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D 8.3 - Requirements & Specification & first Modelling for the Control Room AdCoS and HF-RTP Requirements Definition

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Glossary

AdCos	Adaptive Cooperative Human-Machine System(s)
APA	Advance Pattern Assessment
BVT	Behavioural Validation Tool
CBR	Case Based Reasoning
CR	Control Room
DB	Database
DODAF	Department of Defense Architecture Framework
GUI	Graphical User Interface
HF	Human Factors
HF-RTP	Human Factor Reference Technology Platform
HMI	Human Machine Interface
HW	Hardware
IR	Infra-Red
LEA	Learning Classification Tool
MTT	Methods, Tools and Technology
OSLC	Open Services for Lifecycle Collaboration
PC	Personal Computer
PED	Procedure Editor
RTP	Reference Technology Platform
SDK	Software Development Kit
SW	Software
UC	Use Case
WP	Work Package

<u>HMI-related terms and definitions</u>

Interaction modality: input modality or output modality;

Input modality: sense or channel through which a human can receive the output of an ICT device or service;

Modality: (see sensory modality);

Multimodal: relating to multiple input modalities and/or output modalities;

Multimodality: simultaneous support of multiple input modalities and/or output modalities;

Output modality: channel through which a sensor, device or service can receive the input from the human;

Sensory modality: sense or channel through which a human can send input to or receive output from an ICT device or service.

1. Introduction

This document describes the requirements for the AdCoS applications in the Control Room domain along with specification including use cases referred to both the Border Surveillance Control Room and the Energy Network Surveillance Control Room. It includes the results of a first attempt to model the AdCoS using the HF-RTP and methodology utilising either pre-existing and new tools to be developed in the frame of the HoliDes project. In addition, feedback from WP1-5 is reported. Section 2 contains a list of the tools which are more likely to be applied from WP2 in the AdCoS developed within the framework of WP8. Section 3 describes each AdCoS use cases including AdCoS operational definitions, HMI for the AdCoS, tools applied from the HF-RTP, requirements and specifications, and the system architecture. Section 4 reports feedbacks from WP 1-5. Section 5 concludes.

2. Tools and Services applied from the HF-RTP

Table 1 shows a list of tools applied from WP2-5 in the Control Room domain, showing which tools are utilised respectively in the Border Surveillance AdCoS and the Energy Network Control Room AdCoS.

Table 1: Overview of Tools and Services Applied in the Control Room AdCoS (Customized versions are marked with *)

Tool name	Tool type	Tool provider	AdCoS
Advanced Pattern Assessment (APA)	Data mining	Airbus group	Border Control AdCoS
Learning Classifying System (LEA)	Machine learning prototype	Airbus group	Border Control AdCoS
Procedure Editor (PED)	Machine learning prototype	OFFIS	Border Control AdCoS, Energy Network Control AdCoS
Human Efficiency Evaluator (HEE)	Software	OFFIS	Border Control AdCoS
Case-based Reasoning (CBR)	Software	Manufacturer to be defined	Border Control AdCoS
Behavioural Validation Tool (BVT)	Software	RE:Lab	Energy Network Control AdCoS
Enterprise Architect*	Enterprise Architecture Modelling and Simulation	Sparx Intentional	Border Control AdCoS
DOORS*	Requirements Management	IBM	Border Control AdCoS
DoD Architectural Framework	Framework for Architectural Analysis	US Department of Defence	Border Control AdCoS

	and Design		
Human Views	Architectural Concept	Airbus Group	Border Control AdCoS
D-Lab	Software	Ergoneers	Border Control AdCoS
Tobii Eye-Tracking Sensor	Human monitoring tool	Tobii	Border Control AdCoS
Kinect Sensor	Human monitoring tool	Microsoft	Border Control AdCoS
Kinect Development SDK	Software	Microsoft	Border Control AdCoS
Vibration actuator	Human monitoring tool	Manufacturer to be defined	Border Control AdCoS
RT Maps	Modelling Tool	Intempora	Border Control AdCoS

3. Each AdCoS use cases

This section describes in detail the AdCoS and the relative use cases in the Control Room domain, including the operational definitions, the HMI and the tools used for the applications development, as well as their requirements and specifications. We introduce the object of each subsection which is then articulated into the two main AdCoS of the Control Room domain, the Border Control and the Energy Network Control respectively.

3.1. Operational definition of the AdCoS

The operational definition of the AdCoS is introduced here with reference to the constituent concepts it is intended to embody at the operational level. The rationale for the development and utilisation of an AdCoS is based on the problems it addresses and in the increased level of efficiency it ensures. Thus, we introduce the AdCoS by defining for each use case at the operational level what the specific goal for each functionality is intended to achieve, in order to address what problem, and what situations are to be avoided. Broadly speaking, this subsection introduces for each use case what is to be achieved (tasks) and what is to be avoided (regulations) by the AdCoS.

3.1.1. Border Control AdCoS

Just like other control rooms, border control rooms are characterised by alternating periods of very high and very low activity. Both high and low workloads present problems to the border security operators. If the workload is too high, the operators may find it difficult to cope with the number and criticality of events that they have to deal with. If, on the other hand, the workload is too low, the operators are likely to get bored and engage in other activities making them temporarily unavailable if their presence and full concentration become requested at short notice.

The Border Control AdCoS attempts to increase the organisation's effectiveness and efficiency by supporting the operators in maintaining mental and physical presence and in avoiding excessive workload.

The AdCoS is comprised of nine Use Cases that cover the headings "Operator Physical and Mental State Assessment", "User / System Supporting Load Balancing", and "Supporting the Users".

The controlled entity of the Border Control AdCoS is the system that receives inputs from the operator and other external sources.

Use Case #1: Operator absent from workplace (Operator Physical and Mental State Assessment)

This Use Case addresses the problem that operators are often absent from their workplaces for long periods of time. The AdCoS adaptation becomes active if an operator is absent from his workplace for a longer than the accepted period of time. The system calls the operator back to his workplace by discrete electronic means. If he doesn't return to this workplace after a defined length of time, his supervisor is informed. Through this mechanism, the AdCoS avoids the absence of operators when unexpected and critical situations arise.

Use Case #2: Operator idle at workplace (Operator Physical and Mental State Assessment)

This Use Case addresses the problem that operators may fall asleep at their workplaces during quiet night shifts. The AdCoS adaptation becomes active if an operator is registered as idle (present but doesn't move) for a longer than the accepted period of time. The system "nudges" the operator by means of an electronic actuator in order to wake him up. If he still doesn't display any sign of activity after a defined length of time, his supervisor is informed. Through this mechanism, the AdCoS avoids the lack of responses of operators when unexpected and critical situations arise.

Use Case #3: Operator tired at workplace (Operator Physical and Mental State Assessment)

This Use Case addresses the problem that operators may become tired during quiet night shifts, thereby losing concentration and attention. The AdCoS adaptation becomes active if it registers signs of fatigue in an operator. The system "nudges" the operator by means of an electronic actuator in order to motivate him to take measures to stay awake. Through this mechanism, the AdCoS avoids the lack of attention and responsiveness of operators when unexpected and critical situations arise.

Use Case #4: Registration of unusual behaviour patterns (Operator Physical and Mental State Assessment)

This Use Case addresses the problem that perpetrators can observe the border security station and spot regular behaviour patterns. They can latter exploit these by scheduling illegal activities during those periods when the operators are likely to be absent or otherwise unresponsive.
The AdCoS adaptation functions by logging behavioural patterns (in particular absence of operators from their workplaces) and analysing them for exploitable gaps. The border security centre's management can use those patterns to raise the operators' awareness of the potential dangers of regular and exploitable behaviour patterns. Through this mechanism, the AdCoS avoids threats to the border security operation through observable and exploitable habits.

Use Case #5: Load balancing at operator level (User / system supporting load balancing)

This Use Case addresses the problem that operators perform sub-optimally when their current workload exceeds a manageable limit. The AdCoS adaptation is able to recognize the load of a single operator compared to the overall load of all operators in one border security centre. To avoid overloading an individual operator, the system shall distribute incoming events to operators with a lower current workload and offer the redistribution of events from operators who are dealing with a number of events above a critical threshold. The individual workload of an operator is computed with the help of variables such as number of years in current position, training levels successfully achieved, number of critical events successfully dealt with, number of normal and critical events currently to be dealt with, and others. Through this mechanism, the AdCoS avoids an impaired effectiveness of the border security centre through operators with workloads that are too high to allow effective performance of the individual.

Use Case #6: Monitor and update the status of employees (Supporting the user)

This Use Case addresses the problem that the border security management needs support in assessing the operators' levels of expertise in order to assign tasks at the appropriate level. Based on a set of parameters, the AdCoS adaptation can support the border security centre management in categorising their staff into meaningful categories such as 'basic experience', 'advanced experience', and 'expert experience'. These categories can be used for selecting appropriate functional, help and training levels. In order to quantify each individual's current level of expertise, variables such as number of years in current position, training levels successfully achieved, number of critical events successfully dealt with, number of errors previously made, assessment by immediate superior and others are kept in a database. If an operator has reached all prerequisites for advancement into a higher level, the supervisor is informed and can take appropriate action (e.g. suggest trainings or job enlargement). Through this mechanism, the AdCoS avoids an impaired effectiveness of the border security centre de-motivated or sub-optimally assigned personnel.

Use Case #7: Layered help functions (Supporting the user)

This Use Case addresses the problem that – depending on their experience and level of expertise – different operators need different help materials to support them for training and in real-time operation. The AdCoS adaptation supports the operators by offering help information that are tailored to the staff member's existing knowledge based on their rating as having 'basic experience', 'advanced experience', or 'expert experience'. Through this mechanism, the AdCoS avoids operators being sub-optimally trained or informed.

Use Case #8: Context-dependent help functions (Supporting the user)

This Use Case addresses the problem that – depending on their current operational context – different operators need different help materials to support them. The AdCoS adaptation supports the operators by offering help information that are relevant to the current context and the functionalities most likely accessed next. Through this mechanism, the AdCoS avoids operators being sub-optimally informed during operation.

Use Case #9: Localizing the system to cultural requirements (Supporting the user)

This Use Case addresses the problem that the organisation operating the control room expects that the local cultural and localization requirements are taken into account in the design of a control room system. In addition, people from a range of cultures may work in a control room having different individual preferences on the localization settings of their workstations. The AdCoS adaptation supports the border security centre management by having pre-defined variants for aspects of the HMI that are related to the local culture, data standards, and regulations in the customer’s country. Through this mechanism, the AdCoS avoids errors made by operators due to unfamiliar localization of the workstation software.

3.1.2. Energy Network Control AdCoS

The energy network surveillance AdCoS consists of an Emergency Management System for the maintenance of energy distribution networks. The Call Centre receives either calls from customers who report network failures or signals from the controlled network segments which are displayed on a big screen on the Control Room wall.

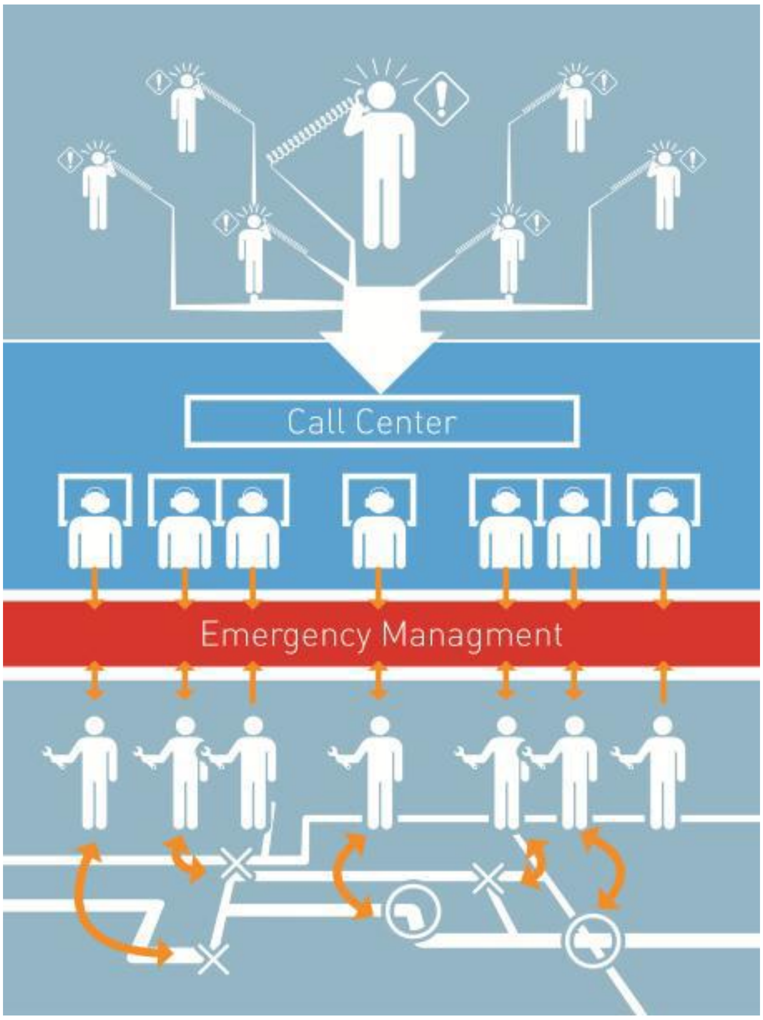

Figure 1: Energy Control Room scenario

As far as the use cases identified and analysed in the first cycle of the project are concerned, the main focus is set onto use cases 3, 4 and 6. Namely, the controlled entity of such a system is the traffic of emergency calls and the most critical passages it has to cope with are located between the Control Room Call Centre and the Operative teams on the field.

IRN AdCoS will thus affect mainly the communication between operators in the control room and Operative teams on the field (Use case no. 4) without neglecting to make reference to the collection of relevant information (Use case no. 3) and historical records of the relevant infrastructure (Use case no. 6).

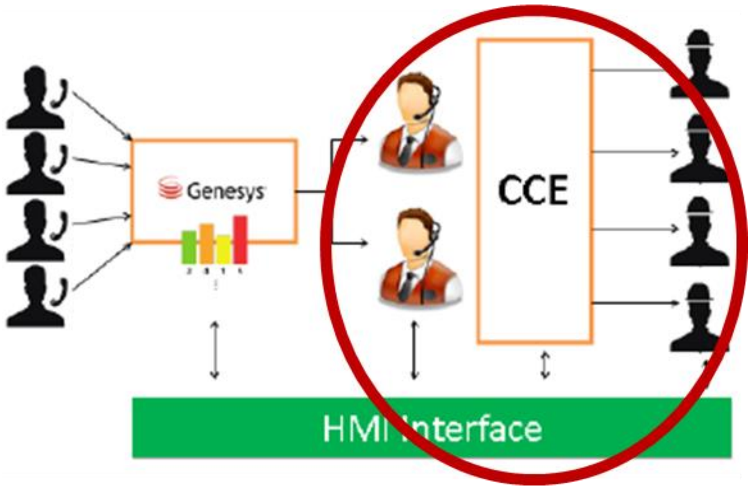

Figure 2: Focus on Use Case 4 for the communication between the Emergency Call Centre and the Operative Teams

Use Case #1: Management of Not Pertinent Calls

This use case deals with the optimization of the Emergency Call Centre by lowering response time as a consequence of a faster and enhanced management of not pertinent calls. In this case, adaption takes place in both tasks and resources allocation as the AdCoS is expected to warn Emergency Call Centre operators when the received call can be classified as 'not pertinent' and thus providing them with fast solutions in order to close the call as soon as possible. The system will be able to identify 'not pertinent' calls utilising vocal sensors capable to detect a list of words most commonly associated with calls classified as 'not pertinent' (e.g. bill, invoice, contract, etc): in case one of these words is detected during the conversation by the vocal sensors, the system will warn the operator and suggest possible solutions in order to close the call as soon as possible.

Use Case #2: Peak of incoming calls - Emergency for an exceptional event (Call frequency adaptivity and Operator State Assessment)

This use case is represented by a high number of incoming calls concerning the same emergency. In this case, adaption takes place in terms of resource allocation. In fact, the AdCoS supports the operator to return to normal working state and allocates, in case on high workload, any exceeding task to the most suitable operator in the Control room. In case maintenance works are planned to take place on the net in a given day, the system adapts helping operators in managing the predicted peak of calls (e.g. allocating calls to less loaded operators) and/or automatically handling information concerning planned services interruptions.

Use Case #3: Collection of relevant information for the correct interpretation of the malfunction

This is a crucial use case in terms of the enhancement of performance of the system as a whole. What we want to address here is the collection of as much information as possible without expanding too much the average time of phone conversations. In this case, adaptivity refers to both resource and task allocation, where resources are represented by the information to be gathered and the task by the collection process itself. In a sentence, the AdCoS is able to collect relevant information concerning the malfunction (such as type and number of nearby/relevant infrastructure) starting from the localisation of the emergency and provide this relevant information to the operative teams on the field, without requiring any input from the Emergency Call Centre operators. This information collection procedure takes place either by automatically localising the caller in case the call comes from the landline or by manually searching the company records and street maps. At present, the Emergency Call Centre is not provided with any kind of adaptive system capable to optimize the collection of relevant information concerning the emergency itself. This UC, along with UC 4 and 6, represents the major and most important field of application of the new concepts and system developed within the HoliDes project and it is thoroughly described and discussed throughout subsections 3.2, 3.3, 3.4 and 3.5.

Use Case #4: Communication between the operator and the operational teams in the field

This use case addresses the main problems driven by the human factor. Adaption is triggered by time, the allocation of resources (operative teams and equipment) is based onto operational time-tables and functionalities of the AdCoS are fully described below in the "*Adaption and Human Factors*" subparagraph in section 3.5.2. At present, IRN does not deploy any type of adaptive nor cooperative system intended to address the allocation of tasks to available agents. The communication between the Control Room and the operative teams takes place only via phone calls and the allocation of tasks and responsibilities is based onto the senior experience of Control Room operators. These operators collect emergency signals (from either callers and the big monitor that reproduces the electric energy city network located on the wall of the control room) and fill in the emergency call form on the computer, utilising CCE (the abbreviation for "Centro Chiamate Emergenza" which in English means "Emergency Call Centre"), a software application developed in house by Iren ICT Department. What IRN wants to achieve with the new AdCoS is to disclose the information contained in this form and make them available to the Operative teams in a cooperative and adaptive way. This goal is achieved with the development of a mobile app for the Operative Teams, enabling the transmission of the emergency call forms to the available teams on the basis of the working time.

Use Case #5: Non Italian speaking caller

This use case deals with calls from non Italian native speakers. The AdCoS adapts to the language competences of the caller to help him pre-selecting the desired service. In addition, the system provides accordingly hints and keywords in the language of the caller to the Emergency Call Centre operators in order to help them in the information collection.

Use Case #6: Collection of historical information about intervention of each installations for future events

In order to better understand the nature of the malfunction and inform in a more effective and efficient way the operational teams to be sent in place, operators must have access to historical and geographical data concerning the local area where the emergency has been signalled. This use case addresses this need. The AdCoS provides both Call Center operators and operative Teams on the field with historical records concerning the relevant infrastructure by querying the CCE databases automatically once the caller/emergency has been localised as described in UC3. The availability of relevant and historical information is in fact crucial in order to enable an optimal and timely understanding of the nature of the malfunction thus allowing better deployment and allocation of teams and resources on the field.

3.2. HMI for the AdCoS

Once the goals and regulations of the AdCoS are set, it is extremely important to tailor the interaction between humans and the system accordingly. The communication between the operators and the system itself is crucial in order to ensure that the correct tasks are operated by the correct agent to reach the correct goal. In addition, HMI is crucial for adaption to take place correctly, avoiding redundancy, human errors and tasks/resources misallocation. Given that an efficient HMI in the Control Room domain can be considered as use case specific, the available devices and their relative input and output channels are listed and described below distinguishing again between the Energy Network and the Border Control AdCoS.

3.2.1. Border Control AdCoS

The border control room AdCoS will use the following channels and devices for communications between operators and the AdCoS:

Input channels (human actors to AdCoS)

- Indication of presence
  - UC#1, UC#4
  - HW: Kinect Sensor
  - SW: Own application based on Kinect Development SDK
  - Data: IR emitter and sensor data used to register presence / absence
  - Interaction: No explicit interaction from the side of the operator other than presence or absence
  - Innovation: Touchless interaction based on IR sensor data registering presence
- Indication of movement
  - UC#2
  - HW: Kinect Sensor
  - SW: Own application based on Kinect Development SDK
  - Data: IR emitter and sensor data used to operator movement
  - Interaction: No explicit interaction from the side of the operator other than presence or absence of movement
  - Innovation: Touchless interaction based on IR sensor data registering movement
- Indication of fatigue
  - UC#3
  - HW: Tobii Eye-Tracking Sensor
  - SW: D-LAB Analysis of Eye-Tracking Data
  - Data: IR emitter and sensor data used to capture eye movements and eye-lid behaviour
  - Interaction: No explicit interaction from the side of the operator
  - Innovation: Touchless interaction based on IR sensor data registering fatigue (based on eye-lid behaviour)
- Logging of behavioural data
  - UC#4

    - HW: Kinect Sensor
    - SW: Own application based on Kinect Development SDK and database registering and analysing behavioural data across time and across the entire operator crew
    - Data: IR emitter and sensor data used to register presence / absence
    - Interaction: No explicit interaction from the side of the operator other than presence or absence
    - Innovation: Touchless interaction based on IR sensor data registering presence; warning of unusual and / or exploitable behavioural patterns
- Computation of performance workload
    - UC#5
    - HW: Operator workstation HW
    - SW: Operator workstation SW plus application that computes current workload based on a number of variables
    - Data: N of non-critical events currently handled; n of critical events currently handled; current level of expertise; training levels reached; etc.
    - Interaction: Operator performing his tasks, no additional inputs required
    - Innovation: None in terms of the interaction technologies employed
- Computation of level of expertise
    - UC#6
    - HW: Operator workstation HW
    - SW: Operator workstation SW plus application that computes current level of expertise based on a number of variables
    - Data: N of years of service in current position; n of non-critical events successfully handled; n of critical events successfully handled; current level of expertise; training levels reached; etc.
    - Interaction: Operator performing his tasks, no additional inputs required
    - Innovation: None in terms of the interaction technologies employed
- Personalised user experience
    - UC#7, UC#8, UC#9
    - HW: Operator workstation HW
    - SW: Operator workstation SW plus application accesses personalised information based on context (help information), level of experience (help information) and cultural background (localised user experience).

- Data: Level of experience; current context of the application; login-selection of localised presets.
- Interaction: Operator performing his tasks, no additional inputs required
- Innovation: None in terms of the interaction technologies employed

Output channels (AdCoS to human actors)

- Operator notification tactile
  - UC#1, UC#2, UC#3
  - HW: Vibration actuator (model and technology tbd)
  - SW: Own application sending activation and de-activation signal to actuator device
  - Data: Start and stop of outgoing actuator message
  - Interaction: No explicit interaction from the side of the operator other than perceiving the message and taking appropriate action such as returning to workstation or fighting fatigue
  - Innovation: Discrete and minimally obtrusive means of notifying the user of a required response.
- Operator notification dialogue
  - UC#5
  - HW: Operator workstation HW
  - SW: Operator workstation SW with additional notification events
  - Data: Notification messages and prompts for decisions
  - Interaction: The operator acknowledges a message (e.g. that an event will be transferred to another operator) and / or accepts or rejects a proposed option (e.g. to agree to a load balancing proposal)
  - None in terms of the interaction technologies employed
- Supervisor notification dialogue
  - UC#1 - UC#6
  - HW: Supervisor workstation HW
  - SW: Supervisor workstation SW with additional notification events
  - Data: Notification messages and prompts for decisions
  - Interaction: The supervisor acknowledges a message (e.g. that an operator has been absent from his workplace for an extended amount of time) and / or accepts or rejects a proposed option (e.g. to agree to a load balancing proposal)
  - None in terms of the interaction technologies employed

3.2.2. Energy Network Control AdCoS

The actual solution adopted for the communication between the Emergency Call Centre and Operative teams relies solely on phone calls. In such a configuration, the identification of the most suitable teams and equipment is demanded to the individual experience of CR operators, who must identify the operators according to the zone of intervention, know in advance the timetable of the available teams and communicate to them the relevant information.

On the other hand, in general the technicians in the field do not have any instrument to store the information received by the Control Room. Only in case the technician is in the office while he receives the call from the Control Room, the information about the emergency call is sent as a pre-compiled file to a local printer. Therefore, the position of the technician is key to identify the interaction modality for the communication between the control Room and the Operational Teams.

Since the technicians in the field are already using Android mobile phones, we planned to exploit this device to provide them with a mobile app.

Input channels (human actors to AdCoS)

- The touch screen of the mobile phone (for the physical interaction with the technicians)
  - UC#3, UC#4 ans UC#6
  - HW: Smartphones
  - SW: newly released own mobile-application developed from CCE
  - Data: information communication and feedback
  - Interaction: physical
  - Innovation: new-to-the-firm adoption of smartphones in the stream of data and information between CR and technicians on the field

- The CCE system, that sends (and receives) information regarding the emergency call and the intervention.
  - UC#3, UC#4 ans UC#6
  - HW: PCs, Smartphones
  - SW: CCE and newly released own mobile-application developed from CCE
  - Data: information communication and feedback
  - Interaction: physical

    - Innovation: new-to-the-firm adoption of smartphones in the stream of data and information between CR and technicians on the field; new connections and webservices with several DBs.

Output channels (AdCoS to human actors)

- The touch screen of the mobile phone (for the physical interaction with the technicians)
    - UC#3, UC#4 ans UC#6
    - HW: Smartphones
    - SW: newly released own mobile-application developed from CCE
    - Data: information communication and feedback
    - Interaction: physical
    - Innovation: new-to-the-firm adoption of smartphones in the stream of data and information between CR and technicians on the field

The touch screen will be used also as output device, in order to visualize the information provided by the CCE to support the technicians in the field.

The actual communication modality (by using the mobile phone) will be kept in order to strengthen the communication channel and to maintain a continuity with the previous interaction modalities the control Room and the operators in the field are used to.

The HMI will be mainly visual, thus it is important that it achieves a good readability, contrast, resolution and field of view.

In particular, for visual information, important properties would be:

- brightness/intensity
- visual acuity/spatial contrast sensitivity
- colour specification
- perceptual organisation:
    - figure-ground organisation,
    - grouping principles (proximity, similarity, continuity, closure, common elements with common motion tend to be grouped) etc.

Acoustic outputs will be also employed, for example to inform him about the arrival of a new emergency call. The main advantage of using auditory feedback is to provide information without distracting the operators while working on another intervention.

Like the visual output, also the acoustic output have to respect some general requirements in terms of sound pressure level, frequency range, and spatial resolution.

First of all, it is important that the sounds used are well distinguishable from the other environment sounds in the field, secondly the sounds' loudness level need to be calibrated in order to transmit the proper level of urgency without creating annoyance.

Contrary to the visual output, it is better that the acoustic feedback is given associated to other output. Therefore, since the mobile phones will be maintained as communication mode, the tonal sounds (earcons) will be used to reinforce the actual communication (via mobile phone) between the Control Room and the Operational Teams.

Some example of signals that can be used are:
- sweeping sounds for immediate acoustic feedback
- patterns of segments with constant pitch for short-term acoustic feedback
- two-times chimes, high-low non recurrent for long-term acoustic feedback

From the operators' point of view, sometimes acoustic signals are more annoying than haptic feedback. Therefore, the design of the HMI will take into consideration both of them, to be used either separately or at the same time.

As regards to the priority of the different interaction modalities the visual channel has to be considered as the main feedback channel, followed by the acoustic and haptic one.
In some cases the three channels could work separately (or only one output channel is available), but it is better to design them to work together (in multimodality) in order to give a more appropriate feedback to the operator.

In multimodality mode, based on the different level of information/warning to be provided to the driver, a sort of prioritization of the output channels has to be planned.

It has been shown that when auditory information can be replaced with haptic information in certain use cases this may result in a higher level of acceptance (Brockman, et al., 2012).

Finally, the design of the HMI has also to take into consideration the real conditions of work of the operators in the field. In fact, if they have had to use the app during the intervention, an important usability issue would have been the option to use them while wearing gloves. As shown in Figure 3 and Figure 4, two types of gloves are used.

Figure 3: Fire protection glove: Softer, bigger fingertip.

Figure 4: Working glove: harder, smaller fingertip.

Since the app is meant to be used in the preliminary phase of the intervention (for its planning and analysis), and not during the actual operations in the field, this usability issue will not be considered in the design of the HMI.

3.3. Tools applied from HF-RTP

We now want to introduce the tools provided by the scientific WPs (2-5) that are to be integrated into the development process of the AdCoS in order to address specific needs of the developers. These tools have already been listed in Table 1 and are here discussed in order to explain the rationale/purpose and context of their utilisation.

3.3.1. Border Control AdCoS

The tools and services listed in Table 1 are used in the following contexts and for the following purposes:

- Advance Pattern Assessment – at present this tool is under evaluation to be used in the Airbus DS demonstrations. D8.5 will provide the final WP8 Airbus DS AdCoS with all its associated products, tools and technologies.
- Learning Classifying System - at present this tool is under evaluation to be used in the Airbus DS demonstrations. D8.5 will provide the final WP8 Airbus DS AdCoS with all its associated products, tools and technologies.
- Procedure Editor - at present this tool is under evaluation to be used in the Airbus DS demonstrations. D8.5 will provide the final WP8 Airbus DS AdCoS with all its associated products, tools and technologies.
- Human Efficiency Evaluator – this tool could be used post and pre demonstration to define and calculate the operator interaction with the specific sections of the Human Machine Interface and provide metrics on said interactions.
- Cased Based Reasoning - at present this tool is under evaluation to be used in the Airbus DS demonstrations. D8.5 will provide the final WP8 Airbus DS AdCoS with all its associated products, tools and technologies.
- Behavioural Validation Tool- at present this tool is under evaluation to be used in the Airbus DS demonstrations. D8.5 will provide the final WP8 Airbus DS AdCoS with all its associated products, tools and technologies.
- Tobii Eye-Tracking Sensor: a set of mobile eye-tracking sensors to be used for registering signs of fatigue in the operators.

- D-Lab: a software for analysing the data from the Tobii eye-tracking sensors. The software can capture and analyse data on the eye movements across the PC screen of a person. It can visualise eye-movement tracks and so-called ‘heatmaps’ both of individuals and entire samples. For the detection of fatigue, algorithms based on existing research still have to be developed.
- Kinect Sensor (Microsoft): A sensor bar with optical camera, IR emitter and sensor and a microphone array to be used for registering the presence / absence and movement or lack thereof of operators.
- Kinect Development SDK (Microsoft): A collection of functionalities used to develop applications for the Kinect Sensor.
- Vibration actuator (model and manufacturer still to be defined): A device worn like a wristband that can play a tactile message (e.g. vibration alert).
- Enterprise Architect – This tool will be used to capture and model the DODAF and Human View products, to provide the underlying architecture for the Airbus DS demonstrations.
- DOORS – this will be used to capture the WP8 requirements and map them to Enterprise Architect via an OSLC interface.
- DODAF – The Department of Defence Architecture Framework will be used to capture System and Operational views as defined in section 3.5.1.
- Human Views –These have been created via internal Airbus DS research funding and will be used within WP8 to provide a Human Viewpoint to be used within DODAF.

3.3.2. Energy Network Control AdCoS

Table 1 in Section 2 also shows the tools developed in the scientific WPs (WP2-WP5) that will be used in the first project cycle for the design and development of the Energy Network Control AdCoS.

These tools are used in the following contexts and for the following purposes.

- Procedure Editor (PED)

The PED (from WP2, provided by OFFIS) will be used in the design phase to model the interaction of the operators with the mobile app, and in the evaluation phase to identify and quantitatively measure the critical tasks that may affect the performance of the AdCos.

Namely, with reference to the design phase, the task model and the task analysis will be used to support the developers in the creation of different HMI prototypes with different interaction modalities (as shown in Figure 4).
In details:

- ✓ Task model: to identify all tasks that must be included in the HMI (the task model is complementary to the state flow diagrams for the navigation and the interaction among the tasks)
- ✓ Task analysis: to associate interaction modalities to the tasks, as well as other properties (such as the rules of interaction among the tasks)

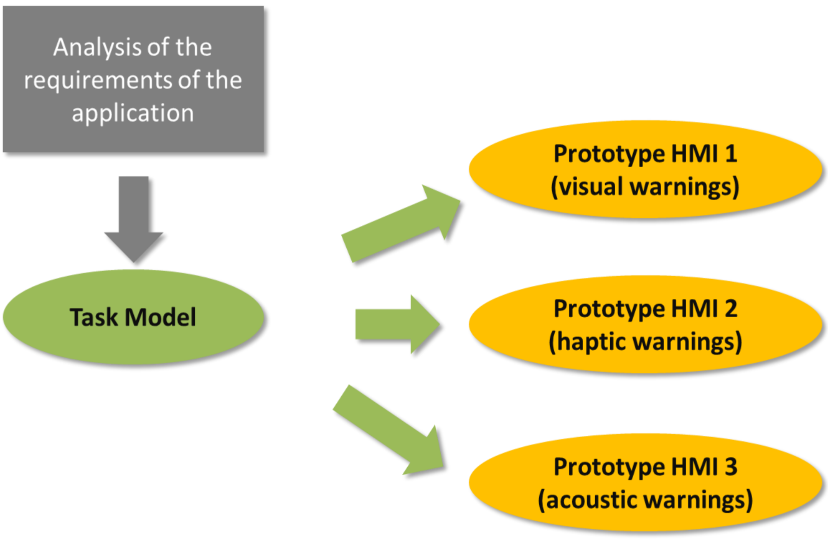

Figure 5: Use of task model in the design phase.

Using the task model (in collaboration with the state flow diagrams for the navigation) will improve the formalization of all interaction tasks (as well as their interconnections) and the corresponding interaction modalities (visual, acoustic, haptic, etc..). It will also facilitate the communication among different actors (HMI designers, graphic designers, developers, etc..).

As far as the evaluation of the HMI application (shown in Figure 6) is concerned, the PED will be used to:

- ✓ Create the optimal interaction scenario (by expert-designer) and record the best execution time per task

✓ Compare the performance achieved in the optimal scenario with the performance of real users, to check:
  - Their interaction scenarios (navigation)
  - Their execution time

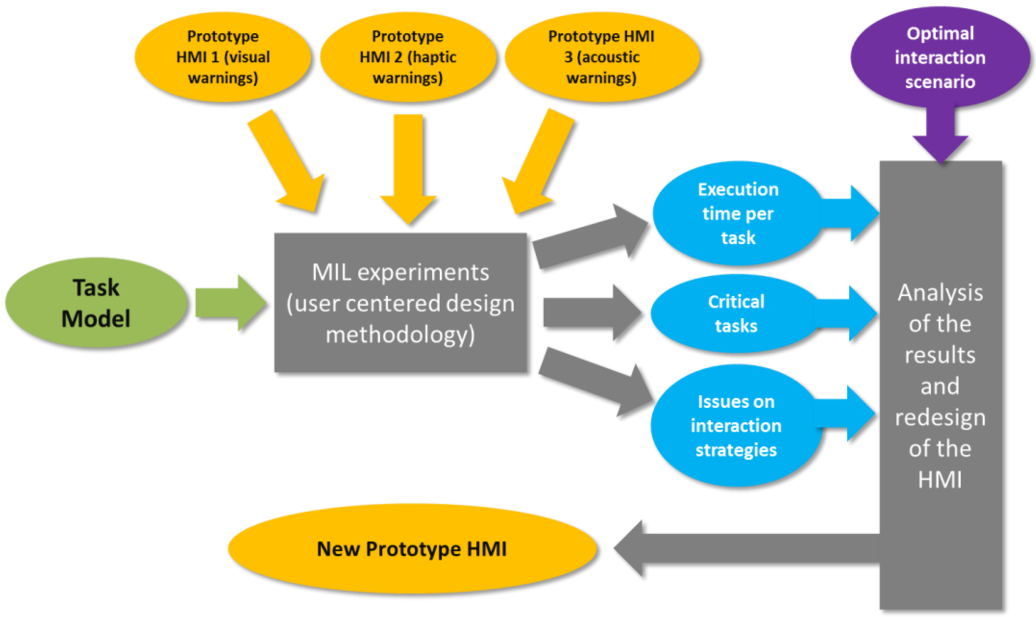

Figure 6: Use of task model in the evaluation (or redesign) phase.

This process is key to identify the critical tasks (in terms of navigation and time), and to have quantitative data to understand how to improve them.

- Behavioural Validation Tool (BVT)

The BVT (from WP5, provided by REL) addresses a specific problem in the validation of adaptive embedded systems with a physical human-machine interface (HMI).
In fact, even if the AdCos and its HMI have been correctly developed, the final product might not have the expected behaviour on all physical devices the HMI has be deployed on, because a number of these devices could not support some feature of the HMI. In this case, the behaviour of every single device must be validated to ensure it meets quality standards: ensuring that these systems perform as intended prior to release them on the market is utmost importance for the producers.

However, since the number of Android devices is increasing very fast, testing the mobile app on all potential Android phone models is extremely time-consuming.

Nowadays these systems are mostly tested by engineers/developers manually pressing buttons while going through a test procedure. It is a very monotonous task, that gets the operator very tired and increase the probability to make mistakes and not to repeat the procedure correctly (e.g. by skipping parts or distracting while checking the results).
Moreover, even when the operator identifies a problem in the HMI, it is hard to re-create it to understand which combination of inputs has caused it.

If the behaviour of the application can be represented as a finite-state machine, a relevant part of the validation can be conducted by forcing the inputs of each state and then automatically checking whether the graphical layout matches the expected behaviour.

Therefore, to test the correctness of the HMI of each state, the BVT graphically compares the expected HMI with the actual HMI of the device, in order to understand if any discrepancy occurred.

The BVT will support the developers of the Android applications to validate them on a great number of different Android devices.
The purpose of the BVT is to provide the developer with a tool to perform repetitive (and iterative) testing on Android mobile apps, ensuring accurate and measurable results and eliminating the need for time-consuming and labour-intense manual test plans.

The BVT is meant to be included in the development tool chain and process, to speed up the validation process, reduce human errors and human factors by ensuring the compliance of the process to a pre-defined test protocol.

Moreover, it provides a test report with relevant information to easily identify the HMI issues and recreate them to understand which combination of inputs generate them and how to solve them.

In addition to the PED and the BVT, more tools are likely to be employed in the next cycles after the identification of new needs for the development of the Energy Network Control AdCoS.

3.4. Requirements and specifications

Requirements and specifications for the AdCoS identified and introduced in D8.1 are reported in this subsection, as updated and refined during the whole time span of the first cycle of the project.

3.4.1. Border Control AdCoS

The following table contains ADCOS requirements from Work Package 1. The requirements selected here are relevant to the border control room work in WP8. The work done here will feed into the Human Factors RTP in the wider scheme of the HoliDes project. Not every HF-RTP requirement is relevant to border control but the ones which are have a Rationale to justify it.

Table 2: Requirements selected for the Border Control AdCos in the first project cycle.

ID	Name	Definition	Rationale
WP8_ADS_CTR_REQ014_v0	Operator Categorization	The system shall be able to determine quickly the level of Competence & Expertise of the Operator in categories [basic/advanced/expert]	[Performance] The system will be able to categorize the operator quickly in order to adapt itself accordingly
WP8_ADS_CTR_REQ015_v0	Operator State Assessment	The system shall be able to determine the psycho-physical status of the operator	[Performance] In order to enable the system to 1) support the operator to return to nominal working state 2) inform the supervisor on the operator state in order to subsequently initiate measures if necessary the psycho-physical state of the operator is needed

ID	Name	Definition	Rationale
WP8_ADS_CTR_REQ016_v0	Log file analysis	The system shall be able to analyse the system-user-interactions in the log file and do a subsequent classification (to be detailed)	[Performance] in order to enable the system a classification of the operator and/or generally to adapt to the user log file analysis is a prerequisite
WP8_ADS_CTR_REQ017_v0	Load balancing Headquarter (HQ) level	The system shall be able to analyse the status and workload of adjacent HQs and subsequently offer support to transfer events to them	[Functional] In case of a massive surge in border events or a HQ breakdown the higher echelon should have support for transferring events to other HQs safely and quickly
WP8_ADS_CTR_REQ018_v0	Load balancing Operator level	The system shall be able to analyse the workload of operators in one HQ and subsequently offer support to the supervisor to redistribute events among them	[Functional] In case an event escalates (partly system break, too many decisions,..) the system the supervisor should have support for transferring other events to further operators
WP8_ADS_CTR_REQ019_v0	Decision support	The system shall help the operator to take decisions timely	[Functional] Local cultures may inhibit the rapid responses
WP8_ADS_CTR_REQ020_v0	Layered Help Function	The system shall provide a 3 layered help function for [basic, advanced, expert] operator competence	[Functional] Help function as an "easy" test case
WP8_ADS_CTR_REQ021_v0	Adaptive operator support function	The system shall offer context-dependent support	[Functional] In case the user needs support in terms of operational context and/or effective system operation
WP8_ADS_CTR_REQ022_v0	Scalability of functionality	The system shall offer scaled functionality	[AdCos] Reduce system complexity for novices or adapt system functionality in accordance with operator experience

3.4.2. Energy Network Control AdCoS

Table 3 shows the requirements selected for the development of the AdCos in the first project cycle. The table includes only the requirements for the AdCos, and not the requirements for the MTTs that would support the development process (e.g. the BVT), that will be included in other deliverables (D1.4) in their original as well as revised format.

Table 3: Requirements selected for the Energy Network Control AdCos in the first project cycle.

ID	Name	Definition	Rationale
WP8_IRN_CR_REQ002_v0	Response time	The AdCoS shall reduce the time needed to complete an emergency case without reducing the amount of information gathered and provided to the operational team	[Performance] The response time is fixed by the Authority. The response time should be lower than the maximum time allowed by optimizing the gathering of information and the call management.
WP8_IRN_CR_REQ005_v0	Procedure standardization	The AdCoS shall introduce a standardized procedure	[Process] A standardized procedure guides the operator in managing incoming calls and collecting the necessary information in order to interpret correctly the mulfunctioning
WP8_IRN_CR_REQ006_v0	Operation procedures	The AdCoS shall not have an impact on the ordinary and current operations of the Control Room	[Process] The current working procedures are not affected by the tests with the AdCoS performed in the Control Room
WP8_IRN_CR_REQ007_v0	Cooperation between operators and operational teams	The AdCoS shall improve the cooperation of the operator with the operational teams	[Performance] The operator is in the conditions of providing all the necessary information to the teams in the field for the correct interpretation of the event and the identification of the correct equipment needed
WP8_IRN_CR_REQ008_v0	Usability	The AdCoS shall improve the current system usability	[Performance] the usability of the emergency management tool is improved in terms of efficiency, efficacy and user satisfaction
WP8_IRN_CR_REQ00	Operator Categorizati	The AdCoS shall adapt to the competence and expertise	[Performance] The system will be able to categorize the

ID	Name	Definition	Rationale
9_v0	on	level of the operator	operator quickly in order to adapt itself accordingly
WP8_IRN_CR_REQ013_v0	Geographical localization adaptivity	The AdCoS shall adapt to the geographical localization of the caller and of the target installation	[Process] The AdCoS recognize the localization of the caller and provides to the operator the visualization on a map of the caller
WP8_IRN_CR_REQ019_v5	Historical data	The AdCoS shall adapt to the historical intervention gathered on a target installation	[Performace] The operator receives the information on the historical interventions that have been performed on a target installation in order to evaluate if it is the case of a recurring problem
WP8_IRN_CR_REQ020_v6	Load balancing Headquarter level	The AdCoS shall adapt to the number of operators available	[Performace] In case of a peak of incoming calls, the AdCoS supports transferring events to other operators safely and quickly

The app will include the following feature/section:

1. A section to visualize the information about the emergency call
2. A section to formally take in charge the call (thus assigning a specific operator that will be responsible for the intervention)
3. A section to visualize the map of the intervention, including a feature to drive the operator (by using the Google navigator installed on the Android mobile phones)
4. formally close the intervention
5. A section to search any previous intervention according to the specific criteria (such as the address of the intervention)

According to these features, the app will include (at least) the following screens:

1) Login
2) Current interventions, with a dropdown menu for the selection of the operator and a button to either take the intervention in charge or to close it
3) Information of the emergency call, including a button to see a map to localize the intervention
4) A map to localize the intervention, including a button to start the Google Navigator

5) A search based on different criteria (such as the address) and a map to show the results
6) A menu (transversal to the other screens) to navigate the app (and access the other main screens), including "Interventions", "Map" and "Disconnect").

Figure 7 show the workflow for the development of the Energy Network Control AdCoS.

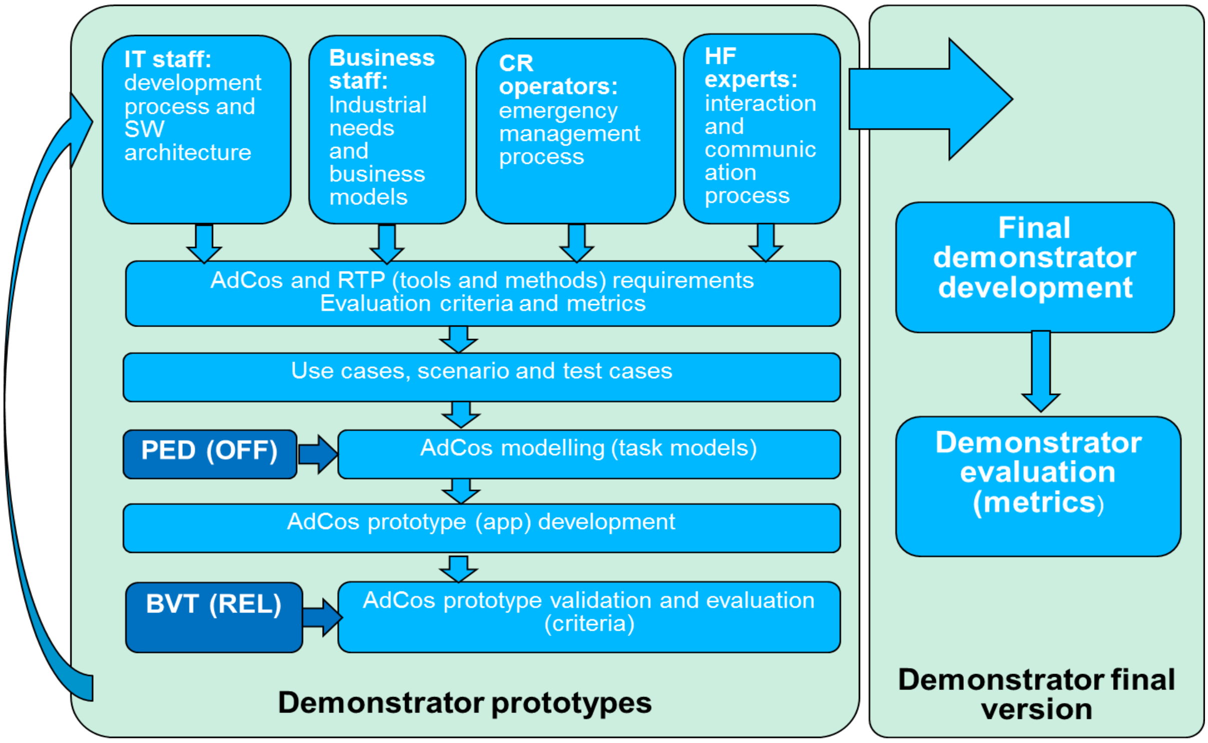

Figure 7: Workflow for the development of the Energy Network Control AdCos.

During the project iterations, heterogeneous information from different stakeholders has been collected, in order to identify the industrial needs of IRN, and how they can be addressed by taking into consideration the actual emergency management and the development processes.
This information has be also used to define the requirements as well as the quantitative metrics and criteria to validate and evaluate the improving versions of the AdCos.

By using the PED (developed in WP2 by OFF), the tasks included in the use cases will be modelled. Then the AdCos prototype will be developed and tested.

The HMI of the AdCos will be automatically validated by using the BVT (developed in WP5 by REL).

Moreover, by considering the criteria defined (and iteratively revised) at the beginning of each cycle, the AdCos prototype will be evaluated, in order to indirectly evaluate also the tools used to develop and validate it (PED and BVT).

The results of these activities will be used for the development of the final version of the AdCos demonstrator, and it will be evaluated with metrics that take into consideration the industrial, technical, human factors and Artemis point of view.

3.5. System architecture

3.5.1. Border Control AdCoS

The system architecture for the border control AdCoS will be produced using an Architectural Framework, specifically the Department of Defence Architecture Framework (DODAF), together with a set of Human Views developed within Airbus Defence and Space. The model will be defined using one of the WP8 MTTs Enterprise Architect, produced by Sparx International.

HoliDes deliverable D8.3 defines 'the first modelling for the control room AdCoS', therefore Figure 8 is the initial logical architecture definition for the Border control room AdCoS. It defines the logical architectural products defined in a system interaction resource diagram. As we are defining a logical architecture we have a mixture of resource types – Capability, Human Roles, System Resources, Software, Platforms and Physical Assets. HoliDes deliverable D8.5 will take this logical architecture model from D8.3 and define the physical architecture for the control room solution.

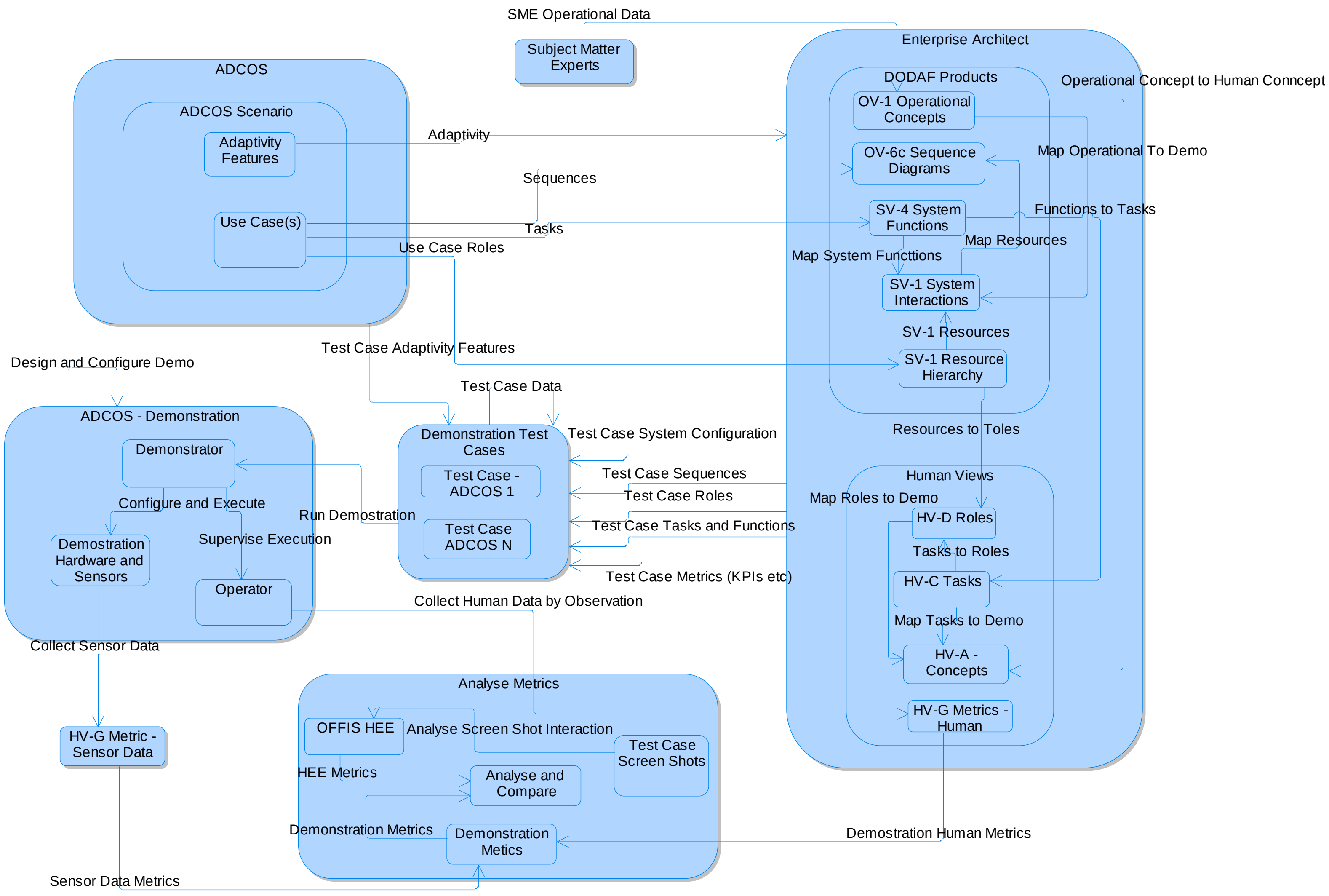

Figure 8 Logical Architecture for the Border Security AdCoS

The major components of the AdCoS Logical Architecture are defined as follows:

AdCos (Capability)

- AdCoS Scenario – The Border Security Scenarios will comprise a number the Use Cases defined in section 3.3.1
- Adaptive Features – The adaptive feature will be added to the scenario as they are created, reviewed and refined
- Use Cases – the Use Cases as defined in section 3.3.1

Enterprise Architect (Software)
DODAF products

- Operational Concepts – This will define one or more operational concepts diagrams that define a typical border security scenario. They will be a diagrammatic representation of the one or more of the AdCoS Scenarios
- Sequence Diagrams – The sequence diagrams will define the detail interaction between resources defined and derived from each of the Use Cases and will be aggregated into one or more scenario.
- System Functions – This defined all system functions for each resource required for the demonstration, these functions can then be mapped onto the appropriate System Resource
- System Interactions – This will define the interactions between all the system resources for each demonstration. Figure 1 is an example of a system interaction diagram at the logical level. D8.5 will define the detailed physical system architecture
- System Hierarchy – this diagram defines the resource components in a hierarchy structure
- Human Roles – This defines and details all the human roles involved in the demonstration e.g. all the actors defined in the each of the Use Cases
- Human Tasks- This view adds Human functions to each Role
- Human Operational Concepts – This diagram will detail the Human Interaction, defined in the Operational Concepts model. It only contains Human Interaction with a System Resource or another Human
- Human Metrics – this will collect metric data based on the overall model and then via collection during the demonstration

Demonstration Test Cases

- AdCoS Test Cases (1 to N) (Physical Assets) – The test case will be derived in tandem with each AdCoS Scenario and will define in detail how the demonstration will be conducted in terms of all Resources, Sequence of events and all demonstration planning

AdCoS Demonstration (Capability)

Figure 9 define the initial logical generic architecture for the overall demonstration(s)

- Demonstrator (Human Role)
- Operator (Human Role)
- Demonstration Hardware (Physical Asset)
- Demonstration Software (Software)

Analysis Metrics (Capability)

- Sensor Metrics (Software) – Metric data will be collected from each of the sensors for later analysis
- Human Metrics (Physical Asset) – Metric data will be collected for each human for later analysis
- OFFIS HEE (Software) – This will be used for off line analysis of the Human resources use of the HMI system used within each demonstration.

Tools to be evaluated and integrated into the AdCoS for Deliverable D8.5. The following tools will be evaluated for the inclusion into the Border Control AdCoS

- Airbus Group - Advanced Pattern Assessment (APA)
- Airbus Group – Learning Classification Tool (LEA)
- Case Based Reasoning (CBR)

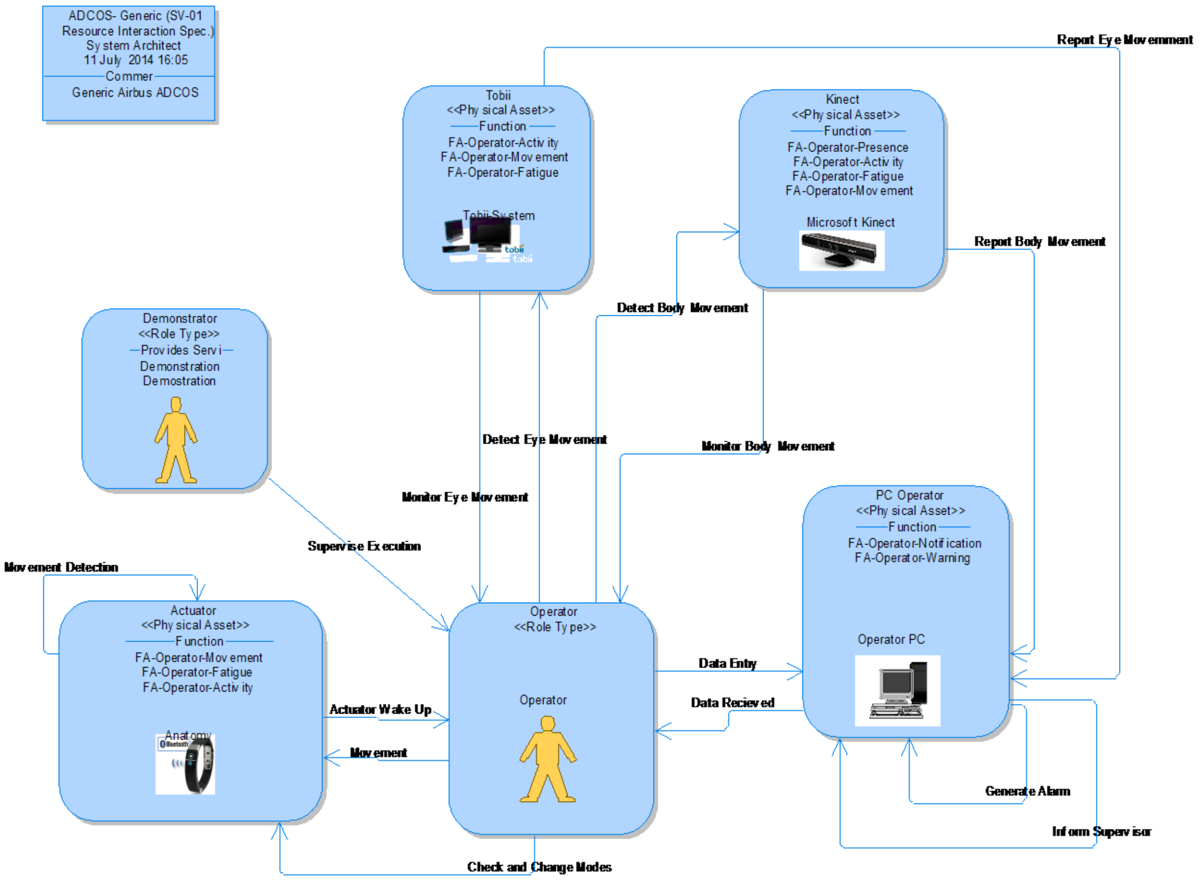

Figure 9 Initial generic logical architecture that maps to section 3.2.1, Use Cases, with initial 'used functions' mapped.

- Kinetic Sensor – Used in Use Cases 1, 2 and 4
- Tobii – Used in Use Case 3
- PC Operator Workstation – Used in Use Cases 5 and 6
- The actuator sensor is under evaluation.

3.5.2. Energy Network Control AdCoS

Figure 8 shows the overall architecture of the Energy Network Control Room AdCoS.

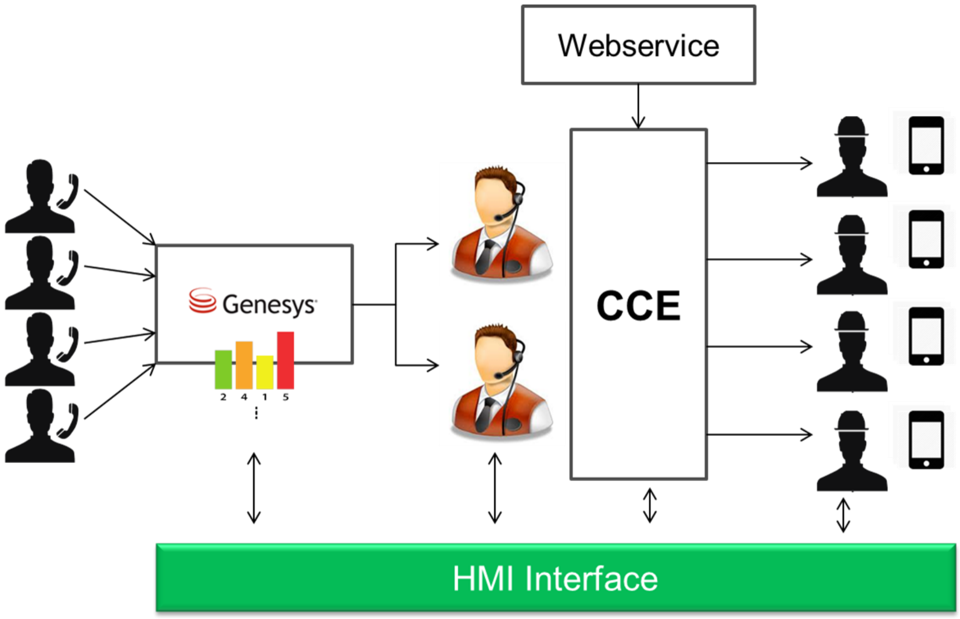

Figure 8: Overall AdCoS architecture, including all systems (Genesys, CCE, web services and mobile app)

By comparing this figure with Figure 2 (that shows the current architecture) it is clear which additional elements will be included in the overall control room workflow:

- The operators will be provided with a mobile app installed on their android phones;
- The CCE will be connected with external Web Services to collect up-to-date information on the status of the operators in the field (zone of intervention, working hours, roles, responsibilities, etc..);
- the mobile phones will be connected with the CCE to receive and send information on the emergency call and the intervention.

Adaption and Human Factors
The trigger for adaption is represented by working turns of the operative teams on the field as reported in the timetable provided to CCE and the AdCoS via webservices. It will take place in terms of allocation of tasks

and resources. The development of the mobile app is needed in order to improve the current system as a whole, allowing Operative Teams to access information stored in CCE on the basis of time, avoiding the misallocation of tasks and resources due to possible human errors. The AdCoS will in fact automatically broadcast the emergency call forms to the teams on duty at the time of the transmission. In order to cope with human factors, the system must have the following functionalities:

- *Allocation of tasks and resources* on the basis of time to the Operative Teams on duty. This allocation of the emergency must enable the Operative Teams to access data from CCE concerning the emergency itself, the localisation of the malfunctioning, the relevant information (avoiding any possible forgetfulness due to human errors on both sides of a phone call), the historical record of previous interventions on the same installations/infrastructure;
- *Taking Charge Feedback Function*, with which the Operative Team that takes charge of the emergency communicates it to the CCE and simultaneously to the CR operators. In case no teams take charge of the emergency, signals and notifications on the app are repeated with increasing frequency and volume;
- *Emergency Feedback Function*, with which the Operative Team that has run the intervention communicates to CCE (and CR operators) the situation at the time of arrival on the place of the malfunctioning, the type of intervention and activities required and undertaken and the outcome of the intervention with the possibility to quit the emergency procedure and store the record in the historical database for future emergencies.

4. Feedback WP1-5

The deliverable D8.1 extensively described Control Room domain requirements delivered to WP1-5. All these requirements were thus associated with stages of the development life-cycle and described how the WP1-5 results were expected to reduce development cost and times/cycles. In this respect, Control Room AdCoSs requirements as well as HF-RTP requirements represented an important input for both the definition and, subsequently, tailoring to Control Room purposes of the HF-RTP itself.

WP1-5 partners have worked since then at the revision, refinement and, finally, update of the WP8 requirements which have now been incorporated in the D1.4 deliverable as a table included in the Annexes to that report listing refined and updated requirements from WP6-9 application domains. By now, this exhaustive table represents the most relevant feedback from WP1-5 thus constituting a major input for further HoliDes cycles devoted to the development of Control Room AdCoSs.

5. Conclusions

During the first year of the project, WP8 partners have identified, refined and updated a number of use-case-specific requirements and specifications of the Border Control AdCoS and Energy Network Control AdCoS. This report describes the outcome of such activities and tasks, with further reference to the underlying linkages with the development of the HF-RTP and the activities carried out in the scientific WPs (2-5).
As a matter of fact, the collection and analysis of the operational definitions, the HMIs and the tools used for the applications development, as well as their requirements and specifications, has highlighted some constituent relations which are consistent with the development process we wanted to follow in the first cycle of HoliDes.
First, the requirements of the AdCoS identified and collected in D8.1 have provided a solid basis onto which building the development of the AdCoS concepts. Namely, the problem statement, goals and regulations of the different functionalities show deep and strong connections with the objectives the system is designed to achieve. The AdCoS concepts, in turn, play a key role when determining in each use case the relative specifications and architecture.
At a broader level, the analysis of requirements for WP8 AdCoS has also enabled a better understanding of which methods, tools and techniques were relevant to account for human factors in the Control Room domain thus constituting an important input for WP1 and the HF-RTP, and the other scientific WPs (2-5).
WP1, in turn, has provided feedbacks concerning the WP8 requirements that have supported to a certain extent the definition of the preliminary HMI concepts. This interaction between application domains (WP 6-9) and scientific activities (WP 1-5) has granted an effective iterative process which constitute an added value of HoliDes and its project cycles.

6. References

Brockman, M., Johansson, E., Rambaldini, A., Hesse, T., Nawrat, F., Larsson, C., Benmimoun, A. et al. (2012). *interactIVe Deliverable D3.1. Results from IWI Evaluation.*