Evaluation Plan

D3.1

MINIMA

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MINIMA

MITIGATING NEGATIVE IMPACTS OF MONITORING HIGH LEVELS OF AUTOMATION

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Abstract

An increase of automation in air traffic control can have negative effects on the air traffic controller's performance. The effects are known as out-of-the-loop phenomenon. The MINIMA Project developed a vigilance and attention controller to mitigate these effects. A highly automated arrival management task will be used as a case study. Psychophysiological measurements like EEG will be used to identify the state of the Air Traffic Controller and combined with adaptive task activation. This will allow for activating tasks based on the Air Traffic Controllers state to keep their performance on a high level and to ensure safe operations.

This deliverable describes the evaluation plan for the planned human-in-the-loop study. In order to evaluate the performance differences between the MINIMA Solution and Baseline scenario, participants, procedures, sequence of events, material, and dependent variables are outlined. More concrete the experimental design of the crucial activities of Validation of the MINIMA prototype is described: the experiments aim to evaluate the possibility of measuring online the actual vigilance and attentive level of the Air Traffic Controller by measuring his/her brain activity and ocular movements, and to use such *neurometrics* to trigger Adaptive Automation solutions implemented in the highly automated Terminal Manoeuvring Area they are facing. The expected outcome is that such prototype will be able to keep the Air Traffic Controllers performance on a high level and to ensure safe operations. The results will be presented and discussed in the D3.2.

Table of Contents

List of Acronyms

Abbreviation	Description
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
AOI	Area Of Interest
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
EEG	Electroencephalography
ENAV	Ente Nazionale per l'Assistenza al Volo
FMS	Flight Management System
HALA!	Higher Automation Levels in ATM
MINIMA	MItigating Negative Impacts of Monitoring High Levels of Automation
OOTL	Out-of-the-Loop
PSD	Power Spectral Density
SDD	Situation Data Display
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
TE	Task Environment
TTFF	Time To First Fixation
TMA	Terminal Manoeuvring Area

1 Executive Summary

1.1 Problem Area

Over the past few years, the global air traffic growth has exhibited a fairly stable positive trend, even through economic immobility, financial crisis, and increased security concerns. It is now clear that traffic flow patterns will become more complex, making conflicts and situations harder to identify for a human operator and will put immense pressure on the air traffic control (ATC) system. In this context, several solutions have been proposed for modernizing air traffic control to meet the demands for enhanced capacity, efficiency, and safety. These different solutions rely on higher levels of automation as supported by both SESAR JU and HALA! Research Network.

On the one hand, implementing higher levels of automation can improve the efficiency and capacity of a system. On the other hand, it can also have negative effects on the performance of human operators, a set of difficulties called the Out-Of-The-Loop (OOTL) phenomenon. In the current context of a continued increase in automation, understanding the sources of difficulties in the interaction with automation and finding solutions to compensate such difficulties are crucial issues for both system designer and human factor society.

While this OOTL phenomenon is considered as a serious issue in the human factors literature, it remains difficult to characterize and quantify. Detecting the occurrence of this phenomenon, or even better detecting the dynamics toward this degraded state, is an important issue in order to develop tools for evaluation and monitoring.

The general objective of MINIMA project is to improve our comprehension of the OOTL performance problem especially according to a future air traffic scenario. Further, MINIMA will develop tools to detect and compensate the negative impact of this phenomenon and a carefully selected allocation of tasks between the human agent and the automated system for the use case of a highly automated Terminal Manoeuvring Area (TMA).

1.2 Description of Work

This deliverable provides a description of the experimental protocol used to evaluate and validate the MINIMA concept.

In MINIMA, we aim to compensate the negative impact of automation on human performance with a specific focus on the vigilance decrement observed during the OOTL phenomenon. In that sense, we have developed a tool which aims (1) to measure the current vigilance level and the attention focus of the human operator with the aim to detect or anticipate typical OOTL performance issues and (2) to adapt automation in case of vigilance decrement with the aim to compensate it. A study to evaluate the MINIMA concept and to develop suggestions for further improvements will be accomplished.

Within this document, we describe the protocol proposed to evaluate the MINIMA concept and quantify the relevance of the tool proposed. In that sense, an evaluation plan has been developed which describes the planned activities of the evaluation regarding participants, procedures, sequence of events, material, and dependent variables. The evaluation plan also defines requirements for the test scenarios.

The MINIMA concept is first introduced in chapter 2. This introduction will be identical to the one in the other deliverables. Although this will result in some level of redundancy, it will assure consistency between both Deliverables and readability of this deliverable as a whole. Following the introduction of the MINIMA concept, we describe in chapter 3 the experimental protocol in detail with, in turn: the participants, the procedure, the material, and the measure.

2 Introduction to MINIMA Concept

Increasing the level of automation in Air Traffic Management (ATM) is seen as a measure to increase the performance of ATM to satisfy the predicted future demand. This is expected to result in new roles for human operator. Human operators will often work in a supervisory or control mode rather than in a direct operating mode. Operators will mainly monitor highly automated system and intervene seldom. It can be expected that human operators in such a role are affected by human performance issues like lack of attention, loss of situational awareness and de-skilling known as out-of-the-loop phenomenon [4]. These problems are observed in other domains like flight-crew performance in the glass cockpit.

MINIMA will address these performance issues. Its aim is to identify out-of-the-loop behaviour and to find solutions to minimize the negative impact of monitoring high levels of automation on the human operator's performance.

In this sense, MINIMA will develop a dynamic adaptation of the task environment which is foreseen as a major requirement to keep the human 'in the loop', perfectly aware of the traffic situation. As a consequence of the developed concept, not all tasks potentially automated will be automated every time. To trigger adaptations of the automation, MINIMA will develop a real-time monitoring system that constantly measures the operators' vigilance and attention levels. This is called "Vigilance and Attention Observer" in MINMA. A component called "Adaptive Task and Support Activation", based on the measured vigilance and attention level, will decide which adaptations of the task environment should be activated. An Overview of the MINIMA Concept is shown in Fig. 1.

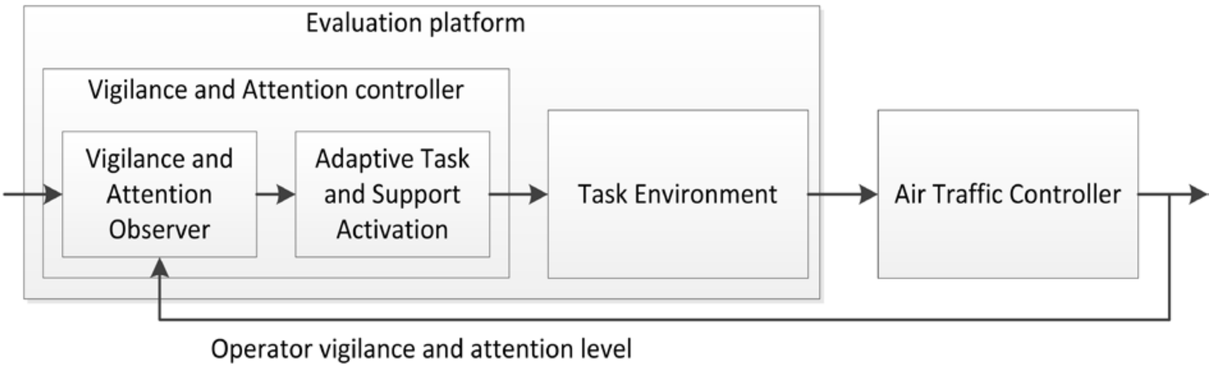

Fig. 1. Evaluation environment for MINIMA and influences of components on others.

In MINIMA, a highly automated TMA has been selected as use case. This task environment (TE) represents an ATC task as it is expected for the future: Most of the interaction with the aircraft is automated. A principle assumption of MINIMA is that Air Traffic Control Officers (ATCOs) are required to intervene in a few situations as error-free automation cannot be guaranteed.

In the MINIMA use case, the arrival management will be highly automated. On-board Flight Management Systems (FMS) will negotiate with an Arrival Manager (AMAN) on 4D-Trajectories automatically. However, these trajectories are only guaranteed to be conflict free at a merging point. Conflicts between arrival aircraft at other locations, conflicts between arrival and departures, and deviations form 4D-Trajectoreis are still possible - but seldom - and need to be managed by the ATCOs.

Several adaptations mechanisms are planned to be integrated into the use case. An adaptation mechanism changes the tasks that ATCOs have to perform during operation, either by providing additional or by handing over task to automation temporarily. These mechanisms include different methods to guide the ATCOs attention and different tasks that can be activated dynamically during the simulation.

This document has the purpose to describe the MINIMA use case, planned adaptation mechanisms, and methods used to measure the vigilance and attention of ATCOs in the planned experiment. It will be the reference for the implementation of the Evaluation Platform during work package 2 and used as guideline for the development of a detailed evaluation plan and the conduction of the experiments in work package 3.

It should be noted that the implementation of all adaptation Mechanisms described in this document would require more effort than available. Therefore, these mechanisms are evaluated within this document and recommendations regarding the priority of implementation are given.

3 Evaluation plan

This chapter will provide a detailed description of the protocol used for the MINIMA concept evaluation. Conduction of the evaluation is scheduled for 6th to 17th of November 2017 (Annex A).

3.1 Participants

The sample recruited for the evaluation will consist of 15 professional ATCOs from the Italian Air Navigation Service Provider (ANSP) ENAV. All participants have to be naive to the purposes of the study. Before starting the procedure, participants will be asked to read and sign the informed consent form approved by the UNIBO Ethical Committee. Participants will be informed about the study's purpose after the experiment.

3.2 Procedure

3.2.1 Task

Participants will be seated in a comfortable armchair with an appropriate height (see Fig. 2). A simulated ATC task will be presented in front of the subject on a 27-inch computer screen. The distance from the screen to the plane of the subject's eyes will be roughly 60cm.

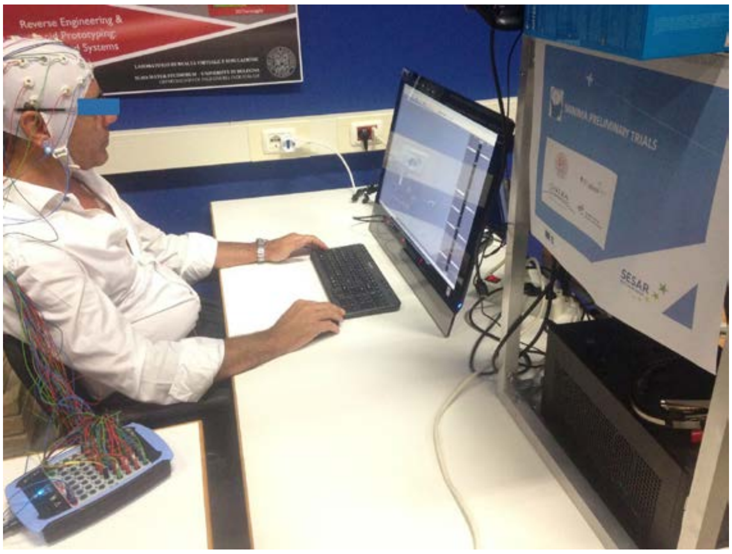

Fig. 2. General set-up.

Participants have to perform an ATC task. A highly automated TMA has been selected as use case (see Fig. 3). This TE represents an ATC as it is expected about 40 years from now: Most of the interaction with the aircraft is automated, i.e. the decisions are not taken by the ATCO but by the system. On-board FMS hypothetically negotiate with an AMAN on 4D-Trajectories automatically. Only two of those trajectories per scenario will have a conflict by purpose. These seldom conflicts need to be detected and managed by the ATCOs. The subject will be instructed to monitor arriving and departing traffic and to intervene only in cases of conflicts or emergencies.

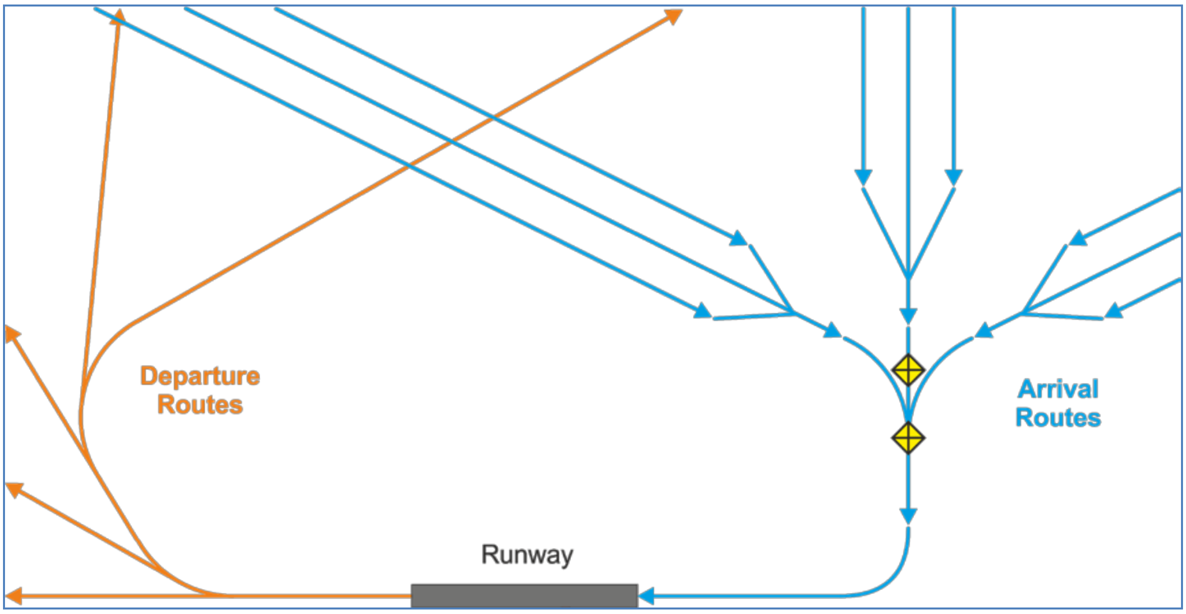

Fig. 3. Route Structure inside the TMA (Temme et al. 2015)

3.2.2 Scenario

The scenario developed will be used as a reference scenario for how air traffic control is expected in the future. In this scenario, air traffic is simulated. Airspace will be quite dense as automation will optimize traffic flow during normal operations. So, the scenario includes a mix of aircraft approaching and departing from the airport. For each condition (see below), a 45-minute (roughly estimated simulation run duration) traffic scenario was prepared. Traffic in each scenario is comparable throughout the different conditions. Traffic consists of roughly 30 arrivals per hour and runway as well as 15 departures per hour and runway. Scenarios do not contain overflights. The weight category of aircraft consists of 10% "heavy" and 90% "medium". Munich airport was chosen as simulation airspace as the second largest airport in Germany with already high numbers of flight movements. Typical call-signs of Munich airport are used, but differ between different scenarios to avoid learning effects. The starting points of aircraft that appear sometime after the scenario begins are outside the TMA. These points are moved to different positions almost semi-circle-wise rotating around the runways due to airspace structure (again to avoid learning effects of study participants).

The aircraft routes will hardly have any conflicts during scenario time as MINIMA assumes a well-functioning automation with only very few necessary controller actions. Two experimental conditions have been developed to evaluate the MINIMA solution, the *BASELINE* condition and the *MINIMA SOLUTION* condition. As most of the work is expected to be left to a highly automated system in the future, the human operator's role is reduced to that of a supervisor in our two conditions. As described in the State of the Art Report and the MINIMA concept ([3] & [4]), such low levels of involvement are expected to cause low levels of vigilance, thus increasing the risk of the operator being unable to take over control of the system if automation fails.

3.2.2.1 Baseline condition

The *BASELINE* condition serves as a reference condition for how high level of automation impact ATCO's performance. In this *BASELINE* condition, automation will continuously be on the highest level (see [5] for detail). As automation is set to a high level throughout the 45 minutes scenario, controller vigilance is expected to decrease over time, ultimately resulting in out-of-the-loop occurrences.

3.2.2.2 Solution condition

In the *MINIMA SOLUTION* condition, the vigilance and attention controller developed for MINIMA will actively adapt the level of automation within the TE, based on the subject's vigilance as measured via Electroencephalography (EEG) data. When subjects show low levels of vigilance caused by their passive monitoring role, the level of automation is lowered and vice versa. Different levels of automation are provided through different automation and attention guidance systems featuring different operational modes (see [5] Chapter 4: *Task Environment*). Depending on the level of automation, controllers are either affected by the reallocation of part of their manual tasks or are provided with additional information such as unmonitored aircraft and potential separation losses. This way, vigilance is expected to return to a normal level avoiding OOTL occurrences. Likewise, if controllers show high levels of vigilance from overextension, automation can be set back to a higher level. For both *BASIC* and *MINIMA SOLUTION* conditions, two situations (unresolved conflicts or emergencies) requiring intervention of the ATCOs will be implemented.

In addition, one training scenario and two short *EEG REFERENCE* scenarios ('Relax' and 'Stress') will be used.

3.2.2.3 Training Scenario

The *TRAINING* scenario will be used to introduce the subject controllers to the MINIMA concept. It will serve two purposes. First, subjects will be given the necessary time to familiarise with the Integrated Vigilance and Attention Controller (also getting familiar with all three levels of our system). The familiarisation is very important, since brain-related physiological phenomena are recorder: It has to be ensured that vigilance and attention shifting, and the related physiological phenomena, are due only to the actual mental state of the ATCO and not to potential "learning effects" because of his unfamiliarity with the system. Second, this is expected to cause subjects to trust the system and therefore increase their naturalness and will of using it during their work.

3.2.2.4 EEG Reference Scenario

Two five-minute scenarios will be used to gather reference EEG data for each subject. While one was especially designed to cause a very high level of vigilance in the controller ('Stress'), the other was designed to cause very low levels ('Relax'). This was achieved by setting traffic flow to either a very high level or a very low one. No adaptation mechanisms are used during both scenarios, as their sole purpose is to cause a constant level of vigilance to gather clean, distinct EEG data related to high and low vigilance levels. During both scenarios, EEG data is collected as a reference, to characterize how high and low vigilance is represented in each subject individually. Since EEG data serves as the "metric" for choosing the appropriate automation level, such data is deemed necessary to cope with potential artefacts stemming from inter-individual differences.

3.3 Sequence of events

The experimental protocol is conducted along 2 days. The first day will be for training the subject with both the experimental tasks and the automated system proposed. Such training phase is critical to avoid any training effect during the second day and to be sure that the variations observed at both behavioural and cerebral levels are induced by the solution proposed. During this second day, we aim to compare the performance of the ATCOs with and without the MINIMA solution. For each participant, the experiment will be performed as follows:

Day 1:

Activity	Duration
Briefing and Informed Consent signature	10'
Tobii EyeX calibration	10'
Familiarisation with TMA simulator	30'
TRAINING SCENARIO in BASELINE CONDITION	30'
TRAINING SCENARIO IN SOLUTION CONDITION	30'
1st day Debriefing	10'

Day 2:

Activity	Duration
Briefing	**10'**
Installation of EEG system and Eye-Tracking calibration	20'
EEG Reference Scenario RELAX – Low Vigilance	15'
EEG Reference Scenario STRESS – High Vigilance	15'
BASELINE EXPERIMENTAL SCENARIO (or SOLUTION for randomization)	45'
SOLUTION EXPERIMENTAL SCENARIO (or BASELINE for randomization)	45'
2nd day Debriefing and Filling Questionnaire time	20'

3.4 Material

All the traffic scenarios will be supported by an air traffic simulator that is responsible for proceeding radar tracks of each aircraft. This simulator will also provide the aircraft behaviour triggered by automatically executed controller commands in all simulations. Those controller commands (e.g., DESCEND, REDUCE) are calculated by an AMAN and sent to the simulator on time. Nevertheless, the controller is still able to insert additional commands for each aircraft via the mouse interface of the radar display. Departing aircraft radar paths will also be generated by an air traffic simulator without following AMAN trajectory calculation (e.g., automatic commands). For all scenarios, it must be ensured that they are almost free of conflicts except for those conflicts that the controller should detect in very seldom cases.

3.4.1 The Arrival Manager (AMAN)

All trajectory planning is done by a software-based Arrival Manager [7]. The AMAN software consists of amongst others several modules: A lateral path predictor, an arrival interval calculator, and a scheduler. In combination, these modules are capable of calculating arrival sequences for aircraft within a specified TMA. Aircraft movement is processed through a dedicated air traffic simulator for flight movements.

3.4.2 Radar display: RadarVision

Visualisation of radar data calculated within the simulation software is done via the RadarVision display (see Fig 4). RadarVision visualizes static airspace dependent data as well as calculation results from the AMAN. The central view consists of the Situation Data Display (SDD) that displays runways, TMA borders, routes, points, and aircraft. By using the “mouse over”-functionality on an aircraft icon corresponding data like the planned 4D-trajectory or weight category can be visualized in an extended label (for more details see [5]). A timeline is shown right of the SDD. Each aircraft has a label dedicated to a certain time and runway. All dynamic elements will move downwards as time goes on.

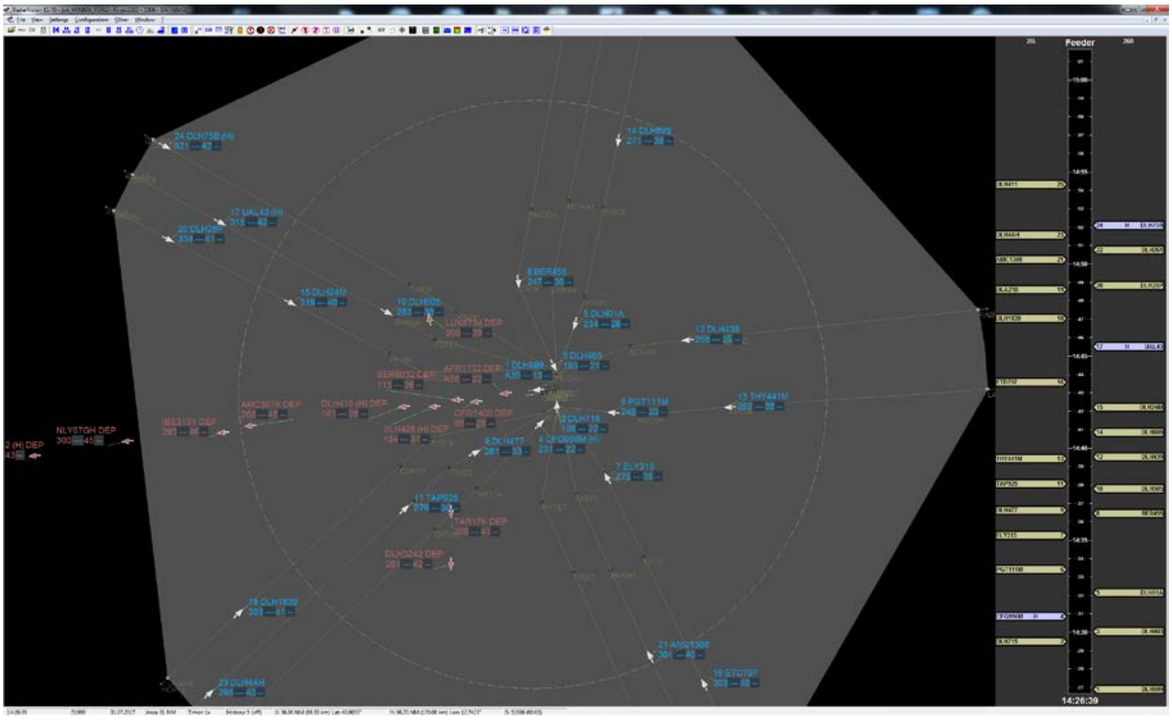

Fig. 4. DLR radar display RadarVision.

As stated above, RadarVision also serves as a human machine interface as it allows the controller to give clearances to the aircraft displayed within the TMA. As operational modes are expected to be highly automation in the MINIMA scenario, manual clearances given via voice radio are not considered to be the usual mean of communication. Instead, clearances are expected to be transmitted via data link procedures. In RadarVision, mouse control interfaces are used to give commands to the aircraft within the controller's area of responsibility. For instance, altitude clearances are given as follows: The controller selects the altitude label of aircraft DLH123 via mouse click. Then, a drop-down menu unfolds from which the desired altitude value is selected and confirmed by clicking a button labelled OK. The confirmed command is forwarded to a simulator control module of the AMAN from where it is sent to an air traffic simulator for flight movements.

3.4.3 Instruments of measurements

3.4.3.1 Electroencephalography (EEG) recorder

The EEG device used in MINIMA is the Galileo BEPlus (EB Neuro Spa, Italy), a wired EEG system able to record up to 64 EEG channels with a sampling frequency up to 1024 Hz. In MINIMA, the sample frequency will be 256Hz. Wet electrodes will be used. 16 electrodes will be used during this evaluation in order to reduce the intrusiveness. The electrodes will be placed mainly on the prefrontal, frontal, frontotemporal, and parietal sites. Electrodes in mastoids will be used as reference. The impedance of all electrodes will be kept below 10 kΩ.

As previously explained (see the description of the MINIMA concept in [3]), these measures serve to assess online the level of vigilance. Online classification of the ATCO's mental state will be performed by the EEG software developed by BrainSigns s.r.l. It allows recording, processing and visualizing bio-signals, in particular EEG. Moreover, the computation and online classification of neuro indexes of the investigated mental state and its dispatching (i.e. the online index) through a specific network protocol (TCP/IP) are also implemented. In the framework of MINIMA, it has been implemented to capture the vigilance level by means of an EEG-based Vigilance Index. The different steps of the signal processing (pre-processing, Feature extraction and pattern classification) are detailed in deliverable D2.1 [4]. Based on this categorisation, automation adaptation will be performed. The different adaptations proposed are described in deliverable D2.2 [5].

3.4.3.2 Eye tracking recorder

Eye position will be recorded using a Tobii Eye-Tracking System EyeX (https://tobiigaming.com/product/tobii-eyex/). The Tobii EyeX Controller uses near-infrared light to track the eye movements, the fixations and gaze point of a user. The device provides data at a time resolution of 60 Hz and can capture the human gaze pointing at a screen point up to a dimension of the screen of 27". This eye tracking system will be set on the desk in front of the subject, between the subject and the screen (see Fig 5). These measures serve to assess the allocation of visual attention on the different features of the simulation and will be used as input for the attention guidance system as described in both deliverables 2.1[4] and 2.2[5].

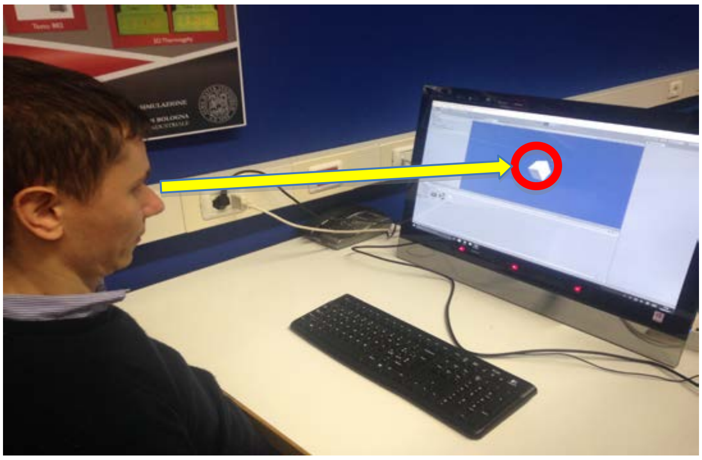

Fig. 5. Eye tracker system Tobii EyeX.

3.5 Dependant variables

The dependent variables must be those that allow to test the hypotheses quantitatively. Particularly, it shall be quantified how the MINIMA solution impacts both attention/vigilance mechanisms and operator performance. In this sense, two different kinds of measure are proposed: biometric measure and behavioural measure.

3.5.1 Biomarkers of vigilance/attention

The EEG system will serve to monitor in real-time the operators' vigilance and attention levels to trigger adaptations of the automation. However, these measures could also be used offline to evaluate the difference in term of level of vigilance and the deployment of attention in the two experimental conditions. The different relevant markers have been described in the deliverable D1.2 [3].

During the MINIMA evaluation, particular interest will be brought to power spectral densities (PSD) within the classically defined frequency bands (alpha, beta, theta, delta, and gamma). The general evidence is that lower levels of vigilance are related to increases in lower frequencies (theta and alpha) in EEG spectrum. In that context, it will be quantified how these low frequencies evolved along the two scenarios of interest (*BASELINE* vs *MINIMA SOLUTION*). Therefore, we expect to have more brain activity in the *MINIMA SOLUTION* scenario than in *BASELINE*.

Moreover, time to first fixation (TTFF) will be used as an index of performance in the evaluation. TTFF indicates the amount of time it takes a respondent to look at a specific Area of Interest (AOI) from stimulus onset. TTFF can indicate both bottom-up stimulus driven searches (a flashy company label catching immediate attention, for example) as well as top-down attention driven searches (respondents actively decide to focus on certain elements or areas on a website, for example). TTFF is a basic yet very valuable metric in eye tracking. It could be relevant when an important event appears in the simulation. In this MINIMA evaluation plan, it is proposed to collect the TTFF for each relevant target and to compare for each scenario (*BASELINE* and *MINIMA SOLUTION*) the average TTFF.

3.5.2 Behavioural measure

Behavioural measures will be used to quantify the effect of the MINIMA solution. The lack of operator involvement in supervisory modes and passive information processing contribute to critical human cognitive errors. Amongst other, literature has shown that OOTL phenomenon is characterized by difficulties to detect and to understand critical situations. Moreover, correct detection, reaction time, accuracy, omission and commission errors are performance parameters used to measure vigilance, assuming that better performance is synonymous of a greater vigilance level during the task. In that context, we aim to evaluate the relevance of the solution proposed by quantifying the impact of the MINIMA solution on three different markers of performance: (1) the time to detect the system failure, (2) the detection rate, and (3) the relevance of the correction proposed. These different markers will be computed for each situation requiring ATCOs intervention (as a reminder, two per scenarios).

We expect that the comparison between detection rates and times of *BASELINE* and *MINIMA SOLUTION* reveals better results for *SOLUTION* as we keep controllers better in the loop in this run. The recovery performance will be evaluated more on a qualitative basis. In most cases the ATCO will give a “reduce” or “descend” command to an aircraft to resolve a conflict. We analyse if this command was already sufficient to really solve, if there was another command necessary afterwards or if the conflict got really got more urgent afterwards. We expect that controllers will find at least as good solutions in the *MINIMA SOLUTION* compared to the *BASELINE* scenario. If these hypotheses will be accepted when analysing the study data, the *MINIMA SOLUTION* really mitigates negative impacts of high levels of automation which is one objective of MINIMA.

3.5.2.1 Reaction Time

Increase in response times has been shown in case of OOTL phenomenon. Moreover, slow reaction times, which have long been seen as indicators of lapses of attention. In this context, we propose to compute the mean reaction time in case of system failure for the two scenarios. By comparing these two values (one for each scenario), we can quantify the benefits of the MINIMA solution. The experimental hypothesis is that the more the ATCO is “in-the-loop”, the lower his/her reaction times will be, therefore the MINIMA solution should definitely help to decrease ATCOs’ reaction times.

3.5.2.2 Detection rate

Several studies (see [2] for details) confirm that ATCos may be poor in detecting aircraft-to-aircraft conflicts when they are not actively controlling the airspace but nevertheless have to monitor for occasional anomalies. Since detection failure is one of the major markers of OOTL, we aim to identify how MINIMA solution impact detection rate in case of system failure. In that sense, we propose to quantify the detection rate for each scenario and to compare this detection rate. The experimental hypothesis is that the more the ATCO is “in-the-loop”, the higher his/her detection rate will be, therefore the MINIMA solution should definitely help to increase ATCOs’ detection rates.

3.5.2.3 Recovering performance

After detecting the failure, the ATCo has to perform the relevant action to take over the system. We propose to quantify the relevance of the action performed by the ATCOs in case of system failure for the two scenarios. The experimental hypothesis is that the more the ATCO is “in-the-loop”, the better his/her conflict solution will be, therefore the MINIMA solution should definitely help to improve ATCOs’ recovering performance.

4 Conclusion

In this document, the evaluation plan proposed to quantify MINIMA benefits is reported. This deliverable is the first step for the upcoming evaluation study scheduled for the last quarter of 2017.

This evaluation plan represents a critical phase of the MINIMA project. The design of such evaluation represents a difficult challenge for several reasons. First, generating OOTL phenomena in experimental set-ups remains difficult. Second, we need to combine this difficulty with the constraints relative to EEG acquisition. As illustration, whereas OOTL phenomena need time to appear, we cannot use EEG caps for very long periods of time for comfort reasons. Finally, whereas OOTL phenomena need high reliability systems, we need system failure to quantify how the MINIMA solution impacts operator performance.

Within this evaluation plan, it is proposed how to deal with these different constraints and how to both trigger OOTL phenomena and quantify the benefits of the MINMA solution at different levels of analysis (biometrics and performance). Results according to this evaluation plan will be reported in the Evaluation Report (D3.2).

5 References

[1] MINIMA (699282) – Grant agreement.

[2] MINIMA (699282) – D1.1 State of the Art report, Ed. 00.02.00, 1 December 2016.

[3] MINIMA (699282) – D1.2 Concept description, Ed. 00.02.00, 8 February 2017.

[4] MINIMA (699282) – D2.1 Integrated Vigilance and Attention Controller, Ed. 00.01.00, 31 July 2017.

[5] MINIMA (699282) – D2.2 Task Environment, Ed. 00.01.00, 31 July 2017.

[6] Verberne, F. M., Ham, J., & Midden, C. J. (2012). Trust in smart systems: Sharing driving goals and giving information to increase trustworthiness and acceptability of smart systems in cars. Human factors, 54(5), 799-810.

[7] Helmke, H., Hann, R., Uebbing-Rumke, M., Müller, D., & Wittkowski, D.: Time-Based Arrival Management for Dual Threshold Operation and Continuous Descent Approaches. In: Proceedings of the 8th USA/Europe Air Traffic Management Research and Development Seminar, 2009.

[8] Ohneiser, O.: RadarVision – Manual for Controllers. DLR (IB112-2010/54), 2010.

6 Annex

Annex A. Evaluation schedule.

MINIMA EVALUATION SCHEDULE
(6 Nov 2017 - 17 Nov 2017)
Via Fontanelle, 40 - 47121 Forlì

Day, Date	Session 1 (2 hours)	Session 2 (2 hours)	Session 3 (3 hours)	Session 1 (2 hours)	Session 2 (3 hours)	Session 3 (3 hours)
	9:00 -11:00	11:20-13:20	15:00-18:00	9:00-11:00	11:15-14:15	15:00-18:00
Mon,6 Nov 2017	ATCO 1_1	ATCO 2_1	ATCO 1_2			
Tue,7 Nov 2017				ATCO 3_1	ATCO 2_2	ATCO 3_2
Wed,8 Nov 2017	ATCO 4_1	ATCO 5_1	ATCO 4_2			
Thu, 9 Nov 2017				ATCO 6_1	ATCO 5_2	ATCO 6_2
Fri, 10 Nov 2017	ATCO 7_1	ATCO 8_1	ATCO 7_2			
Mon, 13 Nov 2017				ATCO 9_1	ATCO 8_2	ATCO 9_2
Tue, 14 Nov 2017	ATCO 10_1	ATCO 11_1	ATCO 10_2			
Wed, 15 Nov 2017				ATCO 12_1	ATCO 11_2	ATCO 12_2
Thu, 16 Nov 2017	ATCO 13_1	ATCO 14_1	ATCO 13_2			
Fri, 17 Nov 2017				ATCO 15_1	ATCO 14_2	ATCO 15_2

**ATCO A_1: PART 1:Training module: 2hrs
**ATCO A_2: PART 2: Experiment module: 3hrs