Dynamic Airspace Re-configuration for Drones with Varying Mission Requirements

The Evolution from Project AURA to Project ENSURE

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***Abstract*—In the future, operators of Unmanned Aerial Systems (UAS) are expected to further extend their activities beyond altitudes of 500 ft, which is the current very low-level (VLL) limit in urban and suburban environments. This means that vehicles performing such operations will need to share airspace resources with manned traffic at higher altitudes.**

The SESAR Industrial Research Project AURA investigated requirements for an interface between Air Traffic Management (ATM) controlled airspace and highly automated U-space airspace for large numbers of unmanned aircraft to identify practical segregation methods. ATM U-space Shared Airspace (AUSA) was defined as a generic type of airspace that can be delegated between the two regimes by a process called Dynamic Airspace Re-configuration (DAR). In AURA this process was not automated but carried out by an air traffic controller, the DAR Manager. AURA results indicated that DAR processes will need refinement to better streamline communication between all actors. Furthermore, investigated U-space contingency scenarios showed that different types of situations need different DAR approaches. Accordingly, automation support levels may also change when different types of contingency are encountered. The SESAR 3 ENSURE project is expected to address these communication and automation issues in the DAR process and validate the changes through simulations and flight trials.

This paper describes the results of NLR experiments with human-in-the-loop simulations carried out for AURA and what changes will be introduced and tested in ENSURE. It will also give an outlook into the different types of scenarios considered for future flight tests.

Keywords-UAS, U-space, air traffic management, dynamic airspace re-configuration, AUSA, CISP, contingencies, NARSIM, U-FLY, SESAR, AURA, ENSURE

I. Introduction

In the near future, it is expected that an increasing number of Unmanned Aerial Systems will operate at very low-level altitudes of up to 500 ft in urban and suburban areas. If these new airspace users will extend their operations to higher altitudes to perform special service missions, such as military inspection flights, they will have to share available airspace resources with manned traffic.

Considering this dilemma, the SESAR Industrial Research Project AURA investigated requirements for an interface between airspace managed by air traffic control (ATC) and highly automated U-space airspace for large numbers of unmanned aircraft and defined the so-called AUSA, ATM U-space Shared Airspace. AUSA is a generic type of airspace that can be delegated to contain both ATC and U-space controlled airspace volumes. Within such airspace, the different volumes may be delegated between the two regimes by a process called Dynamic Airspace Re-configuration, short DAR.

AURA developed DAR as a process that would be carried out by an experienced air traffic controller, called the DAR Manager. One of the assumptions was that contingency situations would require too many non-standard considerations for airspace changes and that current automation solutions would not be able yet to accommodate such complex tasks. Furthermore, investigations into human decision processes for DAR operations were a primary objective of AURA, so that the decision to pursue this option as a first step was an obvious one.

Towards the end of the AURA project several results obtained during highly-realistic simulation activities with air traffic controllers (ATCO) indicated that DAR processes will need refinement to better streamline communication between all actors, particularly between U-space users affected by DAR solutions and the DAR Manager. Furthermore, the different character of contingency scenarios hinted at the necessity to more clearly categorize the different urgency levels in a contingency DAR request. Only when these steps are taken, more automation options could be employed that may support the DAR Manager or even lead to a redistribution of tasks and responsibilities between the DAR Manager and automation.

The recently started ENSURE project is expected to address the mentioned issues in the DAR processes and will address DAR urgency levels and automation needs in one of its validation activities. The activity proposed by NLR together with the Royal Netherlands Navy will investigate special drone missions in Dutch airspace with different DAR urgency levels and timespans in a multi-layered approach encompassing highly-realistic simulations on the ATC side and a drone flights for testing the developed interfaces and automation.

In the following, a summary of the AURA concept and its implementation into a highly realistic simulation environment, the NLR ATC Research Simulator (NARSIM) will be given. The major results of the experiments carried out by AT-One, the European ATM Research Alliance of DLR and NLR, will be presented and approaches to address encountered issues and detected gaps in the concept will be sketched. Finally, a number of potential flight trial scenarios will be identified that may help gaining a better understanding of the required procedures, information exchanges and interfaces to appropriately support both air traffic controllers and drone pilots when carrying out drone operations with dynamically changing mission requirements.

II. AURA Concept Elements

A. *General Considerations*

The operational concept developed by AURA was based on the idea that VLL airspace is the most fundamental option for safely separating manned and unmanned aircraft operations [1]. This is because manned aircraft typically fly above a minimum safe altitude, especially when flying over obstacles or densely populated areas. In contrast, UAS typically operate within VLL airspace. However, AURA also recognized that in the medium-term future, unmanned missions may require UAS to operate at higher altitudes. For example, special inspection flights may necessitate flying at higher altitudes and within other types of airspace. In AURA, a particular emphasis was placed on the use of so-called Za-volumes, as proposed in the CORUS concept of operations [2]. When UAS operate in Za-volumes, there are additional requirements placed on both the UAS and its operator. These requirements concern communication and system aspects of the vehicle (e.g. Detect-and-Avoid, DAA) and certification and licenses that the operator must acquire. An approved operation plan is required as well.

The operational solution for separation between manned operations in controlled airspace (CAS) and unmanned traffic in abovementioned U-space volumes suggested by AURA relied on the definition of AUSA, which is airspace wherein both manned and unmanned operations can be carried out. Dedicated AUSA volumes can be delegated to U-space (Za-volumes), if required, and the operational solution to achieve this was Dynamic Airspace Re-configuration, DAR.

B. *Interface between ATM and U-space*

The AURA concept is built upon a collaborative interface connecting ATM and U-space. This interface relies on U-space services on one side and additional services necessary for implementing the concept on the other. In order to address potential shortcomings in the U-space concept, AUSA was defined. Moreover, the exchange of information among various actors, roles, and services within AUSA was further developed and described. To facilitate this analysis, detailed information flow diagrams were created, taking into account the specific tasks associated with each role or service. These tasks were categorized as pertaining to either the strategic phase, the tactical phase, or both. One section of these diagrams, which is also detailed in the AURA concept, concentrates on the essential components needed to enable DAR processes [1]. The relevant sections are shown in Figure 1.

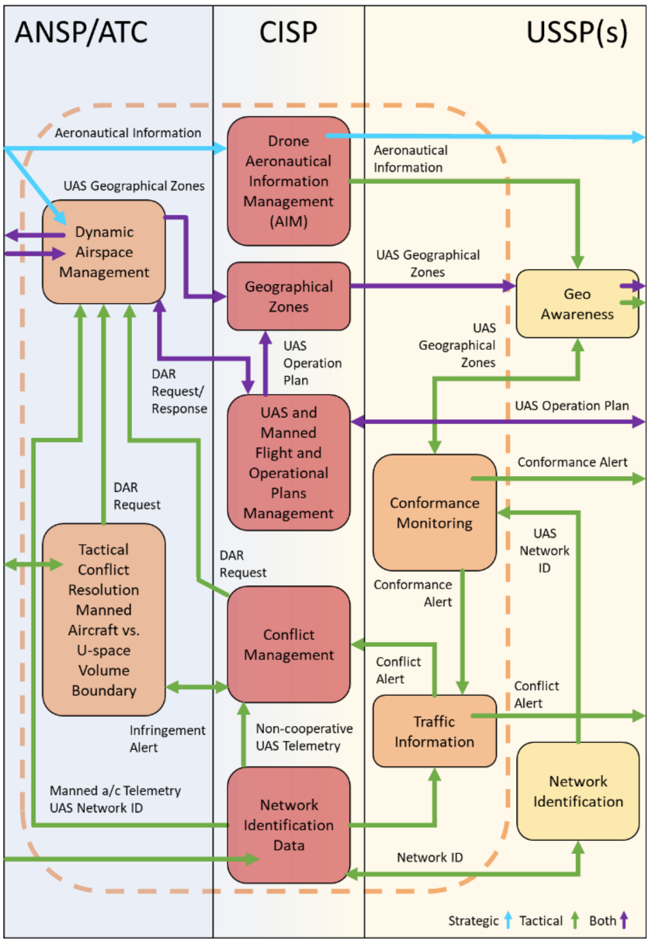

Figure 1. Collaborative ATM/U-space Interface with Focus on DAR

The diagram provides a clear separation between manned aircraft operations, overseen by ATC, on the left-hand side, and U-space operations, overseen by U-space Service Providers (USSPs), on the right-hand side. The essential bridge connecting these two domains was conceptually facilitated by the Common Information Service Provider (CISP) situated at the centre. Consequently, the Dynamic Airspace Service on the side of ATC needed to be defined for interaction with the CISP.

C. *Dynamic Airspace Re-configuration Processes*

The AURA operational solution to allow strategic planning and contingency planning and support for activating U-space airspace elements in AUSA was called Dynamic Airspace Re-configuration, DAR. Initially, DAR may involve manual intervention by ATC personnel, such as when planning strategic missions for UAS. However, it was anticipated that in the future, automation will take a more prominent role. This automation will streamline the process, primarily by conveying planned airspace changes to tactical controllers well in advance through a collaborative interface. Responsibilities will gradually shift towards systems with higher levels of automation. In this evolving landscape, human operators will still play a crucial role, requiring effective support, especially in situations where airspace changes occur rapidly with short planning windows. This scenario is often encountered in U-space airspace contingencies.

When applying the DAR process, a designated DAR Manager, typically an experienced ATCO, assumed the role of overseeing and managing AUSA volumes depending on the demand for either manned or unmanned operations. The initial state of these airspace volumes was considered to be contingent on local agreements, but as a general practice, particularly in the vicinity of ATM-controlled airports, it was anticipated that the default setting would be CAS. Thus, in such conditions, AUSA was reconfigured by the DAR Manager, transitioning from so-called blue volumes (ATC-managed) to orange volumes (U-space-managed) wherever required and feasible with the purpose of accommodating an increased volume of unmanned operations alongside manned operations around an airport. In accordance with the concept description, management of the orange airspace volumes was entrusted to U-space Service Providers (USSPs) employing the necessary U-space services for safe operations. Several assumptions came into play regarding the DAR process and the responsibilities of the DAR Manager (Figure 2).

One of the primary assumptions was the necessity for coordination and agreement between USSPs and ANSPs when taking actions that impact both manned and unmanned operations. Additionally, it was essential to determine that ATM maintains ultimate authority in approving any re-configurations within AUSA to safeguard manned aviation interests. Another crucial consideration involved recognizing a broad spectrum of re-configuration timeframes. Demand variations can range from being relatively stable, prompting more strategic decisions, to being highly dynamic, leading to constantly evolving airspace configurations.

Furthermore, technical prerequisites for vehicles operating within AUSA volumes had to be specified. The enforcement of area restrictions and the containment of UAS within orange volumes often relies on geofences and geo-cages. This, in turn, necessitated compliant software for unmanned vehicles.

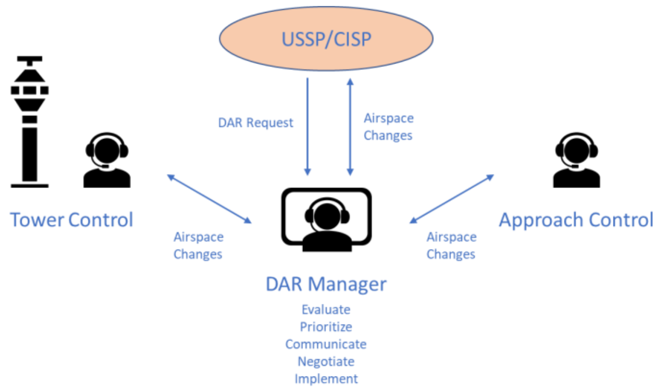

Figure 2. Simplified Depiction of DAR Manager Role

Additionally, all vehicles were supposed to undergo registration with the relevant authorities and equip themselves with Traffic Collision Avoidance System (TCAS) or Detect-and-Avoid (DAA) technology as an added layer of safety. In light of these considerations, the AURA-defined DAR stood as a secure means to facilitate the flexible utilization of dedicated airspace volumes by both manned and unmanned traffic, ensuring safety and adaptability.

DAR processes are supposed to work for strategic decisions and planning, but also in situations with highly varying traffic patterns. On top of that, some of these variations will be due to contingencies that occur inside U-space airspace volumes. For clarification, AURA defined contingencies as unforeseen events that demand swift resolution, ideally within a few minutes. However, certain contingencies necessitate even more immediate attention, with response times measured in the range of seconds. These instances were referred to as emergencies, as they may breach existing airspace restrictions and pose an imminent threat to manned aircraft operations, requiring rapid intervention by ATC. NLR and their AT-One partner DLR focused their research on such contingency operations.

D. DAR Management in UAS Contingency Situations

Together with AURA project partners, AT-One elaborated a concept for DAR contingency requests originating in U-space. Rotterdam The Hague Airport (EHRD) was chosen as an appropriate operational environment in terms of airspace and traffic movements to validate the concept (Figure 3). An ATCO, who had experience in working as an approach controller at the airport, was contacted to discuss potential operational issues that might occur when working with AUSA in the EHRD environment (see also [6] and [7]).

During the discussions the following emerged:

- Designated U-space airspace (orange volumes) above the city centres in the vicinity of EHRD should be defined as VLL with a maximum altitude of 500 ft.
- Terminal airspace separation values must initially be assumed (3 NM horizontal, 1,000 ft vertical) between all manned aircraft and the orange (U-space) volumes, unless safety studies have been performed that allow for smaller separation distances.
- For each of the pre-defined AUSA volumes that can potentially switch from blue to orange, the possible consequences for inbound and outbound movements must be determined. Potential limitations in carrying out approach and departure operations at the airport and in the terminal area, must therefore be identified and must be known to all ATM actors.

As a consequence of this, it was assumed that:

- Designated U-space airspace (VLL) is defined for the cities of Rotterdam, The Hague, and Delft, including the surrounding populated areas and safety studies were conducted determining that all current operations at EHRD can be carried out without limitations.

- The operational consequences at EHRD for each of the pre-defined AUSA volumes becoming unavailable for manned traffic when delegated to U-space are known to ATM actors.

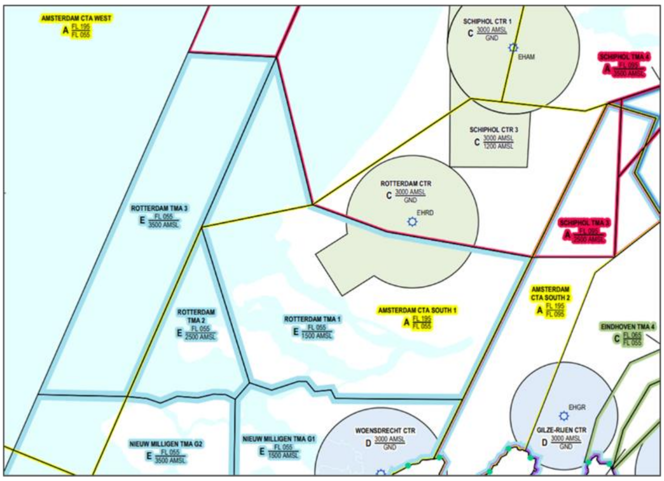

Figure 3. EHRD Airspace Situation, from AIP NL, ENR 6-2.1 (12-Aug-2021)

Initially, the operational assumptions only appeared to be relevant to airport and Terminal Manoeuvring Area (TMA) controllers. However, it later became evident that the DAR Manager, who serves as the key figure in ATM responsible for executing airspace changes, needed to possess a thorough understanding of local agreements (e.g. concerning proximity of airports EHRD and EHAM) and the implications for manned aviation traffic. This became particularly crucial when the objective was to alleviate the workload of airport and TMA tactical controllers for highly dynamic situations, such as contingencies and emergency operations.

Contingencies were characterized as instances where a UAS encountered an irregular operational state preventing it from following the predefined mission profile [3]. In such cases, a special DAR request was deemed necessary, categorized as either a contingency or an emergency, depending on the degree of urgency. Any breaches of geofences or geo-cages were automatically treated as emergencies, whereas contingencies allowed for discussions between the DAR Manager and ATC or USSP before implementing an airspace change.

In AURA use cases for the management of airspace were outlined, distinguishing between contingencies occurring near an airport runway and those taking place within the approach and departure areas (TMA) of an airport. Airspace was structured into predefined AUSA volumes that could switch between blue and orange volumes and could thus be delegated to U-space. In all contingency situations the USSP was expected to either receive an automated non-conformance alert via a U-space system component or an alert triggered by the relevant UAS fleet supervisor for a detected anomaly or situation that would require the execution of an emergency operation plan.

The USSP would then be responsible for propagation of that information to the common interface. The CISP, receiving the alerting information, would then be able to determine the AUSA volumes that would need to be delegated to U-space for segregation of the UAS, experiencing the contingency, from manned traffic. Accordingly, a request for airspace change would then be sent to the DAR Manager. In order to properly compose the DAR request, the CISP had to be capable of automatically determining the geographical coordinates of the requested airspace volumes around the intended flight path (as specified in [3], Ch. 6.4) and would also need to apply a safety buffer.

The contingency DAR request issued by the CISP ideally contained information on the claimed airspace volume (identifier, upper and lower altitude limits, start-time and end-time of the reservation), a priority level for the contingency (indirectly indicating whether there is time for negotiation), and a motivation for the request (based on the operation plan with the included emergency response, see also [2], Ch. 5.1.3.4.3). Submitting the DAR request to ATC was expected to happen within a short time period that depended on the complexity of the situation.

III. AURA Validation Activities

A. *Aims and Objectives*

The AURA validation exercise conducted by AT-One in October 2022 focused on abovementioned contingency and emergency situations originating from U-space within the DAR processes. It assessed the impact on human performance within a future environment for Rotterdam The Hague Airport (ICAO code EHRD). Several typical UAS mission scenarios that result in unexpected changes to the mission plan or in unexpected UAS movements were simulated. An ATC tower (TWR) and an approach (APP) controller were working on the NLR ATM validation platform NARSIM in a highly realistic simulation environment with added VLL U-space airspace above city centres close to the airport. The validated operational solution included the earlier described ATC role of a DAR Manager who was supported by a technical solution for contingency DAR process visualization and communication with both U-space and ATM actors, called Collaborative ATM/U-space Interface for Contingencies (CAUSIC).

In order to present high fidelity Unmanned Aircraft (UA) movements within the simulation exercises, NARSIM was connected to the DLR U-FLY ground control station that could be used to both simulate UA movements and control a real UA [4]. One of the scenarios was carried out performing a UA flight that appeared to be flying at EHRD but was executed at the German Experimental Test Center for UAS (Magdeburg).

B. *Validation Environment*

The highly realistic human-in-the-loop real-time simulation and validation platform NARSIM that is located at the Royal NLR premises in Amsterdam was used for manned traffic generation and simulation of all operational front-ends regarding tower (NARSIM Tower) and approach control (NARSIM Radar), as well as the DAR Manager position (integrated in NARSIM Radar).

NARSIM Tower provided the human-in-the-loop simulation for an aerodrome tower control (Figure 4). One of its main features is the full 360-degrees visual system used for different kinds of airport simulations. The scenery of Rotterdam The Hague Airport was used for the AURA simulations.

Figure 4. NARSIM Tower Control Room for EHRD with CAUSIC Display

NARSIM Radar provided the human-in-the-loop simulation for APP control and the DAR Manager (Figure 5). The easily adaptable and scalable environment was configured to realistically represent the TMA approach controller position for simulation of (pre-pandemic) arrival and departure traffic levels at EHRD. It was manned with one experienced approach controller. The DAR Manager position was integrated into this environment.

Figure 5. NARSIM Radar with Working Positions for DAR Manager and APP

In the pseudo-pilot room there were two manned positions for the pseudo-pilots with a single monitor set-up showing the Terminal Approach Radar (TAR) screen and the HMI for interacting with the simulated aircraft. Observers were able to talk to the pilots on these positions and give them instructions. Observers also had an additional monitor showing the traffic situation (on the TAR). The simulation supervisor position was set up in the pseudo-pilot room as well for quick interaction with observers.

C. *Operational Scenarios*

In order to validate the DAR procedures, the technical interfaces and the related operational situations, several typical traffic scenarios and use cases were devised (see also [5] and [6]). All validation scenarios were carried out with a comparatively high traffic load for EHRD. Traffic was tuned in consultation with operational experts in order to have a good balance between IFR and VFR traffic in both TMA and CTR. In total, 14 departures and 15 arrivals per hour (on one runway) were simulated with roughly 25% of the traffic being VFR.

The two operational environments investigated with respect to contingencies originating from U-space were an aerodrome (EHRD) and its immediate surroundings being controlled by a TWR controller and the approach operation of that aerodrome being controlled by an APP controller. For each environment two use cases were described that could typically occur. When carrying out the planned U-space operation, a contingency would be triggered by the experiment leader which then lead to a situation in which an Emergency Response Plan (ERP) needed to be executed and facilitated by ATC.

In a baseline or reference situation, AUSA was available and dedicated for specific missions, but communication between UAS fleet managers and ATC in case of a contingency had to be achieved via a telephone line to either TWR or APP controllers. In a situation that included the operational solution to reduce the impact on ATC, the DAR Manager role was introduced and communication was achieved via the CISP and the earlier mentioned CAUSIC display and control panel (Figure 6). The DAR Manager could leave the request unchanged, choose an alternative option provided (if available), or change one of the existing options in terms of altitude and activation time using the control panel. A detailed description of the DAR Manager interface and the different steps to be taken for planning, negotiation and implementation of a DAR request can be found in [6] and [7].

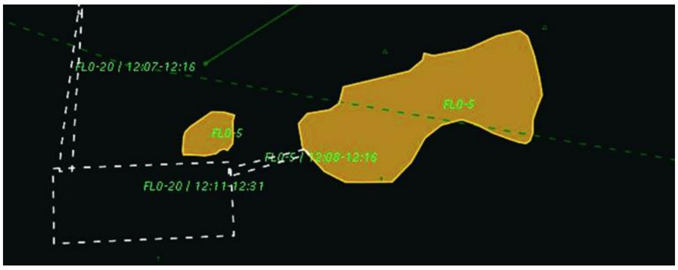

Figure 6. Preview of DAR Request on CAUSIC Display for the DAR Manager

The following use cases were investigated for the aerodrome environment:

- Runway Inspection Drone

A mission was assumed, in which a drone needs the entire runway surface area as temporarily delegated (geo-fenced) U-space airspace to perform a runway inspection. While performing the runway inspection the drone has a malfunction resulting in an emergency landing on the runway.

- UAM Movement to a City Vertiport

A UAM taxi flight with passengers on board takes off from a vertiport in the city of Rotterdam and needs to cross the airport at VLL altitudes to move people to another U-space area. During that operation a medical emergency occurs and the UAM needs to make an emergency landing in the apron area of the airport.

The following use cases were investigated for the approach operation:

- Infrastructure Inspection Drone

In this scenario, the mission of an inspection drone is to take pictures along motorway A20 running in parallel with the EHRD runway south of the airport. This area is pre-planned in AUSA and is segregated from manned traffic in the TMA. An emergency occurs (system failure), forcing the drone to leave the pre-planned U-space airspace and make an emergency landing.

- Search-and-Rescue Traffic in TMA

This scenario consisted of two different SAR mission profiles in the area of Rotterdam and either profile could potentially involve humans.

More details regarding use cases and scenarios, especially regarding the different steps in communication and negotiation between ANSP and USSP actors and entities can be found in the AURA Consolidated OSED [3].

D. Validation Results

The results of the validation activities carried out by AT-One have been described in detail in [6] and [7]. The following section summarizes these results again for completeness and in order to point out the main shortcomings and gaps in the current DAR processes.

Overall, ATCOs were satisfied that the U-space (as well as the extra U-space claimed for the emergency/contingency) was visible on their radar displays. The main information needs were met and additional information requirements for contingency situations were elicited.

ATCOs reported that they were satisfied with…

- Usability and acceptance of the user interface
- Improved situational awareness (SA) when using the interface
- The high level of safety when using the interface
- Operational efficiency when using the interface

However, there were also suggestions for improvement to make the system even safer, more efficient, and more adequate towards human capabilities.

ATCOs recommended the following:

- Adapting the level of detail depending on ATCO role.
- The notification of a DAR contingency request should draw the attention of the DAR Manager immediately.
- More direct feedback on the actual usage of U-space would allow the return to normal operations earlier and give ATCOs more confidence.

A few Human Factors related concluding remarks were made by both ATCOs and researchers:

- ATCOs were satisfied to be able to see the areas claimed for emergencies on their radar displays. It contributed to their SA, which is particularly important in emergency situations. They gave a warning to be careful with too much detail as the increase in SA may be reduced again by a cluttered display.
- Fast refreshers of information for the ATCO will limit the impact on manned traffic and improve the ATCO's trust in the system. After all ATCOs will be better able to respond accurately and at the right moment in time, when the receive continuous and up to date information.
- Emergencies arising out of U-Space in the airport vicinity can have a large impact on the efficiency of operations and workload of ATCOs (and DAR Manager).
- The required minimum separation between U-Space and manned aircraft has to be defined. It must be clarified in advance and it must be clear what operations are feasible for each delegated part of AUSA.
- The presence of a DAR Manager has added value; it increases ATCO SA during contingencies and emergencies.
- Impact on manned traffic can be reduced by accurate and up to date information about U-Space airspace claims. This will also positively improve the trust of ATCOs in the system.

Two major functionality gaps were identified that need to be addressed in future work on the subject:

- For a possible response from the USSP or further negotiation with all actors, the assumption was made that the USSP would always agree with any change to the DAR request. This aspect needs further research.
- There may be a need to develop additional automation tools for the DAR Manager to help assess the request and, possibly, different re-configuration options for the airspace volumes

IV. CONSEQUENCES FOR FUTURE RESEARCH

A. From AURA to ENSURE

The recently started ENSURE project that takes place in the framework of the SESAR 3 Programme will address the detected shortcomings and gaps regarding the DAR processes and the role and support options for the DAR Manager. In particular, NLR will again focus their investigations on contingencies, but with a more strict application in a realistic environment where special drone missions are expected to be carried out by NLR together with the Royal Netherlands Navy above the North Sea.

Altogether, the improved processes are expected to lead to further advancements in the AURA concept with simulations being accompanied by an assessment of associated operational risks and mitigation strategies. The end result must be a comprehensive management framework for DAR contingency requests and an assessment of the scalability and long-term sustainability of the proposed DAR services. In particular, the ENSURE project will have to answer questions regarding the categorisation and prioritisation of DAR requests and how to respond to each of them. This also means that human-machine collaboration and delegation of tasks will be at the centre of the investigations.

B. Expected DAR Process Improvements

NLR will use a multi-layered approach, in which the necessary DAR improvements are first discussed with operational experts for civil ATC operations in the Netherlands who were already involved in the AURA project and military experts who require improved negotiation procedures for special drone missions. These discussions are expected to lead to further insights into the improvements that can be made to incorporate decision and negotiation processes on the U-space side and the required information and support tools needed to adequately react to different types of DAR requests. This concerns both the special drone missions and contingencies that may have comparable timing requirements for implementing airspace changes.

After that phase, the intention is to carry out simulations with the improved service descriptions and support tools within a NARSIM environment, this time focusing on operations around Amsterdam Airport Schiphol (EHAM) rather than the much smaller EHRD environment. The reason for this is that the Royal Netherlands Navy intends to investigate special drone missions in military airspace above the North Sea that will need tighter communication and negotiation procedures with civil ATCOs. It is expected that the improved DAR Manager procedures and tools will also improve communication with special U-space actors such as the military.

For military missions along the coast of the Netherlands with varying requirements, this would mean that early planning of AUSA with dedicated military mission U-space, which could be identical or complementary to already existing military airspace structures, could lead to improved awareness on the side of ATC regarding the impact on civil operations into EHAM. Negotiations regarding this planning could reduce the impact by changing airspace geography, required altitudes and absolute and relative timing for (DAR) reservation of the areas. Furthermore, mission profile indications along a prospected route and the availability of visual indications for an ERP could also improve awareness of possible critical mission situations. This may provide ATC with an improved prediction capability in case of U-space contingencies and the execution and facilitation of the ERPs.

In order to test such improved processes for special U-space missions, a test flight will be carried out by NLR above the North Sea in cooperation with the Royal Netherlands Navy. The test flight will occur in military areas that contain airspace elements (Figure 7) that can potentially be configured as DAR-managed orange U-space volumes in a simulation environment with civil control sectors for EHAM on the NARSIM platform. During the test flight several possible mission profiles will be planned and negotiated via DAR processes and a DAR Manager located in the NARSIM environment, and will then be carried out by the drone. An optional element of these investigations may be the development of an advanced drone pilot interface for military missions allowing to easily communicate the planned mission profiles and negotiate them with ATC via the DAR management processes.

C. Special Drone User Mission Needs

As indicated above, the Royal Netherlands Navy investigates special drone mission profiles that are foreseen for some of their already existing tasks currently carried out from boats and ships, from land or with helicopters. Drones may start their missions, for strategic reasons, from either Maritime Airfield De Kooy (EHKD) close to Den Helder or from specially equipped ships along the coast. The range of drone missions is expected to be large enough to cover even the more remote areas above the North Sea.

Figure 7. First Sketch of an Airspace Grid in the North Sea Test Area

The tasks can be summarized as having the character of ISR missions, i.e. missions for Intelligence, Safety and Reconnaissance. Some of the tasks will happen in close cooperation with other organizations, such as the Royal Netherlands Sea Rescue Institution (KNRM), the police and the Netherlands Coastguard, each having their own area of responsibility. This means that some of the missions will also be related to these other organizations. Possible tasks with special equipment for each of the purposes (such as LIDAR, environmental monitoring tools) are:

- Damage assessment (caused by a storm)
- Counter drug trafficking operations
- Environmental inspection flights
- Search for (rescue of) drowning victims (capsized boats)
- Search for lost shipping containers
- European Maritime Safety Agency (EMSA) related tasks

The missions covering these tasks will require to have drones flying towards a certain location or following a certain route or a certain object and are therefore rather flexible in nature. This means that, while it may be possible to strategically plan them, most missions will evolve or change while being executed leading to timing requirements for the DAR processes that are comparable to contingency or emergency operations. Thus, there will be high interest to look at such special situations and special drone missions within the ENSURE project once the DAR management processes have been improved.

Currently, a first idea discussed with operational experts is the division of airspace above the North Sea and along the coastline into smaller blocks of airspace in a structured approach allowing to easily re-configure them when needed via the DAR processes from CAS to U-space reserved areas. This will mostly be a strategic process which can be automated easily with basic monitoring tasks for the DAR Manager to prepare ATC for upcoming changes. However, if earlier mentioned changes are more imminent, the DAR requests will more and more look like AURA contingency requests that require more management tasks. One of the exciting tasks of the ENSURE project will be to find out how it will be possible to also automate these more flexible changes. It is hoped that the special drone missions will help accomplish this task.

V. SUMMARY

In October 2022, the Royal Netherlands Aerospace Centre, NLR, together with their partners from the German Aerospace Centre, DLR, carried out simulations for the SESAR Industrial Research Project AURA. AURA defined ATM U-space Shared Airspace, which can be delegated to contain both ATC controlled and U-space controlled airspace volumes for traffic segregation, in order to investigate requirements for an interface between the two regimes. The simulations focused on contingency scenarios within U-space and the impact of these contingencies on air traffic control and manned traffic.

Several UAS use cases with varying degrees of urgency were carried out to investigate the concept of Dynamic Airspace Re-configuration (DAR) and the role of a DAR Manager implementing airspace changes to facilitate U-space contingency requests.

The results revealed that introducing a DAR Manager role with ATC background and knowledge helps mitigating the impact of the introduction of UAS in CAS via AUSA delegation and DAR on the tactical control carried out by TWR and APP controllers in terms of workload and situational awareness. A prototype of an interface for the DAR Manager and ATCOs was developed that helped communicating contingency requests originating from UAS via the responsible U-space service provider and an intermediate services layer (CISP) to the DAR Manager and that could further be used for negotiation of these changes with ATC.

This initial step in validating DAR Management and U-space contingencies led to the identification of areas for improvement of the operational concept and gaps in the development of the interface that will need to be addressed in the follow-up project ENSURE. It was recommended to resolve these issues before taking steps to further automate DAR Management and communication between USSPs and ANSPs.

The NLR work in the ENSURE project will address the mentioned shortcomings and gaps focusing on closer integration between ATM and U-space communication and negotiation processes and improving both information content and support options for DAR management. This includes a detailed look at special drone missions carried out in (military) U-space areas above the North Sea that need to be tightly negotiated with civil controllers to avoid CAS traffic delays caused by unnecessary airspace closures.

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