Report on Workshop AI4HyDrop

Online, February 7th, 2024

This Project has received funding from the SESAR3 Joint Undertaking under grant agreement No. 101114805 under European Union's Horizon Europe research and innovation programme.

AI4HyDrop

Abstract

The AI4HyDrop project holds multifaceted significance, aiming to bolster several critical aspects of drone operations in urban and restricted areas. Through the utilization of artificial intelligence (AI)-based tools encompassing flight planning, wind and turbulence prediction, and drone detection, the project seeks to heighten both the safety and efficiency of drone activities. Moreover, by delineating a rational flight approval process and cultivating a dynamic airspace structure organization, the initiative endeavors to optimize airspace usage and capacity. Concomitantly, the project undertakes a comprehensive examination of the legal, ethical, and social dimensions of drone operations, engaging pertinent stakeholders to assess potential impacts and challenges. Additionally, by aligning with the U-space concept and the Digital European Sky initiative, the project intends to provide innovative solutions and best practices to scale up drone operations. Lastly, by fostering the proliferation of new opportunities and markets for drone operators and service providers, the AI4HyDrop project could stimulate growth and enhance the competitiveness of various domain applications such as transportation, logistics, building infrastructure inspection, agriculture, and surveillance.

AI4HyDrop

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1. Introduction

1.1. Purpose and scope of the document

This Workshop report presents the organization of the 1st workshop with the AI4HyDrop Advisory board members and relevant U-Space stakeholders. This event is part of WP2 Requirements and Holistic Conceptual Framework.

1.2. Structure of the document

This document consists of seven sections and contains the following details:

- Section 1 provides the purpose and scope, as well as the structure of the report.
- Section 2 describes the framework of the workshop organization including workshop objectives, agenda, and the participants.
- Section 3 provides the material about airspace structure that is explained in Session 1 and discussion in that session.
- Section 4 provides the material about drone detection that is explained in Session 2 and discussion in that session.
- Section 5 provides the material about flight plan authorization that is explained in Session 3 and discussion in that session.
- Section 6 summarizes the conclusions of the conducted workshop.
- Section 7 consists of the list of references used in this report.

1.3. List of Acronyms

Table 1: List of acronyms used in this report.

Term	Definition
AI	Artificial Intelligence
AI4HyDrop	An AI-based Holistic Dynamic Framework for a safe Drone's Operations in restricted and urban areas
ATC	Air traffic control
ATM	Air Traffic Management
CNNs	Convolutional Neural Networks
CNS	Communication, Navigation, and Surveillance
DACUS	DEMAND AND CAPACITY OPTIMISATION FOR U-SPACE
DCB	Demand and Capacity Balancing
DRL	German Aerospace Center
EASA	European Aviation Safety Agency
EU	European Union
GSM	Groupe Special Mobile

IFATSEA	International Federation of Air Traffic Safety Electronics Associations
ITU	Istanbul Technical University
LoRa	Long-Range
RF	radio frequency
RNNs	Recurrent Neural Networks
SESAR	Single European Sky ATM Research
SVMs	Support Vector Machines
TinyML	Tiny Machine Learning
UAS	Unmanned Aircraft Systems
UEM	Universidad Europea de Madrid
U-Plan	U-Space flight plan
USN	University of South-Eastern Norway
USSP	U-Space Service Provider
UTM	Unmanned Aircraft System Traffic Management
VTOL	Vertical Take-Off and Landing

2. Workshop framework

The AI4HyDrop project organized a virtual workshop using the Zoom platform. The workshop was held on the 7th of February 2024.

2.1. Objectives

The workshop aimed to gather requirements from various stakeholders to gain insight into aspects of the challenges and needs for ensuring safe and efficient U-space operations.

To ensure a successful workshop and achieve the expected goals, the project outlined the following workshop objectives:

- Introduction of the project to the stakeholders.
- Presentation of the WP topics.
- Collecting feedback on the WP topics from the participants.
- Gathering requirements from various stakeholders for the development of solutions.

2.2. Agenda

The workshop was successfully carried out following the structure presented in Table 2. The first session was a plenary session where the AI4HyDrop consortium welcomed the participants. An introductory session was then followed where a brief overview of the workshop (i.e. agenda, objectives, and structure) was provided.

The workshop then proceeded with three separate sessions where the project presented its WP topic with Session 1 for the dynamic airspace structure, Session 2 for drone detection, and Session 3 for the flight plan authorization. At the end of each session's presentation, the participants were encouraged to ask questions, share their perspectives, and provide feedback. The separate sessions were conducted twice to provide participants with an opportunity to attend different topics. The workshop ended with a conclusion session.

Table 2: Agenda of the workshop.

Time	Activity
09:30 – 10:00	Plenary session. Introduction to an AI-based Holistic Dynamic Framework for a safe Drone's Operations in restricted and urban areas.
10:00 – 10:45	Session 1: How could the design of airspace and its structure accommodate UAS operations? Session 2: How to Detect and Identify Drones in restricted areas? Session 3: How can AI Transform the Automation of Flight Plan Approval Processes?

10:45 – 11:30	Session 1: How could the design of airspace and its structure accommodate UAS operations? Session 2: How to Detect and Identify Drones in restricted areas? Session 3: How can AI Transform the Automation of Flight Plan Approval Processes?
11:30 – 12:00	Sharing of conclusions and discussion on next steps

2.3. Participants

There were 67 participants from various corporations, companies, and universities during the workshop, including SESAR 3 JU, EUROCONTROL, IFATSEA, LFV, CRIDA, JRC – European Commission, Skeyes, Efkt, Nommon, Sparsity Technologies, Avium Inc., University of Kannas, Instituto Militar de Engenharia, Enet'com, ONERA, GeoDatalab, Indra Navia, Sant Longowal Institute of Engineering and Technology, UPC BarcelonaTech, National Aviation University, etc as shown in Table 3. The percentage of participants based on the stakeholders' groups is shown in Figure 1 with the top three majority coming from researcher, regulator, and business sectors.

Table 3: List of participants.

Stakeholder Group	Organization	Number of Participants
Regulators	JRC – European Commission	2
	EUROCONTROL	3
	SESAR 3 JU	2
	LFV	2
	Institute of aviation	1
	IFATSEA	1
Researchers	USN	9
	University of Kansas	2
	ITU	5
	UEM	6
	National Aviation University	2
	UPC BarcelonaTech	2
	Høgskolen i Innlandet	1
	CRIDA	1
	ENAC	2
	DLR	2
	Sant longowal institute of engineering and technology	1
	AirCar	1

	Instituto Militar de Engenharia	1
	Sintef Ocean AS	4
Drones operators	Enet'com	2
	Efkt	1
Drones manufacturer	Indra Navia	1
	Fleasy	1
Business	Skeyes	1
	GeoDatalab	1
	D-Flight	1
	Sopra Steria	3
	Future Needs Management Consulting LTD	1
Airport	AVINOR	1
Aerospace research center	ONERA	1
	Lukasiewicz- Institute of Aviation	1
General public	Nommon	1
	Sparsity Technologies	1
Total		67

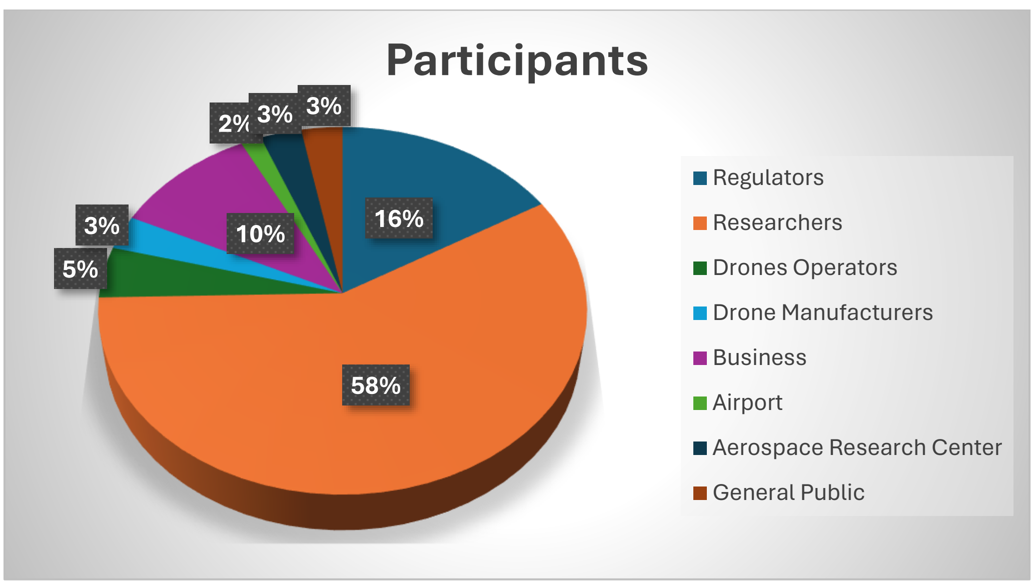

Figure 1: Participants percentage based on stakeholders' groups.

3. Session 1

Moderators: Yannick SEPREY from Sopra Steria Group.

Participants: 24 (part 1) and 12 (part 2).

The session was opened by explaining the objective of the session and the rules of conduct in this session. A whiteboard was used to help participants brainstorm the two subjects of the session.

3.1. Materials

There were two subjects which were presented in the session for the participants to respond to:

a. Which structure for what operation? Why can we use these structures? Which constraints?

There are 4 types of airspace structures were proposed for drone operations which are full mix, layers, zones, and tubes:

- Full Mix
  The Full Mix airspace structure integrates all types of drone operations into a single airspace as shown in Figure 2. It accommodates a wide range of activities, including recreational, commercial, and emergency drone flights [1], [2]. This structure is considered as the least structured airspace which requires comprehensive management and coordination to ensure safety and efficiency amidst diverse drone activities [3]. This airspace allows for higher traffic density and more efficient routes. However, it poses to high collision risk for drones and normally does not consider social factors such as noise and pollution [4].

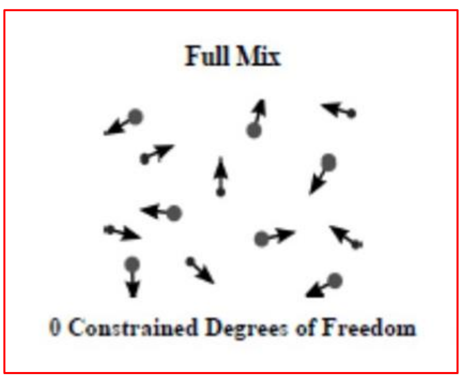

Figure 2: Full mix airspace structure [5].

- Layers
  Layers airspace structure involves dividing the airspace into distinct horizontal layers, each designated for specific types of drone operations or every altitude band corresponding to the heading range as shown in Figure 3. For example, lower layers might be reserved for recreational drone flights, while higher layers are allocated for commercial or industrial drone operations. In between, there could be separated by a buffer layer [1], [5], [6], [7], [8]. This structure helps manage different types of drone activities while minimizing conflicts and ensuring safety. It is considered more structured than the full mix structure. The layer structure could reduce the probability of a collision by creating vertical separation, segregating flight according to its direction, and separating according to aircraft capabilities. This concept also produces an acceptable level of capacity while improving collision risk [4].

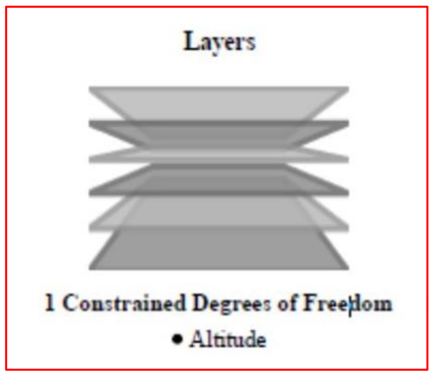

Figure 3: Layers airspace structure [5].

- Zones
  Zones airspace structure involves partitioning the airspace into discrete geographical zones (similar to ATC sectors), with each zone having its own set of regulations and restrictions as shown in Figure 4. These zones could be based on factors such as population density, land use, airspace sensitivity, or drone characteristics. For instance, urban areas might have designated drone-free zones, while rural areas may allow for more flexible drone operations [1], [2], [9], [10], [11]. This structure provides tailored management solutions for various airspace environments. Each aircraft in this zone could be protected by certain volumes which its size corresponds to their performance parameters such as automation, navigation, communication, and surveillance [10]. This structure could benefit from traffic separation without too advanced technology required. However, when the traffic density increases, it becomes constrained in terms of efficiency and safety since multiple aircraft are guided to the pre-set waypoints or structures [4].

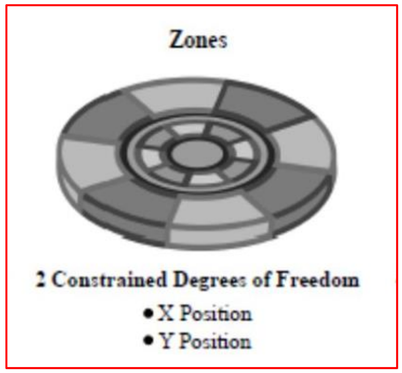

Figure 4: Zones airspace structure [5].

- Tubes
  Tubes airspace structure creates designated aerial corridors or "tubes" for drone operations, similar to air traffic control corridors for manned aircraft as shown in Figure 5. These tubes are typically aligned along specific routes or pathways, allowing for point-to-point drone flights [1], [2], [9], [11], [12], [13]. Tubes airspace structure enables streamlined operations, particularly for long-distance or beyond visual line of sight (BVLOS) drone missions while minimizing interference with other airspace users. The tubes could also define two-way traffic lanes that are horizontally and vertically separated to avoid areas with dense populations to minimize risk [12]. This structure is considered a realistic proposal that relies on the existing technology and is supported by the authorities [4].

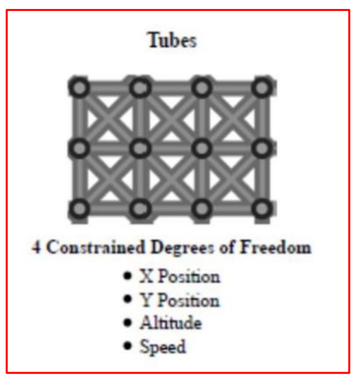

Figure 5: Tubes airspace structure [5].

The performance comparison of these airspace structures is presented in Figure 6 with the full mix as the less structured, followed by layers, zones, and tubes as they increase the structure level of the airspace [4]. The collision risk is high in less structured airspace since the detect-and-avoid system is the only barrier that prevents an accident, and flights can have multiple collision points along their trajectories. Third-party risk is also high since user-selected routes might be located above high-density neighborhoods.

Less structured airspace has been shown to allow for higher traffic capacity by reducing traffic flow constraints and structure. Here, aircraft can fly user-preferred (often direct) routes, while separation responsibility is delegated to individual aircraft using onboard conflict resolution technologies. Energy consumption is lower due to more efficient routes. However, full mix airspace is possible only if vehicles are autonomous, and the concept is not inclusive of aircraft with lesser technological capabilities.

Some structures can be beneficial in terms of traffic separation, but too much structure only reduces performance. As flight paths become constrained, capacity, efficiency, and safety decrease. Since multiple aircraft are guided to the pre-set waypoints or structures, the number of potential conflicts increases, compared even with free flight [1]. Highly structured airspace has an advantage in that it can accept aircraft of different technological capabilities and improve its inclusivity.

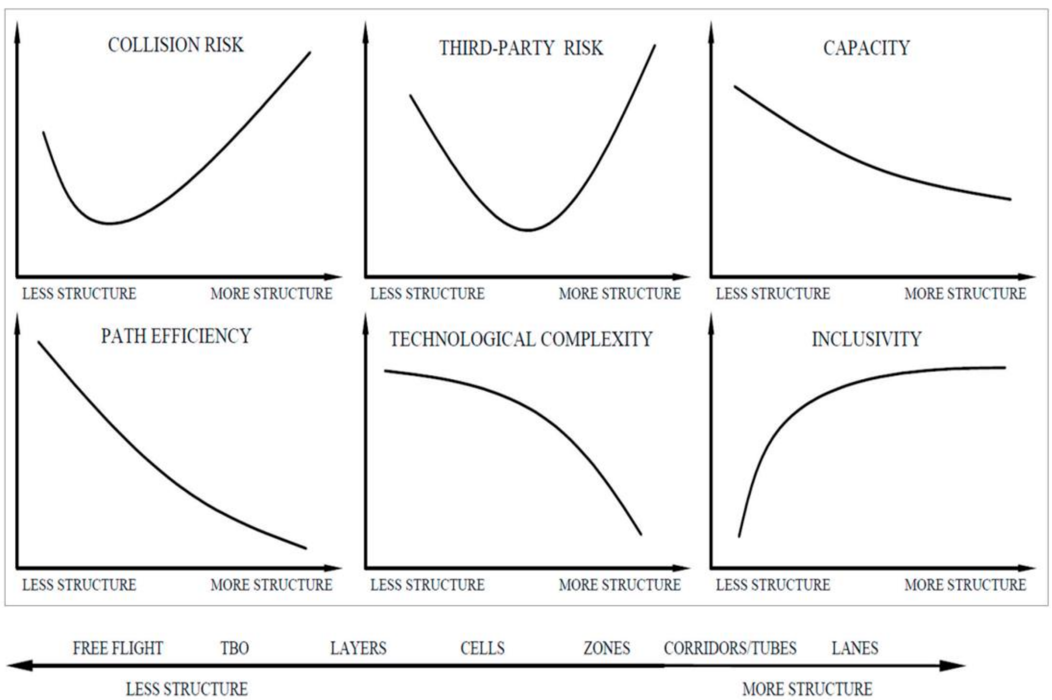

Figure 6: Performance comparison of the airspace structures [4].

Additionally, we find that the structure and restrictiveness of airspace can influence capacity, safety, and efficiency. Less structured airspace, such as the concept of Full mix airspace, allows greater capacity and route efficiency but requires greater technological capabilities and reduces safety. On the other hand, more restrictive structures, such as tubes and zones, enable the operations of less-equipped aircraft but less efficient routes.

b. How can we switch from one structure to another dynamically? What are the requirements and delays?
A dynamic reconfiguration of the airspace could be implemented by adapting the number of controlled sectors and their shape to the current traffic situation. The initial structure of airspace can be temporarily combined to improve the efficiency and safety of drone operation [13]. Many factors could determine the geometry of airspace structure which leads to the importance of dynamic airspace structure such as safety, social, operational, and aircraft characteristics [4].
- Safety factors
Safety can be improved by reducing the risk. However, in the context of airspace, risk cannot be eliminated, but it can be reduced by avoiding objects, areas with turbulence, and areas with dangerous weather.
- Social factors
Drone operations might be constrained by social factors such as the perception of safety, security, privacy, ownership, liability, regulation, noise, and visual pollution.
- Operational factors
The scalability of air traffic control is one of the critical constraints for drone operations. To accommodate large numbers of drone traffic requires new and innovative solutions in Air Traffic Management (ATM) and Communication, Navigation, and Surveillance (CNS).
- Aircraft factors
The design of airspace depends on the characteristics of aircraft that use airspace. These aircraft differ in size, speed, maneuverability, autonomy, and CNS capabilities.

3.2. Discussion

a. The discussion from the participants on the types of airspace structures is below:

- Participants mostly expressed their concern for the Full Mix structure. They expressed that it wouldn’t work or could work only in special situations like emergencies. The reasons stated were increased operational irregularity, requiring self deconflicting system, difficulty to implement, high complexity, high risk, and uncertainty.

- The layers structure got positive comments from most of the participants. The motivations were being able to accommodate different performance UASs, a combination of different operations, and reduced complexity. However, there are some concerns about how to move through between layers or in emergencies.

- Participants stated it would be needed for the zones in high-density urban areas it can be good for short-distance flights or Vertical Take-Off and Landing (VTOL). However, they expressed that the coordination/negotiation needed when passing from one zone to another is a complex and time-consuming process.

- Tubes structure was found interesting for drone operations. It was expressed that being able to optimize/identify common corridors and communication allows the scalability of implementing strategic deconfliction.

- It was also expressed that a hybrid structure such as layers/tubes is a good option. Tubes are good until a certain point, but what do you do when the drone in front of you is too slow? Perhaps layers structure is an alternative. Also, tubes could be used when many drones use the same path, and replaced by a full mix when there are fewer drones.

b. The discussion from the participants on the dynamic airspace structures is below:
   - The changing from a more restrictive to a less restrictive airspace wouldn't be difficult but vice-versa would need more planning and cause more delay. It is also considered easier to move from free routing to constrained airspace in an emergency, for example.
   - The dynamic airspace structure change seemed not appropriate for drone operations. But there are also voices that dynamic airspace reconfiguration is essential for special cases such as emergencies.
   - There is a need for flexible and clear emergency procedures. The aim is to accommodate varying operational requirements and minimize operational delays.
   - The pre-configured alternatives were preferred in dynamic airspace structure so that the drone operators would know beforehand which airspaces could be impacted and activated.
   - The possibilities of reconfiguration should probably be limited because dynamic change is a risk for operators. Also, operators should be aware of the current active structure at all times.

In summary, the session gathered some feedback from participant on their perspectives on each of the airspace structures with more preference for the more structured airspace than the loosened structure. Also, some opinions on how to implement them in drone urban operations including the hybrid approach on the airspace structure. Furthermore, a dynamic airspace structure could be essential to accommodate flexibility in case of emergency. However, there are many concerns that the communication of the airspace changes shall reach the drone operators in advance.

4. Session 2

Moderator: Enrique Puertas from UEM.

Participants: 22 (part 1) and 21 (part 2).

This session started with an illustration of the importance of drone detection such as the accident at Gatwick Airport in 2018 [14]. The moderator presented various techniques for detecting drones and the different signals that can be used for this purpose. Also, it discussed the use of multiple types of sensors to detect these devices.

4.1. Materials

During the session, we conducted a poll with three questions to which participants were asked to respond. Below are the questions and the results obtained:

a. What do you think would be the best solution for detecting drones in urban environments at a reasonable cost?

Table 2 shows the comparison between 5 solutions for drone detection which consists of Radar, optical, radio frequency (RF), thermal camera, and noise.

Table 4: Comparison between solutions for drone detection in urban environments

Solution	Description	Pros	Cons
Radar	Uses radio waves to detect and track objects and covers large areas and works in low-light conditions.	• Long-range detection. • All-weather capability.	• Expensive. • Susceptible to clutter from buildings. • Large blind spots.
Optical (images)	Uses visible light or infrared cameras to identify drones visually and provides detailed information about the drone.	• Relatively affordable • Can be integrated with existing security infrastructure. • Can potentially identify the drone model.	• Limited range • Ineffective in low-light conditions. • Requires clear line of sight. • High false alarm rate due to birds.
Radio	Detects and tracks the control signal between the drone and its operator and is effective in identifying the operator's location.	• Can differentiate between authorized and unauthorized drones. • Relatively good range. • More affordable than radar.	• Susceptible to interference from other radio signals (WiFi, cellular). • Limited ability to detect autonomous drones.

Thermal Camera	Detects heat signatures emitted by drones and is effective in low-light and some weather conditions.	• Good all-weather and low-light performance. • Can detect drones hidden from view.	• Expensive • Prone to false alarms from other heat sources (birds, cars). • Limited ability to identify the type of drone.
Noise	Uses microphones to detect the sound of drone propellers and is a cost-effective option for short-range detection.	• Low cost • Easy to deploy.	• Highly susceptible to ambient noise (traffic, wind). • Short detection range. • Difficulty in pinpointing drone location.

Based on the responses to the poll during the session, the most voted solution is radar as shown in Figure 7.

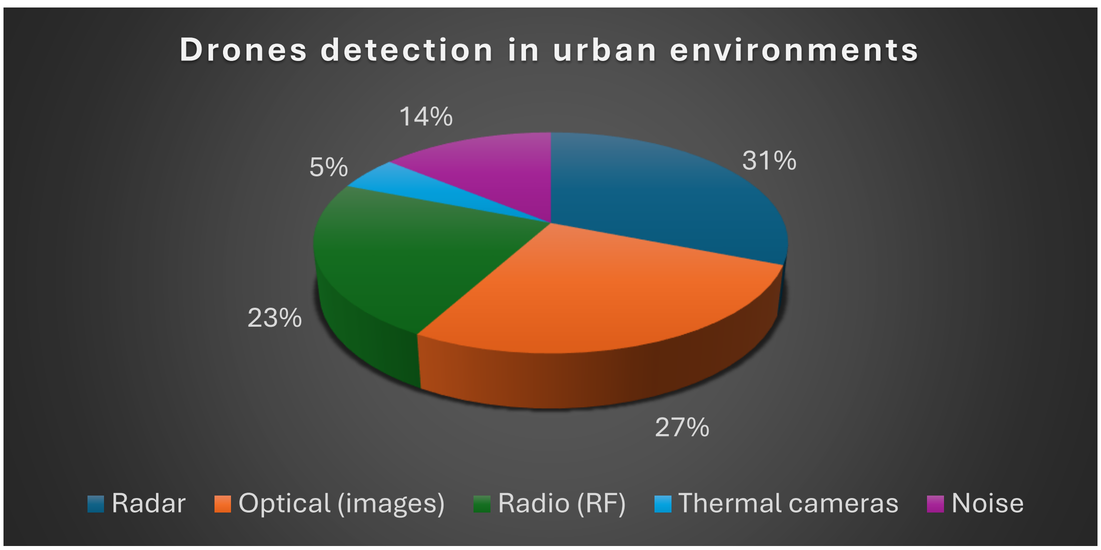

Figure 7: Best solutions for drone detection in urban environments.

In urban environments, drone detection has various solutions. Cost-effectiveness is one of the key factors, with RF and Noise detection mechanisms being more suitable for budget-conscious organizations. Radar systems and thermal cameras offer a significant advantage for detection performance. However, dense urban landscapes can interfere with the sensory capabilities of these detectors. To ensure optimal drone detection, integration with existing security frameworks, scalability, and regulatory compliance are crucial. Solutions should be compatible with current infrastructure and scale to accommodate future expansions. Regulatory compliance is also essential, as it ensures the chosen approach aligns with local laws and regulations, enhancing security and operational frameworks in urban environments.

b. What do you see as the main challenges in drone detection?

Figure 8 shows some challenges in drone detection. Participants were asked to choose which would be the better challenge in this regard, and out of the 20 options. The participants chose the best four which are coverage, sensor data fusion, Wheather and technology, and Differentiated drones. Table 3 shows the results in percentages.

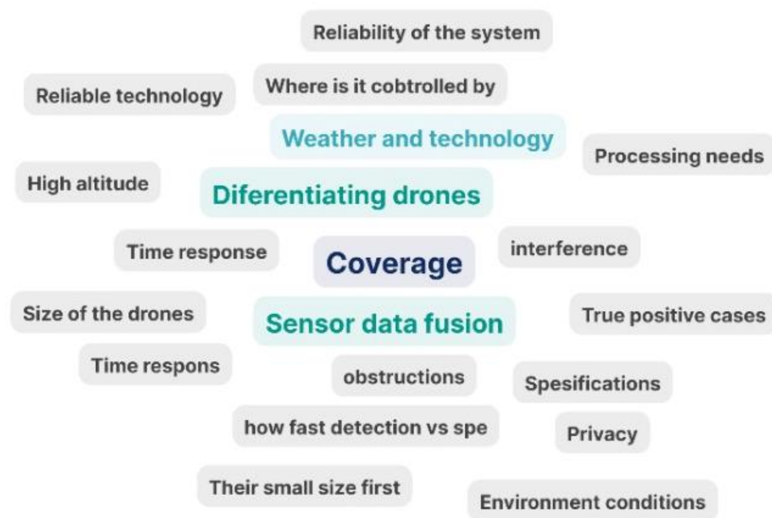

Figure 8: Cloud answers about drone detection challenges.

Table 5: Most popular challenges in drone detection

Answer	Percentage (overall)	Percentage (top 4)	Number of responses
Coverage	17.1%	29.2%	7
Sensor data fusion	14.6%	25%	6
Weather and technology	14.6%	25%	6
Differentiating drones	12.2%	20.8%	5

c. What do you think is most important? Specificity (a very good solution distinguishing if it is a drone or not) or Sensitivity (a very accurate solution in drone detection).
The concepts of specificity and sensitivity are critical in evaluating the performance of detection systems. Specificity refers to a system's ability to correctly identify negatives, which in the context of drone detection, means distinguishing non-drones from drones accurately. For instance, a high-specificity system would not mistake a bird for a drone

[15]. Sensitivity, on the other hand, measures the true positive rate of the ability of the detection system to identify actual drones. A highly sensitive system would rarely miss a drone that is present in the airspace [16].

During the session, a poll indicated a 62% preference for specificity and a 38% preference for sensitivity. This outcome suggests that for most of the participants, the ability to correctly dismiss non-drone entities is of higher importance than capturing every single drone intrusion without fail.

Considering the criticality of accurate drone detection for security and privacy, prioritizing specificity in areas where the airspace is crowded with non-drone entities could trigger false alarms. This is particularly important in urban areas where the cost of false positives could be significant, such as triggering unwarranted emergency responses or causing public distress. Nonetheless, in high-security areas or controlled environments where the presence of any drone is considered a serious breach, sensitivity might be the more critical metric to focus on. In such scenarios, the failure to detect a drone could have dire consequences, outweighing the inconvenience of false positives [15], [16]. In conclusion, the choice between specificity and sensitivity should be context-dependent: specificity for areas with a high likelihood of non-threatening objects, and sensitivity for high-security spaces where drone detection is crucial.

4.2. Discussion

We also received some questions, such as:

- How will machine learning be used to detect drones?

  We can use various machine-learning techniques to detect drones. The choice of one will depend on a kind of characteristics, such as the available data, the environment, and the specific requirements of the detection system. Following the methods commonly employed:

  Computer Vision-based Approaches: This technique utilizes cameras or sensors to capture images or videos and apply computer vision algorithms to detect drones based on their visual features such as shape, size, color, and motion patterns. Techniques such as object detection, image segmentation, and tracking can be employed. The most common solutions to image processing using approaches, such as Convolutional Neural Networks (CNNs), specifically YOLO (You Only Look Once) [17], [18], [19].

  Acoustic Detection: Drones emit distinct sounds, which can be captured by microphones and analyzed using machine learning algorithms. Audio-based detection can involve techniques like spectrogram analysis, signal processing, and pattern recognition to distinguish drone noise from background noise. Machine learning models such as Support Vector Machines (SVMs) [20] or Recurrent Neural Networks (RNNs) [21] can be applied in this context.

Radar Signal Analysis: Radar sensors can detect drones based on their electromagnetic signatures. Machine learning algorithms can analyze radar signals to identify drones by recognizing their unique signatures or behavioral patterns [22]. Classification algorithms like Random Forests, Gradient Boosting Machines, or Deep Learning models can be used for this purpose.

Radio Frequency (RF) Signal Analysis: We can use classic classification techniques such as Random Forests or Deep Learning models to detect drones based on RF signals [23]. The algorithms will work by analyzing the radio frequency signals emitted by the drones to identify their presence. When the algorithm learns the drone's RF signature, it will be able to differentiate it from other noise sources.

Sensor Data Fusion: Combining information from multiple sensors, such as cameras, microphones, and radars, can enhance drone detection accuracy. Machine learning techniques such as ensemble learning, or multi-modal fusion algorithms can integrate data from different sources to improve detection reliability and reduce false positives [24], [25].

In conclusion, we can use these approaches separately or combined. They can be customized based on drone detection system requirements. Some requirements that may be considered are detection range, environmental conditions, tolerance to false alarms, and deployment restrictions.

- How does the approach change for detecting drones at higher altitudes compared to lower altitudes?

The detection of drones at varying altitudes necessitates differentiated approaches due to the distinct operational challenges and technological requirements. At lower altitudes, urban infrastructure, such as buildings and other structures, can significantly diminish the efficacy of radar, optical, and noise-sensitive detection systems. These systems are susceptible to environmental clutter which results in signal reflection, scattering, and attenuation that impede accurate drone identification [26], [27]. Conversely, high-altitude drone detection faces challenges from extended distances and reduced sensor resolution due to the increased spatial separation between the sensor system and the target. Higher altitudes might require more sophisticated technologies that have better resolution and range capabilities, like high-resolution radar or electro-optical systems that can distinguish drones from a complex background [28].

To effectively detect drones at higher altitudes, there may be an emphasis on systems with greater range and detection capabilities, such as long-range cameras equipped with high-powered zoom or radar systems that can track objects over greater distances [29]. Adaptations might also include advanced signal processing algorithms to filter out noise and other irrelevant signals. In contrast, at lower altitudes, detection systems might prioritize technologies like RF scanners that can navigate the urban clutter or acoustic sensors that detect the unique sound signatures of drones [30].

For urban environments where low-flying drones are common, incorporating a multi-layered detection approach that combines RF, acoustic, and optical sensors would enhance the ability to discriminate drones from other objects [27], [30]. Conversely, the security strategies for high-altitude drone detection should integrate long-range radar and high-resolution optical systems to cover vast expanses of airspace [28]. In both scenarios, the synergy between different technological systems and advanced analytics plays a key role in attaining high sensitivity and specificity in drone detection.

- Should we restrict RF to 2.4GHz and 5.4GHz? If we limit these ranges, operators may use others, like sub-GHz. Is there any restriction for RF transmission in the airspace window?
  The regulation of the radio frequency (RF) spectrum varies from country to country, but in the European Union (EU), some specific guidelines and regulations have been meticulously crafted and need to be checked with the European Aviation Safety Agency (EASA) [31]. This ensures a reliable and secure environment for your drone detection operations.
  Regarding the use of RF for drone detection, in the literature consulted, we did not find any specific restrictions regarding the 2.4 GHz and 5.4 GHz frequencies in the EU for this purpose. This flexibility allows you to choose the most suitable technology for your operations, considering that these frequencies are commonly used for Wi-Fi communications and other wireless devices to try to avoid interference and underutilization in the drone detection system.
  If other frequencies, such as sub-GHz, are possible, it is essential to check the specific regulations of the country where we intend to operate the drone detection systems. The Long-Range (LoRa) communication protocol is an example of the use of sub-GHz frequencies.
  LoRa protocol operates in the Sub-GHz band [32], and its attraction is low energy consumption and long-range transmission capacity. Information about interference between channels and modulation can be found in [33], [34]. Furthermore, [35] tests the energy consumption performance of LoRa, Wi-Fi, and Groupe Special Mobile (GSM) protocols. The estimate considered the processes of data acquisition, transmission, storage, and processing of raw data. The final assessment was that the LoRa protocol was the most suitable for internal and external environments.
  In [36], an investigation is carried out to use the LoRa protocol to detect drones. In [37], the authors highlight the importance of LoRa for providing low energy consumption and long-range communication and use the protocol in combination with Tiny Machine Learning (TinyML).

In conclusion, the session provided a comprehensive overview of various drone detection techniques and the challenges associated with this crucial task. The Gatwick incident in 2018 served as a striking reminder of the real implications of these threats. The poll revealed valuable insights into participants' preferences for detection solutions, emphasizing the importance of Specificity. Additional questions prompted relevant reflections on the role of machine learning and the adaptation of approaches based on altitude. With the intersection of technology and security, the discussion emphasized the need for effective and balanced solutions to address emerging challenges in the drone landscape.

5. Session 3

Moderator: Emre Koyuncu from ITU and Miguel-Ángel from DLR

Participants: 24 (part 1) and 30 (part 2).

The session commenced with an explanation of the U-Space flight plan (U-Plan) and its data format.

5.1. Materials

The U-Space flight plan (U-Plan) life cycle encompasses four distinct stages [38]: draft, approved, activated, and terminated as shown in Figure 9. During the draft stage, a U-Plan is initiated in response to a recognized business need. Upon approval, signifying strategic deconfliction and other necessary considerations, the U-Plan is filed, and resources such as airspace and vertiports are allocated for the flight. Subsequently, the activated status denotes that the flight services, encompassing tracking, tactical deconfliction, and emergency management, are operational. The last is terminated status when the flight is over.

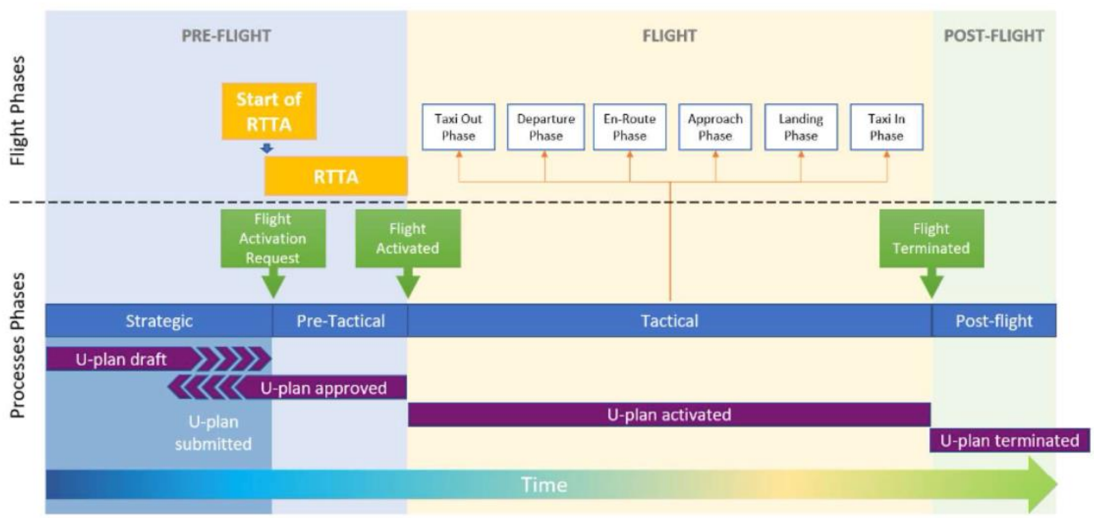

Figure 9: U-Plan life cycle [38].

The conceptual process in the U-Plan authorization is shown in Figure 10. This includes creating the flight plan, called the U-Plan, and submitting it for review and authorization. The authorization process consists of several checks and validations to check whether the proposed flight plan is possible and conforms to all applicable standards and regulations.

The U-Plan authorization system starts with a strategic conflict check to identify whether there will be any conflicts or obstacles that can divert the proposed flight plan. This will include cross-referencing existing flight schedules for any overlaps and ensuring that the flight path does not conflict with any restricted or dangerous airspace zones. Then comes the Demand and Capacity Balancing (DCB) stage. This stage checks whether the proposed flight is possible given the existing demand and capacity. It is necessary to ensure that the flight management system can take the proposed flight without draining resources or violating the efficiency of other planned flights.

The process also includes Other Checks, which must be minor evaluations or checks done to guarantee the general safety, practice, and compliance of the flight plan. Other requirements could be exercised to confirm that all requirements for flight authorization are fulfilled. Eventually, the data accrued from the checks are fed into the Decision Support System. It uses such data to form collective decisions. In case all the checks have been satisfied, and all requirements have been met, then the U-Plan is marked as Decision for activation. In case the U-plan gets rejected by DCB measure, deconfliction, or any other issues, the system will re-draft the U-plan based on recommendations for another submission. This rigorous step-by-step process guarantees optimal safety, efficiency, and regulatory compliance in the flight authorization approach.

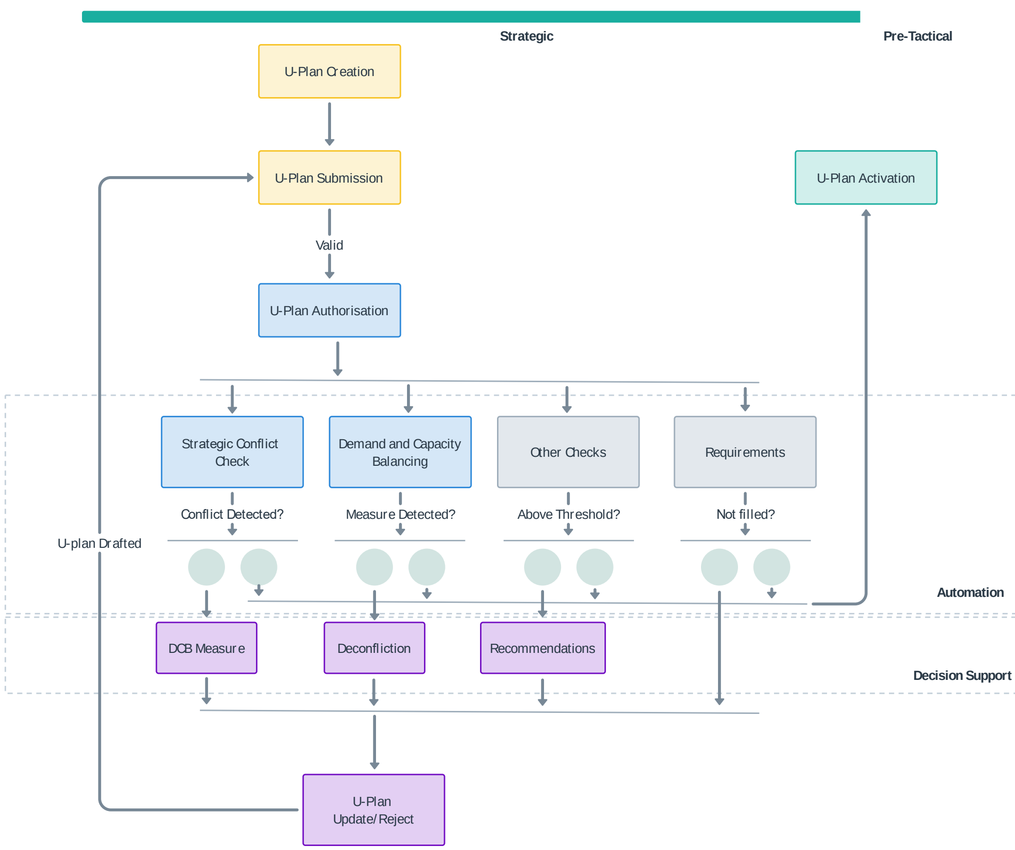

Figure 10: U-Plan Authorization System [38].

Based on the current approval systems, it require drone operators to submit flight plans several days in advance, and the authorities issue U-plans manually in the form of binary decisions (accepted or rejected). For the improvement, automation the U-plan approval system is proposed for scalability to be able to manage more than thousands of flights/hour with the same U-Plan quality (priorities, fairness, etc.), real-time processing for approvals or rejection, improving efficiency and consistency using standardized decision-making process. In the AI4HyDrop project, AI-based method will be proposed in U-Plan approval systems that could improve the explainability of decisions which provide graded decisions (not just binary) and resolution recommendations to suggest actionable plan adjustments.

For the submission purpose of U-Plan data between drone operators and USSP, a data format is required such as GeoJSON. This format is suggested by previous SESAR projects such as DACUS [39] and Labyrinth [40] to represent the flight plans. This format allows to description of the trajectories as a sequence of points and as volumes. Also, a large number of elements can be added to the coordinates, which allows to specify information and constraints associated with the waypoints. suggesting a high-level format that would be translated into a list of waypoints to be uploaded to the drone.

5.2. Discussion

The discussions in this session are:

- The importance of fairness and priority in the authorization system.
- UAS operators need to know when the restrictions are active or deactivated, and AI could elaborate on the required information.
- The missing assistance system in UTM, the importance of vertiport in terms of economics and its networks, and the seamless integration between vertiports in planning the UAS flights.
- There was a question from a participant asked about how to get the airspace information, when there are emergency cases, airspace should resume completely, and the deconfliction in the air is part of flight conformance.
- Suggested that the format of flight plans should be a common language between drone operators and other stakeholders. Also, the deconfliction of the flight plan, airspace capacity affected, and the conformance monitoring during flight should be included in the flight plan format consideration.
- Suggestion for additional parameters for drone types in flight plan data.
- Document ED-318 (Technical specification for geographical zone and U-Space data provision and exchange) should be considered for U-Plan communication.

The session concluded that the discussion was fruitful providing feedback on the U-plan approval process and its data format. The AI-based method could be one of the methods to allow for more fairness and priority in the process of U-plan authorization. Also, the flight plans should be a common language between U-Space stakeholders that allows the flow of important information in drone operations.

6. Summary

Preliminary results from the Workshop are presented here with some limitations (in the range of stakeholders) in terms of number and expertise.

Session 1: How could the design of airspace and its structure accommodate UAS operations?

- Full mix and zone structures got a negative perception from the audience. While layer and tube structures got a positive acceptance from the audience.
- A hybrid or dynamic airspace structure could be crucial in the case of an emergency event.
- Pre-configured alternative structures were preferred in dynamic airspace changes.

Session 2: How to Detect and Identify Drones in restricted areas?

- The audience selected Radar as the best solution for detecting drones in urban environments.
- The main challenges in drone detection were the coverage and sensor data fusion.
- The audience expressed that specificity is more important than sensitivity in drone detection.

Session 3: How can AI Transform the Automation of Flight Plan Approval Processes?

- The importance of fairness and priority in the authorization system.
- The airspace information should be transparent to all U-space participants.
- The format of flight plans should reflect common language from drone operators.

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This Project has received funding from the SESAR3 Joint Undertaking under grant agreement No. 101114805 under European Union's Horizon Europe research and innovation programme.