



E.02.09-D13-ADAHR-Final Project Report

Document information

Project Title	ADAHR
Project Number	E.02.09
Project Manager	ISDEFE
Deliverable Name	Final Project Report
Deliverable ID	D13 (D0.8 in contract)
Edition	01.00.00
Template Version	03.00.00

Task contributors

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Abstract

The final report of the ADAHR project provides a publishable summary of the results. In addition it lists all deliverables, dissemination activities, eligible costs, deviations, bills and lessons learned.

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Document History

Edition	Date	Status	Author	Justification
00.00.01	11/06/2011	Draft	[REDACTED]	New Document
00.01.00	11/06/2011	Final		New version of the document according to the changes proposed by Eurocontrol and SJU

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This deliverable consists of SJU foreground.

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Publishable Summary

The “Assessment of the higher Degree of Automation on Human Roles” (ADAHR) project carried out serious gaming sessions to assess the impact of increasing Levels of Automation (LoAs) on roles and responsibilities within Single European Sky ATM Research (SESAR) programme in the Airspace Organization and Management (AOM) and Airport Operations Centre (AOC) environments. Both environments are related to the planning phase of the flight operation.

These results were obtained performing two gaming sessions per environment: the first one using paper-based games and the second one using platform-based games. Paper-based games were useful to perform a preliminary assessment of the scenarios and the roles and also to support the configuration of the platform to undertake the platform-based games. These latter were performed using a platform which provides realism to the games and the assessment of the objectives could be completed.

The players in the gaming sessions were five experts for two environments. Three players participated in each gaming session and they were all ATM experts. Hence one of them contributed to the gaming sessions of both environments performing two different roles. It must be noted that due to the limited number of experts, the results collected from the experts’ assessment could be biased by the personality and the proper experience.

Taking into account this limitation of the experts’ gaming sessions and to enrich the results of the project, it was decided to perform one extra platform-based gaming session whose participants were students only in the AOC environment. Consequently, this gaming session was carried out with 60 students, (20 groups of 3 people. This allowed the project to carry out a quantitative assessment to complement the results coming from the experts’ assessment.). As none of the students had any specific knowledge in ATM, this should be taken because of the lack of operational experience could influence in the results of the gaming sessions.

The results of the ADAHR project were based on the definition of the roles and the LoAs foreseen by the supporting systems expected in the future ATM environment. This description was done within ADAHR project as initial activity to set the expectations for each environment in the different timeframes (2020, 2035 and 2050) taking into account the existing literature about the automation and the ATM roles and responsibilities for those timeframes. Therefore these results cannot be generalised and they should be interpreted considering this initial definition.

Regarding the Levels of Automation, three different levels linked to different timeframes were explored: The 2020 timeframe represented the baseline scenario in which system provided users with solutions according to the individual problems and objectives. The 2035 timeframe represented the scenario with an intermediate LoA in which the system provided users with different global solutions but the costs were different per each user. Finally the 2050 timeframe was the highest LoA to be assessed. During this timeframe, the system provided users with one optimal global solution and the possible actions were approving or rejecting that solution.

The results obtained showed some differences between environments and also among roles. As a result, a specific analysis of the results per environment was included aside from the new/updated responsibilities of the assessed roles. Apart from this, overall conclusions and recommendations were detailed about the impact that increasing LoAs on the human roles.

The roles selected to be assessed within the environment of **Airspace Organization and Management** were the Regional Network Manager (RNM), the Local Traffic Manager (LTM) and the Airport collaborative decision making (A-CDM) Manager.

The main results for this environment were that the increasing role of automation was positively perceived throughout the different timeframes. Experts showed that they had a higher level of acceptance of the higher LoAs, (2035 and 2050 timeframes). This was also supported by the experts’ rating of confidence and self-efficacy in these timeframes.

Trust in the system was maintained over the timeframes but highlighting the preference that humans were still in command to accept and apply the solutions. This indicator depended on the solution proposed: if the solution proposed by the system was according to the experts' experience and within the cost-index parameters indicated as acceptable, the individual trusted the system. However if the proposed solution was near or passed the acceptable boundaries, then they would review the solution to follow the reasoning behind it. This was more directly related to situational awareness which then impacts trust on the system.

Apart from this, when the role of the human was replaced by the automation it did not influence the subjects' trust in the system. Experts indicated that automation was needed to deal with the high traffic levels presented and they indicated that it was easier for them to trust the system as the demand and capacity balancing process was a task of the planning phase, and there will be another layer supervising the execution of the flights.

SA was assessed by all the actors in all timeframes as sufficient. The best results were obtained for the LTM role in the 2035 timeframe. It was not possible to determine a trend linked to the level of automation because, as mentioned, the SA is more related to the appropriateness of the solution.

It was also found that parameters such as flexibility and human kindness, considered better used by humans than by automated systems, should be taken into account by the design of the systems, so as to provide the possibility for interactions between human and machines.

Some outputs about the supporting tools, (for the management of the network and the what-if tools supporting the airlines and the network manager), were that communication tools that are new to the ATM environment, but normal to the general public (for example chat) could be introduced in the Airspace Organization and Management environment. Furthermore it was requested that systems should allow the visualization of the impact of the possible solutions to be implemented, showing multiple scenario data. Another suggestions were about to include non-economic costs in the cost-index parameters.

For the **Airport Operation Centre environment**, the assessed roles were Airport Agent (AA), the Major Airline Agent (MAA) and the Charter Airline Agent (CAA).

The main results for this environment showed that the experts pointed out the best situation for the 2035 environment, being the best perception by the Airport Agent role. However the worst perceived LoA was for the 2050 environment by the Major Airline Agent. This was supported by the assessments on confidence and self-efficacy.

Similarly to the AOM environment, trust in the system was also maintained as the LoA increased. However in terms of acceptance, the scenario in which was only feasible to give the operator only a "go" or "no-go" choice showed a reduced level of user acceptance. This result was confirmed by the results of the students whose level of user acceptance decreased significantly with an increasing level of automation. One mechanism suggested to increase the trust in the systems was the involvement of the user since the very beginning of the lifecycle of systems development.

Situational Awareness was assessed differently per role. The most positive assessment was for the 2035 environment by the Airport Agent role and the worst rating for the 2050 environment by the Charter Airline. This could be explained by the fact to lose the control of the situation as they could not influence in the decision, only in their acceptance.

Other important comments were about the importance of insight into the reasoning of the system and the resultant required training. Also the importance of the authority and accountability was highlighted due to the need to have a clear definition of the responsibilities when high LoAs are implemented since humans could feel less responsible because their tasks would be simply monitoring situations and systems would provide the solutions.

With regards to supporting tools, (for the analysis and management of the optimal Airport Operation Plan and also another tool for the assessing of the cost of the solution per each role), and especially in the developing of solutions, some needs were stated by the experts such as the accessibility to the

list of updated parameter to build a specific solution, the access to the information of the winner and loser when the application of one solution and the perception of transparency in the optimization process of a solution to increase the user's confidence in the system

Extrapolating the results of each environment, broadly the experts who participated as players in this study showed a positive overall impression about the perception of the increasing LoA. All these players trusted in the system considerably and the level of trust of each role was maintained over the different LoAs. This high degree of acceptance could be explained by the fact of the scenarios were running in a pre-tactical/planning phase. So that conflicts or any other unexpected event happened during this phase could be addressed in time and the level of safety would not result compromised. The need to obtain solutions with transparent reasoning of automated systems was repetitively stated in all gaming sessions independently of the environment.

This latter statement was also linked to an improvement of the Situational Awareness of the roles. The assumption that higher LoAs increase SA could not be demonstrated because strong differences between actors/roles were observed.

Similar to SA assessment, results on workload differed per role although there was a tendency to decrease workload in higher LoAs. It should be considered that the main contributors to workload could vary along the timeframes being the negotiation time the main contributor in lower LoA, whereas in higher LoA, the main contributor could be the understanding of the system's reasoning.

Regarding the impact of higher LoAs on the interaction between the human roles, it was perceived that it decreased, but this was not rated by the actors as negative. In fact, the quantitative assessment showed that the design of the systems for highest LoA led to improving the group performance because the system provided the global and optimal solution.

This quantitative assessment also provided results about the improvement of group performance at a cost of the individual one when higher LoAs. The changed roles and responsibilities thus assisted the group but not the individual to gain better performance. Moreover, this assessment provided an interesting result about the influence of conscientiousness on the individual performance throughout the increasing LoA. In these timeframes, this personality trait and user acceptance contributed more to the prediction of performance. In turn, user acceptance was determined to a larger extent by the IT suspicion.

1 Introduction

1.1 Purpose of the document

The purpose of this document is to:

- Summarise the technical results and conclusions of the project (Publishable Summary);
- Provide a complete overview of all deliverables;
- Provide a complete overview of all dissemination activities (past and in progress). Where appropriate, provide feedback from presentations. Describe exploitation plans.
- Provide a complete overview of the billing status, eligible costs, planned and actual effort (incl. an explanation of the discrepancies).
- Analyse the lessons learnt at project level.

1.2 Intended readership

The intended audience for this document consists of representatives of R&D communities, who have an impact on future levels of automation in the ATM environment. More concretely the audience includes the people involved in SESAR projects, in which human performance assessment and analysis is performed.

1.3 Inputs from other projects

No inputs from other projects have been used.

2 Technical Project Deliverables

Number	Title	Short Description	Approval status
D2	E.02.09-ADAHR-D1.1-Roles and Responsibilities	The aim of this document is to provide building blocks for serious game scenarios which will be used within ADAHR project to explore the impact of different Level of Automation (LoA) on Human roles, concretely, from 2020 via 2035 to 2050. In these games a number of SESAR roles with the LoA expected for 2020 will be compared with the expected LoA of these roles in the far future, (2035 and 2050). This document includes the analysis carried out for the selection of the SESAR roles to be explored taking into account the two Environments in which ADAHR's assessment is focused. Moreover additional information about the expected evolution of each selected role from nowadays until the future in the different timeframes, (2020-2035-2050) is provided.	Approved
D3	E.02.09-ADAHR-D1.2-Scenarios Description	This document describes the outlines for scenarios that were developed for the design of serious games. The description of the scenarios is based on the roles identified and selected in ADAHR D2 document. The scenarios are aimed at the different levels of automation, (2020-2035 and 2050), reflecting the future of aviation in two different environments (Airspace Organisation and Management and the Airport Operations Centre).	Approved
D5	E.02.09-ADAHR-D2.1-Exercise Plan Paper Based Gaming ENV1	This document provides the Exercise Plan for the performance of paper-based games of Airspace Organization and Management environment. This exercise plan was described taking into account the Roles detailed in D2 and the scenarios related to this environment described in D3. It contains the information needed to plan and manage the paper-based games including a detailed description of the scenario related to this environment and of the roles' responsibilities to be explored. Other details such as the schedule of the runs, the analysis methods to be used, the indicators to be measured and the actors involved are also provided.	Approved
D6	E.02.09-ADAHR-D2.2-Exercise Plan Platform Based Gaming ENV1	This document provides the Exercise Plan for the performance of platform-based games of Airspace Organization and Management environment. This exercise plan was described taking into account the Roles detailed in D2, the scenarios related to this environment described in D3 and the outputs from the performance of the paper-based gaming sessions. It contains the information needed to plan and manage the platform-based games including apart from the same information required for the performance of the paper-based games, information about the platform to be used and their configuration for these games.	Approved

D8	E.02.09-ADAHR-D2.3-Exercise Plan Paper Based Gaming ENV2	This document provides the Exercise Plan for the performance of paper-based games of Airport Operation and Centre environment. This exercise plan was described taking into account the Roles detailed in D2 and the scenarios related to this environment described in D3. It contains the information needed to plan and manage the paper-based games including a detailed description of the scenario related to this environment and of the roles' responsibilities to be explored. Other details such as the schedule of the runs, the analysis methods to be used, the indicators to be measured and the actors involved are also provided.	Approved
D9	E.02.09-ADAHR-D2 4-Exercise Plan Platform Based Gaming ENV2	This document provides the Exercise Plan for the performance of platform-based games of Airspace Organization and Management environment. For this environment, two different platform-gaming sessions were planned, one performed by experts and another one performed by students. This exercise plan was described taking into account the Roles detailed in D2, the scenarios related to this environment described in D3 and the outputs from the performance of the paper-based gaming sessions. It contains the information needed to plan and manage the platform-based games including apart from the same information required for the performance of the paper-based games, information about the platform to be used and their configuration for these games.	Submitted
D7	E.02.09-ADAHR-D3.1-Gaming report ENV1	This document details the gaming exercises performed for the assessment of Airspace Organization and Management environment and the results obtained from both the Paper-based and Platform-based games.	Submitted
D10	E.02.09-ADAHR-D3.2-Gaming report ENV2	This document details the gaming exercises performed for the assessment of Airport Operation Centre environment and the results obtained from both the Paper-based and Platform-based games.	Submitted
D12	E02.09-ADAHR-D4.1-Conclusions and Strategic Recommendations	This document contains the main conclusions and the recommendations coming from the ADAHR assessments. The document contains the main conclusions by environment as well as an overall analysis taking into account all the results obtained from the assessment of both environments. The consolidation of the information will provide the main conclusions about the objectives of the ADAHR projects and a list of recommendations to be taken into account.	Submitted
D11	E02.09-ADAHR-D5.2-Dissemination Report	This document describes all the dissemination activities undertook during the project. In addition to this the technical papers presented in the ATM international conferences have been attached.	Submitted

Table 1 - List of Project Deliverables

3 Dissemination Activities

3.1 Presentations/publications at ATM conferences/journals

- Presentation of technical paper “Use of role games in automation assessment” [1] in First ATACCS Conference hosted by HALA Research Network at Barcelona between 26th and 27th May 2011. The presentation dealt with the use of the gaming technique to perform assessments about automation and more specifically about the impact of automation on humans.
- Presentation of technical paper “The Effect of a Highly Automated Environment on Human Behaviour – Plans and first results of the WP-E project ADAHR” [2] in First SESAR Innovation Days hosted by ENAC at Toulouse between 29th November and 1st December 2011. The presentation dealt with the planning of activities to be performed in ADAHR project and the first results provided. These results consisted of the definition of Roles and Responsibilities foreseen for 2020, 2035 and 2050. The main feedback was related to the concern of having actors who could be focused on the future. In this event, the possible participation of students arose.
- Presentation of technical paper “The effect of an Increasing level of Automation in Demand-Capacity Balancing process on human actors and their Roles and Responsibilities – A Gaming assessment” [3] in Second SESAR Innovation Days hosted by DLR at Braunschweig on the 28th November 2012. The presentation dealt with the description of the first results obtained from the gaming sessions performed within ADAHR in the environment Airspace Organization and Management. The results included the outputs coming from both, paper-based and platform-based gaming sessions.
- Presentation of technical paper “Assessment of impact of Degree of Automation on Human Roles: the Experts’ Analysis using Gaming” [4] in Third ATACCS Conference hosted by HALA Research Network at Naples between 28th-30th May 2013. The presentation dealt with the presentation of the results of the experts’ assessment performed within ADAHR project. The presentation described the main aspects obtained from the gaming sessions performed in both environments, Airspace Organization and Management and Airport Operations Centre. The main feedback was about to compare and analyse these results taking into account the studies performed by Marek Bekier, an expert in automation and the effect on human performance.

3.2 Presentations/publications at other conferences/journals

- Presentation in Measuring Behaviour 2012 Conference at Utrecht between 28th and 31st August 2012. Some slides about the how serious games were used in ADAHR were shown. The title of the presentation was “Selection of a Measurement Battery for Human Behaviour Assessment in Serious Games in the Aviation Domain”.

3.3 Demonstrations

No demonstrations apart from the gaming assessments performed within ADAHR were carried out.

3.4 Exploitation plans

CRIDA will be using the experience gained in ADAHR with regards to the gaming techniques and the future roles and responsibilities in future research regarding Capacity and Demand Balancing. The gaming technique is especially useful in initial validation of new concepts, and as more and more of the air traffic control environment becomes automated, this methodology is hoped to be more and

more useful. Both scenarios studied, Network and Airport CDB, are of interest to CRIDA as areas of future study, even though CRIDA only participated in the Network CDB gaming.

DLR will consider the results obtained in the ADAHR exercises in the design of future airport operations assistance systems, which are under development several research projects. The experience gained in the technique of gaming as a validation means will also be very helpful for future projects.

The most important results from ADAHR for NLR are the knowledge we have accumulated on different SESAR roles; which of them are most likely influenced by higher levels of automation (LoA's); and in what way they will be influenced. This knowledge can directly be applied in other projects, for example for SJU or EUROCONTROL. In these future projects and publications the work can be better focused on those roles where automation has the highest impact, and more realistic situations and possible solutions can be studied.

The gaming technique is a methodology that NLR is applying more and more. That is done in a wide range of different gaming techniques ranging from high level board games to detailed full scope simulations. After this project NLR feels even more strongly that there is a lot of potential in applying serious games as a means to answer a number of (operator performance related) research questions. As such the additional knowledge that NLR gained about gaming, and evaluation of gaming sessions, will be applied more often in other studies.

As such the knowledge that was gained by NLR will directly be used to improve NLR's capability and quality to support EUROCONTROL and SJU in studies about automation in future SESAR settings and roles.

ISDEFE will take advantage of ADAHR project and its results from different aspects. Firstly, ISDEFE has obtained experience about using the gaming technique to explore new concepts and aspects related to human performance. From the point of view of automation, more understanding has been gained about how and what to automate and this will be applied to other operational projects within ISDEFE, (i.e. non Research and Development projects). With regards to the operational concept and processes of Airspace Organization and Management and the Airport Operations Centre environments, more expertise in these areas has been acquired that can be applicable to other on-going operational projects, especially related to airport processes and the Airport Management Centers. Finally and regarding organizational processes, the relationship and knowledge transfer between Research and Development (R&D) projects and the operational projects has been improved and reinforced. Moreover, this has allowed to transmit and to promote the main activities of SESAR WPE and ISDEFE R&D activities throughout ISDEFE organization.

4 Total Eligible Costs

Date	Deliverables on Bill	Contribution for Effort	Contribution for Other Costs (specify)	Status
15/11/2011	D0.1, D0.2, D1.1	48.803,07	3.293,74 (Travel costs and web site domain costs)	Paid
29/06/2011	D0.3, D0.4, D1.2	31.014,84	1.634,43 (Travel costs)	Paid
20/12/2012	D0.5, D0.6, D2.1, D2.2, D2.3	89.160,39 (including the subcontracting cost from ISA software, 37500 euros)		Paid
	D2.4, D0.7, D0.8, D3.1, D3.2, D4.1, D5.2	289.004,16	7.743,675 (travel costs of partners for gaming sessions and dissemination activities + travel costs of experts for participation in gaming sessions of environment 2).	Estimated/Planned
GRAND TOTAL		457.982,45	12.671,85	

Table 2 - Overview of Billing

Company	Planned man-days	Actual man-days	Total Cost	Total Contribution	Reason for Deviation
ISDEFE	235	435	217.980,11	163.485,08	<p>There are several reasons:</p> <ul style="list-style-type: none"> Isdefe has spent more effort than planned. The planned costs per day per engineer are lower than the ones stated at the beginning of the project. The initial estimations of man-days were based on the specific number of hours per profile. As the profiles of the engineers has

					changed during the lifecycle, the number of actual man-days were also changing
CRIDA	163	203	118.170,71	85.091,21	The work required to set up and perform the gaming proved to be more than expected when the project was first planned. However, the contribution requested on the part of CRIDA did not increase above the budgeted for the final deliverables.
DLR	146	146	163.500	122.625	
NLR	98	114	110.992,20	83.191,65	The main deviation from the planning was that initially NLR was scheduled to do more work on location. That is participating in experiments in the facilities of ADAHR partners. However it turned out that the project would benefit more from NLR working on the deliverables (in particulars D3.2/1 and also 4.1) and processing experiment data in spread sheets etc., and that partners would run the experiments on their own. Therefore NLR could do more of the work on their own site rather than on location. As such the reserved travel budget was spent on additional reporting and data analysis. Which is concerned an efficient move.
GRAND TOTAL	642	898	582.842,37	454.392,84	

Table 3 - Overview of Effort and Costs per project participant

5 Project Lessons Learnt

What worked well?
<i>The involvement of the same set of experts in both, paper-based and platform-based gaming sessions. The paper-based gaming sessions allowed the experts to familiarise with the concept and the gaming technique further than the support to the platform configuration. The platform-based gaming sessions offered the realism of a platform to the actors for obtaining more reliable and confident results.</i>
<i>The combination of paper-based games with platform-based games. This allowed performing a preliminary assessment of the scenarios and the solutions to be explored and taken this into account, the design of the platform-based exercises could be done closer to the real operations, avoiding experts felt out of the context with unexpected solutions or unexpected events of the scenarios.</i>
<i>The performance of one additional platform-based gaming session with students. This allowed ADAHR project to enrich the results with quantitative data.</i>
<i>The experts who participated in the gaming sessions. All of them have the proper skills to take part in the gaming sessions, as they were open-minded and their operational experience and their close link with the current operations was not a blocking issue to focus on the different situations in far future proposed to them.</i>
<i>The performance of additional runs in the gaming sessions of the Airport Operation Centre environment to avoid the order effects. This allowed obtaining higher confident results from the experts' gaming sessions.</i>
<i>The evaluation methodology that was used for the gaming sessions allowed gathering a detailed impression about how each subject experienced the different scenarios.</i>
<i>The theoretical foundation of the work that was created in WP1 allowed focusing the experiments quickly on those roles and scenarios that were most relevant for SESAR.</i>
What should be improved?
<i>The delivery of the experimental plan of the gaming exercises in the due time. This would facilitate the discussion between project partners, and also SJU, about obtaining a better design of the exercises and it would still be possible to modify some aspects or characteristics for improving the quality and reliability of the results.</i>
<i>The procurement of more expertise for the gaming exercises. The experts' participation is one of the crucial aspects to obtain valuable results in gaming exercises. In ADAHR, the lack of experts was an important limitation for the analysis of the results because only three experts per environment participated. Therefore, the results could be biased by the personal opinions or the operational experience of the participants.</i>
<i>The duration of the training for the gaming sessions should be longer. The training session is very important to familiarize the experts with the technique and also with the platform. It is important that experts feel secure with both aspects to be focused on the objectives of the exercise instead of being focused on the operation of the platform or on how they should use the materials provided to play.</i>
<i>The compliance with the deadlines scheduled for the project. This would allow more time for discussions and reactions when some changes need to be made and it would improve the mechanism to provide feedback from one gaming session to the subsequent ones.</i>
<i>An earlier involvement of experts in the project. Some presentations of the scenarios or the techniques could have helped to familiarize with the concept and the technique. Moreover, the engagement of the experts in the review of the scenario's documents could have been positive for the validation of these scenarios and again the familiarization with the processes to be assessed.</i>
<i>The Cost Breakdown From is difficult to use and the fulfilment of this document takes more effort than expected. The main weakness are about the lack of flexibility to include or modify information</i>

Table 4 - Project Lessons Learnt

6 References

- [1] R. Casar Rodríguez and R. García Lasheras, "Use of role games in automation assessment", 1st International Conference on Application and Theory of Automation in Command and Control Systems (ATACCS 2011), pp. 100-103, 26-27 May 2011, Barcelona, Spain
- [2] M. Koolloos and R. Zon, "The Effect of a Highly Automated Environment on Human Behaviour - Plans and first results of the WP-E project ADAHR", First international Conference on Single European Sky ATM Research Innovation Days (SIDs 2011), 29 November-1 December 2011, Toulouse, France.
- [3] M. Koolloos, D. Escribano, R.Casar, T. Bos, R. García, A. R. Grosskreutz, "The Effect of a Increasing levels of Automation in Demand-Capacity Balancing processes on human Actors and their Roles and Responsibilities - A Gaming Assessment", 2nd International Conference on Single European Sky ATM Research Innovation Days (SIDs 2012), 27-29 November 2012, Braunschweig, Germany.
- [4] R.Casar, A. Arranz, B. Escribano, A. Grosskreutz, R. García, R.Suikat, M. Jipp, G.D.R. Zon, M. Joose, "Assessment of impact of Degree of Automation on Human Roles: The Experts' Analysis using Gaming", 1st International Conference on Application and Theory of Automation in Command and Control Systems (ATACCS 2013), 20-30 May 2013, Naples, Italy.