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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 the Rodez flight trials conducted in the framework of PODIUM SESAR/Horizon 2020 Very Large Scale Demonstration Projects. The Rodez trials aim to assess initial use of U-space services (usefulness and easiness) to facilitate integration of drone operation within controlled airspace.

The demonstration was led by Airbus and consisted in performing five drone mission scenarios (including non-nominal situations) within the Rodez Class D CTR. For the demonstration purpose, dedicated systems were developed to support mission preparation/authorisation and flight execution. Overall, feedbacks from participants were positive and initial results are encouraging for a safe U-space service deployment in the next years. However, further investigations are needed in particular in environments that are more complex.

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.

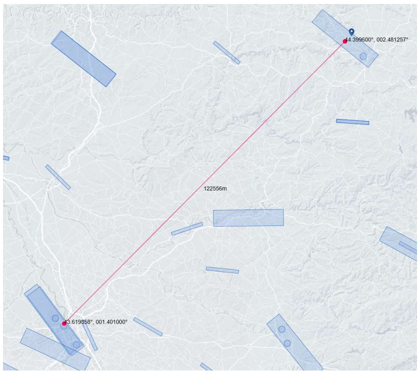

Figure 1 Rodez is not Toulouse!

Whereas the grant agreement refers to the Toulouse trials, the demonstrations actually took place at Rodez-Aveyron airport. Hence, this report refers to Rodez!

Table of Contents

List of Tables

List of Figures

1 Executive summary

The present document constitutes the demonstration report for the Rodez flight trials conducted in the framework of PODIUM SESAR/Horizon 2020 Very Large Scale Demonstration Projects. The Rodez trials aim to assess initial use of U-space services (usefulness and easiness) to facilitate integration of drone operation within controlled airspace.

The demonstration was led by Airbus and took place over 2 days in June 2019. It consisted in performing five drone mission scenarios (including non-nominal situations) within the Rodez Class D CTR with the active participation of the main identified stakeholders: Rodez Air Traffic Controllers (DSNA) and Delair drone pilots/operators. For the demonstration purpose, a UTM prototype system was used for mission preparation/authorisation. Flight execution phase was supported by dedicated situation awareness with a collaborative interface and an embedded trackers providing “air situation” to the air traffic controllers (ATCO) and allowing silent communication with drone operators.

The feedback from both controllers and pilots were positive. The mission preparation system provides relevant information for the operators to prepare the mission and to the supervisor to support authorisation process. The flight execution systems were reported as very intuitive and providing benefits in terms of:

- situation awareness (through monitoring of drone mission and intention);
- workload through silent communication with the pilots.

Some improvements have been identified (e.g. additional features to further ease mission preparation/authorisation tasks, integration of the collaborative interface in the piloting software, redundancy of tracker). Further investigations shall be planned for a more complex environment (e.g. more manned traffic, multiple drones)

As a conclusion, the tested systems represent a solid basis for the future experimentation and then deployment of the U-space services.

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-TOU-003: BVLOS flights entering and exiting a CLASS D CTR

A.1 Summary of the Exercise Plan

Next sub-chapters describe how Rodez demonstration was planned according to the PODIUM VLD Revised Demonstration Plan [1] .

A.1.1 Exercise description, scope

The exercise took place in Rodez during 2 days in June 2019 (Figure 2 and Figure 3) and consisted in assessing a subset of U-space services provided by the UTM system, which include mission preparation, trackers with tracking fusion system and situation awareness with a particular focus on interactions between drone operators and controllers .

New features have been tested by Airbus in complement of the Unifly system with the aim to provide situation awareness with collaborative interface to air traffic controllers.

The exercise consisted in BVLOS flights using a fixed wing drone in and out a CLASS D CTR for testing interactions thanks specific tools deployed for this purpose between the drone pilot and the controller.

The main objectives were:

- To define:
    - The most useful way for the air traffic controller to follow drone operations in a controlled area
    - the interactions between the drone pilots and air traffic controller
- Assess the relevance of a dedicated collaborative interface between the air traffic controller and the drone pilots:
    - To ensure safe operations
    - To segregate drone traffic from the other users
    - To liaise with drone pilots
    - An minimizing impact on controller workload and frequency

The demonstrations at Rodez used the following services as described at chapter 9 of the PODIUM Concept and Architecture Description [2]:

- E-registration (9.2.1) thanks to the UTM system for mission preparation and the missions plan
- E-identification (9.2.1) thanks to the trackers and the unique ID for each drone
- Drone location surveillance and tracking (9.2.2)
- Automatic and manual flight permissions (9.2.4)
- Post flight services (9.2.12) thanks to the legal recorder

- ATC collaborative interface[1]

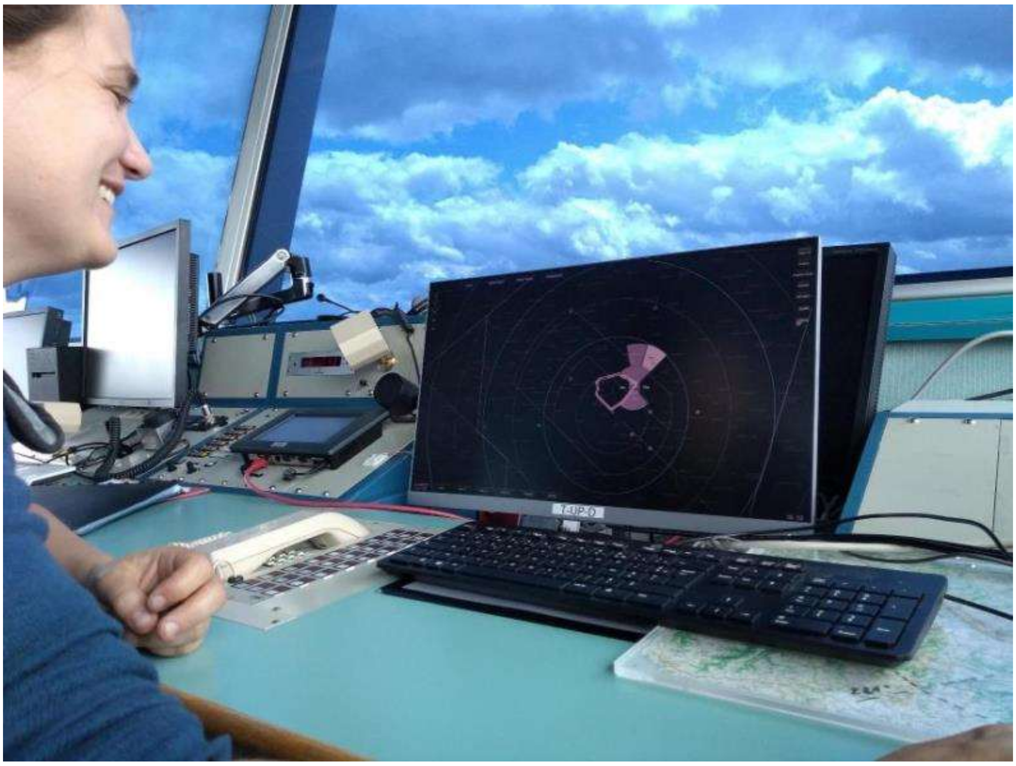

Figure 2 - ATCO collaborative interface HMI

The demonstrations at Rodez used the following systems as described at chapter 9 of the PODIUM Concept and Architecture Description:

- Types of drones: DELAIR DT18 Fixed-wing
- General aviation aircraft
- Unifly
    - Sentry (Supervisor/ATCO tool)
    - Unifly Pro (Drone operator/pilot role)
- Airbus
    - U-space surveillance Tracker And Server (URTAS) for fusion
    - Integrated Controller Working Position
    - Recording
- Orange Access Point Name connectivity
- Trackers
    - DELAIR GSM-based
    - Airbus Identifier and Tracker (UNB/L band)

[1] To be highlighted in the next revision of the PODIUM Concept & Architecture Description [2]

Figure 3 - PODIUM Rodez team and the drone

The global architecture for the Rodez demonstration is described in next scheme.

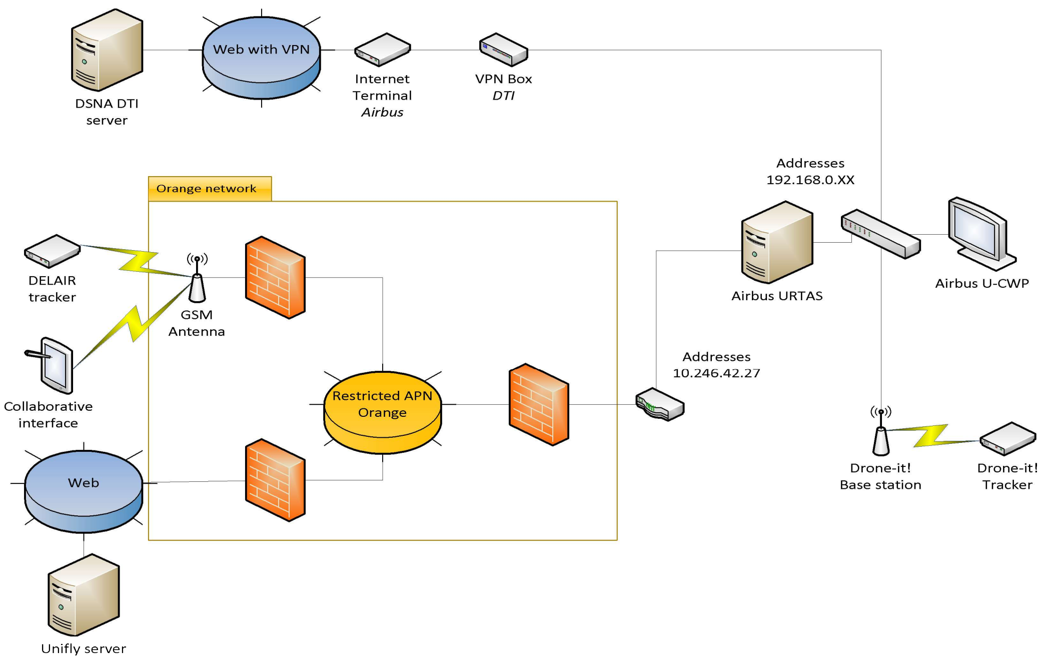

Figure 4 - architecture used for Rodez demonstration

Situation awareness with collaborative interface for controllers:
With the same aspect as that used by the controllers (IRMA basemap), the system displays the mission plan(s), divided into sectors (corridors). A temporary wrapper was created to take the KML file gives by drone operator and convert it as a mission plan suitable for Airbus tools. During the flight of the drone only the corridor where the drone is located is displayed. The ends of the corridors have an overlap allowing a continuity of the display when passing from one corridor to another. The position of the drone is automatically displayed when it leaves the active corridor or at the request of the controller.

As part of the demonstration, and in order to make the environment even "richer", other airspace users are also displayed, ATM tracks returned by the DTI (refresh period of 1 minute), and those which are equipped with ADSB Out, thanks to the implementation of a local ADSB receiver. The dialogue with the operator takes place by sending and receiving preformatted messages accessible by screen and mouse ("Pie Menu") or by certain specialized keys of the keyboard.

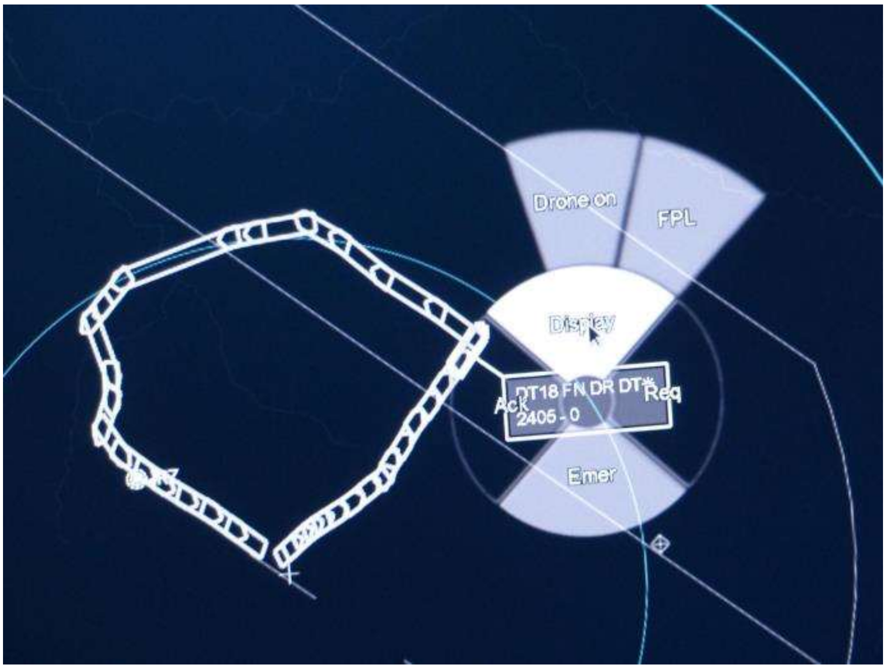

Figure 5 - Mission plan and Pie menu on collaborative interface

Drone Pilot side.
The interface allows the dialogue with the ATC: it was not as mature as the ATC interface, which was the main objective. It is composed of push buttons and input field to fill in drone ID or flight plan ID. The buttons permit to send predefined messages to the Air controller such as “CTR entry” to ask a CTR entry permission or “Exit Area” to inform the controller that the drone exit a particular area. There is also some drop-down menus to choose a drone if the pilots control multiple drones, or name of areas wherein the drone want to enter or leave. Before each flight the pilot has to connect, thanks to the Orange 4G (Access Point Name) networks, to the ATCO HMI with a dedicated button.

Figure 6 – Mock-up collaborative interface for drone operators

A.1.2 Exercise Objectives and success criteria

Demonstration Objective (as in section 3 of [1])	Demonstration Success criteria (as in section 5 of [1])	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	Partially covered: Not all u-space services to be implemented and no degraded situations foreseen	Assess the operational feasibility and acceptability of the new features (ground control station and collaborative interface) to facilitate safe integration of drone in controlled airspace	Ground control station and collaborative interface suitable to pilots/operators and controllers' needs.

Demonstration Objective (as in section 3 of [1])	Demonstration Success criteria (as in section 5 of [1])	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
			Assess the operational feasibility/acceptability of other initial U-Space services for mission preparation (e.g. E-registration/identification, pre tactical geofencing)	Interface is usable and easy to use Ground control station and collaborative interface increase situation awareness of both drone pilots/operators and controllers. Workload of both drones pilots/operators and controllers is at least maintained Roles and tasks are clear and acceptable for both pilots and controllers initial U-Space services are operationally useful, easy to use
OBJ-VLD-POD-002 Technical feasibility	CRT-POD-002-001 CRT-POD-002-002 CRT-POD-002-003 CRT-POD-002-004	Partially covered: Not all u-space services to be implemented, no simultaneous drone flights and no degraded situations foreseen	Assess the technical feasibility of the various features of the UTM systems Assess the interoperability of the various systems: tracker, ground control station, ATC systems and UTM system for flight preparation	Communication and tracking latency time are suitable to both drones pilots/operators and controllers' needs (e.g. short enough) Data fusion provide sufficiently accurate Air traffic situation to both drones pilots/operators and controllers

Demonstration Objective (as in section 3 of [1])	Demonstration Success criteria (as in section 5 of [1])	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
				The various systems are interoperable.
OBJ-VLD-POD-003 Safety	CRT-POD-003-001 CRT-POD-003-002 CRT-POD-003-003 CRT-POD-003-004	Partially covered: No demonstration about U-space services and ground risk	Assess the level of safety (in particular air risk) with the new feature when flying within a CTR	Level of safety considered at least maintained by both drones pilots/operators and controllers (e.g. mitigation of the air/ground risk, segregation with manned traffic, detect abnormal behaviour)
OBJ-VLD-POD-004 Security	CRT-POD-004-001 CRT-POD-004-002	Partially covered	Assess the level of security (mainly cybersecurity) of the U-space services tested	Level of security considered at least maintained by both drones pilots/operators and controllers)
OBJ-VLD-POD-005 Standards & regulation	CRT-POD-005-001 CRT-POD-005-002	Partially covered: Not all U-space services to be implemented	Assess that impact of U-space services on operational or technical standards is appropriately documented. Assess that impact of U-space services on and regulation	Initial recommendations and requirements are provided in terms of standard and regulation in particular for the use and performance of the collaborative interface)
OBJ-VLD-POD-006 Initial benefits assessment	CRT-POD-006-001 CRT-POD-006-002	Partially covered: No cost efficiency measures Increased capacity: more flights in airspace	Assess the initial benefits and limitation of the new features and initial U-space services tested	Benefits, limitations and recommendations provided by both drones pilots/operators

Demonstration Objective (as in section 3 of [1])	Demonstration Success criteria (as in section 5 of [1])	Coverage and comments on the coverage of Demonstration objectives	Demonstration Exercise Objectives	Demonstration Exercise Success criteria
				and controllers are documented

Table 1 - Demonstration Objectives

A.1.3 Exercise Operational scenarios

To verify the interest of the overall system in various situations, the 5 following scenarios were made:

Description	**EXE-VLD-TOU-003**: Flying BVLOS flights using a fixed wing drone in and out a CLASS D CTR in order to test interactions, and the tools deployed for this purpose, between the drone pilot and the ATCO. The flights will occur in the vicinity and in the CTR of the airport of RODEZ (LFCR). The flights will be performed by the DT18, which is a fixed wing from Delair. The flights will be BVLOS and automated. **Scenario 1**: The scenario will consist in flying, North-East in the axis of the runway for a few hundred meters, then turn right exit the CTR. Then the drone turns back into the CTR. **Scenario 2**: Same as SC1 except that the ATCO to put the DT18 on-hold. Then the DT18 pilot will perform a hippodrome outside the CTR. Enter the CTR again, however on its way forward, the pilot will declare a C2 link loss to the ATC. **Scenario 3**: Same as SC1, however the DT18 is flying off course: the UTM system raises alerts to the pilot and the ATCO. The ATCO requires the pilot to correct the route, or to reach the closest alternative landing area. **Scenario 4**: The DT18 takes off as planned. The ATCO is informed. Then a clearance is requested to enter the CTR. The clearance is not granted and the DT18 enters a hippodrome. Then the DT18 is cleared to proceed. For some emergency reasons, the ATCO needs the DT18 to change route and inform the pilot about the new desired trajectory to exit the CTR. **Scenario 5**: Same as SC4. The clearance is granted. The mission proceeds. Then the pilot informs the ATCO that the DT18 is unable to complete its mission as planned and request to land at the closest defined landing point. The ATCO clears.
Demonstration Technique	<Live Trial>
KPA/TA Addressed	Safety, Flight efficiency, Security, Capacity, Human performance
Number of flights	3 to 10 Flights, 50-60 km each
Start Date	24/06/2019
End Date	25/06/2019
Demonstration Coordinator	Airbus

Demonstration Platform	U-space service (Smartphone application, Desktop application, Platform DELAIR SOLAPP, Airbus ATC CWP, U-space Service Provider application); Trackers (UNB L-band, Delair Tech) ; Drones (Fixed-wing)
Demonstration Location	Airport RODEZ LFCR
Status	Ended

Table 2: Demonstration Toulouse Exercise layout

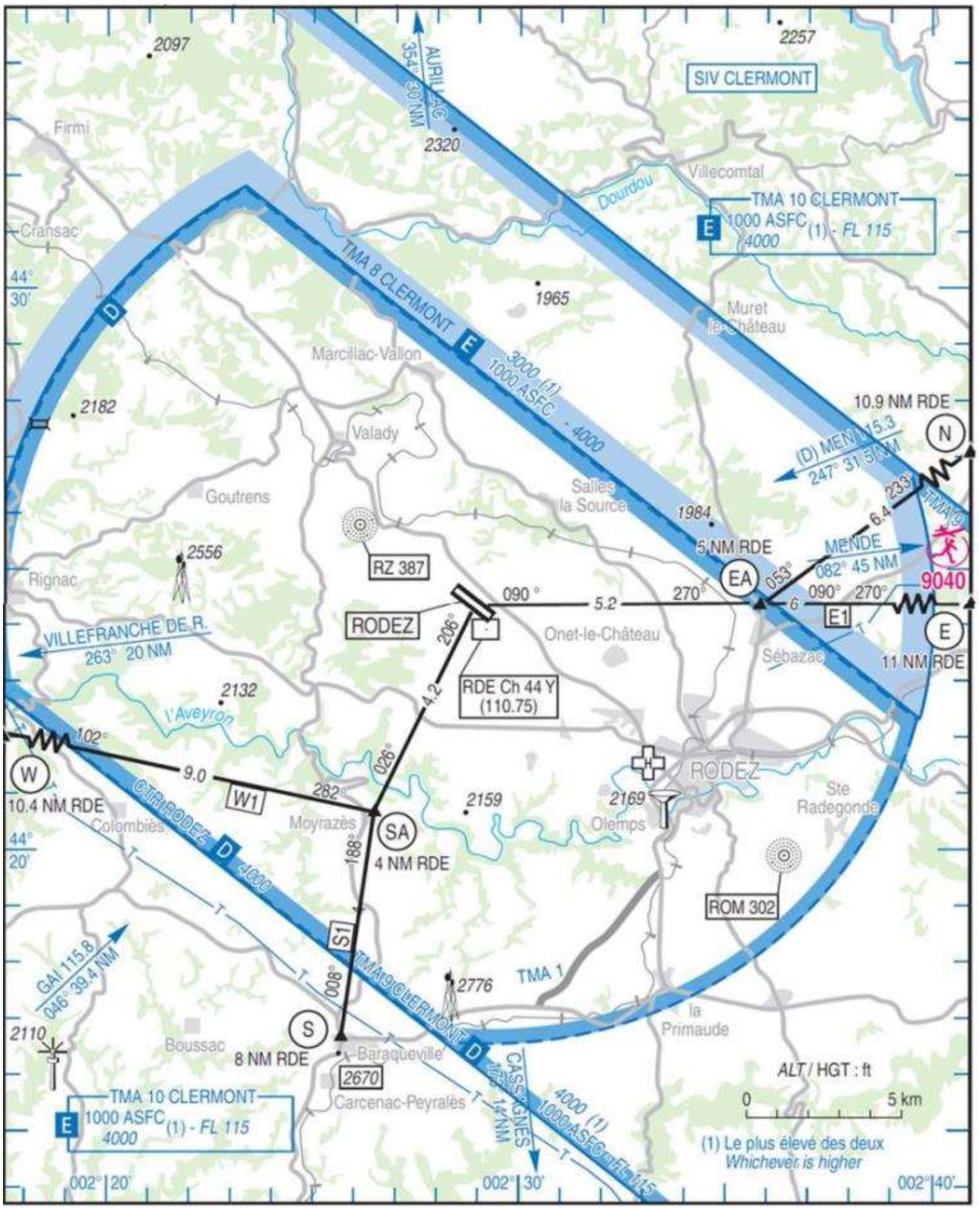

Figure 7 - Rodez airspace map

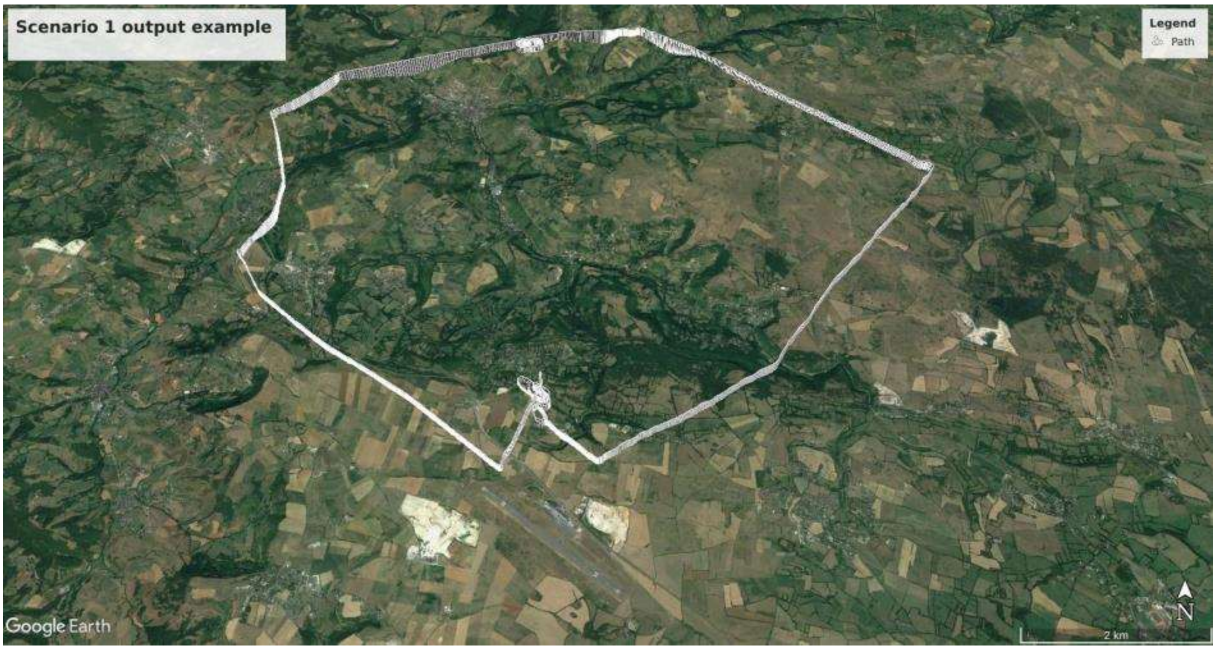

Figure 8 - Example of a scenario trajectory

A.1.4 Exercise Assumptions

Identifier	Title	Description
POD-A1	BVLOS procedures	BVLOS procedures are in place
POD-A2	BVLOS approvals	BVLOS operations are approved by the NAA
POD-A3	Tracker compatibility with drone	The tracker configurations are compatible with the drones (weight, dimensions, power consumption etc.).
POD-A4	Tracker compatibility with U-space	The Trackers are available (DELAIR, ~~Unifly,~~ AIRBUS) and integrated to the UTM system for mission preparation(identification, drone and user registration, GNSS position) and the collaborative interface.
POD-A6	Drone flight route design	The routes and procedures for drone operations are appropriately designed and approved by all relevant authorities (overflight, distance form building, etc.)
POD-A7	Airport procedures	Airport coordination procedures are validated.
POD-A9	Baseline U-space documents	In the absence of suitable baseline documents on U-space, the PODIUM Concept & Architecture document from WP02 can be used as the operational and technical baseline for the document
POD-A10	Drone pilot and operator availability	Drone operators and pilots are available to perform the flights

POD-A11	U-space platform available	The UTM system for mission preparation is available and instantiable in the frame of the demonstrations.
POD-A12	ATC available	ATC is available to participate in the trials
NEW-01	The collaborative interface is deployed	Both on the ATC side (collaborative interface) and on the pilot side (~~Unifly Pro,~~ Airbus interface)
NEW-02	The pilot is located in an area where the GSM signal allows to connect to the internet	The pilot will connect to the ~~Unifly Pro~~ collaborative interface through an internet connection.

Table 3: Demonstration Exercise Assumptions

A.2 Deviation from the planned activities

Some deviations were observed during preparation of flights and flights themselves:

- Drone mission plans for the first day were inserted in UTM system (Unifly) for mission preparation after the flights (priority to scenarios as weather conditions were at limits)
- Weather pushed the drone sometimes outside its limits, due to wind (scenario 2)
- The take-off location was changed to ensure that the drone will still be in radio range for the C2 link. The take-off site was set on a hill a few hundred of meters off the runway.
- In the scenario 4, the drone had to wait in a holding pattern just after the take-off because of trackers problem: there were no positions sent to the system (No DELAIR tracker message and message with empty position for Airbus tracker)
- The direction of the mission plan was short-cut in order that the drone comes back to the pilot with a tailwind (scenario 2)
- Unplanned stacks of drone were necessary due to traffic of manned aircraft in scenario 1 and 5

A.3 Exercise Results

A.3.1 Summary of Exercise Results

This section provides a summary of exercises which happened during the demonstration in Rodez the 24th and 25th of June 2019.

This section provides an analysis of exercise results per objective. Next tab contains a summary which are developed objective per objective in next subchapters.

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: • Pilots: positive feedback. Relevant information provided although some features could be added further support the tasks • Supervisor/ATCO: useful to have information on pilot/mission through the mission. However, lack of some functionalities for decision making and usability issues reported	POK
		Flight-execution: • Overall positive feedback about the Collaborative interface system • Supervisor/ATC: collaborative interface was very intuitive, useful, easy to use and it simplified decisions • Pilots: the system was not integrated in the piloting software. This is a must have • Supervisor/ATCO: the system improved available information of the drone position in airspace • Supervisor/ATCO: the system permitted to get continuous position with the tracker redundancy • Collaborative interfaces allowed to exchange specific messages	OK
OBJ-VLD-POD-002 Technical feasibility	CRT-POD-002-001 CRT-POD-002-002	Pre-flight: • The timeliness of info rated overall a little bit less than medium • Accuracy of info rated overall high	OK

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))
	CRT-POD-002-003 CRT-POD-002-004	<u>Flight-execution</u> • The UTM system was accurate and stable over time • The delay of communications was compatible with the operational needs, even when there were tracker problems (because of redundancy) • When the system got the tracker positions, these ones were stable and seem to be accurate. • The timeliness of info rated overall medium • Accuracy of info rated overall high	POK
OBJ-VLD-POD-003 Safety	CRT-POD-003-001 CRT-POD-003-002 CRT-POD-003-003 CRT-POD-003-004	<u>Pre-flight:</u> • The pilots were aware of restricted area and/or no fly zone • The supervisor was aware of mission but not able to assess fly zone overlaps (e.g. for strategic deconfliction)	POK
		<u>Flight execution:</u> • The dedicated ATCO/pilot interface greatly improved situation awareness especially on controllers side • The impact was positive on safety and mission effectiveness	POK
OBJ-VLD-POD-004 Security	CRT-POD-004-001 CRT-POD-004-002	• Use of dedicated Orange Network to avoid/limit cyber-attack • Airbus drone identifier and tracker works on a specified band. Other protection is not published currently for this tacker.	POK 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-005 Standards and regulation	CRT-POD-005-001 CRT-POD-005-002	• Predefined messages for the communication between the UTM interface and the drone operator interface • Predefined stack areas outside the CTR • To go further alternate landing area shall be defined • Currently there is no regulation for drone/manned aircraft interaction • The UTM system reduced the number of procedure to do the mission preparation • Collaborative interface was considered as primary communication channel with voice radio as a backup	POK POK
OBJ-VLD-POD-006 initial benefits assessment	CRT-POD-006-001 CRT-POD-006-002	Pre-flight: • The system provided all info about the mission. It allowed to store all the requests • The system needs some improvements	POK
		Flight-execution: • There was an overall positive impact of the UTM system during mission execution • The UTM system was useful especially to monitor flight execution and ensured respect of the restricted area • The UTM system meets controller’s need	OK

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))
		• The communication with ATC was facilitated through the system although it was currently not possible to communicate with the ATC if no tracker position is available (specification of the HMI) • There was a better flight control on the pilots side • The system needs as improvements to handle more situations (more messages)	

A.3.2 Analysis of Exercise Results per objective

This part details the results obtained after the fulfilment of all the Rodez scenarios and the receipt of the feedback of all the stakeholders. The different graphs in the following part come from surveys conducted after each flight and after the demonstration. As the next parts show, there is an overall improvement of the feedback with the number of flight.

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

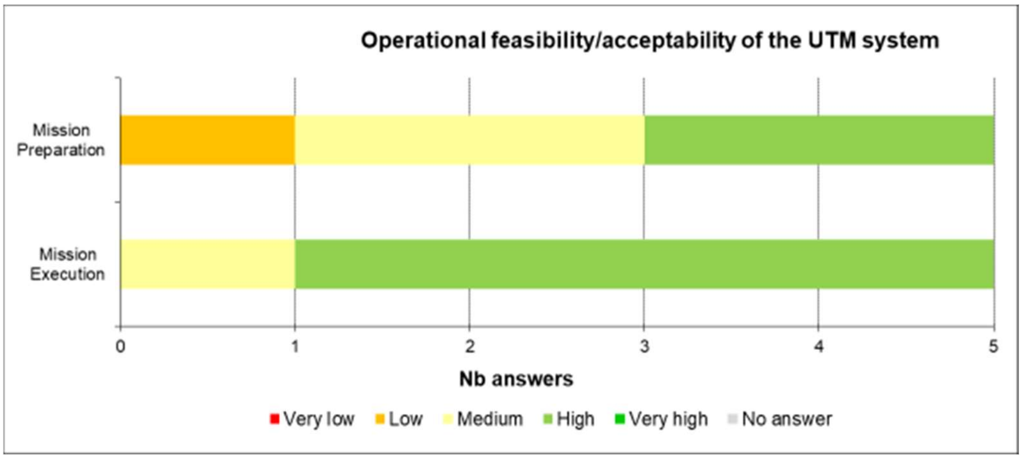

Figure 9 - Operational feasibility/acceptability of the UTM system (per flight phase)

Figure 10 - Operational feasibility/acceptability of the UTM system

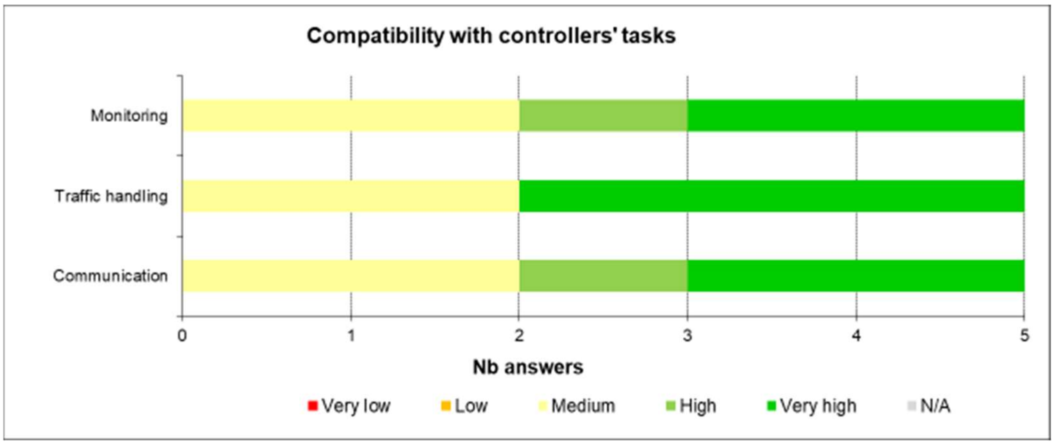

Figure 11 - Compatibility with controllers' tasks

- Pre-flight services:
  - Operator reaction: good feedback for the pilots. The pilots agreed with the interface

- Supervisor/ATCO: they noticed that there is a lack of some functionalities (e.g. strategic deconfliction) and usability issues on mission form (e.g. zoom)
- Supervisor: useful to have information on pilot/mission through the mission form
- Supervisor: there is a lack of information for decision making in the system
- The briefing prior missions helped clarifying roles tasks and procedures.

- Flight execution services:
  - Overall positive feedback about the system
  - The supervisor/ATCO reported that the Airbus system was very intuitive, useful and easy to use and it simplifying decisions
  - For the pilots, the system was not integrated in the piloting software and this is clearly a must have. This situation was due to the lack of time and financial means.
  - The system was quickly adopted by all the stakeholders and used to fly the different scenarios. Furthermore, the necessary workload to use the drone operator interface or the UTM HMI is low, that explain the good feeling.
  - Finally, the main points for the collaborative interface and DELAIR/Airbus trackers noticed to facilitate air traffic controller work are:
    - They improved the available information of the position of drone in airspace: when aircraft requested to taking-off, transit or landing, the decision was easier by having situation awareness with drones' position. Before that, air traffic controllers used to request the drone to land. Now, they can keep drone and aircraft spaced.
    - They permitted to get continuously the position of drone in the controlled airspace, because of the tracker redundancy. And even if one of the trackers was not functioning (as it has been observed), no reduction of control was observed as at least 1 tracker were operational during the flights.
    - They permitted to exchange specific drone messages easily with collaborative interface. For instance, twice, drone was put in predefined stacks to keep a good spacing with manned aircrafts. Other exchanges were done with the same way without any use of the radio (VHF).
  - Air traffic controller used collaborative interface as a new system for integrating drones in their CTR. In scenario SC4, the DELAIR tracker didn't provide any position while in scenarios 5 and 3 it was the same for Airbus tracker. Nevertheless the controllers could still work as they had drone positions, thanks to the redundancy. The collaborative interface work flawless.
  - Concerning pilot, the use of exclusively collaborative interface during all scenarios leads PODIUM partner to approve the operational use. The next step will be to include interface in drone pilot software, as in PODIUM it could not be done.

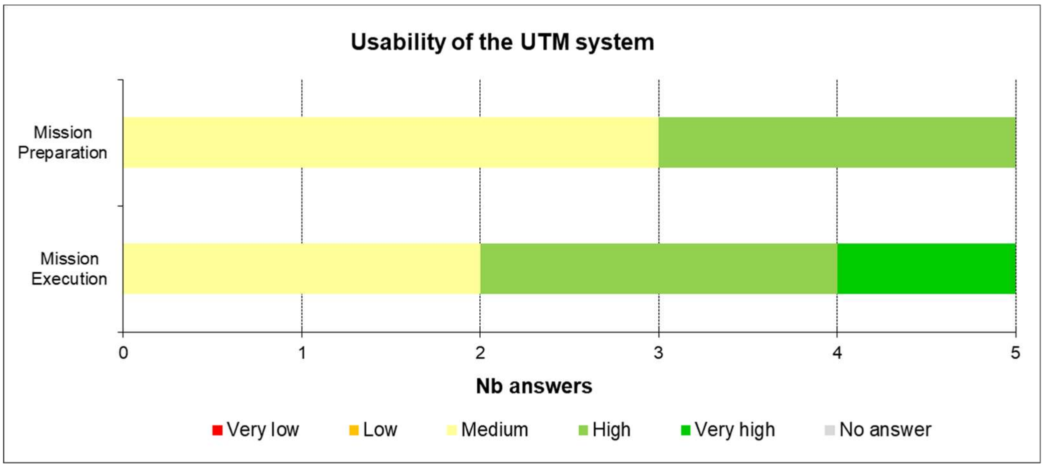

Figure 12 - Usability of the UTM system

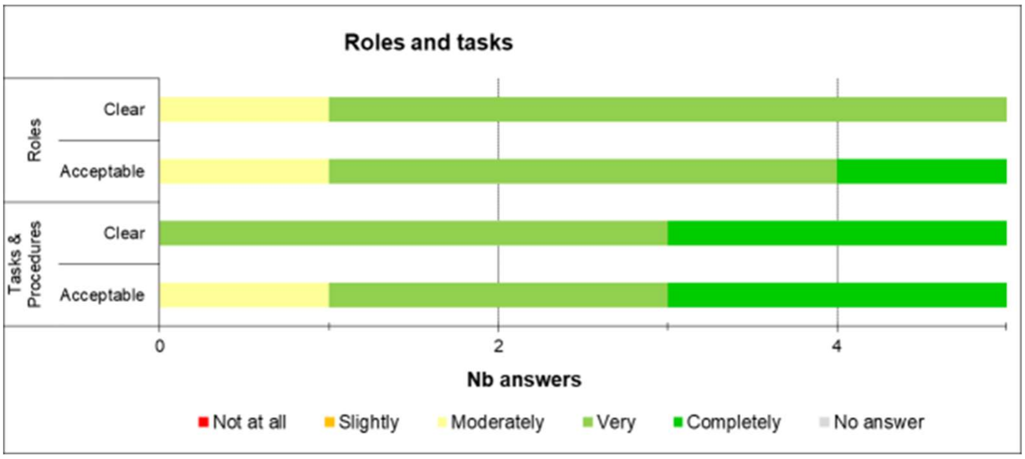

Figure 13 - Roles and tasks

The role and tasks were globally reported clear and acceptable for all the participants. As conclusion, the results go clearly in the way of the U3 establishment for the ATC collaborative interface.

2. OBJ-VLD-POD-002 Technical feasibility

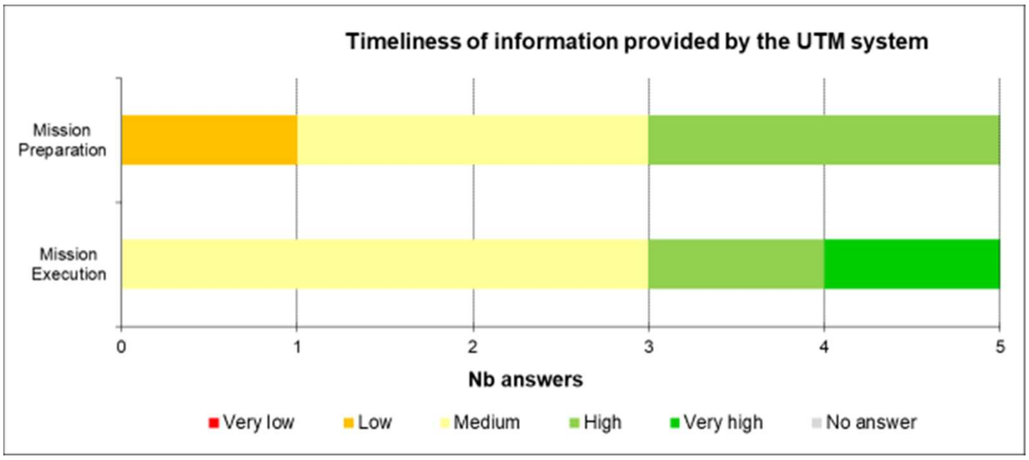

Figure 14 - Timeliness of information provided by the UTM system

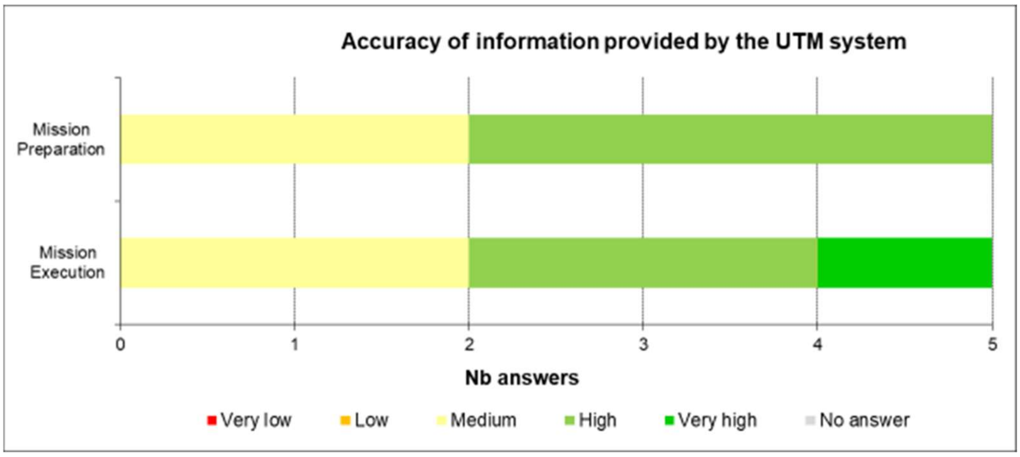

Figure 15 - Accuracy of information provided by the UTM system

- Pre-flight:
  - The timeliness of information rated overall a little bit less than medium
  - Accuracy of information rated overall high and medium for 1 ATCO and 1 pilot
- Flight execution:
  - The UTM system was accurate and stable over time (no system crash detected nor inability to use the HMI)
  - The delay of communication was compatible with the requirements, even when there were tracker problems (because of redundancy).
  - Once the system got the tracker positions, these ones were accurate and stable over time

- Regarding the performance of the communication systems, we noticed the following results:
  - Communication latency (duration between the positioning and the reception in collaborative interface:
    - DELAIR tracker (via Orange network): $\approx 1.5s$
    - Airbus tracker: $\approx 1.75s$
  - Tracking latency (duration between the positioning and the display): $< 2s$
  - Data fusion process: $\approx 1.5s$
- The refreshment rate of the UTM system is based on the frequency of the different trackers :
  - Delair tracker: $0.4s \leftrightarrow 2.5\ Hz\ (position/second)$
  - Airbus Tracker: $2s \leftrightarrow 0.5\ Hz\ (position/second)$
- Accuracy of information rated overall high and medium for 1 ATCO and 1 pilot
- The timeliness of information rated overall medium

3. OBJ-VLD-POD-003 Safety

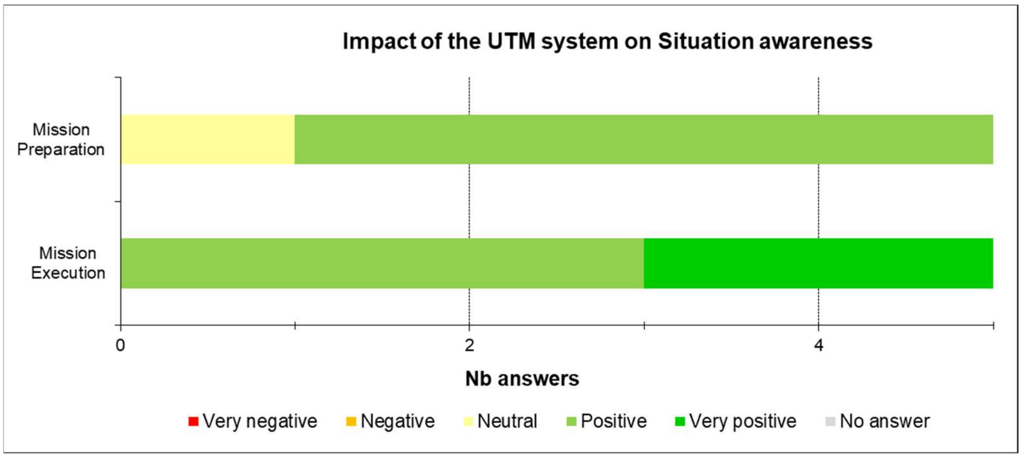

Figure 16 – Impact of the UTM system on Situation Awareness

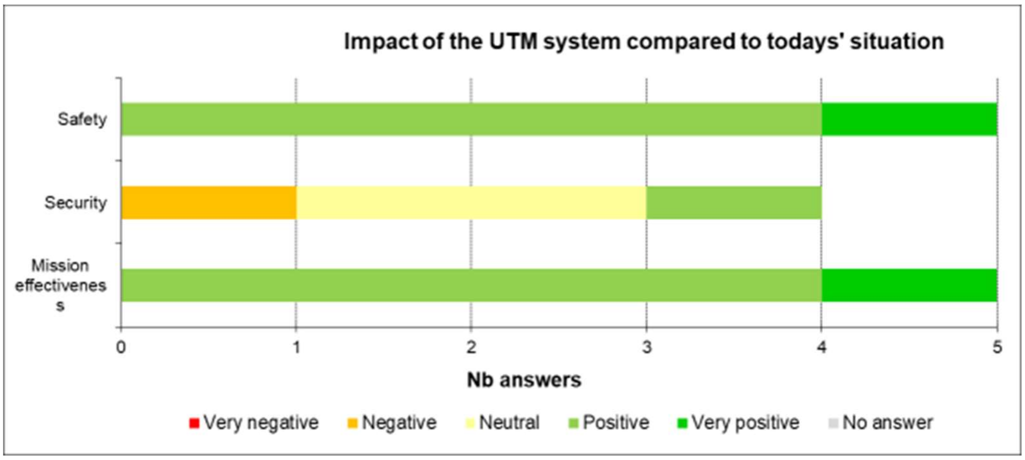

Figure 17 - Impact of the UTM system compared to todays' situation: the safety

- Pre-flight:
  - Pilots: they were aware of restricted areas and/or no fly zones but NOTAM or Aeronautical Information Package Supplements were not provided (in UTM system for mission preparation)
  - Supervisor: they were aware of mission (pilot, areas, …) but not able to assess zone overlap (e.g. between missions and its areas of responsibility area or among several missions)
- Flight execution:
  - The dedicated air traffic controller/pilot interface greatly improved situation awareness especially on controllers' side
  - The impact was positive on safety and mission effectiveness (gain of time, shared awareness of drone intentions and position, enhanced procedures and communication). With all the elements at his disposal, the controller can monitor situation and provide to the drone operator the right order at each time with the aim to maintain safety. For instance, air traffic controller spaced manned aircraft to drone in two scenarios. The situation was not initially planned but controllers were confident with the information provided by the system. In the case where the drone was out of its mission plan, the plot appeared which indicated the situation to the controller. No specific alarms were triggered for abnormal position of drone and no message was implemented in collaborative interface for this situation.

4. OBJ-VLD-POD-004 Security

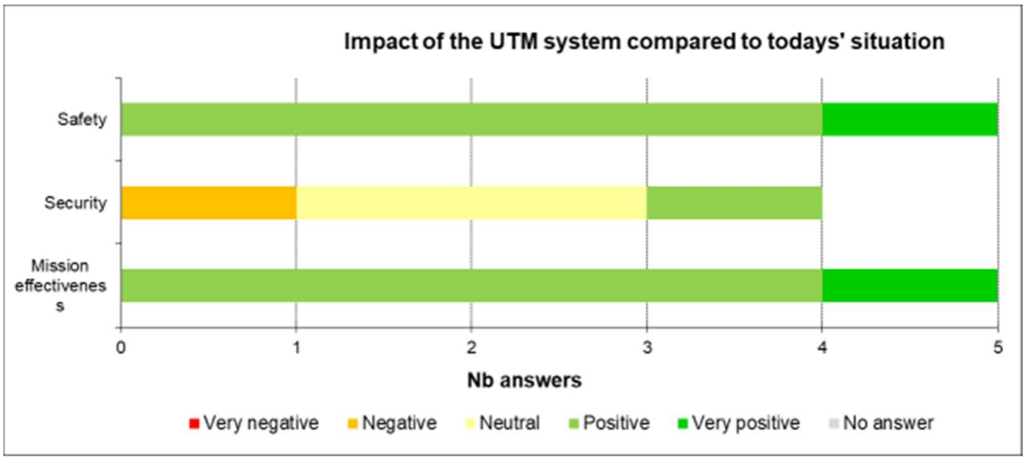

Figure 18 - Impact of the UTM system compared to todays' situation: the security

- Pre-flight and flight execution :
  - To face up to external attack, the system communicated with a private 4G Orange networks with dedicated sim card. The networks worked well during the trials.
  - The Airbus drone identifier and tracker works on a specific band, avoiding internet attack. Other protection is not published currently for this tracker.

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

For pre-flight and flight execution, the links with the standards and regulations for the demonstration are the following:

- Predefined stack path (hippodrome) were used outside restricted areas (CTR and airport) in order that the drone can wait the clearance to get in for instance
- To go further, the regulation shall defined alternate landing areas to face up to emergency cases.
- Using the UTM system, less procedure are necessary to do the mission preparation (authorization submission) in comparison to the current procedure established
- Currently, on the air traffic controller side, there is no regulation for drone/manned aircraft interaction
- There is no possibility with the system to do the spacing with non-ADS-B (or tracker) equipped aircrafts because period of refreshing for radar plot from DSNA was too long (1 min). Also, there is no regulation for separation between drones.
- Collaborative interface was considered as primary communication channel with voice radio as a backup. During all scenarios, the voice radio was not used or just for testing reception of signal. Some operational decisions showed that the ATCO were confident in the system. For instance Air Traffic Controllers decided to take into account drone in airspace for managing

manned aircraft and drone if necessary while the procedure was to land drone if manned activity was reported in CTR close to drone activity

- The existing drone is not managed as an airplane. The ATCO cannot give a heading or a speed to the drones. So, he has to adapt his habits to space drones from the traffic and drones between themselves because his job is to monitor the drones, not to control them

As conclusion, there are currently no sufficient regulations to face up to all the possible scenarios. To develop and provide an operational UTM system, new standards and regulations shall be acted and implemented. This process is currently in progress for the European regulation and the U-space. This type of exercise shall orient the development of such regulations. Results help to find new interesting points to consolidate as the definition of stack areas or the collaborative interface. For instance, the direct feedback of the ATCO allows highlighting what we need to improve, what is useless and what new features would be useful. That is linked to the future standards and regulations.

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

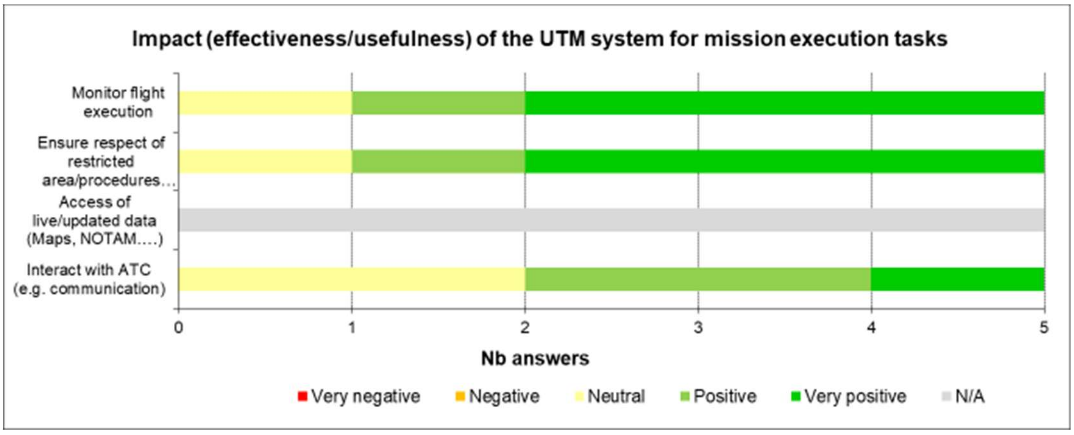

Figure 19 - Impact of the UTM system for mission execution tasks

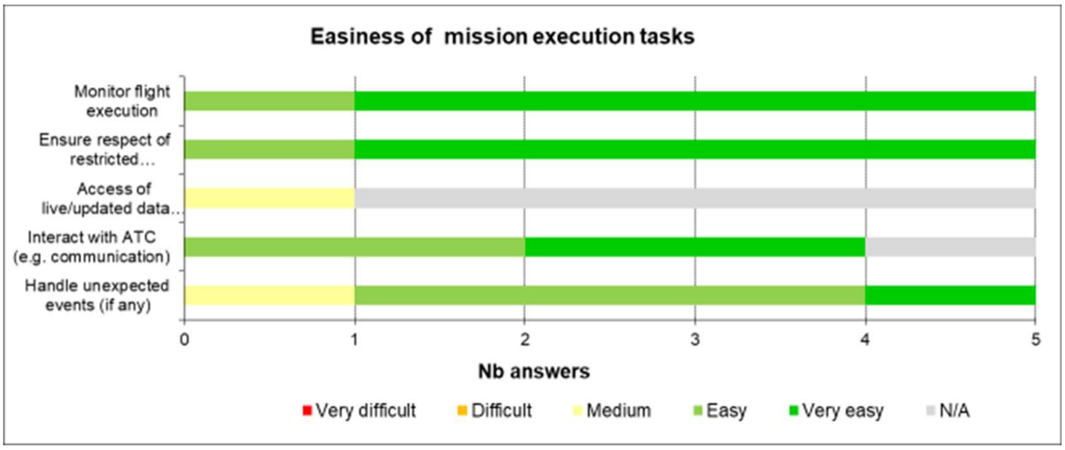

Figure 20 - Easiness of mission execution tasks

The overall feedback was positive from participants about UTM system:

- Pre-flight (authorization provision) performed through UTM system for mission preparation
    - The feedback was globally positive. The system provides all info about the mission, it allows to store all the requests
    - The system needs some improvements (e.g. possibility for strategic deconfliction, improved map view to provide authorization, notifications/pop-up for new request)
    - The system was slightly less useful for mission preparation than for mission execution seeing the feedback of the usefulness of the UTM system.

- Flight execution:
    - There was an overall positive impact of the UTM system during mission execution in particular to monitor flight execution and ensure respect of restricted area
    - The UTM system met controller's need (increase awareness/monitoring of drone intention and allows communication without phone)
    - The communication with ATC was facilitated through the system although it is currently not possible to communicate with the ATC if no tracker position is available. Indeed, in the HMI, the ATCO can send messages through the label of the drone. But, currently, the label is only displayed when a tracker send a position so, if there is no position, there is no possibility to establish communication.
    - There was a better flight control on the pilots side
    - The system needs as improvements to handle more situations (more messages)

We can notice that only one drone executed scenarios and it was not possible technically to add more (Airbus tracker, budget…). Nevertheless the objective can be checked with the same system in a new demonstration or simulations which will implicate more drones.

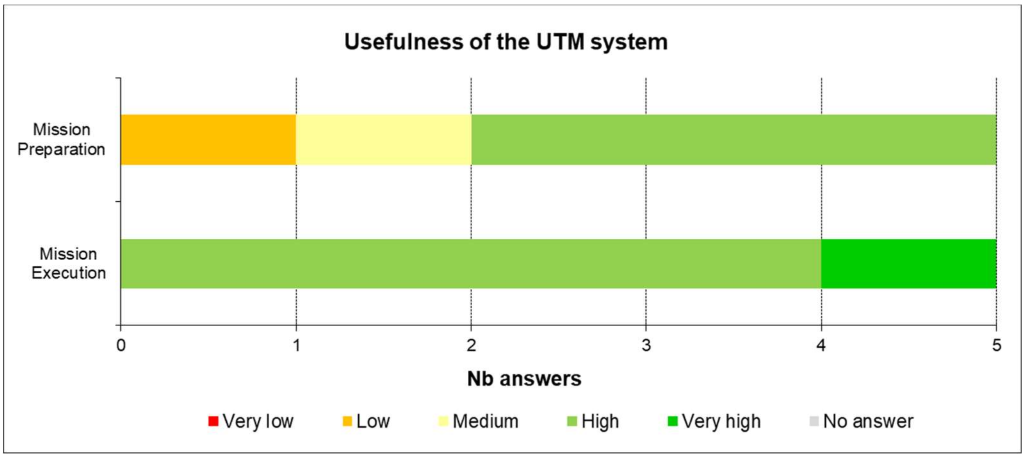

Figure 21 - Usefulness of the UTM system

The UTM system reported useful for mission execution and slightly less useful for mission preparation.

As conclusion, we can notice that it was easier to the ATCO to answer a drone operator's request with the collaborative interface than with the radio. It was also the case for the drone operator side. Moreover the ATCO could answer when he wanted, as the information stayed on the screen, and quickly thanks the keyboard shortcuts. Even if it was a first draft version, the collaborative interface leads to cost effectiveness introducing drones into the airspace. The confident in the system shown by the ATCOs make us to think that they probably could monitor more drones. Nevertheless, it is essential to take into account the specificity of the exercises (see A.3.41) to qualify the results.

A.3.3 Unexpected Behaviours/Results

The main issue that impacts the quality of the results is the robustness of the trackers:

- The drone identifier and tracker of Airbus took a long time to initialize (around 10 minutes after take-off to get a position). Issue was identified during dry-run. The prototype integration has to be quick for PODIUM project due to resource shortage within Airbus. This should be easily solved in the frame of the tracker development.

- The Delair tracker had an issue during one scenario and so it didn't provide drone positions.

Nevertheless, thanks to redundancy, tracking function was still operative.

1. Scenario 1

The scenario 1 consisted in flying, North-East in the axis of the runway for a few hundred meters, then turn right exit the CTR. Then the drone turned back into the CTR

Scenario 1 was executed respecting description and objectives. Following events were noted:

- Before the take-off, Airbus tracker needed time to get position (issue already reported during dry-run, GNSS chipset issue, waited regularly 10 minutes)
- Due to IFR traffic, the drone was stacked at the entry of CTR

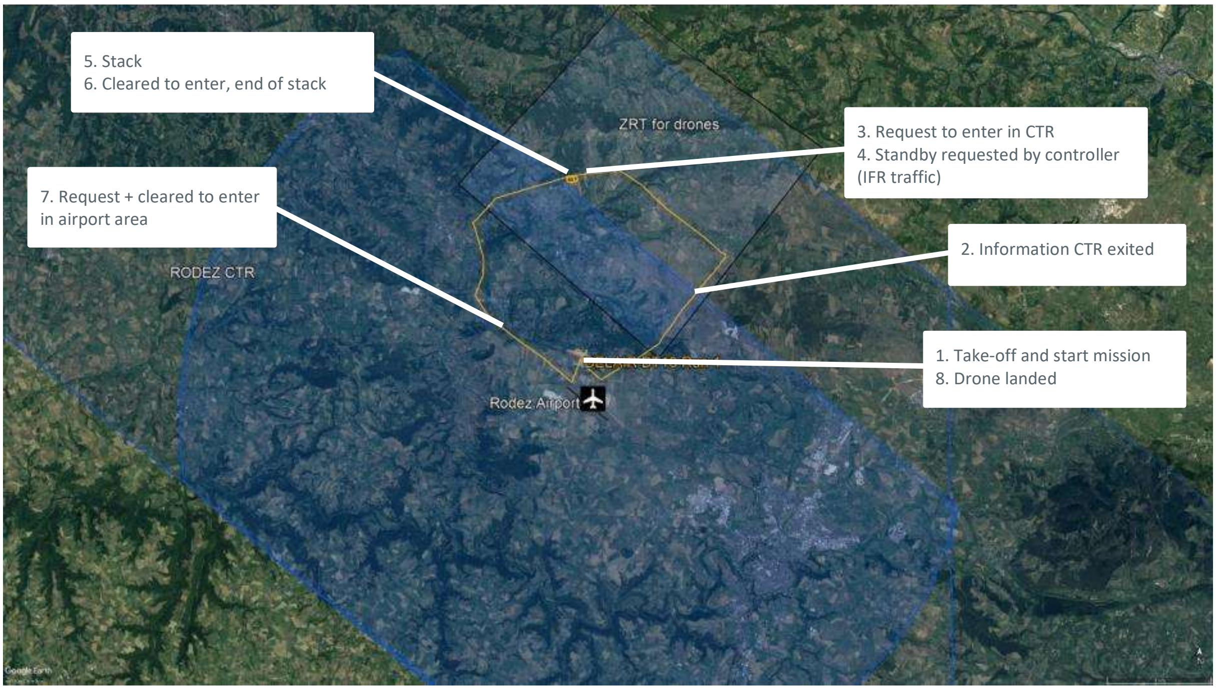

Figure 22: Tracking data of scenario 1 and exchanges between controller and pilot (Rodez demonstration)

2. Scenario 2

The scenario 2 was the same as SC1 except that the ATCO put the DT18 on-hold. Then the DT18 pilot performed a hippodrome outside the CTR. It entered the CTR again, however on its way forward, the pilot declared a C2 link loss to the ATC

Scenario 2 was short-cut due to weather conditions but objectives were reached and actions (e.g.: emergency loss of C2 link) were executed. Following events were noted:

- Wind level was considered too high regarding UAV envelope to perform the full flight plan. As a conclusion a shortened alternate one was established
- The exit/entry of CTR was done at the border for reducing flight time due to weather conditions
- The information of CTR exit was not transmitted to air traffic controller (oversight)

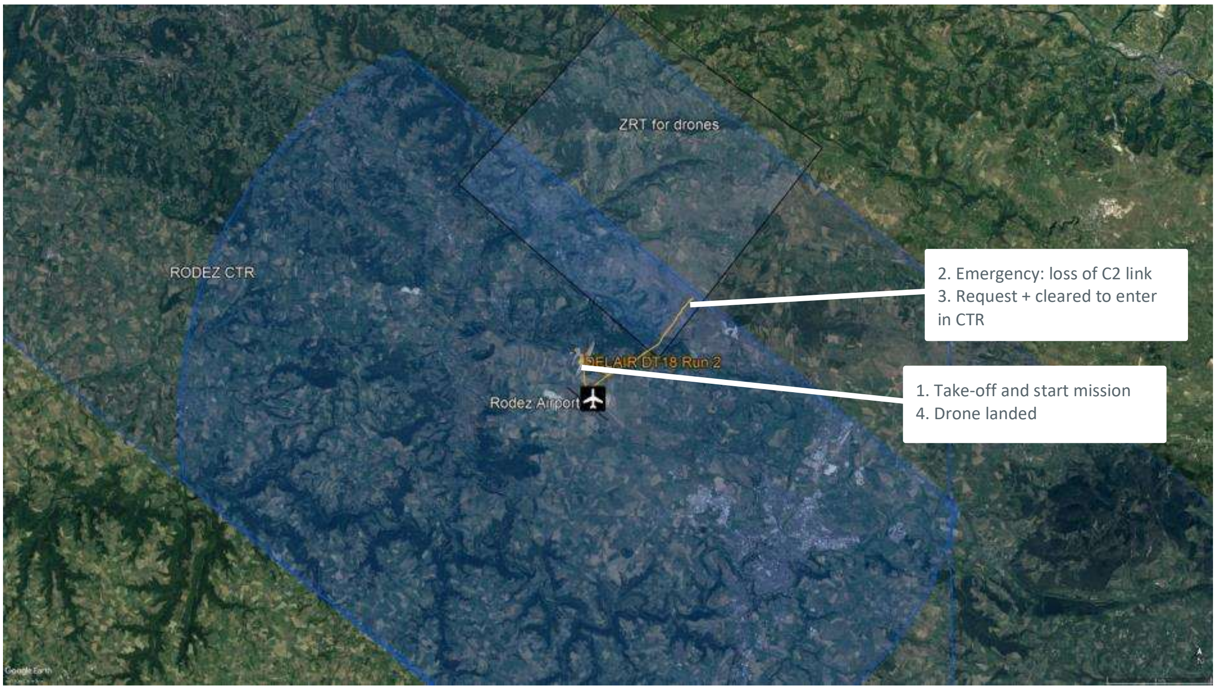

Figure 23: Tracking data of scenario 2 and exchanges between controller and pilot (Rodez demonstration)

3. Scenario 3

The scenario 3 was the same as SC1, however the DT18 was flying off course: the UTM system raised alerts to the pilot and the ATCO. The ATCO required the pilot to correct the route, or to reach the closest alternative landing area.

Scenario 3 was executed respecting description and objectives. Following events were noted:

- Airbus tracker was operational as was the DELAIR's tracker
- No alarm when drone is out of mission plan, only visual sign (drone plot is visible instead of corridor)

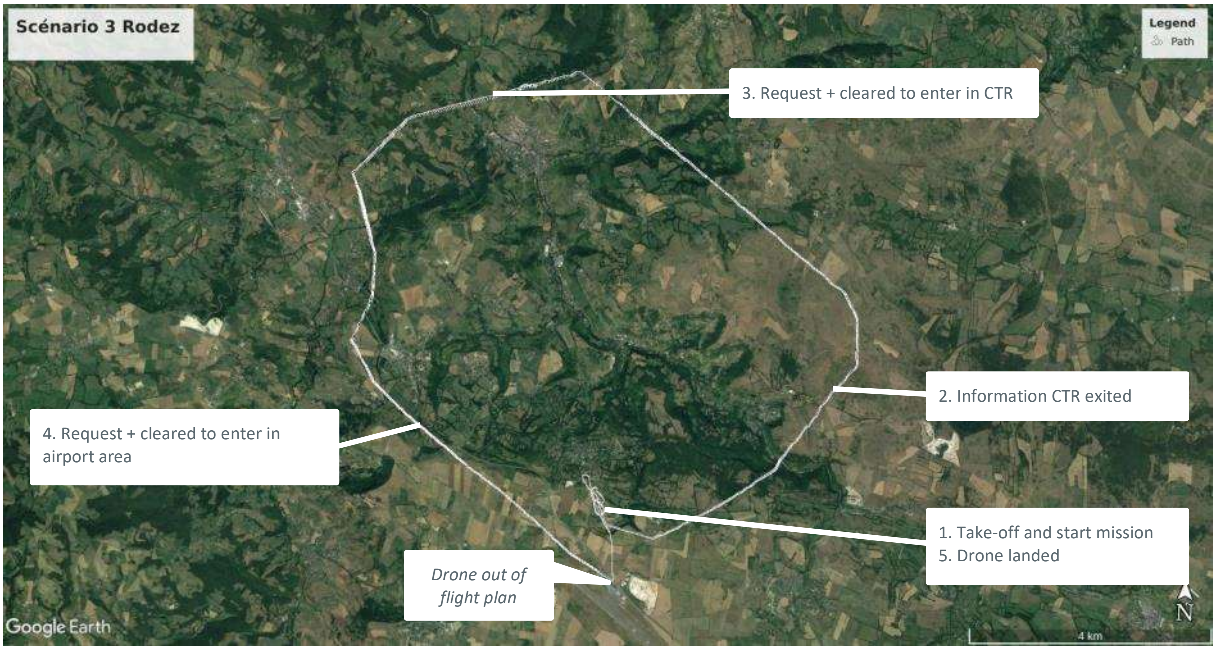

Figure 24: Tracking data of scenario 3 and exchanges between controller and pilot (Rodez demonstration)

4. Scenario 4

The DT18 took off as planned. The ATCO was informed. Then a clearance was requested to enter the CTR. The clearance was not granted and the DT18 entered a holding pattern. Then the DT18 was cleared to proceed. For some emergency reasons, the ATCO needed the DT18 to change route and informed the pilot about the new desired trajectory to exit the CTR

Scenario 4 was executed respecting description and objectives. Following events were noted:

- DELAIR's tracker can't transmit position (UAV positioning and feedback provided to UAV ground station was nevertheless fully operative).
- Airbus tracker was operative

So tracker function was operative thanks to redundancy between Airbus and DELAIR tracker.

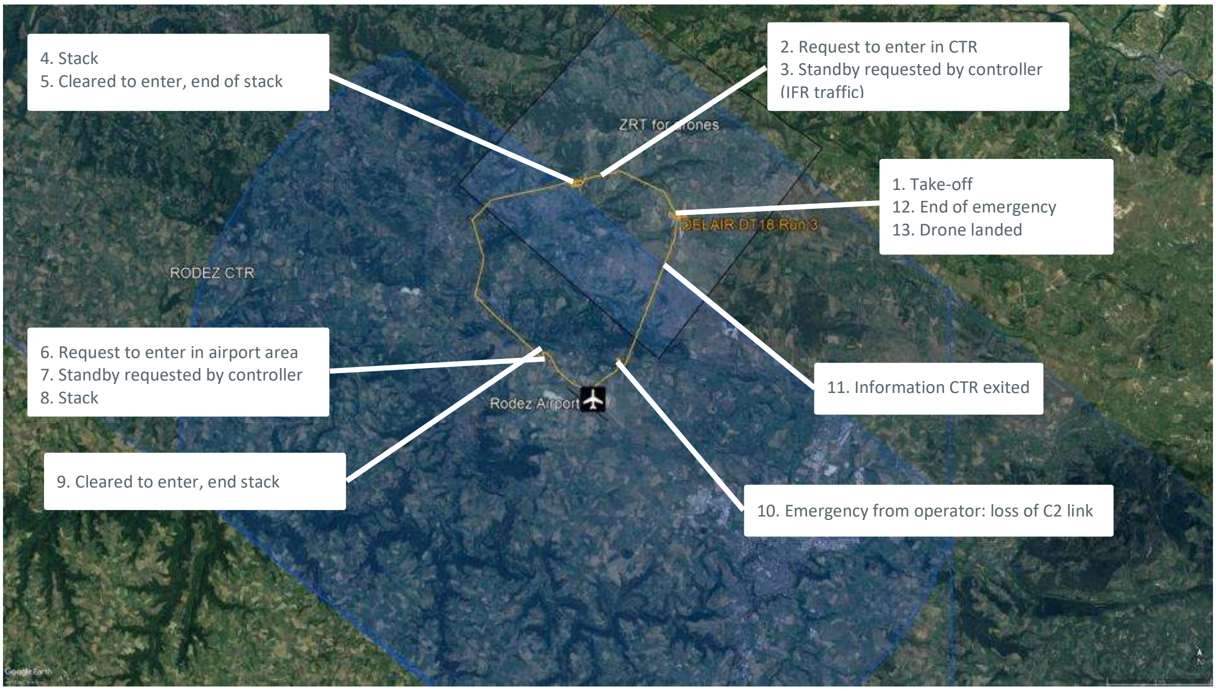

Figure 25: Tracking data of scenario 4 and exchanges between controller and pilot (Rodez demonstration)

5. Scenario 5

The scenario 5 was the same as SC4. The clearance was granted. The mission proceeded. Then the pilot informed the ATCO that the DT18 was unable to complete its mission as planned and requested to land at the closest defined landing point. The ATCO cleared

Scenario 5 was executed respecting description and objectives. Following events were noted:

- Airbus tracker was operational but its GNSS chipset could not provide position. Hopefully, this was compensated by DELAIR tracker

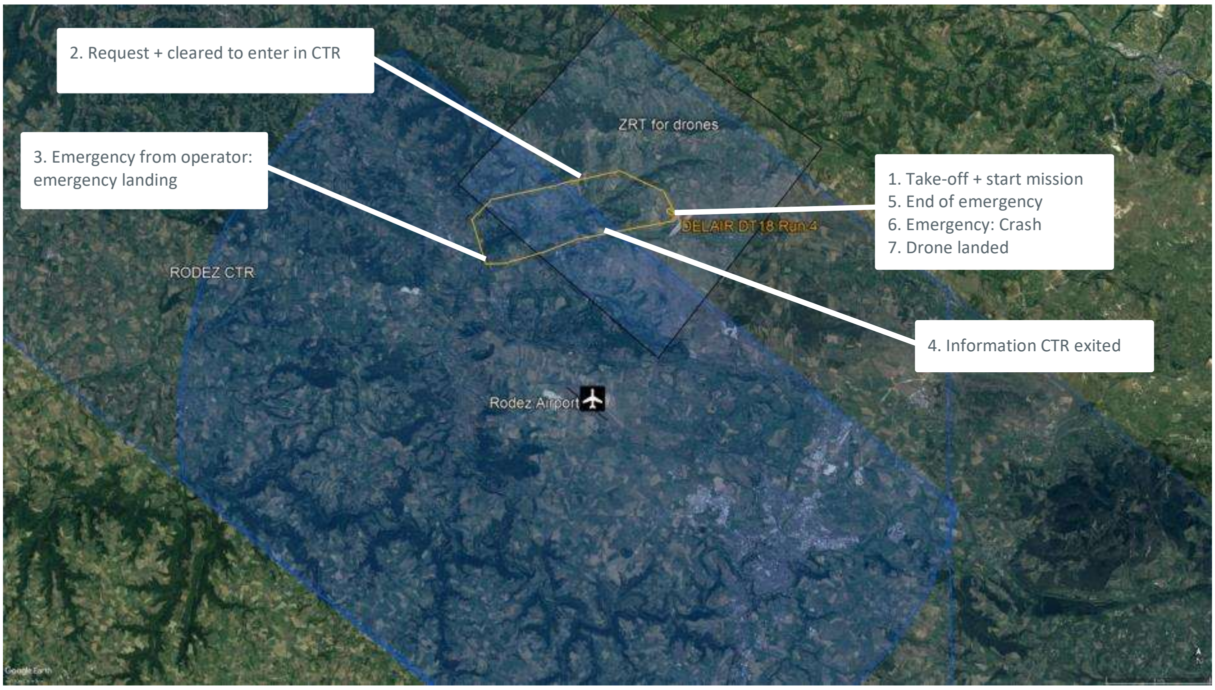

Figure 26: Tracking data of scenario 5 and exchanges between controller and pilot (Rodez demonstration)

A.3.4 Confidence in Results of exercises

The results obtained during the 2 days of demonstrations plus the visitor day are convincing for different actors (air traffic controllers and drone operator). Following sub-chapters explains limitations, quality and significance of results.

1. Limitations of Exercise Results

The main operational limitation relates of the nature of the exercise during a limited period (only 2 days plus dry-run) in PODIUM project. Number of flight (5) was limited and each flight was conducted one at a time (no simultaneous flights) with 1 pilot/operator (DELAIR) using one type of drones (fixed wind) in BVLOS scenario in a given low density CTR (Rodez). In addition, due to current protocol followed by DSNA, the air traffic controller in charge of PODIUM demonstration was not the same than the controller in charge of CTR. Each decision was coordinated as control working positions were very close to each other.

Therefore, it might be difficult to extrapolate the obtained results to other operational environments.

From the technical perspectives, the plots of manned aircrafts provided by radars (Thanks to the data flow provided by DSNA through a secure connection) were displayed in the collaborative interface. However, the refresh period (1 min) was too long to be useful for the control

2. Quality of Exercise Results

The results stress that the system permitted to assure a drone mission safely in and out a CTR under French regulation. The controller could interact directly with no major latency with the drone operator and there was no loss of messages, no loss of connectivity nor interface crash.

The realism of the demo (flight trial within a CLASS D CTR), the participation of operational experts (controllers, pilots/operators) to the demo and technical features provided contribute to obtain significant results, which are considered of quite a high quality.

3. Significance of Exercise Results

As stated above, although the realism of environment and of the technical system was high, the quantitative results from all exercises 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.

A.3.5 Conclusions

At the end of the exercise, feedbacks of air traffic controllers and drone pilots were positive and confident for the next steps.

1. Conclusions on concept clarification

Implementation of some U-space services provides benefits to drone operations. Thanks to the demonstration, following concepts were shown:

- Pre-flight:
    - The system is useful. It allowed to have the authorization to flight and provide all information about the mission

  - The system needs some improvements : new functionalities and correction to be fully operational

- Flight execution:
  - The air traffic controller can interact with drone operators thanks to the collaborative interface that permits to avoid the use of the radio
  - Pilots can interact with the air traffic controller thanks to the collaborative interface, currently not integrated in the pilots' software but it reduces the workload of communications and leaves free the radio frequency.
  - Independent tracker allowed redundancy and greatly facilitate the controller's work.
  - The ATC interface is easy to handle. The keyboard shortcuts are useful to act quickly and efficiently. It allows seeing clearly where the drones are and their mission plans. For more safety, the drone is automatically displayed if it goes-out of its mission plan. Currently the panel of messages that the ATC can send to the drone operators is limited but it permits to handle enough scenarios for the Rodez' exercise.

2. Conclusions on technical feasibility and architecture

Even if the overall system used during the demonstration has rather convinced, some points needs to be consolidated for pre-flight and flight execution:

- A drone operator interface should be developed, in common or not with the different operators to be integrated in piloting software. The common point between these different interfaces is the messages format which must be standardized. The ATC HMI must use the same standardized messages.
- The communication between the controller interface and the operator interface use currently the dedicated 4G orange networks. It is efficient but in case of uncovered areas (e.g. mountains) or network problem, it is impossible to the drone operator to communicate with the ATC. In that case, a backup communication means must be present.

A tracker using a non GSM technology seems to be very interesting because it completes the loss of 4G connectivity of a 4G tracker. Reciprocally, the 4G tracker permits to counterbalance the loss of connectivity of the non GSM tracker. The probability that the two trackers at the same time can't transmit their position is very low because they use different technologies. Thus the combination of the two trackers improves safety.

- Thanks to URTAS, the ATC can merge automatically the two labels in one (as the plots) and so have only one label if there are two trackers on the same drone. There is no visible latency using the algorithm but the result can change with more drones
- Some improvements of PODIUM system and collaborative interface have been reported:
  - System: Automatic transmission of mission plan between flight preparation and execution system
  - Alarm system in case of drone is out of mission plan

- New emergency cases: go to stack and standby in position (stack here)
- Distinguish emergency landing case function to source (controller or operator)

3. Conclusions on performance assessments

If the number of drone operations continues to increase as it is planned in many studies, the performance of the system needs to be in agreement with the forecasts. For the moment, the main points that can be noted are:

- Human performance:
  - Even if there were two air traffic controllers for the Rodez demonstration (one for airplanes and one for drones), the workload needed is compatible with the workload of one controller. The two controllers were just needed due to current regulations.
  - The UTM system was smooth and air traffic controllers integrated it easily in their habits.
- Safety:
  - The global feeling about the exercise and the linked results is that the system allows an improvement of the actual situation in terms of safety and security. The only default of the communication between the ATC and the controller depends on the 4G connectivity. Once the communication is established, there is no delay to send the messages and no transmission errors. Moreover, it has been considered much easier to the ATC to handle drones with the interface than with the radio because it is more dedicated to the airplane traffic and not to the drone traffic.
  - During the exercise, no problems of safety were noticed
  - During the exercise, there was no noticed delay in the systems compromising the safety.
- Security:
  - In term of security, the use of a dedicated 4G networks offered by Orange allows to reduce the possible security breaches. Moreover, even if it was not used during the demonstration, the communication between the drone operators and the U-space system can be cyphered.
  - During the exercise, no problems of security were noticed.

A.3.6 Recommendations and requirements

- Need to warn the supervisor (e.g. send email) for new mission and for any change
- Need for a procedure to use,
- Tracker easy to install in drone
- Improve usability of the flight preparation mission system
- Need for clear regulation and procedure to handle numerous drones while managing manned traffic to increase acceptability on controller side (spacing/safety)

- Use of independent tracker for increasing safety and reliability: GSM trackers are not sufficient in ATC controlled area.
- Need to define areas for stacking or emergency landing, known by controller and drone operator, in or closed to controlled areas. In case of abnormal situation (failure, conflict…), drone can be redirected to this type of area. These areas shall be defined by authorities.
- Operational procedures as for entering/exiting restricted area (CTR, airport) or in case of contingency (loss of tracker) have also to be defined
- Need to be tested in more dense and complex airspace with more various and new scenarios (e.g. land in another area that the take-off one).
- The ATC in charge of the control should be the one who use the system
- The number of drones in the control area should be greater than 1
- It would be great to the ATCOs to have the mission plan corridors altitude because currently the only altitude displayed is the drone's altitude (in the label)

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)

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