France (Bretigny) Demonstration Report

Deliverable ID:	**D5.1**
Dissemination Level:	**PU**
Project Acronym:	**PODIUM**
Grant:	**783230**
Call:	**H2020-SESAR-2016-2**
Consortium Coordinator:	**EUROCONTROL**
Edition Date:	**30 August 2019**
Edition:	**01.00.00**
Template Edition:	**02.00.01**

Founding Members
EUROPEAN UNION EUROCONTROL
SESAR JOINT UNDERTAKING

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Document History

Edition	Date	Status	Author	Justification
00.00.01	29/07/2019	DRAFT	Bonhomme	First draft
00.00.02	26/08/2019	DRAFT	Bonhomme	Second draft
00.01.00	27/08/2019	Pre-release	Alty	Quality
00.02.00	30/08/2019	Pre-release	Alty	Clarifications
01.00.01	30/08/2019	Final	Alty	Approvals

PODIUM

PROVING OPERATIONS OF DRONES WITH INITIAL UTM

This Site Demonstration Report is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 783230 under European Union's Horizon 2020 research and innovation programme.

Abstract

The present document constitutes the demonstration report for Bretigny Demonstration conducted in the framework of PODIUM SESAR/Horizon 2020 Very Large Scale Demonstration Projects. The project aims to assess the initial use of U-space services (usefulness and easiness) to perform current business operations (VLOS and BVLOS) and get initial feedback on how UTM can support future and more complex operations. The demonstration was led by Drone Paris Region (DPR) and consisted in performing three drone mission scenario within the Bretigny reserved flight area (supervised by DPR) corresponding to current business operation. Two complementary future scenario were addressed through workshop/expert group. For the demonstration purpose, dedicated systems were developed to support mission preparation/authorisation and flight execution.

The overall feedback from the participants show that their expectations are high as they see the potential of U-Space upon their business operations. In its current form, the participants could not fully validate these benefits, and this is reflected in the conclusions and recommendations. The PODIUM project has created a very reactive community of professionals that are ready to be active in further U-Space development activities or projects

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1 Executive summary

The Proving Operations of Drones with Initial UTM (PODIUM) is a SESAR/Horizon 2020 Very Large Scale Demonstration Project, which demonstrates U-space services, procedures and technologies across five sites in Denmark, France and the Netherlands. This document is the site demonstration report for Drones Paris Region from Brétigny sur Orge, France, describing the work performed, the main results, and most important conclusions and recommendations.

The main objective of the demonstration flights in Drones Paris Region was to assess how current U-space systems can enhance business operations of drone operators, manufacturers, and service providers. Eleven start-ups and one large company participated into specific workshops. Drone operators and manufacturers were invited to participate to workshop during which they could test the functionalities of the system on the ground before flying with the system. For those companies more involved in services, they were interviewed. Participants shared their feedback through on-line questionnaires or group debriefing. 12 measured flights have been conducted including one BVLOS. In addition, the project performed ad-hoc flights and handled over 50 flight permission requests.

It is concluded that the concept of U-space is clear and acceptable, despite some software and HMI limitations. The pre-flight U-space service needs to be simplified and a more specific supervisor oriented module needs to be implemented. In-flight services need to be turn-key services that provide a real return on investment to users. Safety is a concern as it relies on timely information provided to the pilots through new specific equipment. Based on these conclusions it is recommended that:

- Clear benefits should be brought to the user – whether they are operators or supervisors. That means the system should provide effective mission planning tools as well as robust mission execution services
- Operators insist on getting information about their flight area and around it. This information should be available on a mobile App
- Supervisors modules will be key in granting future flight authorizations: the process should be acceptable for them and the end-users
- Incremental regulation for U-Space should be issued to ensure that U-Space offer is available in a safe manner for users. This regulation should cover the three main aspects: the concept of operations, the UTM conception, the certification of the UTMS company
- Standards for equipment (trackers,..), software and data should be developed so as to ensure seamless operations across all UTM Systems and safe implementation of UTMS

The contents of this individual site demonstration report will form an appendix of the overall Demonstration Report for PODIUM – addressing five sites across Denmark, France and the Netherlands - which the project plans to make available by September 27 prior to a dissemination event at EUROCONTROL Brussels on October 17. This individual site demonstration report does not take into account the Guidance for U-space recommendations and conclusions [3]. PODIUM will, however, take this guidance into account for the development of the overall demonstration report.

Appendix A EXE-VLD-BRE-002: Enhancing business operations with UTM services

This appendix provides the demonstration report for the demonstrations as planned in the PODIUM VLD Revised Demonstration Plan (version 02.00.01, 02/04/2019 [1]).

A.1 Summary of the Exercise Plan

A.1.1 Exercise description, scope

The exercise consists in a demonstration of multi-mission scenarios operated in a drone reserved flight zone - LF R 333 – located in Bretigny-sur-Orge. The LF R 333 is managed by Drones Paris Region and dedicated to VLOS and BVLOS drone operations.

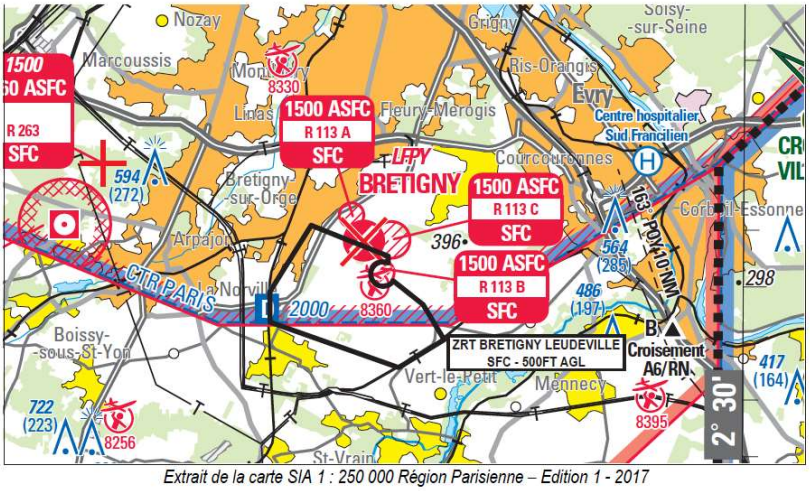

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Figure 1 Drones Paris Region flight test area as published in the AIP (top) and on the Unifly system (bottom)

The main light trials were conducted during summer 2019 (May/June/July) and involved a large community of drone professionals from various industrial segments (e.g. pilots or drone manufacturers) as well as LF R 333 supervisor (authority providing flight authorisation). In addition, a mock-up exercise was performed on the 21st and 22nd of November 2018 [4].

The scope and objectives of the demonstration are twofold:

- Demonstrate the relevance, usefulness and usability of the UTM services, for current operations. The primary focus is to assess potential UTM benefits and limitations for mission preparation (e.g. mission plan, contact information, no fly zone) from both supervisor (authority providing authorisation) and pilots/operators/drone manufacturer perspectives. This is done through a UTM prototype developed for the demonstration purpose. The secondary focus is on mission execution. It is addressed through the use of a handheld application and a "supervisor view" allowing monitoring of the mission via communication with a dedicated GSM-based tracker.

  This assessment was done through "flight trials" encompassing the full mission preparation process (including authorisation provision) and execution (the flight in itself). 12 operators and LF R 333 supervisor participated in performing three scenario corresponding to current business operations: multirotor drone flying in VLOS for specific industrial applications and site surveillance and fixed wings drones flying in BVLOS for surveillance.

- Get initial feedback and collect needs on how future operations or environments such as anti-drone systems, new technologies or operations (e.g. swarm flights) could be integrated in the UTM systems.

  This assessment was done through experts group/workshop.

To support the demonstration, the following UTM services and systems were used as described in chapter 9 of the PODIUM Concept and Architecture Description [2]:

- Services
  - E-registration (9.2.1)
  - E-identification (9.2.1)
  - Drone location surveillance and tracking (9.2.2)
  - Automatic flight plan validation (9.2.3)
  - Automatic and manual flight permissions (9.2.4)
  - Generation and management of no-fly zones (9.2.5, 9.2.7, 9.2.8)
  - Geoawareness (alerting the drone flying close to the defined no-fly zones, including those that change during flight) (9.2.6)
  - Conflict detection and alerting (9.2.11)

- Drones: Fixed-wing (including their own command and control station) and Multi-rotor.

- Unifly UTM system
  - Sentry (Supervisor)
  - Unifly Pro (Drone operator/pilot role)
  - Unifly Launchpad (Handheld application)
- Airbus system
  - RT Data Collector (U-space surveillance Tracker And Server)
  - Recording

- Trackers: HIONOS GSM-based

- Orange Access Point Name connectivity

Figure 2 Aeromapper flight control display

Figure 3 Unifly supervisor view showing HIONOS tracker

A.1.2 Exercise Objectives and success criteria

The table below presents the objectives and success criteria defined in the Revised Demonstration Plan [1].

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
OBJ-VLD-POD-001 Operational feasibility and acceptability	CRT-POD-001-001 CRT-POD-001-002 CRT-POD-001-003 CRT-POD-001-004	Partly covered	Assess the operational feasibility and acceptability of the addressed U-space services for current business operation including various environments, mission type or drone type. Investigate the potential changes in human performances and system acceptability in relationship with future operations or environments.	The roles and responsibilities of the involved actors (operators/pilots and authorities) are clear and acceptable. The tasks and procedures of the involved actors (operators and authorities) are clear and acceptable. The technical systems proposed are usable (HMI) and acceptable (e.g. trust in the systems, limitation of human errors, generated acceptable level of workload) to operators and authorities. The technical systems proposed support the end users' performance in order to achieve their tasks in an efficient, accurate and timely manner (e.g. data provided are reliable and up to date, situation awareness increased). Potential change in roles, responsibilities, tasks and procedure of the involved actors (operators and

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
				authorities) in future operations are identified. Potential changes needed for technical system (e.g. performance requirements) to support end user tasks in future operations are identified.
OBJ-VLD-POD-002 Technical feasibility	CRT-POD-002-001 CRT-POD-002-002 CRT-POD-002-003 CRT-POD-002-004	Partly covered	Demonstrate that the various technical systems (transponder tracking devices and the UTM system) meet critical functional and performance requirements to cope with current business operation including various environments, mission type or drone type. Investigate the systems and infrastructure technical agility to support future operations or environments.	The various systems provide the information required as it is needed and when it is needed. The various systems perform as expected even when used to supervise simultaneously multiple drones. The various infrastructures support U-space services addressed. The various systems are interoperable to provide expected benefit. Infrastructure and/or technical system needs to support future operations.
OBJ-VLD-POD-003 Safety	CRT-POD-003-001 CRT-POD-003-002 CRT-POD-003-003 CRT-POD-003-004	Partly covered	Assess the contribution of the UTM system and in particular services of detection/alerting and flight mission update during flight to safety of operations.	Safety level is increased in particular during flight through increased awareness of all airspace users, strategic deconfliction and conformance monitoring.

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
			Demonstrate limitation of ground risks by U-space services.	Conflict detection/alerting and flight mission update during flight services contribute to the limitation of air risk. Conflict detection/alerting and flight mission update during flight services contribute to the limitation of incursion into no-drone zones . Drone pilots get relevant information to identify, locate and avoid ground hazards.
OBJ-VLD-POD-004 Security	CRT-POD-004-001 CRT-POD-004-002	Partly covered	Investigate the resilience of U-space services alignment with business & safety requirements Investigate that the U-space services are preventing abuse of drone operations for malignant purposes	Potential security issues and mitigations are identified for regular business operations and for future operations.
OBJ-VLD-POD-005 Standards and regulation	CRT-POD-005-001 CRT-POD-005-002	Partly covered	Document the impact of U-space services on operational or technical standards appropriately	Bottlenecks (if any) in the current standard are identified for current and future operations. Recommendations on operational or technical standards are provided.
OBJ-VLD-POD-006 Benefits and limitations	CRT-POD-006-001 CRT-POD-006-002	Partly covered	Collect initial feedback from the different stakeholders on the benefits/limitations of the U-space services addressed and in particular conflict	Initial benefits and limitations of the U-space services addressed in terms of cost effectiveness (e.g. potential time, effort,

Demonstration Objective	Demonstration Success criteria	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
			detection/alerting and flight mission update during flight services	cost saving) are identified. Initial benefits and limitations of the U-space services addressed in terms of capacity are identified (e.g. potential for enabling more simultaneous flights).

Table 1 - Demonstration Objectives

A.1.3 Exercise Operational scenarios

The exercises assessed the demonstration objectives based on the solution scenario described herein, including the PODIUM services and systems.

The scenario performed could be split in two categories: current business operations and future operations.

CURRENT BUSINESS OPERATIONS

- **General description**

The scenario comprised two steps: mission preparation and authorisation (given by DPR supervisor) through the UTM tool on ground and mission execution (flight trials) in the reserved flight area.

All the flight trials were conducted in the LF R 333 Bretigny Leudeville that is a drone dedicated flight zone. It is 300 ha wide and maximum altitude is 150 m. Drones Paris Region manages the airspace. Since Orly Airport is nearby, a protocol has been signed between Drones Paris Region and French DSAC to define rules of operations. A similar protocol is signed between Drones Paris Region and each operator that comes to fly in the zone. VLOS and BVLOS operations can be conducted in the zone. BVLOS flight can also be conducted from the flight zone to the outside. In that case, a specific protocol has to be declared by the BVLOS operator.

All flights were conducted in accordance with French legislation.

Each drone was equipped with a Hionos Tracker.

- **Scenario 1 - VLOS mission for specific industrial application with multirotor drones**

The purpose was to use UTM system to run current business operations with drones (e.g. video, building inspection, telecom antenna inspection). It involved four start-ups belonging to Drones Paris Region: Drones Center, Iva Drones, CDSI and Target Drone.

The operators/pilot performed VLOS flights with multirotor drone from an automated flight plan, which has been defined beforehand using the PODIUM system for mission preparation.

- **Scenario 2 - VLOS mission for site surveillance with multirotor drones**

The purpose was to use UTM system to run site surveillance operations with drones. It involved five start-ups belonging to Drones Paris Region: UAVIA, Aeraccess, Engie, Dronetix, and Dronehive. Their technical solutions and concept of operations varies depending upon their end customer. For instance:

  - UAVIA, Engie, Dronetix, Dronehive are developing fully automated solutions to run surveillance from a distance.
  - Aeraccess customer are dual: military and civilian, therefore their technical solution and operation are set differently from the others.

The operators/pilot performed VLOS flights with multirotor drone from an automated flight plan, which has been defined beforehand using the PODIUM system for mission preparation.

Figure 4 Scenario flights and debriefing

- **Scenario 5 - BVLOS mission for surveillance or transport with fixed wing drones**

The purpose was to use UTM system to run current BVLOS business operations with drones for surveillance and transport. It involved two start-ups belonging to Drones Paris Region:

- Aeromapper is a BVLOS drone manufacturer. Their drones are dedicated to surveillance applications with high resolution data. They operate in various environments.
- Skydrone is a BVLOS drone manufacturer. They are currently developing a drone that can carry parcels in BLVOS operations.

Their technical solutions have already been deployed for several customers.

The operators/pilot performed BVLOS flights from an automated flight plan, which has been defined beforehand using the PODIUM system for mission preparation.

Figure 5 BVLOS flight team

FUTURE OPERATIONS

- **General description**

Contrary to the first one described above, this second scenario did not include mission preparation nor flight trials in itself. Based on the current version of the PODIUM system and participants' knowledge and experience, the objective was to collect initial feedback on how future and more complex operation (e.g. drone fleet management) could be integrated in an UTM tool. Although it was not initially planned (see section A.2), the two following scenario were assessed through workshop/expert groups rather than flight trials.

- **Scenario 3 - Interaction between UTM and anti-drone systems**

The purpose was to identify how UTM system and anti-drones systems can contribute to enhance safety of airspace and drone operations. It involved Cerbair start-up company belonging to Drones Paris Region.

This sessions was planned as a workshop with Cerbair only for confidentiality reasons. No flight was necessary, only discussion about :

- their conops
- their willingness to collaborate with UTM systems
- their vision of the further steps to go towards integration of both types of systems

- **Scenario 4 - UTM services enhancement with regards to new operational technologies**

The purpose was to identify how UTM system can integrate or accommodate services or technologies that are currently being developed and will be available for market in the near future. It involved five

start-up companies from Cluster Drones Paris Region: Green Communication (developing new telecommunication solutions and drone swarm flight activities), Luceor (developing specific Long Term Evolution communication solutions), Flyinstinct (developing IA based modules for drone navigation), Volons (developing customized solutions for planning management) and Synovia (developing customized solutions for fleet management optimization);

A.1.4 Exercise Assumptions

The assumptions from A1 to A11 is applicable for the whole PODIUM project and demos whereas assumption from A12 to A15 are specific to Bretigny exercise.

Identifier	Title	Description
POD-A1	BVLOS procedures	BVLOS procedures are in place
POD-A2	BVLOS approvals	BVLOS operations are approved
POD-A3	Tracker compatibility with drone	HIONOS tracker has already been tested. An upgraded version will be deployed to enhance its operational readiness
POD-A4	Tracker compatibility with U-space	HIONOS tracker compatibility with UNIFLY system has been tested and verified
POD-A5	Airspace users	All DPR flight zone users are willing to operate with UTM
POD-A6	Drone flight route design	Airspace users are fully involved to ensure unmanned cooperation tests
POD-A7	Airport procedures	Orly Airport will be involved if necessary
POD-A8	Manned aircraft	Not applicable here
POD-A9	Baseline U-space documents	All the necessary documentation is delivered during WP 2.2
POD-A10	Drone pilot and operator availability	Drone pilots are available during the demonstration period
POD-A11	U-space platform available	The U-Space platform is delivered sufficiently in advance (i.e. beginning WP 4.2) to facilitate testing
POD-A12 (Exercise specific)	Hionos Tracker availability	DPR has purchased them from HIONOS
POD-A13 (Exercise specific)	Availability of the large fixed wing drone	Both Aeromapper and Skydrone will provide those drones
POD-A14 (Exercise specific)	Delivery route design	Flight will be performed within LF R 333
POD-A15 (Exercise specific)	Drone autonomy	Autonomous flight will be performed with supervision

Table 2: Demonstration Exercise Assumptions

A.2 Deviation from the planned activities

The following deviation from the planned activities were observed:

- The project experienced bad weather (rain and/or strong wind) that led to post pone several times the trials and led to issues in terms of participants' availability.
- Due to availability issues, some of the start-up companies could not participate to the project. (5 out of 17). They are namely:
    - For scenario 2: Aeraccess
    - For scenario 5: Skydrone
    - For scenario 4: Green Communication, Luceor, Volons
- Considering the limitations of the mobile application compared to user expectations, the "Current Business Operations" scenario focused on mission preparation and authorisation process rather than the mission execution.
- Scenario 3 and 4 did not include mission execution and rather focused on integration of future and more complex operations in a UTM system through workshop/experts group.
- The UTM system was not used on a day-to-day basis as originally planned. This was due to the fact that the tool, although suitable for demonstration purposes, was not in a form that was suitable for live day-to-day operations requiring coordination with authorities, etc.

As a result from these above deviations, the number of flights was reduced compared to what was initially planned (12 live lights performed instead of 47 originally planned for the 5 scenarios). The current status of the system would not have permitted additional data collection and analysis by flying more tests. However a lot of valuable information have already been collected and will be shared in this report.

In addition to the live flights, the supervisor logs indicate that over 50 flight permission requests were submitted. This shows that a significant amount of experience was gained in the flight preparation activities. Moreover, several live flights were flown during the mock-up exercise [4], and in support of the DPR Expo in September 2018.

A.3 Exercise Results

A.3.1 Summary of Exercise Results

This section provides a summary of exercises results performed in summer 2019 (May, June and July) at Bretigny sur Orge in collaboration with Drone Paris Region.

Demonstration Objective (as in section 3 of Demo Plan)	Demonstration Success criteria (as in section 5 of Demo Plan)	Exercise results	Demonstration objective status (OK, NOK, POK (Partially OK))
OBJ-VLD-POD-001 Operational feasibility and acceptability	CRT-POD-001-001 CRT-POD-001-002 CRT-POD-001-003 CRT-POD-001-004	Pre-flight: • Conclusion #01: The concept of operations regarding flight plan submission and updating was mostly compared to the French "Alpha Tango" application. There is a clear discrepancy in terms of HMI between the two systems. Expectations are that future UMTS pre-flight preparation will be seamless and "automatic" for pilots. We suggest that drones manufacturers should be more involved in the functions definitions • Conclusion #02: There are high expectations from Flight Zone supervisors regarding planning of operations and zone allocations. They need to be involved in the future concepts of operation as their role will be critical for airspace management	POK NOK
		Flight-execution: • Conclusion #03: The U-space interface should provide reliable updated information about the surrounding environments: drones flying around, updates in aeronautical charts or information • Conclusion #04: Mobile application is necessary for flight crews to be able to benefit from the U-space system; using a laptop is not practicable in the field, also because connectivity may not be ensured.	NOK NOK
	CRT-POD-002-001	Pre-flight: • Conclusion #05: The trackers performances are key. There should be standards defined to ensure safe operations	POK

Demonstration Objective (as in section 3 of Demo Plan)	Demonstration Success criteria (as in section 5 of Demo Plan)	Exercise results	Demonstration objective status (OK, NOK, POK (Partially OK))
OBJ-VLD-POD-002 Technical feasibility	CRT-POD-002-002 CRT-POD-002-003 CRT-POD-002-004	Flight-execution • Conclusion #06: U-space provides a promising mean of managing drone traffic. However, pilots, drone manufacturers, … should be more involved in the development of future generation of UMTS to make sure the steps to full development of U-Space are deployed in a timely and effective manner	POK
OBJ-VLD-POD-003 Safety	CRT-POD-003-001 CRT-POD-003-002 CRT-POD-003-003 CRT-POD-003-004	Pre-flight: • N/A	OK
		Flight execution: • Conclusion #07: The pilots need real time information about aeronautical situation • Conclusion #08: Situation awareness has to be addressed from the pilot side: knowing who is flying around in order to take proper decision	POK
OBJ-VLD-POD-004 Security	CRT-POD-004-001 CRT-POD-004-002	• Conclusion #09: Flight operations have been conducted at Drones Paris Region to avoid any mishappening. However the deployment of U-Space will raise several key security questions some of which can be listed here: wordings, supervisor modules, infrastructure, airspace allocation…	OK
OBJ-VLD-POD-005 Standards and regulation	CRT-POD-005-001 CRT-POD-005-002	• Conclusion #10: regulation for UTM needs to be deployed to ensure appropriate and reliable level of services across Europe • Conclusion #11: specific standards have to be set to ensure proper communication level across all UTM stakeholders	NOK

Demonstration Objective (as in section 3 of Demo Plan)	Demonstration Success criteria (as in section 5 of Demo Plan)	Exercise results	Demonstration objective status (OK, NOK, POK (Partially OK))
OBJ-VLD-POD-006 initial benefits assessment	CRT-POD-006-001 CRT-POD-006-002	• Conclusion #1Z: The demonstrations performed have not validated clear benefits for using the system, but the expectations are high, and the demand is there	NOK

A.3.2 Analysis of Exercise Results per objective

1. OBJ-VLD-POD-001 Operational feasibility and acceptability

The aim of this objective is to demonstrate the impact on human performances through assessment of the operational feasibility and acceptability of the addressed U-space services. It is to be noted that Drones Paris Region brought two sets of user/testers: those who are actually conducting operations with drones on an everyday basis – the "current business operation" group of Linked Third Parties, and those who are potentially candidates to provide modules or additional services for the U-Space – the "future operations group of LTP.

On top of this, since Drones Paris Region is currently managing operations of its flight test area on an everyday basis as well, its expectations as supervisor regarding the U-Space services are quite high and are challenged as well. Moreover, the cluster includes a number of drone manufacturers and module providers who are interested in the development of U-space.

UTM/U-Space evaluations have been performed between May and July 2019. Each participant received their own Podium Manual (Unifly system) and Podium Trial Livret (Role, expectation, agenda of the day) prior to the sessions.

Several group sessions have been organized during those three months, each following the same agenda:

Morning session : Eurocontrol Experimental Center (EEC).

- 10 :00-10 :15 Briefing (Podium Project context and demonstration goals)
- 10 :15-10 :45 Missions review with supervisor
- 10 :45-11 :30 Mission preparation (with training and assistance) through Unifly UTM
- 11 :30-12 :00 Hionos tracker / Unifly and Airbus system communications check
- 12 :00-12 :30 First de-briefing on morning session
- 12 :30-13 :30 Lunch

Afternoon session : Drones Paris Region (DPR)

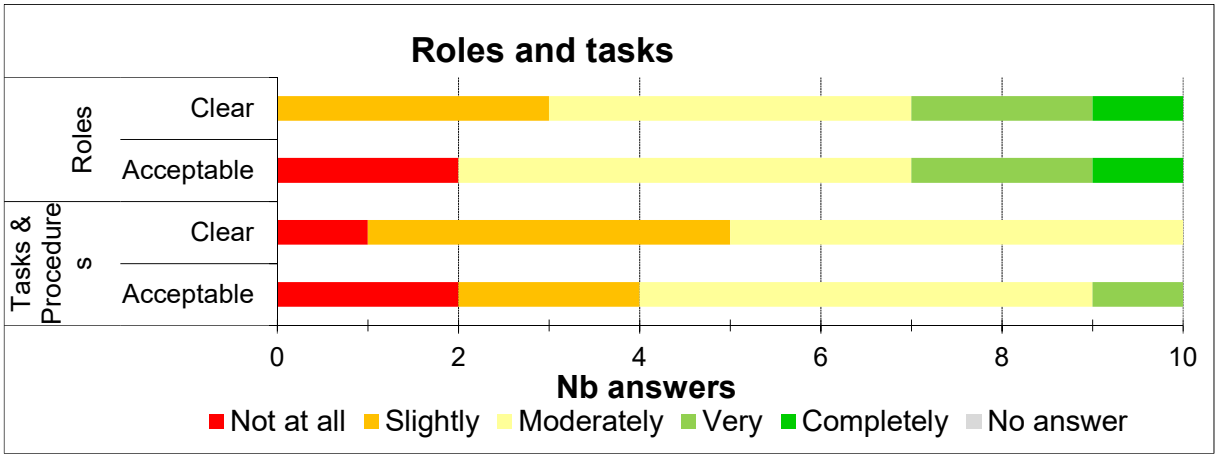
- 13 :30-15 :30 Mission execution within DPR test flight area + Post flight on line questionnaire
- 15 :30-16 :00 Post demo questionnaire
- 16 :00-17 :00 Group debriefing

After the flight execution program, all participants were asked to first fill in a questionnaire, and then to discuss this during a plenary group discussion, focussing on:

1. Whether their roles and responsibilities were clear and acceptable, as well as their tasks and procedures
2. The operational feasibility and acceptability of the system,
3. The timeliness of the provided information, while preparing the mission as well as during mission execution,
4. The accuracy of the provided information, as perceived by the crews and the supervisor, and
5. Whether the respondent had sufficient trust in the system.

From the textual comments to the questionnaire it appeared that it was difficult to separate the Unifly system from the U-space concept. The graphs below represent a cumulated view of the drone operators and supervisors involved in the demonstrations, as well as the view of the manufacturers and module providers that have been present during the demo sessions and have evaluated the UTM system after shadowing the supervisors and operators. The particular opinions of each of the three actors involved are described for each of graphs, if available.

Roles and tasks

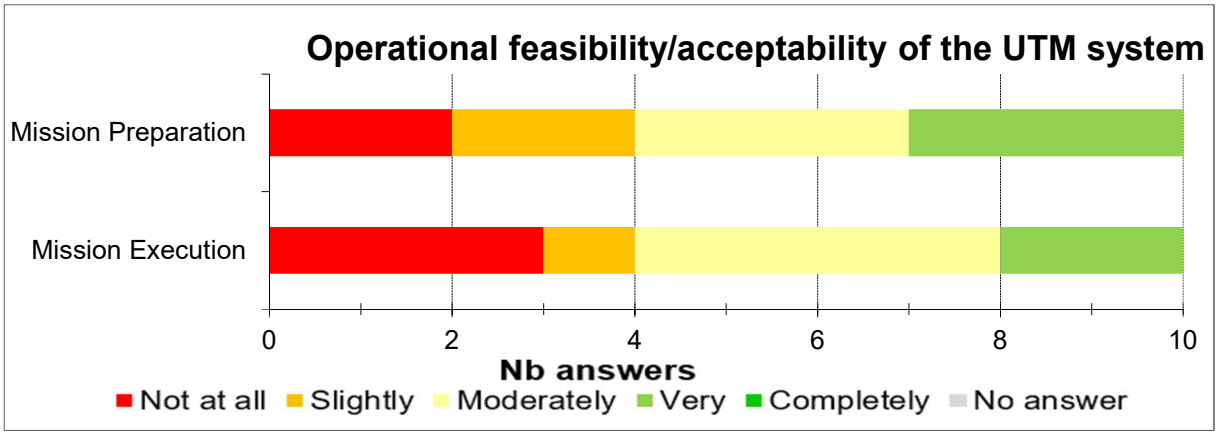


The diagram shows that in majority the respondents have perceived their roles and associated tasks, as presented in the demonstration, to be “moderately” clear and acceptable. A more in depth view of the answers indicate though that the more positive answers (corresponding to “very” and “completely” clear and acceptable) have been given by the drone manufacturers and module providers whom were just observing the simulation, whereas the hands on actors (drone operators and supervisors) are the ones who provided the less positive answers.

- for the supervisor, roles & responsibilities are rated maximum “Moderately”, while Tasks & Procedures are rated maximum “Slightly”,
- for the pilots, the ratings are maximum “Moderately”
- for the others – drone manufacturer or module provider -, there are the only one to rate this part of the questionnaire up to “Completely”

The results could be attributed to the fact that the flight operators and drone supervisors were not fully trained and familiar with the new responsibilities and associated tasks, relying on their previous experience in the drone cluster- which might have influenced their performance and perception.

Operational feasibility and acceptability



The diagram above indicates a wide array of opinions regarding the operational feasibility and acceptability of the UTM system, ranging from “very low” to “very high”. It has to be noted though that only the supervisors had access to the UTM system during the ”mission execution” phase, while the drone operators no U-space system was available during any of the flights, due to unavailability of a mobile application that they could run on tablet/mobile phone.

- for the supervisor, this measure is rated “Very Low” for both sequences of the mission : preparation and execution
- for the pilots, the ratings are maximum “Medium” for the mission preparation and execution
- for the others – drone manufacturer or module provider -, are ranked as “High”

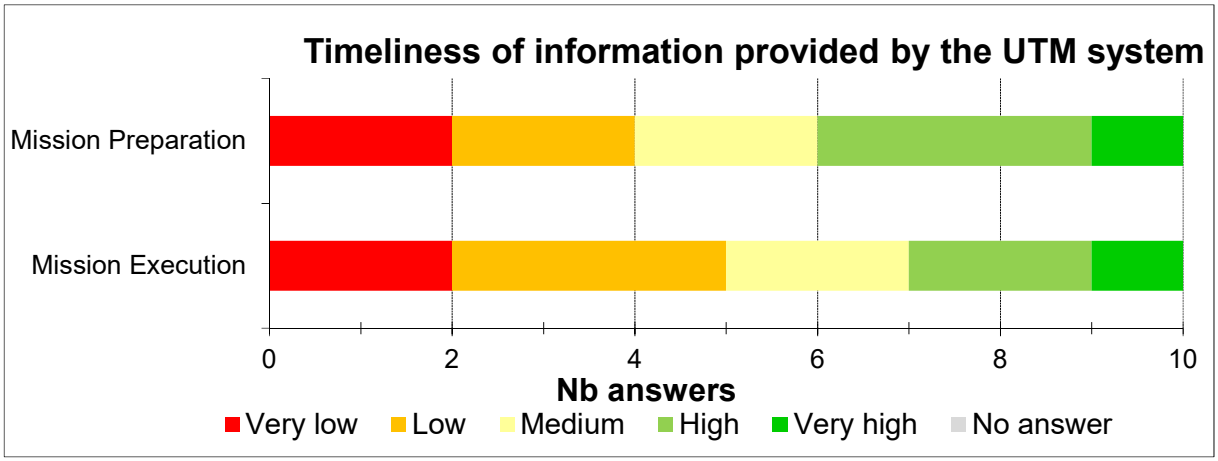
As for the “roles and tasks” section, it can be observed that the “hands on” actors rated their answers less positively than the observers (manufacturers and module providers). Hence, through expert judgement and observations it can be concluded that the drone operators and supervisors had troubles separating the provided UTM system from the U-Space concept and have rated their answers solely based on their user experience and not on the foreseen feasibility of an enhanced UTM system. As a result, due to some of the technical issues encountered, limited familiarity with the tool and due to the fact that some of the features of the UTM system were not yet available in the proposed version (e.g. no interface for operators in the “mission execution” phase) the results should be interpreted with caution. They results indicate the acceptability of the proposed UTM system which was still a prototype and not the acceptability of the U Space concept.

The low supervisor score may reflect the lack of a map view for planned flights that would help to avoid conflicts.

For the pilots, all are currently using the French DGAC system – Alpha Tango. Besides the underlying question of why would there by two systems with similar functions in the future (at least for registration), the settings proposed by the system did not provide any additional benefits compared to Alpha Tango for both sequences of the mission: preparation and execution.

For BVLOS operators/ manufacturers, the module “Mission Preparation” does not match the preparation steps they have had to set up to be able to guarantee mission success and get DGAC approval for operations.

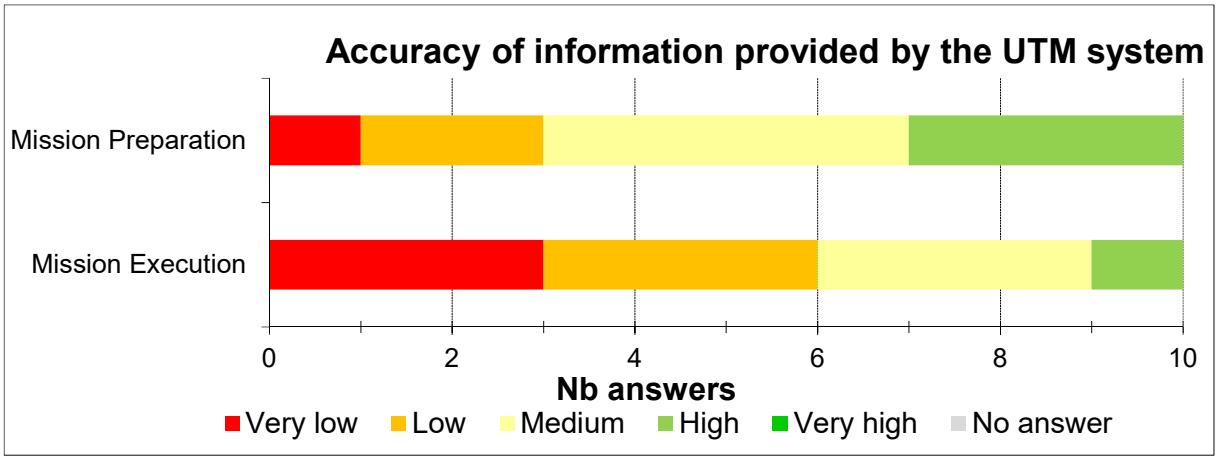
Timeliness of the provided information



- The timeliness question assesses how the different stakeholders perceived the ability of the U-space system to perform all the requested functionalities in time. The detailed analysis shows the reason behind the variations in the answers given: for the supervisor, the rating will remain "Very low", as the system is not fit for his mission as such
- for the pilots, the ratings varied through the whole spectrum : from "Very Low" to "High"
- for the others – drone manufacturer or module provider -, are ranked "Very High" or "High"

The results can be explained by the limitations of the system, which requires additional updates. Although known to the subjects, the limitations were more difficult to cope with during the demo, aspect explained as well by the fact that the observers had always rated their answers with more positive results than the "hands on" subjects had. Hence, it can be derived that the overall idea behind the U-Space concept is seen as very positive but it was hard for the hands-on subjects to separate their feedback between the actual UTM system provided and the U-Space concept.

Perceived accuracy of the provided information

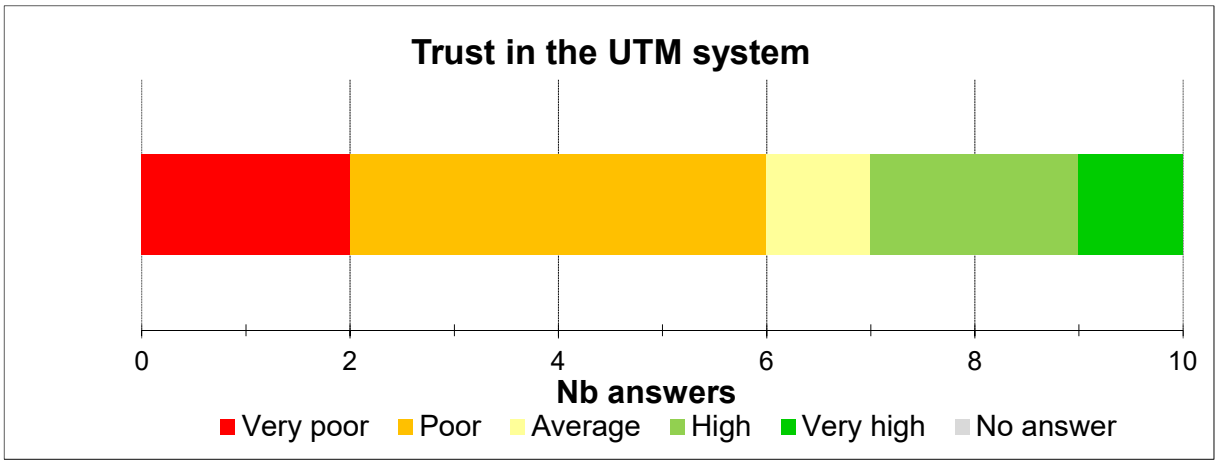


As for the other diagrams, the results recorded are varied, corresponding to “very low” and “high” ratings for the accuracy of information. The less positive results attributed to the “mission execution” phase are once again attributed to the fact that only the supervisors had access to the UTM system during the simulation.

The information gathered mainly from the drone operators indicate some of the feature required for an enhanced version of the UTM system, which would increase the users` acceptability. As a result, the pilots would need to have additional information:

- about the zone covered by the flight
- about different possible altitude of evolution within the zone (CTR)
- whether or not they are still flying in the planned zone
- they cannot see other drones flying around (this should be number one function of a mobile App)
- they have no information about the surrounding events
- they should have immediate aeronautical chart or info updates (ex: current SUPAIP was not displayed)

Trust



Based on debrief discussions and observations, the variations depicted in the “trust” diagram indicate that some of the answers given were based on the user experience with the current UTM system, whereas the others (the more positive ones) were given by those reflecting their expectations for the future generation of the UTM systems.

The conclusions for pre-flight preparations are:

Conclusion #01: The concept of operations regarding flight plan submission and updating was mostly compared to the French “Alpha Tango” application. There is a clear discrepancy in terms of HMI between the two systems. Expectations are that future UMTS pre-flight preparation will be seamless

and “automatic” for pilots. We suggest that drones manufacturers should be more involved in the functions definitions

Conclusion #02: There are high expectations from Flight Zone supervisors regarding planning of operations and zone allocations. They need to be involved in the future concepts of operation as their role will be critical for airspace management

The conclusions for flight execution are:

Conclusion #03: The U-space interface should provide reliable updated information about the surrounding environments: drones flying around, updates in aeronautical charts or information

Conclusion #04: Mobile application is necessary for flight crews to be able to benefit from the U-space system; using a laptop is not practicable in the field, also because connectivity may not be ensured.

2. OBJ-VLD-POD-002 Technical feasibility

The aim of this objective is to assess the technical feasibility of the various systems (e.g. trackers, Unifly U-space system).

Trackers

Drones Paris Region decided to use locally manufactured trackers. They used the HIONOS tracker which is based on GSM technology. This decision was made for the following reasons:

- A technical specification for trackers has been issued by the French government, but it will come into effect at a later date. HIONOS proposed to use its technology in the meantime
- DPR wanted to promote cluster member technology
- We wanted to have non expensive technologies to test

We knew from the beginning that the trackers were at prototype stages, and we experienced some issues while testing them. Occasionally, the supervisor could not follow the drone tack on the display. The availability of the tracker signal appeared to be influenced by: the integration of the tracker on the drone; humidity problems related to the tracker container However this did not have any effect on the questionnaire answers as we are dealing with experienced professionals operators.

The question remains though about the trackers and the way they should be defined, developed and qualified in the future.

From the pilot perspectives, trackers should have no impact on operations (weight or cost), information provided should be segregated and differentiated depending on their final usage (authorities or other pilots should have different sets of information).

From the drone manufacturer perspective, their integration in their own drones will be an issue that has to be cleared for the sake of the future UTM system deployment.

Unifly U-space system

The foreseen architecture provides a promising mean of managing drone traffic.

Expectations are high from all the stakeholders.

Main questions that are at stake are the following:

- the HMI should be seamless for the pilot and the supervisor
- flight information should be updated real time and reliable : who is responsible in case of false information provided by the UMTS?
- Flight execution information is key for operations. There should be standards developed to make sure flight pictograms are uniform across all UMTS
- Real time data is key and supporting communication means (infrastructure) and protocols should be set to ensure real time information is provided
- Pilots stressed that the UTM should also communicate with existing planning or flight management applications (ex DJI)

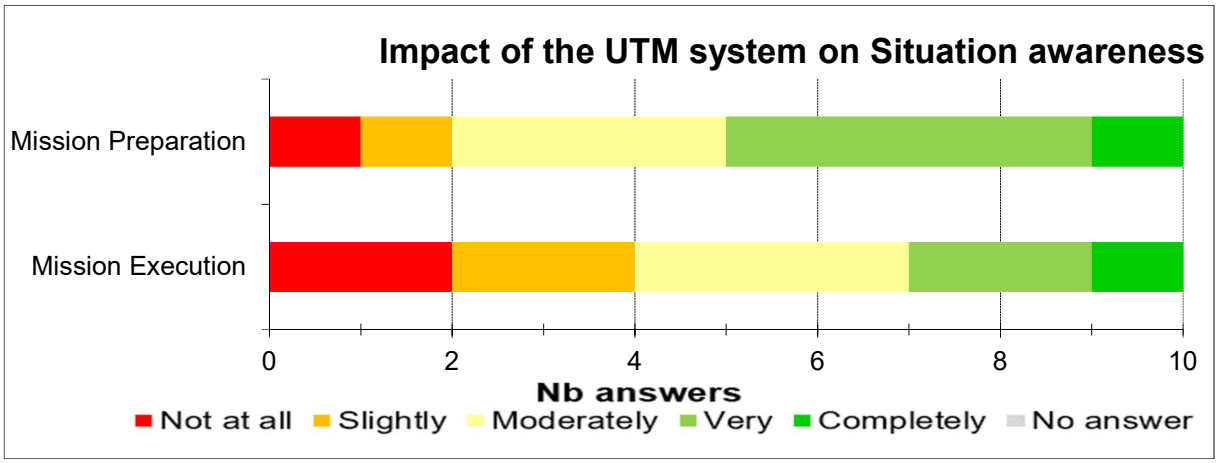
Conclusion #05: The trackers performances are key. There should be standards defined soon to ensure safe operations

Conclusion #06: U-space provides a promising mean of managing drone traffic. However, pilots, drone manufacturers should be more involved in the development of future generation of UMTS to make sure the steps to full development of U-Space are deployed in a timely and effective manner

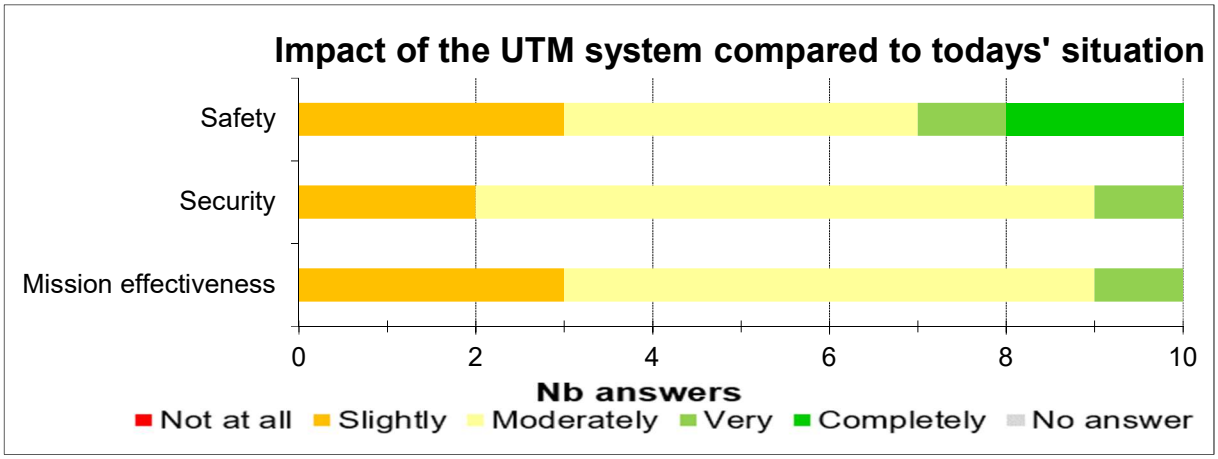
3. OBJ-VLD-POD-003 Safety

Podium demonstration companies at Drones Paris Region were mainly concerned by the following issues related to safety:

- See the surrounding flights
- Be informed real time about aeronautical events
- Define clear flight path so they can operate like in a “bubble”



For the "mission preparation" phase 50% of the respondents answered with "positive" and "very positive" when asked to rate the impact of the UTM system on Situation Awareness, indicating the envisaged benefits of the availability of the UTM system in the drone industry, for both drone operators and supervisors. As explained before, for the "mission execution" phase, the UTM system was only available for the supervisors during the simulations, which has negatively influenced the answers.



Overall, the results must be interpreted with caution as they indicate a subjective assessment of the respondents that have answered the questions in two different ways. Some of the respondents rated their answers solely based on their user experience (with the current UTM system prototype) while others have given their feedback based on the potential seen in the enhanced UTM system.

There is a need to further develop the UTM system proposed, which was acknowledged by both the participants and the providers, but if we are to see beyond the current status of the tool, the envisaged benefits of an enhanced UTM system have been described by the participants as such:

- an enhanced level of situation awareness for the drone operators
- the availability of information about drones flying in the area
- a decrease in Air to Air risk

- a more efficient and concise interaction with other users
- access to all flight restrictions

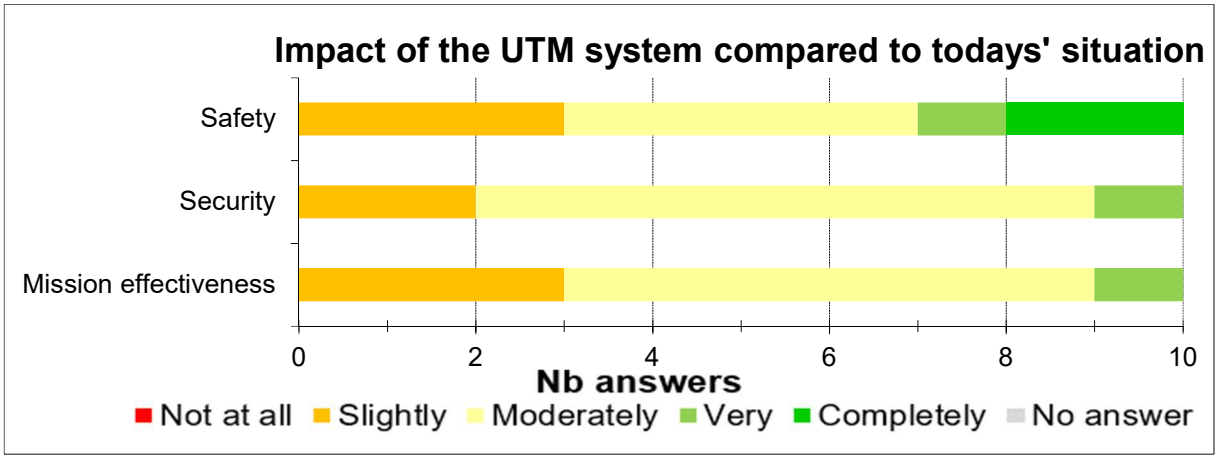
The conclusions are:

Conclusion #07: The pilots need real time information about aeronautical situations.

Conclusion #08: Situation awareness has to be addressed from the pilot side: knowing who is flying around in order to take proper decisions.

4. OBJ-VLD-POD-004 Security

All flights were performed within the LF R 333 flight area to avoid any risk with Podium external parties.



There had been no security issue reported as such, however the U-Space as such raises real security issue before its full implementation. They can be addressed in the following way:

- terminology: the terminology used in the U-Space future systems will have a potential impact on security. The population that will use it will come from different horizons and culture. A specific glossary will have to be implemented. For instance the word “tracker” has a total different meaning in the pure aeronautical world
- supervisor or authorities modules: they will be key in granting access to airspace. Full automatisation seems a long term target if not properly addressed
- infrastructure: U-Space architecture relies on seamless data exchanges. However for the time being, data is flowing through different channels – 3/4/5 G Internet, GPS- How can we ensure that real time information is always available? Cybersecurity issues fall into this chapter as the topic is too large to be covered and addressed by Podium.
- Airspace allocation: pilots will fly the U-Space if they are sure that they can rely upon the systems. So far, there is no specification available and all UTM systems providers are

developing their products independently. Will those systems be issued a label by a valid authority?

The conclusion for security is:

Conclusion #09: Flight operations have been conducted at Drones Paris Region to avoid any mishappening. However the deployment of U-Space will raise several key security questions some of which can be listed here: wordings, supervisor modules, infrastructure, airspace allocation…

5. OBJ-VLD-POD-005 Standards and regulation

On one hand, U-Space is a brand new system that is to be used for a quite nascent industry. No standards have been implemented yet. Regulations have already been implemented by different countries in the world, and SESAR JU regulation for drones has just been issued in June 2019.

On the other hand, drones are using the airspace which has seen standards and regulation developed since the happening of manned aviation.

Due to the high potential of application, there is a need to develop those drones standards and regulations for several reasons:

Regulations for UTM system under U-Space specification

It is quite surprising to see the growing number of UTM offers across the world, while no regulation or standard has been set for those.

Regulators are focusing on the risk created by the drone itself, but there seems to be no concern about the fact that the pilots are going to rely on a system (the UTM) to operate their business about which they don't know anything and for which no label or certification is yet available!

For the record, Drone regulations are addressing three topics:

- the drone operation
- the drone conception
- the training of the pilots

For the UTM regulation, the following topics should be addressed:

- the UTM concept of operations in order to enable their progressive and homogeneous deployment across Europe
- the UTM conception : what are critical functions of the UTM, how do we ensure safe operations?
- the UTM companies certification : how do we ensure that the software are developed in a robust fashion, and that subsequent maintenance or upgrade of the systems do not jeopardize operations

More, from Drones Paris Region participants perspective, the following issues have to be addressed:

- stating full responsibility of the UTM provider for the information and data they display is key for operators
- anti-drone and drone manufacturer are all concerned about data that are exchanged through the UTM : who owns them?
- anti-drone and drone manufacturers are concerned by the infrastructure needed to operate the UTM. Who will specify it? who will own it ? What cost of operations is foreseen? For the time being, trackers, communication systems -3 to 5G-, cybersecurity fall into this category
- anti-drone and drone manufacturers are concerned by the fact that they will have to share data with the UTM manufacturer via specific API, how can they be sure that those channels will be open and not technically restricted to few
- for all, concern is important regarding the cost of usage of the U-Space services

Standards

The creation of U-Space regulation should be backed by the development of key standards that will ensure the systems architecture are open and efficient.

That applies for the time being to the following key technical elements:

- trackers
- communication links (equipment)
- communication protocols (communication formats)
- aeronautical data format and accuracy
- drone protection
- cybersecurity protocols

This is just a preliminary list that needs to be updated as work goes on

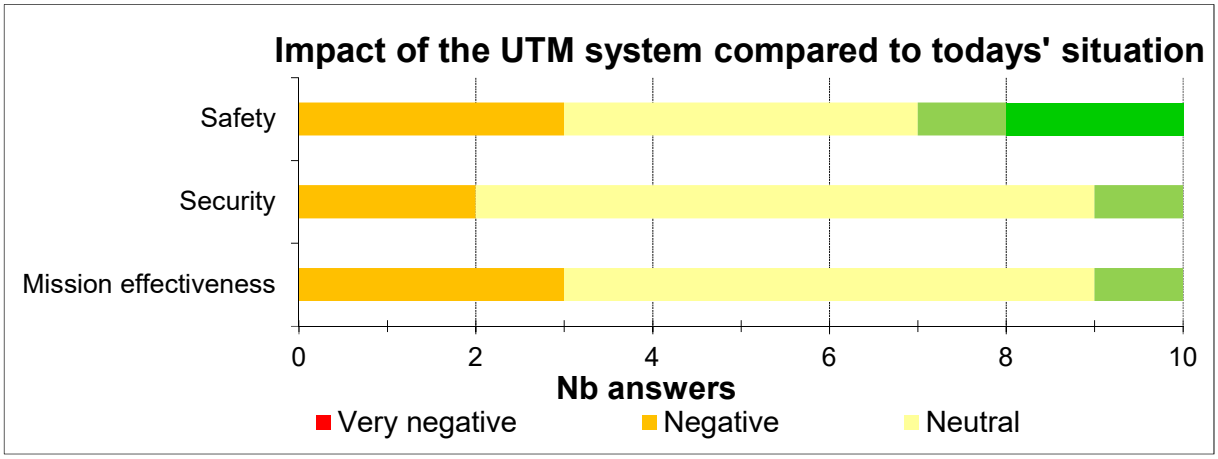
The conclusions for this section are:

Conclusion #10: regulation for UTM needs to be deployed to ensure appropriate and reliable level of services across Europe

Conclusion #11: specific standards have to be set to ensure proper communication level across all UTM stakeholders

6. OBJ-VLD-POD-006 initial benefits assessment

The aim of this objective is to assess the benefits of the U-space services that were used during the demonstrations, notably cost effectiveness in terms of time, effort and costs, and capacity increase in terms of the potential for enabling more simultaneous flights.



The “mission effectiveness” related answers were mainly attributed to the features currently available in the UTM system that have impacted the way the mission was conducted. The debrief discussions indicated that the majority of the participants see nonetheless the positive potential impact the system could have on their everyday operations. However Further research is required with an enhanced UTM system that would allow the participants to use the tool appropriately not just for the mission preparation phase, but for the mission execution and post-mission analyses purposes as well.

Conclusion #12: The demonstrations performed have not validated clear benefits for using the system, but the expectations are high, and the demand is there.

A.3.3 Unexpected Behaviours/Results

The main unexpected events affecting the quality of the results were:

- Bad weather: as stated in A.2, rain and strong wind occurred during May and June leading to postpone some trials inducing thereafter availability issue of some participants (link to assumption POD-A10).

- User experience: a number of participants stated that the UTM tool did not meet their expectations with regards to the “user experience”, e.g. long response times; features that did not correspond to the user guide. This led to some low scores for the usability and usefulness of the tool. Hence, although the participants were asked to focus their feedback on UTM as a concept, they were inevitably impacted by their individual experience.

- Technical system issues: Although it was tested during the acceptance/dry run session and on ground prior flights, loss of communication signal between the tracker and the UTM supervisor module were experienced during flight. The drone “plot” was thus not visible anymore on the supervisor view (link to assumption POD-A4).

A.3.4 Confidence in Results of exercises

1. Limitations of Exercise Results

The limitation came from the various unexpected events previously described in A.3.3.

The main operational limitation relates of the nature of the exercise which consisted in flight trials demonstration lasting a few days. In addition, the bad weather experienced led to reduce the number of participants. Therefore only a limited number of live flights (<20) were conducted. As stated previously, the number of live flights was complemented by a significant number of flight preparation activities, e.g. over 50 flight permission requests.

The UTM system was not used on a day-to-day basis as originally planned. This was due to the fact that the tool, although suitable for demonstration purposes, was not in a form that was suitable for live day-to-day operations requiring coordination with authorities, etc.

A number of participants stated that the UTM tool did not meet their expectations with regards to the "user experience", e.g. long response times; features that did not correspond to the user guide.

2. Quality of Exercise Results

The quality of the results is considered high due to the nature of the exercise. Indeed, it consisted in flight trials performed in a real environment (Bretigny reserved flight area) and by professional pilots/operators from various drone business companies and under the supervision of DPR director and flight area supervisor. The variety of the panel of participants (pilot, operator, drone manufacturer, specific drone solution providers) also contributes to the high quality of feedback/results.

The main results from the PODIUM trials at Bretigny were debated with a wider range of stakeholders at the visitors day held at the EUROCONTROL Experimental Centre on the 13th of June. Although informal, the feedback from the stakeholders present was in line with the project teams findings.

Figure 6 Panel discussion at visitors day

3. Significance of Exercise Results

As stated above, although the realism of the environment and of the technical system was high and flight performed by professional, the quantitative results from the exercise have to be considered very carefully. Indeed, due to the limited number of flights, the specificities on the local environment

addressed, and the reduced numbers of participants, these results have to be considered as initial trends. In addition, the results mainly rely on feedback from participants (qualitative) and so no quantitative statistical analysis (with significance test) could be performed.

A.3.5 Conclusions

1. Conclusions on concept clarification

The concept of U-space as a set of services was partially assessed (U-Space level 1 and some of the level 2). This concept has raised great interests from the Drones Paris Region Pilot and drone manufacturer community. However their acceptance will rely mainly on following factors: it has to bring large benefits compared to their current operations processes (ease of use, accuracy of information provided, situation awareness,…). Mission preparation is currently a burden for them, and the system should simplify this sequence in a tangible manner. Mission execution is currently performed without proper information about the surrounding elements; the U-Space should greatly secure those to gain users. Cost acceptance will be based on the overall level of performance that the system provides with regards to those two expectations.

The future HMI that will be proposed should be co-developed with operators, drone manufacturers, and supervisors to ensure seamless integration of the main functions.

2. Conclusions on technical feasibility and architecture

U-space provides a mean of managing drone traffic in a way that has never yet been experienced for any traffic: a full digital concept.

However this system relies upon three layers that are interconnected:

- Operational layer: the drones send information to the UTMS and the pilots need information from the UTMS
- Technical layer: the supporting infrastructure that enables communication - networks (3/4/5G), LTE, trackers,
- System layer: The UTM system by itself

The Challenge for the UTMS is to make sure that those three layers are deployed effectively from a local environment to a nation or continent wide environment. Scale up will therefore be an issue.

Podium has proven that the concept can work, however there are several barriers to cross before U-Space is fully deployed over a continent and allows seamless and safe traffic management of large drones operations.

It looks more probable that the U-Space will be able to be developed through different sequences that will depend upon the availability of the supporting technical infrastructure.

The architecture of the UTM at this stage should allow full communication between systems and future modules to be developed.

Regulation and standards should be defined and deployed accordingly to ensure safe and reliable services.

3. Conclusions on performance assessments

U-space performance assessments has been handled over two aspects:

- demonstration of a U-Space concept through the Podium project : result show that the concept is promising although a lot needs to be achieved before it can be fully exploited. That applies for steps 1 and 2 of U-Space.
- Human Machine Interface: the acceptance of the system by the end-user will greatly depend upon its ability to become a turn-key system. This can be achieved while involving pilots, drone manufacturer and supervisors to co-design the future evolutions of the system.

A.3.6 Recommendations and requirements

The Podium project has provided valuable insights about the way future U-Space systems should be developed and implemented. It also raised a number of issues that must be addressed before trying to deploy steps 3 and 4.

- Clear benefits should be brought to the user –whether they are operators or supervisors -. That means the system should provide effective mission planning tools as well as robust mission execution services
- Operators insist on getting information about their flight area and around it. This information should be available on a mobile App
- Supervisors modules will be key in granting future flight authorizations: the process should be acceptable for them and the end-users
- Incremental regulation for U-Space should be issued to ensure that U-Space offer is available in a safe manner for users. This regulation should cover the three main aspects: the concept of operations, the UTM conception, the certification of the UTMS company
- Standards for equipment (trackers,..), software and data should be developed so as to ensure seamless operations across all UTM Systems and safe implementation of UTMS

A.3.7 References

[1] PODIUM VLD Revised Demonstration Plan (version 02.00.01, 02/04/2019)

[2] PODIUM Concept & Architecture description (version 02.00.01, 05/04/2019)

[3] Guidance for U-space recommendations and conclusions (version 01.00, dated 04/07/2019)

[4] PODIUM Bretigny Pre-Demo Mock-Up Report (version 01.00.00, 20/12/2018)

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