ARTEMIS	**HoliDes** **Holi**stic Human Factors **Des**ign of Adaptive Cooperative Human-Machine Systems	HoliDes

D6.4 – Tailored HF-RTP and Methodology Vs1.0 for the Healthcare Domain

Project Number:	332933
Classification:	Public
Work Package(s):	WP6
Milestone:	M3
Document Version:	V1.0
Issue Date:	10.04.2015
Document Timescale:	Project Start Date: October 1, 2013
Start of the Document:	Month 15
Final version due:	Month 17
Deliverable Overview:	**Main document:** D6.4 Tailored HF-RTP and Methodology Vs1.0 for the Healthcare Domain – Public
Compiled by:	Robert Hofsink, PHI
Authors:	Robert Hofsink, PHI Carlos Cavera Barca, ATO Nico van den Berg, UMC Pedro Ruiz, INT Peter van der Meulen, PHI
Reviewers:	Sara Sillauren Landaburu, TEC Sonia Bilbao Arechabala, TEC
Technical Approval:	Jens Gartner, EAD-DE
Issue Authorisation:	Sebastian Feuerstack, OFF

DISTRIBUTION LIST		
Copy type[1]	Company and Location	Recipient
T	HoliDes Consortium	all HoliDes Partners

[1] Copy types: E=Email, C=Controlled copy (paper), D=electronic copy on Disk or other medium, T=Team site (AjaXplorer)

RECORD OF REVISION		
Date (DD.MM.JJ)	Status Description	Author
26.02.2015	Template + input from PHI	Robert Hofsink
23.03.2015	AdCos Querying openEHR data, AdCos Internal analysis and reporting and AdCos Patient access of data	Miriam Quintero, Carlos Cavero
27.03.2015	Deployment descriptions for Integrasys, UMCU and PHI MRI added	Pedro Ruiz, Nico van den Berg, Peter van der Meulen
30.03.2015	Version for review	Sara Sillauren
07.04.2015	Reworked contributions merged	Robert Hofsink

Table of Contents

1 Introduction

1.1 Objective of the document

The objective of this document is to explain the tailoring of the HF-RTP for the AdCos in the healthcare domain. It follows deliverable D6.2 [3] and describes the use and tailoring of MTTs in the AdCos context. For each AdCos the tailoring steps as defined in D1.4 [1] are described in more detail.

1.2 Structure of the document

The document starts in chapter 2 with a recapitulation of the HF-RTP in generic terms, referring to D1.4. In chapter 3 for each AdCos the deployment of the HF-RTP tailoring rules is described, starting with an introduction and status update, followed by an overview of the Methods and Tools that are applied in this AdCos. Following the description of MTTs, the exchange of information between the methods and tools is described in the semantics section.

1.3 Main results and achievements

Each AdCos has progressed in identifying Methods, Techniques and Tools (MTT's) that will help to improve their specific development process and product quality. Most AdCos are working on the specification of information exchange (semantics) between MTTs. The work on the actual implementation will be done in a next iteration.

2 Holides Reference Technology Platform (RTP)

A development environment is a set of workflows, tools and practices that are applied for all phases of a product development. Nowadays, the environment is typically heterogeneous with a significant overhead work spent on moving from one step to another or transferring data from one tool to another. Recent activities have addressed the problem creating interconnected tool chains providing a uniform approach to batteries of tasks; however a global uniform approach is missing.

Such a uniform approach requires a set of tools that can cover the whole development process and that can exchange or share data via a defined and respected standard. Together with tools the approach should define methods and processes that on one hand form a framework, within which the tools are used and on the other they describe generically what should be done without explicitly defining tools to be used. Such system is further called a reference technology platform (RTP).

2.1 HF-RTP tailoring methodology

RTP is based on complementarity and interoperability of its compounds. There are many ways how interoperability can be achieved, the most efficient one relies on well-defined communication and data formats. Each compound can communicate and understand the data, still its role and configuration remains undefined until the compound is used in a specific context. The process of selection, configuration and linking of RTP compounds is called tailoring and it produces an RTP instance applicable for a specific use.

A first approach to the tailoring process has been sketched in D1.3. According to this approach, tailoring is about
"*Selecting tools and services for the project at hand and creating an instance of the RTP which should be apt to address the needs of a specific project.*"

In D1.4 the tailoring methodology is further defined and will be used as such in chapter 2.2.

2.2 Tailoring steps

The tailoring rules include the following steps:

2.2.1 Step 1 Purpose and intended workflow

The first step of the tailoring process will be the description of the overall purpose of the project, the AdCos workflow and the identification of weak points or unmet needs in the development process.

In the medical domain, the following AdCos's will be considered:

1. Operator task schedule and guidance
2. Querying openEHR data
3. Internal analysis and reporting
4. Safe patient transfer
5. Guided patient positioning
6. Robust ECG triggering
7. Safe parallel transmit scanning
8. 3D acquisition

2.2.2 Step 2 Selection of methods and tools

In the second step, related methods and tools are selected to fit the needs of the project purpose. A library of generalized descriptions of methods will support the method selection. A HoliDes tool list supports the tool selection.

Regarding the integration platform, HoliDes will rely on the OSLC specification as a general precondition of implementing and tailoring an RTP instance.

2.2.3 Step 3 Semantics and mapping between methods and tools

The next step is to decide which level of information exchange is needed for each of the RTP instances. A common semantic approach will be used to generalize the information exchange across several methods and tools. To this end, the common meta-model together with the Human-Factors ontology will be used.

2.2.4 Step 4 Implementation of information models and connectors.

Once the common semantics and mappings have been decided upon, the information management has to be implemented. This is mainly an engineering task.

2.3 Adaptivity in the context of the medical domain

Acquiring and working with medical data can be very complicated for many users. The tools require repetitive training and a lot of know-how, which is not always available in the hospital. Furthermore staff rotation and variability in their task division (roles) is high, so users are not likely to become expert users before the end of their rotation.

Therefore in current practice it is a challenge to design optimal user interfaces and product behaviour for the variance in user roles/skills and ways of working in diagnostic minimally invasive procedures. Inability of the product to adapt to specific user roles/skills and workflows result in sub-optimal workflow support and usability. This leads to low adoption rate of valuable clinical tools, e.g. like 3D acquisition.
Various methods and tools from the HF-RTP have been selected for the Healthcare AdCos to help in the design and evaluation of adaptivity in the HMI's. The HEE tool will provide valuable early feedback about new adaptive HMI concepts and the expected usability improvement.
With help of good design our objective is to make users become more confident and efficient in acquiring and using medical data. An example of adaptivity is to play with level of user guidance, target information to the right users concerned with the related task and remember repetitive actions/preferences.

3 Deployment of the HF-RTP tailoring rules

This chapter describes how the HF-RTP tailoring rules, as described in chapter 2, are applied in the actual AdCos.

3.1 AdCos Operator task schedule and guidance (Integrasys)

3.1.1 Purpose and intended workflow

One of the problems older adults and newcomers face at work is the adaptation to a changeable working environment, which comes from many factors: new computer and machine interfaces, new devices, new procedures and workflow, new business line and markets etc. An incorrect introduction of changes in the working environment can cause an improper assimilation of concepts, and it could cause demotivation and low productivity, especially in older employees. Furthermore, it can lead to user errors, which can put patients at risk.

The workflow for operators in medical environment (nurses, physicians…) comprises very complex procedures with many factors that influence the execution of tasks, such unexpected events that make difficult to accomplish a pre-organized plan. Informal process at hospital is very common. For instance, short disruptions of daily tasks of nurses are usual in Hospital. When the number of small interruptions outweighs the amount of planned work done in a given hour, that impact is felt in slower progress, lower job satisfaction, and potentially lower quality of care.

The intention of our AdCoS system is to ease the development of workflow solution for hospital focused on the following aspect:

- Help to proper staff assignment to tasks
- To provide real time instructions – trigger alarms – reminders and check points
- To optimize the workflow and cooperation with rest of operators
- To provide feedback to the platform for further refinement

Given the broad scope of workflow, we will focus on a subset of casuistic: Our application focused on a **prototype implementation** of a dynamic workflow system that helps to hospital operators to carry out their daily tasks.

However **the testing and deployment is one of the main problems in the development of this system, since experimenting in real scenarios is a complicated task in health systems**. Early testing of system designs is important to reduce the risk of undesirable behavior. In Holides, we plan to use tools for this purpose: Pre-testing applications with tools for critical environment. These tools will be used both for functional pre-evaluation (to assess the correct functioning), to help to validate and improve the algorithms, and to assess the usability.

Our intention is to implement a simulation tool that helps us to pre-validate the implementation of an AdCos System, before the full implementation on real hospital is carried out.
The basic functionalities are:

- To help to assign/re-assign tasks to operators
- To give context-aware instructions to operators
- Different user interfaces are foreseen: Tablet, smartphone, smart-watch.

The high level objectives are:

- To improve the efficiency of activity management in Hospital
- To ensure the usability of the system: satisfaction of operators, instructors and patient
- To accomplish strict requirement of hospitals procedure in terms of patient safety.

As explained above, the objective of this use case in Holides is to pre-validate the development before the deployment in a real scenario. For this reason we aim to propose a simulation tool that allow to automatically inject input/stimulus (inputs) and in conjunction with mobile operators, to assess the usability of the solution.

To implement such system we assume the following design process:

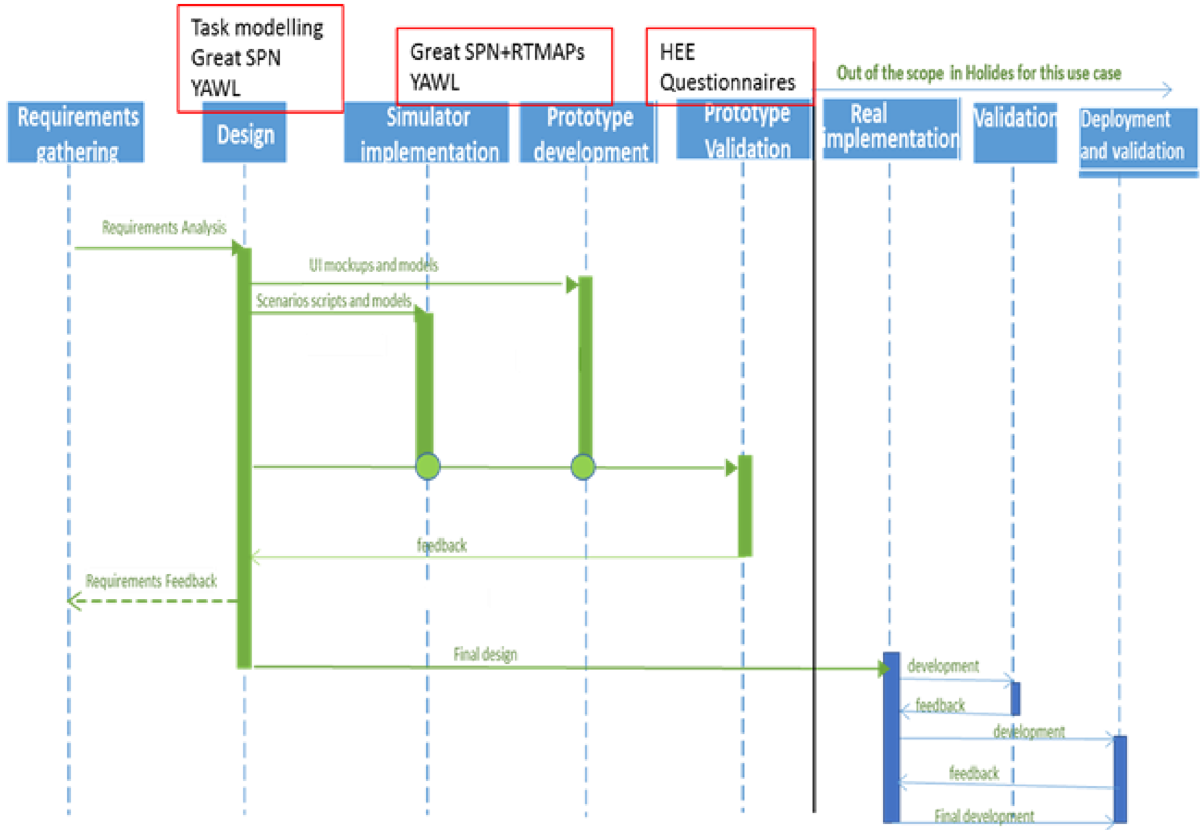

Figure 1 Design process for Operator task schedule and guidance AdCos

- Requirement gathering: No special tool is required, although a tool that allows for management and traceability through the development cycle would be useful.
  - Open source tool preferred, such as RMF for Eclipse
  - A list of requirements was provided in D6.2.
- Requirements analysis: this is a previous step to the design and model
- Design: It mainly consists in the model of tasks, contextual information and functionality. Given the heterogeneity of

information sources, we need a modelling profile that allow to cover all type of information

- Enterprise Architect is preferred
- Graphical interface to ease the generation and comprehension of model.
- Based on UML (at least 2.0 specification supported)
- To facilitate the export to standard text format which may be imported by other tools. XMI format is desired.
- In this point the most suitable tools are:
  - Holides task model is a good candidate
  - GreatSPN to model task workflow

- Modelling user interfaces: Mockups and interaction among them. This is already defined in this document.
- Prototype development: Implementation of the solution in a prototype basis. Modules to be implemented are mainly related with user application and interfaces. The implementation will include the scenario engine that helps to simulate the environment where the application would be deployed.
- Testing and validation: The testing is based on high fidelity simulation environment, where we are able to create scenarios that are automatically executed although they allow manual inputs to stimulate the system.

3.1.2 Selection of methods and tools

At this stage we have analysed the tools that would help to the development process of this AdCoS.

Basically, the results are:

- **RTMAPS**: We analysed to use this tool as a "context management" module and "simulation engine" by allowing to add inputs/stimulus to the system, synchronizing, implemented the decision algorithms and distributing it.
    - Positive aspects: The tool offers facilities to automatically execute both real time inputs and predefined scenarios (saved in a file), and logs the output for further analysis. It is also possible to implement decision algorithms as a module with RTMAPS platform. Its modular and flexible architecture allows to communicate with external and distributed platforms (as mobile devices) so it enables that simulated outputs feed real or prototype applications on mobile devices. The output of RTMAP will feed the prototype application implemented in previous stage.
    - Desired features: RTMAPS is more focused on real time monitoring, which is not a requirement for this use case. The development of customized modules for our application is a time-consuming task, although later benefits are expected. We also consider that the effort to learn how to develop new modules will be high.
- **Human Efficient Evaluator**: The HEE could be applied to compare the task performance of the current design with the context-based guidance adaptations for different user profiles.
    - Positive aspects: It is based on cognitive model, which seems to be appropriate for our use case. It would be used to assess the usability of interfaces and extract conclusions. Interesting specific targets of the performance analysis could be an inspection of the user interface navigation options of the mobile device, to figure out how they affect the overall task performance.

- Desired features: For the use with the HEE, currently the best way to identify the tasks is for a linear workflow, without alternative branches or loops. Alternative branches can be modelled as separate versions of the workflow. We emphasize that different workflows need to be created for parallel tasks. The tool does not cover human error.

- **Task modelling and analysis tools**: Propose a model based in Task model by W3C. Although not intensively tested, it covers most of our requirements, such as: (i) Formal language, UML compliance, (ii) Order Independence Choice: The task can be performed in any order, (iii) Concurrency: The tasks are concurrent and can exchange information among them, (iv)Suspend and Resume: A task can interrupt and exchange information with others, (v) Disabling/enabling: Task can be disabled/enabled when other tasks starts and (vi) There are tools like Magic Draw that ease the application of such model with intuitive graphical interfaces.

GreatSPN: this is the first tool we are using for this design process. Petri Net is a good candidate for task modelling. Basic Petri nets (usually referred to as place-transition nets) were used to create models for clinical guidelines. They are easy to learn and the diagrams are easy to understand. Petri nets are based on graph theory, and thus can be defined mathematically. The simplest Petri net modelling 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. Fortunately GreatSPN is based on *Generalized Stochastic Petri Nets and their coloured extension: Stochastic Well-formed Nets*. 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, 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, WYSISWYG application, where the modeller 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 behaviour, and to identify the invariants.

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

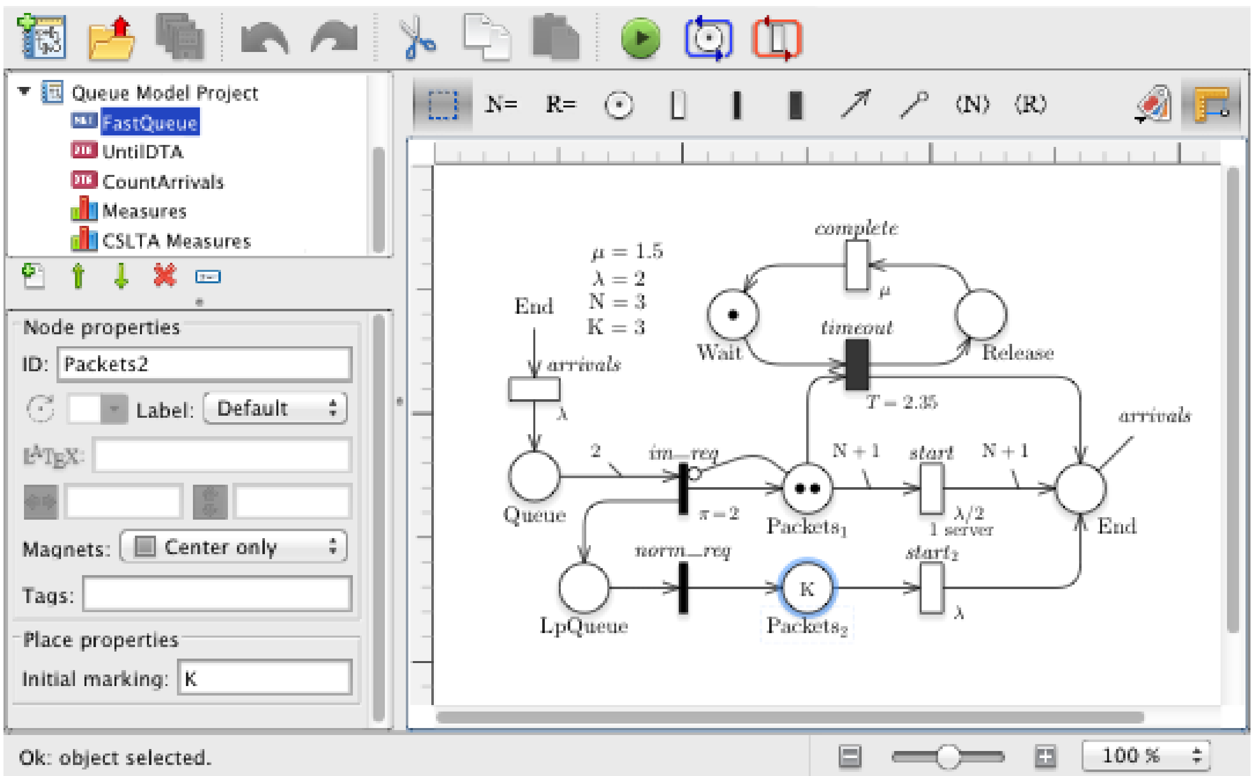

Figure 2 GUI impression

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

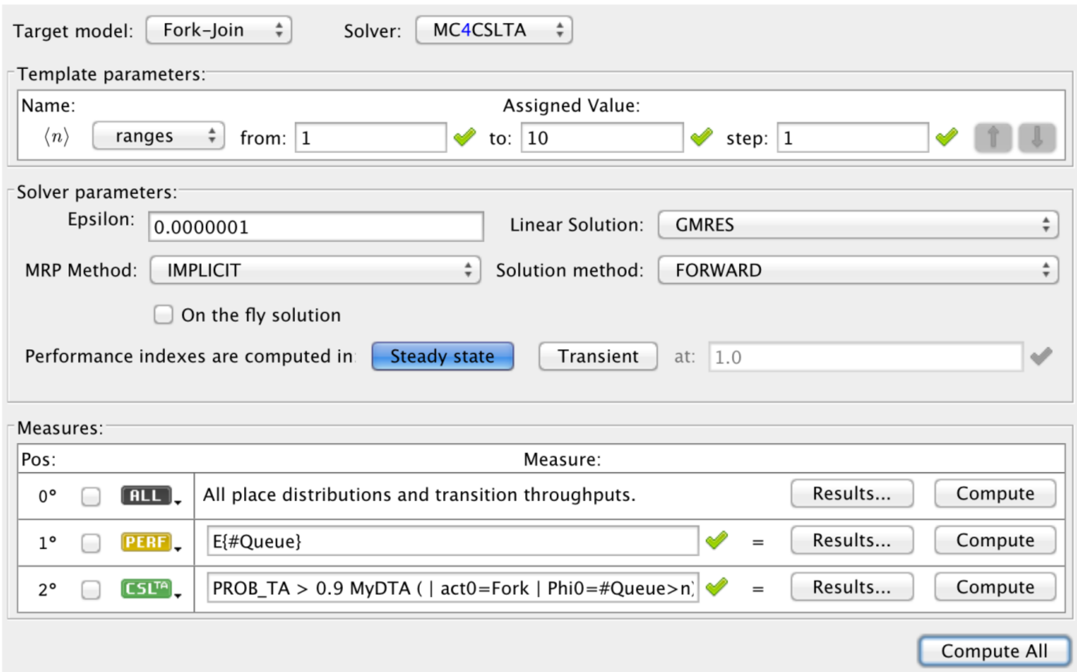

Figure 3 GUI impression

However, GreatSPN as tool is more focused on modelling and simulation and it is not ready for real-time interaction with the rest infrastructure. So, many developments are needed to be used as scenario and simulation engine. Moreover GreatSPN does not still have implemented all features of Coloured Petri Nets, which makes inconvenient for use it in this use case.

At this stage, we are discussing how to tailor this GreatSPN for our AdCoS. Our decision is to use GreatSPN from WP2 to design and analyse the workflow, and from WP4, we are discussing potential integration of GreatSPN and RTMAPS, which will give us all the functionalities to integrate real users with simulation engine that allow the distributed iteration between users and the simulation engine, and automate the execution of scenarios (as described in D6.3)

3.1.3 Semantics and mapping between methods and tools

At this stage, only initial testing has been done, and there is no defined the interfaces among method and tools for this use case.

In Deliverable D6.3, we detail a general graphical interface of the application to be developed. After that we are selecting a specific and simple example, to make a progressive integration with GreatSPN.

We plan to model a subset of the workflow in a Hospital laboratory environment. It is an Automated Laboratory of Biochemistry General.

<u>Previous information</u>
The laboratory is composed by 3 immunoassay test instrument (ADVIA) daisy-chained, with an output port of tubes and two sample managers, one for the input tubes and the other for the tested tubes. Furthermore, it also disposes of 3 glycated hemoglobin analyzer (HbA1c)

The technicians are distributed in the following way:

- Technician A manages two immunoassay test instrument ADVIA.

- Technician B manages one immunoassay test instrument ADVIA and the three HbA1c analyzer.

- Technician C manages the tubes of the output port and the sample managers. The work developed of the Technician B with the HbA1c analyzer is completely independent of the global work with the laboratory chain. This workplace doesn't depend of the rest of work in the laboratory.

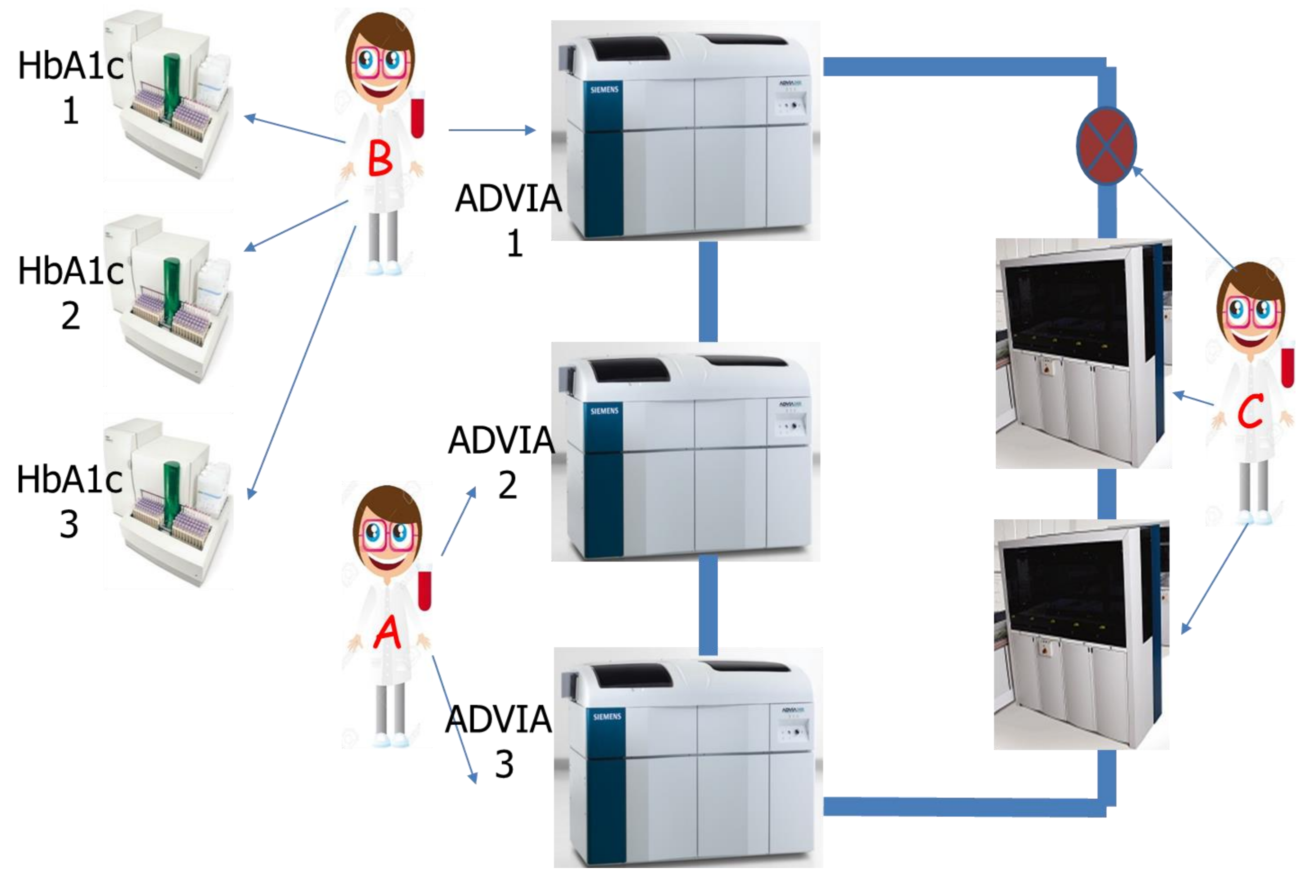

Figure 4 Graphical representation of the hospital laboratory

Task analysis for GreatSPN

The tasks of a typical workday for the laboratory technician in charge of analysis of biochemistry analyzer in the automation laboratory are:

```
8:00 - 8:30: Startup biochemistry analyzer and replenishment of reagents and consumables.
8:30 - 9:00: Preparing controls serum/urine and request for its realization on the analyzer
9:00 - 9:30: startup glycosylated hemoglobin analyzer, application of quality control and simple loading
9:30 - 10:00: verification and acceptance of quality control serum and urine correct. Corrective measures on quality controls erroneous.
10:00 - 10:45: marking biochemical analysis of urine.
10.45 - 11:00: Connection Biochemistry analyzer to the chain automation
```

11:00 - 11:30: coffee break.
11:30 - 19:00: processing and analysis of serum samples and glucosylated hemoglobin analyzer.
12:30 - 14:00: technical validation of analytical results.
14:00 - 15:00: replenishment of reagents needed in biochemistry analyzer. It implies to stops and turn off the chain automation. Around 20 minutes.
15:00 - 15:30: disconnecting the analyzer off chain automation to perform the test O´Sullivan.
15:00 - 19:00: technical validation of analytical results.
19:00 - 19:30: Replenishment of reagents needed in biochemistry analyzer.
19:30 - 20:00: Procedure "end of day": process of washing biochemistry analyzer, store serum archive in a refrigerator , turn off the automation chain

For initial works, we only make an initial identification of subtasks for the first 5 tasks, which are show:

Work for technician A (with 2 ADVIA) and technician B (with 1 ADVIA)

8:00 – 8:30: Startup biochemistry analyzer and replenishment of reagents and consumables.

- Replace the cleaner liquids of the reagent drum:
  - 10 minutes.
- Check the cleaner liquid, auxiliary reagents and analyzer oil
  - 10 minutes
- Check analysis reagents in the analyzer monitor interface
  - 2 minutes.
- If there is a lack of any reagent: reagent replacement is needed in the analyzer reagent drum
  - 10 minutes.

Work for technician A (with 2 ADVIA) and technician B (with 1 ADVIA)

8:30 - 9:00: Preparing controls serum/urine and request for its realization on the analyzer.

- Monday: Preparation and reconfiguration of controls and ion calibrators.
  - 25 minutes.
- Rest of days: Extract the reagents from the freezer in order to process them with the analyzers.

- o 5 minutes.
- Programming the daily controls and calibrations in the analyzer monitor interface
  - o 5 minutes
- Load process of the controls in the analyzer disc of samples
  - o 5 minutes
- Manual labelling of the urine samples for their tests in the ADVIA-1 (technician A)
  - o 15 minutes

Work for technician A (with 2 ADVIA) and technician B (with 1 ADVIA)

9:30 - 10:00: verification and acceptance of quality control serum and urine correct. Corrective measures on quality controls erroneous.

- Verification of control results in the monitor
  - o 5 minutes
- If it is a successful result, it is validated for the revision of the laboratory responsible
  - o 5 minutes
- If it is a failure, the control is repeated
  - o 15 minutes
  - If the second result is a success, it is accepted/validated for the revision of the responsible
    - o 5 minutes
  - If the second result is a failure, the reagent is calibrated
    - calibrator reconfiguration
      - o 5 minutes
    - calibration programming
      - o 2 minutes
  - verification of the calibration and controls results
    - o 5 minutes
      - if the result is correct, it is accepted
      - if the result is incorrect, the reagent is replaced
        - o 15 minutes
      - calibration and control of the new reagent
        - o 15 minutes

Work for technician A (with 2 ADVIA)

10:00 - 10:45: marking biochemical analysis of urine.

- Manual urine tests with the ADVIA 1

- o 30 minutes
- Verification of the results and elaboration of the urine data base
  - o 15 minutes

<u>Work for technician A (with 2 ADVIA) and technician B (with 1 ADVIA)</u>

10.45 - 11:00: Connection Biochemistry analyzer to the chain automation

- Once all controls and reagents have been verified, the equipment are connected to processing chain for all samples of the day
  - o 15 minutes

<u>Work for technician B (with 3 HbA1c)</u>

- Thawing and rehydration of the daily controls
  - o 5 minutes
- Manual programming of the control in the analyzer and controls loading
  - o 5 minutes
- Checking procedure of the comatograms of the controls
  - o 5 minutes
- Verification of pending samples lists
  - o 5 minutes
- Verification of the positive result of the control
  - o 5 minutes
- Samples loading in the analyzer in series of 50 samples
  - o 20 minutes
- Repetition of the control each 50 samples
  - o 5 minutes
- Change the filter of the analyzer after 250 samples (once a day)
  - o 15 minutes
- Change the column of the analyzer after 2500 samples de la (once a week)
  - o 30 minutes
- Calibration of the column
  - Reconfiguration of calibrators
    - o 5 minutes
  - Controls
    - o 5 minutes

Work for technician C (output port of the chain of tubes)

- Connection of the chain and check test of the communication between analyzers, middleware and LAS workspace, sample manager configuration
  - o 15 minutes
- Check of the last day pendent tubes
  - o 5 minutes
- Verification of the racks for the analysis in the sample manager in rerun configuration
  - o 10 minutes
- The rack in rerun is taken and introduced in the sample manager for its analysis
  - o 5 minutes
- Verification of the disordered tubes for their manual programming
  - o 10 minutes
- small tube labeling for the analysis in the chain
  - o 10 minutes
- se retoma la bandeja de tubos proveniente del alicuotador para pasarla a seroteca
  - o 10 minutos
- Revision of the pendent test of previous days
  - o 60 minutes
- Urine samples loading in the simple manager for their test
  - o 45 minutes
- Once the connections and controls are verified, the analysis of the samples for the day begins

We did initial implementation of workflow based on PetriNet approach. The following figures illustrate an example:

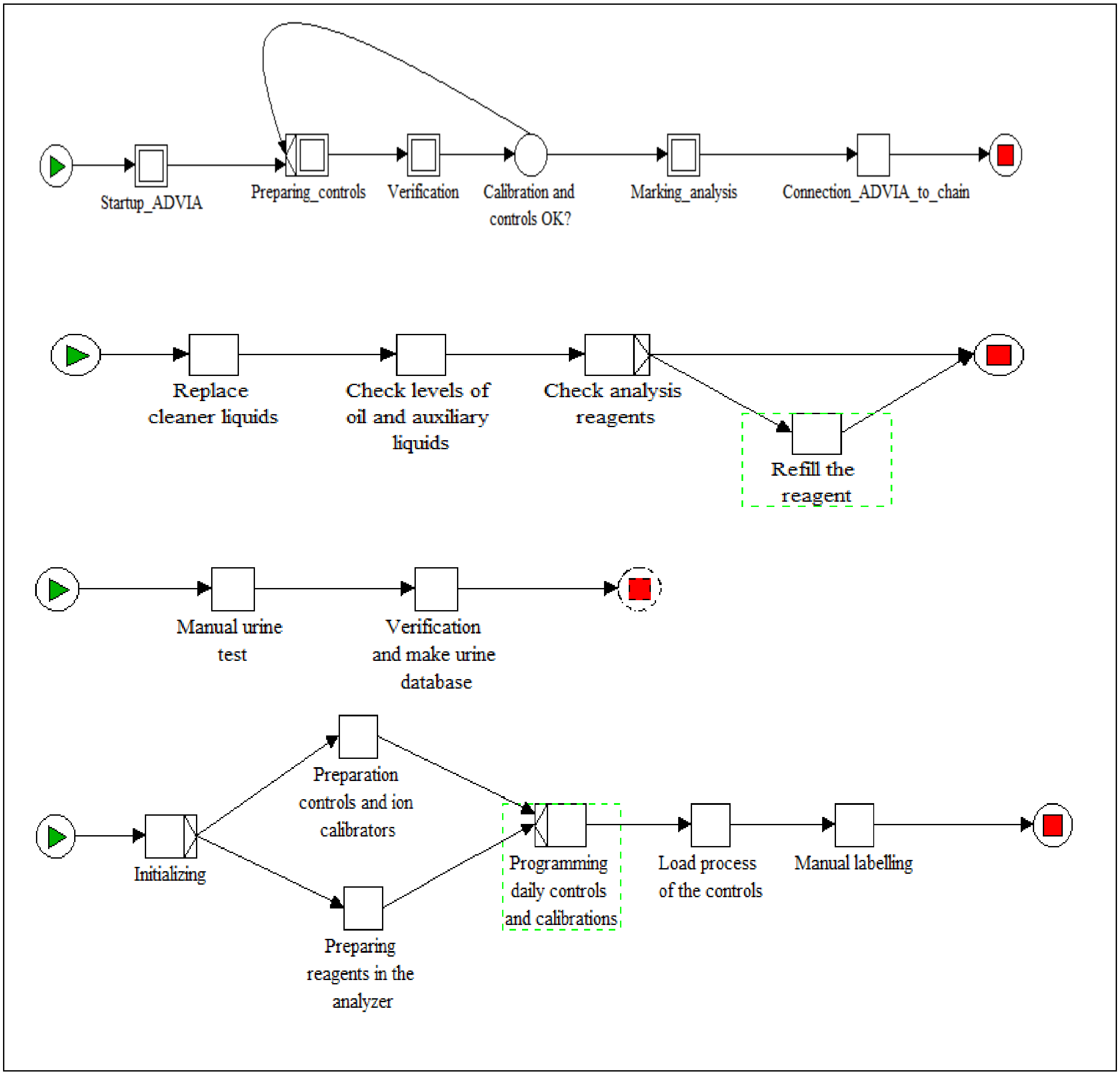

Figure 5 Examples of workflow for task modelling with Petri Nets

As commented above, the process of tailoring and definition of interfaces is still a work in progress. So, in this section we only show partial results of the performed work.
The first implied tool for this process will be GreatSPN. This section shows the preliminary work (detailed identification of tasks) needed to use this tool in our use case. The tailoring of GreatSPN to this use case is ongoing activity which is currently in its early stage.

3.1.4 Implementation of information models and connectors

For this AdCoS we do not have started the implementation of Information model and connectors yet.

3.2 AdCos Querying openEHR data (ATOS)

3.2.1 Purpose and intended workflow

This AdCos has two main objectives based on physician and patient:

1. To provide the physician with a helpful tool to help him/her in the diagnosis of disease; this AdCos joins images with patient´s EHR (Electronic health record) using WADO (Web access to DICOM images). WADO will connect to the PACs (Picture Archiving and Communication System), as an image server, and taking the information from yourEHRM middleware (openEHR/EN13606 compliant) and displays full patient clinical data, so, the physician (authorized) provides proper treatment based on specific patient information; profile (foreign patient, English mother tongue, symptoms…) and patient´s EHR which contains clinical details: diseases, habits, allergies, DICOM (Digital Imaging and Communications in Medicine) images, etc.

2. To provide access to patients (and other authorized people like physician), to their own medical and clinical data, always in a secure way. The data to be displayed to the patient are demographic, habits patterns and personal details as well as clinical reports previously

generated by his or her professional. In addition, the patient is allowed to modify some data like demographic, habits or personal details in order to keep his or her information as updated as possible.

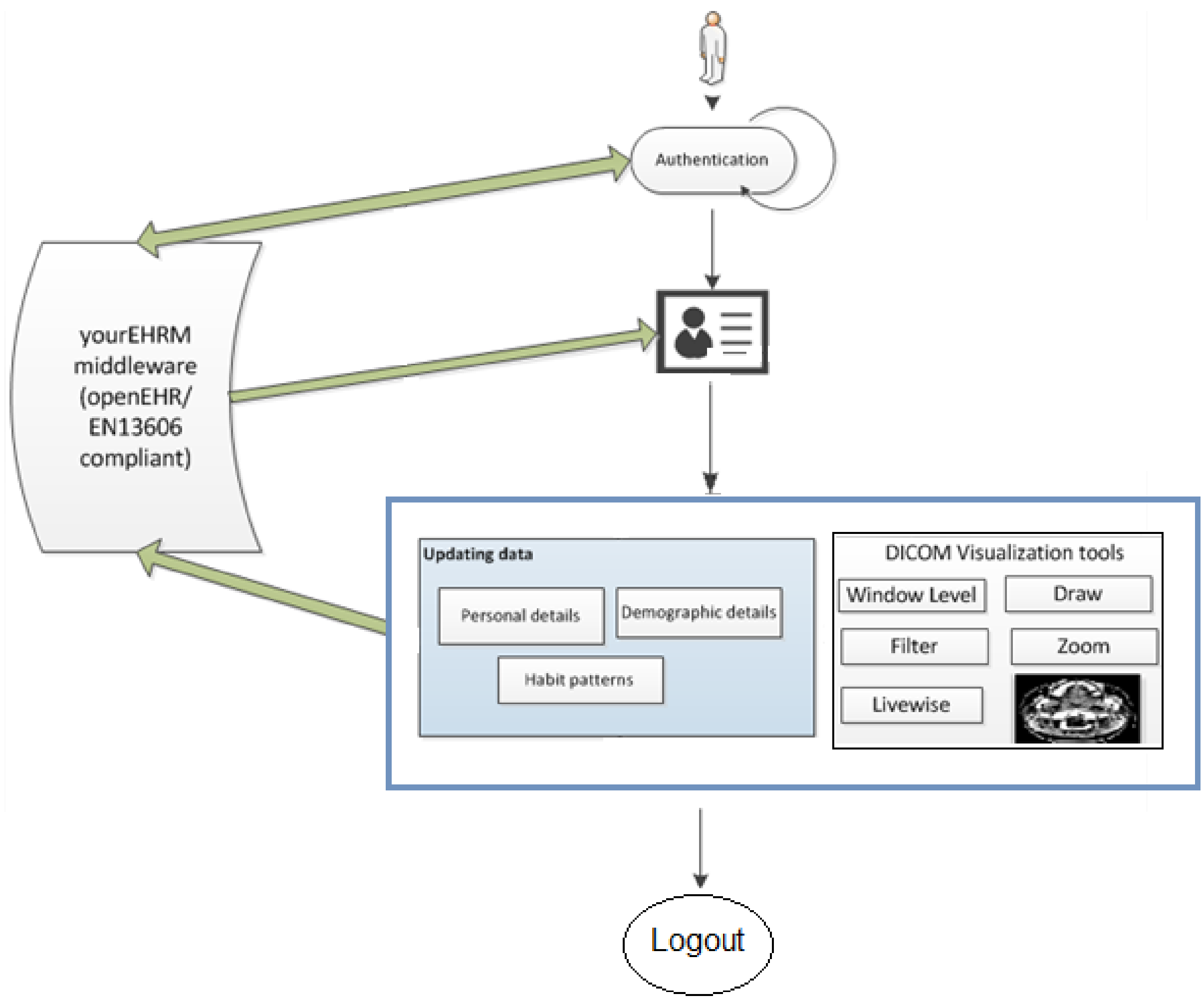

Figure 6 Querying openEHR data workflow.

<u>Workflow weak points or unmet needs</u>

There are two big issues; (1) speed to access to DICOM images and (2) interoperability problems.

To deal with DICOM images access, which the system can retrieve earlier acquired, it has been decided via WADO, but still, it has to be carried out some tests to ensure usability, speed and efficiency on different devices (PC and android systems like tablets or mobiles).

About interoperability, the solution integrates the data from heterogeneous and fragmented healthcare information systems and devices based on generic information models, which conform to openEHR/EN13606 archetypes and besides offers the possibility to exchange information with other Hospital Information Systems (HIS) using Health Level 7 (HL7) Clinical Data Architecture (CDA), Continuity of Care Record (CCR), Continuity of Care Document (CCD) or virtual Medical Record (vMR) as the payload: yourEHRM, standard-based management of your personal healthcare information.

DICOM images are the core of Querying openEHR data AdCoS; if considering that the user waiting time is not acceptable, the possibility of obtaining a certain number of DICOM images, each time, will be considered, it means that the AdCoS will download DICOM images (.dcm) by stretches. Regarding interoperability the use of AdCoS allows to adapt the information given to the patient profile.

Status of the AdCos development and workflow

Within the Querying openEHR data AdCos the following task has been carried out:

- Investigation of secure access of patient data; secure protocols, encryption, certificates, etc.
- Investigations of clear presentation of data to avoid misunderstanding and unnecessary worries.
- Identification of an appropriate framework and environment.
- Investigation and test to ensure usability, speed and efficiency on different devices to deal properly with DICOM images.
- Definition of inputs and outputs in detail.
- Because of the system will allow updating data, new medical tests can be carried out to the patient and added to his electronic health record, it is essential to investigate the proper way to perform this action

3.2.2 Selection of methods and tools

HEE

The Human Efficiency Evaluator from OFFIS has been identified as a tool that can help analyse workflows – or parts of larger workflows – for Querying openEHR AdCoS in the healthcare domain.

The most critical part of the whole workflow has been identified as "Display Patient Studies"; therefore, the HEE will be applied in Patient Studies use case. In this Graphical User Interface (GUI) we will have several tools and options.

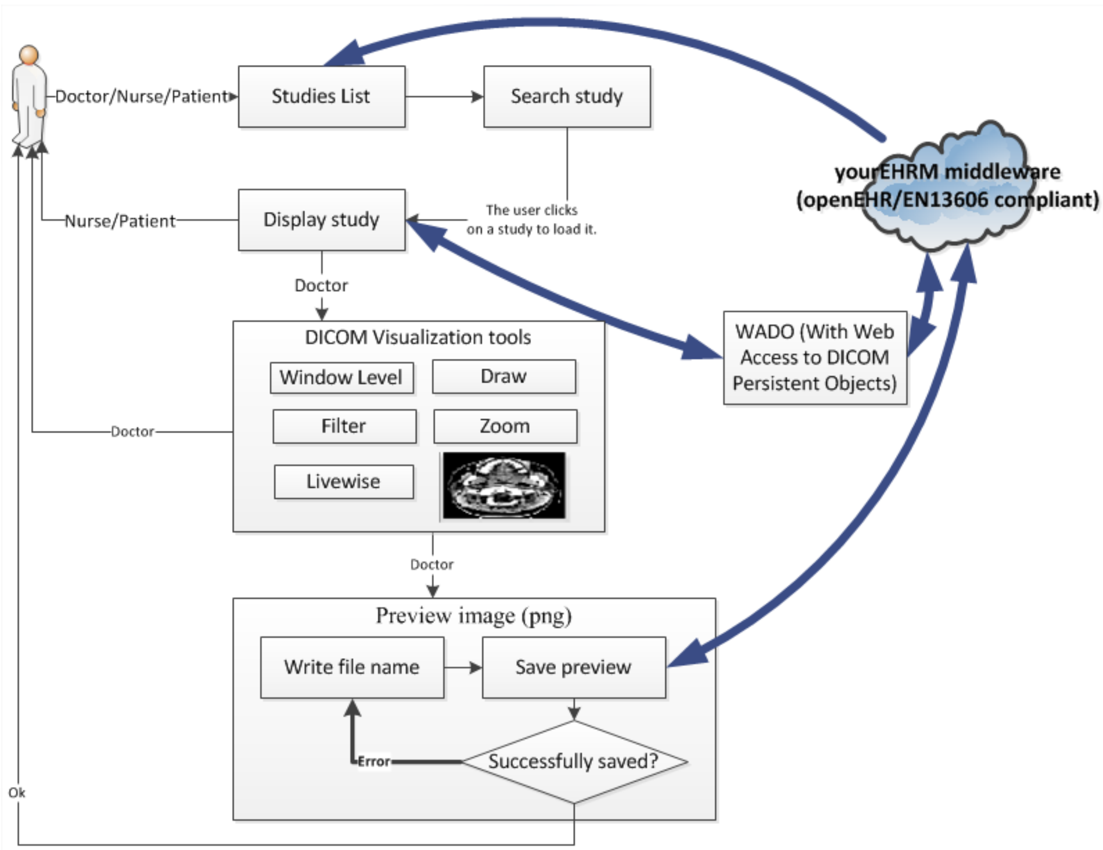

Figure 7 Patients studies (DCM images) display diagram

<u>AEON</u>
In order to exchange information between the systems we will use the cloud message capability of AEON.

Data Race Detector & Healer

We are considering to use this tool to detect and heal data races and atomicity violations in the use of the GUI (same doctor accessing the same EHR or image).

Modelling of AdCoS from a means end perspective
We are considering to use this methodology to model the AdCoS for retrieving the data from the electronic health record taken into account the human factors related to the user.

HF Filer
For the AdCoS we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases.

3.2.3 Semantics and mapping between methods and tools

The following steps have been performed:

1. Describe the workflow
2. Focus the most critical part of the workflow
3. Mock up the UI
4. Identify the tasks
5. Create a table with the task sequence

Modelling of AdCoS from a means end perspective and HEE were used to model the AdCoS and the related use cases as shown in the above list.

The HF-filer will be used for the validation process. AEON will provide the cloud message capabilities to exchange the information between modules. Finally the Data race detector and healer will be used to control thread activities as atomic tasks.

3.2.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tools and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

3.3 AdCos Internal analysis and reporting (ATOS)

3.3.1 Purpose and intended workflow

The objective of this AdCoS is (1) to access the patient data for statistical analysis of pathologies and (2) to generate patient clinical reports based on data coming from heterogeneous and fragmented healthcare information systems.

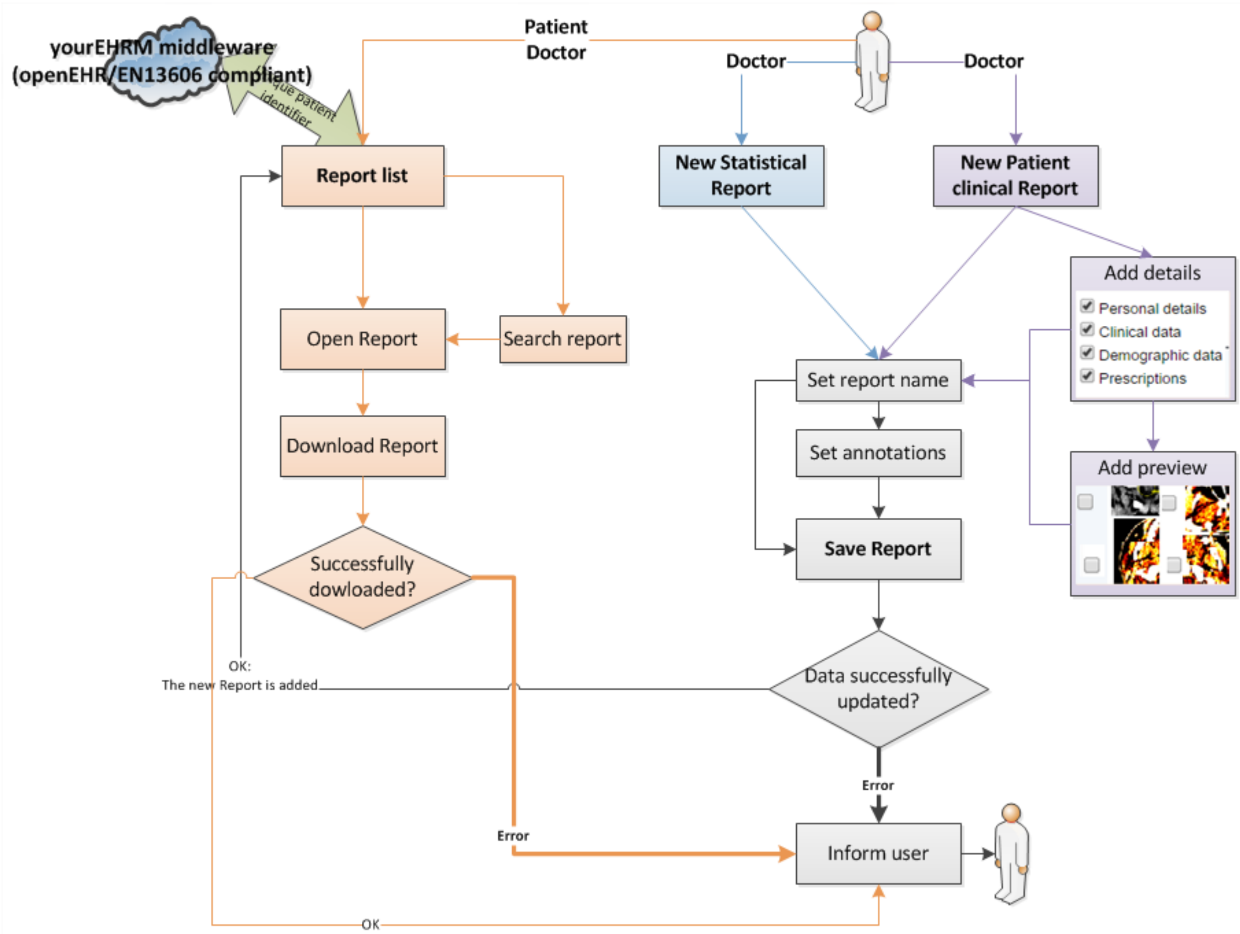

Figure 8 Internal Statistical Report and Patient clinical Report workflow.

Internal statistical 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.

Besides the predictive report the AdCos permits to generate custom patient reports in order to provide a general overview of his/her health status. This report includes clinical patient data; MRI (Magnetic Resonance Imaging), Lab Tests, prescriptions, etc. any EHR data considered by the professional.

Workflow weak points or unmet needs

Data mining process needs large data set and the quality of our data mining results will directly depend upon the quality of our data collection.

The system will be trained with fake data and only when the relevant real data will be available the final modelling phase will be completed.

At this moment, It is important to define a scope (what do we want to know) by defining some questions to answer, starting with high level ideas. The quality of our data mining results will directly depend upon the quality of our data collection and organization.

3.3.2 Selection of methods and tools

HEE
The Human Efficiency Evaluator from OFFIS has been identified as a tool that can help analyse workflows – or parts of larger workflows – for Internal Analysis and reporting AdCoS in the healthcare domain.

AEON
In order to exchange information between the systems we will use the cloud message capability of AEON.

LEA
As we are using Machine Learning techniques we are considering the option of using AI techniques of LEA over data to efficiently learn about behaviours.

CBR
The Case Base Reasoning is widely used in eHealth environments, the application of this tool will allow to solve statistical problems based on the solution of similar cases in the past.

Data Race Detector & Healer
We are considering using this tool to detect and heal data races and atomicity violations in the use of the GUI (same doctor accessing the same EHR or image).

Modelling of AdCoS from a means end perspective

We are considering to use this methodology to model the AdCoS for retrieving the data from the electronic health record taken into account the human factors related to the user.

HF Filer

For the AdCoS we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases.

Other internal tools planned to be used are:

- **yourEHRM middleware**: yourEHRM uses standards that enable medical information exchange (HL7, ISO 11073/IEEE 1073, CEN 13606, openEHR family of standards). It is mainly used to get clinical patient information and update it.
- **Java open source PDF libraries**: It is necessary to generate a PDF document in this AdCoS.
- **Java open source machine learning libraries**: It is necessary to generate a model from our collated data and apply it in order to generate our Analytic report in Analysis and reporting AdCoS. This report is generated by applying the model (previously) obtained with data mining techniques.

We are evaluating the possibility to implement RTP tools to plugged in those internal components in the HOLIDES ecosystem and let others to reuse them.

Figure 9 Data mining process steps or phases.

3.3.3 Semantics and mapping between methods and tools

The following steps have been performed:

1. Describe the workflow
2. Focus the most critical part of the workflow
3. Mock up the UI
4. Identify the tasks
5. Create a table with the task sequence

Modelling of AdCoS from a means end perspective and HEE were used to model the AdCoS and the related use cases as shown in the above list.

The HF-filer will be used for the validation process. AEON will provide the cloud message capabilities to exchange the information between modules. LEA and CBR can help on extract useful statistical information based on machine learning techniques and similar cases solved in the past. Finally the Data race detector and healer will be used to control thread activities as atomic tasks.

3.3.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tooling and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

3.4 AdCos Safe patient transfer (Philips MRI)

3.4.1 Purpose and intended workflow

The AdCoS is the system that enabled the design and validation of the Safe Patient Transfer System, also called the MRI Trolley.

This Trolley needs to be safe and easy to use for a broad range of operators and patients.

Anthropometric data:
MR operators with different stature will work with MR patient transportation and different patient sizes needs to be supported:
Patient weight: 0 – 250 kg.
Patient height: 0 – 2.20 m

The MRI Trolley is used to transport an immobile patient to and from the MRI scanner. The patient typically arrives in a non-MR compliant bed or wheel chair at the MRI facility. Outside the examination room the patient is put on the MRI table top, which is on the trolley. The operator wheels the trolley + patient into the examination room, and places this over the patient support, which is in lowered position. If the patient support is lifted the tabletop with patient will be automatically put on top, ready to be shifted inside the MRI scanner.

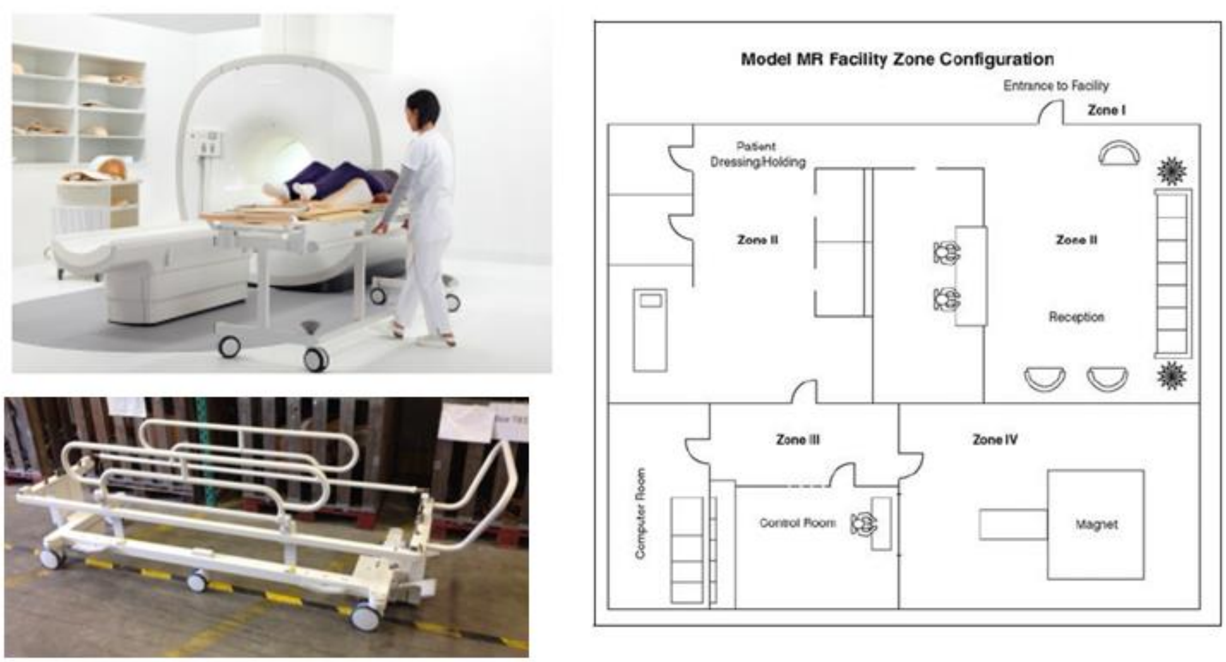

Figure 10 MRI trolley and system explanation.

- Left below: Picture of the MRI Trolley;

- Left above: Patient on trolley is wheeled to the MRI system. Right: typically lay-out of the radiology department

The AdCoS needs to be able to model the variety of applications, operators, patients and physical properties of the radiology department.

3.4.2 Selection of methods and tools

HF Filer
For this AdCoS we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases, with a specific eye to use cases where task analysis or usability evaluation is employed.

HF Filer is a tool that allows the filing of human factors evaluations for several development projects simultaneously, and for each project several evaluation reports can be created and filled. This work is all undertaken in the web-based user interface (UI) of the tool itself.

HF Guideline
HFC just started the development of the HF guideline. If available the applicability for this AdCoS will be evaluated.

Usability Validation
HFC will participate in various usability validation sessions to determine if their methods can improve the current way of working.

CPM-GOMS and PROSIVIC
In a later stage we will determine if the CPM-GOMS tool, made for task analysis of a Lane Change for manual and automated driving, and PROSIVIC, a virtual car and 3D road environment simulator, are also applicable for patient transport modelling.

3.4.3 Semantics and mapping between methods and tools

This AdCoS is focussing on improving the efficiency of design and validation of the MR trolley. The HF-filer and HF Guideline are generally applicable tools. The usability validation can potentially improve the currently applied usability validation process. The modelling tools might be helpful during the design phase.

3.4.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tooling and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

3.5 AdCos Guided patient positioning (Philips MRI)

3.5.1 Purpose and intended workflow

The AdCoS is the system that provided guidance to the operators during preparing and positioning patient for MRI examinations.

Figure 11 Pictures of several actions during patient positioning

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 the operator is trained for this. The on-line guidance system intents improve usability and to reduce risks, also in case of novice, less experienced users.

<u>Input:</u>

The Guided Patient Positioning System has access to the on-line information from the MR system (patient characteristics, MRI examination procedure, actual system status, physiology signals and connected devices).

Output:
The Gantry Display, positioned at the front of the magnet at a fixed location, provides information and instructions for the operators. Additionally sound can be used to provide feedback to the operator.

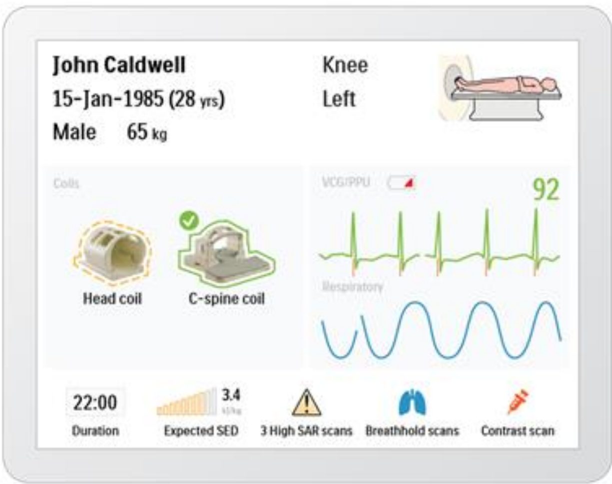

Figure 12 Example of the gantry display

Operator control:
The touch screen UI on the Gantry Display allows the operator to access various levels of information (e.g. more detailed instructions for novice users, more details of received physiology signals)

3.5.2 Selection of methods and tools

HEE

The HEE tool supports evaluation in early design phases to predict task performance, the attention allocation of the operator and operator's reaction times of different HMI designs by simulating the human behaviour with a cognitive architecture based on low-fidelity prototypes such as photos, screenshots or sketches as input.

Within WP 6 we first study the applicability of the tool for iXR 3D acquisition, and will evaluate HEE for the guided patient positioning as next step. This might be combined with the next AdCoS: robust ECG triggering.

CASCas
This tool is connected to HEE, both developed by Offis. During the evaluation of HEE for guided patient positioning the applicability of CASCaS will also be assessed.

Modelling of AdCoS from a means end perspective
The guided patient positioning has been modelled by AnyWi. In this model the parts ('means') of the AdCoS are used as starting point and linked to functional properties and actors. This model can be used as input for the more elaborate modelling in the next tool:

MagicPED
MagicPED is a tool that can be used for task modelling. We consider to translate the model that already has been made in the previous MTT (Modelling of AdCoS from a means end perspective)
to MagicPED for evaluation.

HF Filer
For the Guided Patient positioning AdCoS we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases, with a specific eye to use cases where task analysis or usability evaluation is employed.

HF Filer is a tool that allows the filing of human factors evaluations for several development projects simultaneously, and for each project several evaluation reports can be created and filled. This work is all undertaken in the web-based user interface (UI) of the tool itself.

Adaptivity analysis

Together with EAD-F we will assess the value of their adaptivity analysis for this AdCoS, potentially in combination with the AdCoS Robust ECG triggering.

<u>HF Guideline</u>
HFC just started the development of the HF guideline. If available the applicability for this AdCoS will be evaluated.

<u>Usability Validation</u>
HFC will participate in various usability validation sessions to determine if their methods can improve the current way of working.

3.5.3 Semantics and mapping between methods and tools

Several tools are indented to model the AdCoS and the related use cases, from different perspective (Modelling of AdCoS from a means end perspective, HEE, CASCas, MagicPED, Adaptivity analysis). It is expected that the modelling data can be exchanged between the various MTTs.
The HF-filer and HF Guideline are generally applicable tools. The usability validation can potentially improve the currently applied usability validation process.

3.5.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tooling and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

3.6 AdCos Robust ECG triggering (Philips MRI)

3.6.1 Purpose and intended workflow

System for real time acquisition of physiology signals from the patient to derive trigger signals required during MRI scanning.
Acquired signals:
- VCG (Vector Electro Cardiogram, via sensors on the chest)
- PPU (Peripheral Pulse Unit, typically via a finger clip)

- Respiratory (via sensor on the chest)

The system displays the signals, allowing the operator to judge the quality, and all data are logged for off-line analysis.

Many MRI scans require synchronization on the cardiac motion, either to minimize motion artefacts due to the motion of the heart itself or the pulsatile blood flow.

Two methods are available:

- VCG (Vector-ECG) signals, derived from electrodes on the patient's chest
- PPU, peripheral pulse unit, which measures the oxygen level in the fingertip.
-

The VCG signals are accurately linked to the cardiac motion and are needed if images are taken close to or of the heart. In that case trigger pulses are derived from the signal, either to directly synchronize the scans or to administer the timing together with the MR data collection, used to retrospectively align the MR data with the ECG signal.

Detection of the ECG signal during MR scanning is complicated because of the following effects:

- The ECG signal is distorted because blood flow in the presence of a strong magnetic field creates significant potential differences, which interferes with the normal ECG signal
- Fast gradient switching induced additional potential differences in the body, which easily can be much larger than the normal ECG signal

Filters are available to deal with these issues. However, positioning of the electrodes in relation to the physiology of the patient and respiratory motion are still important sources for distortion.

Figure 13 Placement of the ECG electrodes

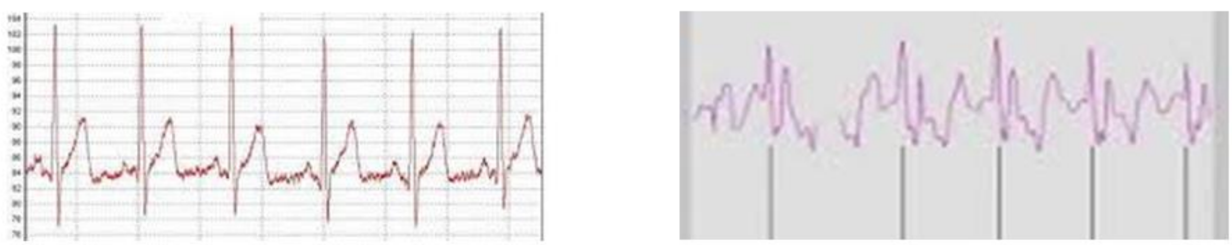

Figure 14 Left: Clean ECG signal outside the magnet, right distorted ECG signal in the magnet due to MHD effect in combination with blood flow

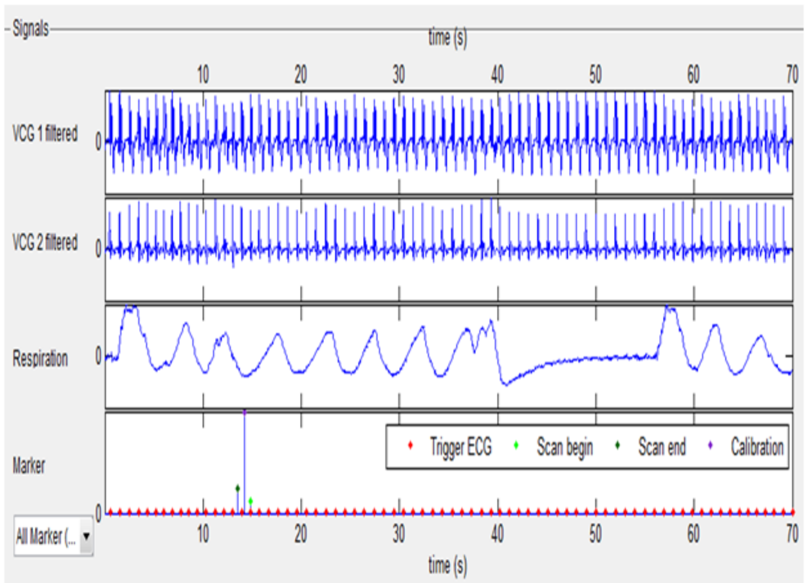

Figure 15 Example physiology display

Fehler! Verweisquelle konnte nicht gefunden werden. shows the following: from top to bottom: two ECG traces, one respiratory trace, and the red trace with trigger signals. Note that this was a breathhold scan, as can be seen from the respiratory signal

3.6.2 Selection of methods and tools

<u>HEE</u>

The HEE tool supports evaluation in early design phases to predict task performance, the attention allocation of the operator and operator's reaction times of different HMI designs by simulating the human behaviour with a cognitive architecture based on low-fidelity prototypes such as photos, screenshots or sketches as input.

Within WP 6 we first study the applicability of the tool for iXR 3D acquisition, and will evaluate HEE for the guided patient positioning as next step. This might be combined with the previous AdCoS: Guided patient positioning.

CASCas
This tool is connected to HEE, both developed by Offis. During the evaluation of HEE for guided patient positioning the applicability of CASCas will also be assessed.

Modelling of AdCoS from a means end perspective
The guided patient positioning has been modelled by AnyWi. We consider extending this to Robust ECG triggering. This model can be used as input for the more elaborate modelling in the next tool:

MagicPED
MagicPED is a tool that can be used for task modelling. We consider to translate the model that already has been made in the previous MTT (Modelling of AdCoS from means end perspective) to MagicPED for evaluation.

HF Filer
For this AdCoS we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases, with a specific eye to use cases where task analysis or usability evaluation is employed.

HF Filer is a tool that allows the filing of human factors evaluations for several development projects simultaneously, and for each project several evaluation reports can be created and filled. This work is all undertaken in the web-based user interface (UI) of the tool itself.

Adaptivity analysis
Together with EAD-F we will assess the value of their adaptivity analysis for this AdCoS, potentially in combination with the AdCoS Guided patient positioning.

HF Guideline
HFC just started the development of the HF guideline. If available the applicability for this AdCoS will be evaluated.

Usability Validation

HFC will participate in various usability validation sessions to determine if their methods can improve the current way of working.

3.6.3 Semantics and mapping between methods and tools

Several tools are indented to model the AdCoS and the related use cases, from different perspective (Modelling of AdCoS from a means end perspective, HEE, CASCas, MagicPED, Adaptivity analysis). The same modelling semantics and data will be used at the different MTTs.
The HF-filer and HF Guideline are generally applicable tools. The usability validation can potentially improve the currently applied usability validation process.

3.6.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tooling and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

3.7 AdCos Safe parallel transmit scanning (UMCU)

3.7.1 Purpose and intended workflow

To optimize the Magnetic Resonance (MR) image quality for certain anatomical regions, a so-called phased antenna array is used in 7T head imaging.
A set of (e.g. 8) Radiofrequency (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 special selective (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.

The AdCoS consists of the following parts:
- Tool to calculate the dielectric composition of the patient
- Tool to calculate the local absorption of RF energy in the patient
- Tool to calculate the local temperature change in the patient
- Mechanism to adjust the RF transmit system based on calculated temperature map, taking safety limits into account
- UI elements to communicate the status and required actions to the operator
- Control elements to run-time monitor the status of all elements in the RF transmit chain
- Mechanism to generate an interlock followed by a scan abort if any malfunction is encountered

The AdCoS makes use of the general capabilities of the MRI system to calibrate average RF power and to scan a series of scans and real-time generate images.

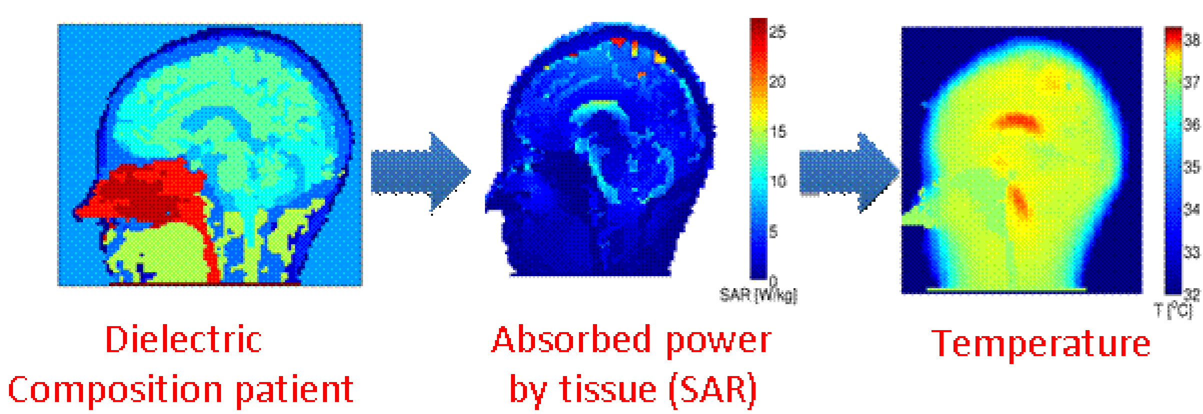

Figure 16 Relation between absorbed power and temperature

3.7.2 Selection of methods and tools

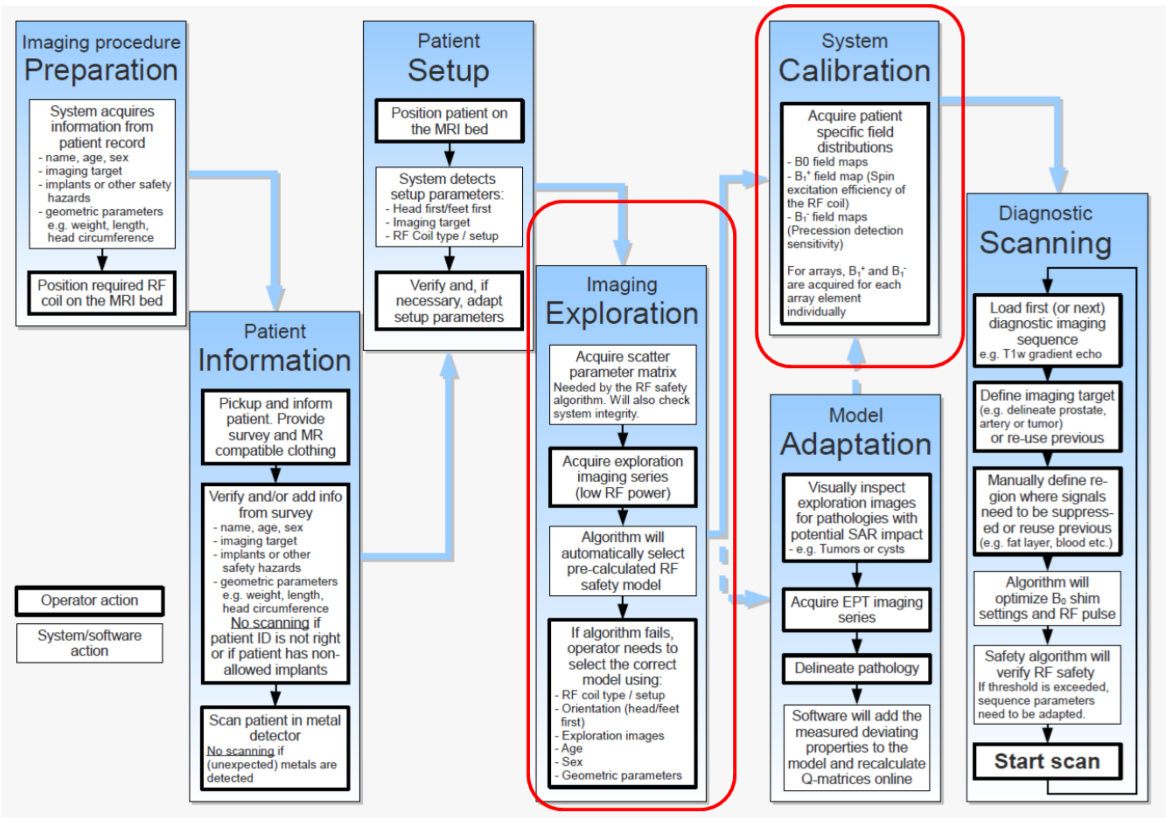

Figure 17 Workflow overview

Workflow for the entire patient preparation, patient setup and System calibration procedure for parallel transmit scanning. The work is this AdCos is focussed on the red marked tasks designing technology to set safe radiofrequency power setting to keep patient heating under control.

The work in his AdCos is mostly related to the development of technology to be able to predict patient heating in individual subjects to allow safe parallel transmit scanning. For this purpose we are building a database of segmented patient models for who the electromagnetic heating can be calculated using electromagnetic and thermal modelling platforms. Up to this moment we have scanned 10 patients resulting in anatomical images of their trunks. We have developed image segmentation tooling to make dielectric models of these patients. This has resulted in 10 successfully segmented patient models. The heating is currently being evaluated by electromagnetic and thermal simulations.

The idea is to include extending and using this database for heating assessment for individual patients. For this purpose a to-be-scanned patient will be registered to the database and the best matching model will be used for determining safe Radiofrequency power settings. Various patient and image features (dimensions, weights, water/fat fractions, thickness subcutaneous fat layer) will be tested for maximal predictive power for patient heating to be able to define a set of match parameters.

This procedure will be tested in a virtual scanning environment where a small sub-selection of the images database will be treated as virtual-to be scanned patients. These virtual patients are matched to remaining patient models in the database. As the ground truth heating is also available for these test virtual patients, we can test the accuracy and reliability of this procedure. The coming half year will be used to extend the database to include sufficient anatomical inter-patient variation.

In the next step we will design a virtual scanning environment which allows us to study and design on the human factor aspects related to control of our safety system by MRI radiographers (RTTs). This safety procedure will be performed in a virtual scanning environment by RTTs that will perform also the parallel transmit scanning on the real scanner. By evaluating this RF safety procedure on this virtual platform, we hope to identify critical aspects in terms of human factors, protocol and UI design.

3.7.3 Semantics and mapping between methods and tools

We would like to stress that the work in this AdCos is mostly related on technology development to be able to perform individualized heating assessments. Nevertheless, various explorations have been performed and are ongoing how MTTs can be used.

1. GreatSPN tool. UTO

In the time period May 2014-Oct. 2014 various meeting have taken place between UMCU and UTO on the potential use of their GreatSPN tool to be used in patient specific RF safety assessment. During this meeting the UTO has been made familiar with the AdCos which required in depth discussions. The greatSPN tool is based on PetriNet modelling and to be able to use this tool as a predictor of RF safety, it needs to be trained by a large number of datasets. After elaborate discussions, it was concluded that the large number of training patient datasets (~100-200) required to obtain reliable estimates was not realistic. After this, the collaboration has been discontinued.

2. Behavioural Validation Tool. REL / Elisa Landini

A first meeting has taken place at the Berlin meeting on how this tool could play a role in the design of the UI interface and instructions/guidelines for the RTTs for safe parallel transmit scanning. In the coming week a follow up telco will be held.

3. Empirical analysis of cognitive and communication processes, SNV Simona Collina
Also with SNV a meeting has taken place at the Berlin looking as similar aspects as described at 2.

3.7.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the MTTS and its applicability to our AdCos. This will include a detailed analysis of the steps in our workflow. This will be described in the next tailored HF-RTP document.

3.8 AdCos 3D Acquisition (Philips iXR)

3.8.1 Purpose and intended workflow

An angiography x-ray system is used to visualize anatomy, catheters and other instruments during minimally invasive procedures like coronary stenting in the heart or aneurysm repairs in the brain. The X-ray images used are only 2D, but advances in technology now also allow making a 3D scan to better visualize the anatomy and use this 3D volume as planning and 'navigation' tool for the intervention. **Fehler! Verweisquelle konnte nicht gefunden werden.** shows a 3D volume which is overlaid on a pre-operative Magnetic Resonance Imaging (MRI) scan.

A 3D scan allows better visualization of the anatomy, but is difficult to perform due to the amount and complexity of the steps that need to done. Safety is an important issue here, because making a 3D scan when the patient area has not been fully cleared and the positioning of the patient in the system has not been done correctly, will imply the need of doing a retake, which takes extra time and patient discomfort. As a result of this highly skilled personnel are required to perform the 3D scan and in some cases, when the staff does not feel comfortable in making a 3D scan, they will rely on the 2D images only to do the procedure.

It is the objective of this AdCos to help the staff to become more confident in acquiring and using 3D data, by analysing the workflow steps and developing an improved Human Machine Interface that helps the user in the preparation and execution of the 3D Acquisition.

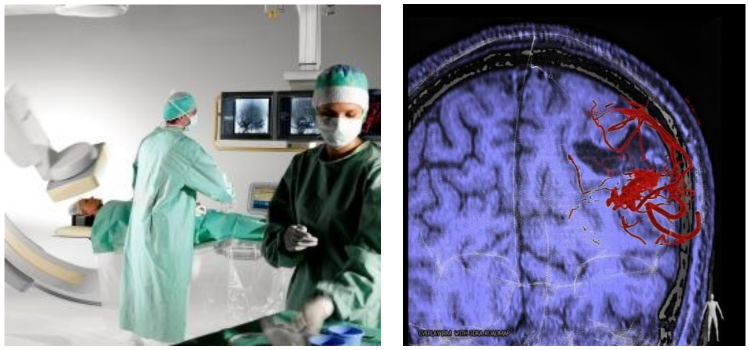

Figure 18 X-ray system acquires 3D volume to visualize the vessels (see red).

<u>Workflow weak points or unmet needs</u>

An important aspect of any X-ray system is how the User Interface supports the doctor in doing the diagnosis and treatment of patients. The design process of adaptive user interfaces, including validation of intermediate and final solutions, is hardly supported by tools. Within the Holides project, the 3D Acquisition AdCos will use tools from the HF-RTP to address this.

State of the Art of the development process:

Currently, in the development process of the 3D Acquisition AdCos, HMI prototypes are developed and evaluated with the help of users. User testing provides valuable information about the HMI quality and is done both in labs as well as on site in hospitals.

Expected improvement in the development process:

Through the use of early structured task analyses and early evaluations of the HMI efficiency with the HEE-tool we expect to speed up the development process with faster iterations and reduce the cost of evaluation.

State of the art of the product quality:

As it has already been mentioned in earlier deliverables on the AdCos, the execution of a 3D Acquistion scan in a clinical setting is difficult and can only be done by experienced users. Even then it takes a considerable amount of time to prepare and align the patient and system, before the actual 3D scan can be made.

Expected improvement of the product quality:

With the improved HMI the user will get better and more intuitive guidance. We expect that it will be much easier to perform a 3D Acquisition and that the user will be more confident in making the 3D scan. In the end this will result in improved user satisfaction, a shorter learning curve for inexperienced users and a faster workflow.

Status of the AdCos development and workflow

Within the 3D Acquisition AdCos, a new HMI is currently under development. User experiences with the existing HMI show that some steps in the workflow are difficult to perform and that improvement in the form of guidance or adaptivity is required. New concepts for the HMI are under investigation at Philips and a comparison and early evaluation using the Human Efficiency Evaluator (HEE) is currently in progress.

The typical workflow of an interventional procedure, including 3D scan, consists of multiple steps. A snapshot of the full workflow is shown in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

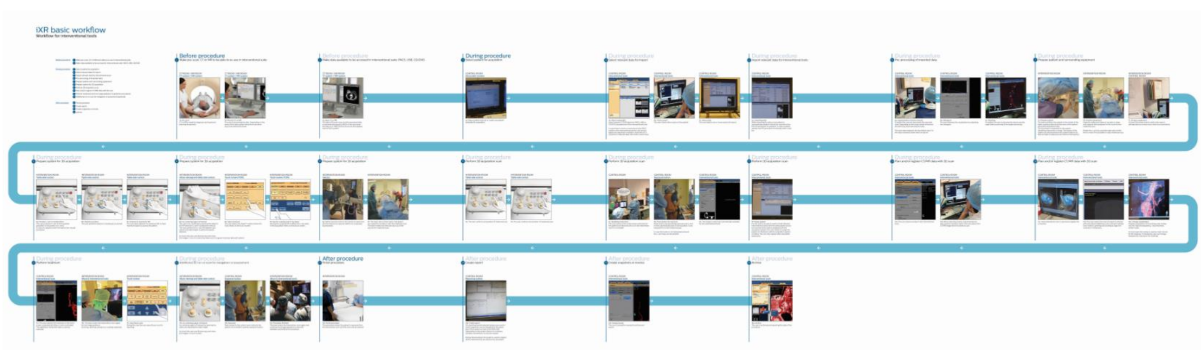

Figure 19 Workflow overview of interventional procedure, including 3D image acquisition

Within the scope of the Holides Project, steps 7, 8 and 9 will be considered; i.e. addressing:

- patient preparation
- system preparation
- performing the 3D scan.

A detailed description of the AdCos and the workflow steps has been made in deliverable D6.3 [4]

Adaptivity

Specifically the system preparation step involves a complicated set of user actions that sometimes need to be repeated when it shows that the alignment of the patient with respect to the system is not correct. A desired situation would be that the system adapts its position automatically, based on the clinically relevant part of the anatomy, which is indicated by the user.

3.8.2 Selection of methods and tools

HEE

For the 3D Acquisition AdCos the HEE tool has been selected for the early evaluation of the new HMI and the task performance comparison between the existing and new HMI.

The HEE tool supports evaluation in early design phases to predict task performance, operator's workload, the attention allocation of the operator and operator's reaction times of different HMI designs by simulating the human behaviour with a cognitive architecture based on low-fidelity prototypes such as photos, screenshots or sketches as input.

It is possible to analyse and compare HMI designs:

- without the involvement of real users,
- without implementing a system prototype,
- with a huge amount of different variants in a short amount of time, and
- without the need to involve experts in user testing or cognitive analysis

The measurement result quality rather depends on the quality and amount of the input data. Thus, an absolute measurement (e.g. how much faster is variant X compared to Y) cannot be exactly stated in such an early phase of the design with only limited data available. Instead relative results are in focus (Which variant is faster?). If absolute measurements are still required, the most convincing variants can then be part of a more detailed user study, or an extended cognitive analysis.

HF Filer

For the 3D Acquisition AdCos we are considering the use of the HF Filer tool. The HF Filer is being developed to handle evaluation data from mainly healthcare AdCoS use cases, with a specific eye to use cases where task analysis or usability evaluation is employed.

HF Filer is a tool that allows the filing of human factors evaluations for several development projects simultaneously, and for each project several evaluation reports can be created and filled. This work is all undertaken in the web-based user interface (UI) of the tool itself.

3.8.3 Semantics and mapping between methods and tools

In this section the information exchange between the various steps in the HEE related method/tool chain is described. See **Fehler! Verweisquelle konnte nicht gefunden werden.** for a graphical representation of the method/tool chain.

Task analysis:
Work break down of all the "atomic" steps that need to be done for the 3D acquisition task. The result is captured in a structured way in an excel sheet, describing for every step the following items:

- Step ID nr
- Step Description
- Indication which UI items are involved in this step or which UI guidance is given by the system

HMI model:
A graphic representation of the system and its UI components, including physical dimensions and positioning with respect to the user is provided. The information is captured in a set of ppt-slides depicting the typical dimensions of an X-ray system.

HEE:
The task analysis and HMI-model are input to the HEE. A third line of input is generated by the tool user with the help of the HEE: demonstrations of single or a set of tasks (depending on the tasks granularity).

In this step, the communication between the AdCos owner and the tool provider is very important; to make sure that the information from the task analysis and HMI-model are well understood and translated in a correct way in the HEE. The HEE then internally creates a "virtual environment" (the operator's mental model of the X-ray system + control room) and a "virtual operator model" (the operator's process knowledge of how a 3D acquisition is performed with the X-ray system).

Task simulation:
From the operator model and the environment model the HEE then starts a simulation of the operator in the environment performing the process/tasks several times and then can calculates the average task performance and workloads. These simulations result in a file with:

- task performance
- operators' workload
- attention allocation of the operator
- operator's reaction times

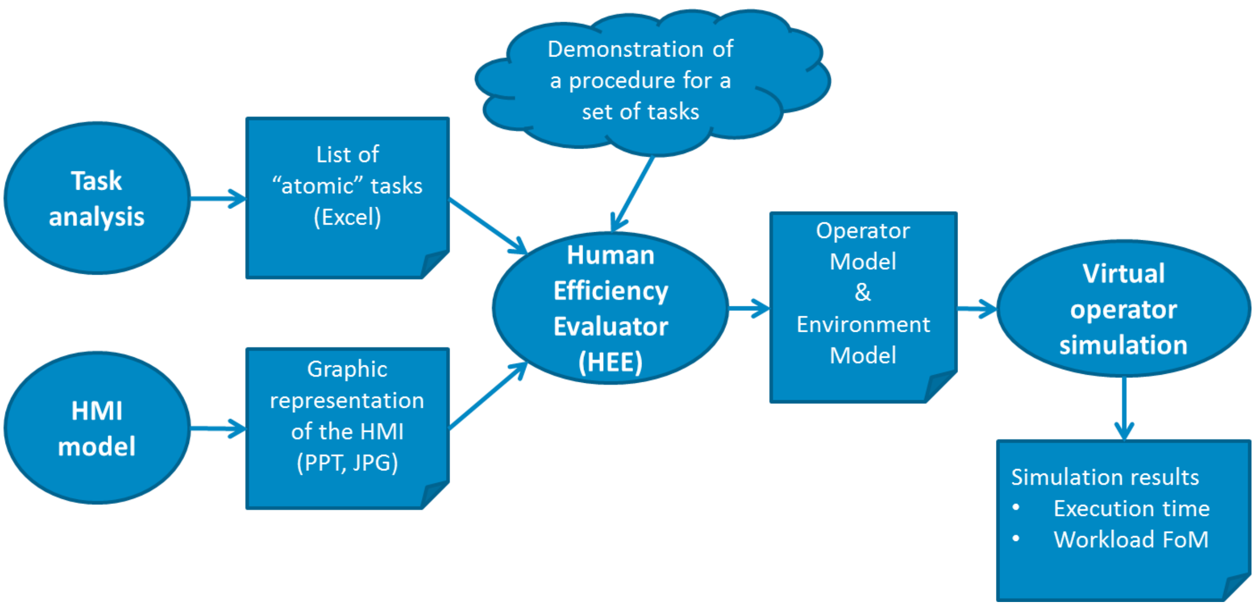

Figure 20 HEE related data flow in the 3D Acquisition AdCos

3.8.4 Implementation of information models and connectors

In the current stage of the AdCos development the focus is on understanding the tools and on the information exchange between workflow steps. The implementation of information models and connectors will be described in more detail in the following iteration of the tailored HF-RTP document.

4 Conclusions and summary

In all AdCos's good progress has been made by identifying and evaluating MTT's from the HF-RTP that can be used to improve the AdCos development process and/or to improve the AdCos quality.

Most AdCos owners are somewhere between step 2 and step 3 in the HF-RTP tailoring process. While some MTT's are still under evaluation to check the usefulness in the AdCos, others are already actually applied in good cooperation between tool suppliers and AdCos owners.

An interesting spin-off worth mentioning in the 3D Acquisition use case is the fact that the task analysis that needed to be done as input for the Human Efficiency Evaluator (HEE) is now also used as a structured means to describe the workflow and it has already provided insights in the AdCos development team about the actual workflow and possible improvements.

5 Way forward and upcoming activities

All AdCos's will continue with their evaluation of MTT's, continuing in step 2 and moving on to step 3 and 4 of the HF-RTP tailoring process. Tailoring will be done by connecting the methods, techniques and tools such that they fit the needs of the AdCos and the information flow between the MTT's will be formalized in a semantics description before going towards the actual implementation of the information models.

HF-RTP plan for 2015 for Querying openEHR data AdCos
Q2:

- Make task analysis according to new proposed HMI
- Analyse the AEON cloud message platform to be integrated in the tool.
- Study the application of Data Race Detector & Healer to the software.
- Study the methodology to model the AdCoS from a means end perspective and HF Filer

Q3:

- HMI performance comparisons using HEE
- AEON integration
- Application of the modelling the AdCoS as the means end perspective.
- Integration of Data Race Detector & Healer and HF File if suitable

Q3+4:

- User evaluations/questionnaires and clinical feedback of new HMI
- Validation and testing

HF-RTP plan for 2015 for Internal analysis and reporting AdCos
Q2:

- Make task analysis according to new proposed HMI
- Analyse the AEON cloud message platform to be integrated in the tool.
- Study the application of Data Race Detector & Healer to the software.
- Study the methodology to model the AdCoS from a means end perspective and HF Filer
- Analyse LEA and CBR pros and cons to be used in the reporting tool.

Q3:

- HMI performance comparisons using HEE
- AEON integration
- Application of the modelling the AdCoS as the means end perspective.

- Integration of Data Race Detector & Healer and HF File if suitable
- Integration LEA and CBR if it is statistically relevant.

Q3+4:
- User evaluations/questionnaires and clinical feedback of new HMI
- Validation and testing

HF-RTP plan for 2015 for Safe patient transfer
Q2:
- Usability validation together with HFC
- Apply HF-filer to store results

Q3+4:
- User evaluations/questionnaires and clinical feedback of new HMI

HF-RTP plan for 2015 for Guided patient positioning and robust ECG triggering
Q2:
- Formative usability validation together with HFC
- Build HEE operator model and environment model
- Make task analysis according to new proposed HMI
- Make MagicPED version of the model
- Build mockup UI prototype
- Apply HF-filer to store results

Q3:
- Build HEE models of new HMI
- HMI performance comparisons using HEE

Q3+4:
- User evaluations/questionnaires and clinical feedback of new HMI

HF-RTP plan for 2015 for 3D Acquisition AdCos
Q2:
- Build HEE operator model and environment model
- Make task analysis according to new proposed HMI
- Build mockup UI prototype

Q3:
- Build HEE models of new HMI
- HMI performance comparisons using HEE

Q3+4:

- User evaluations/questionnaires and clinical feedback of new HMI

6 References

[1] D1.3 HF-RTP v0.5 – Methodology and Requirements Analysis update
[2] D1.4 HF-RTP v1.0 – Methodology and Requirements analysis update
[3] D6.2 Tailored HF-RTP v0.5 for the health domain
[4] D6.3 Requirements & Specification & first modelling for the Health AdCos and HF-RTP