DREAMS U-space Scenarios

December 2018

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DREAMS
U-space Scenarios

The Reference Scenario identification task consists on identifying some relevant scenarios of particular interest for UAS operators in both VLOS and BVLOS conditions, according to a proposed and shared methodology which may involve more than one iteration for the final convergence, considering also the final U-space CONOPS and feedback deriving from other projects.

During the implementation of this process, a stronger understanding of data items and services that are important for the drone operators and U-space stakeholders will be achieved.

This document is an extract of the deliverable D3.1 – Scenarios identification and requirement analysis produced by the DREAMS Consortium.

For more information about the project, and to obtain other public documents, please visit the project website

www.u-spacedreams.eu

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Glossary of terms

Term	Acronym	Definition
Above ground level	AGL	Altitude (of an aircraft) measured above the terrain.
Air traffic control	ATC	A service provided by ground-based air traffic controllers who direct aircraft on the ground and through controlled airspace, and can provide advisory services to aircraft in non-controlled airspace.
Beyond visual line-of-sight (operation)	BVLOS	An operation in which the remote pilot **does not** maintain direct unaided visual contact with the UAS at all times.
Command and control (link)	C2	The communication link required by the pilot to modify the behaviour of the drone and by the drone to indicate its state to the pilot.
Controlled traffic region or control zone	CTR	A volume of controlled airspace, normally around an airport, which extends from the surface to a specified upper limit, established to protect air traffic operating to and from that airport.
Detect and Avoid	DAA	A system to detect incoming traffic, ensure separation and avoid a collision with said traffic.
Geotagging		The process of adding geographical information metadata to various media, such as photographs or video.
Geofence		A virtual geographic boundary, defined by GPS, RFID, Wi-Fi or other technology, that enables software to trigger a response when a device enters or leaves a particular area.
Global navigation satellite system	GNSS	The generic term for satellite navigation systems that provide autonomous geospatial positioning with global coverage using GPS, Galileo and other satellite constellations.
Notice to airmen	NOTAM	A notice containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.
Radio line-of-sight	RLOS	The radio frequencies used to establish the communication links between drones and their ground control station require that the transmitting and receiving antennas are in view of each other.
Visual line-of-sight (operation)	VLOS	An operation in which the remote pilot maintains direct unaided visual contact with the UAS at all times.
Very low level (operation)	VLL	An operation taking place below 500 feet (400 feet in some countries) above ground level (AGL)

About DREAMS

WHAT IS DREAMS

Aviation has relied on dependable and readily available information to conduct safe operations, based on internationally agreed standards and procedures for its data quality, including origination, maintenance and distribution.

The new unmanned aviation will also require a comparable level of information to support the new operational scenarios that are envisaged. The variety and complexity of these scenarios, the number of operations expected (millions instead of a few thousand) and the fast evolution of drone technology requires a different approach, using concepts derived from the ICT and mobile telephony sectors but maintaining the same level of integrity and reliability of the information required by aviation.

The DREAMS project will analyse the present and future needs of aeronautical information to support the growth of unmanned aviation, ensuring safe and cost-effective operations.

DREAMS OBJECTIVES

- Fill the gap between the existing information used by traditional manned aviation and the needs of the new unmanned aviation
- Analyse and simulate present and future real world applications, to ensure that the system can be scaled as the market for drones grows and the number of applications increases
- Analyse and validate the technologies related to information exchange that will make possible the implementation of the future U-space concept for the management of drones in Europe

METHODOLOGY

DREAMS will analyse operational and technical aspects, environmental scenarios, technologies, safety, security and confidentiality aspects in order to identify potential U-space data (e.g. airspace structure, terrain, obstacles and weather), service providers (for authentication, flight planning, fleet management, geofencing) and facilities and how the information needs to be tailored for drone traffic management.

The DREAMS project methodology is based on the following steps:

1. Identification of reference scenarios and high-level U-space services
2. Elicitation of data and service requirements
3. Data and service availability analysis
4. Scenario selection validation
5. Validation of the results

DREAMS CONSORTIUM

IDS – Ingegneria Dei Sistemi S.p.A.

The Coordinator – is a company with more than 20 years of experience in the development of Aeronautical Information Management Systems and it is also a UAS manufacturer with a portfolio of drones ranging from less than 5 kg up to 25 kg.

Delft University of Technology – Faculty of Aerospace Engineering

Is the largest Aerospace Engineering faculty of Western Europe. It has performed pioneering work into autonomous airspace, detect & avoidance algorithms and micro-aerial vehicle (MAV) system design.

EuroUSC España, S.L.

Is a limited company established in Madrid, part of the European group EuroUSC, leading independent Accreditation Specialist for 'Operations, Airworthiness and Pilot Qualification' covering Unmanned Aircraft Systems (UAS) with a Maximum Take-Off Mass of less than 150kg.

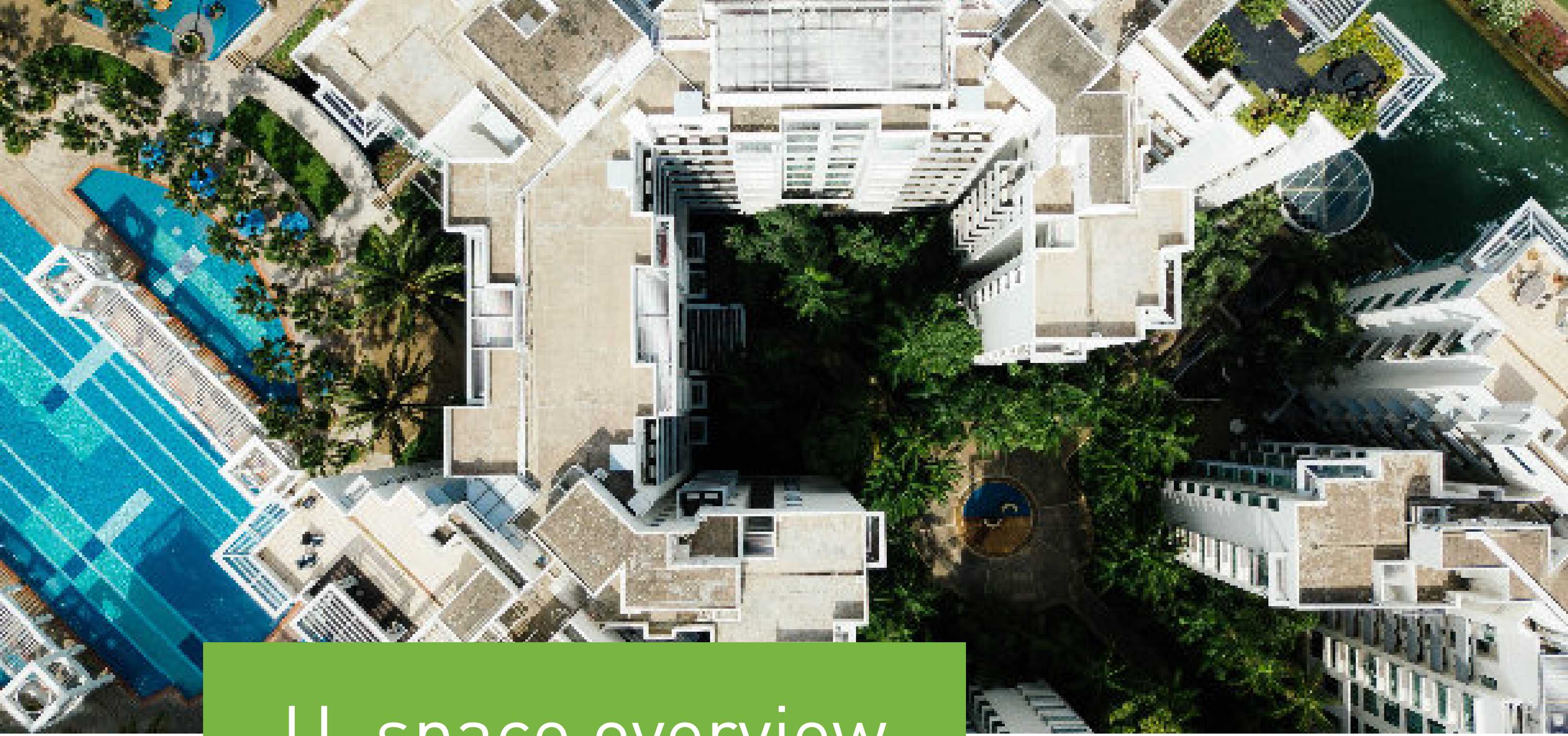
EuroUSC Italia SRL

Is a consultant company with practical experience on drones, internationally achievements in safety assessment, human factors, safety regulation, flight test of new prototype aircraft or new airborne systems and flight inspection of navigation aids. The company is also involved in Air Traffic Management matters and Aerodrome rulemaking.

TopView SRL

UAS operator authorized since 2014 – is an innovative SME focused on study, research and development of autonomous remote piloted systems for aerial, maritime and terrestrial applications, together with innovative products as custom payloads and IoT (Internet of Things) sensors.

The DREAMS Consortium is comprised of five organisations with a proven track record in drone operations



U-space overview

U-Space[1] is a set of new services and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones. These services rely on a high level of digitisation and automation of functions, whether they are on board the drone itself, or are part of the ground-based environment. U-space provides what is needed to enable and support routine drone operations, as well as a clear and effective interface to manned aviation, ATM/ANS for service providers and authorities.

U-Space will be capable of ensuring smooth operation of drones in all operating environments, including urban areas, and in all types of airspace, in particular to VLL airspace. It will address the need to support the widest possible variety of missions, and may concern all drone users, as well as every category of UAS, as defined by EU Commission proposed Regulation on unmanned aircraft operations. According to the criticality of the provided services, performance requirements will be established for both structural elements and service delivery, covering safety, security, availability, continuity, resilience and so on.

U-Space services will be delivered by service providers within the given U-space environment. They do not replicate the function of ATC, as known in ATM: instead, they will deliver key services to organise the safe and efficient operation of drones and ensure a proper interface with manned aviation, ATC and relevant authorities.

INITIAL SERVICES

The first two U-space services, which rely on agreed EU standards, are the following:

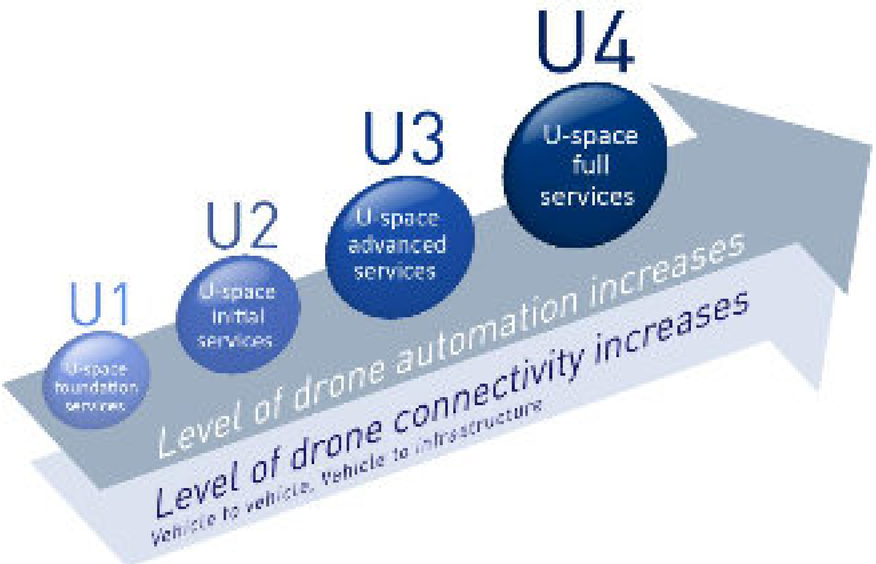
1. Electronic registration (**e-registration**): Draft EU UAS Regulation envisage that electronic registration will be mandatory for drone operators, except operators of drones weighting below 250 grams, as well as some classes of drones used in the **open category**, and all drones used in the **specific category**.

2. Electronic identification (**e-identification**): It will allow authorities to identify a drone flying and link it to information stored in the registry; the identification supports safety and security requirements as well as law-enforcement procedures.

U-space

[1]*The diagrams and the U-Space Use Case example on this chapter have been extracted from the SESAR JU document U-Space Blueprint.*

U–SPACE ROLL OUT



The progressive deployment of U–space is linked to the increasing availability of blocks of services and enabling technologies. Over time, U–space services will evolve as the level of automation of the drone increases, and advanced forms of interaction with the environment are enabled (including manned and unmanned aircraft) mainly through digital information and data exchange over a **cloud–based platform**.

- **U1**: U–space foundation services provide e–registration, e–identification and basic geofencing services
- **U2**: U–space initial services support the management of drone operations and may include flight planning, flight approval, tracking, airspace dynamic information, and procedural interfaces with air traffic control.
- **U3**: U–space advanced services support more complex operations in dense areas and may include capacity management and assistance for conflict detection. Indeed, the availability of automated DAA functionalities, in addition to more reliable means of communication, will lead to a significant increase of operations in all environments and may require a more robust framework.
- **U4**: U–space full services, particularly services offering integrated interfaces with manned aviation, support the full operational capability of U–space and will rely on very high level of automation, connectivity and digitalisation for both the drone and the U–space system.

By 2019, U–space is expected to be established with U1 services facilitating a great number of current drone operations while enabling new ones.

Also in 2019 pre–operational demonstrations of the initial U–space services (U2) will take place, as well as the first results from SESAR research and development projects, including the DREAMS project, paving the way for the roll–out of U–Space (U2–U4).

SUPPORT FOR MISSION PHASES

The diagram below and the example case of use on the following page show how U–Space will provide support to all phases of a mission, when its complete deployment is finalised.

U-SPACE USE CASE EXAMPLE

A drone operator plans to fly a drone to carry a small package from a village to the city centre 30 kilometres away. She selects a suitable drone from her fleet and selects a drone supervisor who will not actually be piloting the drone, but will be supported by automated functions and tools allowing to monitor several drones flying at the same time.

1. Preparation of the drone mission

To prepare the flight, the drone operator uses information-sharing services, like meteorological conditions, combined with other U-space services, such as navigation and communication coverage services, flight planning assistance services and services providing the expected density of traffic in the mission area. Since the drone is registered, the system automatically links the elements described in the registry with elements of the flight request, in which full details of the airworthiness of the drone and its behaviour in emergency situations are described. For example, this information could include designated safe landing areas, or details of the equipage and capabilities of the drone. That way, if the drone fails at any point in its flight, it will behave in a predictable manner, minimising risk to people and property on the ground.

2. Submission of a flight request and reception of an acknowledgement

The planned route adheres to applicable regulation, airspace requirements (including airspace availability, temporary and permanent restricted areas) and requirements on specific drone equipment. If the flight requires an additional approval, then the request is submitted to the relevant entity and an answer is sent to the drone operator. The planned flight does in fact conflict with several other planned drone operations so, the operator is offered the possibility of a longer route or a delay to the drone's arrival by 5 minutes. She chooses the latter option and receives an acknowledgement, which includes the drone's 4D trajectory describing the entire flight. When the drone is airborne, it receives information and alerts and might alter its original route to avoid traffic, meteorological conditions or any changes to airspace accessibility. Throughout the flight, the drone broadcasts its unique identifier. The tracking service allows the drone flight path to be followed and supports other services like the situation awareness, which is provided, with some limitations, to a wide range of customers (e.g. drone operators, ATC, police).

3. Execution of the flight

The drone is equipped with a "detect and avoid" (DAA) system which allows it to avoid hazards. The DAA system navigates it around a flock of birds and an unreported obstacle (e.g. a crane). As it arrives in the city, it receives an alert on a modification of airspace availability on its route: a car accident has just taken place and the local police have set up a temporary highly restricted zone to automatically geofence the site. The geofenced zone is not actually empty as the police are using a drone to give them an aerial view of the accident, and this mission is approved. The incoming helicopter ambulance is a priority flight, and this information is shared to ensure drones crossing its path will route round it.

4. Mission completed

The drone arrives safely at its destination, delivering the parcel. It is now ready to be prepared for its next mission: a roof survey of a building 500 metres away.

U-SPACE SERVICES

The following table shows the services defined for the U-space implementation organised by the stage of development blocks (U1 to U4) for which they are planned. Services for the U4 block have not been defined yet.

U1	U2	U3	U4
E-registration	Tactical geofencing	Dynamic geofencing	*[Pending definition]*
E-identification	Tracking	Collaborative interface with ATC	
Pre-tactical geofencing	Flight planning management	Tactical deconfliction	
	Strategic deconfliction	Dynamic capacity management	
	Weather information		
	Drone aeronautical information management		
	Procedural interface with ATC		
	Emergency management		
	Monitoring		
	Traffic information		

DREAMS scenarios

As mentioned before, the methodology used in the DREAMS project starts by identifying a number of real-world scenarios of use of the U-space services, as a means to explore their information requirements and perform a gap analysis between these requirements and the current state or the planned implementation of the different services that will constitute the future U-space, once the the first three stages are rolled-out (U1 to U3).

Thus, DREAMS uses a bottom-up approach, trying to answer the three following questions:

- *What kind of operations will be carried out in the future?*
- *What flow of information will be required by the different users (and providers) of U-space services?*
- *How does the planned implementation of the U-space services complies with these requirements?*

This document concentrates on the first question. Future documents distributed by DREAMS will provide answers to the second and third questions.

SCENARIO IDENTIFICATION

The process followed to identify the scenarios that will be analysed by the DREAMS project is shown on the diagram at the bottom of the page.

The first step of the process is to consider current drone operations that are taking place on the market, using the knowledge of an experienced drone operator, complemented with a public survey on the DREAMS website to get input from the drone community.

The second step is to analyse the information made available by other parallel drone traffic management studies and market forecasts, to determine the main drivers for future operations.

The final step uses the information obtained on the first steps and identifies relevant scenarios, taking into consideration:

- The actors (users) involved
- The requested functionalities
- The applicable U-space services
- The type of data requested or exchanged

Scenario identification process

SCENARIO DEFINITION

The result of the process has been the definition of the 11 scenarios shown on the table below. Each scenario describes the behaviour of actors, their interactions and the wider context of use. From a detailed scenario, the U-space stakeholders should be able to identify user requirements and potential business cases.

As it can be seen on the table, the scenarios capture all the flight phases and utilise services from the three first U-space roll-out blocks, thus providing a good representation of U-space.

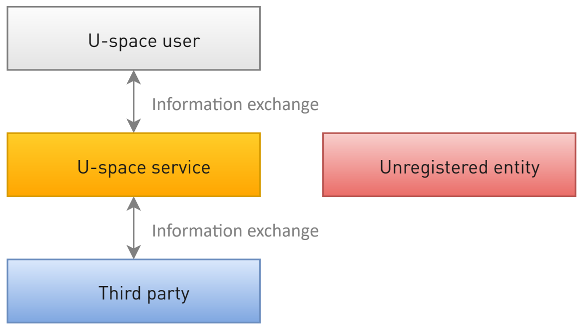
The scenarios are described in detail below. For each scenario, the following information is provided:

- Key parameters of the scenario
- A storyboard to provide the scenario context
- One or more information flow processes that are triggered by the scenario
- A summary of the initial conclusions and recommendations arising from the analysis of the scenario, as well as potential issues that will require further exploration

INFORMATION FLOW DIAGRAMS

Each scenario involves a number of processes in which information is exchanged between the different users of U-space, and in some cases third parties. Some of the scenarios also involve unregistered entities (users or drones) which might constitute a security threat.

The diagram below shows the conventions used in these diagrams.



Scenario	U-Space block	Flight phases
1 Electronic Registration	U1	1
2 Concurrent Operations	U1, U2	2, 3
3 Territory Control	U1	3
4 Cooperative Geo-tagging	U1, U2	1, 2, 3
5 CTR Crossing	U2	1
6 Long Range Operations	U2	1, 3
7 Deconfliction Management	U2	3
8 Emergency Management	U2, U3	3
9 Capacity Management	U2, U3	1, 2, 3
10 Intelligence Service	U2	4
11 Personal Mobility	U2, U3	1, 2

DREAMS Scenarios

COVERAGE OF U–SPACE SERVICES

As can be seen on the following table, the scenarios capture all the proposed U–space services from the three U–space roll–out blocks. Also, most scenarios, involve different services, thus demonstrating the interactions and information flows between them.

	Service	1	2	3	4	5	6	7	8	9	10	11
	e–registration	●										
U1	e–identification			●								
	Pre–tactical geofencing		●		●							
	Weather information		●				●					
	Drone aeronautical information management						●	●				
	Tactical geofencing				●			●				
	Tracking			●	●		●					
U2	Flight planning management		●	●	●	●	●	●	●	●	●	●
	Strategic deconfliction		●					●				
	Procedural interface with ATC					●						
	Emergency management								●			
	Monitoring			●			●					
	Traffic information						●					
	Dynamic geofencing									●		
U3	Collaborative interface with ATC											●
	Tactical deconfliction									●		
	Dynamic capacity management									●		

Coverage of the U–space services

1 Electronic Registration

U-SPACE SERVICES

U1 – E-registration

U2 –

U3 –

FLIGHT PHASES

1 Preparation

ACTORS INVOLVED

Drone user, drone operator, authority

INFORMATION FLOWS

1. Drone user registration – Hobby
2. Drone registration – All
3. Drone operator registration – Professional

STORYBOARD

Bob buys a commercial drone weighing more than 250 g. He is aware of the drone EU Regulation (now in draft form) and knows that he needs to have a profile on the U-space system and to associate his drone with his profile before using it even if he is a leisure user.

Since he is a new user, on the U-space public website he is requested to register himself, creating a user account and password, and providing certain personal information, including his address and active mobile phone number.

During registration Bob is also requested to insert his ID card details and his Licence/Attestation information (if any) with associated validity and expiration dates in order to grant him access to certain types of airspace. Bob has learned by himself to pilot a drone, but he does not have any licence as the purpose of his flights is just for leisure.

Finally, the U-space registration process prompts Bob to the payment page where he is requested to insert his credit card details (or other means of payment) for registration service. After payment Bob receives the U-space registration unique number.

1 DRONE USER REGISTRATION – HOBBY

The user provides the following information to the **E–registration** service:

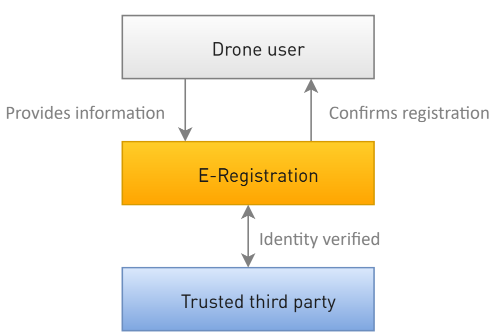
- Name, postal and email addresses and mobile number. The phone number serves as a redundant way to check the identity and to communicate with the user in case of a temporary network failure
- Valid ID document (passport or national ID). A trusted third party outside the U–space services might be integrated in the registration process to verify the identity of the user using e–banking or blockchain mechanisms
- For professional users only, a Drone Pilot Attestation or License. If provided, will enable the user to perform specific operations such as operations in controlled airspace

The **E–registration service** notifies the user that he will be always accountable for flight operations, even in the case of leisure flights.

The **E–registration service** prompts the drone user to a payment page. In this case, the drone user will only have to pay an annual fee for the basic services provided to hobby users.

At the end of the process the **E–registration** service provides:

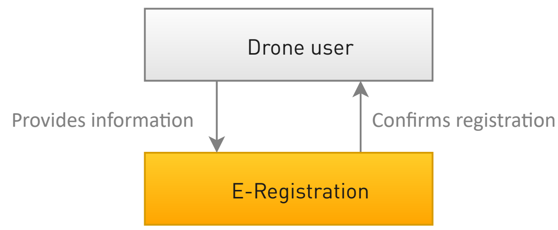
- U–space identification number;
- Permit to fly in VLOS and subject to other conditions;
- Green / Yellow / Red zones where flying for leisure is allowed and other information available to the user by means of other U–space services



2 DRONE REGISTRATION – ALL

After the user has obtained his unique code to access the U–space services, he can associate his profile with one or more drones.

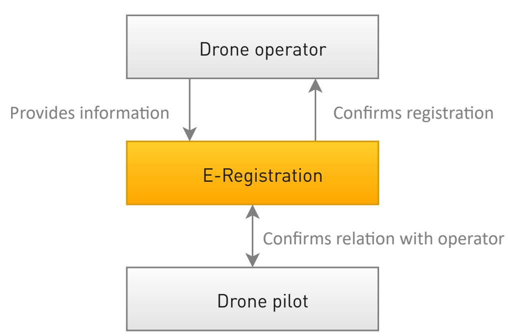
- The user associates to his profile the drone he intends to operate, using the unique serial number provided by the drone manufacturer.
- The unique sequence generated by the user code, combined with the drone code is stored by the E–registration service.



3 OPERATOR REGISTRATION – PROFESSIONAL

A professional drone operator proceeds in a similar way as an individual user, but during the registration process more professional services that are generally not allowed to hobby users can be requested, subject to compliance with the applicable regulation.

Following similar procedures as the ones described in the previous sections, the operator can add the pilots working for the organisation, who should be already users of U–Space. The **E–registration** service sends a request to the email addresses of the pilots registered on the system, to confirm their relation with the operator. Likewise, the operator can register the drones used by the organisation, which are associated with the operator code, rather than with individual pilot codes.



CONCLUSIONS AND RECOMMENDATIONS

The sequence generated by combining the drone user (or drone operator) U-space unique registration code and the unique drone serial number uniquely identify any registered flying drone with a similar mechanism used by the cellular telephony operators, as follows:

- Serial number of SIM linked to the contract (and ID) of the subscriber
- Cellular phone unique vendor's code (IMEI)

The same identifier can be used (with minimal effort in configuration) on the "U-space Box" needed to broadcast such identification code (for the e-identification service) during the flight.

ISSUES

1. Use of **trusted third parties** for identity verification
2. **Model for payment**: Indirectly through EU citizen taxes or directly from users, possibly using the model of free basic services and premium advanced services

2 Concurrent Operations

U-SPACE SERVICES

U1 – Pre-tactical geofencing

U2 – Strategic deconfliction, Flight planning management, Weather information

U3 –

FLIGHT PHASES

2 Pre-flight

3 Execution

ACTORS INVOLVED

U-space Controller, Drone User, Stand-by Drone User, Flying Drone User

INFORMATION FLOWS

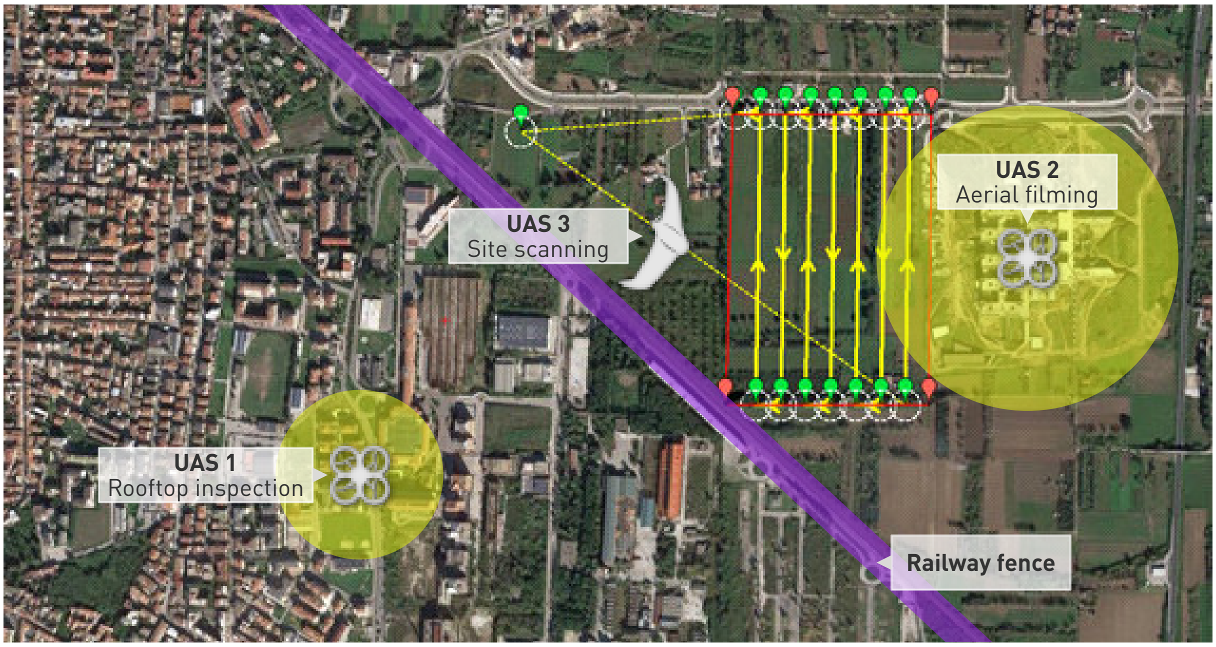
1. Flight plan approval
2. Flight plan rejection
3. Broadcast notification to land immediately

STORYBOARD

Three UAS are involved in concurrent operations in the same uncontrolled airspace. The first is is a heavy lift aerial filming platform being used for filming production in VLOS conditions, inside an industrial area. The second is a rotary wing drone, performing an inspection mission over a rooftop in VLOS conditions. The area of operations is at the limits of an urban area. The third is a fixed wing drone in a mapping operation (site scanning), for a construction site located in a suburban/rural area. Each UAS takes off at a different location.

The flight plan of the fixed wing drone has been previously approved by the U-space Controller, a software system without human intervention (a "bot"), and it is already in the execution phase of its automatic waypoint mission. The other standby drone users are about to submit their flight plans, before take-off. The wind is increasing beyond the capabilities of some of the UAS.

The scenario focuses on concurrent flight operations, with particular reference to flight plan submission and authorisation.



Concurrent Operations Scenario

1 FLIGHT PLAN APPROVAL

The pilot of UAS 1 submits his intended flight plan. The mission is limited to a very small area (inspection of a rooftop) and it is to be performed in manual mode. The pilot and the drone are already registered into U-space.

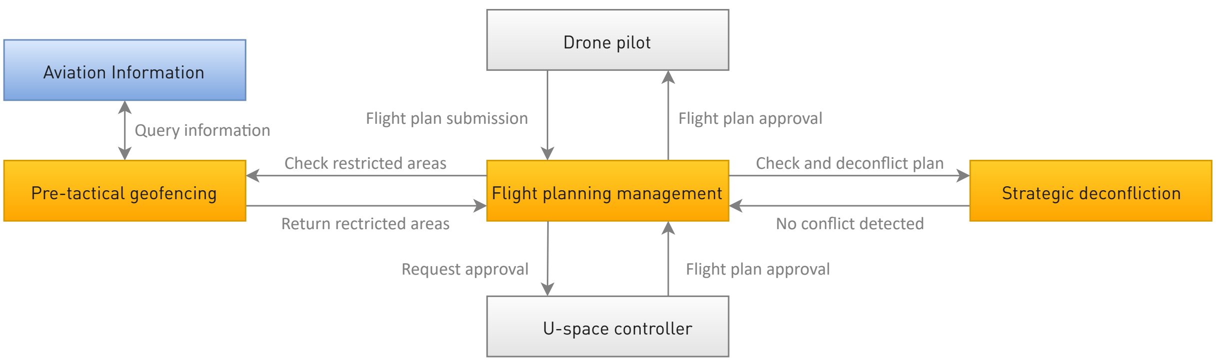
The submission of the flight plan includes the following information:

- Drone identification, capabilities and settings
- Pilot identification
- Position of the drone, intended height, time of the operation, duration, etc.

The **Flight planning management** service uses the information provided by the user on the request for approval to check for any possible restricted zone in the area of operations and other available aviation information, such as active NOTAMs, by querying the **Pre-tactical geofencing** service, which has the internal business logic and the interfaces with external aviation services to obtain and process the aviation information. In this case it provides the information regarding the geofence established around the railway.

After a positive check, the Flight Planning Management service, connects with the **Strategic deconfliction** service which has a database containing all the approved and current flight plans on the zone. The service can compare the planned flight plan with those already approved to determine any potential conflict. In this case none is detected.

After all checks are completed successfully, the final authorization is requested to the **U-space controller**. The **U-space controller** can be a human or a software system. If the final clearance is given, the notification is forwarded to the drone pilot.



2 FLIGHT PLAN REJECTION

The pilot of UAS 2 also submits his flight plan. In this case the area of operation is bigger, conflicting with the flight plan of UAS 3, which is already taking place.

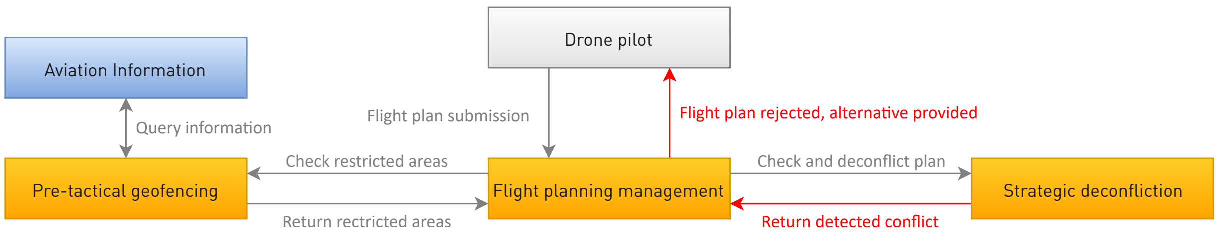
The information flow follows the same patterns as in the previous case up to the point in which the **Flight planning management** service connects with the **Strategic deconfliction** service.

When the **Strategic deconfliction** queries its database, it determines that the proposed flight plan conflicts in altitude, position and time with that of UAS 3.

The **Strategic deconfliction**, on the basis of the conflict detected tries to implement possible modifications to the submitted flight plan to remove the conflict. In this case, the alternative is to reduce the maximum height of the flight.

The **Flight planning management** notifies the stand–by drone pilot the rejection of the flight plan submitted, as well as the alternative solution provided.

The user can accept the alternative solution and resubmit the new flight plan, following the procedure described before, obtaining an approval of the modified flight plan this time.



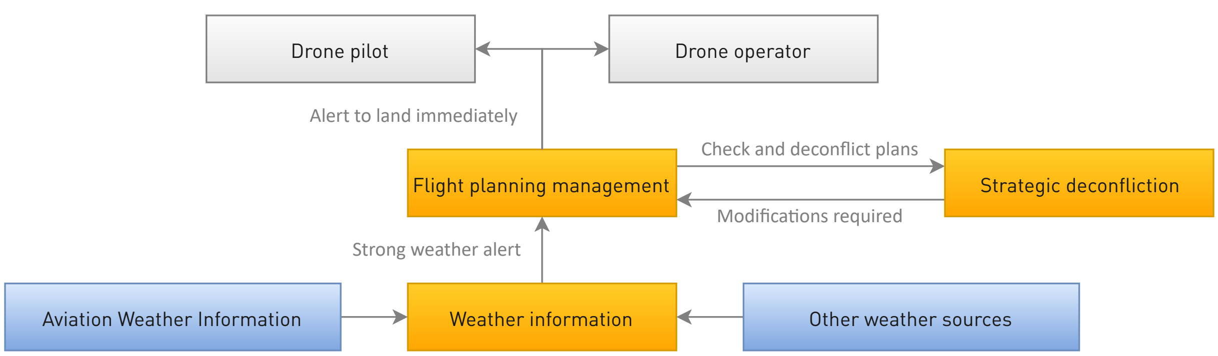
3 BROADCAST NOTIFICATION TO LAND IMMEDIATELY

The **Weather information** service, which is connected with aviation weather related services and other sources of local weather information, notifies the **Flight planning management** service of a strong wind alert.

The **Flight planning management** service checks all the flights that are taking place in the area that might be affected by the strong winds, obtaining a list of affected drones.

Before warning the affected users, the **Flight planning management** service requests from the **Strategic deconfliction** service a chek for any modification required for the Return to Home or landing procedures of the drones involved.

Finally, the **Flight planning management** service notifies the pilots and operators of the drones involved the strong wind alert and, if necessary, any contingency action to avoid posible conflicts.



CONCLUSIONS AND RECOMMENDATIONS

In this scenario, two drones have flight plans that overlap horizontally. To ensure a safe vertical separation, a modification of the maximum altitude is proposed to deconflict both operations.

For VLL operations in uncontrolled airspace a geodetic approach is more accurate than the traditional barometric approach used in manned aviation. Geodetic altitude relies on satellite navigation systems that are already widely used by manned aviation and are almost exclusively used by drones.

In low altitudes, the precision and accuracy provided by the European GNSS (Galileo, complemented with EGNOS) can ensure safe vertical separation and is not influenced by barometric perturbances that take place at low altitudes.

ISSUES

1. **UAS vertical separation**: Use the traditional barometric approach of manned aviation, or a new geodetic approach, based on GNSS data

2. **U-space as an autonomous system**, without human intervention, at least for some U-space services such as flight plan approval when no conflicts are detected

3 Territory Control

U-SPACE SERVICES

U1 – E-identification

U2 – Monitoring, Tracking

U3 –

FLIGHT PHASES

3 Execution

ACTORS INVOLVED

Drone pilot, drone operator, authority, unauthorised drone pilot, unregistered drone

INFORMATION FLOWS

1. Authority checks e-identification of authorised drone
2. Remote identification of unauthorised drone
3. Incursion of unidentified drone

STORYBOARD

An important public cycling event will take place in urban environment, in uncontrolled airspace. The place will be crowded by cyclists, journalists, law enforcement officials, as well as public. Local police is monitoring the event, using a tethered drone in the proximity of the starting line (50 meters AGL and 100 meters horizontally from the gathering of people). Moreover, the police has installed a ground surveillance anti-drone system, capable of detecting incoming drones and neutralising them.

A drone operator has been accredited by the authorities to fly in the proximity of the start line of the cycling event, without overflying people, inside the geofenced area. The purpose of the flight is live video broadcasting of the event. The flight is in VLOS conditions.

Right before the start of the event, two additional drones enter the geofenced area. One of them is registered, but has not been authorised, while the other is not registered into U-space and might constitute a security threat.

1 AUTHORITY CHECKS E–IDENTIFICATION OF DRONE

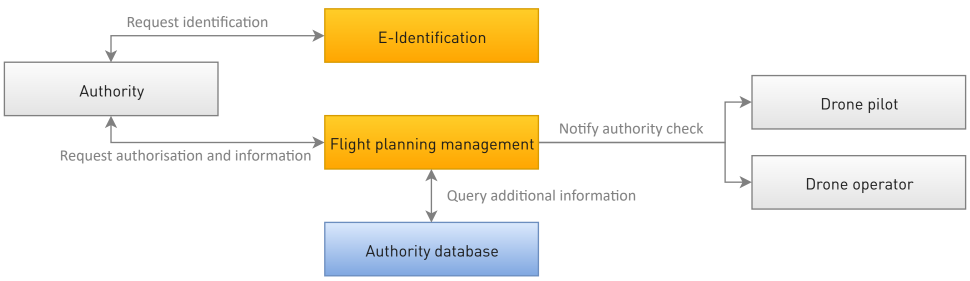
Local police has established a geofenced area around the event to temporarily close it during the event by accessing U–space with authority privileges.

At a certain moment, the police officer in charge of drone security sees a drone operating within the closed area. Using her U–space tablet application she points the tablet to the drone, to request information about it.

The drone is broadcasting continuously its e–identification code during the flight. This signal can be processed by the U–space application to identify the drone.

As soon as the drone is identified, the U–space application queries the **Flight planning management** service to obtain information about the drone. The Flight planning management service confirms that the drone has been authorised and can provide additional information about the pilot, the operator and the drone capabilities, by querying the authority registry database. The pilot and operator are also notified of the check performed.

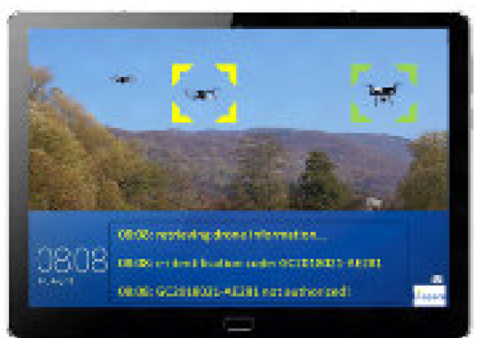
E–identification application showing the information of an authorised drone



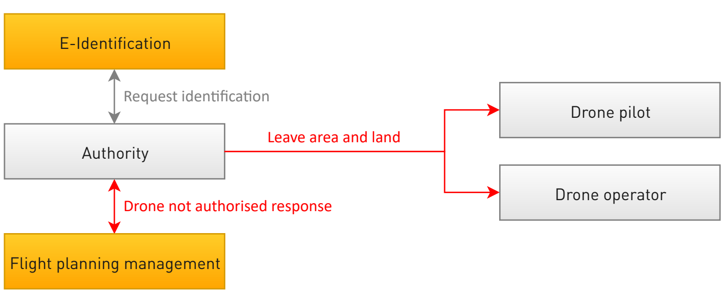
2 REMOTE IDENTIFICATION OF UNAUTHORISED DRONE

A second drone is spotted by the police officer. In this case, the drone is also identified, but the **Flight Planning management** service reports that there is no authorised flight plan for that drone.

Using her U–space tablet application, the police officer initiates the procedure to notify the drone pilot and operator to abandon the geofenced zone and land immediately.



E–identification application showing the information of an unauthorised drone



2 INCURSION OF UNIDENTIFIED DRONE

In the case of the third drone described in the storyboard which is not registered (and therefore not authorised), it breaks completely the regulation and might constitute a security threat.

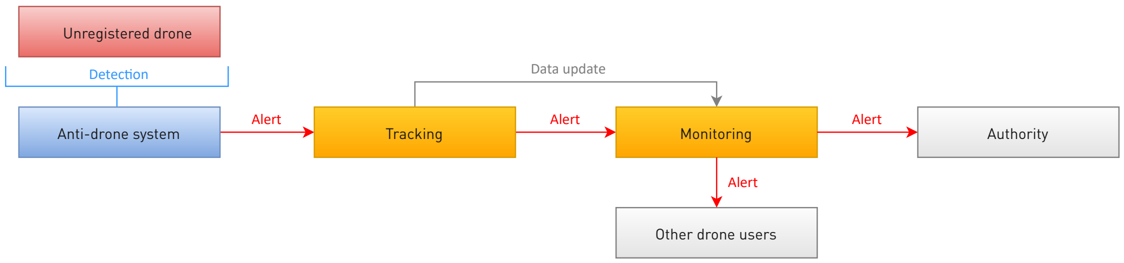
To cope with this case, other systems, such as ground anti-drone systems may alert in time the authority, interfacing with U-space services to provide better relevant data to the authorities.

The ground anti-drone system detects the incoming drone, before visual contact by the police officer and alerts the **Tracking** service, providing information on the drone position, physical characteristics and capabilities (such as flight speed).

The **Tracking** service generates a temporary e-identification code, similar to the code used in the **E-identification** service and notifies the **Monitoring** service.

The **Monitoring** service integrates this data with other data sources to improve the situational awareness of the threat for the law enforcement officials and other users of the airspace.

The Authority is alerted of the incursion by the **Monitoring** service and may operate appropriate countermeasures to neutralise the drone incursion. Some of these measures could impact other legitimate users of the airspace. Therefore they should also be alerted.



CONCLUSIONS AND RECOMMENDATIONS

The U-space box guarantees access to the U-space. It should be a hardware system, totally independent from the flight controller of the drone and can benefit from emerging technologies such as "Internet of Things" (IOT) adopting mature technologies coming from the mobile telephony sector.

ISSUES

1. **U-space box** independent from the flight control system
2. **U-space box** implemented using Internet Of Things (IOT) technology
3. Interface between **Security Anti-drone Systems** and U-space to identify and neutralise unidentified drones

4 Cooperative Geo–tagging

U–SPACE SERVICES

U1 – Pre–tactical geofencing

U2 – Tactical geofencing, flight planning management, tracking

U3 –

FLIGHT PHASES

1 Preparation

2 Pre-flight

3 Execution

ACTORS INVOLVED

Flying drone pilot, stand–by drone pilot

INFORMATION FLOWS

1. Flying pilot notifies an obstacle
2. U–Space notifies flying drone pilots
3. U–Space notifies stand–by drone pilot

STORYBOARD

Two neighbouring mid–size cities in Europe in uncontrolled airspace have two hospitals, each with an heliport on its rooftop. The heliports are equipped with a landing pad for manned helicopters and small landing pads for multicopter drones. There are no prohibited/ restricted zones, nor an airport in the proximity of the hospitals.

The first hospital requires a particular drug and requests a fast drone delivery from the other, after checking via telephone the availability of the drug. The second hospital acknowledges the request and prepares one of its UAS for the flight mission, uploading the flight plan to U–space, and receiving the authorisation for the mission. The route uploaded for the mission has not been flown recently.

The UAS used by the hospital has DAA capabilities (ground obstacle detection only). During the flight, the UAS encounters an unpredicted hazard, represented by a crane inside an unreported construction site. The UAS slows down autonomously, while modifying its path to avoid the obstacle. This event is notified to the drone pilot through the ground control station. The estimated position of the crane, obtained through the DAA and UAS positioning information, is geotagged and notified to U–space for fencing purposes.

Continues

In the meantime, two other U-space users (a flying user and a stand-by user) with possible route conflicts with the crane position are notified by U-space for a flight plan or route modification.

The scenario focuses on cooperative mechanisms that drones could use for geotagging new obstacles and how U-space could notify the information to other users.

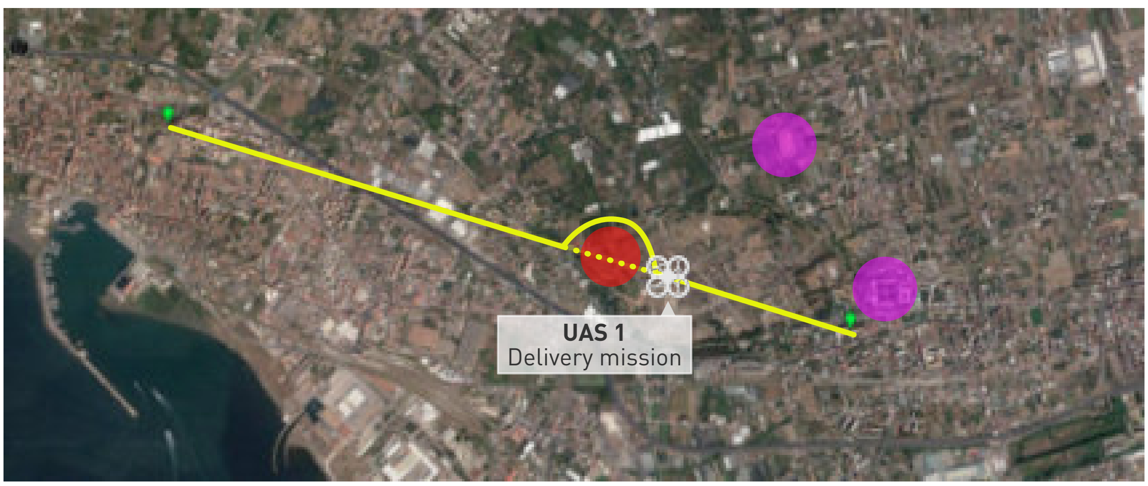
1 FLYING PILOT NOTIFIES AN OBSTACLE

The DAA sensors installed on drone 1 detect an obstacle, in this case an unreported crane. The system notifies the pilot through the ground control station, and the drone autonomously reduces its speed and varies its path to avoid the detected obstacle

Normally the **Tracking** service uses cooperative data (sent automatically by the drones) and non-cooperative data (obtained with airspace surveillance sensors) to maintain track-identity of individual drones.

After the obstacle is successfully avoided, the drone pilot can notify the **Tracking** service its existence for the benefit of other users.

The **Tracking** service, possibly after an automatic or semi-automatic internal control to validate the information, issues an *Update geofence* request to the **Pre-tactical geofencing** and **Tactical geofencing** services, which in turn, notify other services such as the **Flight planning management** service to update the flight plans of other users that might be affected by the obstacle.



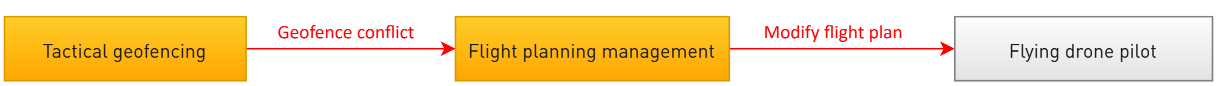
2 U-SPACE NOTIFIES FLYING DRONE USERS

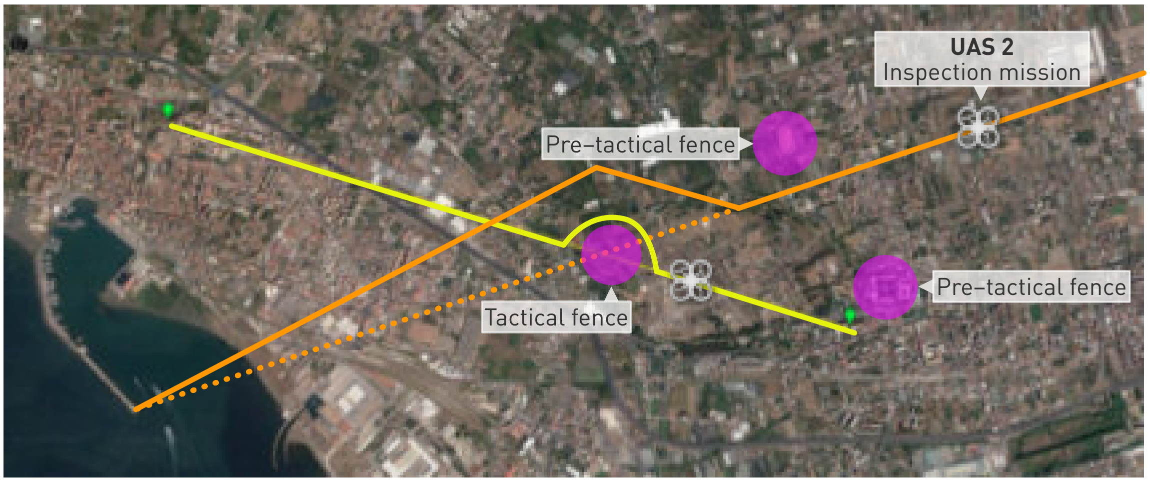
The **Flight planning management** service checks internally the effect of the new hazard on other flights that are taking place in the area.

In the case of drone 2, its flight plan would intersect with the new geofence. Therefore the **Flight planning management** service notifies the pilot of drone 2 the hazard just detected and suggests an alternative flight plan (like the one shown on the figure on the next page).

The pilot can accept the suggested change, or decide to abort the mission.

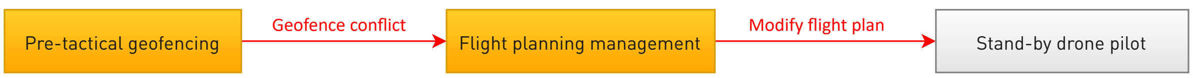
Other users of the airspace not affected by the obstacle, are also notified of the existence of a new tactical fence on the area, but no further action in their part is required.

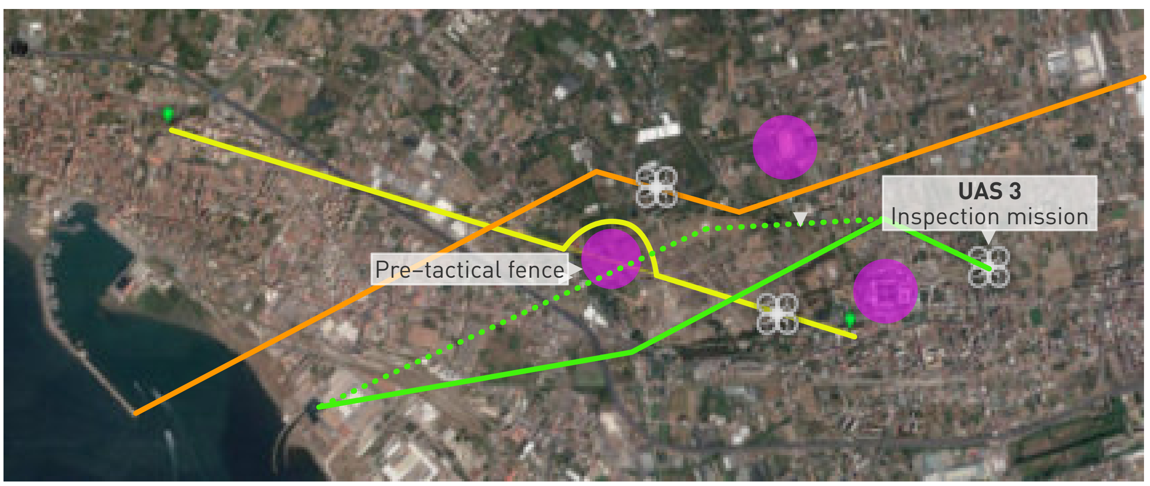




3 U-SPACE NOTIFIES STAND-BY DRONE USERS

In the case of drone 3, which has already submitted an approved flight plan, but is still on the ground, the situation is conceptually similar, with the important difference that, in this case, the new obstacle becomes a pre-tactical fence and therefore, its pilot would receive a notification from the **Flight planning management** service to modify the flight plan when U-space reaches the U-2 development stage (in the previous case, the U-3 stage is required).





CONCLUSIONS AND RECOMMENDATIONS

Cooperative geotagging can become one of the preferred ways to ensure that the information on U-space remains current although it requires that the system implements the necessary internal controls to ensure that the information is accurate.

5 CTR Crossing

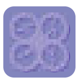
U-SPACE SERVICES

U1 –

U2 – Flight planning management, Procedural interface with ATM

U3 –

FLIGHT PHASES

1 

Preparation

ACTORS INVOLVED

Drone operator, U-space controller

INFORMATION FLOWS

1. Flight plan rejected
2. Alternative flight plan approved

STORYBOARD

An express courier, which is also a drone operator, wants to use an UAS for a delivery mission between two Hubs separated around 15 km.

The first Hub is located in a village with low density population. The second Hub is inside controlled airspace (CTR) in an industrial zone of a mid-sized European city. However, it is separated more than 8 km from the city airport.

The scenario focuses on the pre-tactical phase of mission preparation and the interfaces between ATM and Drone Traffic Management.

1 FLIGHT PLAN REJECTED

The drone operator submits a flight plan to the **Flight planning management** service. The service parses the route information identifying that part of the route takes place in controlled airspace.

The **Flight planning management** service, or the U–space controller, interact with the **Procedural interface with ATC** service, which involves digital and non–digital procedures (like voice communication with an ATC official).

The **Procedural interface with ATC** service provides an interface with ATM, which rejects the request on the basis that, even if the drone has enough capabilities to access the airspace, the proposed flight plan might interfere with the established approach/departure procedures of the airport.

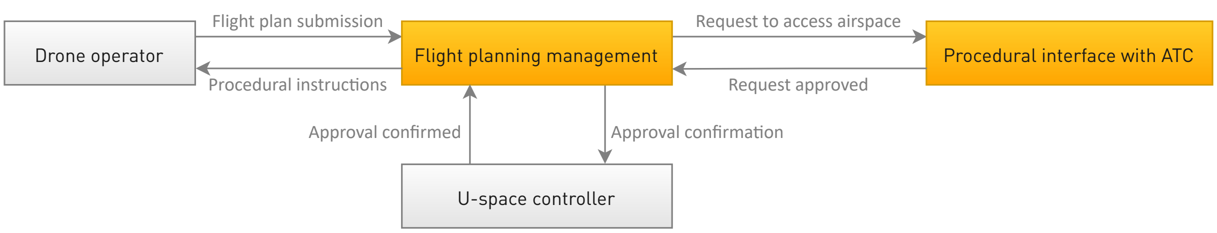
The **Flight planning management** service rejects the flight plan, but provides an alternative route that minimises the time the drone flies inside controlled airspace and does not interfere with the existing procedures at the airport.

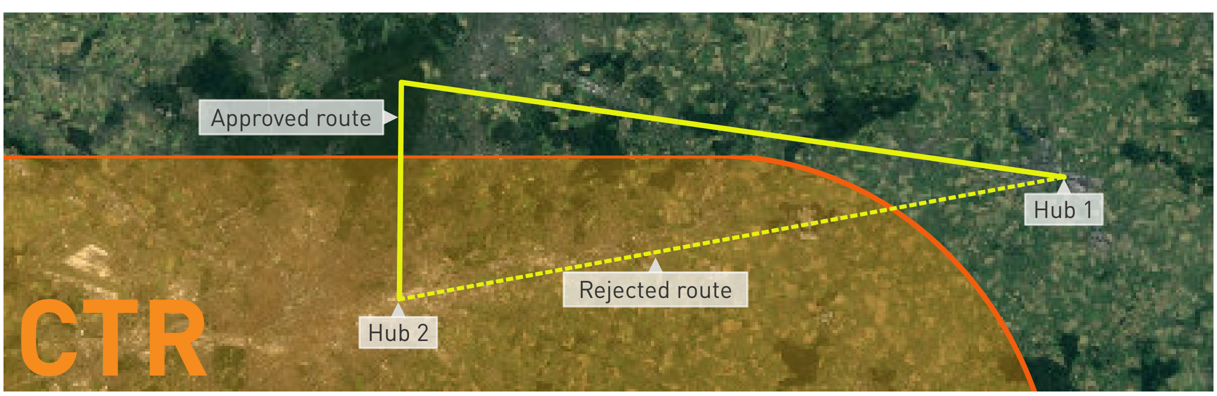
2 ALTERNATIVE FLIGHT PLAN APPROVED

After receiving the rejection from the **Flight planning management** service, the operator modifies the flight plan to comply with the alternative proposed by the **Flight planning management** service.

The **Flight planning management** service process the request again through the **Procedural interface with ATC** and, this time, the flight is approved.

As a final check, the **Flight planning management** service might request a final approval by the U–space controller.





CONCLUSIONS AND RECOMMENDATIONS

This scenario shows the boundaries between the traditional ATM and the new U–space worlds. The **Procedural interface with ATC** is the first U–space service to connect both worlds.

This service should support commercial drone operators by providing a single interface to access controlled airspace through U–space services.

ISSUES

1. ATM/U–Space boundaries

6 Long Range Operations

U-SPACE SERVICES

U1 –

U2 – Weather information, Drone aeronautical information management, Traffic information

U3 –

FLIGHT PHASES

1 Preparation

3 Execution

ACTORS INVOLVED

Drone operator, Manned aircraft pilot

INFORMATION FLOWS

1. Support to flight planning for long range operations
2. Support to general aviation pilots for drone situational awareness

STORYBOARD

An operator wants to use a fixed wing drone for pipeline inspection, in BVLOS conditions in uncontrolled airspace with prevalence of trees and hills in a rural environment. No villages or cities are supposed to be encountered during the flight.

The mission of the fixed wing drone is to identify possible oil spills on a given segment of the pipeline, using hyper-spectral and thermal sensors. To detect faults on the pipeline, the drone should maintain a vertical distance of 50 meters from the pipeline, which follows the terrain slope.

The segment of pipeline to inspect has a length of 25 km, and the maximum distance from the launching point is 35 km, for a total distance of 70 km to be flown. Due to the characteristics of the mission: distance, low altitude and the existing obstacles on the terrain, the command and control link will not maintain RLOS conditions.

The scenario focuses on the Mission planning stage for long range operations and also explores how general aviation pilots might use U-space services to increase their drone situational awareness.

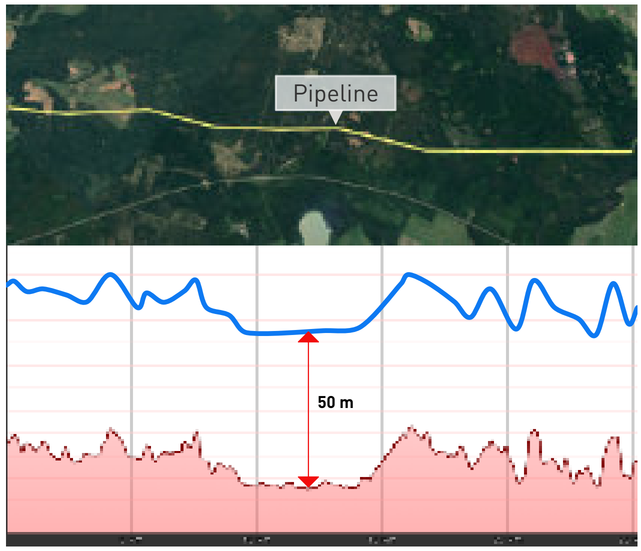
1 FLIGHT PLANNING FOR LONG RANGE OPERATIONS

The success of a long range operation is dependent on the availability, reliability and integrity of the data provided by different service providers. The information is required during the planning stage, to analyse the feasibility of the mission and during the execution of the flight to ensure the safety of the operations.

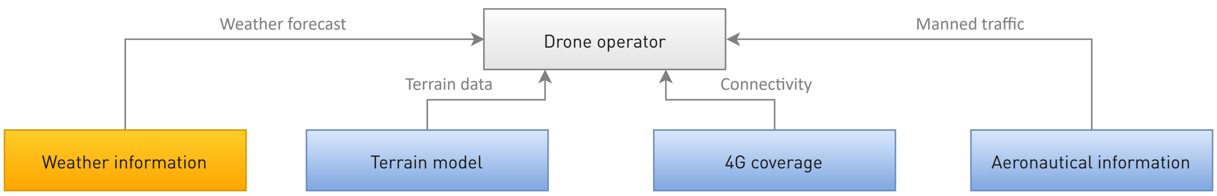
At a minimum, the following information sources have to be considered:

- Local weather information
- Terrain model
- Coverage for C2 and other communication links (telemetry, payload, etc.)
- Aeronautical Information System, to obtain information about manned traffic

According to the present definition of the U–space services, only weather information would be available through U–space. Therefore, the operator would have to use other sources of information, which may not be reliable, indicating the existence of a possible gap in the current definition of U–space.



Horizontal and vertical profile of the long range operation



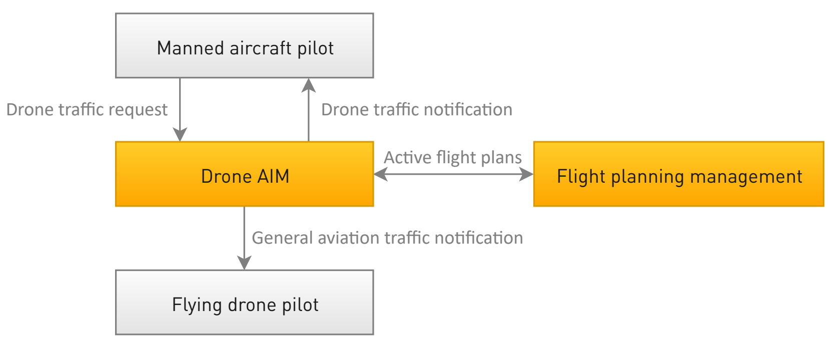
2 DRONE SITUATIONAL AWARENESS FOR GENERAL AVIATION PILOTS

Manned aircraft pilots can use digital application on smartphone or tablets to gain situational awareness of the presence of drones. These applications could be executed on portable Electronic Flight Bag (EFB) devices, as described on EASA AMC 20–25.

The E–space application requests the **Drone aeronautical information management** service (Drone AIM) service information about the drones flying in the vicinity.

The **Drone AIM** service updates the information by requesting the **Flight planning management** service the active flight plans.

As a bonus, the U–space application could also provide information about the presence of general aviation traffic to drone users, using the same interface.



Example of a possible U-space application for general aviation

CONCLUSIONS AND RECOMMENDATIONS

The scenario introduces some possible gaps between the current definition of U-space and what would be required to support long range operations.

Also, long range operations will require the existence of reliable C2 links when RLOS conditions are not possible. Satellite communications can be a viable solution, using small transceivers, taking advantage of reasonable operating fees. An alternative based on the mobile telephony network can also be explored.

The scenario also investigates the support of U-space to general aviation. An application for U-space which is usually overlooked.

ISSUES

1. Alternatives for **C2 links in long range operations**; 4G/5G or satellite
2. Services to **support long range operations** (like a terrain model service) are required
3. Availability of video (or other payload) link

7 Deconflict Management

U-SPACE SERVICES

U1 –

U2 – Tactical geofencing, Flight planning management, Drone aeronautical information system, strategic deconfliction

U3 –

FLIGHT PHASES

3 Execution

ACTORS INVOLVED

Flying drone User, Authority, U-space controller

INFORMATION FLOWS

1. Authority requests temporary segregation
2. Flying drone user is requested modification of flight plan

STORYBOARD

A rotary wing UAS is involved in a delivery mission application (delivery of medical supplies to a hospital) inside an uncontrolled airspace in urban environment. The UAS flight plan has been approved and the UAS is executing the flight.

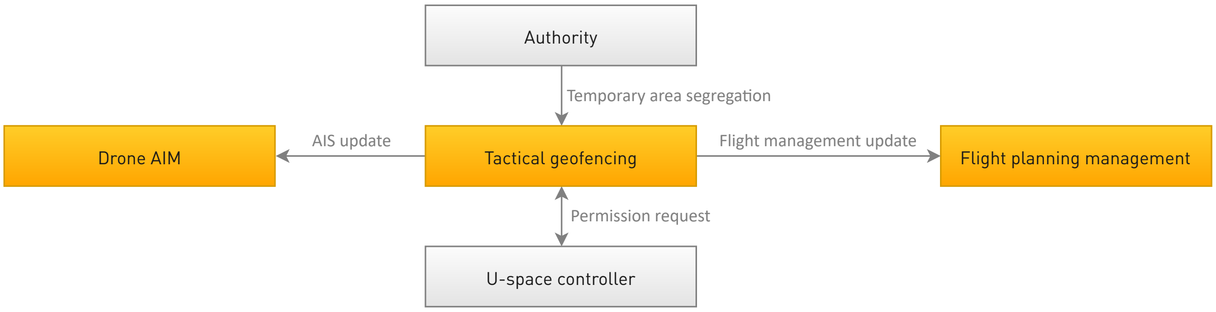
At that moment the police requests a temporary restriction of airspace to perform a survey related with the investigation of a car accident. Law enforcement has a higher priority to other users of the airspace and, therefore, other flying drone users in conflicting paths are immediately notified and possible contingency actions are suggested to the drone users.

The scenario focuses on modification to a flight plan during UAS flight because of possible conflicts, unknown when the flight plan was approved.

1 AUTHORITY REQUESTS TEMPORARY SEGREGATION

The police requests to the Tactical geofencing service a temporary segregation of certain airspace. The Tactical geofencing service requests authorisation to the U–space controller. This request can be processed by an automatic system, without requiring a human intervention.

After receiving the authorisation, the **Tactical geofencing** service updates the **Drone aeronautical information management** service and the **Flight planning management** services.



2 FLYING DRONE USER IS REQUESTED MODIFICATION OF FLIGHT PLAN

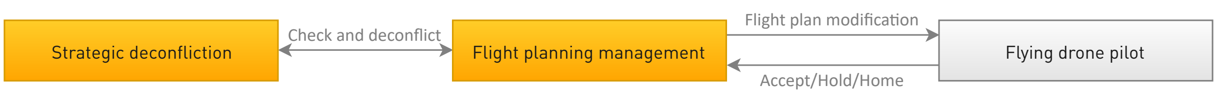
The **Flight planning management** service working in combination with the **Strategic deconfliction** service check the active flight plans that might be affected and any potential conflict that a change in flight plan might cause on existing traffic.

To do so, the **Strategic deconfliction** service relies on an internal engine for the recalculation of the flight plans of all affected flying drones, taking also into account that individual drone users might not accept the proposed modifications to their flight plan.

The **Flight planning management** service requests flying users to modify their flight plans, proposing a viable alternative.

Drone users have the option to:

- Accept the proposed modification
- Hold their current position, hovering in place in case of rotary wing UAS, or loitering around its current position, in the case of fixed wing UAS, or,
- As a last resolution, to abort their mission, performing a Return To Home procedure



CONCLUSIONS AND RECOMMENDATIONS

When a flying drone user maintains the drone on hold, he might also decide to edit an propose a different flight plan that does not conflict with the fenced area and other traffic, obtaining an authorisation in real time.

When there are several users in this situation, human factors might become an issue while the system tries to accommodate several conflicting requests at the same time.

ISSUES

1. Human factor for the resolution of cascading dynamic flight plan modification requests

8 Emergency Management

U-SPACE SERVICES

U1 –

U2 – Emergency management, Tactical geofencing, Flight planning management, Drone aeronautical information system, strategic deconfliction

U3 –

FLIGHT PHASES

3 Execution

ACTORS INVOLVED

Flying drone pilot, Authority, U-space controller, Drone (as an actor)

INFORMATION FLOWS

1. Emergency landing procedure
2. Loss of control notification

STORYBOARD

A hospital has been using a drone daily, without any incident so far, to deliver blood samples to an external analysis center on another hospital. Both hospitals are in a medium sized city, in uncontrolled airspace, in a southern country of Europe with mild climate.

In a particularly cold morning of February, with temperatures below 0°C (uncommon for the zone), the pilot of the drone, Luca, prepares the drone as usual and obtains the approval to conduct the operation.

Just after 5 minutes after starting the flight, the flight control system detects a sudden reduction of the voltage of the batteries, most likely due to defective battery packs degraded by the low temperature. Luca is alerted of the situation and is notified by the Emergency management service about the closest emergency landing site.

Luca accepts the flight plan proposed by U-space, and the drone changes its trajectory autonomously. A few seconds later, both batteries stop working, causing a critical loss of power to maintain the drone in the air. The flight controller detects the situation, powers down the rotors and launches the parachute which is powered by a completely independent battery.

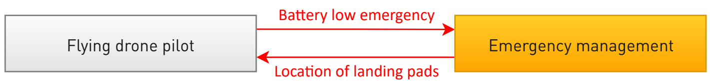
While the drone descends slowly, U-space notifies the emergency to the Authorities for a fast intervention on the affected area.

1 EMERGENCY LANDING PROCEDURE

The drone pilot becomes aware of the situation through an alert shown on his ground control station. He notifies the situation to the **Emergency management** service, which provides the location of the nearest emergency pad located on the roof of a nearby building.

Note that, even if the pilot could have acquired the location during the planning phase of the mission, it is still necessary to check during the execution phase because other users might have occupied it.

Since it is an emergency, the drone pilot gets notified of the nearest landing site, and he can reject it, to be provided an alternative site, but upon accepting a proposed site, the drone itself should have the capability to fly and perform an automatic landing autonomously.



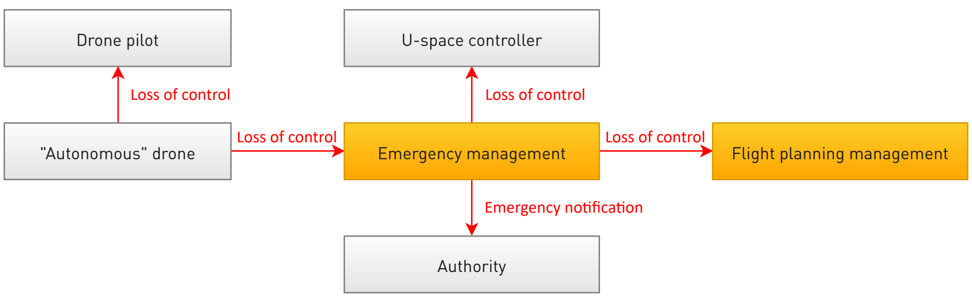
2 LOSS OF CONTROL NOTIFICATION

Due to the deteriorating conditions of the batteries, the drone is not able to reach the emergency landing site.

However, the flight controller of the drone is able to detect the critical loss of power failure to activate the failsafe automatic flight termination system, i.e. cut the power to the rotors and deploy the parachute, to reduce the descent speed and minimise the kinetic energy of the crash.

The flight control system of the drone also notifies autonomously the **Emergency management** service the "Loss of control" condition.

In turn, the **Emergency management** service, acting as a "producer" notifies the event to all "consumer" services and actors involved.



CONCLUSIONS AND RECOMMENDATIONS

In BVLOS missions at VLL altitudes, the reaction time of a human pilot might be insufficient to handle a contingency situation with a remote pilot approach.

Independent and autonomous flight termination systems activated by unexpected or potentially dangerous flying conditions, such an unusual attitude or high descent speed, may constitute a viable mitigation.

In these conditions the drone itself becomes an "actor" of U–space, capable to take conditional decisions. The liability boundaries between drone operators, pilots, manufacturers and U–space itself is a topic which should be addressed by other U–space studies. This situation will become specially important at the U–3 development stage.

ISSUES

1. Liability boundaries between drone operators, pilots, manufacturers and U–space as drones increase their autonomous emergency procedures

9 Capacity Management

U-SPACE SERVICES

U1 – Flight planning management

U2 – Dynamic capacity management, Dynamic geofence, Tactical deconfliction

U3 –

FLIGHT PHASES

1 Preparation 2 Pre-flight 3 Execution

ACTORS INVOLVED

Drone (as an actor), Drone Operator, U-space controller, Drone operations manager

INFORMATION FLOWS

1. Drone requests access to airspace
2. Tactical deconfliction
3. Drone dynamically modifies its route

STORYBOARD

In a mid sized European city, in uncontrolled airspace, experiences daily hundreds of drone flights, mainly for delivery missions. Take-off and landing sites have been upgraded to provide automatic recharging stations, reducing the requirements for supporting personnel, and many of them are shared between different operators.

With the introduction of U-3 the level of automation has increased. For example, many routes are scheduled and pre-approved, subject only to a capacity check, triggered by the drones autonomously, and validated by an automated software system.

As a consequence, drone pilots have become operation managers, overseeing simultaneous fully automated operations and intervening only in contingency situations.

This scenario focuses on some aspects of one of these scheduled routes, performed by whatever drones of the fleet of the operator responsible of the route is available on each particular operation.

1 DRONE REQUESTS ACCESS TO AIRSPACE

UAS 1 is about to start a daily delivery route, from its current position to a particular Hub.

The drone itself, autonomously, requests authorisation to take-off to the U-space controller (which is also an automatic software system).

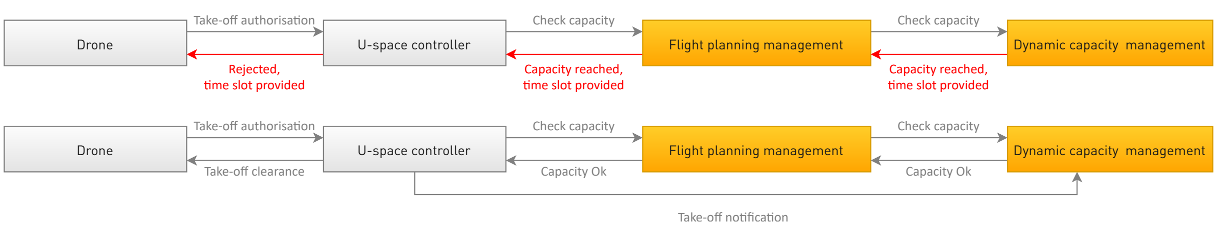
The U-space controller requests from the **Flight planning management** service a capacity check which is forwarded to the **Dynamic capacity management** service.

In this moment, the capacity has been reached, but using its internal logic and the knowledge of the characteristics of the flight plans of the current users of the airspace, the **Dynamic capacity management** service can estimate an adequate time slot for the route intended by Drone 1.

The U-space controller is notified about the current saturation and the proposed time slot and, in turn, notifies Drone 1.

The drone requests again access to airspace at the proposed time slot, or alternatively, is notified automatically for clearance by the system.

When UAS 1 finally takes-off, the **Dynamic capacity management** service is notified to increment its internal airspace capacity counter and to store the flight plan of Drone 1 for future reference.

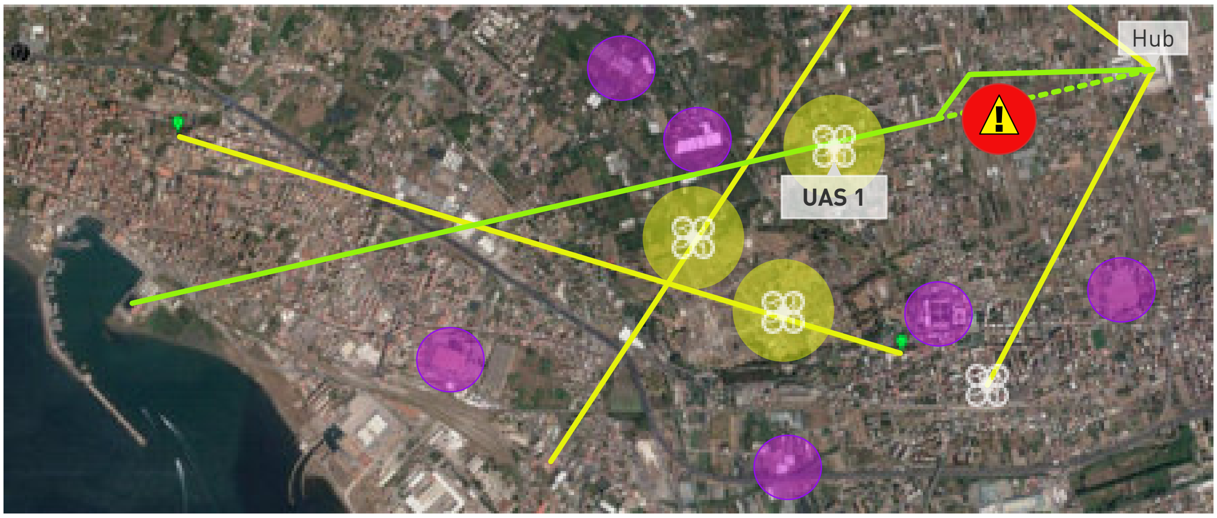


2 TACTICAL DECONFLICTION

During the flight, Flying drones might be notified about possible conflicts that require a change on their flight parameters.

For example, due to the density of traffic, the U-space controller commands UAS 1 to reduce its speed to maintain the separation with other unmanned traffic.

3 DRONE DYNAMICALLY MODIFIES ITS ROUTE



During the flight of UAS 1, a new prohibited zone (fence) appears due to an unplanned event that conflicts with the flight plan of UAS 1.

The Dynamic geofencing service gets updated by the geofencing system.

The Flight planning management service is notified. It checks all existing active flight plans to detect possible conflicts and determines that, in fact, UAS 1 route would cause it entering into the prohibited zone.

Therefore, the Flight planning management service calculates a new flight plan to avoid the prohibited zone and transmits the new plan to the U-space controller.

The U-space controller acting as a front-end for the drone at this stage, uploads directly the new flight plan to the drone.

CONCLUSIONS AND RECOMMENDATIONS

At later stage of development of U-space, advanced conflict resolution will involve U-space to modify the flight plans of flying drones in real time.

Therefore, a standardisation of data link requirements and real time flight plan modification will be required.

MAVLINK, an open protocol for communications between UAS and ground control stations, which is a de facto standard for micro UAS, provides already much of the required functionality, but lacks the data integrity and security requirements that would be necessary.

ISSUES

1. Data links and communication protocol standards.

10 Intelligence Service

U-SPACE SERVICES

U1 –

U2 – Flight planning management

U3 –

FLIGHT PHASES

4 Post Flight

ACTORS INVOLVED

Authority: Police and National Aviation Authority (NAA), Drone Operator, Authority

INFORMATION FLOWS

1. Police requests from NAA drone operator contacts

STORYBOARD

After a bank attack, the police has acquired all the surveillance videos available from surveillance cameras installed on the bank office and in the area surrounding the bank.

The police contacts the National Aviation Authority to request a list of drone operators that have flown on the vicinity at the time of the bank attack. Even if there is no guarantee that the drones were equipped with cameras or that appropriate footage can be obtained, the NAA can use U-space to identify all flights that took place in an specific area at a particular time and provide the police with the contact details stored on U-space of their operators.

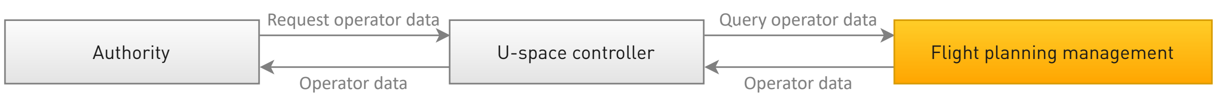
3 POLICE REQUESTS FROM NAA DRONE OPERATOR CONTACTS

The police acting as an Authority actor in U-space requests the information to the NAA providing the location (with geographical coordinates) and the time frame of the bank attack.

The NAA, after confirming the legitimacy of the request, and acting in the role of U-space controller, performs a query against the **Flight management** service using the spatial and temporal restrictions provided to filter the database of stored flight plans by these criteria.

In this case, the query results in three flight plans executed by three different drones, including their e-identification codes as well as the e-registration codes for their respective operators.

Finally, the NAA returns the information to the police, who can contact individually each operator to enquire about the availability of relevant video footage or other data that might help the investigation.



CONCLUSIONS AND RECOMMENDATIONS

Video captured by drones in inspection missions or used for navigational purposes and other data gathered by drones could be invaluable to law enforcement agencies and have a positive impact in the security of EU citizens, if it is possible to be integrated into criminal investigation activities.

Of course, it will involve solving first the privacy and data protection concerns arising from the acquisition and storage of video and other sources of personal information.

ISSUES

1. Privacy and data protection issues

11 Personal Mobility

U-SPACE SERVICES

U1 –

U2 – Flith plan management

U3 – Collaborative interface with ATC

FLIGHT PHASES

1 Preparation

2 Pre-flight

ACTORS INVOLVED

Client (Passenger), U-space controller, Drone, Drone operator, Drone supervisor

USE CASES

1. Taxi flight plan rejected
2. Take-off authorisation

STORYBOARD

After landing at the airport of a big European city, a businessman decides to take a taxi drone service to reach the city center. The reservation is made through a dedicated mobile phone app created specifically for this purpose that interfaces directly with the Service Provider (Taxi Drone Operator).

These taxi drones (electric jet-powered) have both Vertical Take-Off and Landing and Rapid Horizontal Flight capabilities, are "parked" in reserved areas of the airport ("skyports") at a sufficient distance from the airport runways, from where they take-off and land. They fly in autonomous mode and have all the safety systems required for the transportation of passengers.

The businessman books and pays for the taxi drone service directly from his mobile phone and receives the instruction to board taxi drone N°5 in the skyport. While he arrives to the skyport an assistant checks and prepares the drone for the trip.

1 TAXI FLIGHT PLAN REJECTED

Adequate procedures for drone operations in the airport area should be established and coordinated with ATC, so that they do not interfere with manned traffic operations or cause an increase of the workload of the controllers.

In fact, the **Collaborative interface with ATC** should not imply any active participation in the part of the airport controller, but rasher be based on a common situational awareness, so that the **Collaborative interface with ATC** independently denies access to the airspace if there is a potential conflict with manned traffic.

The drone itself provides the flight plan to the **Flight planning management** service based on the destination of the client, since each destination on the city centre has a predefined route.

In turn, the **Flight planning management** service asks for an update of the situational awareness to the **Collaborative interface with ATC** service.

In this case, the **Collaborative interface with ATC** services responds that there is a higher density of manned traffic with an estimate of how long this situation will be maintained.

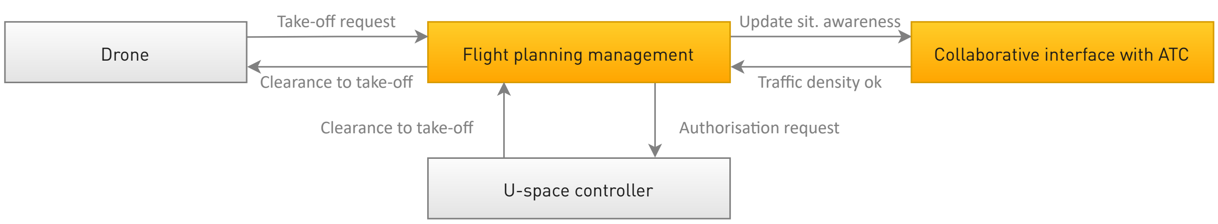
In consequence, the **Flight planning management** service rejects the flight plan and provides an estimated time slot so that the drone can inform the client, through a display, of the estimated delay for departure.

2 TAKE–OFF AUTHORISATION

At the specified time slot, the drone requests the take–off authorisation for the flight plan already submitted to the **Flight planning management** service.

The **Flight planning management** service updates again the situational awareness from the **Collaborative interface with ATC** and receives this time a normal traffic density response.

The **Flight planning management** service requests to the U–space controller authorisation for take–of and, after receiving a final approval, forwards the clearance for take–off to the drone.



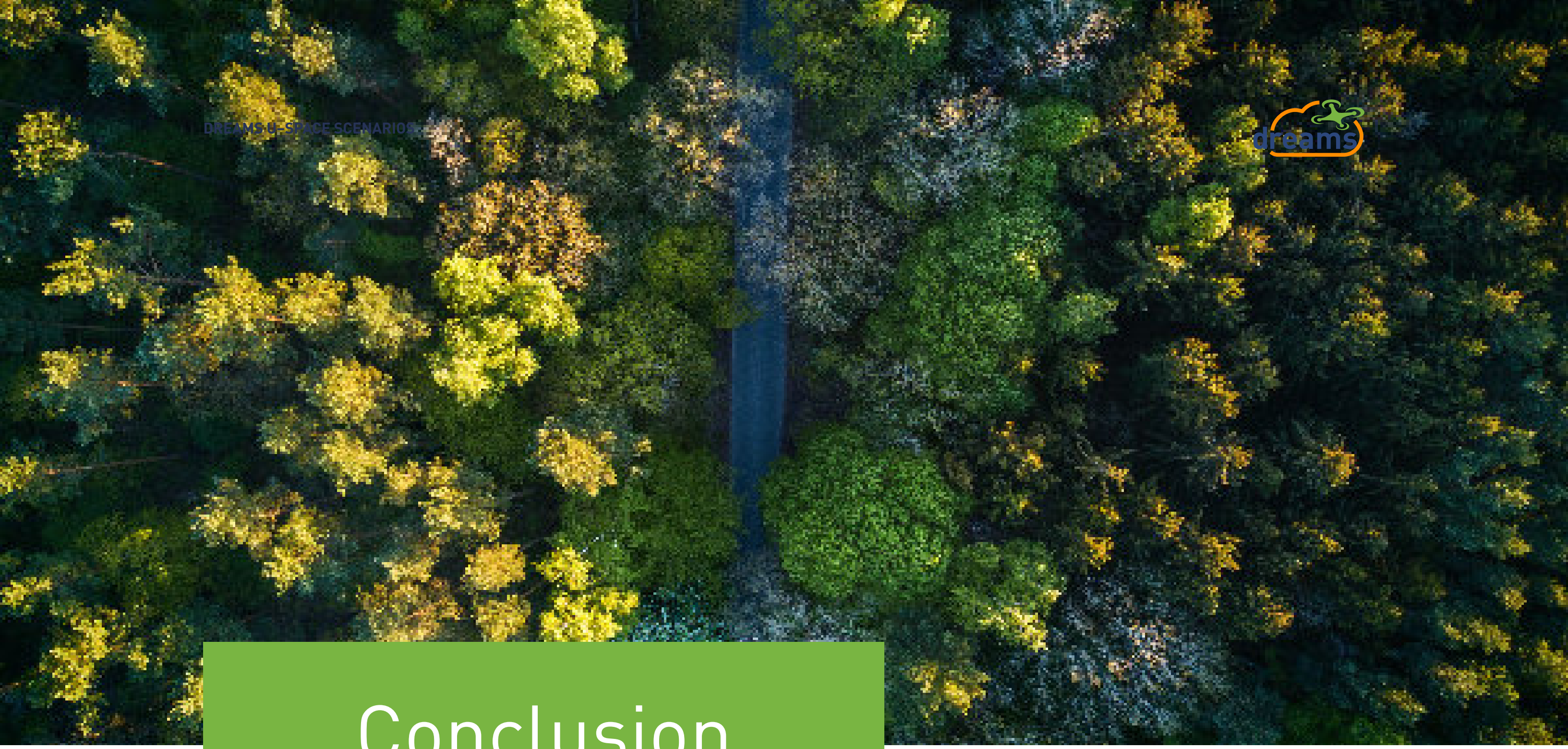
CONCLUSIONS AND RECOMMENDATIONS

As the level of automation increases, the figure of remote pilot for a single drone will evolve towards the role of drone supervisor, in charge of the monitoring of multiple drones and control only in case of contingency situations that require a human decision.

This evolution not only requires the deployment of the more advanced U–space services, supported by reliable communication interfaces and other technologies, but also public acceptance.

ISSUES

1. Public acceptance



Conclusion

DREAMS has identified a number of relevant scenarios which, although not exhaustive, represent a first attempt to analyse in detail the interactions among actors (users) and services, starting from the preliminary definition of the U-space services.

The logic used to identify the scenarios has taken into account different factors, such as the coverage of U-space services with respect to the different phases of flight of a mission, the experience and best practices that are being used currently by drone operators, as well as the potential market opportunities that can be unlocked with the introduction of new U-space services.

The exercise has proved to be very useful for the DREAMS consortium to:

- Build a list of representative cases of use
- Define the boundaries and the typology of information that will be shared among the actors (users) and the U-space services, between the different U-space services, and the interactions with other services and systems external to U-space
- Identify the categories of actors and functions that should be considered to implement the U-space services
- Analyse the different interfaces that will be required to convey the communication between human and machine actors

The main outcomes of the scenario identification and analysis work are:

- Integration of the experience, best practices and needs of existing drone operators
- Identification of the actors and their evolving behaviours as U-space develops
- Development of relevant scenarios describing U-space real world use
- Initial requirement analysis for the various U-space services, including the preliminary assessment of the information that will be shared and the main data flows involved
- A first contribution to the analysis of BVLOS operations, both in remotely piloted and fully autonomous conditions

Finally, the analysis of the different scenarios has raised a number of potential issues that will have to be considered and solved to develop the U-space concept and unleash the true market potential of the drone technology.

Notes

To get more information about the project DREAMS, please contact us at:

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