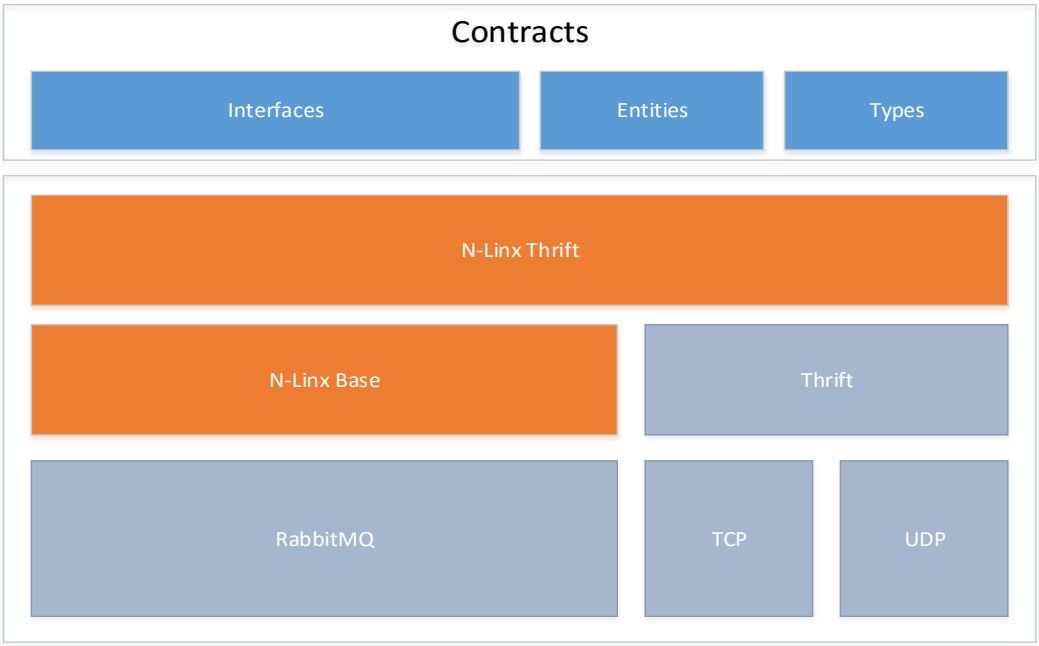

Figure 20. N-Linx architecture, built on top of RabbitMQ and TCP/UDP network protocol and extended with Apache Thrift module

N-Linx consists of a Base library and a Thrift library. N-Linx Thrift extends Thrift over RabbitMQ. The contracts define what is sent between applications.

Opensource libraries

RabbitMQ is the distributed message broker of N-Linx since it is open source, fast, scalable and platform independent. It is easy to use and there are client libraries in various languages available (e.g. C++, .NET, Java, etc.). RabbitMQ implements the AMQP (Advanced Message Queuing Protocol, see also http://www.amqp.org) which is an open standard for passing messages between applications. The vision of AMQP is to create the standard protocol for interoperability between all messaging middleware in the same way as SMTP, HTTP, and FTP have created interoperable systems. AMQP is not an API but a wire level protocol. Consequently any tool that can create and interpret messages that conform to this data format can interoperate with any other compliant tool irrespective of implementation language.

Thrift is a software framework for scalable cross-language services development (https://Thrift.apache.org/). It has a code-generation engine that produces source code from an IDL file in numerous programming languages. Thrift has a three-layered architecture consisting of a lower transport layer, a middle protocol layer and a top server layer. N-Linx Thrift has a special transport layer based on RabbitMQ messaging which highly enriches the communication possibilities as compared to the standard point-to-point TCP communication.

5.4.3 Applying the approach in LetItFlow project

After study and analysis of different communication technologies from the LetItFlow point of view it is possible to draw some conclusions. The communication protocols that are initially envisaged to be the best candidates are WiFi for medium range and Bluetooth for short range. Moreover, an IP approach for networking level is considered to allow the interoperability of data exchange and a paradigm of request-response is the logical way. This decision may be revisited during the architecture and implementation depending on further tests and available devices.

In next deliverables the protocols, detailed specifications of the solution components and architecture will be described.

5.5 Training, Human behaviour and cognitive factors

5.5.1 Background

In human factors research, the physical or cognitive properties of humans are studied while handling a certain operating system. The aim of human factors research is to improve the performance and safety of the system. The behavior of test participants is monitored when handling the system in a normal way. These data are used to improve the system.

Next to the behavioral observation, a variety of data can be collected from the test participants, like eye movements with an eye-tracker, emotional states with FaceReader, or physiological data like heart rate and galvanic skin response. This results in a rich set of data streams, the manual observation, the external data, and in some cases simulator data as well.

For proper analysis of these diverse data sets, they need to be synchronized. The results can then be integrated and analyzed together. This way one can, for example, analyze what the emotion of

test participant was while carrying out a certain task, or what the behavior of a test participant was during a certain phase in a simulator.

The Observer XT is a powerful tool for human factors studies. The behavior of test participants while handling an operating system can be coded and analyzed. In addition to this, external data like data from a simulator, eye tracker, FaceReader or a physiological data system, can be imported into The Observer XT.

These data can be synchronized with the manual observation in The Observer XT. Then you can select certain time fragments, based on the behavior of the test participants, or the external data, and analyze the data during this time.

Examples of human factors studies are monitoring a flight crew in a flight simulator, monitoring drivers in a car simulator, or monitoring test participants while carrying out a task on a computer.

Figure 21. Example of a setup of a human factors study

The image above represents the video footage of a test participant is opened in The Observer XT and the behavior is manually coded. External data, like simulator data, physiological data, eye-tracker or FaceReader data are imported into The Observer XT and synchronized with each other and with the observation.

5.5.2 State of the art and practice

5.5.2.1. Multi-video recording for detailed task analysis and training

The use of video can greatly expand the scope of research projects. It allows you to make frame-accurate descriptions of behavior. Audio signals are visualized, providing another graphical aid in objective behavior assessment.

Viso is a tool, developed by Noldus, for high quality recording of video and audio in multiple rooms and therefore extremely suitable for medical simulation labs. With Viso, you can create

synchronized recordings from up to 4 IP cameras (Pan-Tilt-Zoom or stationary) at once, including audio in each room. When recording, you can set markers or add comments from any location. In each session you can choose a different marker list and annotate the behaviors you want to focus on. Videos with markers and notes can be viewed both in real-time and after a session, from any location, allowing you to set up a debriefing session wherever you want. Because there is no delay in the debriefing, the educator's attention can be completely focused on the learners' behavior.

For comparing different sessions recorded with Viso, The Observer XT can be used. All videos can be imported to and analyzed in The Observer XT.
With the The Observer XT, software tool see also http://www.noldus.com/observer, researchers can code behaviors, but, they can also use it for data integration and synchronization of video, audio, and simulator data, such as heart rate and blood pressure of the medical simulation mannequin. As a result, medical professionals can quickly analyze user tasks, human performance, and combine physiological data with behavioral data. The Observer XT automatically synchronizes physiological data and scored behavior with the video files of one or more cameras.

Figure 22. Integrating eye tracking into your simulation lab to capture gaze patterns

With reliability analysis you can compare recordings made by different users (inter-rater). The annotations are compared record by record and The Observer XT reports Cohen's Kappa, along with a listing of agreements and disagreements between users. This list is linked to the video, and clicking on an event allows you to see the point in the video it refers to. Reliability analysis is also used as a basic quality check and quickly indicates task errors.

Figure 23. A simulated OR can provide a secure environment for training and evaluation: protocols or high-tech tools can be tested and scenarios can be simulated

5.5.3 Applying the approach in LetItFlow project

The training of the persons that will use the types of devices and specific applications developed in this project is very important taking into account that all this devices and software applications are addressed to elderly medical staff over 50 years.

Using the developed application LETTRAIN and the proposed devices will improve the quality and safety of the medical act, but also the health care efficiency and time spent with patients.

The proposed devices used by nurses and orderlies/sisters will help them to better schedule the daily tasks, to streamline the approach of emergencies regarding other colleague or a patient and will offer a good way for preventing errors and adverse events as medication errors, miscommunications, delays in treatment.

The quality of training programs depends on factors such as the format, duration and content of the training program, the expertise of the trainer in this area, staff education level, and staff attitudes toward implementation of these new techniques/procedures. All of these factors should to be addressed to improve the quality and efficiency of the training. Effective training positively impacts the knowledge, attitudes, and self-efficacy of mental health staff and can improve generalized care giving skills as well.

It is to be expected that characteristics of nurses/sisters will affect the adoption of this new technology used in a hospital within LetItFlow project but from our point of view every nurse/sister will be willing to use these devices because they will be convenient, easy to use and will target a high-risk and high-prevalence problem such as emergencies having in mind that this devices are dedicated to the personnel working in an emergency hospital. These all above mentioned data are consistent with organizational goals of this training.

The key outcomes of implementing this technology by different methods of training are effectiveness, efficiency, nurse/orderly satisfaction, competency with improved work productivity, shorter performance times, improved quality of medical act and desirable psychological and behavioral outcomes.

Optimally, the training of target group of LetItFlow for implementing these devices has an important goal because this technology is designed to minimize errors and buffer the consequences of errors by eliminating errors and adverse events; reducing occurrence of errors/adverse events; detecting errors early, before problems occurs; and mitigating the effects of errors after they occur.

The goal of the training program is to prepare competent nurses/sisters over 50 years to use the specific application LETTRAIN and the newly implemented devices and to evaluate at the end of the training the cognitive (knowledge), psychomotor (skills), and affective (behavior) learning domains.

The training program will contain lectures regarding the type of devices to be used (tablets, wide touch screens connected with the tablets, smart bracelets/watches), the type of applications used by these devices and the applicability of these regarding day by day activities, the way every application is useful for patients, how to get information about the tasks scheduled for the day in course, how to modify, delete or add a task, what is the status of the task if it is completed or not but the most important fact is to help elderly nurses/sisters understand how all the alarms works in case of different emergencies like in case of an emergency with a member of the target group from this project like an elderly nurse/sister as described in the scenarios and use-cases or in a case of emergency regarding a patient. The lectures will be designed and implemented according to the scenarios compatible with these devices.

The lectures will be followed by practical sessions in all the labs of the University Emergency Hospital Bucharest but also in the rooms, in these sessions practically the elderly nurses/sisters will be assisted by the training stuff to learn how to use these devices. In these practical sessions all the

scenarios will be simulated especially those emergency ones where the time of action should be very short and they should respond promptly.

Upon completion of the training the abilities of the elderly nurses/sisters will be assessed using written tests but also by evaluating their newly developed skills by using directly these devices and applications run by them.

The nurses/sisters will be encouraged to ask for supplementary hours of training if some of the data regarding these procedures or techniques are not clear or misunderstood.

After one month of using all the implemented devices it would be performed training for those persons who are not fully familiar with the devices, and again all the knowledge gained during the lectures and practical sessions will be assessed.

The nurse or the orderly that shall need support in the situation when a new work procedure or new technique will be put into practice (e.g. she forgets a certain aspect/element and needs for refreshing the information) will use the specific features offered by LETTRAIN.

6. SUMMARY AND OUTLOOK

The current deliverable explores the most representative scenarios based on the analysis of *processes workflows* and *tasks management*, based on the daily activities of the Neurology Department (UHB) and of the Automated Laboratory of Biochemistry – SAR (HUVM).

The selected Scenarios were then formalized into specific use-cases, using the Agile and UCD (user centered design) methods and principles.

The result for this stage of the project is represented by the major functionalities of the solution that would be implemented in LetItFlow:

- LETAPP
- LETALARM
- LETCRITICAL
- LETSIM
- LETTRAIN.

The section **4.3. UHB and HUVM – Similarities and particularities in the scenarios** presents the common functionalities and the specific ones for the two hospitals, in an intuitive diagram.

The deliverable also presents in section **5. Technology survey** a research about the existing technologies, methods, tools and techniques that are useful for LetItFlow project.

In order to design an optimal solution for LetItFlow project we have used the following methods:

- The workflow processes analysis
- The standardized methodology – Agile
- The User-Centred Design (UCD) method.

As presented earlier, in the section **3. General approach**, by using the above-mentioned methods the deliverable identifies the most representative scenarios based on *the analysis of process workflows*, i.e. daily activities of Neurology Department (UHB) and Automated Laboratory of Biochemistry – SAR (HUVM). The selected Scenarios have been then formalized into specific Use-Cases, through integrating the Agile methodology and UCD (user centered design) concepts and principles.

In section ***5.1 Workflow analysis methods and tools***, two tools for workflow modelling and simulation have been studied and analysed and tha they can be used to evaluate the workflow performance in different scenarios and the detection of bottlenecks.

In section ***5.2 Approach in software development*** the Agile methodology was studied from the perspective of the objectives of the project. The conclusion is that this methodology (and the iterative methods in general) can be adapted and improve the software solution through the communication of the different partners in this project.

In section ***5.3 Approach in user - centered design (UCD)*** the user-centered design (UCD) approach was exposed and particularized for the LetItFlow project. This section summarizes the work scheduled and the next steps from the design point of view.

In section ***5.4 Communication and interoperability*** the communication protocols and some communication specification were analysed from the point of view of interoperability requirements and the project objectives. Some ideas were extracted of the study such as WiFi and Bluetooth are the best candidates as the communication protocols, IP based network eases the data exchange interoperability and the high level paradigm of request-response meets the proposal performance of the application.

In section ***5.5 Training, Human behaviour and cognitive factors*** have been analyzed tools of video recording for human behaviour analysis in order to determinate task features and modelling (such as Observer XT) and simulation tools for provide a secure environment for training. The objective is to recollect ideas and features of the LETTRAIN application.

ANNEXES

See the attached documents:

- Diagnosis schema.jpg
- Protocol – First aid in emergency – 1.jpg
- Protocol – First aid in emergency – 2.jpg
- Protocol – First aid in emergency – 3.jpg
- Protocol – First aid in emergency – 4.jpg
- Protocol – First aid in emergency – 5.jpg
- Protocol – First aid in emergency – 6.jpg.

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