



Collaborative ATM-U-Space Interface

Manuel Martínez López and Marta García Gutierrez

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ATM-U-space interface and services

Manuel Martínez López, Marta García Gutiérrez

U-space systems engineering

Indra Sistemas S.A.

Madrid, Spain

mamlopez@indra.es, mggutierrez@indra.es

The AURA project led by Indra, lays the foundations for the integration of the new entrants in current and future air traffic environment, by developing the required concept of operations and validating a set of selected information exchanges services between ATM and U-space systems by identifying the requirements for U-space information exchange with ATM through SWIM.

I. INTRODUCTION

AURA PJ.34-W3 Collaborative ATM-U-space interface solution, is a medium-term concept focused on the data exchange between U-space and ATM systems in terms of information to be shared. This solution is focused on the generation of a common ATM-U-space interface by identifying an initial set of basic services. This set of services is defined considering the relevant information needed to be exchanged so to permit and guarantee the interoperability between both systems, avoiding airspace fragmentation and allowing safe drones' operations into controlled airspace.

The exchange shall ensure the necessary information is available to the related stakeholders in order to enable a coexistence of ATM and U-space traffic.

In this way, the mentioned set of information exchange services is composed by:

- Operation Plan: U-space flight plan Exchange from U-space to ATM, U-space flight plan authorisation and activation management, flight plan updates from U-space to ATM system.
- Tracking: Exchanges of manned aviation tracks from ATM to U-space and drones tracks from U-space to ATM system.
- Tactical Operational Message: Providing, among others, a message from U-space to ATM system indicating that a drone has conflict alerts.
- Traffic Non-Conformance Message: Provides a Non Conformance Monitoring report. Each U-space report informs to ATM that drone situation is no longer in line with its operational plan.
- Geofencing/Geozones: Provides UAS-Zones and other flight restriction information to drone pilots and operators from ATM system.

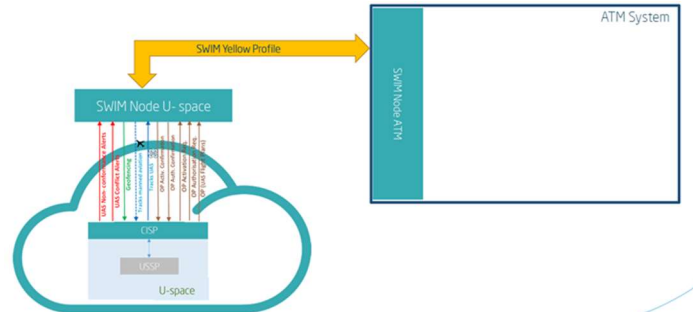


Figure 1: Information exchange services from between ATM and U-space

II. KEY POINTS AT SOLUTION LEVEL

Following key points were identified at solution level to be achieved:

- Permit the U-space operations in the controlled airspace through the definition of a common ATM-U-space interface.
- Maintain the level of safety
- Human Performance focused on:
- Workload being maintained at an acceptable level.
- Increase of Situational Awareness.
- Acceptability and trust on the concept.
- CWP HMI Enriched with graphical elements and functionalities to suit the U-space operations in controlled airspace.
- Identification of the operating environments where the solution can be developed.
- Definition and use of information exchanges and systems architecture configurations.

III. VALIDATION OBJECTIVES

A set of different validation objectives was established at the beginning of the project with the aim of focusing on the most relevant issues related to the ATM-U-space interface in terms of human performance and safety impact, as well as in terms of performance and technical feasibility.

In order to understand the afterwards approach on the different results obtained, the mentioned validation objectives are listed below:

- To assess the operational acceptability of roles, tasks and U-space operations in controlled airspace.
- To assess the technical feasibility which supports U-space operations in controlled airspace.
- To assess the suitability of the ATM-U-space interface for the different solution architectures supporting the U-space operations in controlled airspace.
- To assess the impact on human performance of U-space operations in controlled airspace.
- To assess the impact on overall safety of U-space operations in controlled airspace.
- To assess different operating concepts in terms of missions, operational procedures, information exchanges and architecture configurations.

IV. OVERVIEW OF AURA SOLUTION 1 VALIDATION EXECUTIONS

With the aim of covering a broad variety of ATM practices and platforms, AURA validation activities were divided in four different clusters. Each cluster was centered on a different geographical area or country and focused on different validation cases, allowing the project to cover the full scope of the problem using a “divide and conquer” approach. Thus, each cluster was able to tackle with sufficient depth a subset of the key issues regarding ATM-U-space collaboration and the full set of validations covered a broad variety of ATC systems and practices across Europe.

The mentioned clusters and their correspondent descriptions are:

- Cluster 1, based in Spain and led by Indra: The selected validation scenarios were representative of low density/complexity in very low level, CTR-TWR operations. The major part of the validation scenarios were performed mainly in the Tower of Madrid ACC (very large airport) and some others in the nearby of San Sebastian airport (other airport) considering interaction with manned aviation. Real Time Simulation was used as an appropriate technique to explore the critical aspects of V2 maturity level. The selected validation platform is composed by two systems, the ATM system and the U-space system, distinguishing three different architectures associated to three different iterations.
- Cluster 2, based in Hungary: The scenarios were validated in a location selected in the southeast of Budapest (Hungary), the St.Lőrinc Golf Club located 10 km from the terminals of the Budapest international airport (medium airport). The IEX’s connected different U-space business services between themselves, and to CISP and ATM systems.
- Cluster 3, based in France: These scenarios were validated within a real time simulation in Lille airport (small airport) environment. The purpose was to demonstrate a simplified SWIM oriented architecture between USSP and ATM systems contrasting with

three stakes U-space Architecture involving ANSP, CISP and USSP.

- Cluster 4, based in Italy: Considered a Real time simulation executed in Taranto-Grottaglie airport “Marcello Arlotta” (other airport), in Italy. The architecture to be used regards an ATC system and one USSP exchanging aeronautical Information, NOTAM, weather data, surveillance and track data, operational plan requests, alarms and dynamic airspace reconfiguration through their relevant technical systems and using SWIM as an essential enabler.

Having establish this context, this paper will, from now on, be focused on the detailed operational environment, technical development and specific results obtained within Cluster 1, which was based in Spain and led by Indra.

V. CLUSTER 1 VALIDATION ENVIRONMENT

As already introduced, this Cluster was based in Spain. However, the evaluation and development was managed by Indra’s leadership together with the contribution of other companies which could enrich the validation activity itself. At this stage, we are referring to both Frequentis and Airbus which offered their CISP and USSP correspondingly.

This exercise covered three different iterations based on three different architectures in order to be able to cover the variety of cases which could be offered. In this way, it was possible to propose several casuistries or use cases which could be developed under these three iterations.

In addition, and taking into account the importance of the divide and conquer approach proposed by PJ.34-W3-01, a set of basic services was considered in each casuistry regarding the required information exchanges to be developed within each one of them.

The following subsections will address, then, this three iterations validation framework indicating both the corresponding architectures involved together with the corresponding use cases and their interface’s services coverage.

A. Iteration 1

1) Architecture and use cases

This first iteration reflected the use of the ATM System from one side, and CISP and USSP functionalities from U-space system on the other side.

Both systems exchanged information using the ATM-U-space interface through the SWIM nodes connected to the systems.

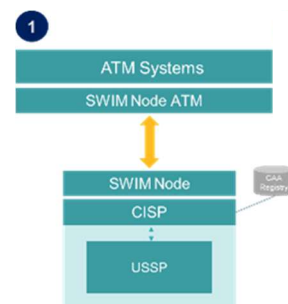


Figure 2: Iteration 1 architecture

Considering this architecture, three use cases were addressed during this first iteration:

- Use Case 1: UAS performing Navaid calibration. Operation plan and tracking IEX were evaluated.
- Use Case 2: UAS performs a Navaid calibration interrupted by a manned aircraft operation. Operation plan, geofence, tracking and traffic non-conformance monitoring IEX were evaluated.
- Use Case 7: UAS suffers a failure triggering a Non-nominal situation. Operation plan, tracking and traffic non-conformance monitoring IEX were evaluated.

2) *Validation scenario and execution*

Starting from the very first point, the first scenario or use case of this validation reflected a nominal operating environment. It started with a flight authorisation request from an UAS operator, which was received by the USSP and then sent to the CISP, being the last one the one who sent the request to the ATM system. In that moment, the ATM system could approve or reject this authorisation request sending the response in the opposite direction (CISP-USSP) to the UAS operator. This is mainly due to the fact that the scenario was considered high-risk, where unmanned planned trajectories may interfere with manned aircraft planned trajectories causing a potential conflict, so that the controller was responsible for authorising the flight authorisation request. Both authorisation and deny were evaluated at this stage so to be able to analyse the impact on the three platforms involved.

When the ATC Controller cleared/approved the flight authorisation request, ATC system displayed the UAS flight plan in CWP. Once the flight authorisation request was approved by the controller, the operator proceeded to perform a flight activation request, which was received by the USSP and CISP, being the last one the one who sends the request to the ATM system. The ATM system, again, could approve or reject this flight activation request sending the response in the opposite direction (CISP-USSP) to the UAS operator. Once the controller cleared/approved the flight activation request, the ATC system displayed the flight plan UAS in CWP, as active. After the activation of the flight plan, the UAS took off, sending the U-space system (through USSP and CISP) the tracking information to the ATM system, displaying this information to the ATCO and providing to him with a complete situational awareness of the U-space traffic.

In the same way, the ATM system shared with the U-space side (through CISP-USSP) the tracks corresponding to manned aircrafts, using this tracking for displaying manned traffic in the U-space system.

Once this whole process was finished, scenario or use case 2 came into play. At this stage, the UAS was currently carrying out the navaid calibration mission when a manned aircraft operation needed to operate at the same operational volume. This situation led ATCO to change the UAS zone condition to a "PROHIBITED" status so that this was notified to the USSP through the CISP.

UAS operator received then by from the USSP the new UAS zone condition and started following the actions stated in its

contingency procedures to vacate the restricted area. For the purpose of this exercise, the procedure to be followed by the UAS was returning back to where the UAS took off, and then land.

USSP was monitoring UAS performing the corresponding procedure to ensure UAS eventually vacated the restricted area in a timely manner. Besides, as soon as the restricted area was published by USSP, USSP conformance monitoring service triggered a non-conformance alert on the UAS flying within the restricted area. Both UAS tracking and non-conformance alert were sent from USSP towards ATS System through CISP.

Upon receiving UAS tracking and conformance alert from CISP, the ATS System displayed such information on the Controller Working Position (CWP) so that to increase ATCO's situational awareness about UAS position with regards to the restricted area. Once UAS left the restricted area, USSP conformance monitoring service detected UAS is no longer within the restricted area and then stopped raising the non-conformance alert. Subsequently, USSP stopped sending conformance alert towards ATS System through CISP.

After receiving confirmation that UAS had vacated the restricted area -by means of UAS tracking information and conformance alert no longer active on CWP- ATCO proceeded to clear manned aircraft, accordingly.

In a second approach of this iteration, scenario 7 or use case 7 took place. This scenario began with the same process of authorisation and activation explained in scenario 1 so that UAS mission has already started.

At some point during the mission, the UAS started deviating from its intended flight plan due to a UAS failure. Then, USSP conformance monitoring service detected an UAS deviation, triggering a non-conformance alert. After that, non-conformance alert due to UAS deviation was sent towards ATS System through CISP. Upon receiving non-conformance alert due to UAS deviation, ATS System automatically displayed UAS tracking and non-conformance alert on the Controller Working Position (CWP). Based on such UAS information displayed on CWP, ATCO warned manned aircraft in the surroundings about UAS deviation in order to raise situational awareness among aircrew.

After a while being deviated from the intended trajectory, UAS pilot managed to get the UAS back to the approved flight plan. Thus, USSP conformance monitoring service detected UAS is no longer deviated from its intended flight plan and then stopped raising the non-conformance alert. Subsequently, USSP stopped sending conformance alert towards ATS System through CISP.

Once ATCO notices that UAS non-conformance alert is no longer active on CWP, ATCO informed manned aircraft about UAS being back to normal, and therefore no longer being a hazard for manned aviation.

B. *Iteration 2*

1) *Architecture and use cases*

This iteration reflects the use of the ATM System from one side, and CISP and USSP functionalities from U-space system on the other side. Both systems exchange information using the ATM-

U-space interface through the SWIM nodes connected to the systems.

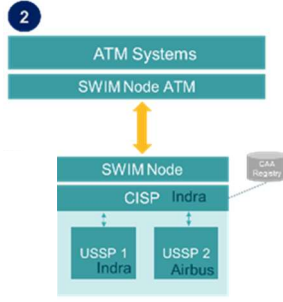


Figure 3: Iteration 2 architecture

Considering this architecture, the following use cases were addressed:

- Use Case 3: UAS performs scheduled aerial works–Flight Plan submission for approval. Operation plan IEX was evaluated.
- Use Case 4: UAS performs scheduled aerial works – Mission (tactical). Operation plan and tracking IEX were evaluated.

2) Validation scenario and execution

Regarding this second iteration, scenario or use case 3 reflected a nominal operating environment, starting with flight authorisation requests from two UAS operators, which were received by the USSP 1 and USSP 2 correspondingly. From USSP 1, a Flight Authorisation Request is generated and automatically approved from USSP 1 since there were no conflicts.

From USSP 2, the same process was followed for FP 2.

Along the assessment process, USSP 2 checked the conflicts of FP 2 and detected a conflict with FP 1. USSP 2 proposed a time deconfliction to Operator 2 (FP 3) and sent it. From USSP 2 HMI, operator checked the FP 3 and approved it, sending the approval back to USSP 2.

Immediately afterwards, scenario or use case 4 took place. Both USSPs sent a flight plan activation request so that both UAS 1 and UAS 2 took off and also helicopters 1 and 2 took off.

As already explained in previous interactions, all tracks from UAS operations and manned ones are shared between U-space and ATM.

At a certain moment, Helicopter 1 violated the conflict distance with UAS 1. USSP 1 correctly detected the conflict. The same happened with Helicopter 2 and UAS 2.

Both USSPs informed the UAS about the conflicts and these were presented through USSP HMI. Then, USSPs sent conflict alerts to the CISP correspondingly and CISP transmitted the alerts to ATM through SWIM. ATM received the alerts and presents them to the ATCO through CWP HMI.

Then, both UAS executed a contingency maneuver to end the conflict so that a non-conformance alert was presented to each operator temporarily. Finally, UAS 1 and UAS 2 left the conflict area and conflict alerts were no longer presented to operators through USSP HMI.

Then, conflict alerts were no longer sent to CISP, so that they were no longer shared with ATM.

C. Iteration 3

1) Architecture and use cases

Represents 2 countries and the operations are performed under controlled airspace for the country with the ATM system, and the operations are performed under non-controlled airspace for the country without ATM system. The CISPs of both countries are connected by a common USSP representing the cross border between the countries (USSP1).

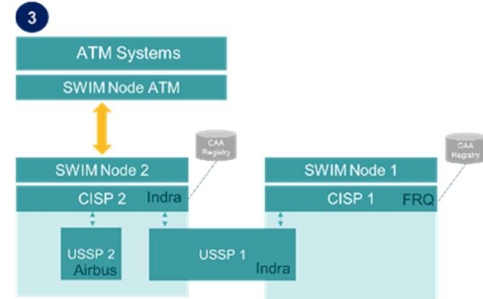


Figure 4: Iteration 3 architecture

Considering this architecture, the following use cases were addressed:

- Use Case 5: UAS performs scheduled aerial works – Flight Plan crosses two countries. Operation plan IEX was evaluated.
- Use Case 6: UAS performs scheduled aerial works – Mission (Tactical) two countries. Operation plan, tracking, traffic non-conformance monitoring and tactical operational message IEX were evaluated.

2) Validation scenario and execution

This iteration had the particularity of validating the casuistry of UAS crossing to one country to another through a controlled airspace boundary.

The case of scenario or use case 5 started with the UAS operator connected to the USSP cross-border, in the uncontrolled airspace side from the origin country, for checking the airspace information provided by the USSP in order to create a flight plan and submitting this to the USSP.

The USSP cross border processed the flight plan authorisation request, based on the information provided by:

- The CISP from its country.
- The CISP from the destination country.
- The USSP information from destination country.

The flight plan authorisation request approved was communicated to the UAS operator who submitted the request to the CISP belonging to the uncontrolled airspace side, from the origin country, and was sent to the CISP in the destination country under controlled airspace. The ATM system in the destination country, received the approved flight plan through the CISP in its country.

Once scenario or use case 6 started, the flight activation request was managed and communicated following the same process as the one followed for the flight authorisation request.

Two types of conflicts were evaluated and tested. The first one took place under non-controlled airspace and it involved the two UAS corresponding to the different USSPs. Once this alert

raised, it was sent to the UAS operator and to the CISP of the uncontrolled airspace side (in the origin country).

After this first conflict, the UAS moved between the origin country and the destination country (cross-border area), so that it sent a notification to the CISP in controlled airspace, indicating the UAS was transferred from no-controlled to controlled airspace. CISP in controlled airspace received this UAS traffic information and sent it to ATM.

On the other side, the ATM system sent the tracks of the manned aviation to the U-space system through the CISP. These tracks of manned aviation were sent also by the CISP to the USSP. It was then when it took place the second conflict, involving a nearby alert between one UAS and a manned aircraft. Following this second situation, alerts were sent both to UAS operator and to the CISP under controlled airspace. The CISP then informed the ATM system.

VI. CLUSTER 1 VALIDATION RESULTS

By the already exposed validation scenarios and executions, Cluster 1 aimed to evaluate and validate the whole set of objectives already introduced in section III. In this way, and according to the different use cases covered, the results extracted are detailed introduced below.

A. Operational acceptability of roles, tasks and U-space operations in controlled airspace

Several questionnaires were distributed for evaluating the acceptability of these new functionalities and the new related tasks in terms of addressing a SATI type questionnaire.

The questionnaires distributed to the operational staff performing the ATCO's role shown also a significant improvement on their perception of the new operating system in comparison with the reference scenario. They perceived a significant reduction on the management of both manned and unmanned traffic, decreasing the score of this parameter from 3.8 to 2.3 out of 6 total points. The adequacy of the support received by the new ATM-U-space collaborative interface was also improved from 2.2 to 4.4 points out of 6. Similar improvement was found in the efficiency and usefulness of the HMI, increasing its score from 2.7 to 4.8 points out of 6. Overall, the new developments and implementation were very positively perceived, increasing its score from 2.1 to 4.4 out of 6 total points.

B. Technical feasibility which supports U-space operations in controlled airspace

The operational staff operating the ATCO's position on the CWP considered the U-space information received adequate enough to manage their new U-space-related tasks. The new information provided by the HMI with relation to UAS operations was considered satisfying and non-invasive as they were able to perform their regular ATM tasks with no major interruption.

An example of the interactions from operation plan and tracking services which allowed this information flow can be seen in the following pictures:



Figure 5: CWP View

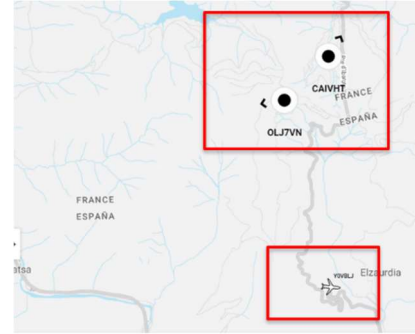


Figure 6: USSP View

In the meanwhile, the CISP correctly received these operation plan requests regarding both authorisation and activation of both UAS from Indra USSP and activation of the other UAS from Airbus USSP.

C. Suitability of the ATM-U-space interface for the different solution architectures

The distributed information allowed to perform the operations safely and ensuring the situational awareness of every actor during all three iterations and different partners.

During the first iteration, the authorisation process performed during the strategic phase was a success as the USSP was able to send via CISP the subsequent request for the operation. CISP sent this information to the ATM systems thanks to the SWIM interface while keeping record of all requests and status evolution. The operational staff performing the ATCO's role was able also to assess all requests and give the confirmation or denegation to these operation plans while performing their regular tasks.

In the tactical phase, the USSP was able to register all tracking, alerts and geofence information coming from U-space.

Operational staff on the ATM systems performed also geofencing for ensuring a manned aircraft emergency landing, clearing the area from all U-space activities.

Next, a series of illustrations showing several of the key moments related to this interaction:



Figure 7: Manned aircraft approaching while the UAS is missioning.
On the right, ATCO change the area's status to PROHIBITED



Figure 8: CISP view of process of the UAS leaving its inspection activities as the restrictive area has been cancelled

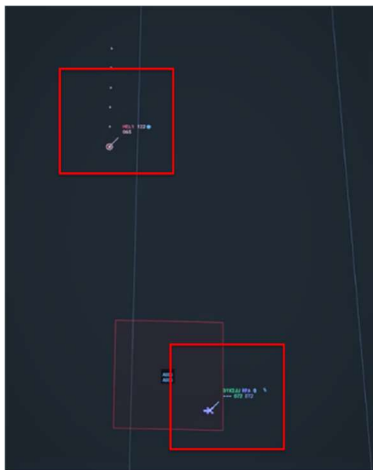


Figure 9: CWP view

The second iteration involved an integration between Indra's platforms and an Airbus USSP.

The information exchange was successfully validated as the system ensured an adequate situational awareness for all the actors, and the Strategic Deconfliction Service allowed the flight plans to operate knowing that their operations will not have any kind of U-space inner conflicts between them.

The Tactical Conflict alerts also proved their benefits alerting of conflicting situations between two UAS (each one subscribed to a different USSP) and to manned aviation.

The next figure shows the Tactical Conflict alarm raised on the CWP once manned and unmanned tracks enter in a nearby situation:

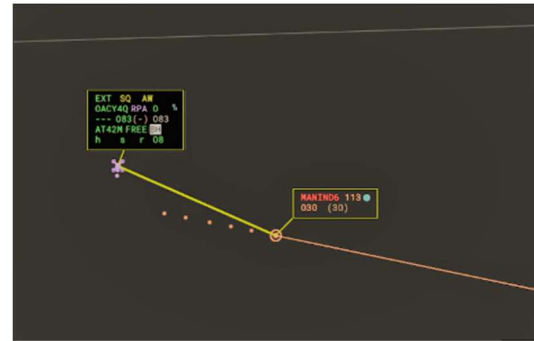


Figure 10: Tactical alert raised on the CWP

During the third iteration, alerts between U-space operations and between UAS and manned aircrafts were raised and managed correctly, keeping all actors successfully informed. In the case of the tactical operational message, a conflict between two UAS within the uncontrolled airspace country was held, correctly showing these alerts both in USSP and CWP.

D. Impact on human performance of U-space operations in controlled airspace

Several questionnaires were addressed by the ATCO involved in iteration 1, 2 and 3 regarding issues like workload, situational awareness and general acceptance of the concept. From a global perspective, the controller workload is not affected by the activity of this interface. Tasks could be performed efficiently and safely. The same went with the situational awareness which at all times remained at high levels, allowing ATCO to have a complete picture of the air traffic situation in its airspace of responsibility.

However, the need for certain improvements in the HMI was identified in order to minimise controller interventions, as well as the need for certain extra services demanded by the controllers.

It is noticeable a decrement from the reference scenario to the solution one in the results of almost every aspect: frustration, effort, temporary demand, physical demand and mental demand, whereas performance has experimented an important increment. This shows a considerable improvement in every aspect thanks to ATM-U-space collaborative interface.

The distributed questionnaires to the operational staff performing ATCO's role shown a significant improvement brought by the implementation of the system. They scored the decrease in Frustration from 9.5 to 3 points out of 20. This measure proves that the implemented services and their interface in the HMI were able to give the necessary information to the ATCO's screen, enough to perform their related tasks without stress and an adequate situational awareness.

The Effort applied during the operational scenario was perceived to decrease also. The ATM-U-space collaborative

interface gave the ATCO the possibility to easily manage operations, geofences while not disturbing their main ATM activities. The Effort parameter shown a decrease from 15.1 to 9.5 points out of 20. Their performance was considered to be raised also, as the flexibility and the effectiveness of the new system allowed to enable successfully a collaborative environment with intuitive commands and clear alerts and other information notifications, such as tracking and geofence.

The Temporary, Physical and Mental demand were also decreased for the same reasons. Temporary demand decreased from 14 points to 8.6. Perception on physical demand also decreased from 8.7 to 4.5 points out of 20 – nearly to its half. And the Mental demand decreased from 15.3 points to 8.7. The new ATM-U-space collaborative interface provide the ATCOs with the necessary tools to perform a more effective management over their jurisdiction having into account the new U-space related activities.

E. Impact on overall safety of U-space operations in controlled airspace.

Some questionnaires regarding safety issues were answered by the operational staff involved and will be furtherly explained. After observations and corresponding debriefings, it was concluded that both manned and unmanned operations could be carried out safely, as the controller had the necessary tools at all times to be aware of the activity of these new users. In addition, being responsible for authorising and activating their flight plans gave the controller the opportunity to assess potential conflicts and keep manned aircraft activities safe at any time. The results on the distributed questionnaires confirmed the acceptance and adequacy of the new implemented technology and services, and its success in enabling safely U-space operations in a CTR.

While it was clear the existence of a necessity for defining contingency procedures, the implementation of the solution gave serious benefits to the ATCO's perception, increasing their score from 1.4 points to 3.2 points out of 6.

With the new technological improvements brought by this solution, an increase in the general safety level is obtained. This is perceived in several ways. The non-nominal U-space operations events are perceived to be a more controlled threat to the manned aircraft operations. This parameter perception increased from 1.3 points to 4.3 out of 6. The interface helped also defining clear procedures for nominal operation. From the ATCO's perspective this score is improved from 1.7 to 4.9 points out of 6 (the biggest improvement in the solution).

As from the USSP's perspective, from the ATCO's one it is perceived as this solution helped in decreasing the necessity of standards definition. Scoring this decrease from 5.3 points to 4.1 points out of 6.

The situational awareness is also much higher now as the ATCO's have the possibility of visualizing more U-space information in their CWP. The score on situational awareness increased from 1.6 to 4.5 points out of 6. The given information seems to be aligned with the operational needs of each actor and does not overload the HMI with unnecessary information.

The overall safety on ATCO's perception was improved thanks to the implementation of the ATM-U-space collaborative interface. They consider that this solution made the integration between manned and unmanned operations more feasible, as potential nearby events between UAS and traditional aircrafts were successfully managed in a safe and secure way. The perception on this kind of events was scored with 4.7 points out of 6 (improving the original 1.9 score of the reference scenario).

F. Operating concepts in terms of missions, operational procedures, information exchanges and architecture configurations

Each USSP had the information necessary to build its flight plans and check their viability against the information recorded on the CISP. The different interfaces allowed both "operators" via USSP, and ATCO's on their HMI to receive enough information for performing all their roles related to this exercise.

The ATCO's position was able to receive all necessary U-space information. This information did not disturb their main activities and was enough to gain an adequate level of situational awareness. They were able to receive authorisation and activation request and responding to them. In the tactical phase, they were able to configure and publish a geofence, to revoke active flight plans and to receive several U-space information, like Non-Conformance and Tactical alerts.

VII. CONCLUSIONS

Operational acceptability and impact of roles, tasks and procedures:

- Adequate roles and responsibilities performance considering all actors involved.
- No major interruption in regular ATCO tasks. CWP functionalities intuitive and well received by the ATCO.

Technical feasibility:

- ATM-U-space collaborative interface enables the integration of U-space platforms with the ATM systems in a coherent and harmonized way.
- Five basic services defined were performed correctly their different functionalities
- ATCO's position considered the U-space information received adequate enough to manage U-space-related tasks.

ATM-U-space collaborative interface validation:

- The performed operations designed in order to test all different interactions that the basic services are able to cover.
- The authorisation process performed during the strategic phase successfully performed.
- ATCO's role able also to assess all requests and give the confirmation or denegation to the operation plans.
- U-space systems able to register all tracking, alarms and geofence information coming from U-space. This information was shared with the ATM systems.
- Operational staff on the ATM systems performed geofencing functionality for ensuring a manned

aircraft emergency landing, clearing the area from all U-space activities.

Human performance:

- The controller workload almost not impacted by the activity of this interface. Tasks can be performed efficiently and safely.
- Situational awareness remains at high levels, allowing ATCO to have a complete picture of the air traffic situation in its AoR.
- The need for certain improvements in the HMI identified, in order to minimise controller interventions, as well as the need for certain extra services demanded by the controllers.

Safety:

- Both manned and unmanned operations carried out safely.
- The results confirmed the acceptance and adequacy of the new implemented technology and services, and its success in enabling safely U-space operations in controlled airspace.

Services defined and the provided means of use of this ATM-U-space collaborative interface, safely carry out an information exchange between all the actors involved allowing the interoperability of the interface:

- Operational staff:
Able to define operations, make a request for authorisation and receive an approval or a rejection of their request.
Receive the tracking and alarms from the unmanned operations on their area of interest, geofence information and ATM information when a proximity situation occurs.
- ATCO's position able to receive all necessary U-space information:
Able to configure and publish a geofence, to revoke active flight plans and to receive several U-space information, like Non-Conformance and Tactical alerts.
Activation and authorisation processes are correctly carried out and accepted by ATCO role.

VIII. FUTURE RESEARCH: FROM AURA TO ENSURE

The recently started ENSURE project is led by Indra and that takes place in the framework of the SESAR 3 Programme. This project is the continuation of AURA. The objective of ENSURE is to achieve full integration of ATM and U-space systems, by refining and completing the definition of the common ATM-U-space interface and identifying new working areas with impact on the already started common interface. New operating methods and services will be defined, completing the information exchanged and permitting take one more step in the interoperability between both systems. Some of the new services identified to be added to the original interface are:

- Collaborative interface with ATC: Offering verbal or textual communication between the remote pilot and

ATC when a drone is in a controlled area. Enables to drone pilot to receive instructions and clearances in a standard and efficient manner as manned aviation. Voice system communication or possibility to explore any kind of CPDLC between Controller and ATM-U-space drone pilot will be explored.

- Emergency Management Service and Contingency Plan: U-space system share with ATM system the emergency procedure (contingency plan) which is going to follow in a particular emergency situation.
- Strategic Conflict Resolution Service: Complementing the current Operational Plan Information Exchange Service, not only by approving or denying the operating plan, but also proposing alternatives to a given flight plan which cannot be approved.
- Dynamic Airspace Reconfiguration Service and Capacity Management Service: Information exchanges between ATM and U-Space (and vice versa) for sharing new volumes definition (U-space Airspace reconfiguration means U-space airspace volumes modifications).

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