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D 8.7 – Implementation of the Control Room AdCoS and HF-RTP Requirements Definition Update (Feedback)

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Table of Contents

1 List of figures

2 Glossary

AdCoS	Adaptive Cooperative Human-Machine System
C2	Command and Control
C#	An Object-oriented programming language from Microsoft that aims to combine the computing power of C++ with the programming ease of Visual Basic
CCE	Centro Chiamate Emergenza
DOORS	Dynamic Object Oriented Requirements System
DS	Defence and Space
EA	Enterprise Architect
HF	Human Factors
HF-RTP	Human Factor Reference Technology Platform
LEA	Learning Classifier System
HEE	Human Efficiency Evaluator
IR	Infrared
IRN	IREN EMILIA
MTT	Methods and Techniques
OSLC	Open Services for Lifecycle Collaboration
REL	RE:LAB
PC	Personnel Computer
RTP	Reference Technology Platform
SDK	Software Development Kit
SNV	Universita Delgi studi Suor Orsola Benincasa
SW	Software
WP	Work Package

3 Introduction

The purpose of this document is to describe the implemented Control Room AdCoS demonstrators developed within WP 8 and as demonstrated during the 2nd Year Project Review in November 2015 in Eindhoven.

Feedback on the HF-RTP is provided in Clause 5.1. This includes a description of the present and planned integration of MTTs in the AdCoS, explaining which MTTs were employed, which ones were planned to be used but did not deliver the expected results, and which ones are expected to be used in the future.

Clause 7 presents an update the requirements (AdCoS, HF-RTP, MTT requirements) based on the experiences gathered during the development of the AdCoS demonstrator. The final clause presents an outlook and conclusion of the document.

4 Implementation of Airbus Control Room AdCoS

4.1 Background to the Control Room AdCoS (Airbus)

This clause briefly describes the functional and organisational background of the work in Emergency Response Control Rooms, the use cases and the performance indicators (PIs).

Emergency Response Control Rooms handle unplanned events that require an immediate response. Examples are Control Rooms of the fire brigade, of emergency services ("112") and of border security organisations. The AdCoS is illustrated with the example of border security operations but applies equally to most other emergency response or command and control (C2) services.

The work in border security Control Rooms is characterised by phases with high activity followed by longer phases with little or no activity. The Control Room is organised to allow a 24/7 operation. The educational level of operators is medium to low, and border security organisations experience a high operator turn over. Border security is organised hierarchically. The Control Room sites are located close to the border and may be subject to assaults. The situation in other C2 or emergency response organisations has similar characteristics.

Currently, no mechanisms exist that ensure that operators are present at their workstations when the situation requires it. Neither are there adaptive and automatic functionalities for increasing the Control Room’s effectiveness by (semi-) automatic workload handover.

Given the status quo, the AdCoS adaptation aims at increasing the emergency response organisation’s effectiveness and security by implementing new adaptation functionalities. The AdCoS focuses on the operators’ physical and mental states, ensuring that they are present and effective when needed. Secondly, the organisation’s effectiveness can be increased by optimising the workload of each operator.

State-of-the-art operator workstations consist of conventional office PC peripherals: two or three screens, a keyboard and a PC mouse (see Figure 1). The AdCoS enriches the operator workstation with novel proximity-based interaction technologies (sensor equipment for capturing the operator’s physical and mental state). The sensors are part of the Microsoft Kinect (see Figure 2) and of the Tobii eye-tracking system (see Figure 3). For more details on the HMI see Clauses 4.2 and 4.3).

It is worth noting that infrared sensors would probably not be acceptable for workplaces in a non-emergency context. In C2 or emergency response services, however, other people’s lives may depend on the high effectiveness of the Control Room personnel, and the presence of sensors may therefore be justified (when dialling “112” in distress, people expect someone to be there to answer the call).

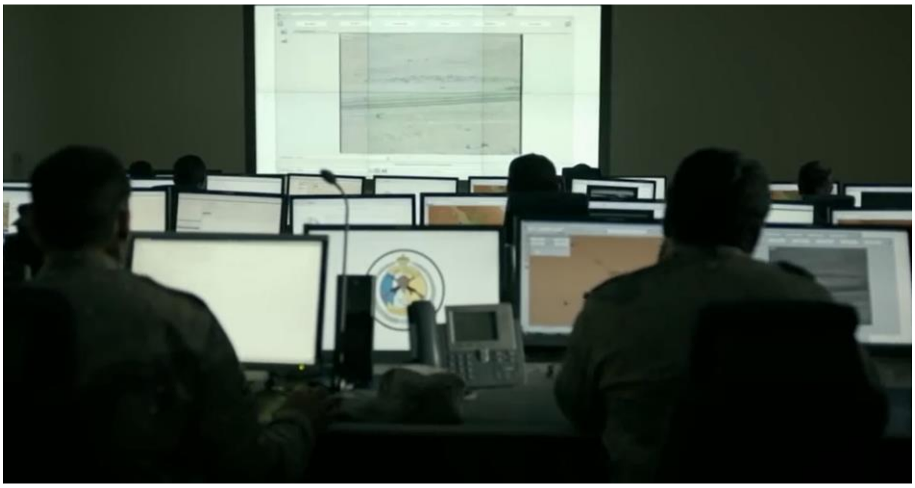


Figure 1 - Workplaces in a Border Security Control Room

Figure 2 - Microsoft Kinect Sensor Device

Figure 3 - tobii Eye-Tracking Sensor Device

The five use cases implemented in the current version of the Airbus AdCoS are:

	Use case	Description
1.	Operator absent from workplace	An operator is absent from his workplace for a longer than accepted period of time. The system calls the operator back to his workplace. If he doesn't return to this workplace after a defined length of time, his supervisor is informed.
2.	Operator idle at workplace	An operator is present at his workplace but idle for a longer than accepted period of time (idle is defined as motionless suggesting that the operator is asleep). The system contacts the operator. If he doesn't display any activity after a defined length of time, his supervisor is informed.
3.	Operator tired at workplace	An operator is present at his workplace but displays signs of fatigue. The system contacts the operator with a warning. If he doesn't acknowledge the warning after a defined length of time, his supervisor is informed.
4.	Registration of unusual operator behaviour patterns	Individual and cumulative instances of operator absence can be plotted with the aim of allowing the border security management to identify behaviour patterns of the crew that can be exploited by third parties in order to compromise a station's security.
5.	Load balancing on operator level	The system is able to recognise the workload of a single operator compared to the overall workload of all operators in one headquarter. 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 implementation of each use case is described in detail below (see Clause 4.2).

The main performance indicators (PIs) for the Airbus AdCoS are:

- *Functionality:* The AdCoS provides functionalities that facilitate the operation of the Control Room and that hitherto have not been available.
- *Effectiveness:* The AdCoS increases the effectiveness of the Control Room operation by providing means that ensure that operators are available at their workstations and in a physical state that allows them to perform their duties in an effective and efficient way.
- *Security:* One specific feature of the AdCoS is the analysis of operator behaviours in order to identify suspicious patterns that can be exploited by perpetrators.

Verification criteria have been defined to be used in the evaluation activities scheduled for Year 3 of the project.

4.2 AdCoS Description

This clause describes the emergency response Control Room AdCoS demonstrator in detail.

The AdCoS demonstration set up represents two Control Room workstations (see Figure 4, Figure 5, and Figure 6). The desk on the right represents the Response Supervisor Workstation, the one of the left the Response Operator Workstation. The workstation in the back is used for the servers needed to supply the software and network context of the demonstration.

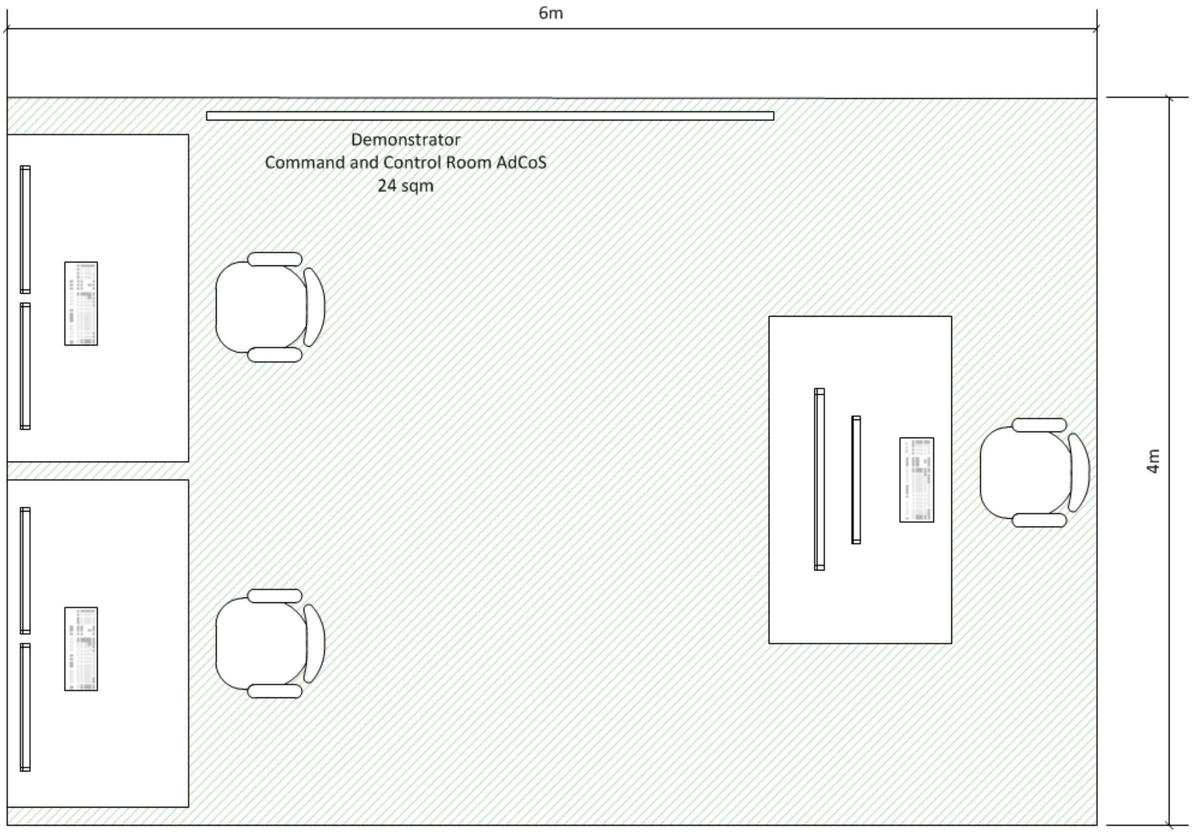


Figure 4 – Spatial Arrangement of the Airbus AdCoS Demonstrator

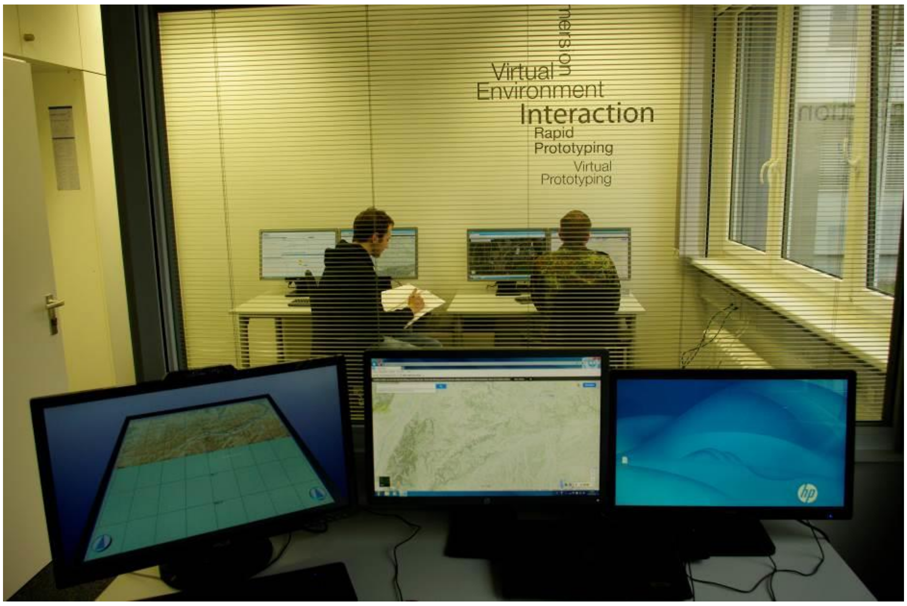


Figure 5 - AdCoS Demonstrator at Airbus in Friedrichshafen

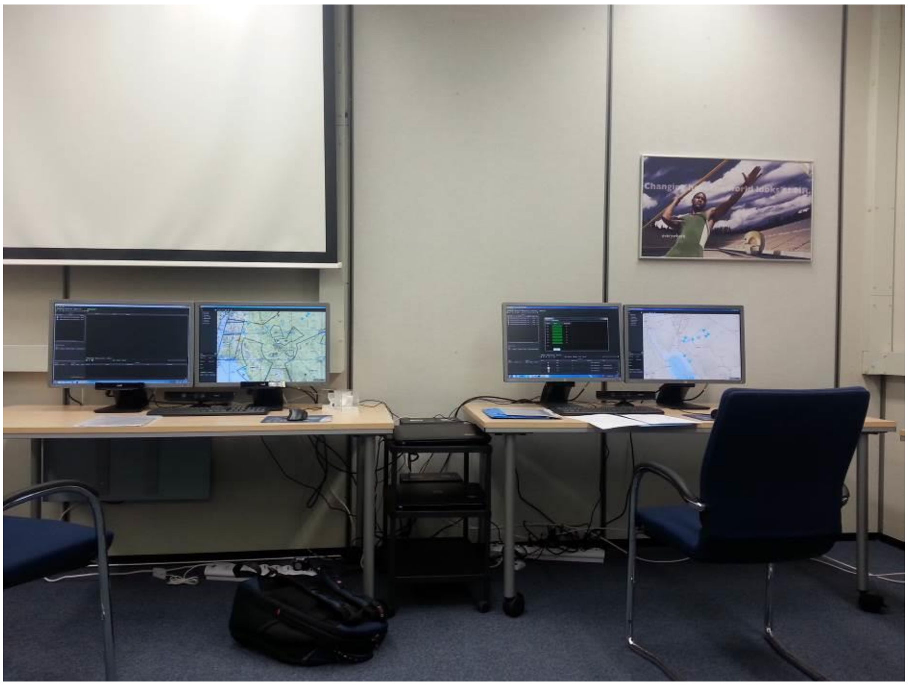


Figure 6 – Airbus AdCoS Demonstrator at the 2nd Year Review

The AdCoS demonstrator requires the computers, peripheral components, SW components, and network components shown in Figure 7 (please note that Fix, Foxi, and Knox are the names of PCs / workstations).

The demonstrator set up includes two client PCs and a workstation with a VM Server. For running the system outside of the Airbus network environment, two additional servers are added and connected to the demonstrator environment, namely the Geo server and the Database server.

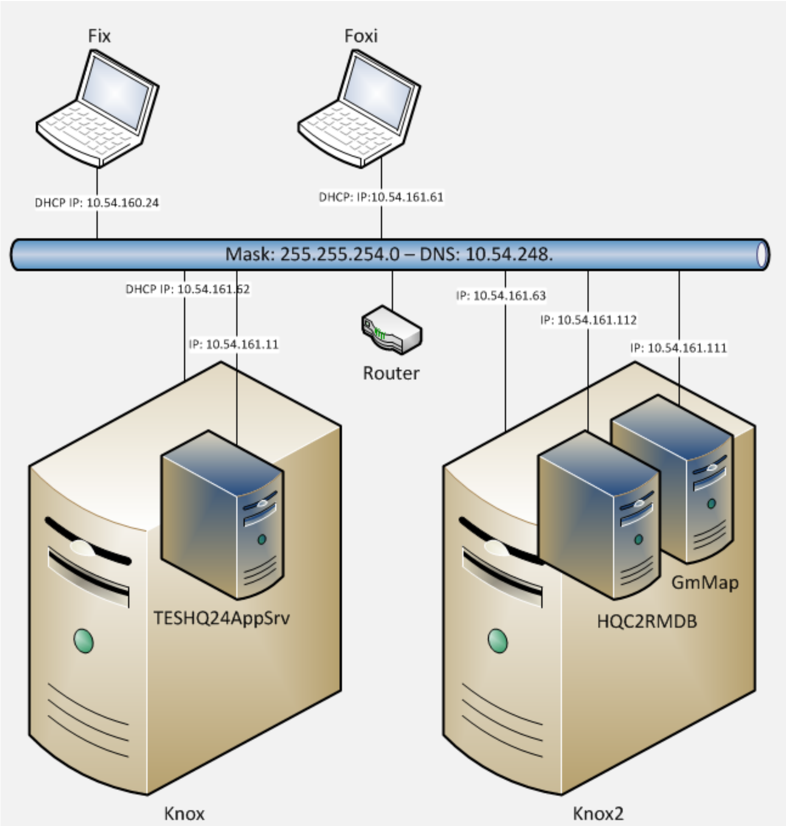


Figure 7 - Components and Network of the Airbus AdCoS Demonstrator

In the following all five use cases realised in the demonstrator are described in detail, including information on the goal / purpose of each use case, the pre-conditions, and the participating agents. In addition, a step-by-step description of the user-machine interaction is documented using screen shots and photos.

4.2.1 Use Case 1: Operator presence / absence

In longer periods of inactivity, operators may be tempted to spend longer times away from their workstations. In the case of a sudden emergency, they may not be immediately available, thereby increasing the Control Room's response times to the emergency.

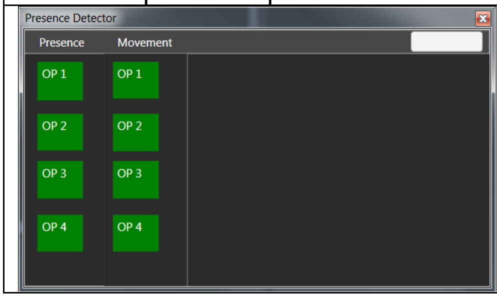
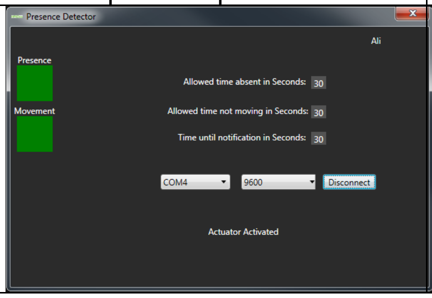
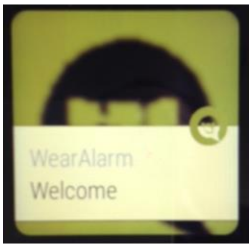
The use case adaptation uses infrared sensors in the Microsoft Kinect device (see Figure 2) to reliably establish whether an operator is present at his workstation or not. If his absence exceeds the permitted length of time (or in case of an incoming urgent case to deal with) the system will alert him discreetly by a vibration alert of his smartwatch to "nudge" him to return to his station (no colleague or supervisor needs to notice).

For the purpose of illustrating the functionality, presence and absence are visualised on both the Response Operator PC monitor and the Response Supervisor PC monitor. In a real-life implementation, those visualisations would only be displayed in maintenance mode.

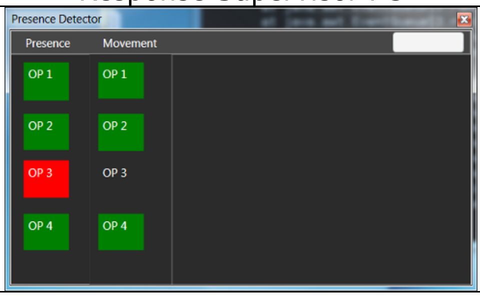
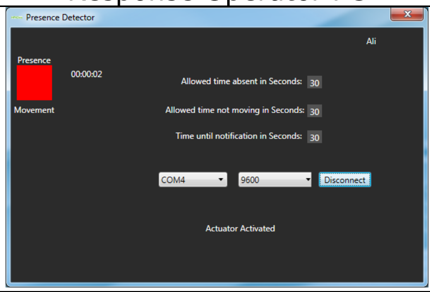
The following table describes the sequence of events for Use Case 1, with the operator returning upon being called back.

State	Response Operator activity	Response Supervisor PC	Response Operator PC	Response Operator Actuator
1.1	Present	Indication Operator present (green)	Indication Operator present (green)	Idle
1.2	Leaves workstation	Indication Operator absent (red)	Indication Operator absent (red)	Idle
1.3	Absent	Indication Operator absent (red)	Indication Operator absent (red), PC locked	Begin vibration, display text message
1.4	Returns (is present)	Indication Operator present (green)	Indication Operator present (green), PC locked	End vibration
1.5	Unlocks PC	Indication Operator present (green)	Indication Operator present (green)	Idle

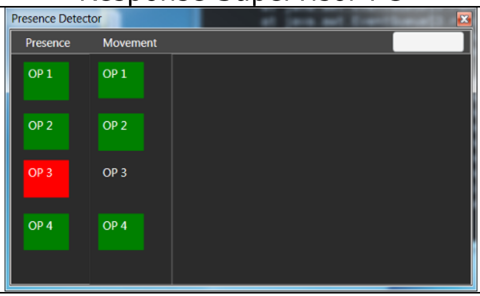
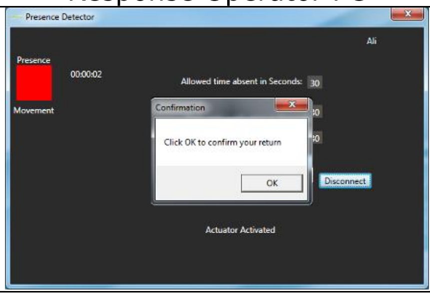
HMI State 1.1 Operator present

Response Supervisor PC	Response Operator PC	Actuator Device
		

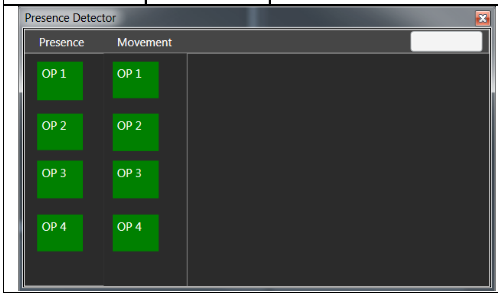
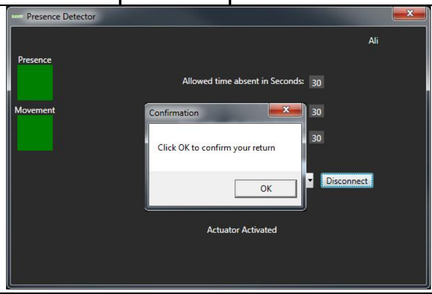
HMI State 1.2 Operator leaves workstation

Response Supervisor PC	Response Operator PC	Actuator Device
		

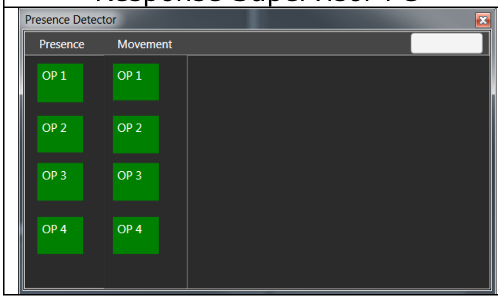
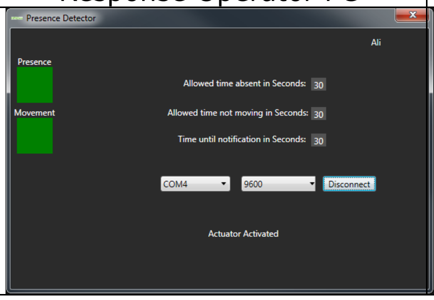
HMI State 1.3 Operator absent (> n minutes)

Response Supervisor PC	Response Operator PC	Actuator Device
		

HMI State 1.4 Operator returns (is present)

Response Supervisor PC	Response Operator PC	Actuator Device
		

HMI State 1.5 Operator unlocks PC

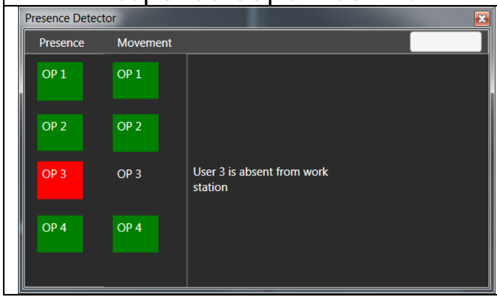
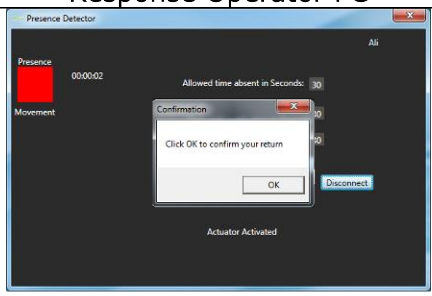
Response Supervisor PC	Response Operator PC	Actuator Device
		

Only if the operator doesn’t respond to the alert within a specified time by returning to his workstation the supervisor will be informed about the extended absence. The following table describes the sequence of events for Use Case 1, with the operator not returning upon being called back.

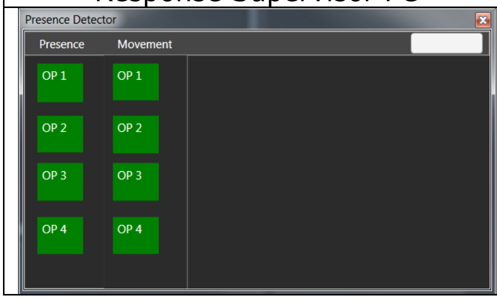
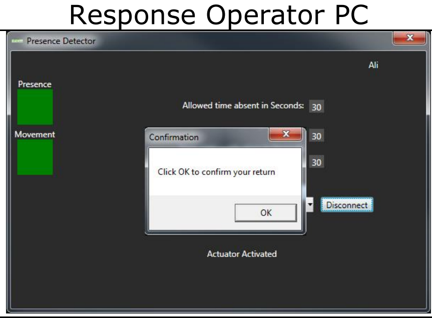
State	Response Operator activity	Response Supervisor PC	Response Operator PC	Response Operator Actuator
1.1	Present	Indication Operator present (green)	Indication Operator present (green)	Idle
1.2	Leaves workstation	Indication Operator absent (red)	Indication Operator absent (red)	Idle
1.3	Absent	Indication Operator absent (red)	Indication Operator absent (red), PC locked	Begin vibration, display text message
1.3a	Continued absence	Indication Operator absent (red) Message window “Operator absent”	Indication Operator absent (red), PC locked	Vibration
1.4a	Returns (is present)	Indication Operator present (green)	Indication Operator present (green), PC locked	End vibration
1.5	Unlocks PC	Indication Operator present (green)	Indication Operator present (green)	Idle

The following screen shots display the HMI of the states 1.3a and 1.4a.

HMI State 1.3a Operator continued absence

Response Supervisor PC	Response Operator PC	Actuator Device
		

HMI State 1.4a Operator returns (is present after continued absence)

Response Supervisor PC	Response Operator PC	Actuator Device
		

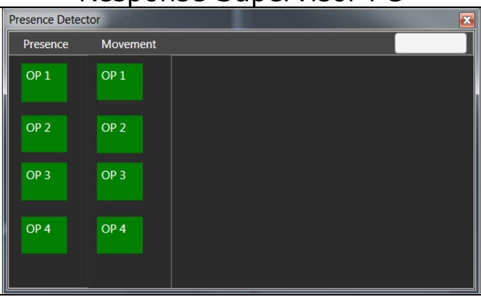
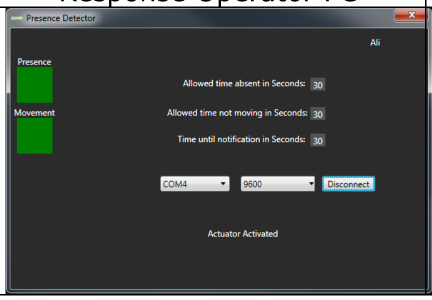
4.2.2 Use Case 2: Operator idle / asleep

Another example of low Control Room effectiveness are operators that fall asleep during night shifts. The AdCoS adaptation recognises sleeping operators (who are present at the workstation but display only minimum movements). If an operator has been identified as sleeping, the system will again activate an actuator to discreetly wake him up without anybody else noticing.

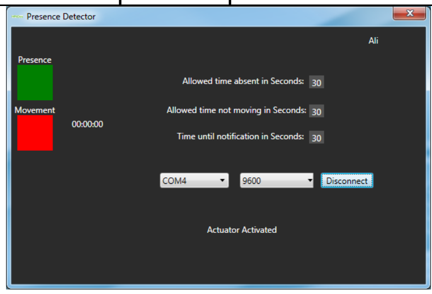
The following table describes the sequence of events for Use Case 2, with the operator waking up upon being called.

State	Response Operator activity	Response Supervisor PC	Response Operator PC	Response Operator Actuator
2.1	Present and moving	Indication Operator moving (green)	Indication Operator moving (green)	Idle
2.2	Becomes idle	Indication Operator idle (red)	Indication Operator idle (red)	Idle
2.3	Operator idle (> n min.)	Indication Operator idle (red)	Indication Operator idle (red)	Begin vibration, display text message
2.4	Operator moves again (is awake)	Indication Operator moving (green)	Indication Operator moving (green)	End vibration
2.5	Present and moving	Indication Operator moving (green)	Indication Operator moving (green)	Idle

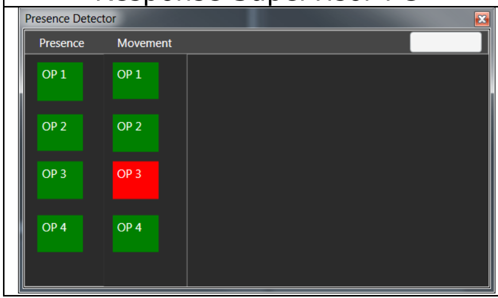
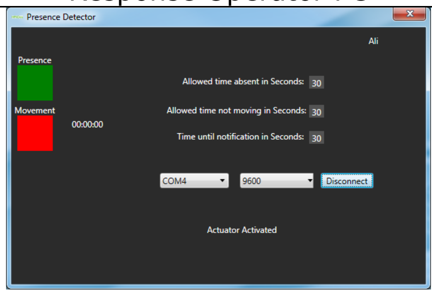
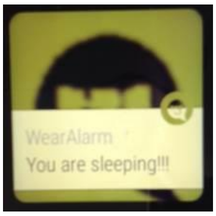
HMI State 2.1 Operator present and moving

Response Supervisor PC	Response Operator PC	Actuator Device
		

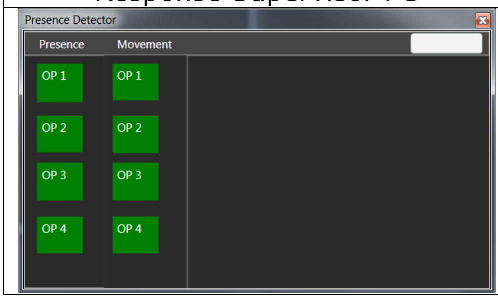
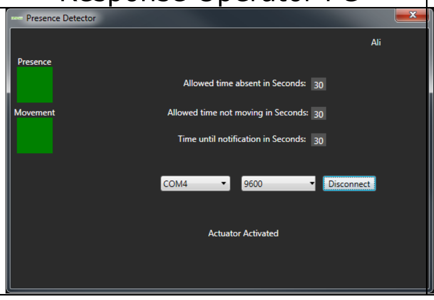
HMI State 2.2 Operator becomes idle

Response Supervisor PC	Response Operator PC	Actuator Device
		

HMI State 2.3 Operator idle (> n min.)

Response Supervisor PC	Response Operator PC	Actuator Device
		

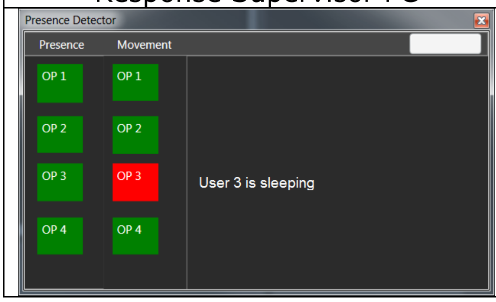
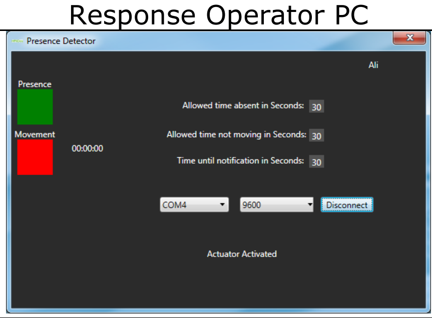
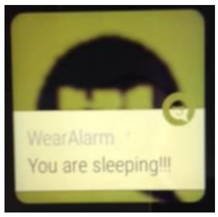
HMI State 2.4 Operator moves again (is awake) and 2.5 Operator present and moving

Response Supervisor PC	Response Operator PC	Actuator Device
		

Only if the operator doesn't respond to the alert after an extended time, his supervisor will be informed.

State	Response Operator activity	Response Supervisor PC	Response Operator PC	Response Operator Actuator
2.1	Present and moving	Indication Operator moving (green)	Indication Operator moving (green)	Idle
2.2	Becomes idle	Indication Operator idle (red)	Indication Operator idle (red)	Idle
2.3	Operator idle (> n min.)	Indication Operator idle (red)	Indication Operator idle (red)	Begin vibration, display text message
2.3a	Operator idle (> n + m min.)	Indication Operator idle (red), Message "Operator idle"	Indication Operator idle (red)	Vibration
2.4	Operator moves again (is awake)	Indication Operator moving (green)	Indication Operator moving (green)	End vibration
2.5	Present and moving	Indication Operator moving (green)	Indication Operator moving (green)	Idle

HMI State 2.3a Operator continued idle state

Response Supervisor PC	Response Operator PC	Actuator Device
		

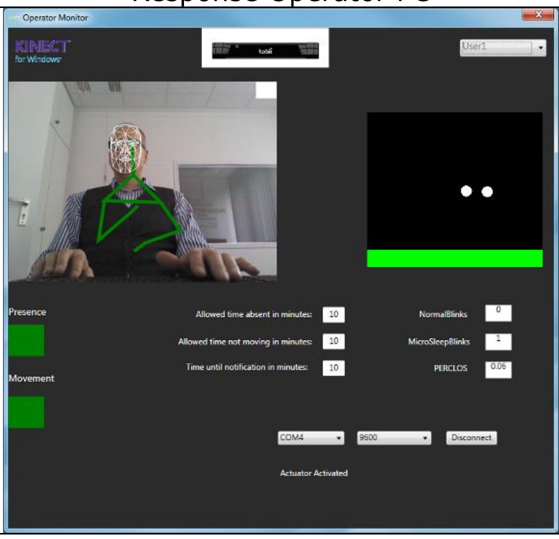
4.2.3 Use Case 3: Operator tired at workplace

Another operator mental state that can negatively impact the C2 organisation's effectiveness is operator fatigue. The level of fatigue of an operator is captured by means of an eye-tracker system. The sensors observe the movements of the operator's eyelid and interpret specific eyelid behaviours as indicators of fatigue (PERCLOS parameter). The position of the operator's head is measured by the Microsoft Kinect's optical camera to provide the system with the information, at which times the operator is facing the screens (and hence the eye-tracking system).

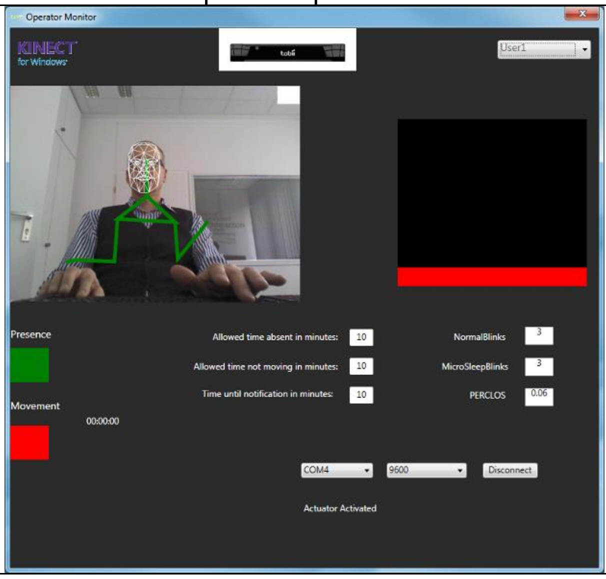
The indication of the operator status is for visualisation purposes only and would only be implemented in a product for maintenance purposes. The supervisor will not be informed about the operator's level of fatigue (this is an optional feature).

State	Response Operator activity	Response Supervisor PC	Response Operator PC	Response Operator Actuator
3.1	Displays normal behaviour	-	Indication Operator awake (green)	Idle
3.2	Displays signs of fatigue	-	Indication Operator tired (red)	Idle
3.3	Operator tired (> n min.)	-	Indication Operator tired (red)	Begin vibration, display text message
3.4	Displays normal behaviour (is awake)	-	Indication Operator awake (green)	End vibration
3.5	Displays normal behaviour	-	Indication Operator awake (green)	Idle

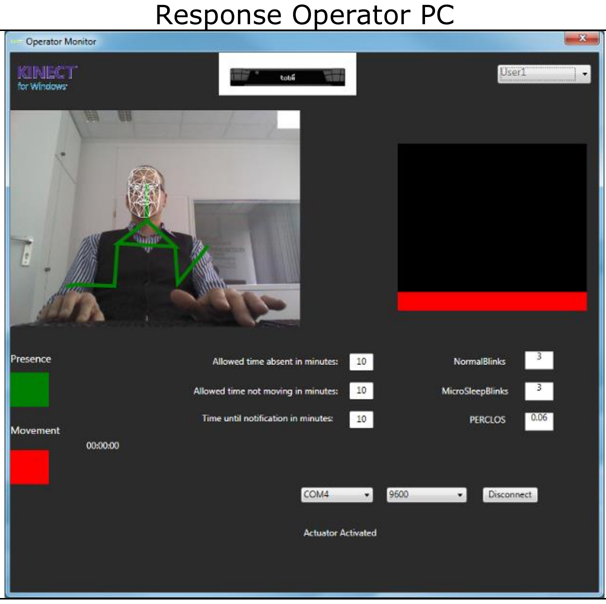
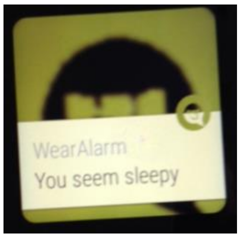
HMI State 3.1 Operator displays normal behaviour

Response Operator PC	Actuator Device
	

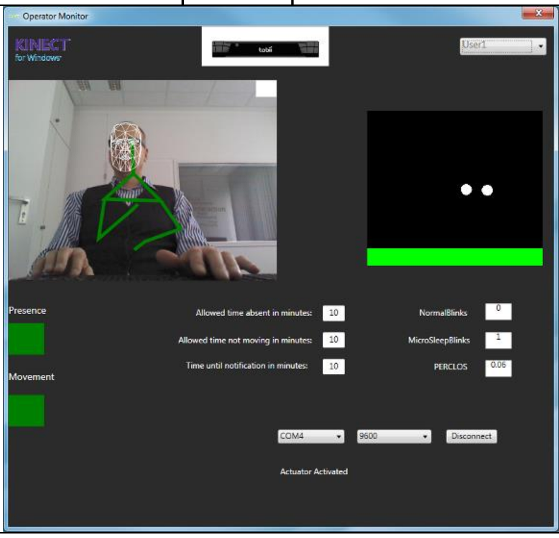
HMI State 3.2 Operator displays signs of fatigue

Response Operator PC	Actuator Device
	

HMI State 3.3 Operator tired (> n min.)

Response Operator PC	Actuator Device
	

HMI State 3.4 and State 3.5 Operator moves again (is awake)

Response Operator PC	Actuator Device
	

4.2.4 Use Case 4: Registration of unusual behaviour patterns

Regular and observable behavioural patterns can be exploited by perpetrators for scheduling illegal activities. The automatic recognition of such exploitable behaviour patterns can support the C2 Control Room management in identifying training needs for operators, focussing on behaviours that help maintaining the Control Room's security.

All instances of operator absent and operator idle (asleep) for longer than the permitted times are entered into the database of data related to operator absences. Instances of operator fatigue can optionally also be entered into the database, however, this is not supported by the AdCoS demonstrator implementation.

Similarly, in most cultures, it will not be accepted to store the operator ID. In those cases, the data will be registered anonymously, but still allowing the identification of operator behaviour patterns (e.g. "An anonymous operator with the arbitrary label 'Operator X' displayed the following exploitable behaviour: …").

The structure of the database contains an operator ID, start and end times of behaviours, the length in minutes of the behaviour, and the day and month of the occurrence (see Figure 8).

dbo.PatternTable [Data]

Max Rows: 1000

OpId	AbsenceStartT...	AbsenceEndTi...	TotalMinutes	Day	Month
29	01.01.2013 22:2...	01.01.2013 22:4...	16	Tuesday	1
10	01.01.2013 10:1...	01.01.2013 10:1...	2	Tuesday	1
2	01.01.2013 12:3...	01.01.2013 12:5...	17	Tuesday	1
14	01.01.2013 16:0...	01.01.2013 16:3...	23	Tuesday	1
4	01.01.2013 10:2...	01.01.2013 10:2...	2	Tuesday	1
1	01.01.2013 12:1...	01.01.2013 13:1...	57	Tuesday	1
19	01.01.2013 16:0...	01.01.2013 16:2...	16	Tuesday	1
7	01.01.2013 10:1...	01.01.2013 10:2...	15	Tuesday	1
7	01.01.2013 12:0...	01.01.2013 12:5...	51	Tuesday	1
16	01.01.2013 16:1...	01.01.2013 16:5...	44	Tuesday	1
6	01.01.2013 10:2...	01.01.2013 10:2...	9	Tuesday	1
8	01.01.2013 12:2...	01.01.2013 13:1...	49	Tuesday	1
11	01.01.2013 16:2...	01.01.2013 16:4...	15	Tuesday	1
13	02.01.2013 09:2...	02.01.2013 09:2...	5	Wednesday	1
10	02.01.2013 10:0...	02.01.2013 10:1...	14	Wednesday	1
4	02.01.2013 12:2...	02.01.2013 13:0...	34	Wednesday	1
11	02.01.2013 16:0...	02.01.2013 16:0...	7	Wednesday	1
4	02.01.2013 10:2...	02.01.2013 10:4...	20	Wednesday	1
8	02.01.2013 12:5...	02.01.2013 13:2...	32	Wednesday	1
14	02.01.2013 16:2...	02.01.2013 16:5...	32	Wednesday	1
7	02.01.2013 10:0...	02.01.2013 10:1...	5	Wednesday	1
9	02.01.2013 12:5...	02.01.2013 13:0...	7	Wednesday	1
13	02.01.2013 16:1...	02.01.2013 16:4...	35	Wednesday	1
2	02.01.2013 10:2...	02.01.2013 10:2...	2	Wednesday	1
6	02.01.2013 12:4...	02.01.2013 13:1...	31	Wednesday	1
14	02.01.2013 16:0...	02.01.2013 16:3...	28	Wednesday	1
17	02.01.2013 14:3...	02.01.2013 14:5...	19	Wednesday	1
19	02.01.2013 14:3...	02.01.2013 14:5...	19	Wednesday	1
1	03.01.2013 01:4...	03.01.2013 02:0...	15	Thursday	1
5	03.01.2013 10:3	03.01.2013 10:3	9	Thursday	1

Figure 8 - Database Structure of Operator Absence-related Data

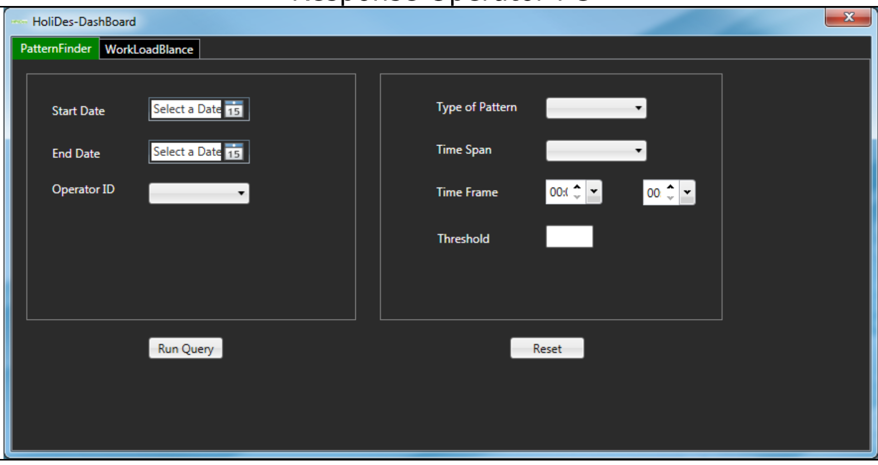
The analysis for patterns in the database can be initiated automatically or manually. In automatic search, a control in the supervisor application can set a time (e.g. 0300h every night) for the automatic search based on a range of parameters (e.g. all supported patterns). In manual search, a control in the supervisor application can initiate a search based on selected parameters (e.g. weekly patterns).

The patterns supported in the AdCoS demonstrator are daily (e.g. regular absences every day between 0200h and 0300h), weekly (e.g. regular absences every Tuesday and Thursday), monthly (e.g. operator is absent on every 15th day of month but at different times, i.e. absolute monthly pattern), complex time patterns (e.g. operator is absent on every second Tuesday between 0300h and 0400h, i.e. relative monthly pattern), or complex correlational patterns (e.g. two individual operators absent together four times in a month at same time).

State	Response Supervisor activity	Response Supervisor PC
4.1	Initiates dialogue	Displays dialogue for manual database search
4.2	Selects search parameters	Accepts search parameters
4.3	Selects control for starting analysis	Performs analysis
4.4	Views results	Displays results
4.5	Selects control for closing application	Closes application

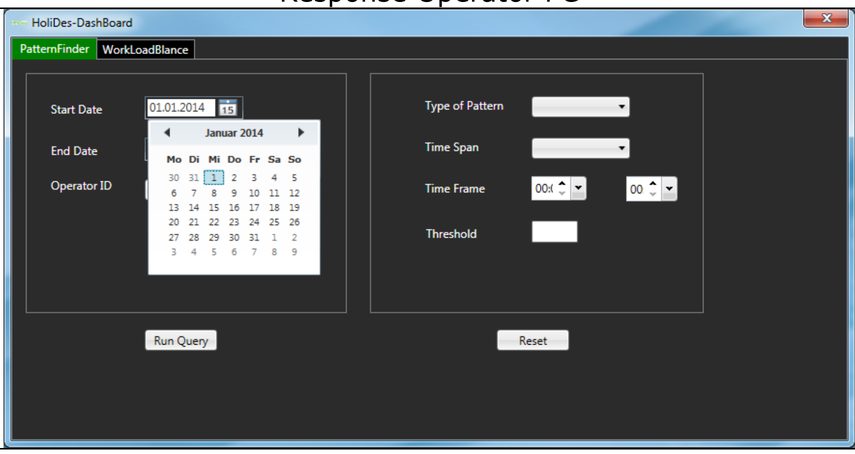
HMI State 4.1 Supervisor initiates dialogue

Response Operator PC



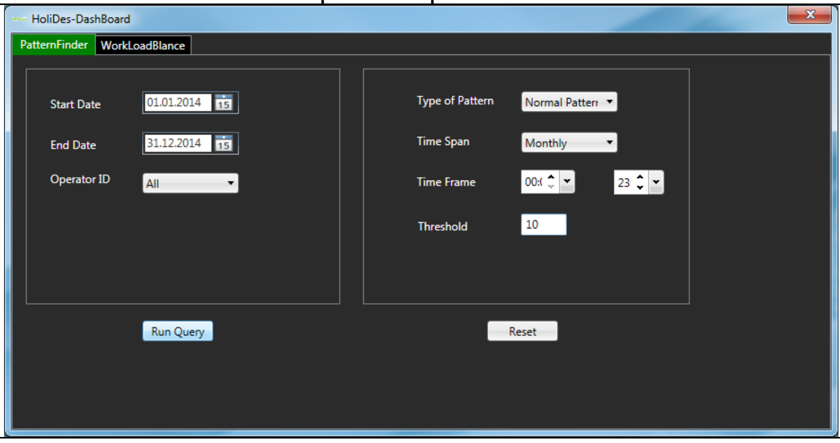
HMI State 4.2 Supervisor selects search parameters

Response Operator PC



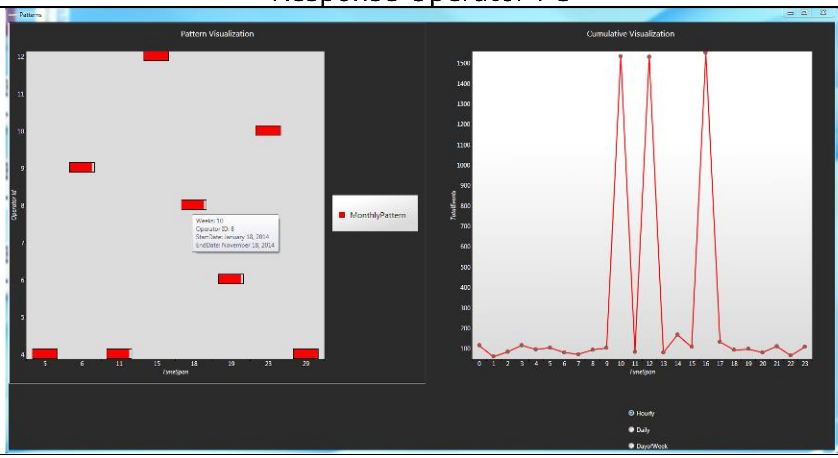
HMI State 4.3 Supervisor selects control for starting analysis (Run Query)

Response Operator PC



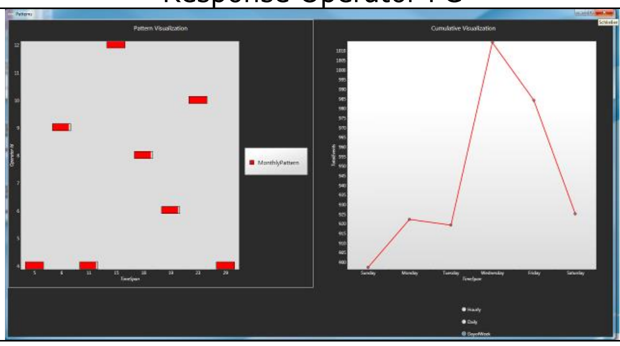
HMI State 4.4 Supervisor views results

Response Operator PC



HMI State 4.5 Supervisor selects control for closing application

Response Operator PC



4.2.5 Use Case 5: Load balancing on operator level

One way of improving the effectiveness of a C2 Control Room is the optimum distribution of workloads among operators. To just consider "objective" parameters such as number of cases to be dealt with is not sufficient, as parameters related to the individual operator such as level of expertise, level of fatigue and level of stress also affect the workload experienced by an operator at a given time (see Figure 9).

Operator	Level of Expertise	Expertise Weighted	Level of Fatigue	Fatigue Weighted	N Hostile	N Hostile Weighted	N Neutral	N Neutral Weighted	N Friend	N Friend Weighted	Subjective Workload
1	1	1,2	1	0,5	2	10	4	12	2	2	14,4
2	2	1	1	0,5	1	5	4	12	2	2	9,5
3	3	0,8	1	0,5	2	10	2	6	4	4	8
4	1	1,2	1	1	1	5	1	3	3	3	13,2
5	2	1	2	1	2	10	2	6	1	1	17
5	3	0,8	2	1	3	15	0	0	2	2	13,6
6	1	1,2	2	1	1	5	2	6	1	1	14,4
7	1	1,2	2	1	0	0	2	6	2	2	9,6
8	1	1,2	1	0,5	1	5	1	3	1	1	5,4

Figure 9 - Computation of Individual Operator Workload

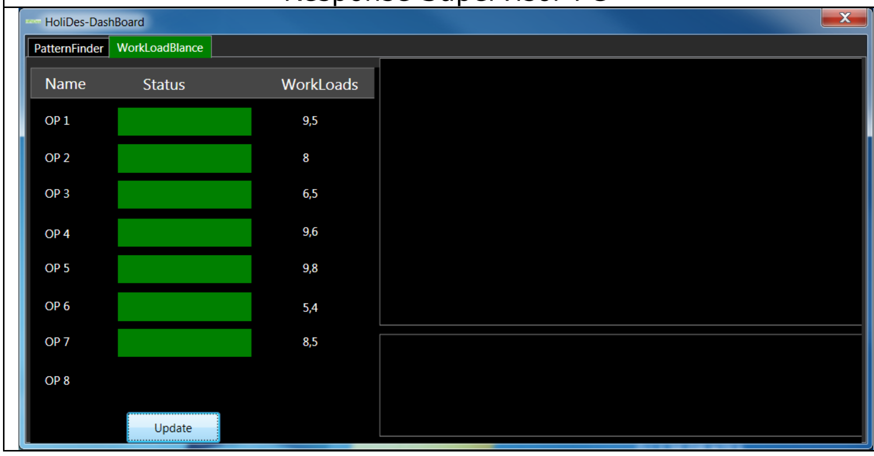
The use case workload handover demonstrates a functionality of the AdCoS that monitors the workload of each operator at any moment, visualises the workloads to the supervisor, and pro-actively suggests the handover of individual cases from one operator to another if this improves the effectiveness of the operation as a whole.

In the example below, all Response Operators (RO) are working within an acceptable workload level, as indicated by the green fields. We now add an event to Operator 5 which leads to him reaching a workload above threshold (the workload indication for that operator turns red). The AdCoS suggests to the supervisor that an event should be handed over to Operator 6 who will remain below threshold even if that event is added. The supervisor accepts the proposal and the indication for Operator 5 is displayed as green again.

In the following description, the activity and screen contents of the receiving Response operator are not displayed.

State	Response Supervisor Activity	Response Supervisor PC	Response Operator in Focus Activity	Response Operator in Focus PC
5.1	Calls up visualisation of RO workloads	Indication all RO below threshold	Working	-
5.2	Adds new event to operator in focus	Accepts parameters and assigns event	Working	Additional event is displayed on event list
5.3	-	Flags RO Focus as being above threshold, proposes handover of events to Receiving RO	Working	-
5.4	Accepts Handover	Performs Handover (manual keyboard command at admin PC to execute)	Working	One event is deleted from event list; RO is informed about this
5.5	-	Indication of RO workload is updated	Working	-

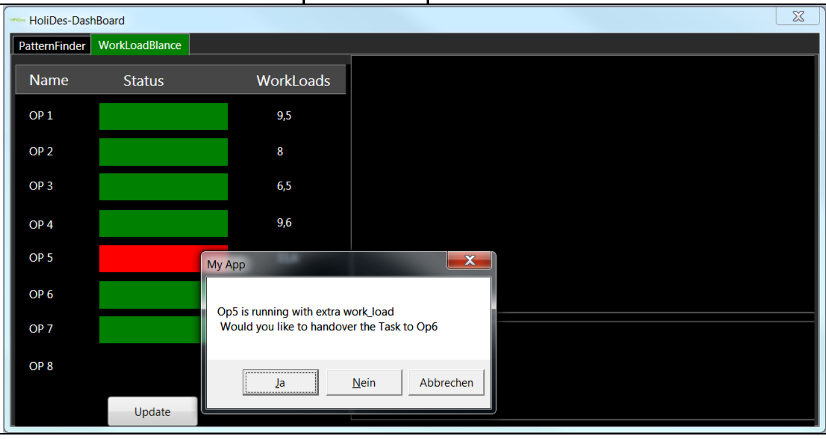
HMI State 5.1 Supervisor calls up visualisation of Response Op. workloads

Response Supervisor PC	RO in focus of activity
	The operator is working normally. The activities of the Response Operator are taking part in the core commercial software which cannot be displayed for confidentiality reasons.

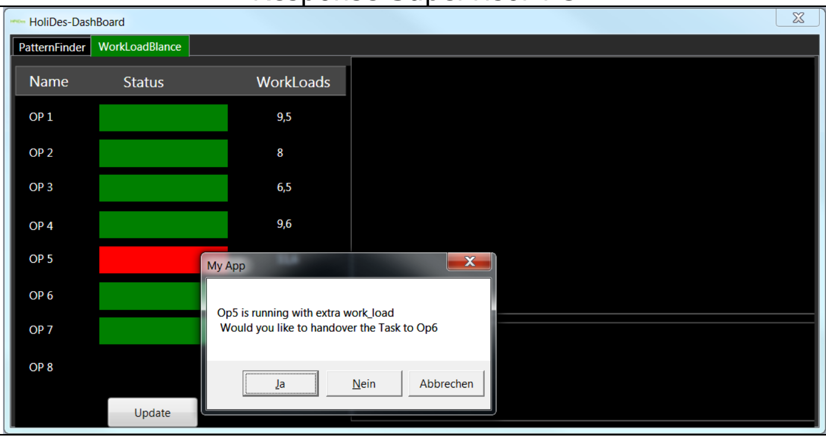
HMI State 5.2 Supervisor adds new event to operator in focus

Response Operator PC	RO in focus of activity
This activity is taking part in the core commercial software which cannot be displayed for confidentiality reasons.	The activities of the Response Operator are taking part in the core commercial software which cannot be displayed for confidentiality reasons.

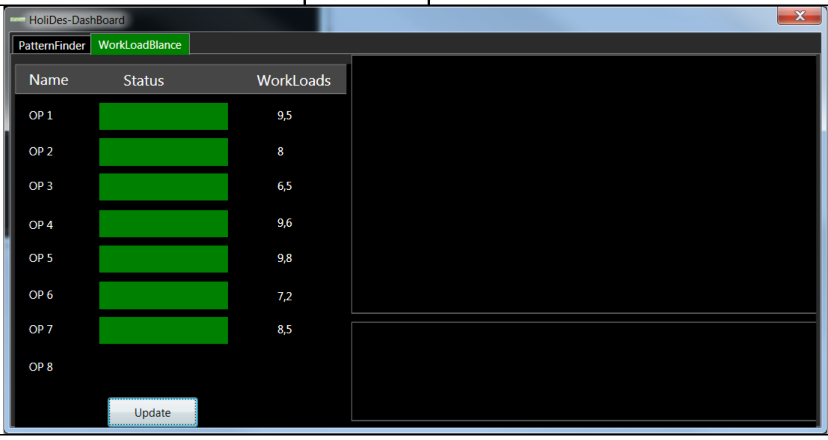
HMI State 5.3 AdCoS adaptation proposes workload handover

<table>
<tr><th>Response Supervisor PC</th><th>RO in focus of activity</th></tr>
<tr><td>
</td><td>The operator is working normally. The activities of the Response Operator are taking part in the core commercial software which cannot be displayed for confidentiality reasons.</td></tr>
</table>

HMI State 5.4 Supervisor accepts workload handover

<table>
<tr><th>Response Supervisor PC</th><th>RO in focus of activity</th></tr>
<tr><td>
</td><td>An event is removed from the operator's list of current events. The activities of the Response Operator are taking part in the core commercial software which cannot be displayed for confidentiality reasons.</td></tr>
</table>

HMI State 5.5 AdCoS adaptation updates the visualisation of workloads

Response Supervisor PC	RO in focus of activity
	An event is removed from the operator's list of current events. The activities of the Response Operator are taking part in the core commercial software which cannot be displayed for confidentiality reasons.

4.3 HMI Implementation

The main challenge of the HMI implementation of the emergency response Control Room AdCoS was the integration of novel proximity-based and touch-free interaction technologies. These technologies work in the background with no or little active user interaction, thereby allowing the users to focus on their main activities.

The sensors that are being used in the AdCoS are infrared cameras for assessing the presence or absence of an operator and for detecting fatigue and stress. The optical camera built into the Microsoft Kinect is only used for computing the operator's head position and cannot be displayed to any party except in maintenance mode (which is being shown in the demonstration). The Kinect microphone array is not being used in the AdCoS.

In the development of the AdCoS demonstrator, the main challenges were:

- The fine-tuning of the presence detection using the Microsoft Kinect's IR emitters and sensors; the challenge was to define the perfect depth space to be covered by a user in a sitting position – this should prevent the sensors from registering people passing by the workstation.
- Finding the correct range of movements of a sleeping person and to develop effective algorithms to interpret those movements correctly were another challenge that required a lot of developing and testing.

- Implementing the PERCLOS parameter for the detection of operator fatigue using eye-tracking technology was not easy. In addition, the solution required the operator's head position to be captured using the Microsoft Kinect's optical camera, so that the eye-tracking system would only look for (closed) eye-lids when the operator's head is facing the screens (and thereby the eye-tracking sensors).

4.4 MTT and Modules Integration

This clause summarises the MTTs that were (a) originally considered, (b) actually implemented, and (c) short listed for integration into the next version of the AdCoS demonstrator and for evaluation purposes.

(a) MTTs that were originally considered but dropped later:

MTT	Reason for not using
LEA	The LEA tool was considered for its ability to spot patterns in operator's behavioural patterns. One of its strengths is allowing the user an easy way of entering new patterns to look for resp. rules to apply. Unfortunately, it was noted that there was a large effort to incorporate new behavioural trends due to the hard coding of certain processes. However, the MTT owner directed WP8 to an alternative tool called KNIME which is better suited to the needs of the Control Room AdCoS (see Clause 6.1).
CBR	The application of this tool will allow the solving of statistical problems based on the solution of similar cases in the past. Due to the fact that we don't have sufficient data to compare similar cases this tool has been rejected for the Control Room AdCoS.
RT-MAPS	RT-MAPS is a modelling tool that builds process models which can handle data input from a variety of sensors and then perform actions on a variety of actuators. Whilst RT-MAPS would have been useful if a Control Room would have been built from scratch, the scope for RT-MAPS to work alongside Airbus DS' existing solution was limited (as the main Control Room operator software has already been developed).
I-DEEP	I-DEEP is a test execution automation server dedicated to the validation of perception and decision making functions, particularly based on vision. I-DEEP works as a plug-in for the software RT-MAPS. Since RT-MAPS cannot be used for the Airbus AdCoS, there is no advantage to utilising I-DEEP.

(b) MTTs that are actually implemented / used:

MTT	Current Status
IBM DOORS	Whilst this is not an MTT native to HoliDes (since IBM is not in the project), DOORS is indeed very widely used in Airbus so its place in the HF-RTP is extremely important from Airbus DS' point of view. IBM DOORS supports OSLC requirements straight out of the box which makes it particularly useful in HoliDes.
SPARX Enter-prise Architect	Enterprise Architect is a UML modelling tool which is highly customisable. Its SDK allows EA to be extended using C#. With this ability Airbus has made EA OSLC compliant such that it can import DOORS requirement objects and test artefacts from the HF-Filer.
HF Filer	The HF Filer is being provided by WP5. It gives a web presence to Human Factor test reports and makes them available through OSLC. EA has been extended so that Human Factors information can be linked to test reports.

(c) MTTs that are planned to be used at a later stage (e.g. in evaluation):

MTT	Planned use
GreatSPN	GreatSPN is a Petri net modelling tool from the University of Turin. It can model processes and simulate the effects of different scenarios on those processes. Airbus is looking at how architectural information could be used directly by Great-SPN to automate the process of creating a Petri net. This exchange would be done with OSLC.
Human Efficiency Evaluator (HEE)	The HEE tool was originally assessed for use with the Airbus Control Room user interface. During the evaluation phase, WP8 will evaluate whether the user interactions with the AdCoS software are sufficiently complex as to yield any worthwhile improvements in efficiency.

4.5 Next steps

The use cases as implemented in the current version of the AdCoS demonstrator achieved their goal of documenting the feasibility of using adaptation technologies to potentially improve the effectiveness and safety of emergency response Control Rooms.

The next steps are the addition of further functionality to the AdCoS demonstrator and the evaluation of the AdCoS in Year 3.

New functionalities of the AdCoS demonstrator include the implementation of:

- Use Case 6 "Monitor and update the status of employees": Based on a set of parameters, the system 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.
- Technologies for identifying the operator (authentication) e.g. by means of a finger-print sensor).

The focus of the evaluation activities will be on:

- the validation and verification of AdCoS requirements (this expands tests already conducted successfully as part of a student Master Thesis), and
- the acceptance of the use of proximity-based technologies by emergency-response operators.

5 Implementation of Iren Control Room AdCoS

5.1 Background to the Energy Control Room AdCoS (IRN)

The Control Room of Iren, established in Parma (Italy), has been recently built as a modern 'control tower' of the services provided by the Iren Group: as shown in Figure 10, on the wall of giant monitors - directly derived from the aeronautics domain - the real-time data of gas distribution, heat, water and electricity is represented. In case of fault, alarms are triggered on the screens with the specific portion of network involved in the fault. The Control Room guarantees a prompt H24 service.

Figure 10 - Energy Control Room of IRN

The Control Room receives either calls from customers who report network failures, or signals from the controlled network segments, with the relevant data being subsequently being displayed on the synoptic system on the giant monitors as well as the monitors of the operators.

The communication between the customers and the Control Room is managed by a specific group of the Control Room operators (Call Center), which is assigned to the collection of the information of each emergency call. The Call Center uses proprietary software:

- “Genesys” for the management of the calls, and
- “CCE” (in Italian *Centro Chiamate Emergenza*) for the management of the intervention.

Once the information has been saved in the CCE, operators in the Control Room apply a first level of intervention (remote intervention) on the network, to fix the problem. In case this is neither decisive nor possible (e.g. in case of a burst pipe), the operators are formally requested to assign the intervention to the technicians in the field (as represented in Figure 11).

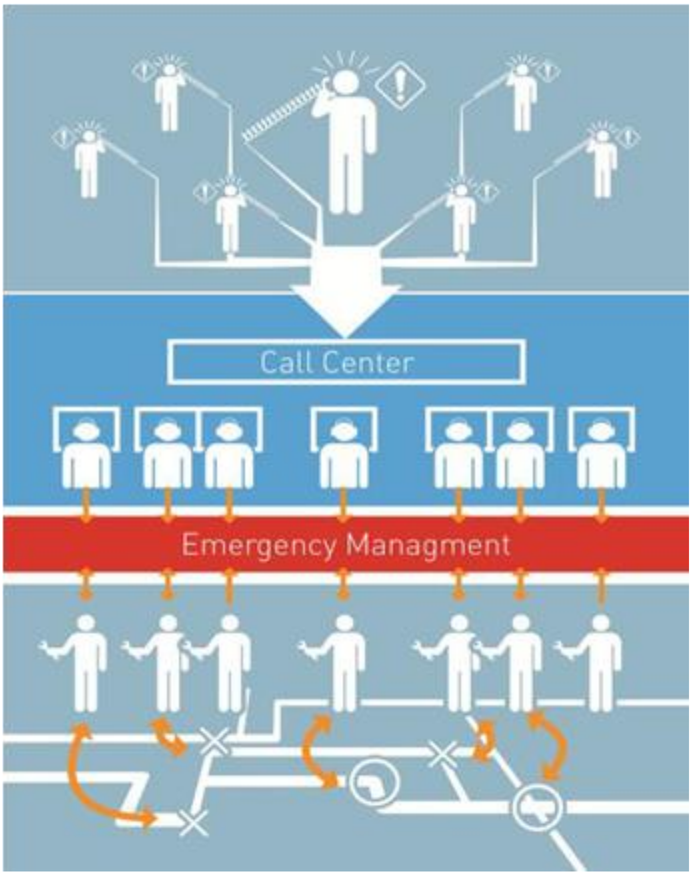


Figure 11 - Schematic Representation of the Communications and Roles

At present, IRN does not use any adaptive system to allocate tasks to available operational teams in the field, but the communication between the Control Room operators and the operative teams takes place only via phone calls (very time-demanding) and the allocation of tasks and responsibilities is based on the senior experience of Control Room operators.

Previous systems (e.g. mobile apps) have been introduced into the Control Room to share data between the operators in the Control Room and the technicians in the field, but none of them have been accepted by the operators and/or the technicians, and they had always switched back to the phone calls.

Use Case 4 ("Communication between the operator and the operational teams in the field", represented in Figure 12) has been selected for the implementation of the AdCoS because we expect it to get the most benefit from the adaptation of the communication strategy, and the failure of previous solutions can be attributed to Human Factors issues not properly addressed (this has led to the rejection of the solutions). The selection of the most appropriate technician according to the experience of the operator is another relevant Human Factors issue to be addressed (this issue is also considered fundamental for standardizing the internal processes of the Control Room, as requested by the Italian Energy Authority).

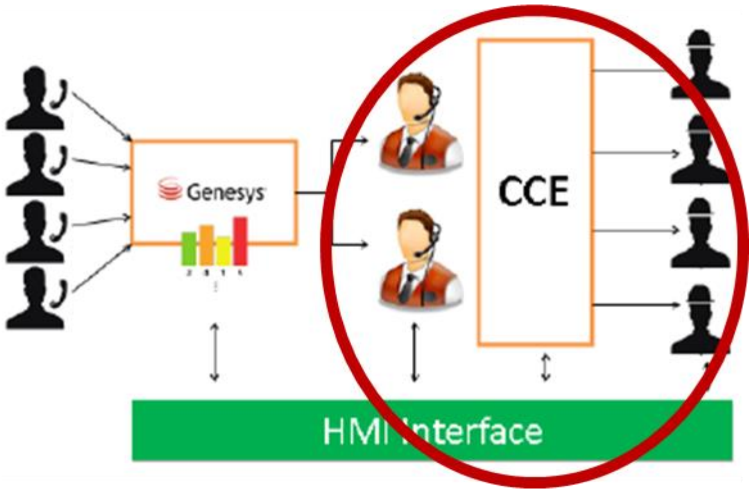


Figure 12 - Focus of Use Case 4

Therefore, the aim of the AdCoS developed in HoliDes is to:

1. support the operators in the selection of the most suitable technician to perform the intervention (according to a dynamic set of criteria);
2. support the technicians in the field by providing them with the relevant information they need for the intervention (in order to reduce the need of phone calls with the operators).

By starting from these objectives, two Performance Indicators (PI) have been identified in order to evaluate the performance of the AdCoS and lead the evaluation activities that will be conducted in task 8.5:

1. The AdCoS shall have a correct rate of at least 80% in the selection of the most appropriate technician (compared to the manual selection performed by an expert operator);
2. The AdCoS shall reduce by 70% the number of tasks that require a communication by phone.

5.2 AdCoS Descriptions

This section describes the current state of the AdCoS demonstrator.

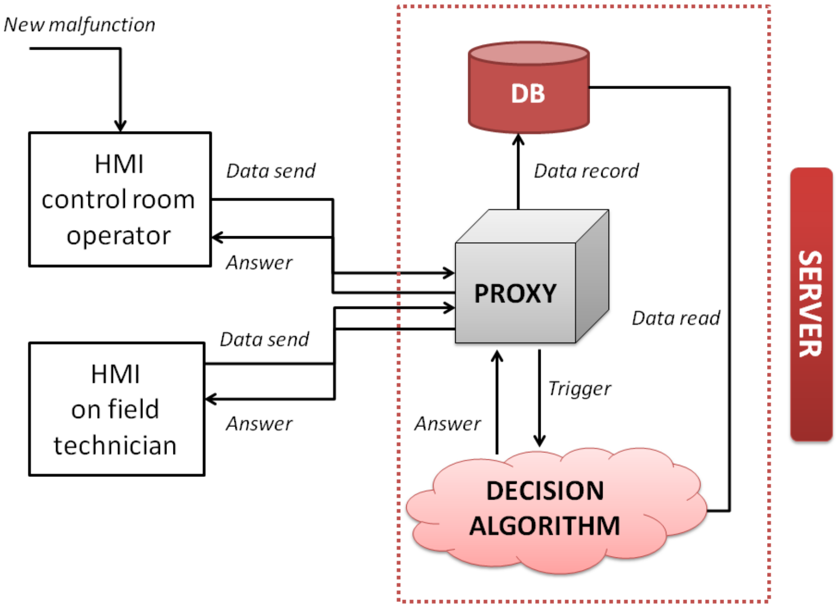


Figure 13 - Architecture of the Control Room AdCoS

The AdCoS includes three macro elements (as shown in Figure 13 and in Figure 14):

- a Server
- an HMI application for the Control Room operators
- an Android app for the technicians in the field, installed on several mobile devices (tablets)

The **Server** includes:

- an Entity-Relationship Data Base with the data about malfunctions and technicians
- the engine with the **Decision Algorithms** for the automatic selection of the most appropriate technician for each intervention,
- a **proxy** to dispatch the information to the operators and the technicians (respectively through a web browser interface and a mobile app)

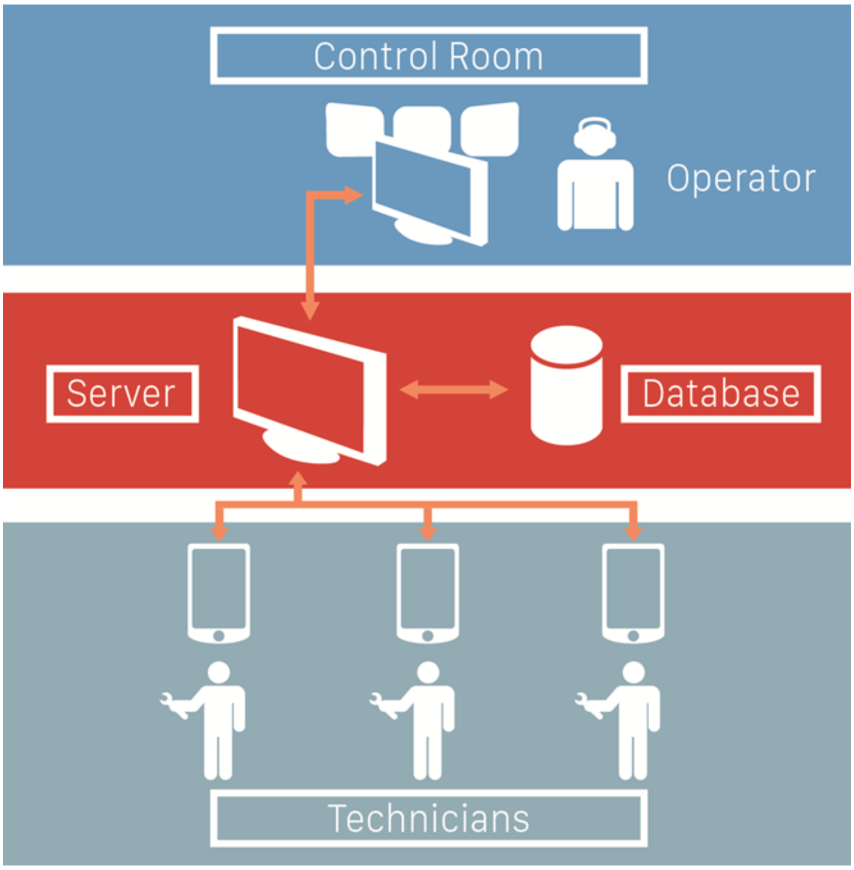


Figure 14 - Logical Representation of the Energy Control Room AdCoS

The HMI application for the Control Room operators is a web-based application that lets them access the list of interventions, assign an intervention to a specific technician (according to the priority list provided by the Decision Algorithm) and see which technician is in charge of which interventions. The application is accessible via internet at the address:

http://relabsrv02.cloudapp.net/malfunction.aspx

The **HMI Application for the Technicians** lets them accept the assignment of an intervention and access the corresponding data (type of intervention, address, etc.).

In order to implement the communication and the interactions among the elements, a sequence diagram has been defined (Figure 15).

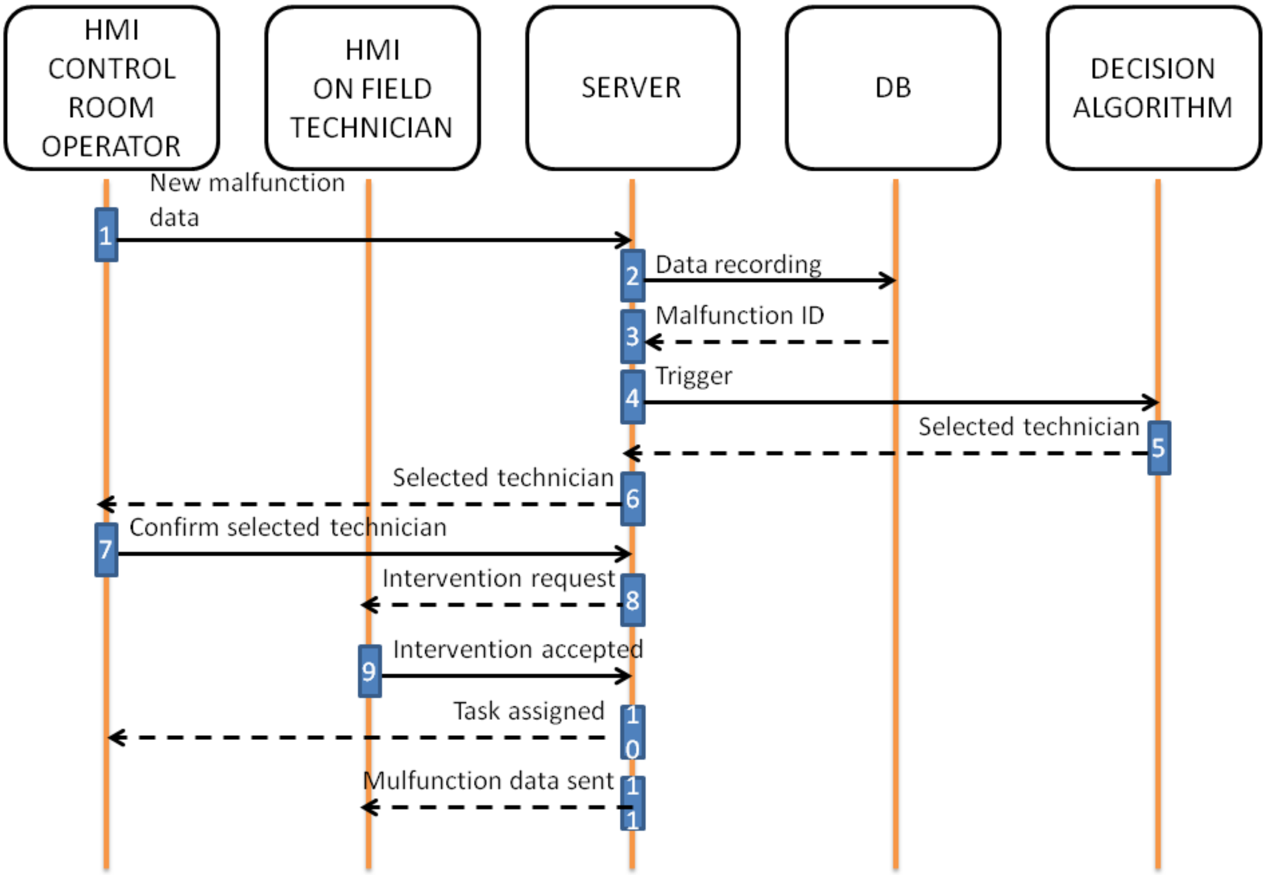


Figure 15 - Sequence Diagram of the Energy Control Room AdCoS

As shown in step 6 of the sequence diagram, the Server (and in particular the Decision Algorithm) is in charge of automatically defining a priority list of the most appropriate technicians to be assigned to the intervention.

The criteria taken into account by the Decision Algorithm to find the most suitable technician are applied in step 4, presented according to the filter order:

1. Skills
2. Geographic zone of authority
3. Work shift
4. Actual assignment of tasks (and estimated duration of each of them)
5. Actual distance to the intervention

The Decision Algorithm works according to the following rules:

1. Check skills required for the intervention
2. Extract the list of technician with those skills (► list1)
3. Check the malfunction zone by considering the address of the intervention
4. Extract from list1 the list of technician for that zone (► list2)
5. Extract from list2 the list of technician in the current shift (► list3)
6. Check whether the estimated hours of the intervention is compatible with the available hours of the technicians in list3
    a. *If so, go to step 8*
    b. *Else go to step 7*
7. Extract from list2 the list of technician in the next shift (► list3)
8. Verify the actual position of the technician and calculate the distance with the address of the intervention
9. Assign the priority to the technician according to the distance

If a malfunction is rejected, the algorithm is retriggered. This logic has been modelled as the Finite State Machine (FSM) described in Figure 16.

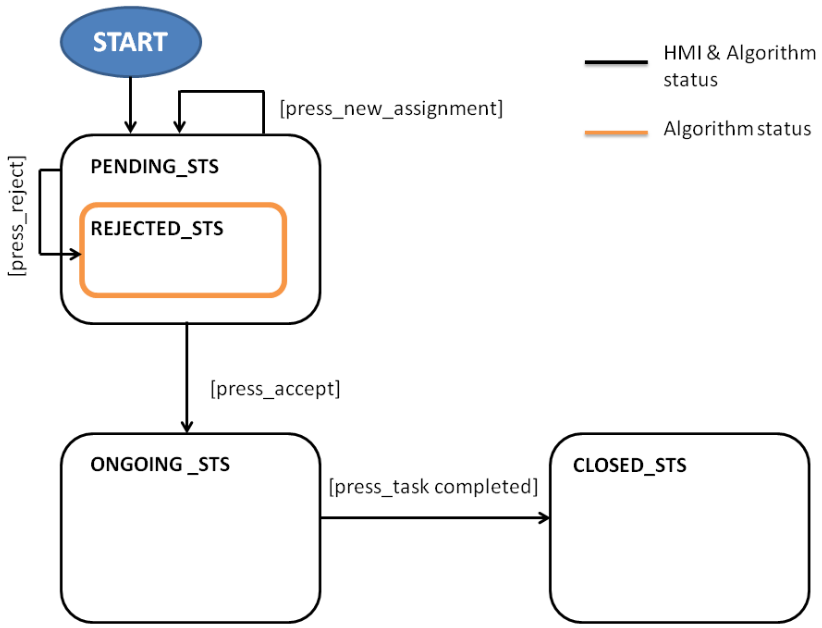


Figure 16 - Finite State Machine (Managem. of the Malfunction Status)

5.3 HMI Implementation

The overall system includes two HMI developments:

- The HMI for a web-based desktop application for the operators;
- The HMI of an Android app for the technicians.

As regards the HMI application for the operators, a web application has been implemented (as shown in Figure 17).

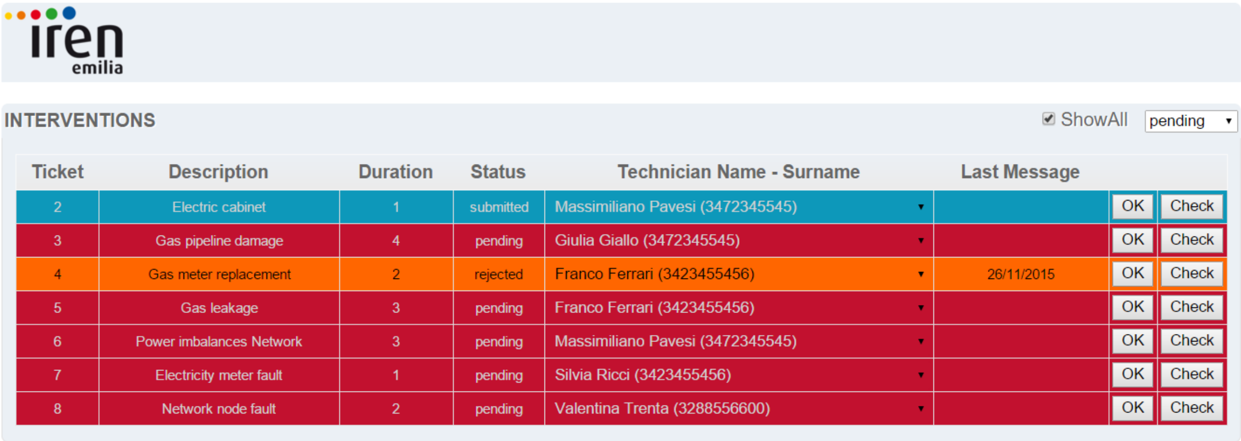


Figure 17 - Desktop Interface for the Operators

The operators of the Control Room must monitor heterogeneous information distributed on (at least) three screens by using different applications and operation systems (mainly windows and UNIX). Therefore, we designed a web-based interface that can be opened in a browser to be easily accessible on different devices (different hardware and software systems).

The HMI provides the operator with the following information:

- Ticket number
- Brief malfunction description
- Expected duration of the intervention
- Status of the assignment
- Technician name
- Time stamp of the last message sent to the mobile app

The Control Room operator can see the malfunction list split according the malfunction status. The statuses of the malfunctions are:

- **Pending**: if the task is waiting for an assignment to a technician (not still accepted or rejected)
- **Submitted**: if the task has been assigned to a technician and him having accepted it
- **Closed**: if the technician finished the intervention and communicates it.

The interface also includes 2 buttons:

- OK button, to assign the operator to the intervention (because the operators explicitly requested to have the final decision on assigning the technician, and not to make this operation completely automatic);
- Check button, to allow the operator to check the application of the decision algorithm for the specific selection of each assignment (as shown in Figure 18).

Figure 18 – Repr. of the Mechanism for the Selection of the Operators

The HMI of the Android application has been designed and developed in order to give a concrete support to the technician, mainly for providing:

- real-time geo-localized information on the intervention (address and details of the intervention, navigation features, etc.) that previously were requested by phone (or via printed data) to the operators;
- an instrument to easily accept (or reject) the assignment of the intervention, without wasting time on the phone.

A screenshot of the HMI of the Android app is shown in Figure 19.

Figure 19 - HMI for the Reception of an Assignment

Figure 20 shows an example of the additional information associated with the assignment (details of the intervention and map).

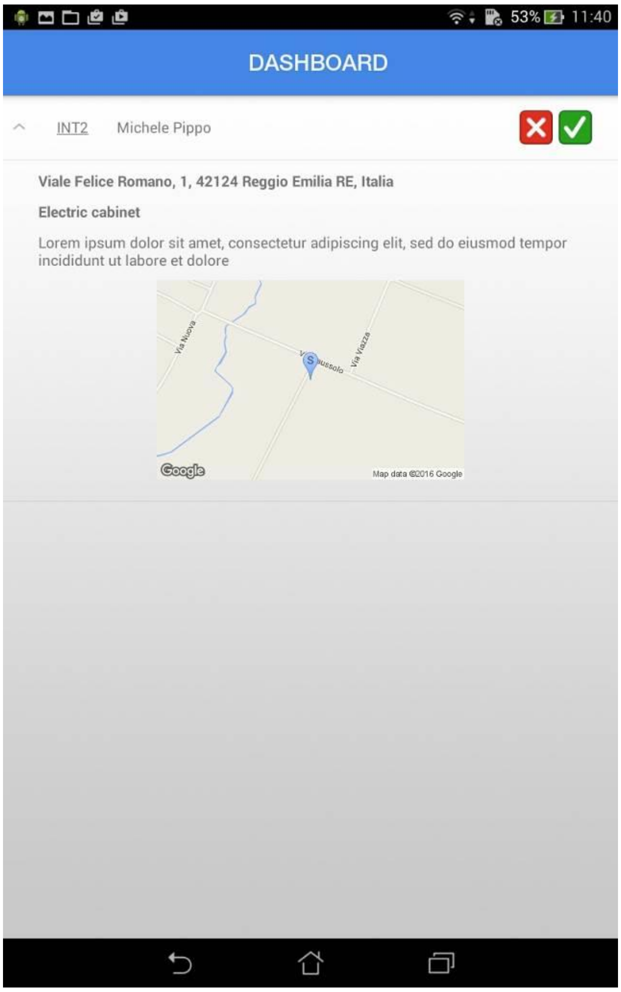


Figure 20 - Additional Information Associated with the Intervention

If the technician presses the green button, a pop-up is shown to confirm the intention of accepting the intervention (as shown in Figure 21).

A similar pop-up is also shown if the technician presses the red button for the rejection of the assignment.

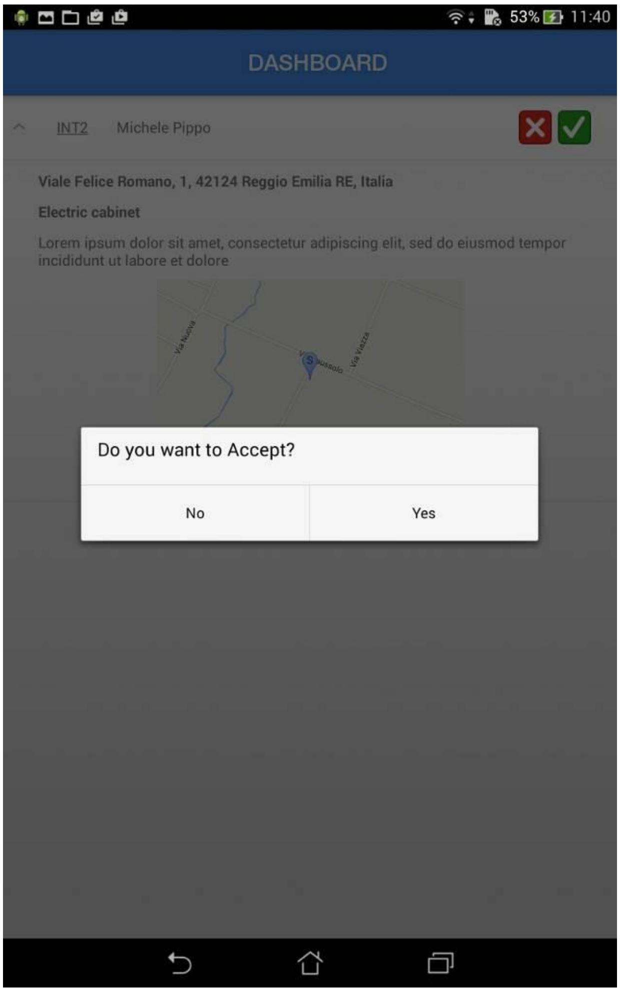


Figure 21 – Pop-up to confirm the assignment of the intervention

5.4 MTT and Modules Integration

Figure 22 represents the new development process of the Energy Control Room AdCoS that includes the MTTs developed in WP2-5 (coloured cells).

The original development was affected by issues in the analysis and evaluation phases:

- **Analysis:** No specific methodology has been applied so far for the analysis of the communication between the operators and the technicians in the field. Other solutions had been tested to automate the communication by using mobile apps, but they have always been rejected by the operators and/or the technicians. So far the reason for the rejection is not clear.
- **Evaluation:** REL develops prototype solutions (and not products). As a consequence, the value proposition of REL depends on its

flexibility and ability to develop rapid prototyping HMI concepts: therefore, REL often sacrifices the quality of the solution to deliver it in a very short time (to show a solution is feasible). However, it would be important for REL to improve the quality of the prototype it delivers without increasing the time for the delivery of the prototype.

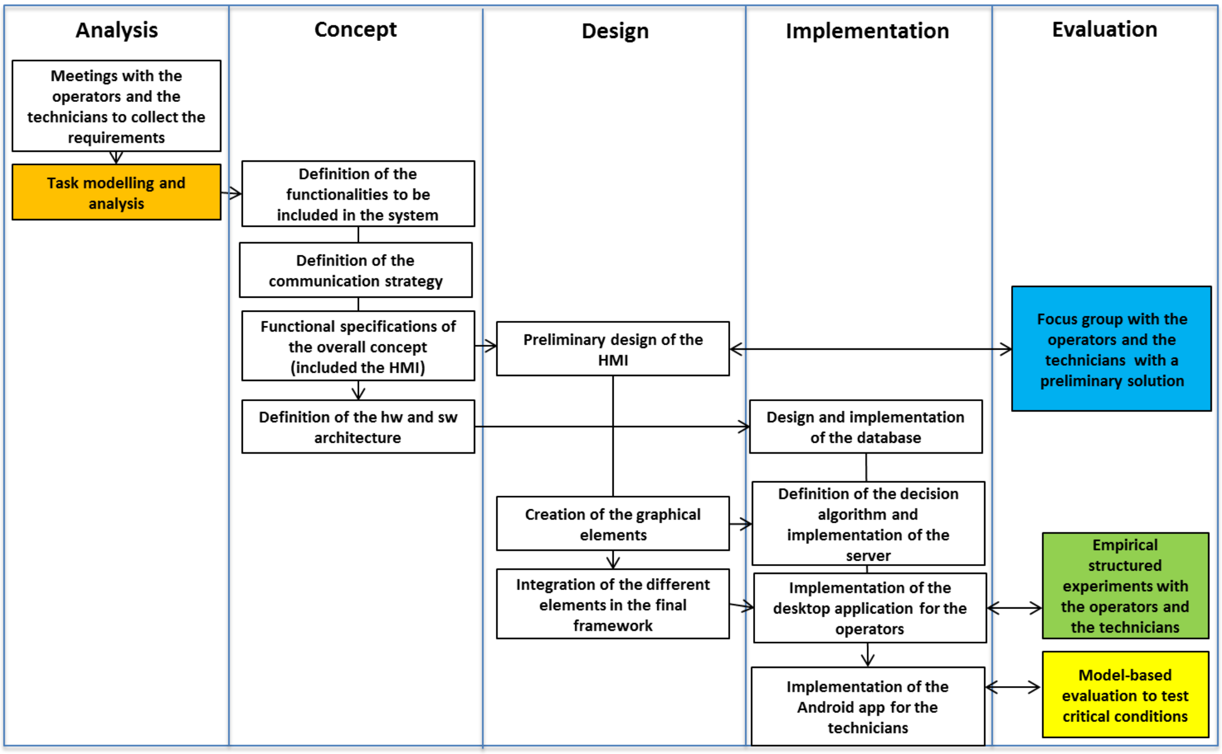


Figure 22 – Energy Control Room Development process

With the introduction of MTTs for WP2-5, several benefits have been observed in the development process:

- **Analysis**
  - **Task modelling and analysis (WP2):** by using the task modelling and analysis, we could
    - identify the tasks that could be automated and the tasks that should be maintained in charge of the operators (i.e. manual)
    - optimize the workflows for the assignment of tasks and the communication with the technicians
    - identify the communication tasks that could be delegated to the app (in order to reduce the phone calls)

- Using the task analysis we could also quantitatively estimate the potential improvements brought of the AdCoS:
  - Optimization of the workflow, reducing the number of subtask for each task and in some cases to unify some tasks **(-35%)**
  - A consistent reduction of manual tasks **(-77%)**
  - Reduction of tasks that require a communication by phone **(-81%)**

- **Evaluation**
  - **Focus group (WP5):** we tested the preliminary AdCoS with real operators and technicians (in collaboration with SNV - WP5).
    - By using the task analysis, we mainly focused on the automation (i.e. how to optimize the resource allocation – the technicians in the field). However, the operators of the Control Room raised concerns about the automation ("How can I trust the decision-making process of the system?")
    - Therefore, the HMI concept has been improved by including features that cope with **the sharing of authority issue**, to share knowledge and increase trust in automation. In particular, the "Check button" has been introduced, as well as the representation of the Decision Algorithm steps to clearly and intuitively show how it works.

5.5 Next steps

For the **Evaluation**, in the 3rd year we plan to evaluate the performance of the AdCoS by applying

- **a model-based approach:** a simulation with the GreatSPN – developed by UTO in WP4 – to show how the AdCoS behaves in case a great number of emergency interventions is expected
- **an empirical approach:** an experiment with real operators and technicians – designed by SNV in WP5 - to measure the performances of the Control Room with and without the AdCoS.

6 Feedback to HF-RTP

This clause provides specific feedback to individual MTT providers.

THIS BOX AND THE TEXT IN IT HAVE TO BE REMOVED FROM THE PUBLIC VERSION OF THE DOCUMENT

This clause contains feedback to the MTT providers that can be contained in the public version of the document. Any feedback not suitable for the public version is contained in Annex A of this document.

6.1 LEA

LEA was suggested by WP 3 for use in Use Case 4 for the identification of behaviour patterns. The tool was tested using extensive test material consisting of a database with more than 12.000 entries and hidden patterns.

During the course of the analysis, WP 3 suggested an MTT called KNIME which seems to be suited even better for this purpose than LEA. KNIME was tested by Airbus Group Innovations using the same sample database and is now considered a viable option. It is strong both for the definition of rules to be tested and for the visualisation of results (see Figure 23 and Figure 24).

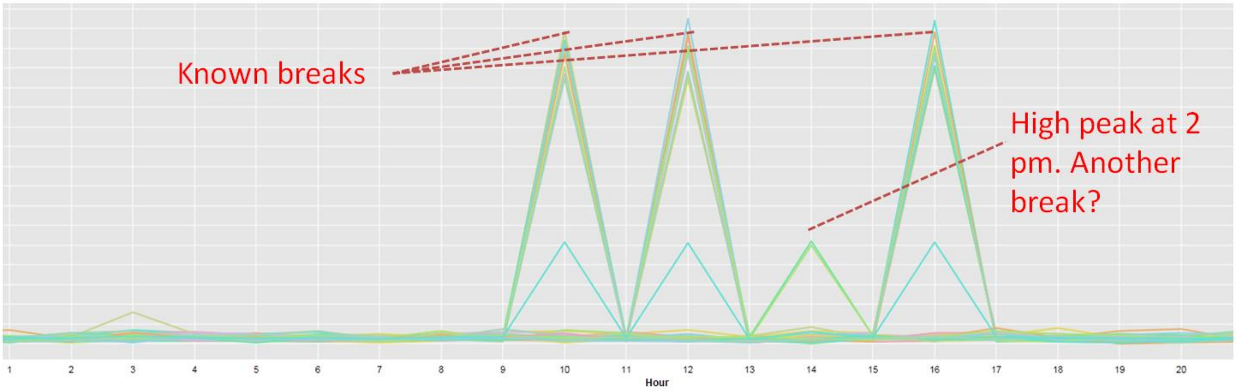


Figure 23 – Visualisation of Behavioural Patterns Using KNIME (i)

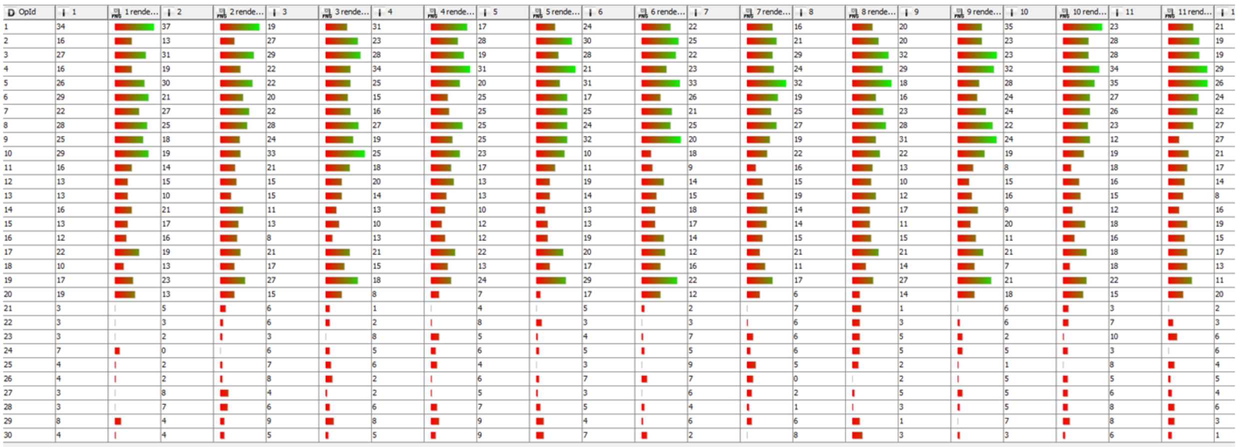


Figure 24 – Visualisation of Behavioural Patterns Using KNIME (ii)

6.2 Platform Builder

A set of tests were defined and carried out for D8.6 in section 1.5.1. Since D8.7 was released, the platform builder has not been updated so the comments from D8.6 remain.

6.3 HF Filer

A good working relationship is in place with AnyWi regarding the HF-Filer. A solid OSLC implementation has been provided which has been built with the Lyo libraries for Java. The feedback from WP8 is to ensure that the HF Filer is followed up with good documentation so that other partners in HoliDes can also see how to incorporate OSLC and the linked data approach into their own MTTs.

6.4 Task analysis tool (WP2)

So far, for the development of the Energy Control Room AdCoS, no specific tool developed in WP2 has been used. However, in the last year a benchmarking of them will be performed in order to assess which of them could address the needs of REL for the development of the AdCoS. Specific feedback to each tool will be provided soon.

7 Requirements Update

7.1 Requirements for the Airbus AdCoS

During the course of any systems engineering project, it becomes necessary to update the requirements from time to time and WP8 in

HoliDes is no exception. For example the original requirements covered areas such as being able to adjust the Control Room GUI depending on cultural needs. For example, Arabic users tend to prefer icons to text on software GUIs. As HoliDes progressed it became clear that (a) no MTTs were available to help us in certain areas and (b) Airbus cannot provide specifics on the workings of its current live Control Rooms owing to security and geographic reasons. This forced airbus to adapt its use cases to what it made sense for WP8 to focus on.

7.1.1 AdCoS requirements

The current updated Airbus AdCoS requirements were developed in the context of the PI definition. They contain verification statements for the evaluation phase. They are up to date and require no further updates at this stage.

7.1.2 MTT requirements

The MTT requirements were submitted by the application use cases, (WP6-9) to guide the MTT owners in the development and application of their MTTs. Please refer to Annex 1 of Deliverable 2.5 for the complete list and more information on the MTT requirements.

The requirements created by WP8 pertain mostly to MTT integration. For example, requiring the use of OSLC and ensuring that HoliDes MTTs can collaborate with tools already used in the Control Room domain. Since D2.5 was released, WP8 has not updated the MTT requirements

7.1.3 HF-RTP requirements

The HF-RTP requirements were created at the start of HoliDes to guide the development of the Human Factors Reference Technology Platform.

The RTP requirements went through several iterations at the start of the project owing to confusion about the RTP topic. (In the early stages, it was assumed that the RTP would be some sort of super software you could install to integrate software tools and solve human factors problems.)

Once the RTP topic was clarified, the application use cases provided requirements which were more applicable. WP8 submitted RTP requirements pertaining to the integration of requirement and architectural MTTs. It is not envisioned that the RTP Requirements will change in the final year of HoliDes.

7.2 Requirements for the Iren AdCoS

The initial requirements defined by IRN have been based on the use cases identified for a potential implementation of the AdCoS.
During the project cycles, these use cases have been further selected, and finally only Use Case 4 has been implemented in the AdCos, because it represented the most promising use case (in terms of benefits we could achieve by introducing the AdCoS compared to the existing condition of work).

Therefore, during the project, the requirements have been iteratively refined (or removed) according to the selection of the use cases that drove the development of the AdCoS.

7.2.1 AdCoS requirements

The current version of the requirements for the IRN AdCoS reflects the status of the demonstrator, thus they are up to date and require no further updates at this stage.

7.2.2 MTT requirements

The selection of the MTTs for the improvement of the development process has been almost completed, as well as their tailoring to adapt them to the needs of the development of the IRN AdCoS.
Therefore, no need for update is requested at this stage.

7.2.3 HF-RTP requirements

The HF-RTP requirements are up to date and require no further updates at this stage for the development of the IRN AdCoS.

8 Conclusion

Both AdCoS demonstrators (Airbus and Iren) have been completed in time and presented successfully at the 2nd Year Review. Concrete plans exist for adding functionalities to the demonstrators (e.g. use cases not yet implemented and new functions) and first plans for the evaluation of the AdCoS demonstrators exist.

The HF-RTP and the relevant MTTs that are part of it have been described with the roles they play in the specification, implementation, and evaluation of the AdCoS. Feedback to the MTT providers has been provided.