# PJ.16-04 CWP HMI

# "Controller Productivity" Solution

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## Abstract

This document provides a detailed overview of the activities performed in the frame of the PJ16.04 CWP-HMI Solution.

SESAR JOINT UNDERTAKING

# Authoring & Approval

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## Document History

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# 4 Introduction

The PJ.16-04 solution deals with new methods of controller interaction with the Human Machine Interface (HMI), applying mature technologies from other domains to ATM. This will increase controller productivity, reduce workload, stress level and enable the use of SESAR advanced tools, safely facilitating performance based operations. Furthermore, the use of modern thin client technology and the processes for developing HMI solutions are investigated, aiming at more efficient controller working position (CWP) development and operation. The six activities below PJ.16-04 (see Figure 1) are (01) Multi-Touch Inputs (MTI), (02) Automatic Speech Recognition (ASR), (03) Attention Guidance (AG), (04) User Profile Management Systems (UPMS), (05) Efficient Process (EP), and (06) Qualification of CWP Virtualisation (CWPV).

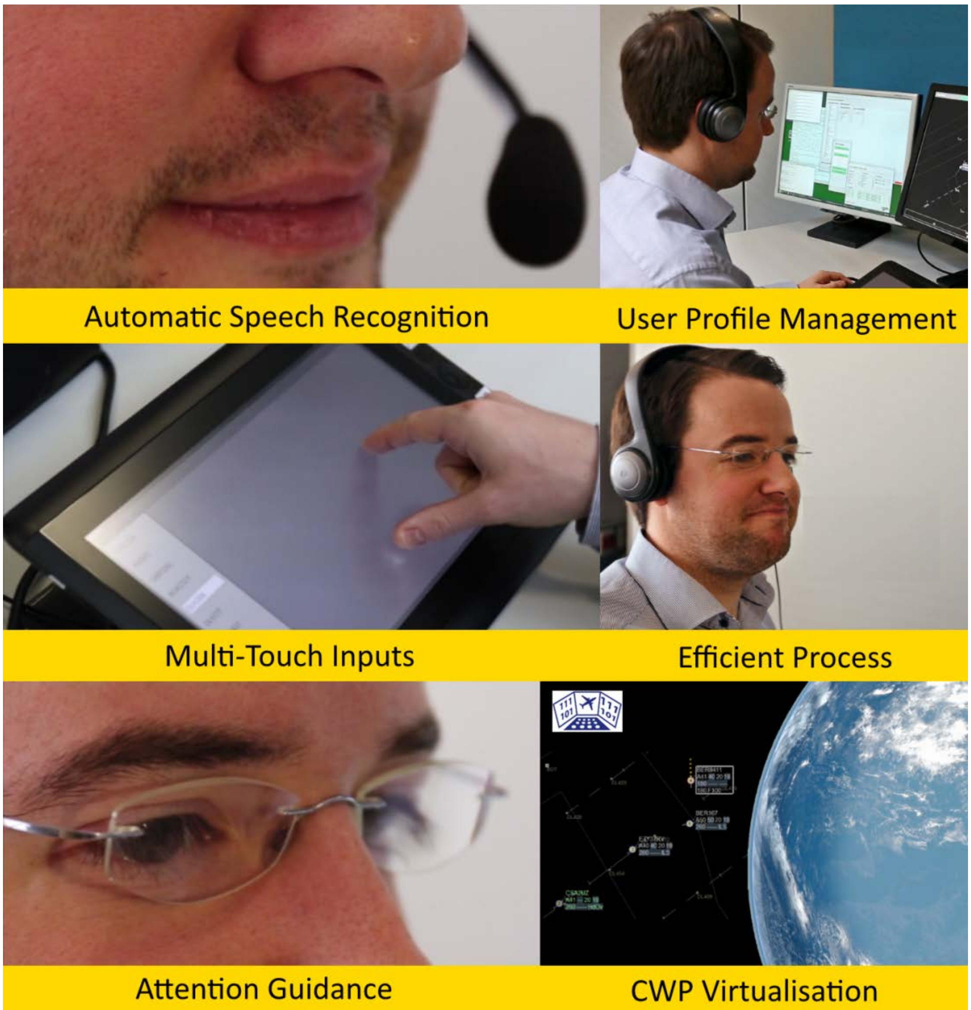


**Figure 1 The six different PJ.16-04 activities**



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# 5 PJ.16-04 Effort repartition and consortium

As Figure 2 shows, PJ.16-04's activities have different efforts:

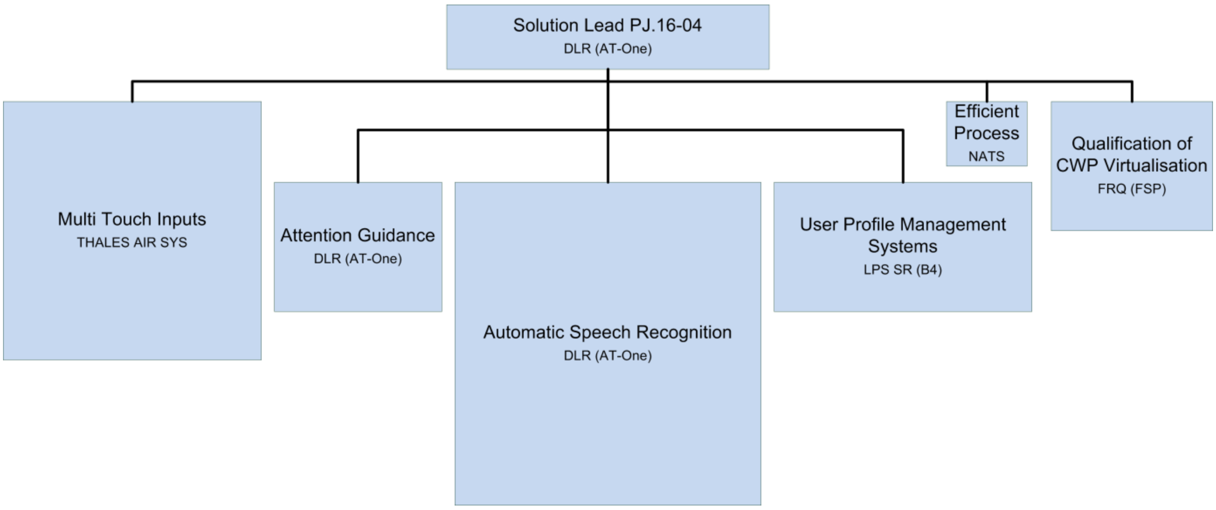


**Figure 2 Organization of PJ.16-04 Activities and Relation of effort in man month (box size).**

The solution consortium consists of THALES AIR SYS, ANS CR (B4), Integra, LPS SR (B4), ACG/COOPANS, CCL/COOPANS, LFV/COOPANS, Naviair/COOPANS, DFS, ENAIRE, CRIDA, NATS, Avinor ANS, SKYGUIDE, SKYSOFT-ATM, EUROCONTROL, DLR (AT-One) as solution lead, FRQ (FSP), HC (FSP), SINTEF (NATMIG), INDRA, ROMATSA.



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# 6 Description of the activities

*The six different activities of PJ.16-04 in more detail (if you click on the activity name you will be linked to more detailed activity descriptions, however the following short description will be provided at the solution front page):*

## 6.1 (01) Multi Touch Inputs

The Multi- Touch Inputs activity will use a touch input device (a trackpad or touchscreen) as a new interaction means with the Air Situation Display of the CWP (e.g. replace the keyboard with a virtual keyboard, new HMI concept with touch events and gesture...) By using multi-touch, data inputs into the system by the controller shall be faster, more efficient and without increasing the failure rate.

## 6.2 (02) Automatic Speech Recognition

An Automatic Speech Recognition (ASR) system gets an audio signal as input and transforms it into a sequence of words, i.e. "speech-to-text" following the recognition process. The sequence of words is transcribed into a sequence of ATC concepts ("text-to-concepts") using an ontology. The word sequence "lufthansa two alpha altitude four thousand feet on qnh one zero one four reduce one eight zero knots or less turn left heading two six zero" is transcribed into "DLH2A ALTITUDE 4000 ft, DLH2A INFORMATION QNH 1014, DLH2A REDUCE 180 OR_LESS, DLH2A HEADING 260 LEFT". The resulting concepts can be used for further applications such as visualization on an HMI.

## 6.3 (03) Attention Guidance

The air traffic controller's visual or mental focus is actively directed to a specific spot at the CWP HMI if necessary. The specific spot is an area where the controller should look at due to determination of an assistance system (e.g. because of a potential conflict, long absence of attention, or demanded actions). The necessity to look at this spot is given if the controller did not look there for a certain amount of time (e.g. determined by an eye-tracking system).

## 6.4 (04) User Profile Management Systems

The key enabler for automated HMI customisation is user authentication, application of ID cards or biometric technology. Once the ATCo is identified in a safe and secure manner, his/her predefined profile related to a particular role or a task on the CWP will be automatically coupled and new customised HMI settings will be applied immediately and automatically. This can happen during a shift takeover or whenever ATCo´s task or role on the CWP changes, for instance in the case of a change of sectorisation.

## 6.5 (05) Efficient Process

The definition of an Agile-style process to provide a better description of Controller needs at an earlier stage of the project life cycle, with higher fidelity and greater user buy-in than traditional "waterfall" development methodologies.

## 6.6 (06) Qualification of Controller Working Position Virtualisation

CWP Virtualisation is understood as technology to allow the controller interacting with the system, without having a fat client necessary on the controller working position. This technology is already used in different aspects of standard IT infrastructure. To improve the controller environment and


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provide more flexibility to the environment the connected technologies of thin clients, and lightweight user applications seem to get more and more of interest for future control rooms in virtual centres.



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# 7 Detailed description per activity

## 7.1 PJ.16-04 Multi-Touch Inputs (MTI) Activity

### 7.1.1 Presentation

The Multi-Touch Inputs activity will use a touch input device (a trackpad or touchscreen) as a new interaction means with the Air Situation Display of the CWP (e.g. replace the keyboard with a virtual keyboard, new HMI concept with touch events and gesture...) By using multi-touch, data inputs into the system by the controller shall be faster, more efficient and without increasing the failure rate.

A broad spectrum of operational air traffic control (ATC) environments has been chosen to demonstrate the general applicability of Multi-Touch Inputs (MTI) to ATC operations. The environments to be used are Madrid Approach, Prague En Route and Milan En Route. In support of PJ.10-01b INDRA and ENAIRE will study the feasibility of integrating the Multi Touch Input device system in the controller working position (CWP) and the controllers' workload. Prague En Route will be simulated internally with Thales Shape platform in Rungis to bring MTI closer to the operational environment. SINTEF (NATMIG) and ENAV will investigate the impact on ATCO of using MTI for managing dynamic airspace configuration (DAC) in the CWP. DFS will demonstrate the usability Multi-Touch solution within an ATM environment.

### 7.1.2 Exercises

#### 7.1.2.1 Madrid APP, HMI Input with large multi-touch device

Indra will demonstrate the usability and feasibility of using a Multi-Touch Input device within an ATM environment. The validation will take place during March 2019, in the context of one of the PJ.10-01b validation exercises and embedded in their platform. The Spanish airspace will be the environment in which a controller of ENAIRE with feeder (executive + planner) role will perform several clearances via the multi-touch prototype.

This exercise will validate the feasibility of integrating the Multi-Touch Inputs Device into the CWP. In addition, the performance of the Multi-Touch will also be assessed by measuring the results of the controller workload.

#### 7.1.2.2 Prague ACC, Shape platform, addressing en-route operation with the help of a multi touch input device

Thales will demonstrate the usability of Multi-Touch solution within an ATM environment. Therefor Thales will build up a Multi-Touch prototype in Rungis to give controllers the possibility to gain experience with such a system. A standardized feedback will be collected via structured interview and questionnaire.

The exercise will be conducted jointly by Thales, ANS Czech Republic and Integra. The exercise will take place in December 2018 in Rungis (France).

#### 7.1.2.3 Milan ACC, addressing management of dynamic airspace configuration using MTI

SINTEF (NATMIG) and ENAV will conduct an exercise to investigate the impact on ATCO of using MTI for managing dynamic airspace configuration (DAC). The PJ16-04 exercise will be arranged in conjunction with the validation exercise VP-08-01-06, conducted by PJ08. The aim of VP-08-01-06 is to do a preliminary evaluation of DAC concept from the ATCOs perspective. The gaming exercise will be



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organised at the ENAV premises and with ENAV controllers, using SINTEF (NATMIG) CWP Prototype hosted in ENAV P-ATM (Milano ACC en route Sectors). PJ08 will compare user acceptance of managing static and dynamic air space configurations. PJ16-04 will compare user acceptance and management of DAC using traditional mouse/keyboard user interface with a solution enhanced with 3D visualization and MTI interaction.

The exercise will take place in Rome, but using ATCOs from Milan controlling the Milan ACC.

#### 7.1.2.4 DFS

DFS will demonstrate the usability of Multi-Touch solution within an ATM environment. Therefor DFS will build up a Multi-Touch prototype in Langen to give controllers the possibility to gain experience with such a system. A standardized feedback will be collected via structured interview and questionnaire.

This investigation is planned for autumn 2018. This activity is not planed as validation; it is only a demonstration to get an early feedback from the operational colleagues about the usability of a Multi-Touch solution.

### 7.1.3 Achievements in the first project period 11/2016-12/2017:

In the first year, a literature research with respect to Multi Touch Inputs applied to Air Traffic Management has been conducted. In order to agreeing on the PMP and Gantt chart, three exercises (Approach Madrid, En-route Prague and Approach Milan) and one demonstration have been defined. Furthermore, an Operational Concept Document was developed and agreed prior to drafting the Data Pack for Maturity Gate 1, i.e. initial version of FRD-MTI (by integration Operational Concept), TVALP-MTI and TVALR-MTI (by integration of literature research results).


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## 7.2 PJ.16-04 Automatic Speech Recognition (ASR) Activity

A broad spectrum of operational air traffic control (ATC) environments has been chosen to demonstrate the general applicability of Automatic Speech Recognition (ASR) assistance to ATC operations. The environments to be used are Munich Approach, Prague Approach, Madrid FIR, Hungary Multiple Remote Tower, and Germany Multiple Remote Tower Environment. In support of PJ.10-02b DFS will analyse Target Location Assistance and Clearance Verification using their DFS simulator. Prague Approach and Vienna Approach will be simulated PJ.16-04 internally with THALES' Shape simulator in Rungis to bring ASR closer to the operational environment. The partners DLR, THALES, ANS-CR, COOPANS, and INTEGRA will perform validation trials using Assistant Based Speech Recognition (ABSR) for radar label maintenance. After trials for Prague approach area an additional run with Vienna controllers is planned for 2019. Therefore, Prague approach includes Vienna approach in this document. CRIDA and ENAIRE will estimate controller workload based on the control events detected by ASR in Madrid En-route airspace. Two different Multiple Remote Tower environments are connected to PJ.05-02 respectively PJ.05-03. DLR and HungaroControl analyse command hypotheses prediction quality for controller commands for three Hungarian remote towers in DLR's TowerLab in Braunschweig. Frequentis and DFS will investigate operations supported by speech recognition for a German multi remote tower environment at DFS premises.

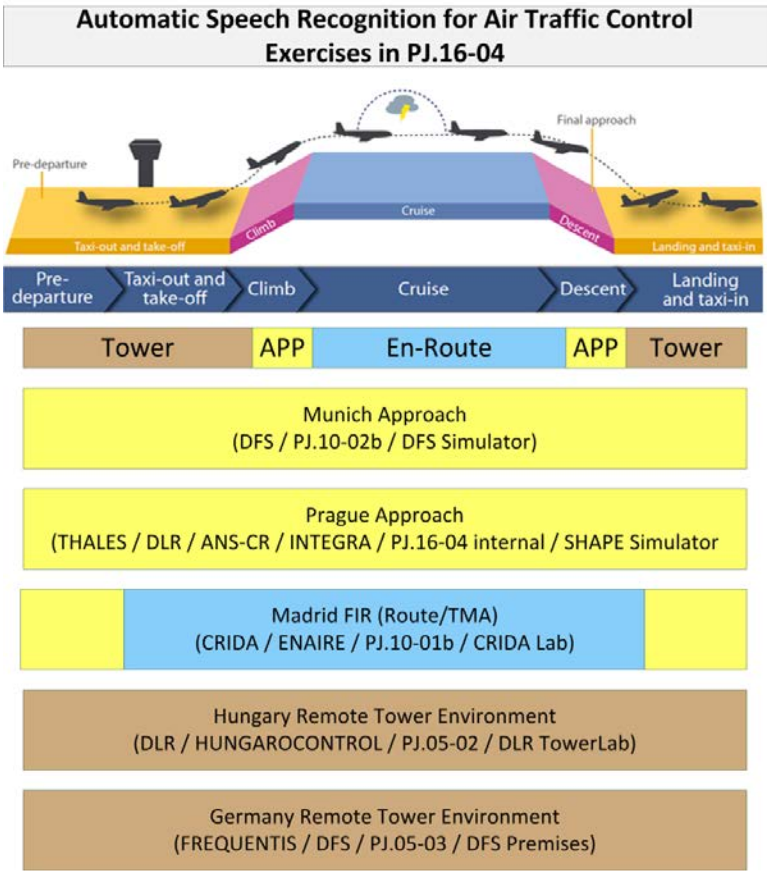


**Figure 3 PJ.16-04-02 Exercises for different controller working positions.**

As Figure 3 shows, PJ.16-04's ASR activity encompasses the whole chain of ATC segments including Tower, Approach, and En-Route with respective Controller Working Positions (CWP).



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Five exercises with air traffic controller involvement will be conducted to shed light on different aspects of speech recognition in Air Traffic Control (ATC) connected to SESAR’s ATM Masterplan flight and control phases.

The partners, involved in the ASR exercise have developed a common ontology for transcription of controller-pilot communications, which will harmonize integration of ASR into CWPs, i.e. the possibility to replace one ASR engine by another. If the controllers says e.g. “bonjour air france one yankee golf left turn aeh zero four zero”, the ontology defines that the command transcription results in “AFR1YG HEADING 040 LEFT”. “austrian golf golf one proceed delta lima four five five” results in “AUAGG1 DIRECT_TO DL455”.

### 7.2.1 Exercises

The five different ASR exercises of PJ.16-04 in more detail:

#### 7.2.1.1 ASR to increase Situation Awareness and Safety at Munich Approach

DFS is already using Voice Recognition and Response (VRR) very intensively in the training environment as simulation pilot replacement. As part of SESAR solution PJ.16-04, DFS wants to go to the next step and make ASR available at the controller’s side. The task is to analyse in which way ASR could increase situation awareness on the one hand and safety on the other hand for the current work of the Munich approach unit. The following areas are identified:

Target Location Assistance (TLA): The callsign in each controller clearance shall be recognized and highlighted on the controller air situation window, so that the controller can more easily identify a current targets’ location.

Controller Clearance Verification (CCV): With this step, the spoken controller clearance will be checked against the manual system input of the controller. In case of a deviation, a warning will be shown.

Both activities shall improve the existing ATC safety net.

#### 7.2.1.2 Safety assessment of ASR application for radar label maintenance

DLR and Saarland University have shown in the AcListant® project that command recognition rates of 95% with command recognition error rates below 2% are possible. Its follow-up project, AcListant®-Strips validated that Assistant Based Speech Recognition (ABSR) can reduce controllers’ workload for radar label maintenance by a factor of three and that fuel savings of 60 litres of kerosene per flight are possible. In this PJ.16-04 exercise Air Navigation Services of Czech Republic (ANS CR), COOPANS, DLR, the aviation consultant Integra and Thales ATM Group concentrate on safety aspects when ASR is used as input device for radar label maintenance instead of mouse. From a safety perspective, a low command recognition error rate combined with a high command recognition rate is naturally desirable. However, in addition to detecting any/all errors it is of importance to allow the controller to identify errors where and when they may occur to be able to override the ASR derived data and to take appropriate corrective action through manual inputs. The importance of more or less constant recognition rate over the instruction variety was identified as well. Therefore, the ASR performance needs to be known by the controller. The roadmap for integration of an ASR application into an operational CWP is addressed. The speech recognizer of Nuance is used as speech recognition engine supported by DLR’s Arrival Manager 4D-CARMA for permanently predicting the set of possible controller commands in order to reduce the search lattice of the ASR engine.



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#### 7.2.1.3 Calculation of Controller's Workload

ENAIRE and CRIDA will apply ASR to En-route and E-TMA (extended terminal manoeuvring area) environment. The application of ASR (i.e. VOICE) for supporting calculation of controller´s workload will be analysed. During the exercise, CRIDA will use VOICE ASR to automatically transcribe voice recordings and determine the associated ATC event (abstraction of command types in ontology). Then the events will be used for controller workload estimation.

The quality of the measured workload is evaluated afterwards against the workload calculated with the true events and against the given workload by controllers.

#### 7.2.1.4 ASR Application in a Remote Tower Environment

In this exercise, DLR and HungaroControl concentrate on ASR application in a Multiple Remote Tower Environment. Simulation airports are the Hungarian airports; Budapest, Debrecen, and Pápa. No speech recognition system is used. However, DLR will develop a Command Hypotheses Predictor continuously predicting the set of controller commands which are possible in the current traffic situation. The quality of the predicted command set will be evaluated against actually given commands. If prediction accuracy is acceptable, it demonstrates that the AcListant® approach of ABSR could be transferred from the approach domain to the tower domain.

#### 7.2.1.5 ASR Supporting Situational Awareness in a Multi-Remote Tower Enviroment

Frequentis together with DFS are developing a multi remote tower concept, which is validated for different German airports. To improve the situational awareness of the controller, operating multiple remote towers, it is foreseen to investigate the use of ASR. Especially for situations with parallel operations, it is important to have a complete overview of the on-going communications (controller and pilot) of each airport and to distinguish between each other. To support the operator in the best possible way, a special focus is set on integrating the recognized information in a user-friendly way within the HMI. To provide the best results between the human and the machine it is very important to extract the relevant information from the actual voice transmission.

### *7.2.2* Achievements in the first project period 11/2016-12/2017:

First, a literature research with respect to Automatic Speech Recognition applied to Air Traffic Management has been conducted. In order to agreeing on the PMP and Gantt chart, five exercises (Approach Munich, Approach Prague, Spain En-route, Hungary Multiple Remote Tower, Germany Multiple Remote Tower) have been defined. Furthermore, an Ontology how to transcribe controller utterance with respect to the 5 exercises was agreed. In addition, an Operational Concept Document was developed and agreed prior to drafting the Data Pack for Maturity Gate 1, i.e. initial version of FRD-ASR (by integration of Ontology and Operational Concept), TVALP-ASR and TVALR-ASR (by integration of literature research results).

Saarland University and DLR created in the AcListant® project (www.aclistant.de) an ontology, which only consists of four elements: 1) callsign, 2) command type, 3) commanded value, and 4) unit. Callsign and command type are mandatory. Unit is only used for altitude commands, i.e. only flight level and feet are used. The utterance "lufthansa two alpha altitude four thousand feet on qnh one zero one four reduce one eight zero knots or less turn left heading two six zero" is transcribed into "DLH2A ALTITUDE 4000 ALT DLH2A REDUCE_OR_ BELOW 180 DLH2A TURN_LEFT_HEADING 260". More than 30 command types were supported. The approach reaches its limits in the MALORCA (www.malorca-project.de) project when it was extended for command transcription for live traffic in Vienna and Prague approach. Departure and overflight traffic had to be included there. In PJ-16-04 also ground and tower controller commands were included. Also VFR traffic was not considered before. More and



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more command types were needed (e.g. QNH, INFORMATION, REPORT_SPEED, EXPECT_RUNWAY) and the necessity to also transcribe conditional clearances occurred. Therefore PJ.16-04 partners (with significant contributions of CRIDA, DFS, DLR, ANS CR, THALES AIR SYS, NATS, Avinor ANS, LFV, SKYSOFT-ATM, Frequentis, INDRA, ROMATSA) soon decided to develop a common ontology which has reached an agreed draft level in the first year. Some modifications and improvement are expected in the next year.

Founding Members

EUROPEAN UNION EUROCONTROL

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## 7.3 PJ.16-04 Attention Guidance (AG) Activity

It is important that air traffic controllers always have their attention at the right parts of their controller working position (CWP) in order to be productive. However, the future role of a controller will encompass more monitoring tasks of automated flights with seldom cases of intervention in unexpected situations. This might lead to decreased situational awareness and thus to lack of attention.

An attention guidance system is able to support the controller at his/her human machine interface (HMI). It can help the controller to perform time critical tasks in an accurate manner. If we assume, that the area where the controller is currently looking at, is the area of attention, there are three different tasks to be fulfilled by an AG prototype:

1) Desired Attention: An assistance system needs to derive where the controller should look at.

2) Actual Attention: Determine where the controller currently looks at (e.g. by use of eye-tracking).

3) Attention Guidance: Develop a system that guides the controllers' attention from the actual to the desired area if they are different.

The aspects 1 and 3 are the main aspects being covered in PJ.16-04's AG activity.

### 7.3.1 Exercises

The two different AG exercises of PJ.16-04 in more detail:

#### 7.3.1.1 Attention Guidance prototype in flight centred ATC environment

Using DLR's attention guidance prototype, controllers will manage en-route traffic within the Hungarian en-route environment (PJ.10-01b). There will be two runs consisting of a baseline of sectored 'normal' operations and the second run consisting of a sector-less ATM scenario where a controller is responsible for a number of aircraft and not a set geographical location. The AG prototype will assist controllers' attention by alerting them to aircraft or conflicts that require their awareness. Specifically, the AG system will monitor where a controller is looking and if they did not observe an event determined to be important by the assistance system, attention guidance is applied in form of visual indications. To disrupt the workflow of the controller as few as possible, escalation levels tailored to the specific event are used in order to trigger the AG HMI elements with adequate intensity (see Figure 4). After specified threshold times, this intensity will increase in case the controller did not respond to the attention guidance cue. From the trials, the usability of the detection of controllers' attention will be assessed, as well as the effectiveness of the attention guidance measures. Furthermore, the impact on the ATCOs performance in terms of improved situational awareness, reduced workload and faster detection of (critical) events will be investigated.


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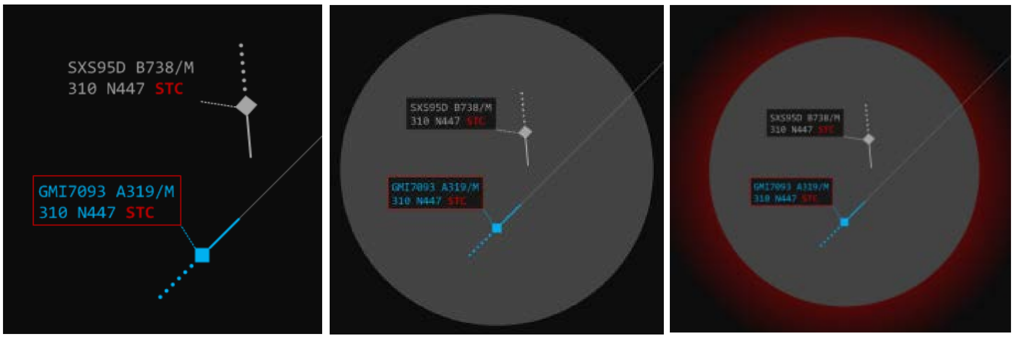


**Figure 4 PJ.16-04-03 Sketch of Exemplary Visual Attention Guidance Elements for STCAs with Increasing Intensity.**

#### 7.3.1.2 Using artificial intelligence for medium-term conflict forecasting and controller HMI visualization

SKYSOFT-ATM’s prototype has the objective of improving controller awareness with an increase in the accuracy of controller assistance tools (trajectory prediction and conflict detection), supported by new-generation tools from the artificial intelligence domain.

The concept addresses flights in a tactical phase, with a first test that will use recorded traffic of Geneva airspace. After an initial analysis phase, one of the potential implementation selected encompasses an improvement in the accuracy by the considering some of the meteorological input parameters that are relevant for real-time tactical trajectory prediction.

The controller situation awareness improvement would consist in:

- Using the real time wind estimation. An artificial intelligence prototype will estimate the wind in real time according to the air situation observation and Mode-S aircraft’s meteorological parameters downstream, and like an expert controller would do. Because the wind is an important input to estimate the flights’ behaviour, increasing its accuracy would definitely impact the situation awareness of the controller.
- Displaying the air situation wind front (intensity and direction) integrated into the controller radar screen image to show the real-time synthesis of the current meteorological geographic global situation.

### 7.3.2 Achievements in the first project period 11/2016-12/2017:

First, a literature research with respect to Attention Guidance and related topics has been conducted. In order to agreeing on the PMP and Gantt chart, two exercises (Hungary En-route, Medium Term Conflict Machine Learning from Radar Data) have been defined. In addition, an Operational Concept Document was developed and agreed prior to drafting the Data Pack for Maturity Gate 1, i.e. initial version of FRD-AG (by integration Operational Concept), TVALP-AG and TVALR-AG (by integration of literature research results).



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## 7.4 PJ.16-04 User Profile Management Systems (UPMS) Activity

Increasing digitalisation in ATM has been dramatically changing the work of an Air Traffic Controller (ATCO). The systems ATCos use are now more complex while, at the same time, there is an increasing availability of multiple versions of Controller Working Position (CWP)/Human Machine Interface (HMI) functions for the same procedure that can cater to each ATCo´s preferences and individuality. With countless CWP/HMI settings and options for every single ATCo, a degree of automation is becoming a necessity.

The User Profile Managements Systems (UPMS) project therefore has an ambition to change CWP as it is known today. It aims at developing an intelligent user profile management system, which would enable further increase of safety and a complete and instant personalization of CWP/HMI settings - all according to the ATCo´s individual operational needs, requirements and preferences.

The key enabler for automated HMI customisation is user authentication. Application of ID card or biometric data reading technology will allow for a safe and secure method of user authentication, which will automatically couple the identified ATCo with his/hers predefined user profile HMI customised settings. In other words, the authentication will allow that once the ATCo is identified in a safe and secure manner, his/hers customized profile related to a particular role or a task on the CWP will be applied immediately and automatically. This can happen during a shift takeover or whenever ATCo´s task or role on the CWP changes, for instance in the case of a change of sectorisation.

The system shall be developed and designed for a multi-profile user management so that each individual ATCo is able to configure and predefine multiple profiles for his/hers particular role (e.g. executive controller, assistant controller, etc.) and task (e.g. top sector, middle sector, low sector, etc.) on CWP, or even multiple profiles for the same task/role configuration for instances when situation changes (e.g. nature of traffic changes, an air show takes place, etc.). Manual user profile selection shall then be used whenever ATCo considers as reasonable or even if the system malfunctions.

The UPMS is being developed in a way that user profiles will be able to be customized with multiple HMI settings, such as strips, tracks, labels, maps and other air situation display settings, several supporting functions activation/deactivation or configuration, HMI objects layout and positions, controlling principles, and so on. UPMS is conceived as an open system, which will furthermore allow full adjustments based on the individual needs of each individual ANSP.

This project foresees one exercise on a validation platform at LPS SR, the Slovak ANSP. The exercise is currently planned for April 2019 with all the UPMS partners on site evaluating the functions and the principle of use defined in PJ.16-04-04 UPMS (see Figure 5).

The major improvements UPMS brings are:

- The use of UPMS reduces HMI arrangement time of controllers compared to conventional manual adjustments.
- Automatic activation of important customized functions will increase safety by decreasing risk of overlooking of some functions activated by ATCO compared to manual selection.

UPMS will decrease workload during shift take-over / re-sectorisation / change of role compared to manual changes of HMI settings



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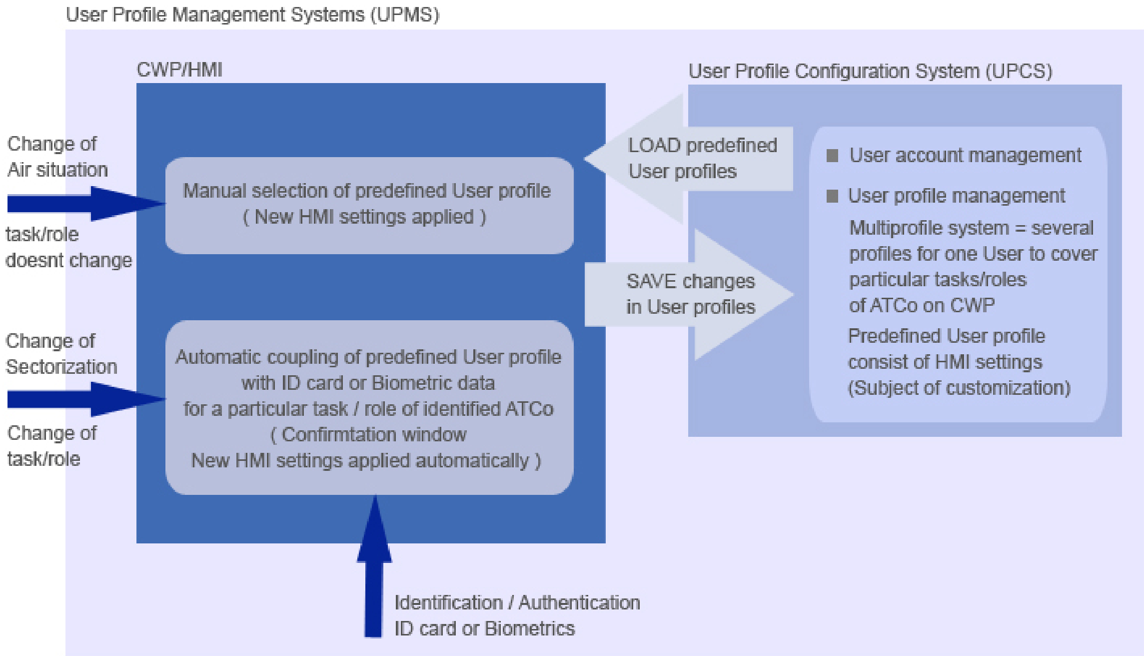


**Figure 5: User Profile Management Systems (UPMS)**

### *7.4.1* Achievements in the first project period 11/2016-12/2017:

UPMS activity has been started with research based on main UPMS topics – identification system, subject of customization, ATCO's tasks and roles, predefined profile configuration and automatic correlation. Face and Voice recognition as a result of the biometrical technologies survey has been identified as the most appropriate combination of technologies for identification system. Finally comparing biometrical technology to ID cards and consider the main purpose of the UPMS identification system, cost analysis and internal experience, ID cards has been selected as the identification technology used for mock-up development in TRL4. Based on Questionnaires No1 and No2 feedback have been defined subject of customization categories, related ATCO's tasks and roles and KPI's and have been presented in UPMS Webexes No1 and No2. The process how to predefine ATCO's profile regarding to the particular task and role and the process of automatic correlation when successfully identified have been defined and documented in User Profile Management System concept TRL2 FRD, the results and methods have been documented even in TRL2 TVALR a TRL4 TVALP. Everything was integrated in cooperation with UPMS partners using common PJ16-04 Webexes and F2F meetings.



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## 7.5 PJ.16-04 Efficient Process (EP) Activity

### 7.5.1 Overview

The Efficient Process activity under PJ.16-04 is led by NATS and supported by partners DLR, COOPANS, ROMATSA, SINTEF and INDRA. The activity has undertaken extensive literature research to determine the state of the art and has defined a draft process, parts of which have been used to derive requirements for some HMI elements of a large NATS project, as well as supporting aspects of ATC Use Case documentation and prototype development. The next phase is about refining the process, determining how it can be applied to a large, complex ATM programme which requires software assurance and validating results to demonstrate efficiencies. This may be complex, as academic studies on accurate process comparison seem inconclusive.

**Figure 6: Efficient Process**

### 7.5.2 Rationale and Detail

Delivering a large scale ATM system which meets user's needs "out of the box" is considered almost impossible with the industry standard "waterfall" processes of today. Traditional development methods used in ATM have evolved over many years to suit large scale projects and these lend themselves very easily to the kind of software assurance required for ATM. A comprehensive set of written requirements can form the backbone of the contract between customer and supplier, providing a framework for testing and validation. However, this does not lend itself easily to describing the user experience in a meaningful way. Although traditional approaches give control over a large programme and satisfy the regulatory and assurance requirements for ATM, a complex user interface is often the cause of significant cost overrun and programme delays due to rework. It can be difficult to engage controllers in the automation or enhancement of a complex ATC task until they have actually used the software and HMI. This late engagement can mean late inclusion of essential changes and late discovery of issues with the software, often leading to significant project delays and cost overruns.

The Efficient Process seeks to reduce the risk of developing complex ATM HMI (which will only get more complex as functionality increases) by employing the best features of modern rapid software development and prototyping techniques and combining them with the testability, assurability and resilience which is demanded in the ATM environment. This reduced risk should translate into more reliable delivery, greater certainty of outcome and real savings in development of complex ATM systems. Whilst only looking at the Controller HMI to start with, it is easy to see how a process like this could be expanded to work with ATC Adaptation and ATM software once it has been proven to be worthwhile.



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It is common within ANSPs to assume that prototyping of HMI or CWP components is wasteful or unnecessary, as prototype code cannot be reused in the eventual assured operational software. However, looking at the cost of the entire software lifecycle there is the suggestion that producing more easily understood requirements which better represent the user's needs may reduce overall project duration and cut costs. Certain "agile" methods of obtaining and prototyping these requirements may even reduce the time taken in the requirements gathering phase. These are the "efficiencies" we mean for the Efficient Process and in this context, prototyping may actually deliver savings.

### 7.5.3 Outline of the Process

The process starts at the very top by creating the Level 1 view – a high level interaction diagram of the ATC interactions for the controller actions relating this portion of the controller task, ultimately to the section of HMI or software module to be designed.

This will be broken down at Level 2 into one or more Process Views, each containing a User Story. This is still at the European Enterprise Level, so actors are ANSP-level.

At Level 3, these are broken down further in sub-ANSP level ATC Use Cases, at least one per Process View, which starts to show the actions the users perform and which services are consumed or provided.

Once this is documented, Level 4 provides HMI designs to interact with the User to allow these actions to be performed. Design and checking of the HMI can lead to iterative rework of Level 3, Level 2 and Level 1 each time detail is added until all levels correctly represent the interactions concerned.

To turn Level 4 designs into HMI or ATM functionality, the manufacturer's software experts should be engaged in the rework of L4 to L1 artefacts. Once each "block" of functionality or HMI is understood and described as requirements or a software specification, these can be grouped together as a traditional "build" and coded and delivered by traditional methods. This should give the opportunity to provide the necessary control and assurance of the software. This stage still needs to be proved somehow for this Activity and will form part of the data contributing to TRL4.

### 7.5.4 Prototyping

Use cases can be quickly turned into functioning examples of HMI within ATC simulation software by teams running the same agile processes as the use case developers.

This allows quick yes/no decisions to be made about key areas of the design and for an early view of partially working functionality with associated HMI for users, validating new use cases and eliciting more informed input to requirements gathering and design of the final product.

### 7.5.5 Sharing Prototype Data with Ops

Provided the same security protocols are followed for Simulator/prototype software and Operational software (not to be confused with Assurance), transfer of certain elements may be allowed from the agile-created Prototype to an operational system and may be beneficial.

Executable code is NOT suitable for transfer but it could be beneficial to share HMI elements (in the form of scalable vector graphics) and the design which goes with them. This not only saves time in description and transcription but allows the prototype and Operational systems to share the exact look and feel, for example, in terms of target symbols, fonts, maps, danger areas, etc.


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### 7.5.6 Validation for TRL4

The concept of comparing the outputs of one process to another and showing which one is more efficient or saves time and money is fairly simple. The detail of defining a set of objective criteria and measuring two processes on a "level playing field" such that the evaluation is meaningful is very complex and the subject of a number of inconclusive academic papers.

To pass TRL4, the candidate efficient process should be –

- Process reviewed, agreed and ready to run.
- Candidate Project(s) for Process Trial Identified
- Agreement in place to run the process for requirements gathering/prototyping of a suitable part of CWP software, HMI or CWP adaptation development.
- Measures and success criteria for the Efficient Process specific to this/these project(s) identified and agreed.
- Trial start and completion dates agreed with necessary project(s)

It is suggested that, to be shown to be more "efficient", the process demonstrates gains, savings or efficiencies in the following 5 areas:

- Content and Effectiveness
- Time
- Cost
- Compliance (or Assurance)
- Efficiency

It is planned to break these down before the V4 gate and define each item and how it may be measured in an ATM application. It is also possible that we may be able to detail "walk through" activities which will provide a level of subjective evidence for the validation of the process.

### 7.5.7 Achievements in the first project period 11/2016-12/2017:

Literature research has been undertaken and a draft process has been documented, with sections of it utilised for HMI design in NATS projects to show that the approach could be valid. The challenge is to apply Agile and User Centred Design methodologies to large scale projects, whilst being able to gain the assurance needed for an ATM project, in order to save costs and rework. We have confidence that a process can be identified and documented fully during 2018 but attention is now focusing on how we validate this process in the context of PJ.16. A great deal of academic research has looked into evaluation of the effectiveness of a process, much of it inconclusive. The question of how we go about proving that we contribute towards CEF3, Reduction of Technology Costs, or even that the process is fit for purpose, is the focus of the work for 2018 – defining a suitable validation activity with meaningful criteria.



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## 7.6 PJ.16-04 Qualification of Controller Working Position Virtualisation (CWPV) Activity

New technologies also enable new opportunities for working positions in ATM. While currently a large number of hardware is required directly at the working positions, new technologies offer a higher degree of virtualisation minimizing the need for hardware at the working position itself. With the Controller Working Position Virtualisation Activity Frequentis, Hungarocontrol, NATS, Indra and Romatsa aim to validate influence of the technical concepts with a set of defined KPIs. Hereby it is foreseen to execute the following tasks:

- Define and prove KPIs of CWP technologies, addressing the area of performance, availability and safety for usage in a productive system of a virtual centre concept.
- Define a set of requirements as baseline for the optimisation of the CWP.
- Prove the assumptions and requirements identified during the project.

The major benefits of a virtual centre are seen in improved interoperability and higher flexibility, increased operational productivity, effective load sharing, independent service provision, better overall cost efficiency and the representation of a solution for contingency. For the CWPV project especially the influence on working position costs is of high relevance whereby performance should not be negatively affected by the change to a CWPV.

Still, while the implementation of virtual centres is expected to bring some benefits, there are also a variety of challenges that need to be solved.

- The necessity to train and license controllers in order to enable them to manage several sectors, especially when taking over control from other centres. To make the concept work an appropriate qualification of controllers need to be achieved.
- The establishment of clear industry standard interfaces to enable communication between the controller workstations and data services
- Regulatory issues that need to be solved
- Vulnerability to cyber-attacks (please also find information within SecRAM of the PJ16-04 TVALR Master document)

Based on the expected benefits, the stated challenges and a questionnaire that was sent to the various stakeholders related to working position virtualisation the project intends to execute exercises focusing on the following aspects:

- Response Time
  The activity will verify if the usage of CWPVs has any influence on the response times on the controller's HMI.
- Environmental aspects (e.g. noise level, heating)
  One of the aims of using CWPVs is to reduce the environmental noise within the control room. The activity validates if the environmental noise is reduced.
- Flexibility
  As the intelligence is not within the client but within a central server there is more flexibility to use different working positions. Controllers no longer have to use to same working position all the time in order to handle traffic for a specific sector. The CWPV technology enables that the working position will be set up according to the user login and selected sector.


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While the many activities in 16-04 focus on the benefits for the controller the CWPV activity also includes benefits for other stakeholders like maintenance as for example Software distribution or software updates should become easier with the use of CWPV as software only needs to be installed centrally the need to update every working position is not given anymore. This should enable easier and faster software updates requiring less downtime. Additionally, one advantage of the CWPV is that less parts are placed locally on the CWP. The CWP client does not contain the intelligence. It serves mainly to ensure the distribution and visualization at the working position and thus can be easily replaced with a new client without affecting nearby CWPs.

### 7.6.1 Achievements in the first project period 11/2016-12/2017:

In a literature analysis the activity identified virtualization technologies useable in the ATM domain focusing on virtual environments. Additionally, a stakeholder analysis has been conducted to identify applicable KPIs and deriving technical use cases and requirements out of it. Hereby the expectations from the various stakeholder groups have been gathered and translated into requirements and use cases. This again was used as an input in the preparation of the technical validation.



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# 8 Partners in Solution PJ.16-04



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