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D6.7 Implementation of the Health AdCoS and HF-RTP Requirements Definition Update

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1 Introduction

This document describes the implementation of the Health AdCoS and feedback to the HF-RTP. Since there are multiple AdCoSs for the Health domain, each chapter covers a separate AdCoS. Each chapter starts with a short AdCoS introduction, followed by a description how the MTT's from the HF-RTP have been integrated. Furthermore, an impression of the HMI is given. Finally, each chapter concludes with next steps, feedback, and if relevant an update of the HF-RTP requirements.

The order in which the AdCoSs are described in this document is derived from an overall scenario, which describes the flow of a patient through the hospital.

AdCoS

1. Medical consult
   - Operator task schedule
   - Querying open EHR Data

2. MRI examination
   - Guided patient positioning
   - Robust VCG triggering
   - Safe parallel transmit scanning

3. iXR treatment
   - 3D Acquisition

4. Data analysis, reporting
   - Internal analysis and reporting

2 Operator task schedule and guidance

2.1 AdCoS description

The objective of this AdCoS is to ease the collaboration between the different actors and systems that compose a laboratory in a medical environment (i.e. Automated Laboratory of Biochemistry General at the Hospital Macarena of Seville). More specifically, the AdCoS is focused in aspects related with the proper assignment of tasks in a clinical laboratory and the ability to manage real time instructions (alarms, checkpoints, reminders) and to optimize the workflow and cooperation among operators.

2.2 MTT and modules integration

In the previous deliverables we have already provided an analysis of the HoliDes methods and tools initially selected as the candidates for accomplishing the use case. These MTTs are RTMAPS, GreatSPN, HEE and the task modelling approach proposed in WP2, with the MagicDraw tool and MagicPED plugin. We also explored the use of RTMAPS.

All those tools, except the HHE –which will be further analysed during the evaluation phase-, have been used for modelling and designing the processes that compose the use case.

At this phase of the project the focus is on the implementation stage, and the current deliverable reports such activity.

For implementing the Operator task schedule and guidance use case it has been finally decided to use the Bonita BPM software as the main workflow engine platform, as it provides a series of advantages over other solutions:

- It enables developers to create highly engaging, powerful, personalized, process-based applications that can be adapted to business changes in real time.
- It uses notation compatible with the Business Process Modelling Notation (BPMN) standards (i.e. BPMN 2.0). Such standards expose a very simple graphical language and nomenclature which can be easily learned by non-technical staff. Therefore, it is a very simple and powerful tool for connecting the business and technical related

departments and for facilitating the agreement on the different business processes that must rule a given organization.

- The Bonita execution engine runs behind the graphical interface, which connects the processes to the existing system to deploy and run the process. The business logic, data and user interfaces are totally decoupled, so it makes easier to develop adaptive user interfaces.
- The platform is totally open and has been designed for allowing to be connected to other systems and platforms through custom connectors.

2.2.1 Prototype architecture

Aiming at planning the deployment of the use case in the real scenario of the laboratory, a basic architecture is proposed. Such architecture is represented in Figure 1. Some further refinement will be probably required during the final releases.

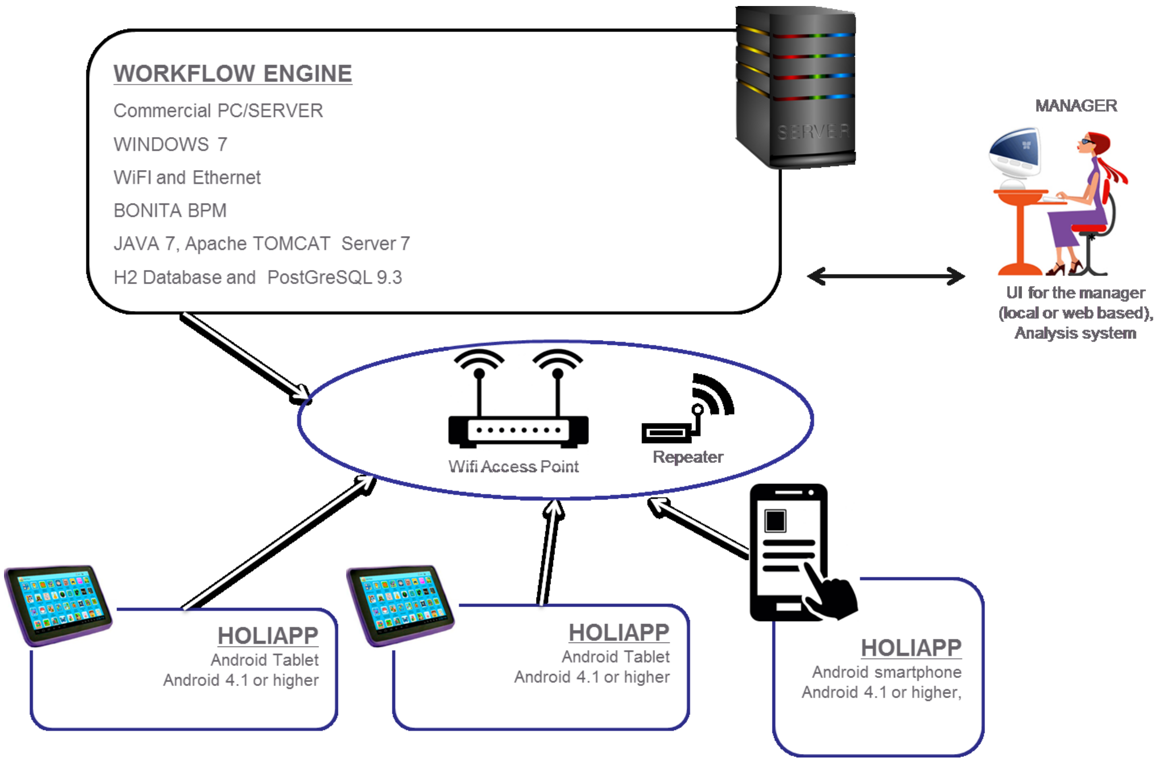


Figure 1 Operator task schedule and guidance use case: tentative architecture

As it can be observed, we plan to deploy a new server at the laboratory, whose main role is to run the workflow engine module. This will be based on the Bonita BPM 7 platform and Java 7 technology. Such platform will make use of the Apache Tomcat 7 web server and the PostGreSQL database technologies for respectively providing web-based user interfaces and persistence to the business process logic.

The mobile devices include two Android tablets, which will be deployed in fixed positions and one smartphone. The connection between the server and the different mobile devices will be established via a WiFi access point. Some repeater might be required for extending the coverage of the WiFi signal throughout the laboratory.

Two main modules compose the Operator task schedule and guidance use case: the workflow engine and the Holiapp. Based on the architecture depicted in Figure 1, we envisage deploying the workflow engine at the server machine, and the Holiapp at the mobile devices.

2.2.2 Data model

The workflow engine communicates with the Holiapp in the mobile devices via REST interfaces. In order to define such interfaces and ease the integration work, it is important to define first a data model that allows creating a common reference point for all the modules.

Aiming at better understanding the data model, we present some of the key concepts that the entities in the diagram represent:

- Process: A process is a sequence of tasks. The sequence has a start and an end, and can contain decision points, known as gateways. A process definition is constructed as a flow diagram (based on BPMN 2.0 standard).
- Task: A task is an activity in a process. Tasks may be performed by people (human tasks, which normally involve using a form to enter data or to receive information) or automatically (service tasks, invisible to users during normal operation).
- Case: A case is an instance of a process. This means that a process might be executed in parallel by different users, and the workflow engine maintains independent information for each instance.
- Organization: The set of all the users who play a part in all the processes that model the business uses. Typically, the organization corresponds to the hierarchy of teams within the business, so an

organization is characterised by groups, users and the role of users in the groups.

- Actor: An actor is a placeholder specified in the process definition for the users. Using an actor instead of specifying real people directly makes the process definition more flexible: when the list of users changes, only the process configuration needs to be changed. Making the connection between the actor definition and the set of users is called actor mapping.

The data model has been defined using a conceptual entity-relationship diagram, which is represented in Figure 2. Usually, such diagrams are used also for describing or modelling the basic structure of the database that will contain the system information.

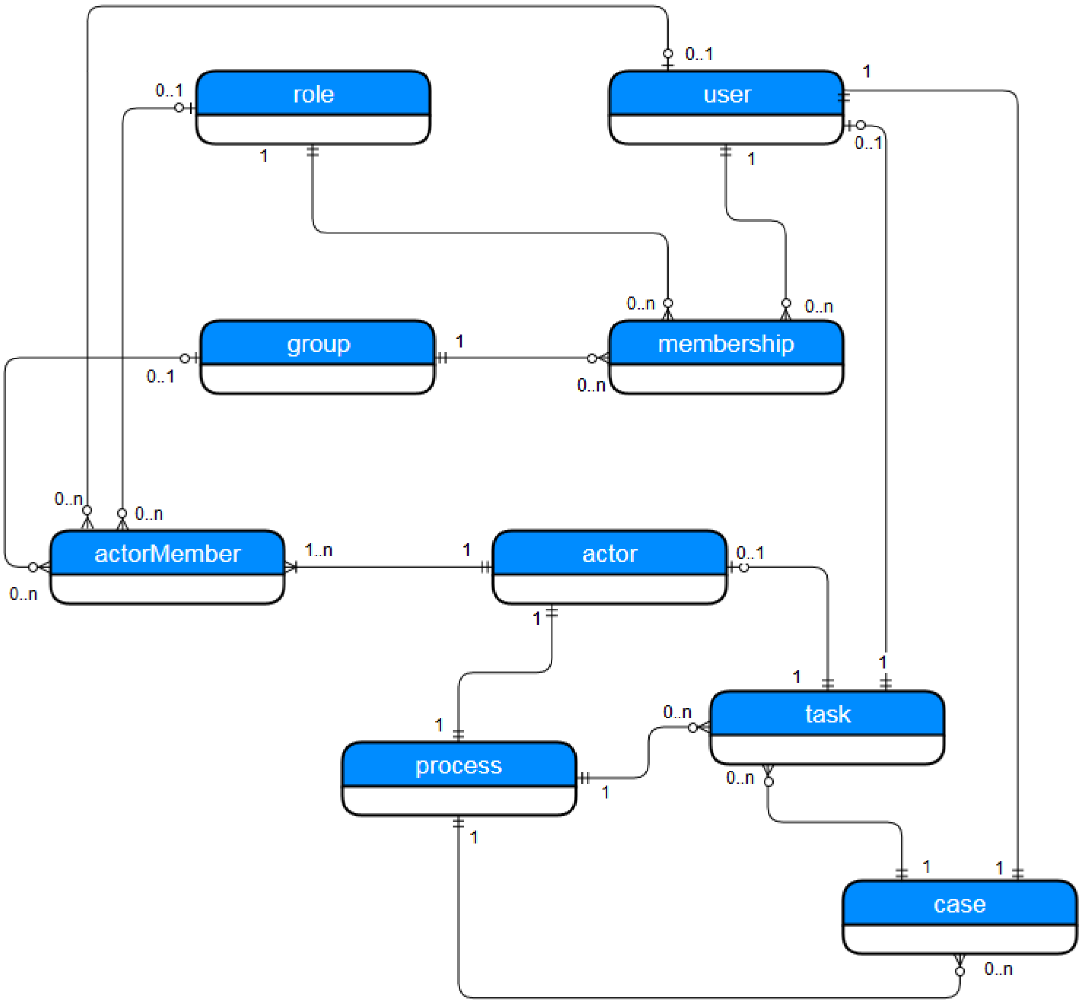


Figure 2 Operator task schedule and guidance use case: workflow engine data model

The entity "role" represents the role of a user in a group, and "group" represents the group a user belongs to. There is a membership when a user belongs to both (a group and a role). A user may have more than 1 membership defined (i.e. different roles in different groups). An example of a membership might be: Mary (the "user") is a member (the "role") of the Laboratory department (the "group"). Therefore, using the "membership" entity, the developer may characterise any organization by distributing the staff (i.e. user) in different departments (i.e. group) and with different functions (role).

The "actor" entity has a similar meaning as the actor of the use case definition; it is a generic categorization of the person who can perform a process. Examples of actors in the use case might be a laboratory technician, chain master, etc. By using the "actorMember" entity, it is possible to establish the mapping between a generic actor of a process and a specific user, group or role.

The "process" entity models a process, which is a sequence of tasks represented as a flow diagram. A "case" entity represents a process instance. The "case" entity is related to a "process" and also to a "user" entity, which represents the user that started the case.

Regarding the "task" entity, there is a relation to the process and case which contain the task, and also to the user who executes the task (only in case it has been already executed). Optionally, it can be defined the actor that can execute this task.

2.2.3 Interfaces

As mentioned previously, the interfaces defined for this AdCoS are based on REST technology. The REST interfaces have been classified in different categories (e.g. user management, task management, business data model, etc.). For each category it has been defined a number of resources (e.g. for the user management category, we can define as resources user, group, role, etc.). The representation of the resource is provided as a JSON object. For each resource it has been defined the services that will operate on it. In most of the cases, these operations fall into the CRUD categories: Create, Read, Update, Delete, which respectively correspond to the POST, GET, PUT and DELETE methods used in REST. Alternatively, some more specific operations have been defined (e.g. Search).

In the following paragraphs we list all the resources that the workflow engine and Holiapp use for communicating and the operations that can be performed on them:

- user: create, read, search, update, delete
- group: create, read, search, update, delete
- role: create, read, search, update, delete
- membership: create, search, delete
- actor: read, search, update
- actorMember: create, search, delete
- process: read, start
- case: create, read, search, delete
- task: read, search, update

2.3 HMI Implementation

At the time of writing this document, the HMI is still being developed. It is mainly composed of a PC based interface for the laboratory manager and a tablet/smartphone based interface for the operators. While some mock-ups of the latter one have been already presented in previous deliverables, we present here some of the PC based interfaces for the manager.

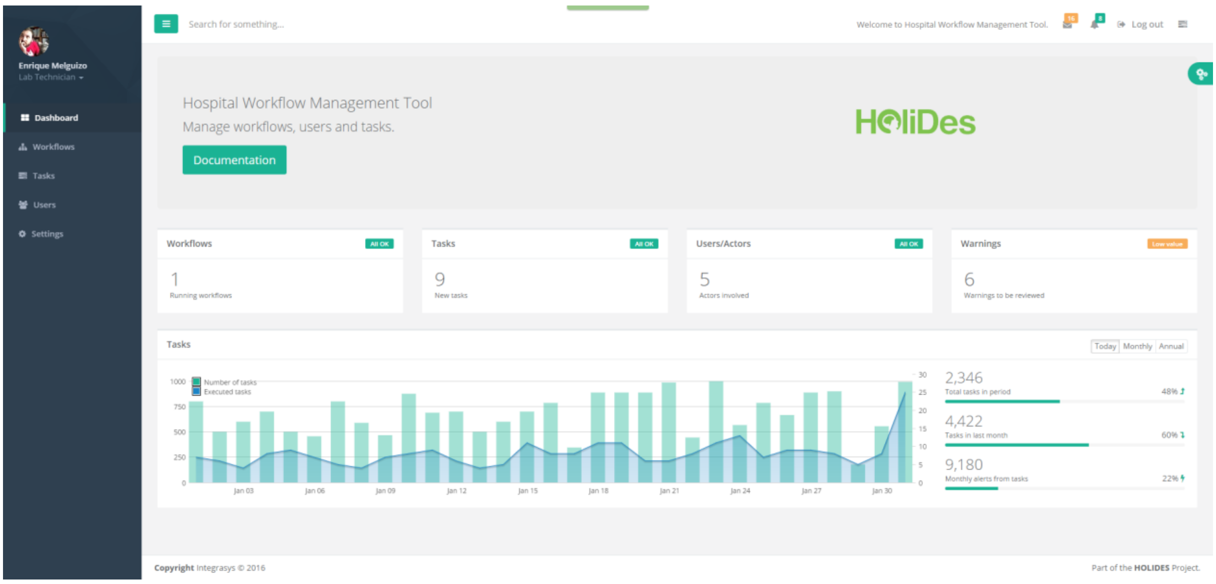


Figure 3 Operator task schedule and guidance use case: workflow engine UI interface (dashboard)

The Figure 3 represents the main page of the workflow engine HMI which will be only accessed by the manager of the laboratory. In this page, the manager may visualize some statistics related to different processes performance indicators and access to other managerial functions.

By using this HMI, the manager is able to visualize the workflows installed in the engine, modify some of their properties (e.g. user assignment, time schedules, etc.), visualize the tasks and the users assigned to those tasks, or manage the users. All these features are represented in the next figures.

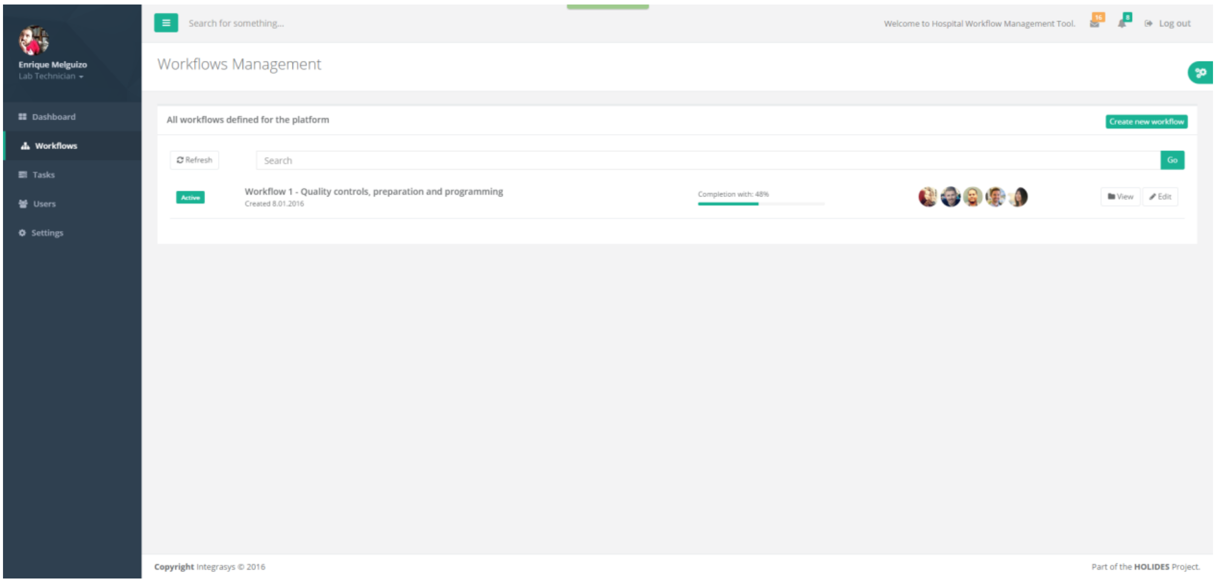


Figure 4 Operator task schedule and guidance use case: workflow engine UI interface (list workflows)

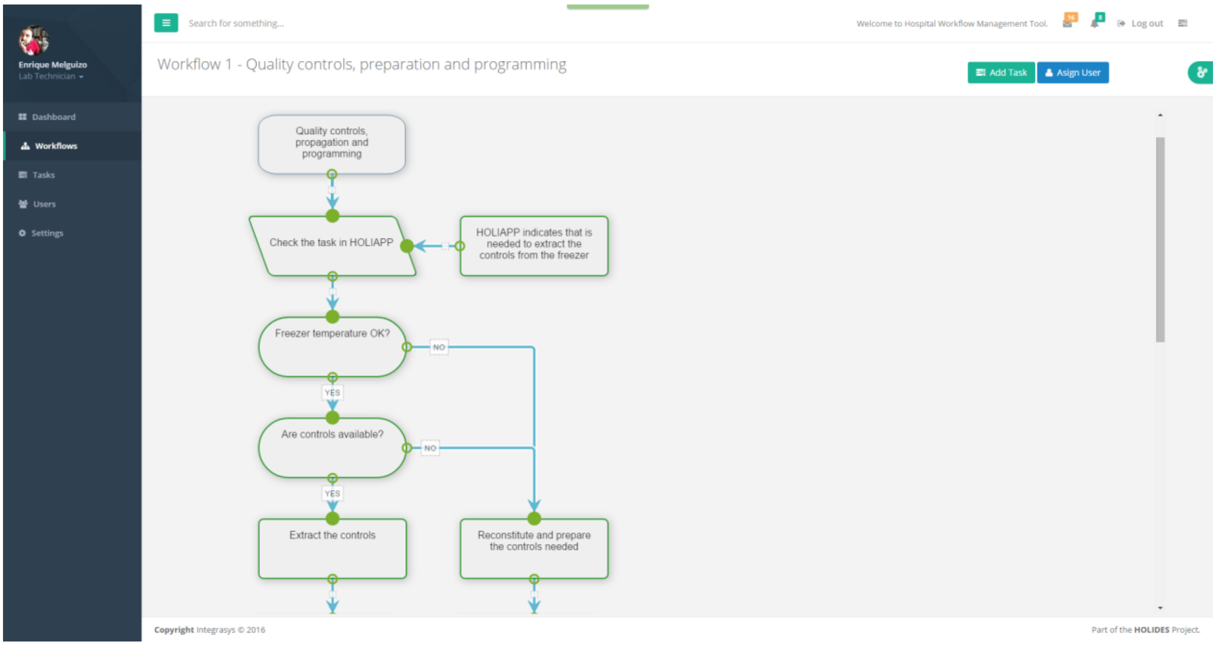


Figure 5 Operator task schedule and guidance use case: workflow engine UI interface (visualize workflows)

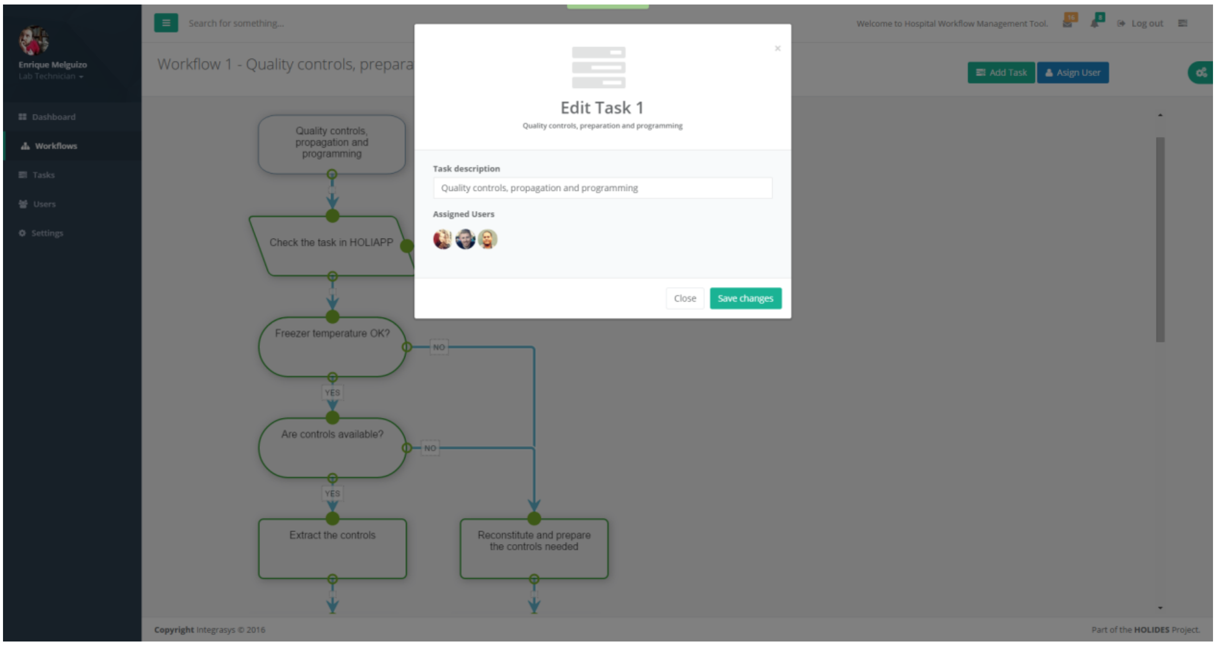


Figure 6 Operator task schedule and guidance use case: workflow engine UI interface (edit workflow properties)

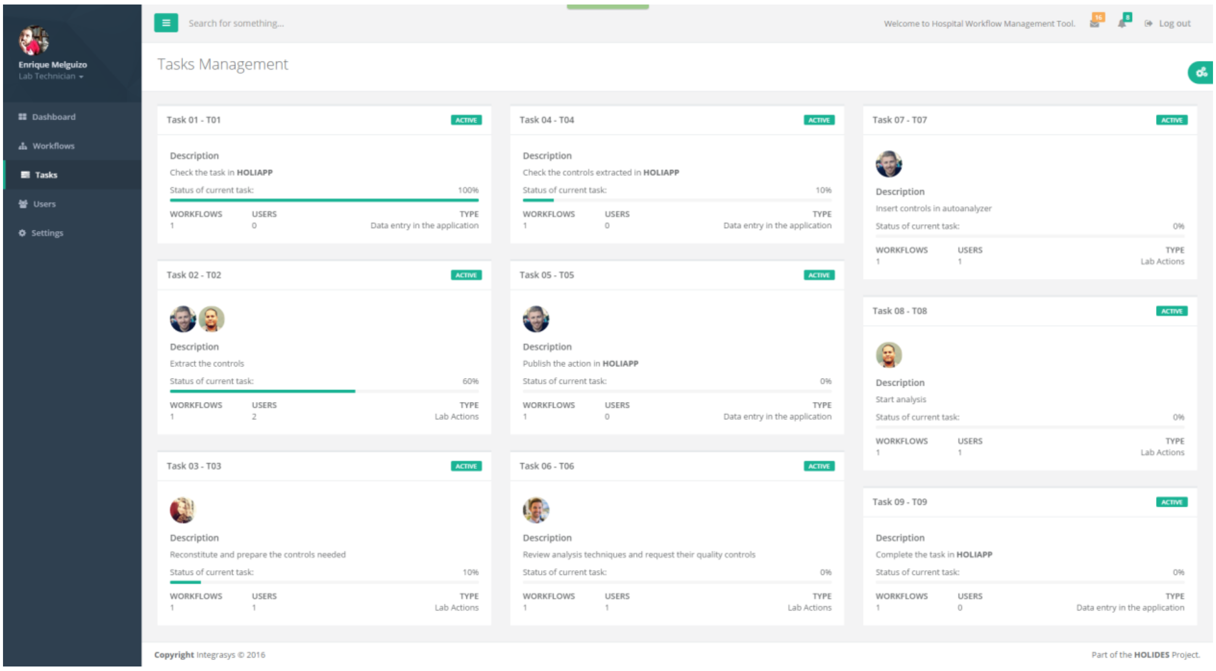


Figure 7 Operator task schedule and guidance use case: workflow engine UI interface (visualize tasks)

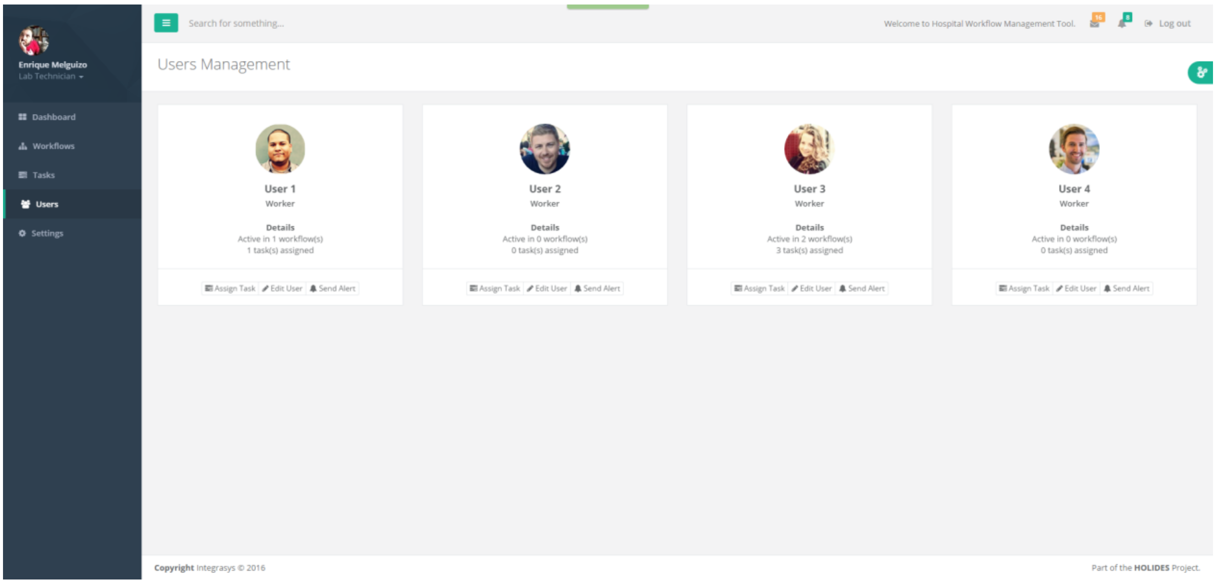


Figure 8 Operator task schedule and guidance use case: workflow engine UI interface (manage users)

2.4 Next steps

The planning proposed in deliverable D6.6 is still valid at the time of writing this report.

Q1-2016

- Prototype implementation (2016) -> Simulator of adaptable workflow with distributed users

Q2-Q3-2016

- Evaluation and analysis: HEE, and functional and non-functional evaluation
- Refinements of implementation and feedback

2.5 Feedback to HF-RTP and Requirements Update

There is no feedback or requirements update to report during the implementation phase.

3 Querying open EHR data

3.1 AdCoS description

Querying open EHR data AdCoS provides effective and secure remote access for patients and authorized professionals to EHR (Electronic Health Records). EHR contains the medical and treatment histories of patients, diagnoses, medications, radiological studies, etc.

The patient may access to his or her own EHR and is allowed to modify some data like demographic, habits or personal details in order to keep his or her information as updated as possible.

In addition, all clinicians involved in a patient's care may access to his/her EHR. With Querying open EHR data AdCoS, information is available whenever and wherever it is needed for fast and full documented medical support.

The users, patient or professional, may access from wherever outside the hospital (Web development), so, this information needs to be safely accessible anytime anywhere.

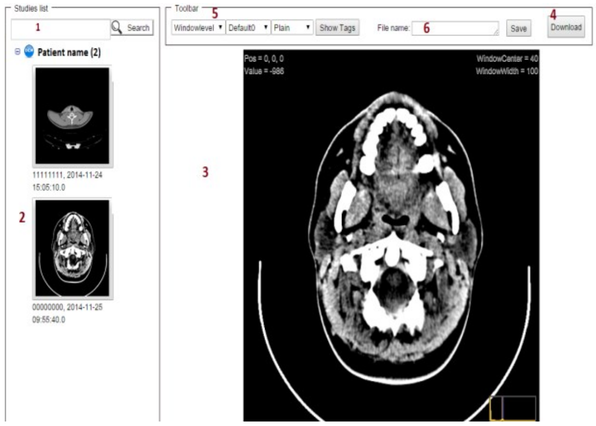
3.2 MTT and modules integration

In the context of the Querying open EHR data AdCoS several tools have been considered in the development process for the new HMI; HEE, AEON, Data race detector & healer and HF-filer. At the moment, HEE has been partially integrated and AEON integration is in its first step.

HEE

The Human Efficiency Evaluator from OFFIS has been integrated in the most critical part of the whole workflow, "Display Patient Studies" use case.

Table 1 - Patient studies Interface options. The red number represents the logical linear sequence of tasks.

Option 1	Option 2
	

HEE simulation of a virtual operator performing the same task by exemplary typing "Carlos" in the search field, later on "patient.zip" in the Save Dialogue Window and finally "patient" in the "File name" field ended up with a predicted task performance of **9.1 seconds** for the task for the design of option 1 and **8.9 seconds** for the design depicted in option 2 (c.f. Table 1).

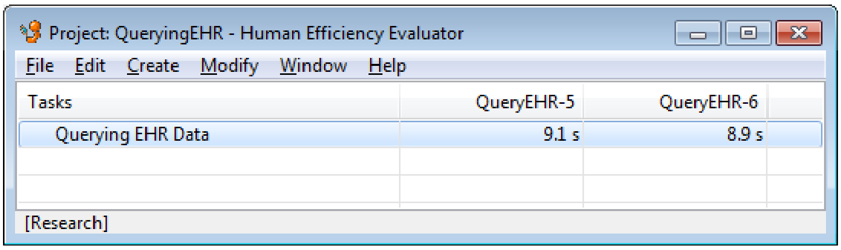


Figure 9 HEE prediction results

Figure 10 depicts the sequence of steps modelled (at the right part of the figure) and the user interface widgets considered for the mode (left part of the figure).

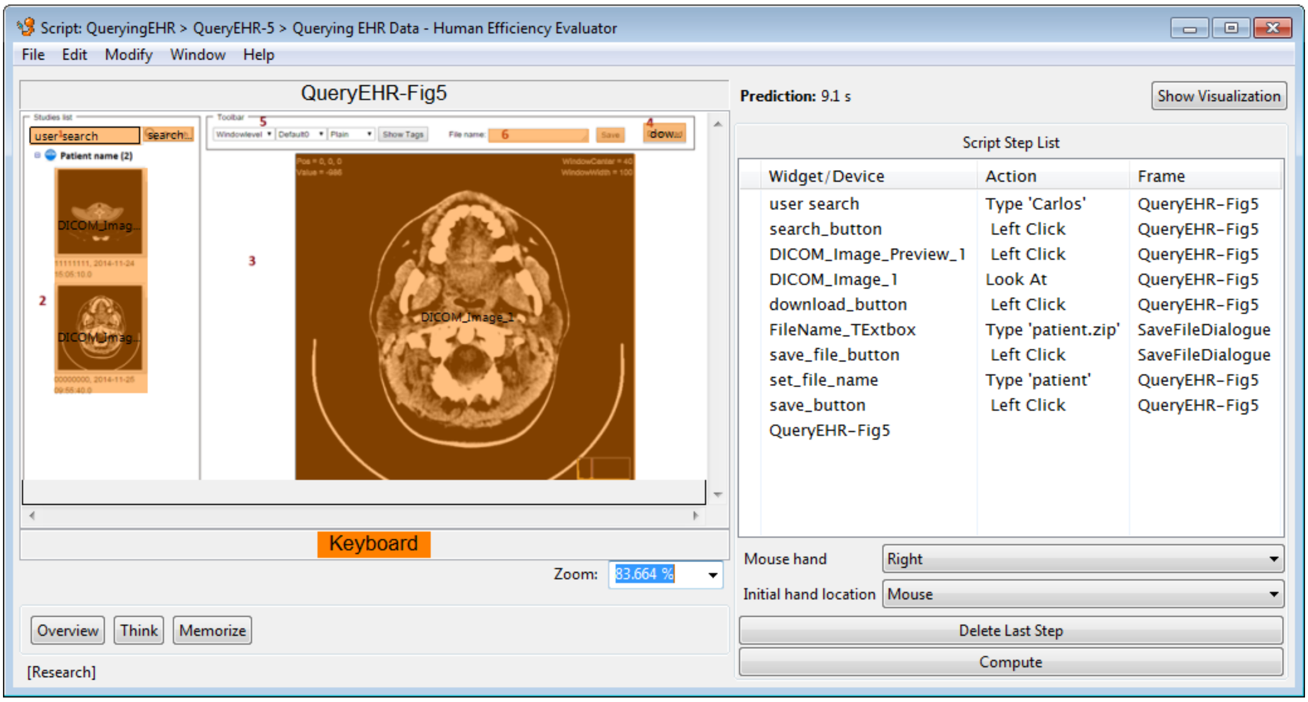


Figure 10 The modelled steps of the user search procedure

Figure 11 shows visualization that compares both designs (top: the design of option 1, bottom: design of option 2 –Table 1-). The x axis scale is in seconds and the y axis lists the different resources of the simulated operator with their load over time.

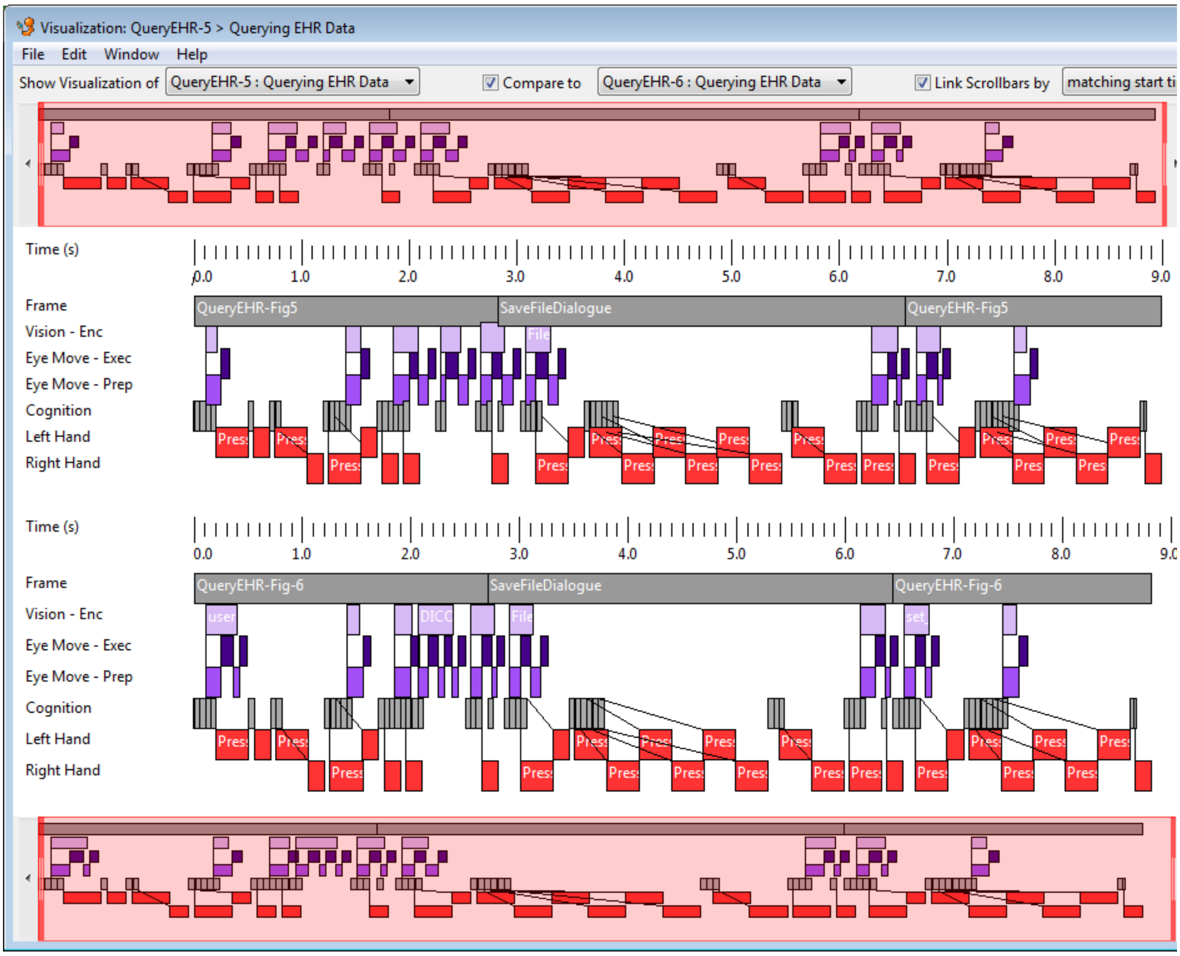


Figure 11 The comparison of the user search task for both designs

From comparing the visualizations we could observe that the task increase could be explained mainly by the re-positioning of the preview image list to the main image presentation: the eye movements times seem to be lower for the second design of (option 2) ending in a task performance increase of approx. 0.2 seconds for the user search task.

The predicted timings do not consider any system timings (e.g. system response times to user actions) – also an experienced operator of the user interface is assumed.

AEON

Cloud-based platform message AEON allows including new data into the web application (besides the openEHR and DICOM). With this data, the system can be adapted to the user needs. The aim is to develop adaptable

Graphical User Interfaces (GUI) taken into account different information from the user stressing the importance of adaptability and interactivity.

Figure 12 AEON initial page

AEON is an easy to use publish/subscribe method to exchange information using Nodejs[2], Angularjs[3], MongoDB[4] and RabbitMQ[5]. After loging into the platform the tools allow the user communicating the applications stored through a real time network. The resources management allows creating, retrieving, updating and deleting the main blocks in AEON:

- Entities: AEON entities are the objects which are the emitter and the receptor of the information. They could be sensors, persons, devices, etc.
- Channels: publish/subscribe mechanisms to send and receive messages (entities data).

[2] https://nodejs.org/en/
[3] https://angularjs.org/
[4] https://www.mongodb.org/
[5] http://www.rabbitmq.com/

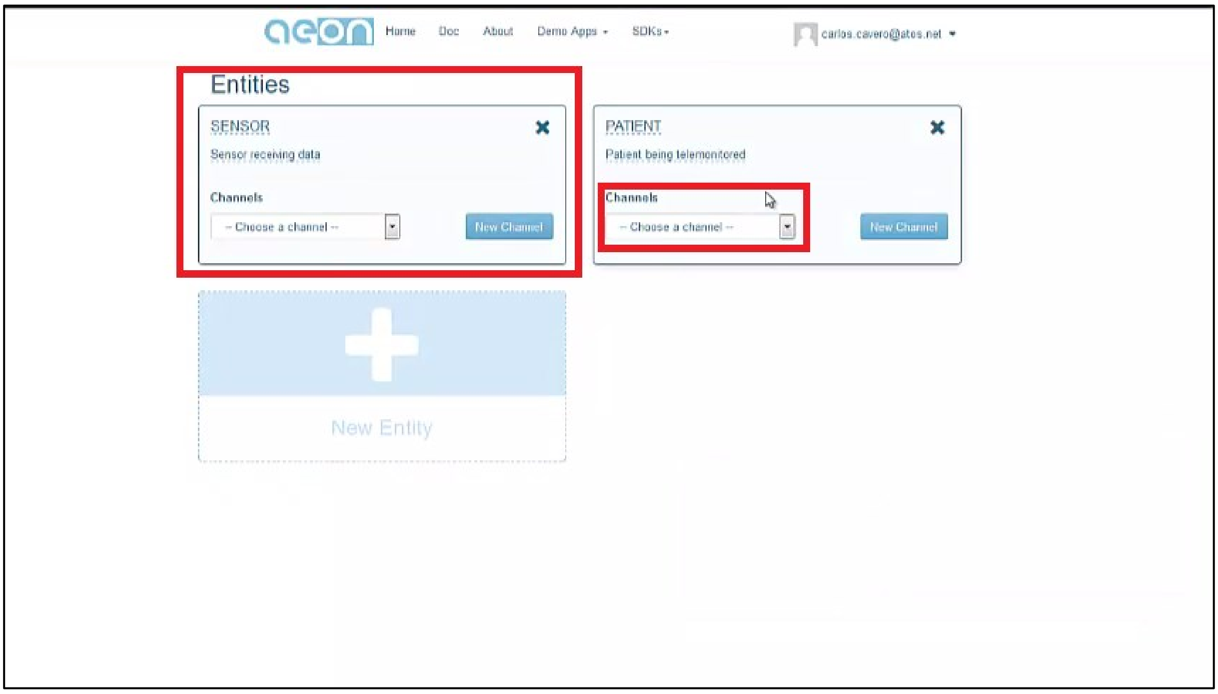


Figure 13 Resources management

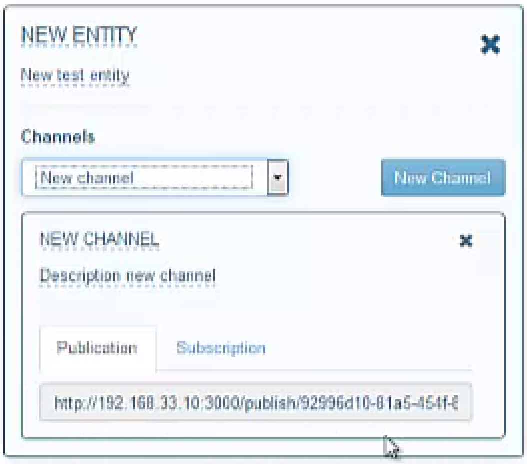


Figure 14 AEON entities and channels

When the channel is created two URLs are generated: one to publish messages and the other to receive them. With two lines of coding it is possible to attach and detach the channel to send the data.

Figure 15 AEON publication demonstrator

The publisher then can start sending the information (random GPS position in this case) while the subscriber continuously listens to the channel and shows the locations in the map.

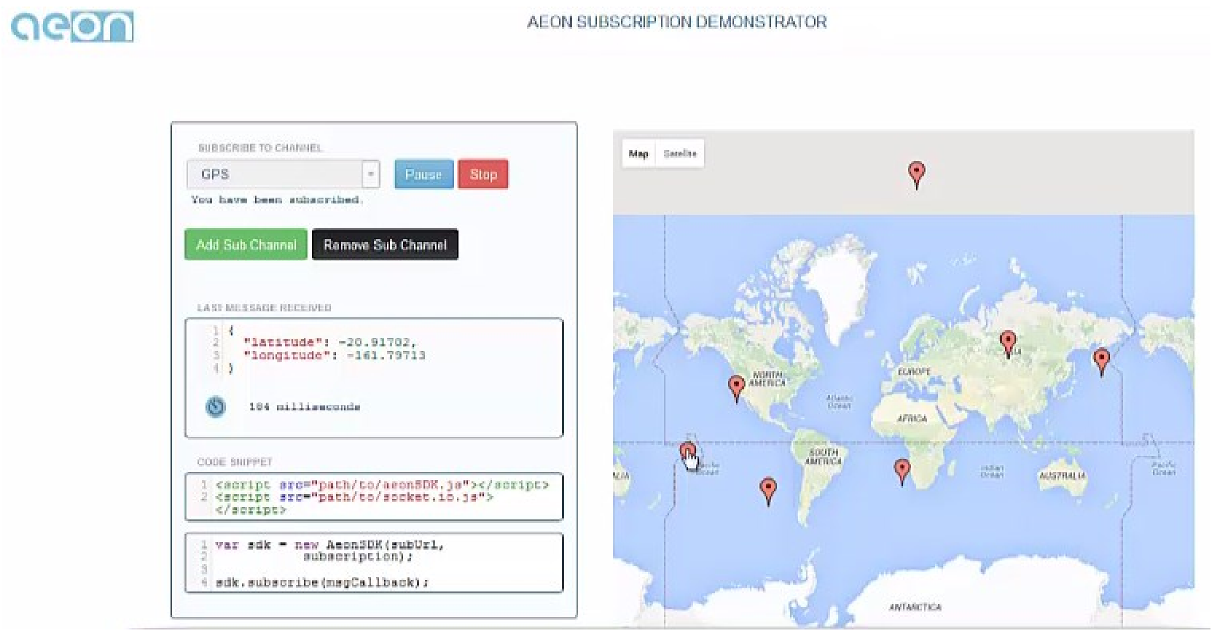


Figure 16 AEON subscription demonstrator

3.3 HMI Implementation

The interaction between the operator and the system is carried out through a technical structure; server, network communication and a device like PC or tablet. This PC or tablets allow the users (patient and/or professional) to interact by using Graphical User Interfaces (GUI).

Querying open EHR data AdCoS has several actions to facilitate access to patients and professionals:

- **Standard GUI Controls**: All GUIs keep a basic and similar appearance and behaviour.
- **Simple interfaces:** It is necessary to avoid unnecessary elements and be clear in the language is used on labels and texts.
- **Common design:** One common design through the AdCoS to facilitate efficiency (colours, light, contrast, progress bar, etc.). Careful placement of items can help draw attention to the most important pieces of information and can aid scanning and readability.
- **Keep the user informed (at any time):** The AdCoS informs the users of actions ("The message has been sent", "You have a new message", etc.). It reduces frustration for the user.
- **Defaults values:** The AdCoS displays clinical data in logical and coherent default values as much as possible. It reduces the user actions and speeds up the interaction.
- **Personalization options:** Personalization can help make users feel more comfortable. So, the users have the option to change language (English, Spanish, etc.) and text size (at any time).
- **Response time limits**: Response times must be as fast as possible; the AdCoS displays a "Busy" cursor if a command takes more than 8 seconds, an explicit progress if longer.
- **Display error messages:** If something is wrong ("The username is empty") the AdCoS displays an error message explaining clearly why and how the user can fix the problem ("Your username is empty. Please, type your username and password and click login button").
- **Required fields:** Any obligatory fields (lists, input boxes, etc.), which must be filled out by the user must be highlighted. This allows us to ensure that the user knows and provides all data needed.

3.4 Next steps

Using digital technologies can be a problem for certain users (mainly patients) like users with arthritis (they cannot use the mouse easily), and elders (they may not see very well) are just some of the conditions that can make browsing the Web hard for some people (patients). These are examples of patient users who may need to use this tool.

In following work GUI will be accessible, providing greater opportunity for participation, especially from patient point of view and more available to all users (doctors and health environment).

Taking into account final HEE results, the Graphical User Interface (GUI) must be slightly modified by changing image preview position.

Furthermore AEON will be used to start feeding the models prepared to adapt the GUI to the user needs.

3.5 Feedback to HF-RTP and Requirements Update

The tools in the HF-RTP have provided valuable insights for the development process of the Querying open EHR data AdCoS. Furthermore, the HEE tool offers an interesting possibility to easily simulate and replay various scenarios.

We highly recommend that the HEE tool is able to simulate different situations and user profiles. For example a user patient elder may have more difficulties to interact with a GUI than a professional.

4 Guided patient positioning

4.1 AdCoS description

The Guided patient positioning system provides guidance to operators of MRI scanner during preparing and positioning patients for MRI examinations. Correct positioning of the patient for the MRI examination and using the right coils and other devices is important to get good diagnostic quality images, but also important to avoid safety issues. Currently, operators are trained for this. The on-line guidance system intends to improve usability and to reduce risks, also in case of novice, less experienced users.

Figure 17 Example of patient positioning in an MRI scanner

4.2 MTT and modules integration

Means-end modelling (AWI) and Adaptive modelling (EAD-F) provide an interesting summary for guided patient positioning and can be combined with other models used for the Robust VCG triggering AdCoS.

The combination of U-DAT (User Test – Data Acquisition Tool, PHI) and HF-Task Analysis (HFC) shows to be very promising. The HF-filer (AWI) can be applied to capture the results.

The figure below shows how the different MTTs cooperate in the context of both AdCoS Guided Patient Positioning and Robust VCG Triggering.
The high level usability steps that are required for both / any AdCoS include Task Analysis, User Tests and Structured Reporting. With the envisioned interfacing between different tools from the HF-RTP you might use different MTTs for each usability step. You can choose what fits best

to your situation. In WP6 Means-End Modeling MTT is used for the Task Analysis of AdCoS Guided Patient Positioning, whereas MTT HF-TA is used for AdCoS Robust VCG Triggering. Similarly, U-DAT has been used for User Test observations for both AdCoS, whereas MTT HF-TA-Observation has also been used for the User Test on VCG Triggering. Finally, HF-Filer will be used for Structured Reporting.

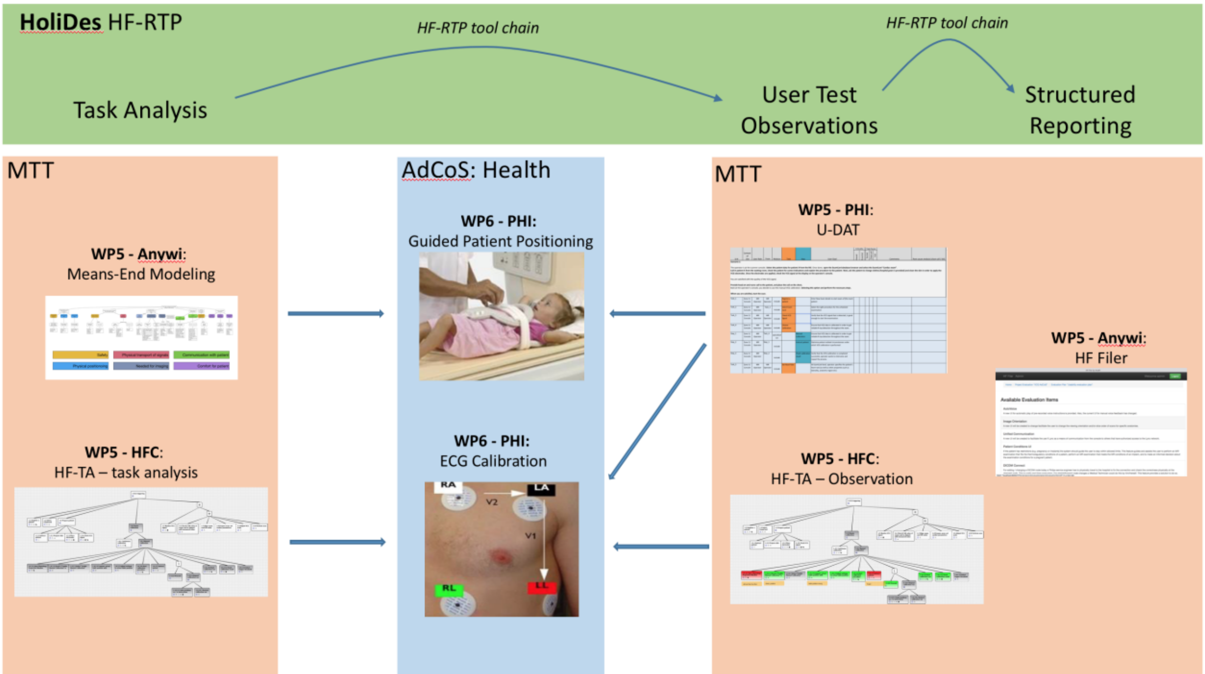


Figure 18 Integration of MTTs in the context of both AdCoS Guided patient positioning and Robust VCG Triggering

4.3 HMI Implementation

Guidance is provided on a screen in the exam room near the bore. The starting screen shows the first items that need to be connected given a selected ExamCard and patient information.

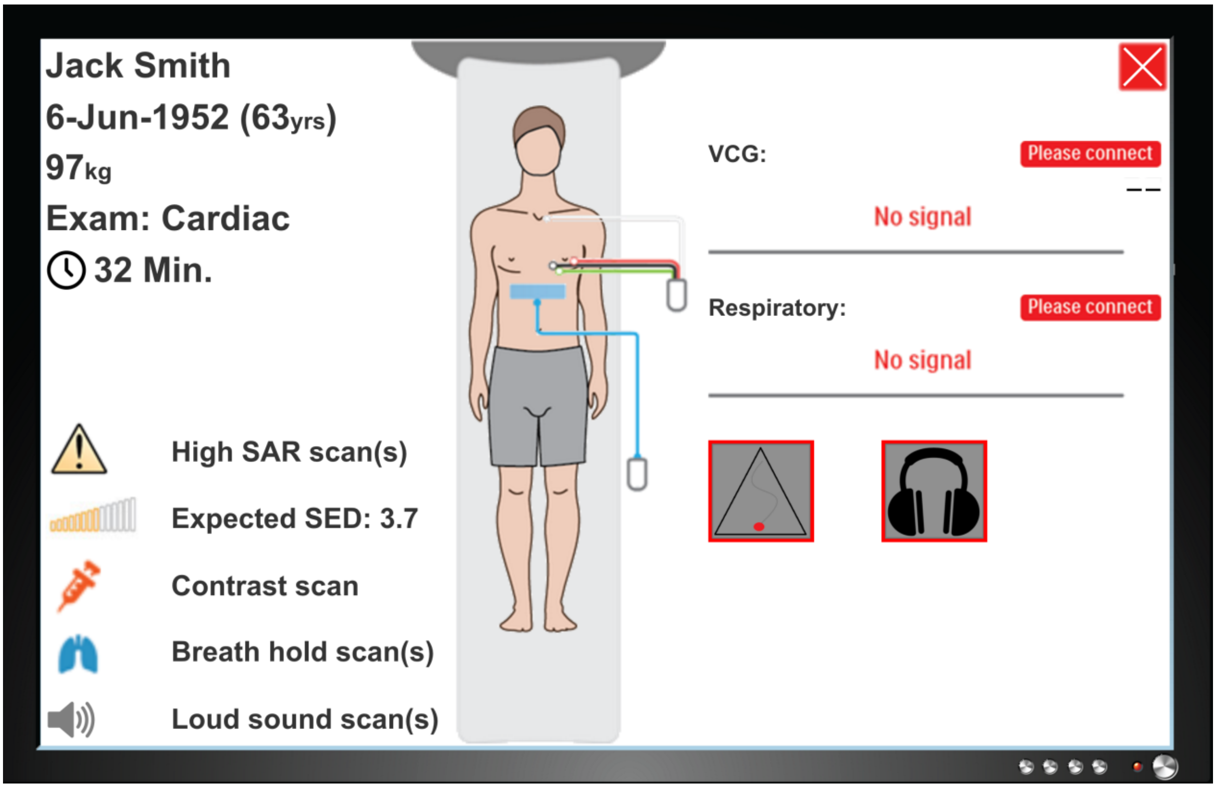


Figure 19 Starting screen

While attaching, in this case, the ECG leads and the respiratory belt, the user interface prompts the user to attach additional equipment. In this case the anterior coil.

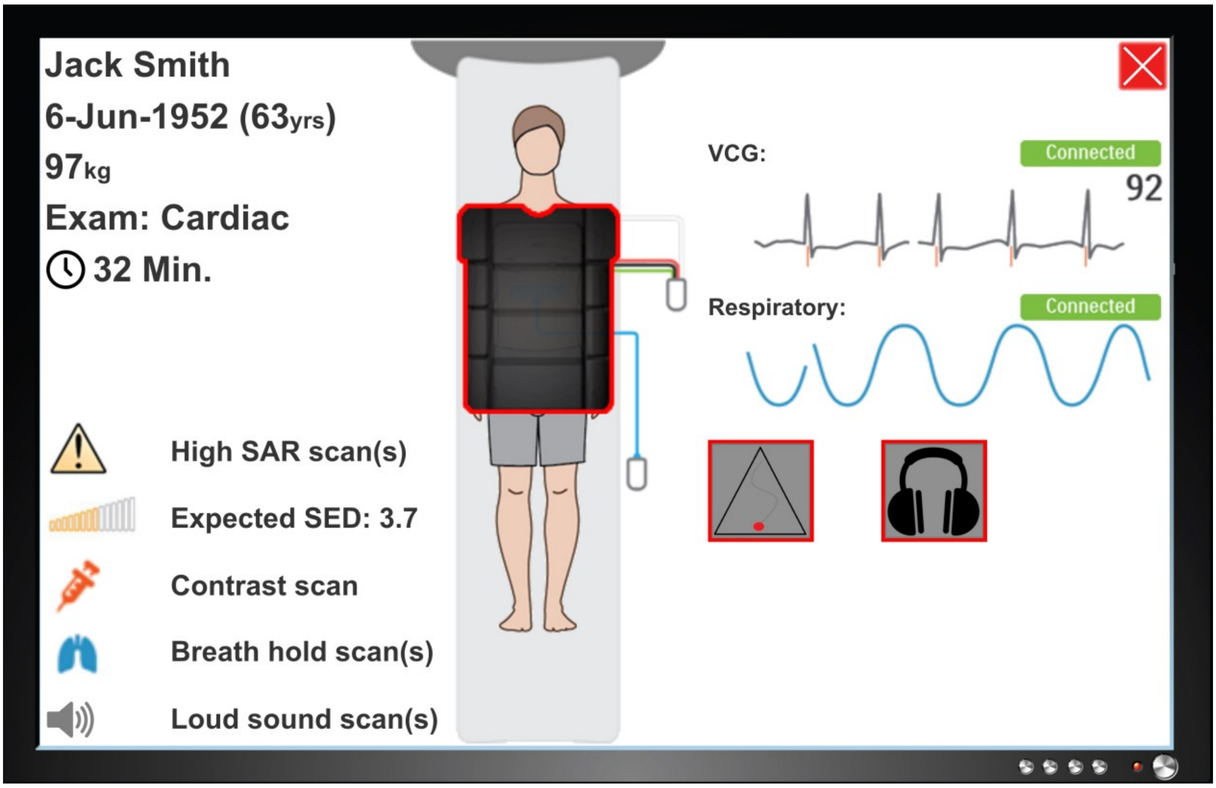


Figure 20 ECG leads - screen

4.4 Next steps

In Q1/2-2016 we will continue with user evaluations and questionnaires and improve the design accordingly. The interface between the tools will be addressed to provide a fluent exchange of data.

4.5 Feedback to HF-RTP and Requirements Update

The modelling tools in the HF-RTP, as described in section 7.2 have provided a structural way to analyse the problem and led to valuable insights for the design of the guided patient position. The tools to validate the proposed designs provided a systematic approach to assess the usability, and the results can be stored and archived in the connected filing tool. The interface between the tools needs to be improved to allow smooth exchange of data.

With respect to the HF-RTP requirements we have no updated or additional requirements.

5 Robust VCG Triggering

5.1 AdCoS description

ECG triggering is often required during MRI scans to avoid image artefacts due to motion of the heart or blood flow. However, it is not very easy to obtain reliable trigger signals, since both the magnetic field and the scanning techniques distort these signals. Additional guidance for the operator is required during patient preparation and scanning to improve the reliability.

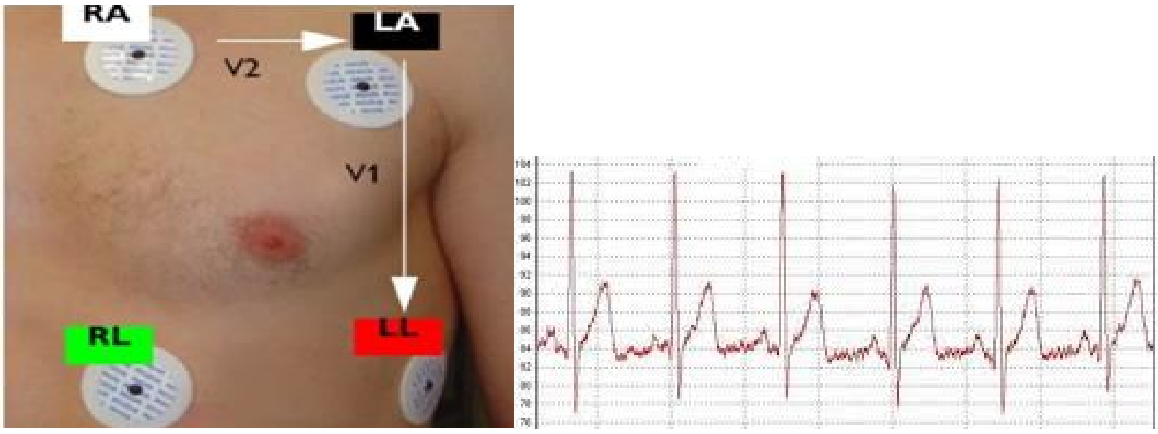


Figure 21 Placement of ECG electrodes

5.2 MTT and modules integration

PHI created an extensive task map, showing the hierarchy of tasks. This is used as input for an Axure model (PHI) that simulates the user interface and is used for early usability evaluation. U-DAT (PHI) is applied to facilitate the user tests. The combination of U-DAT (User Test – Data Acquisition Tool, PHI) and HF-Task Analysis (HFC) shows to be very promising. The HF-filer (AWI) can be applied to store the results.

Section 4.2 of the AdCoS Guided Patient Positioning contains an elaborate discussion on how the MTTs work together in the context of the Health domain, WP6.

5.3 HMI Implementation

After selecting a patient for a cardiac exam you can open the Physiology Properties screen below. This screen provides the option to start manual calibration.

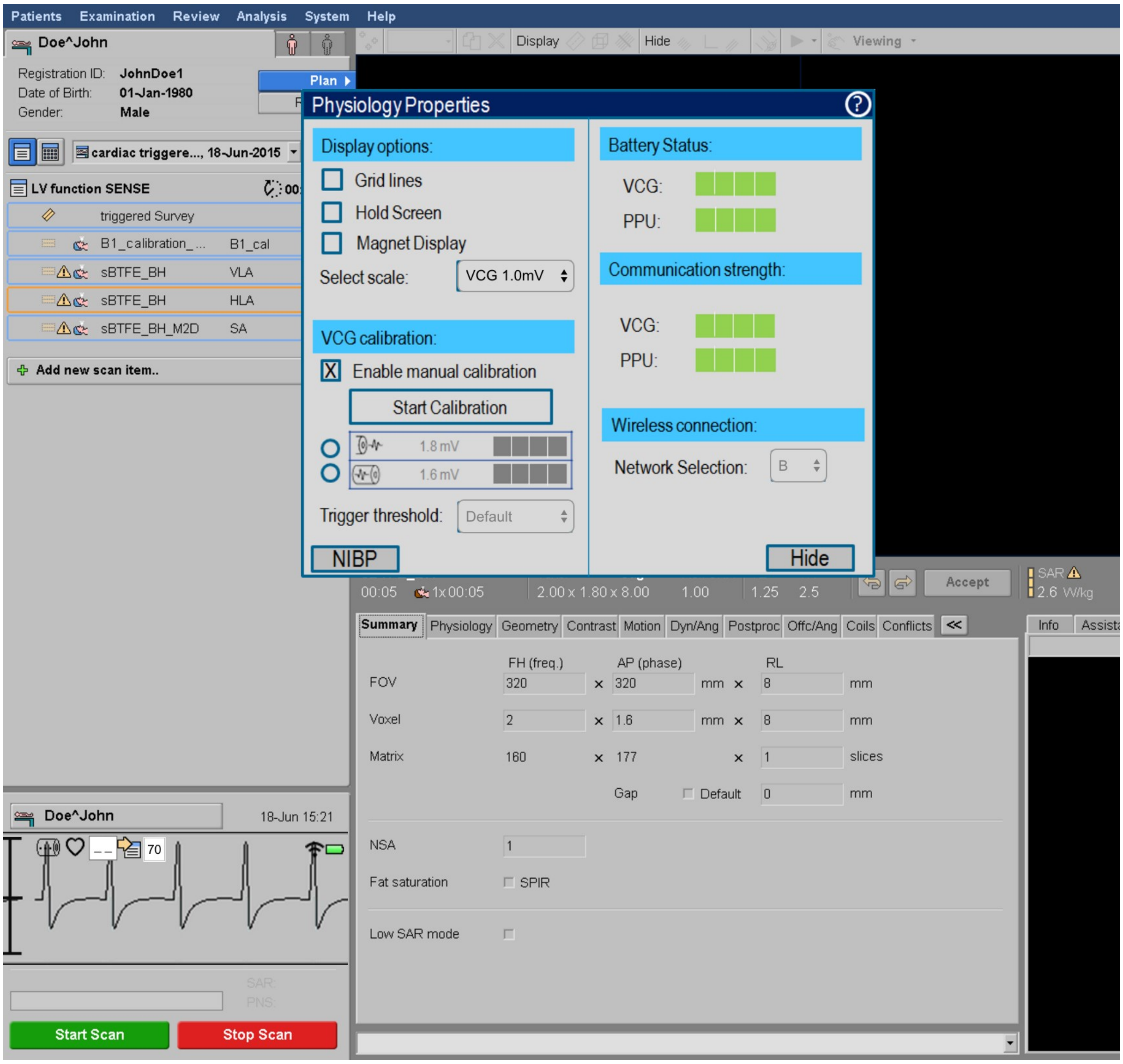


Figure 22 Physiology properties screen

After the calibration is done the results are displayed in the calibration popup. If the result is not satisfying you may repeat the calibration procedure.

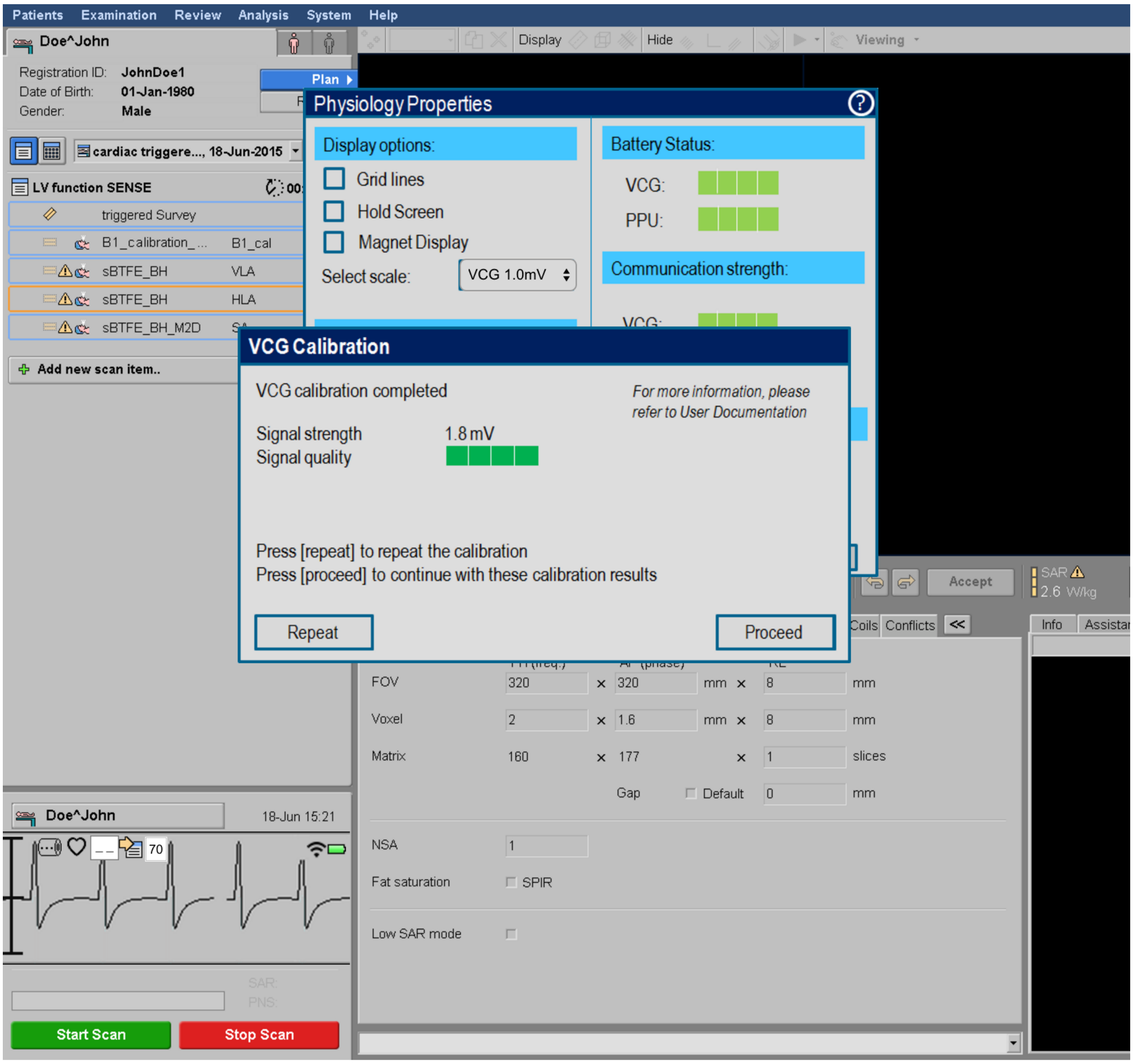


Figure 23 Calibration popup

Eventually the calibration results are stored and used to find the so-called trigger markers in the ECG signal. Note the red vertical lines – trigger markers – in the ECG signal in the lower left part of the screen.

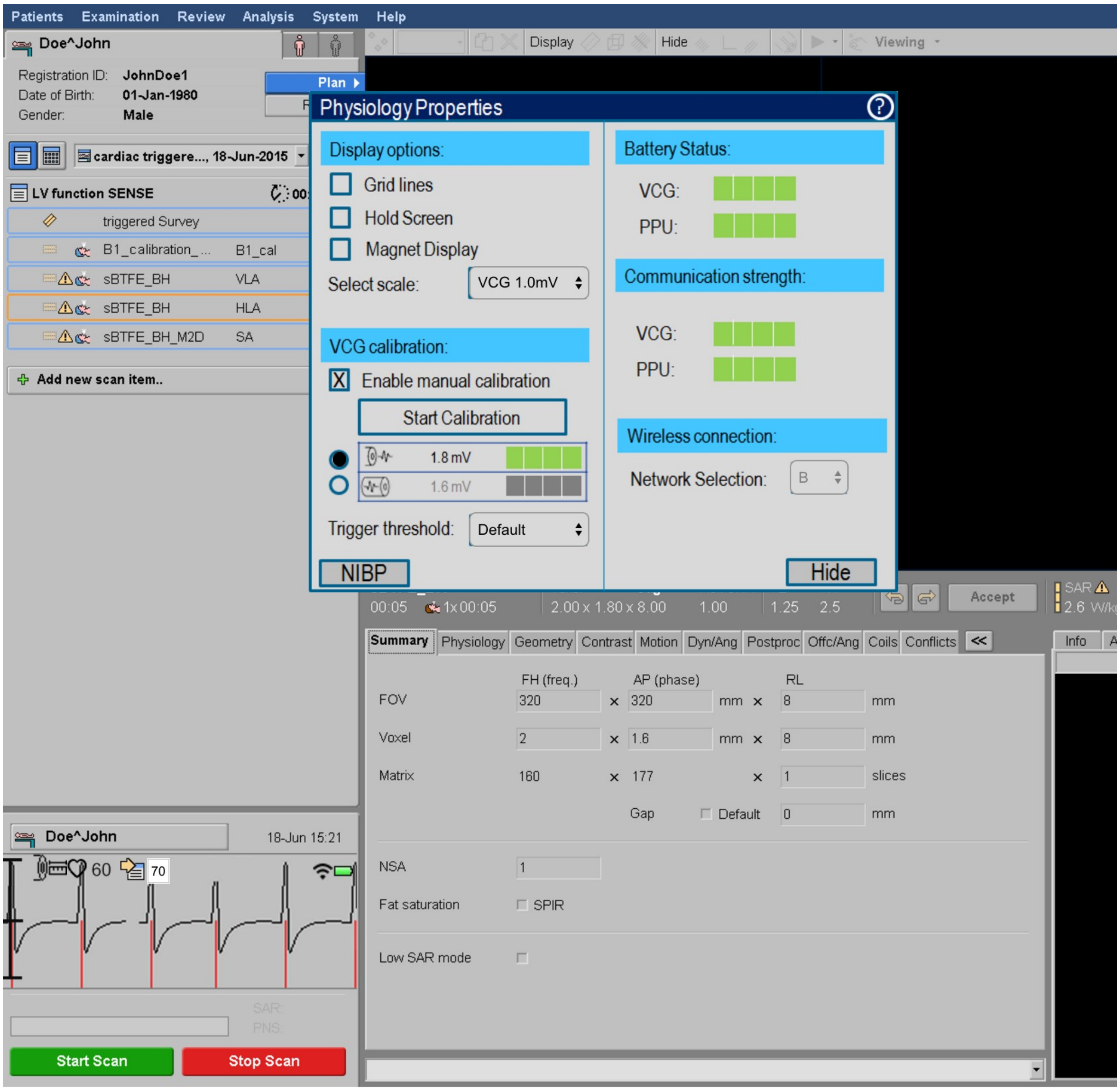


Figure 24 Calibration results screen

5.4 Next steps

In Q1-2016 the first version of this improved design will be released and provided to our customers as an upgrade. Furthermore we will start with the implementation of the HMI and do user evaluations and questionnaires for the new product version, which will be released in Q2/Q3 2016.

5.5 Feedback to HF-RTP and Requirements Update

The modelling and simulation tools in the HF-RTP, as described in section 7.2 have provided a structural way to analyse the problem and led to valuable insights for the design of the guided patient position. The tools to validate the proposed designs provided a systematic approach to assess the usability, and the results can be stored and archived in the connected filing tool. The interface between the tools needs to be improved to allow smooth exchange of data.

With respect to the HF-RTP requirements we have no updated or additional requirements.

6 Safe parallel transmit scanning

6.1 AdCoS description

To optimize the MR image quality for certain anatomical regions, a so-called phased antenna array is used in 7T head MR imaging. A set of (e.g. 8) RF amplifiers each connected to a coil element (antenna) provides the transmit field to generate MR signal. Each channel is independently modulated: optimal phase, frequency and amplitude modulation should lead to the required excitation of part of the patient, e.g. homogeneous (same signal from all parts of the brain), or spatially focussed (e.g. only signal from the spinal cord).

However, this temporal modulation of the RF signals alters also the spatial interference of the concomitant electric fields resulting potentially in unsafe RF induced tissue heating (microwave heating effect) at certain body location. The electric fields and heating cannot be detected directly with MRI and their spatial patterns are highly patient specific due to the complex electromagnetic interaction of RF signals with the human body. The RF power absorption can only be determined by means of electromagnetic simulations employing dielectric models of the scanned subject.

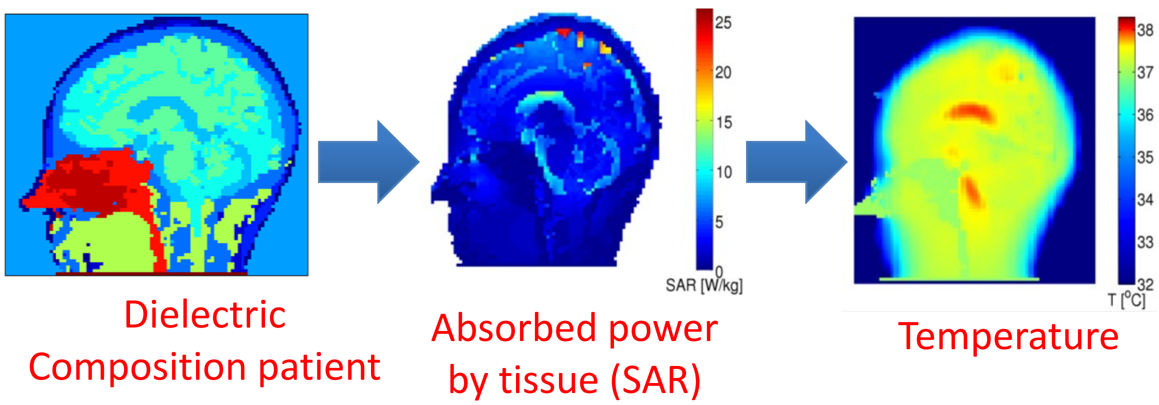


Figure 25 Relation between various calculated maps of field in the patient

The AdCoS consists of the following parts:

1. RF safety assessment technology to estimate safe RF power settings for a given patient prior to scanning and monitor heating during scanning.
2. An operator workflow that enables non-scientific staff to be able to perform safe parallel transmit scanning.
3. UI elements to communicate the status and required actions to the operator.

The third topic is currently developed in collaboration with SNV. The design and implementation is described below. In last section (6.3) an update is given on the first topic, i.e. RF safety assessment which consists of the generation of an atlas of pre-simulated electromagnetic patient models from which a representative model has to be chosen for a given patient.

6.2 MTT and modules integration

For a fast and error-free operation of the interface that will calculate drive settings and the SAR distribution, a good quality layout of the GUI is imperative. To optimize the interface, in cooperation with SNV, we have organized a focus group session. In advance of the focus group session, we have developed a preliminary layout for the interface (Figure 26).

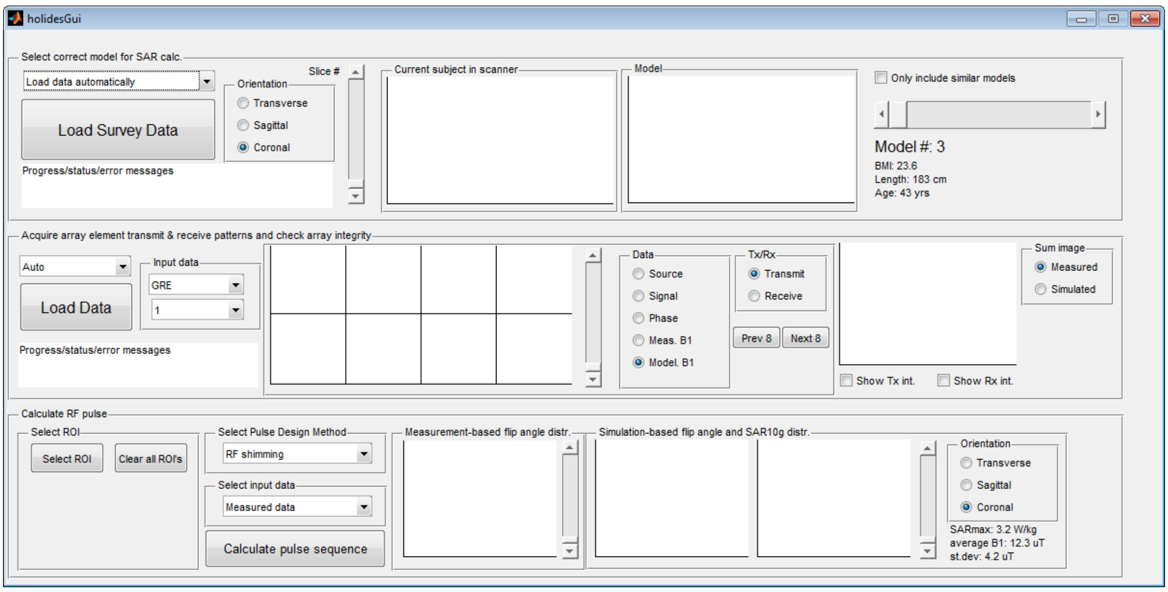


Figure 26 Preliminary design of the interface for safety assessment and pulse design for parallel transmit MR imaging.

Focus group setup

The focus group has been realized for the validation of the UMC AdCoS. The main aim of this phase has been to improve the system in order to make users able to use it at the top of its potentiality in a safe manner.

SNV, together with UMC, participated in the realization of the focus group with the aim of validating a preliminary version of the HMI and to improve the effectiveness of the system collecting relevant information from final users.

SNV has developed the protocol to set up and conduct efficiently the focus group. The protocol has been shared and discussed with partners making them able to manage the interview. In a preliminary phase an expert in the topic of scanner interfaces has been individuated and instructed to conduct an interview. The moderator has been presented with the structure of the interview, a series of questions, to gain relevant feedbacks from participants. Questions were about the contents of the interface, the actions required to interact with the interface, feelings and suggestions for the improvement of the system.
Also important was the identification of an observer, participating in the focus group with the aim to take notes about verbal and non-verbal language used by participants during interactions. SNV and AWI covered these roles.

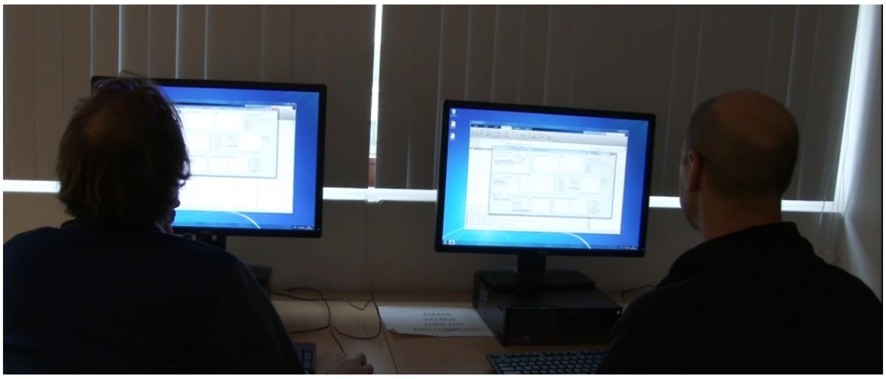
SNV has also defined the setting of the interview. The whole setting contributes to the success of the focus group. The focus group has been realized in a UMC room equipped with computers to let participants explore the interface and with a round table for the plenary session to promote the discussion and interaction between participants. The room has also been equipped with a video camera and a multi-directional microphone to record video and audio information to be post-processed to prevent the loss of relevant information.

Participants
Six subjects volunteered in the focus group. Participants had different degrees of expertise in the use of a MRI interface: two participants were experienced, two were intermediate users and two were beginners with a limited experience in scanning activities. The purpose of this recruitment was to acquire feedbacks from all the typologies of final users.

Materials
Another fundamental step was the definition of the materials to be presented to participants in order to create the context of the interview. Before the focus group, participants have been presented with a mock-up version of the new RF safety monitoring on a computer screen and they were invited to explore **interactively** the interface. See Figure 26

Procedure
The interview has been divided into two sessions:

1- a first session where each participant has been invited to seat in front of a computer to explore the interface and to gain a first impression;



2- a round table session in which subjects have been invited to express their impressions about the interface.

Results
Audio and video traces have been analyzed separately. Video recordings have been analyzed by means of the software "Observer" to evaluate the participation of subjects to the discussion in terms of verbal behaviour and

gestures. These two variables have been analyzed in terms of frequency and duration. A preliminary analysis of the data has evidenced a good degree of participation for each subject, indicating that the conclusions of the round table discussion are meaningful.
Audio traces have been transcribed and analyzed in order to point out human factor issues and suggestions for the improvement of the system.

6.3 HMI Implementation

The first results have highlighted three major concerns:

1. the interface is complicated for clinical uses where the time for a scanning session is limited; it would be better to separate the individual tasks (model selection, array response measurement, pulse design, overall verification) in multiple viewing windows (pop-up windows).
2. the amount of information and options is excessive for a non-expert user; a possible approach would be to use an 'experienced user' option that would enable the additional options.
3. the sequence of steps to calibrate and use the system is not easily accessible.

To these issues, different solutions have been proposed that are going to be considered and integrated in the final implementation of the prototype.

RF safety assessment technology.
Currently, we have scanned 10 male volunteers of 35 years and older with mock ups of the 7T transmit array in place. Their scans have been segmented and converted in the dielectric human body models. These models have been simulated to determine the RF tissue heating of these models. See Figure 27

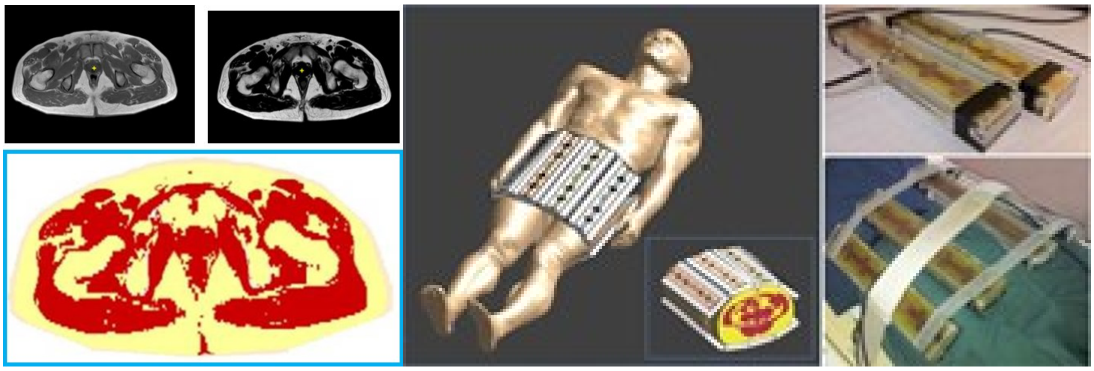


Figure 27 MRI scans of volunteers were segmented to obtain a dielectric human body model. The antennas were inserted in the model and by means of electromagnetic simulation the heating was determined.

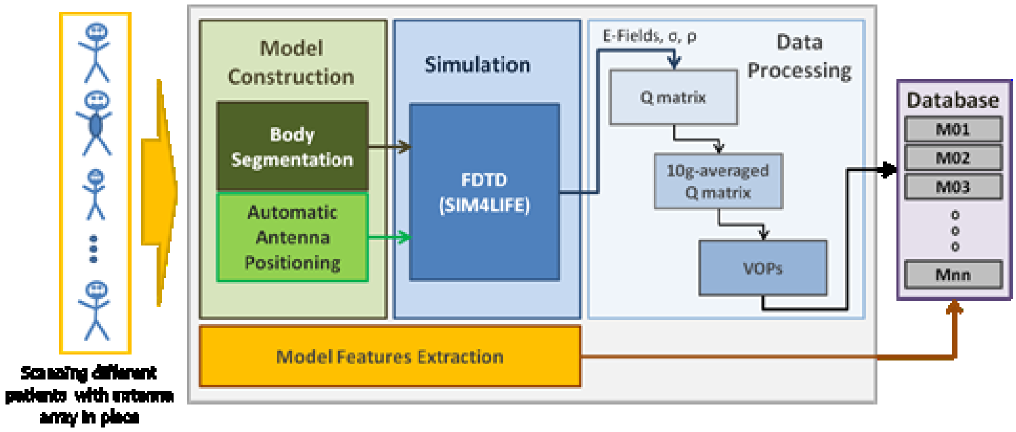


Figure 28 All models were generated by a specially designed automatic workflow to process all volunteer scans and simulate their heating.

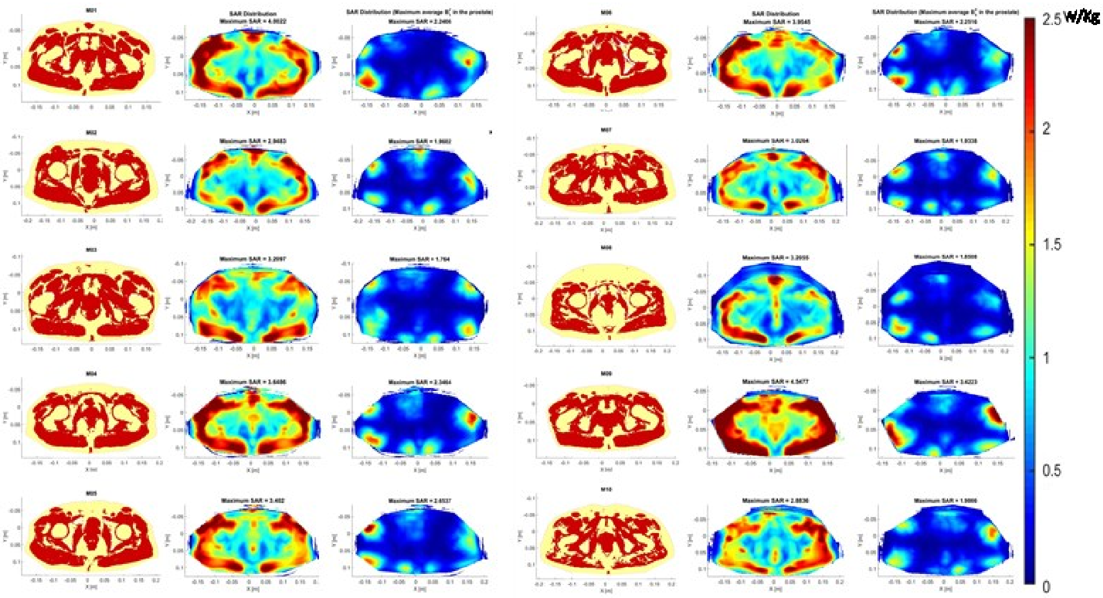


Figure 29 The RF heating (SAR10g distributions with 8x1W accepted power) of 10 volunteers. Left column dielectric patient model, middle column worst case RF heating and left column for realistic antenna drive settings.

6.4 Next steps

Based on the feedback by the users and SNV, the interface will be adapted and all functionality behind it will be implemented. In addition, the model selection algorithm will be further developed and the atlas of models needs further extension.

In terms of RF safety assessment technology we will continue to extend the atlas until we have reached 20 human body models. We are currently working on investigating a quantitative similarity index RF heating distribution of human body models. In this way, we can group models in terms of similar SAR response. Then we will proceed by investigating whether we can derive image features from low power calibration scans that are predictive in terms of best representative SAR human body model from the atlas to use. This can be investigated by an leave out one approach.

6.5 Feedback to HF-RTP and Requirements Update

We have used a focus group combined with audio-video monitoring of which detailed empirical analysis has been made. This has been performed as a collaboration between SNV and UMC.

7 3D Acquisition

7.1 AdCoS description

The iXR 3D Acquisition AdCoS is about the use of an X-ray angiography system during minimally interventional treatments. X-ray image guidance is used and to allow better visualization of the anatomy and planning of the treatment, a 3D rotational scan is made. Performing such a 3D scan is very complex and requires highly skilled personnel.

It is the aim of this use case to develop an AdCoS that eases the 3D scan procedure by developing an improved HMI that greatly simplifies the workflow.

Figure 30 Impression of the table side work spot during minimally invasive treatment

7.2 MTT and modules integration

In the context of the 3D Acquisition AdCoS several tools have been used and integrated in the development process for the new HMI. A task editor is used to identify interaction tasks between the operator and the system. The Human Efficiency Evaluator is used to model the interaction capabilities of the environment, to demonstrate procedures for common tasks and to execute CASCaS, a cognitive architecture for prediction of human behaviour, allowing analysis of Human Factor metrics. The integration of the tools in the workflow is shown in Figure 31.

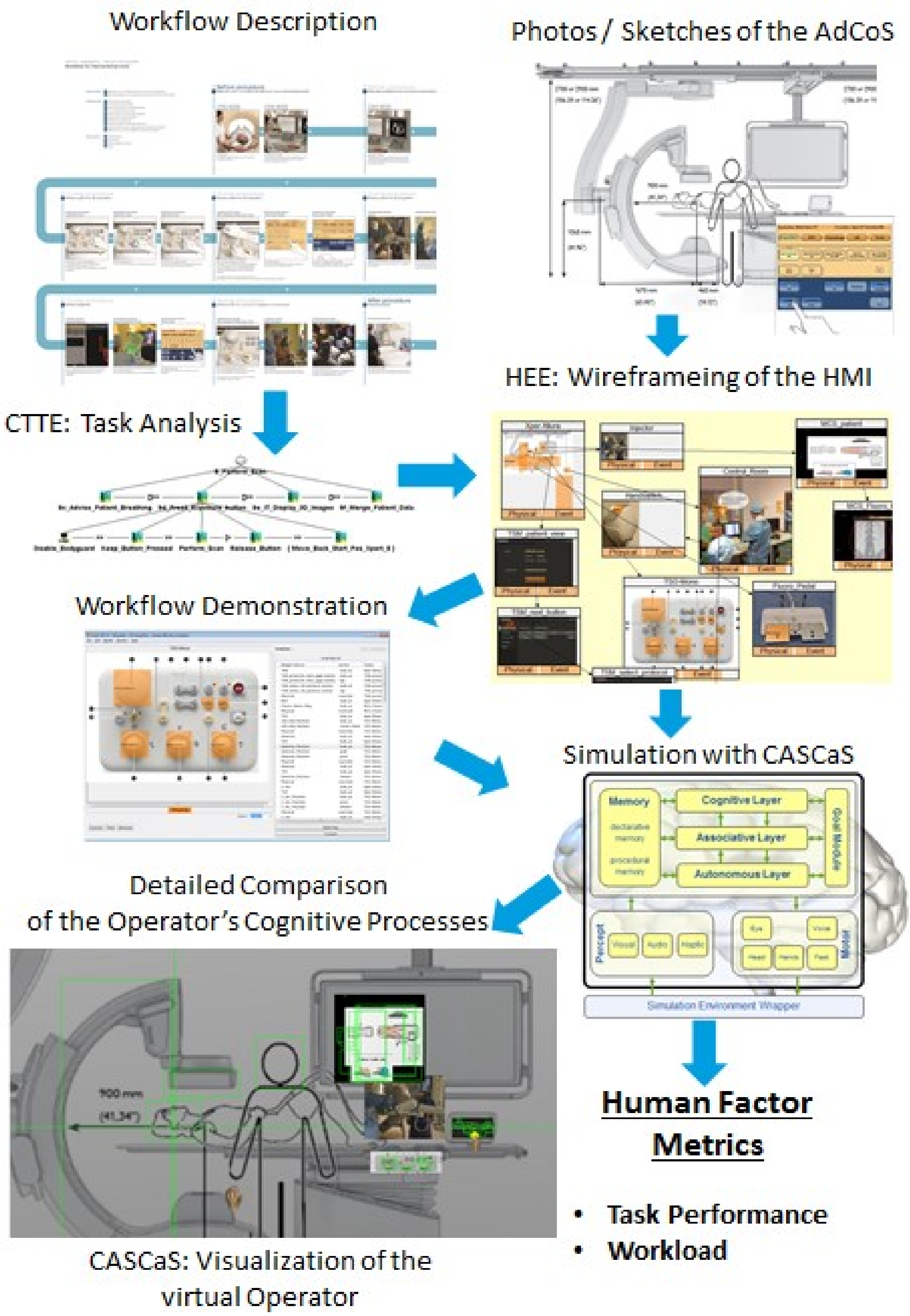


Figure 31 Tool integration in the 3D Acquisition Use Case

7.3 HMI Implementation

The new HMI features three new concepts that will improve the usability of the system and simplify the execution of the 3D rotational scan.

1. The HMI uses graphical user guidance and procedure cards for step-by-step assistance. It forces the user to follow a pre-defined flow of actions and thus prevents any errors in the 3D scan preparations.

2. The alignment of the system C-arm around the clinically relevant part of the anatomy, the Region Of Interest (ROI) is a complex task and requires much experience in both interpreting clinical images and in the handling of the X-ray system geometry. In the new HMI the user can indicate the ROI and the system automatically adapts its alignment based on this.

3. In the case of a system alignment that would lead to a collision between the C-arm and the patient or table, the system will automatically detect this and notify the user before the actual rotation is started.

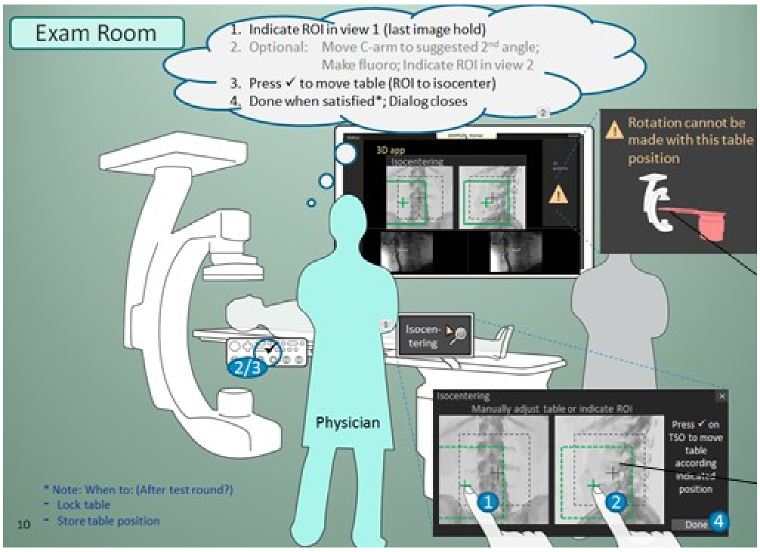


Figure 32 Impression of the new HMI design

7.4 Next steps

In Q1-2016 we will continue our evaluations of the new HMI using the HEE-tool. Furthermore we will start with the implementation of the HMI and do user evaluations and questionnaires. Finally in Q2-3 2016 we will continue with usability tests to collect actual user feedback on the new HMI.

7.5 Feedback to HF-RTP and Requirements Update

The tools in the HF-RTP, as described in section 7.2, have provided valuable insights for the development process of the new HMI for 3D Acquisition. Furthermore, the HEE tool offers an interesting possibility to easily simulate and replay various scenarios. This may be interesting for training purposes of new usability designers or engineers to quickly understand the consecutive actions in a workflow. The HEE tool not only shows the order in which these actions take place, but it also graphically shows which part of the system HMI is addressed.

A recommendation would be that the HEE tool is able to simulate how experienced and inexperienced users interact differently with the system. The new HMI is mainly meant to help inexperienced users to feel more comfortable in performing, so it would be interesting to see how this is reflected in improved human factor performance metrics.

With respect to the HF-RTP requirements we have no updated or additional requirements.

8 Internal analysis and reporting

8.1 AdCoS description

This use case provides a tool which analyses and generates clinical reports based on data coming from heterogeneous and fragmented healthcare information systems.

The access to the system must be available anytime and anywhere, apart from the hospital environment, so it will provide a web Graphical User Interface (GUI). This interface provides easier usage of the information and presents clinical information to the physician in an integrated way.

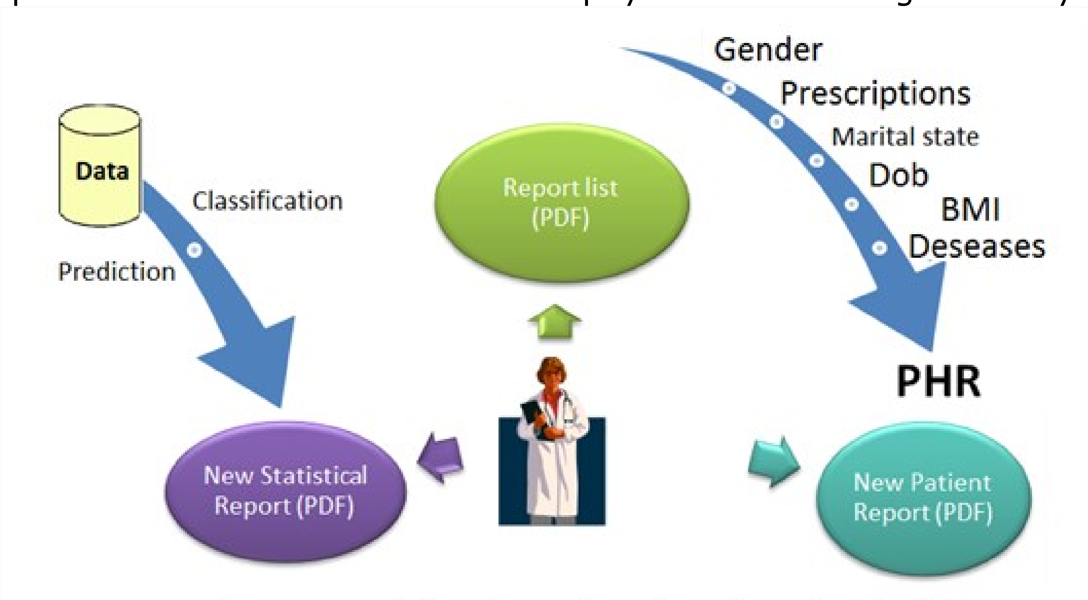


Figure 33 Internal analysis and reporting

Two different clinical reports (PDF format) are provided:

- **Internal clinical report**: This report allows analysing possible causes that has brought a certain patient to the hospital by comparing and analysing data with other patients in order to avoid possible future illness. This report is internal to the hospital and includes risk analysis, predictions, etc.
- **Patient report:** This AdCoS permits to generate simple reports for the patients to provide a general overview of his/her health status. This custom report pretends to avoid additional CDs or paper reports

given to the patient nowadays. This report includes clinical patient data. MRI, Lab Tests, prescriptions, etc... Any EHR data that the professional considered desirable.

8.2 MTT and modules integration

Internal analysis and reporting AdCoS main strength is its capability of data analysis. That is why we are working in the integration of APA and LEA tools, both, related to data mining and machine learning; analysis tools to provide better diagnostic and treatment.

Both, APA and LEA are in a very first step of this integration due to it is needed further development to integrate output in existing pilot.

One first high level approximation may be:
1. Pilot provides data source to LEA and/or APA tool (csv file or other).
2. LEA and/or APA library returns result; prediction, description, etc.
3. Pilot includes this result in a PDF document.

8.3 HMI Implementation

Both, "Internal analysis and reporting" and "Querying open EHR data" AdCoS follow the same practical guidelines related to HMI and are described in section 3.3.

8.4 Next steps

In order to move towards integrations of APA and LEA tools further development is strictly necessary carried out by the owners of these two tools.

8.5 Feedback to HF-RTP and Requirements Update

AEON allows gathering heterogeneous information coming from different sensors and it is extremely easy to use with the incorporated GUI. In the case of APA and LEA, even they are suitable for the AdCos, it is to integrate them with our GWT GUI because they are stand-alone applications.

Regarding requirements no new updates have been included this period.

9 Conclusions

In this deliverable an overview has been given of the implementation of the various Health AdCoSs. First of all for each AdCoS it is explained how MTTs from the HF-RTP have been applied and integrated in the AdCoS. Since usability is a key aspect for each AdCoS, the HMI implementations are shown and explained. Next steps are described; depending on the maturity of the AdCoS development, this varies from prototype implementation to actual user evaluations.

Feedback to the HF-RTP is related mainly to the use of the HEE tool. A common suggestion is that it would be interesting to have the possibility to simulate how experienced and inexperienced users interact differently with a system. For all AdCoSs there is no need to update or add HF-RTP requirements.

10 List of figures