Human Factor Impact Assessment of RPAS Integration into Non-segregated Airspace

A first Overview of the Current RPAS Integration Challenges

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***Abstract* — This study covers one of the most critical operational gaps identified for the integration of Remotely Piloted Aerial Systems (RPAS) into non-segregated airspace, which is the impact on Human Factors. There are relevant aspects of these new actors that may have implications in current ATM environments which have not been investigated yet.**

The analysis of the results obtained during demonstration flights executed as part of ARIADNA and DEMORPAS projects (both co-funded by SESAR) are presented in this paper. Under the umbrella of those two projects, the first real RPAS flights in European segregated airspace emulating a non-segregated one, took place. The representativeness of the results is ensured by using the SESAR program Human Factor indicators in the assessment of the results.

In addition, to provide a truly global overview, the study covers airport, approach and en-route operations, evaluating the impact on air traffic controllers in different operational scenarios, including as notable innovation the assessment of RPAS specific contingency procedures.

The results point out the high workload perceived by Air Traffic Controllers (ATCOs) that becomes a limiting factor for the integration of RPAS in ATM environments in the short term. Moreover, this study brings to light the aspects that impact on controllers´ workload for further analysis like RPAS performance, ATC procedures, communication and phraseology between remote pilot-ATCO. Therefore, it is essential to determine necessary steps to move forward towards a safe integration of RPAS into non-segregated airspace.

Keywords: RPAS integration, Human Factor, SESAR Programme, Non-segregated airspace, Qualitative data.

I. INTRODUCTION

Remotely Piloted Aerial Systems (RPAS), commonly known as drones, are lately experiencing a quick evolution while the range of its applications will continue growing due to the advantages, in terms of endurance, costs and risks to human beings they offer, compared to manned aircraft.

Current heterogeneous regulation does mainly allow its operation in segregated environments. Nevertheless, the increasing interest of various economic sectors in the experimentation and even in the use of these systems more regularly with fewer restrictions have led the integration into non-segregated airspace to become a priority for the air navigation authorities.

In line with this, there is a significant number of on-going initiatives to promote the investigation on technical and operational gaps to safely integrate these new airspace users into current Air Traffic Management (ATM) environments without affecting current system performance [11].

One of these gaps is the impact on current roles of introducing RPAS into ATM environments. The emergence of the RPAS has turned into critical the assessment of human factors considering the importance that these ones have even in manned aviation for years. Human factors is a cornerstone of the air navigation system in general that must be analysed to ensure safety, confidence and acceptance by introducing a new element on the current ATC (Air Traffic Control) environment.

With the purpose of investigating this and other issues, nine demonstration projects have been executed in the context of SESAR Programme promoted and financed by SESAR Joint Undertaking (SJU). Among such projects, DEMORPAS and ARIADNA were defined partly, but not exclusively, to address the feasibility of the RPAS future integration into non-segregated areas, from the human factor perspective to introduce RPAS safely in the European system of air traffic management. Thus, the scope of this paper is focused on the analysis of the impact on the human factors triggered by the integration of RPAS in non-segregated environments making use of the results extracted from both exercises. This analysis allows us to cover a higher number of scenarios and RPAS procedures as airport and en-route phases and nominal and emergency RPAS operations, achieving in this way a complete overview of the studied situation.

Future research, by the hand of Horizon 2020 Research & Innovation Programme, will continue the assessment of the main issues which have been highlighted in the projects developed until now. Thus, the conclusions presented in this paper are not only the product of the analysis obtained through the first experiences in Europe involving drones within simulated non-segregated airspace. Those ones are key elements for upcoming studies in order to achieve an effective approach and a real integration of these actors which seem to be one of the most promising businesses. The final scope is the seamless integration of RPAS into the evolving ATM system through the definition, development and deployment of operational solutions and innovative technology.

II. BACKGROUND

A. Objectives

The main objective of this research is to assess up to what extent the inclusion of RPAS in ATM environments would impact on the current ATCOs (Air Traffic Controllers) and RP's roles and responsibilities. This objective has been achieved through the analysis of a set of indicators used transversally in the SESAR Programme [2], trying to determine whether their variation is manageable by the main actors in a safe way. For that purpose several aspects have been assessed:

- Level of task distribution among different actors and the corresponding increment of stress generated by its imbalance.
- Human errors typology
- Situational Awareness
- Confidence on the new technology
- Communications quality

In order to support the previously mentioned analysis, radar and ADSB (Automatic Dependent Surveillance-Broadcast) information have been used to achieve a deeper understanding of the results obtained.

B. Approach

The Human Performance Assessment described in this paper is based on two projects with parallel objectives focused on different operational environments. In order to achieve a complete outlook, it has been analysed all flight phases under nominal and emergency operations as it is schematised in the Figure 1.

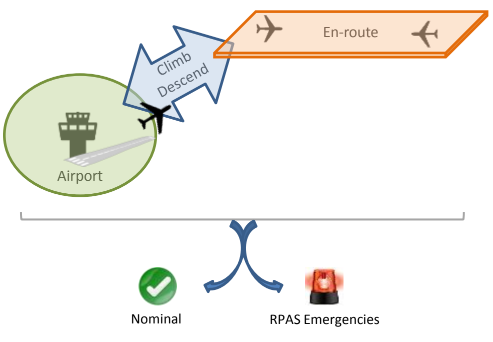

Figure 1. Scenarios schematization

To ensure a proper operational representativeness, the assessment has analysed the perception of the actors when these new users operate in all flight phases with different peculiarities:

- Aerodrome area: ATCOs and remote pilots are able to visualize the RPAS most of the time. In addition, potential communication problems are minimised by being in direct line of sight.
- Climb and approach phases: actors are not in visual contact with the RPAS which position is monitored by progress reports from the RPAS crew, but communication is still performed with the tower in line of sight.
- En-route: apart from being out of visual contact with the RPAS, communications are conducted with a remote area control centre (ACC).

A differentiating factor of the assessment here presented is the coverage of RPAS specific emergency procedures that were simulated in the exercises and which are described below:

- Loss of data-link: it implies that the remote pilot loses not only the control of the aircraft but also awareness of its position, attitude and evolution.
- Loss of Global Navigation Satellite System (GNSS) signal: although the remote pilot remains in command, the RPAS navigation system loses accuracy as time passes.

By this complete assessment it is feasible to compare the impact on human roles for different flight phases and conditions, so that it can be stressed the most limiting types of airspace.

C. DEMORPAS & ARIADNA projects

DEMORPAS project [5] aims at contributing to demonstrate the feasibility of the integration of RPAS in non-segregated airspace, in a mixed environment where RPAS and manned aircraft coexist during different flight phases. To that purpose DEMORPAS has followed a stepwise approach during two different exercises. It has been progressively increasing the complexity of the demonstration until the final exercise where both a RPAS and a manned aircraft have flown together sharing the same airspace while they are being provided with air traffic control.

ARIADNA project [6] addresses the validation of concepts for a "ground based" situational awareness system (GBSAS) with the use of ADS-B and ATC radar data to increase the remote pilot situational awareness of the surrounding traffic in the airport environment. Besides, it will be demonstrated that even very small RPAS can be equipped with ADS-B technology and therefore be "seen" by other manned and unmanned aircraft.

III. METHODOLOGY

A. Context/Environment

As introduced before, current regulation among European countries does not allow a seamless integration of RPAS in non-segregated airspace and has led to heterogeneous frameworks to conduct preliminary tests.

Bearing this in mind, the flight demonstrations used for this analysis were conducted under Spanish regulation, which didn´t permit to the RPAS types used to fly directly in non-segregated airspace. However, to achieve the goal of this Human Performance Assessment it was emulated a controlled airspace were the RPAS and a limited number of manned aircraft were used for the purpose of these exercises.

Next paragraphs give a general review of the context in which the first ever RPAS flights in Spanish controlled airspace were developed: actors, tools and operational environments.

1) *Actors:* The roles that have been analysed in this paper are described below. However, it must be noted that the participants of the trials were not limited to these since manned aircraft pilots and other experts contributed to the goal:

a) *Air Traffic Controllers:* As the flights covered all flight phases, different ATCOs were involved in the exercises: tower (TWR) controllers who had limited radar coverage for approach operations and ACC controllers who relied principally on radar systems.

Taking into account the regulatory limitations and the locations selected for the trials, this human factor assessment has been based on the feedback from military and civil controllers.

b) *Remote Pilots (RP):* Actually this role was carried out by three different actors: The external pilot, who supervised the aerodrome movements, the remote pilot who commanded the instructions to the RPAS and communicated with the different air traffic controllers and in some cases a third person to support navigation and monitoring tasks.

The remote pilot was never in direct observation of the aircraft but he was in direct communication with the external pilot.

2) *Aircraft:* These exercises used two fixed wing RPAS of different sizes and performance capabilities. The smallest one, around 10 kg, was used in airport environments while a larger one, 50 kg and tactic-like RPAS, was employed to operate in en-route airspace, apart from operating in aerodrome and approach phases of course.

In addition, two manned aircraft collaborated in the flights to assess the interaction with these new stakeholders.

3) *Tools:* To increase the situational awareness of the remote crews, some tools and technical solutions were directly involved in the exercises. These solutions and the selected tools aimed at increasing the situational awareness of the remote pilots using ground-based available systems.

a) *ATC Radar:* this innovative solution consisted on providing surrounding traffic information to the remote pilot by presenting the ATC radar signal in the remote pilot station. This technique was limited by the need to be close to ATC infrastructures.

b) *ADS-B:* traffic information from ADS-B out onboard equipments was provided to the remote pilot in a specific display, ADS-B in integrated in the remote pilot station.

4) *Operations Area Characterisation:* The exercises were carried out in two different places corresponding to the two projects explained before:

DEMORPAS: Matacán (Salamanca airport, LESA) an important training centre for Spanish Air Force and with a considerable military activity that makes necessary a close coordination between civil and military authorities. The airspace over Salamanca is responsibility of Madrid ACC which provides control services over FL155. Within this airspace, the area selected to execute the exercises was a subpart of Zamora Lower control sector (ZML) limited by two restricted areas: LER71B and LER71A. It is important to bear in mind that the airspace in which the flights were performed was segregated because of safety reasons but emulating a non-segregated airspace.

ARIADNA: The exercises were executed in ATLAS experimental test centre (under civil authority) where No SACTA ATC radar data was available. The airspace used was limited by the ZOTER (ATLAS TSA 30) and the ZOUAS (Circular cylinder with vertical axis through the ARP, 8 km radius and vertical limits from SFC to 4000 ft. (1000 ft. below TSA 30 limit as safety buffer)).

5) *Scenarios (phases and procedure):* The flights performed by the RPAS in DEMORPAS were divided into different phases. The one that was executed along the working area was subject to variations in order to follow the different scenarios designed. The pre-flight check, taxi-in, take-off and transition corridor phase, as well as the landing, and the taxi-out were common in every flight. Nevertheless, when the RPAS was in the Working area the RPAS could adopt:

a) *Operational procedure:* In this case, the RPAS wanted to modify its flight plan in order to execute a surveillance mission. Due to this, the RP asked Madrid ACC to fly direct to a certain point. Then the RPAS came back its initial trajectory and left the working area as it could be seen in *Figure 2*.

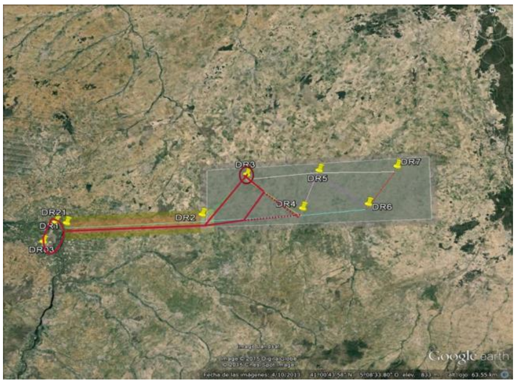

Figure 2. Operation Scenario

b) Emergency procedure: As it could be seen in the *Figure 3*, the RPAS declared first of all a loss of telemetry for 2 minutes, after that it was commanded to fly over a recuperation area until the telemetry was recovered and the RPAS was able to resume the initial flight plan. Before reaching the transition corridor, it was declared a loss of GPS. Once again the RPAS flew to another recuperation area during two minutes when the emergency was finalized and the RPAS recovered the initial trajectory. Finally, a partial loss of engine was simulated during approach phase flying through the corridor.

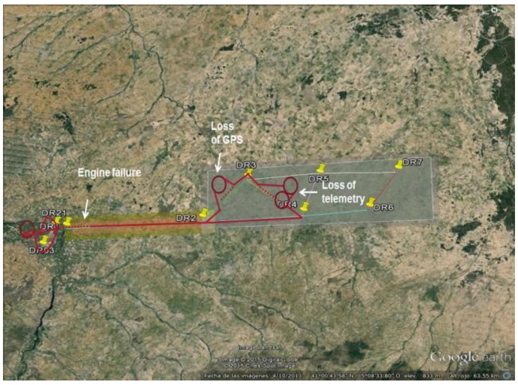

Figure 3. Emergency Scenario

c) Separation Procedure: Flying simultaneously with the manned aircraft, a loss of telemetry was simulated, as in the previous procedure, but now this failure generated a conflict between both aircraft. The conflict was detected by the air traffic controller that commands the manned aircraft to climb 1000ft. Once the conflict was saved, both aircraft resumed their initial flight plan to the transition corridor.

In the case of ARIADNA, what it was simulated was a regular RPAS operation in the vicinity of the airport and the arrival of the GA manned aircraft that generated a separation infringement. Although each aircraft had the correspondent pre-flight check, taxi-in, take-off, as well as a landing phase, the study is focused on the one that took place in the blue area, when both aircraft merged in their established phase. Different scenarios were performed depending on the way through which aircraft converge.

a) Direct angle 90º: General Aviation (GA) aircraft was authorised to perform an aerodrome pattern (yellow line) and the RPAS trajectory (blue line) crossed it. To avoid the conflict ATCO gave separation instruction between points #2 (M2, V2) and #4 (M4, V4).

Figure 4. Direct angle 90º procedure

b) Direct angle 0º (head on): both aircraft performed aerodrome traffic patterns (same colour code as the previous one) in opposite directions. To avoid the conflict ATCO gave separation instructions between points #2 (M2, V2) and #3 (M3, V3).

Figure 5. Head on procedure

c) Direct angle 180º (overtaking): Same scenario as the previous section but both aircraft took opposite directions. The instruction commanded by the ATCO is the same.

Figure 6. Overtaking procedure

d) Runway Incursion: This case is slightly different due to the manned aircraft was not involved but two RPAS. One of them was on the runway while the other one had the authorization to land. Once the situation was detected, ATCO gave the miss approach instruction.

B. Human Performance Assessment

The results of this paper are based on real flights executed in various environments involving different RPAS operators and air traffic controllers, all of them with a large experience on their fields. Consistency of the results is ensured by using the same assessment methodology and data collection methods.

Human Performance assessment was based principally on qualitative data from the actors involved in the exercises backed by the analysis of the RPAS trajectory to identify any deviation from the nominal one. This Human Performance Assessment focuses on two roles: ATCOs and remote pilots.

Actors were requested to express their perception compared to their current operating environments which are considered the baseline scenarios for the assessment. Such scenarios are controlling manned aircraft in the case of ATCOs and operating an RPAS without ATC interaction for the remote pilots: those ones are considered as the reference scenario against which it has been compared the results obtained in both exercises.

The main reason why there were not specific reference scenarios is the innovative character of the exercises executed which simulate a fictitious scenario integrating RPAS into non-segregated environment that has not been developed before. Thus, the scenarios used by the actors involved to compare their perception are the ones in which they usually operate, as that has been explained in the previous paragraph.

C. Metrics and techniques

The lack of a reference scenario as such and the type of exercises, which involved a limited number of aircraft, prevented to conduct a proper analysis of workload; anyhow other indicators were assessed instead. The Human Performance Assessment followed the approach developed within the SESAR program by project P16.06.05 [1], making use of the available catalogue of metrics in order to be comparable with other SESAR validation activities carried out by other current or future similar projects as the present ones.

From the extensive list of human factor indicators defined in the SESAR Performance Framework [1] only those that adapted better to the particularities of the exercises were selected. The aforementioned indicators have been addressed through the observation and questions of different factors that are commonly considered revealing of them.

- Human error –adherence to ATC procedures and communications standards;
- Task balance within the team – distribution of workload among RPAS crew members with the new tasks to interact with ATC;
- Communication – quality and quantity of the communication between controllers and remote pilots;
- Situational awareness – capacity of the different actors to predict the evolution of the traffic;
- Technology acceptance – controllers´ perception about the feasibility of specific aspects (performance, procedures, etc.) of the RPAS.

These indicators are very useful to understand the potential impact of extrapolating the integration of RPAS to more complex environments with larger amounts of traffic that may include several RPAS flying in the same airspace.

The above-listed indicators have been analysed using the perception of controllers and remote pilots as well as behaviour observation from human factor experts.

Data was obtained by different means during the execution and after each flight following a step by step methodology which schema is depicted in Figure 7.

This approach allows obtaining the data on individual and group basis using the following techniques:

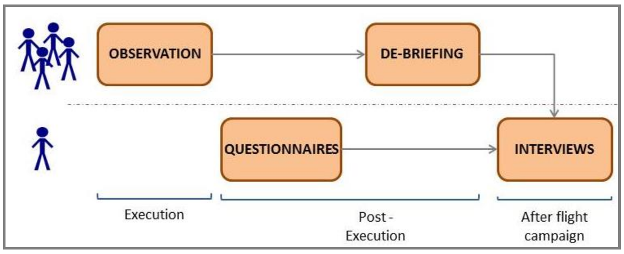

Figure 7. Step by step methodology

- Over-the-shoulder observation being non-intrusive: human factor experts pay attention to the behaviour and reactions of the actors to different circumstances;
- Ad-hoc developed questionnaires: developed before the execution of the exercises they are focused on the perception of expected situations. Questionnaires need to be answered just after each flight to obtain personal perceptions and avoid that the exchange of opinions could influence individuals;
- Debriefings: they are conducted after each flight based on the evolution and the information collected by observers. Individual perceptions expressed in front of other people that has participated in the exercise enrich the result and helps to solve doubts and to define mitigation actions if issues are found;
- Personal interviews: the information from the debriefings and a preliminary analysis of the questionnaires is used to ask for general feedback. As this means ensures the privacy of the opinions is very useful to collect information from more reserved people that may have difficulties to clearly express themselves in front of others.

This qualitative assessment was supported, in a second plane, by a quantitative analysis carried out by means of trajectories comparison. Although that one was not the main instrument used to achieve the goal set up in this paper, it was an effective mean to reinforce the results obtained by objectives metrics, regardless of the perception of the actors involved. The comparison was established between the trajectory seen by Radar (that is, the trajectory that ATCOs could see during the operation) and that one showed by the ADS-B. Also It has been analyzed the compliance of the RPAS trajectory with the flight plan established. Both analysis were developed in the horizontal and the vertical plane.

As it has been mentioned, this last study was only an instrument supporting a deeper understanding of some of the conclusions obtained through the human factor assessment explained before regarding human errors, situational awareness, technology acceptance and the confidence on RPAS.

IV. RESULTS

The main results obtained in this paper are based on using qualitative data from actors who have participated in the exercise as it has been pointed out in previous sections.

In TABLE 1 it is presented a summary of those human factor indicators from SESAR2020 Transition Performance Framework that has been impacted by the introduction of the RPAS in ATM environments. In order to achieve a general view of those results it has been used a colour code: Red colour shows a worsening trend (deterioration), green presents an improvement trend and the white one is synonym of maintenance of the reference value.

TABLE I. HUMAN FACTORS IMPACT ASSESSMENT

	Actors involved		
Human factors	***TWR ATCO***	***ACC ATCO***	***Remote Pilot***
Human error	⚪	⚪	🔴
Task Balance	⚪	⚪	🔴
Communication	🔴	🔴	🔴
Situational awareness	🟢	⚪	🟢
Technology acceptance	🟢	🟢	🟢

A. *Analysis of results*

As a continuation of this brief explanation, a more extensive analysis of those results it has been described below:

1) ***Human error:*** The lack of remote pilots' knowledge of phraseology and procedure might have a negative impact: remote pilots recognized that the interaction with ATC, especially regarding communications, could be a source of errors. It has to be noted that due to this lack of knowledge about the standard procedure, there was a mistake related to the RPAS pressure sensor: The RPAS crew changed the pressure reference from local to standard sea-level pressure at the wrong altitudes (in Spain the transition layer is between 6000 and 7000 feet).

2) ***Task Balance:*** Communications tasks together with navigation duties were under the responsibility of the same person, the station RP, what produced an imbalance on the RP's workload distribution. Concentrating RPAS piloting tasks and ATC interaction in the same person may have a negative impact since it could be missed some important duties.

3) ***Communication:*** Communication burden increased due to the interaction between RP and ATC and the quality of those communications gets worse due to errors related to collation of instructions and lack of authorization requests that however did not impact on safety. Furthermore, the latency between clearance and read-back was considered acceptable by ATCOs. Regarding the communication on the control transference between ATC units, it has been deployed complying with the standard procedure: any unusual situation was identified in which the ATCO had to call the RP. Any unusual situation was neither identified on the tactical renegotiation process to change the RPAS trajectory.

4) ***Situational awareness:*** In terms of safety impact in those scenarios where RPAS had to follow ATC advices for the conflict resolution, controllers' situational awareness was maintained although they dedicated more time to the RPAS that usually to other aircraft. Nevertheless, the use of ATC radar position in RP Station and ADS-B information respectively in each exercise is considered useful by Remote pilots as D&A (Detect and Avoid) alternative and during the execution of emergency procedures, providing them with own and surrounding traffic information. In the case of the ATC radar position it was necessary to change its localization on the station to allow them to check it in a more efficient way (without separating the sight from the main display). In spite of this, it has been considered also as the main source of distraction having to cope with piloting and communication tasks as it has been already explained.
Regarding ATC control, when radar information was not available, ADS-B was the way to provide the TWR ATCO (usually the air traffic control in the vicinity of the airport is carried out visually but due to the small size of the RPAS it was not possible) with information, increasing in this way the ATCO and RPs situational awareness.

5) ***Technology acceptance:*** In general terms, all the actors accepted the introduction of RPAS in ATC environments.
Regarding the integrity of control link for RPAS operations, it has been considered that latency issues was within acceptable levels as well as the integrity of voice communications between RPS and ATC.
Despite the specific procedures, especially for take-off, the runway occupancy times was not considered as having a high impact on runway throughput. Furthermore, landing accuracy was considered acceptable by ATCOs and RPs: ATCO didn't find any unusual event during landing and the precision was perceived like the one of the manned aircraft.
The feasibility of introducing RPAS in non-segregated airspace is supported by the level of compliance of the RPAS to the trajectory submitted in the FP. Moreover, the difference between the trajectory seen by RPs and that seen by ATCOs in en-route phase is within safety levels [15] allowing a proper understanding among different actors involved.

Moreover, the procedure to be followed by the RPAS in case of C2 loss (command and control link) or GPS loss are defined by the RPAS crew and they are not notified to ATC, thus ATC and other pilots are not able to foresee the evolution of the RPAS unless they had been established before the flight. Finally, it has to be noted that RPAS abrupt manoeuvres showed in radar could distract the controllers from other tasks, being this point to take into account in a future integration.

Regarding the quantitative analysis, it could be highlighted the results obtained from the trajectory comparison as it has been clarified in advance.

*6) **Trajectory analysis:*** The deviation of the track provided by ADS-B compared to the ATC radar tracks was within acceptable levels on the horizontal plane, and both showed a compliance with the established flight plan. It has been proved that both trajectories did not represent large divergences. On the vertical plane, the difference was studied in terms of flight levels or hundreds of feet and its average found also within the limits of the allowed error range for commercial aircraft transponder.

The moments when divergences are higher are those ones regarding calibration differences and changes between local QNH (altitude over sea level) to QNE (altitude over sea level calculated with standard atmosphere, 1013) and vice versa. This process could be the source of the main errors. In addition, the RPAS agility turning and ascending and descending could emphasize the divergence between both trajectories. This last difference is consequence of the frequency with which ATC radar take data from the RPAS much lower than the ADS-B one. Thus the trajectory drawn by the ADS-B adapts better to the real one than the ATC radar track in the situation explained (turning and ascending and descending).

V. CONCLUSIONS

Situational awareness of the remote pilots is one of the key issues to be improved in order to ensure a safe RPAS integration into non-segregated airspace. These demonstrations have proved that ground-based systems based on different technologies are effective to provide remote pilots with surrounding traffic information. The actors involved on these exercises have come to the conclusion that a similar technology is essential when operating RPAS close to other aircraft and during RPAS specific emergency situations, especially during the data link loss event. Furthermore, this conclusion is reinforced by the consistence between the different technologies used to track and monitor the trajectories by the actors involved in the scenarios deployed. These participants could have confidence on the ground-based systems used during the exercise increasing, in this way, their situational awareness by means of the information showed. Thus, this improvement is not only based on their own perception but in the quantitative results illustrated before.

Communications have been one of the most demanding tasks due to the remote pilots´ lack of knowledge of the standard procedures and phraseology. Apart from using non-standard phraseology, there were found important mistakes and the communication burden was higher than with manned aircraft. However, this aspect could be solved by means of specific training as part of RPAS pilot license requirements. A more balanced task distribution would be necessary to improve the quality of these communications allowing the RPs to focus on it. Besides those errors, there was another one related to the synchronisation of the altitude reference between RPAS navigation system and the ATC radar made by the Remote Pilot in charge of navigation tasks. The change of this reference has not been carried out at the correct moment which produced divergences among trajectories seen by the radar and the ADS-B. If this human error would have been executed in a correct way, divergences in this plane would have considerably reduced which would increase the confidence on the trajectories seen and the acceptance of the RPAS operations.

Despite the evident acceptance of the RPAS incursion in ATC environment, ATCOs and RPs have agreed about the necessity of more training to achieve a full knowledge about ATC phraseology. RPAS have associated emergency procedures not known in manned aviation, as the loss of data link and the loss of GNSS signal. Management of these simulated procedures requested more attention from controllers and remote pilots and it was considered as a potential risk for safety of the operations. In order to avoid it, it would be necessary to establish specific procedures and share them with all the actors involved on the new scenarios purposed by the introduction of RPAS in non-segregated environments, being the familiarization with those procedures essential to not affect operations safety.

VI. NEXT STEPS

1) Human factor assessment in more operationally representative environments: The execution of demonstration exercises along the European continent has proved the need to define further steps to facilitate a smooth and safe integration of RPAS into non-segregated environments. So far, these trials have been performed in much delimited environments trying to emulate mixed unmanned and manned airspace. However, this has a significant impact on the human analysis performed as the traffic sample is much reduced than usual sector loads. To fully understand the impact of these new stakeholders in current human roles, a proper human performance assessment should be done when integrating RPAS in more complex environments, representative of potential deployment scenarios.

Different validation techniques, like Real Time Simulations, would be a proper developing test for assessing a wide range of human factors and could favour the adaptation of both roles to an ATC environment with RPAS among the users.

*2) Assessment of the impact of a wider sample of RPAS:*These projects have demonstrated the need to integrate RPAS as part of the ATCO training due to the much different performance capabilities of these users compared to manned aviation. However, there is a wide range of RPAS types with unlike operational characteristics and performances. These projects have been useful to test a significant example of RPAS, however to ensure that controllers are appropriately trained to work in mixed environments a full range of unmanned aircraft types should be included in training programs. For this, it is needed to identify the types of RPAS that are more likely to operate in each environment as it is expected that due to the operational needs not all RPAS will use the same airspace.

To achieve a complete understanding of the impact that these new airspace users will have on human roles, especially air traffic controllers, it would be desirable to conduct a sensitivity analysis based on two factors: the type of RPAS and the number of them. It is expected that with an increasing sample of RPAS the workload and stress of human beings would increase and the same trend is anticipated to occur with low performance RPAS.

ACKNOWLEDGMENT

We acknowledge the support of the SJU that has promoted and financed the exercises from which the results have been obtained. We are very grateful to ISDEFE and INDRA as coordinators and contributors to both projects providing their expertise in Air Traffic Management and RPAS, respectively, as well as its proven expertise in managing projects. Also we would like to thank every partner that has participated on these exercises as ENAIRE providing engineers and ATCOs, INTA contributing with the RPAS and the manned aircraft together with the licensed pilots, FADA-CATEC providing engineers to develop the project tasks and AESA which has been involved in the different required authorisation. And last but not least we also would like to thank especially to the Spanish Air Force for their support and courtesy in sharing their facilities.

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