Presentation workshop TindAIR Project

November 10th 2021

SESAR JOINT UNDERTAKING

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EUROPEAN UNION EUROCONTROL

Welcome to TindAIR first workshop

Discover the project and the future demonstrations

Help us to meet the needs of your sector

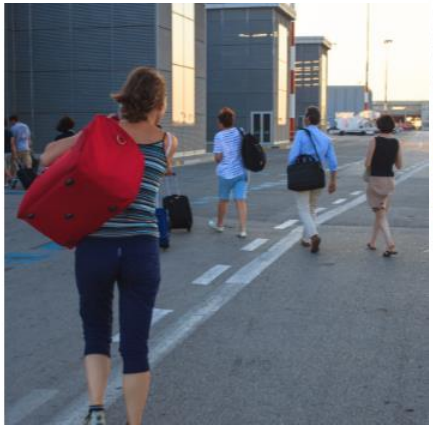
Meet with other urban air mobility stakeholders

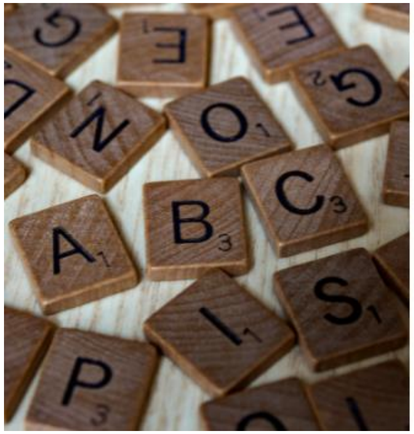
Participation modalities

- Participation through the chat via the question mark button.

?

- Naming of the panellist to ask a question : @Sophie, @Vittorio etc.
- Questions will be answered directly in the chat and at the end of each session.
- The presentation will be available after the workshop.





On the way toward…. Urban Air Mobility

Agenda

1. Introduction
2. The deconfliction service
3. Technical solution description
4. The demonstrations
5. Next steps

1. Introduction

- Project Overview
- U-space Concept & services

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1. Introduction

Project Overview

Sophie Althabegoity – Project Coordinator – Innov'ATM

November 10th 2021

Introduction

- Overview
- Innovative features of the project
- Consortium presentation
- Work packages presentation
- U-space concept & service

Overview

TINDAIR: Tactical INstrumental Deconfliction And in flight Resolution

- A SESAR Very Large-scale Demonstration Project
- Consortium of 11 European partners
- 2 years – 2021/2022
- 4 M€ ➔ H2020, grant n°101017677
- 4 demonstrations: safe integration of UAM
- 2 cities : Bordeaux and Toulouse
- Future real uses cases
- Expected demonstrations: 2022

Innovative features of the project

Provide U-space 3 level service

Deconfliction service:
- Pre-flight detection
- Tactical Conflict Resolution
- Emergency management

Use of AI to Detect And Avoid (DAA) conflict

Use of an eVTOL for 2 exercices

Consortium presentation : A European Team

Innovative companies

Research institutes

A Competitiveness Cluster

Workpackages presentation

Work Package 1
Coordination, Project Management, Governance

Work Package 2
Communication, dissemination and Collaboration

Work Package 3
ConOps, Uses Cases and Requirements definition

Work Package 4
Solution Safety and Security Assessment

Work Package 5
Human Factors and Social Acceptance Assessment

Work Package 6
U-space concept design, architecture, integration and V&V activities

Work Package 7
Execution and UAM demonstrations

Work Package 8
Analysis of the results and recommendations

1. Introduction
U-space concept & services

Robert Palumbo – Research engineer– CIRA

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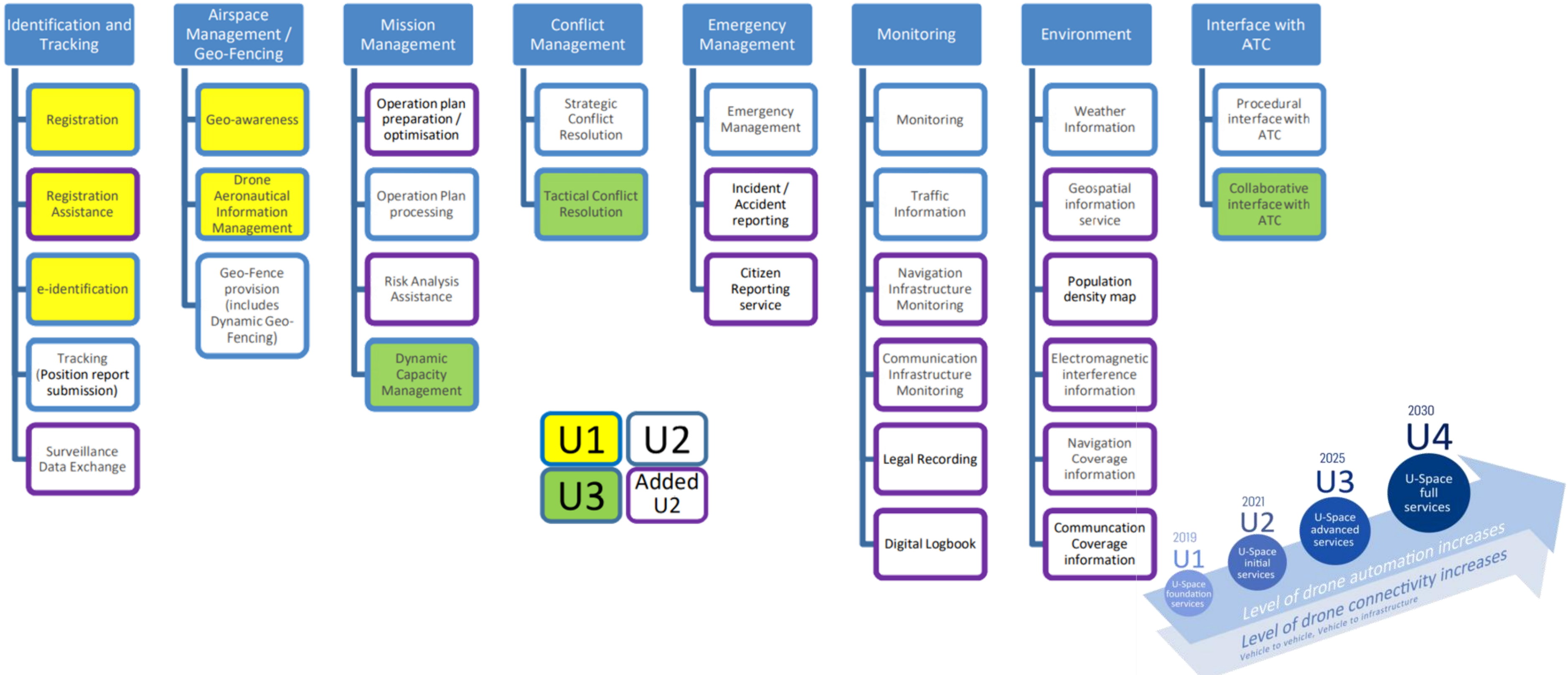
U-space concept & services

CORUS

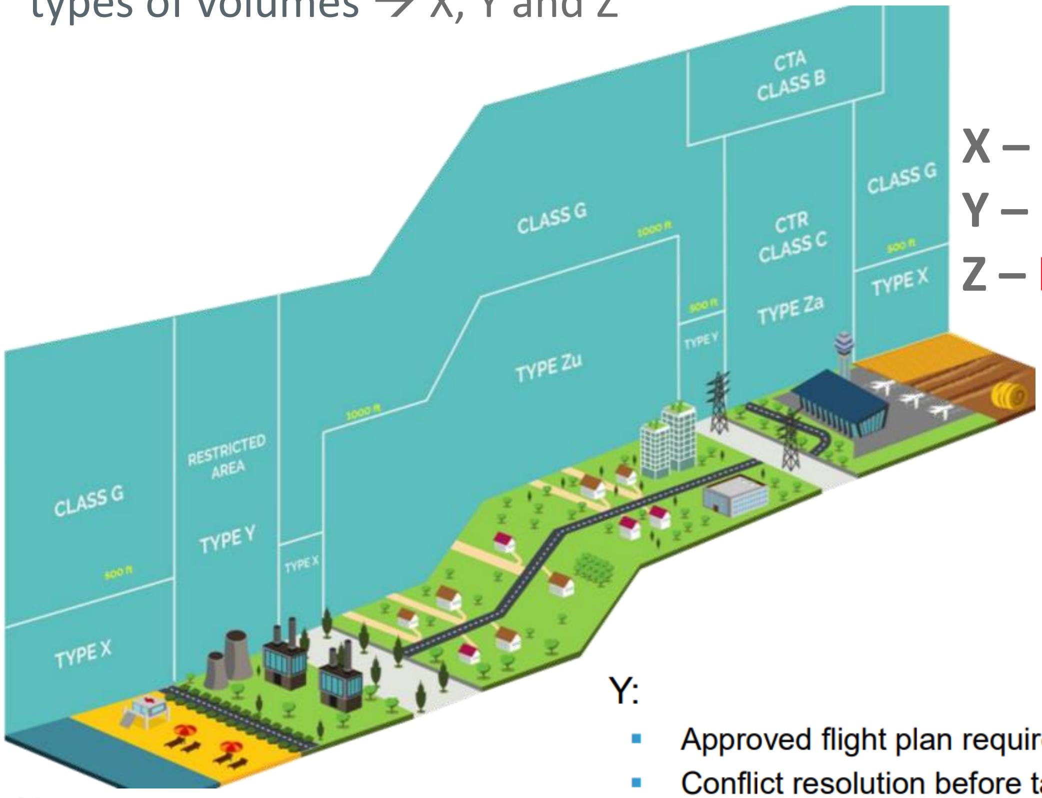
- SESAR2020 Exploratory Research project from 2017 to 2019
- developed a comprehensive Concept of Operations for U-space

U-space is concerned with Very-Low-Level Operations and envisages the (phased) introduction of services and procedures in support of safe drone operations.



U-space concept & services

U-space divides the whole of VLL airspace into three different types of volumes → X, Y and Z



X – Low risk
Y – Higher risk
Z – Highest Risk

level of complexity
number of access requirements
number of U-Space services provided

X:

- No conflict resolution service
- Enables VLOS
- Pilot remains responsible to remain well clear

Y:

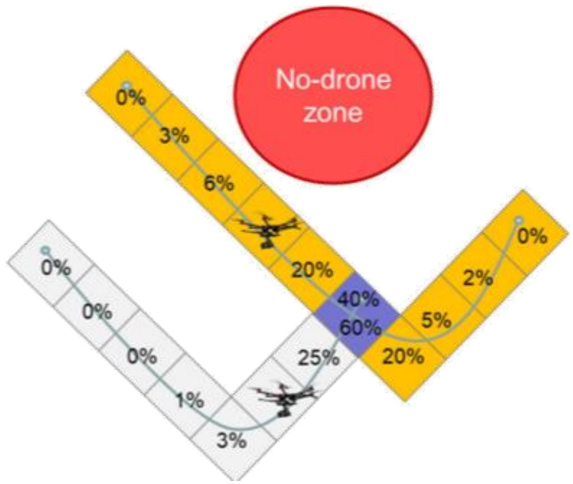
- Approved flight plan required
- Conflict resolution before take off
- Usually:
  - Position reporting required
  - Information given to pilot during flight
    - Conformance & Geo-awareness
    - Warnings & Traffic information

Z:

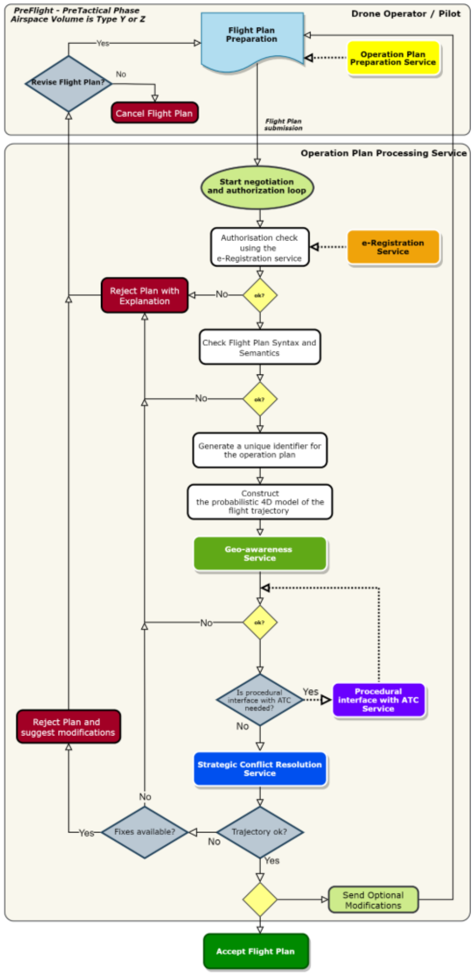
- Conflict resolution before flight **and** in flight
- Requires tracking
  - Separation minima in function of system performance
- Za
  - ATC controlled airspace, e.g. airport
  - U-space provides
    - Situational awareness to ATC
    - Communication tools
    - Standard ways of working
- Zu
  - U-space (software) provides conflict resolution during flight, from the ground

U-space concept & services – Strategic Conflict Resolution

- **Mandatory in Y and Z** types of airspace volumes
- Triggered within the ***Operation Plan Processing Service***. Applicable to pre-flight pre-tactical phase

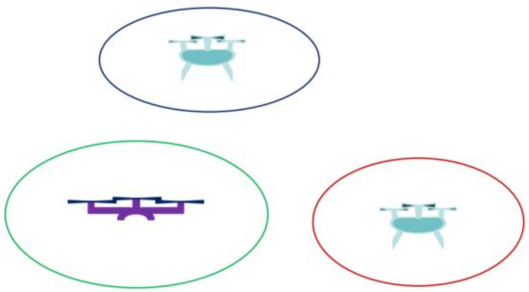


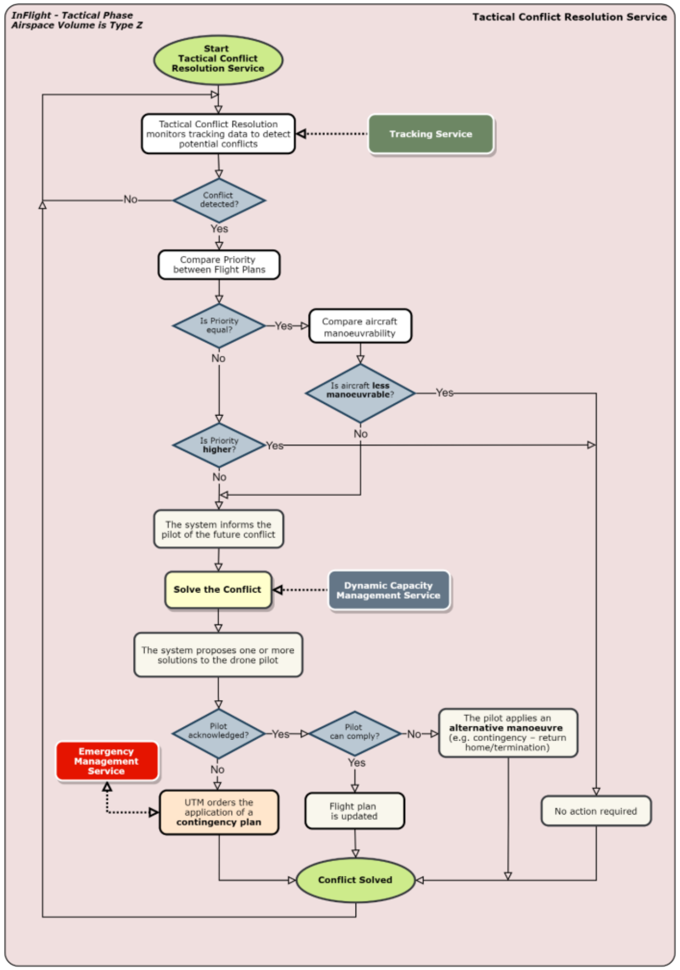
- Linked U-space services:
  - the ***Geo-awareness Service***, to check for geo-fences and other environment constraints (weather, terrain or other restrictions)
  - **the *Dynamic Capacity Management Service***, if the airspace density is an issue
  - the ***Procedural Interface with ATC*** if the flight has a significant probability to interfere with ATS airspaces



U-space concept & services – Tactical Conflict Resolution

- **Mandatory in Z** type of airspace volumes
- This service consumes the tracks generated within the ***Tracking Service*** and allows to detect potential conflicts





- <u>Linked U-space services</u>:
  - the ***Dynamic Capacity Management Service***, if the airspace density is an issue while solving the conflict
  - the ***Emergency Management Service*** if the flight is in off-nominal conditions and a contingency plan is applied

2. The deconfliction service

Valentin Courchelle– R&D Engineer – Innov'ATM

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2. The deconfliction service

Conflict concept

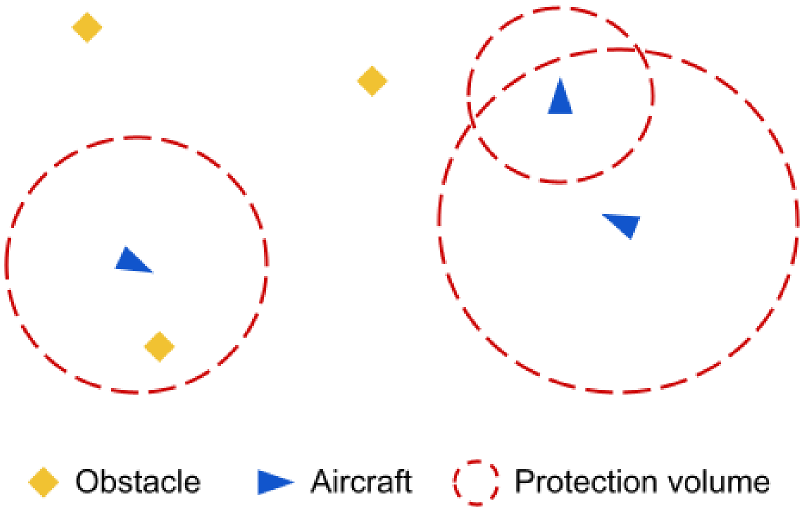
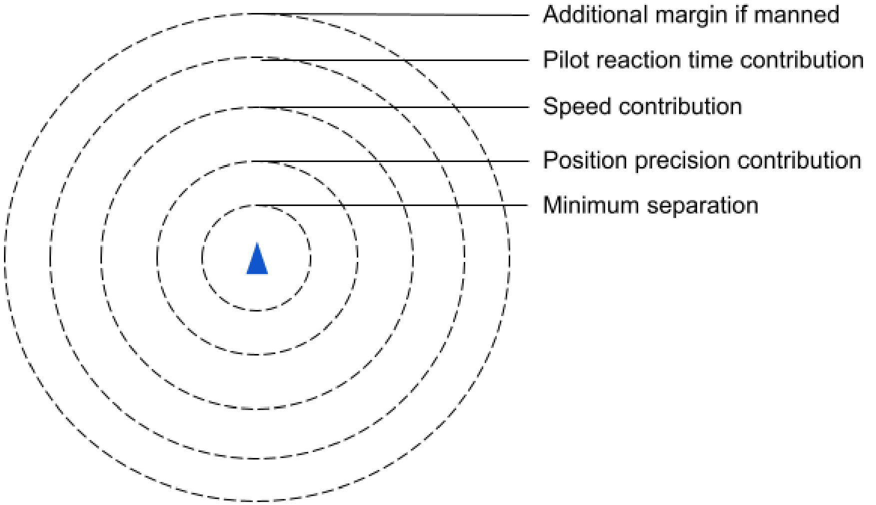


Illustration of conflicts



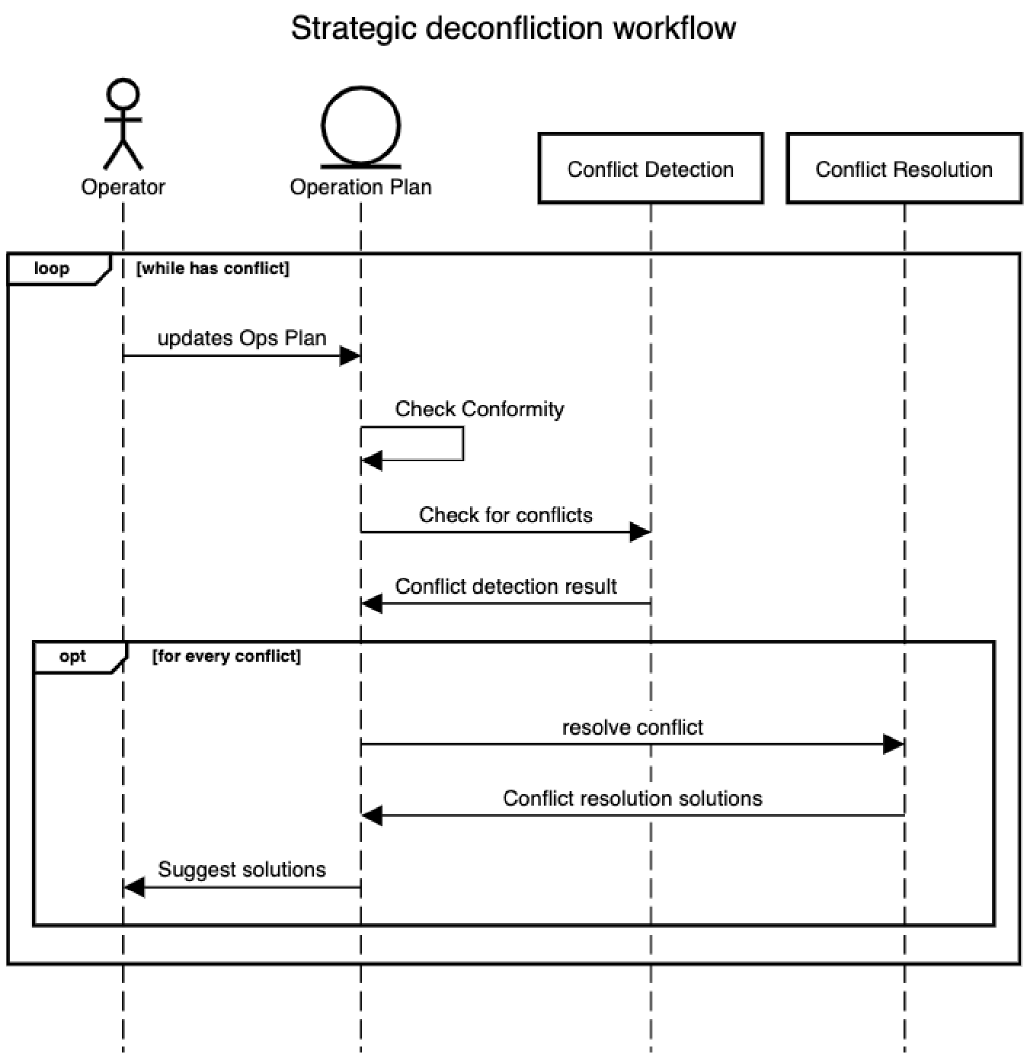
Description of protection volume components

Strategic deconfliction process

Overview

- **Trigger:** At flight plan edition (update / creation)
- **Objective:** Insert the edited flight plan into the existing planned traffic without conflict by minimizing the deviation from the original flight plan
- **Inputs:**
  _ Planned traffic
  _ Edited flight plan
- **Constraints:**
  _ Geo-awareness
  _ Geospatial information (obstacles, ground elevation …)
  _ Existing planned traffic is unchangeable
- **Means:**
  _ Flight modification (delay, speed, route, altitude)
  _ Optimization algorithm (TBD)

Strategic deconfliction process

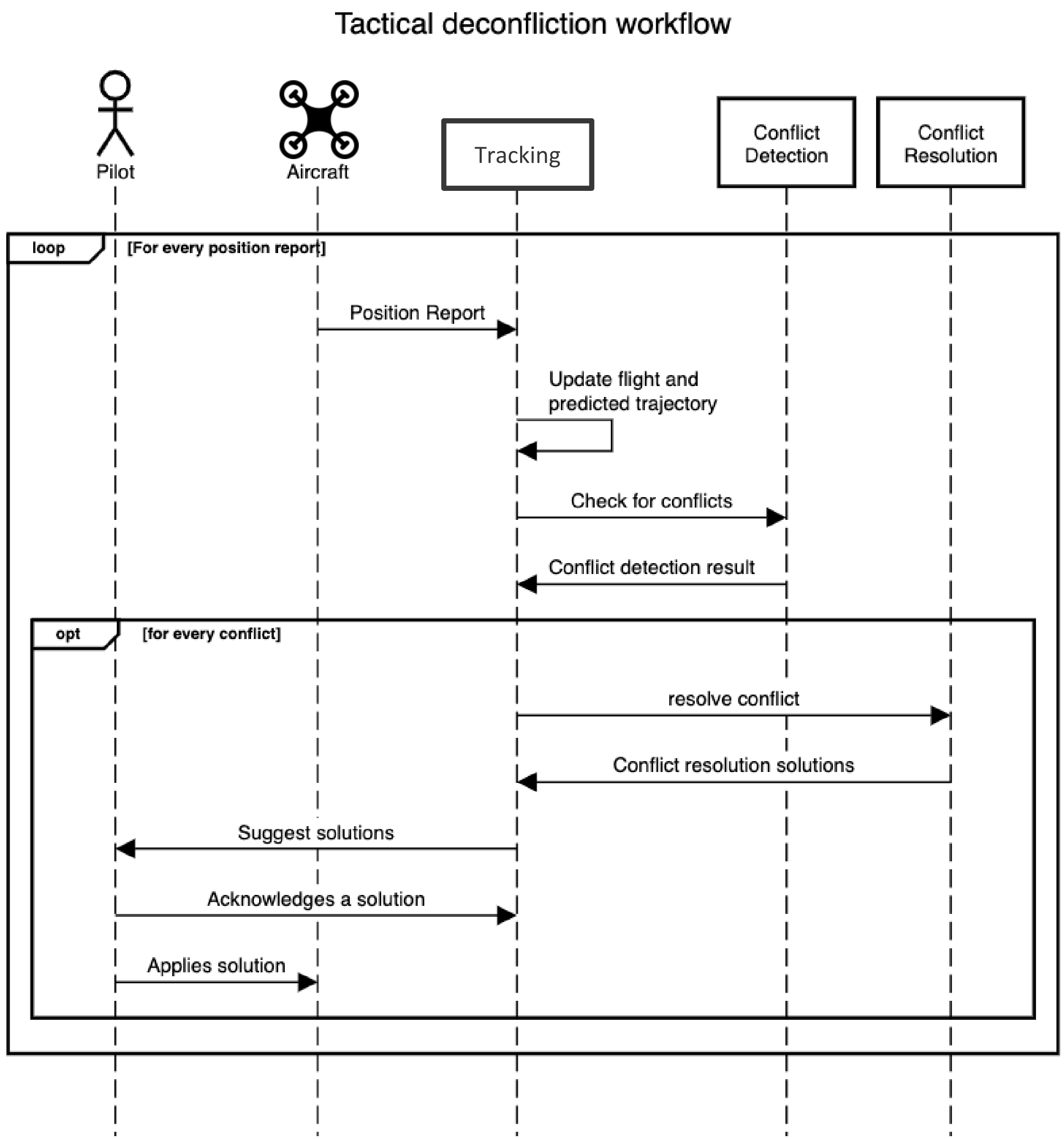


Tactical deconfliction process

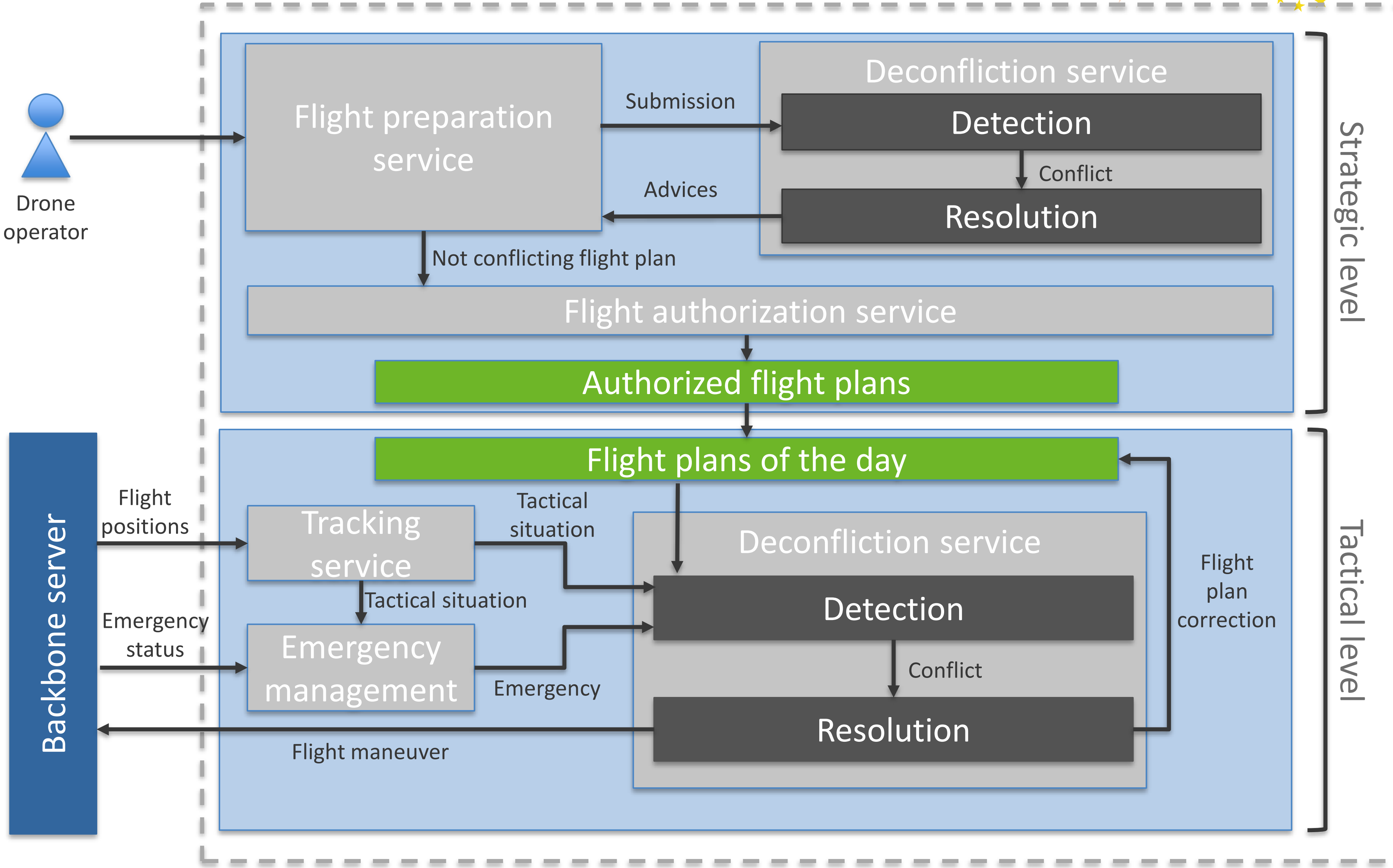
Overview

- **Trigger:** Regular (about 1 Hz)
- **Objective:** Anticipate short-term conflicts and act to prevent them from occurring by minimizing the deviation from the original flight plan (delay, energy consumption, …)
- **Inputs:**
  _ Real time air situation
  _ Flight plans of the day
- **Constraints:**
  _ Geo-awareness
  _ Geospatial information (obstacles, ground elevation …)
  _ Flight priorities
  _ Short computation time
- **Means:**
  _ Flight modification (holding, speed, route, altitude)
  _ Optimization algorithm (TBD)

Tactical deconfliction process



Software architecture



TindAIR

3. Technical solution description

Josep Montolio – Aeronautical Engineer – PildoLabs
Xavier Esneu – Systems Engineer – Collins Aerospace

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Purpose and objectives

The main objective of TINDAiR system is to provide the required **infrastructure** and **capabilities** to conduct **strategic and tactical conflict resolution** in the UAM environment, while providing **new reliable means of communication**.

Infrastructure and capabilities to enable U-Space services

- Network identification
- Geo-awareness & geo-fence
- Dynamic capacity management
- Strategic & tactical conflict resolution
- Emergency management
- Traffic information

Infrastructure and capabilities to detect and solve possible conflicts

- Provide alerts timely
- Send instructions to vehicles

Secure certifiable command and control (C2) datalink

Usable by multiple vehicles (manned and unmanned) flying in the same airspace

Use cases and aircrafts

TINDAIR system is intended to be used for the following use cases:

- Detection of strategic conflicts between operations.
- Management of multiple aircraft in the same airspace, flying the same/different routes.
- Detection of tactical conflicts between aircrafts. Assessment and communication of deconfliction actions between aircrafts in conflict situation.

TINDAIR system is intended to be used by multiple aircrafts:

- Different manned and unmanned aircraft (rotorcraft, multicopter, fixed wing, E-VTOL)
- Different restrictions on payload volume, weight, power supply availability to consider.

Requirements definition

TINDAIR system requirements have been defined:

System purpose and objectives

System use cases and aircrafts

Regulation and assumptions

VERY LARGE SCALE DEMONSTRATION

System Design Document

Deliverable ID:	D6.1
Dissemination Level:	CO
Project Acronym:	TINDAiR
Grant:	101017677
Call:	H2020-SESAR-2020-1
Topic:	U-space capabilities and services to enable Urban Air Mobility
Consortium Coordinator:	INNOV'ATM
Edition Date:	03 June 2021
Edition:	00.03.00
Template Edition:	02.00.02

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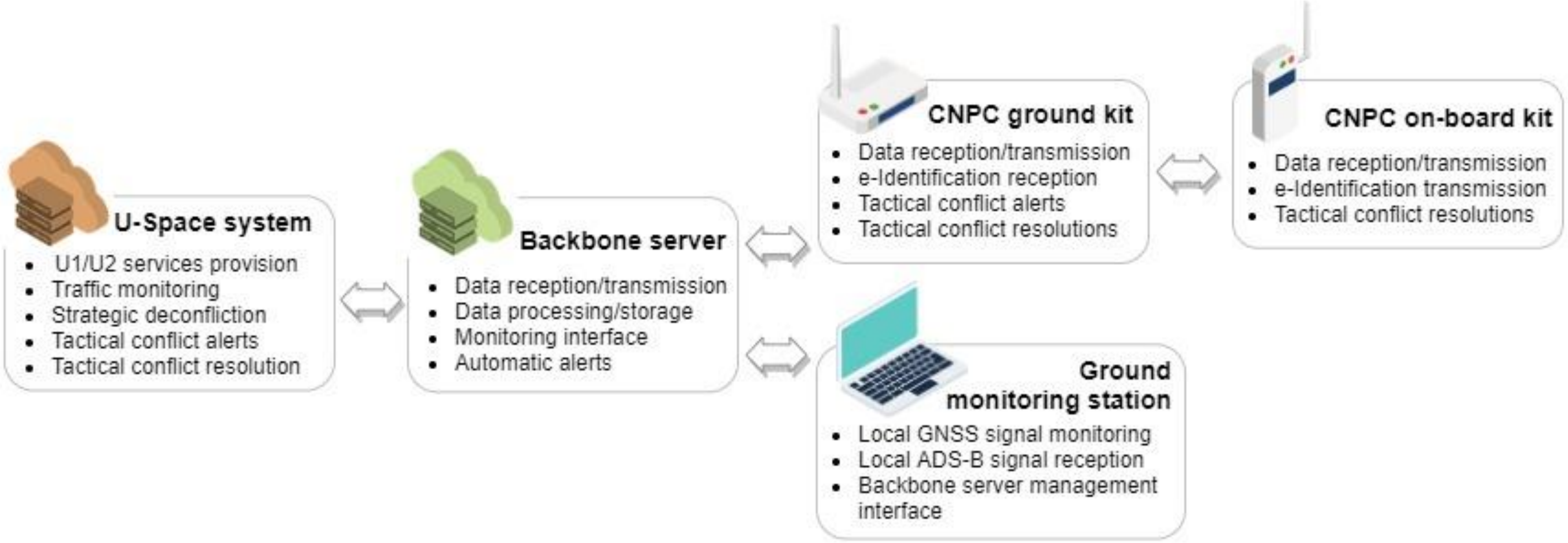
Technical Requirements

Functional Requirements

Proposed architecture

Based on the technical and functional requirements identified, it is proposed the following TINDAIR system architecture which is based on the deployment of five different blocks.

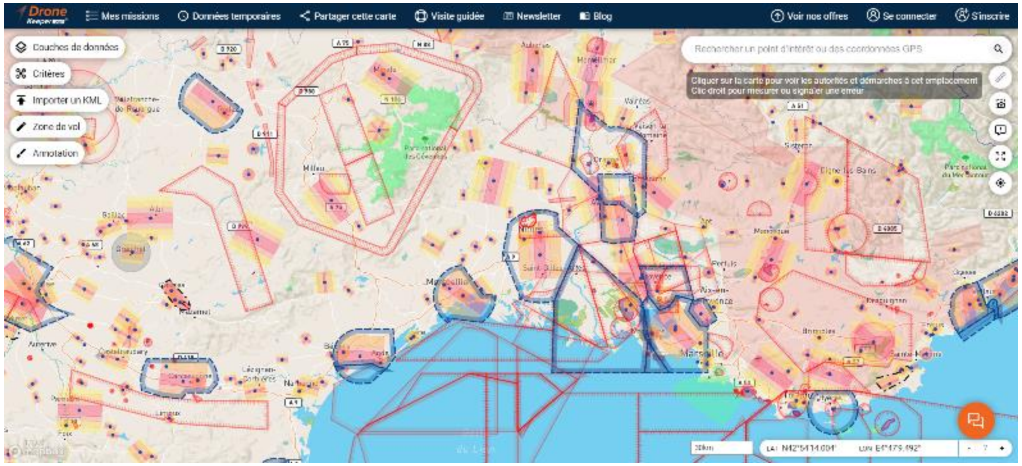


U-Space System

This block consist on a U-Space system platform, providing to the operators the required infrastructure to access U-Space services.

Developed by Innov'ATM, this block will provide:

- A UTM platform (U-space Keeper) to conduct the air traffic management tasks.
- Required GUI through web server to access the different U-Space services.
- New algorithms for detection of strategic and tactical conflict alerts between traffic.
- New algorithms for resolution of conflict alerts, and transmission of instructions to the affected traffic.

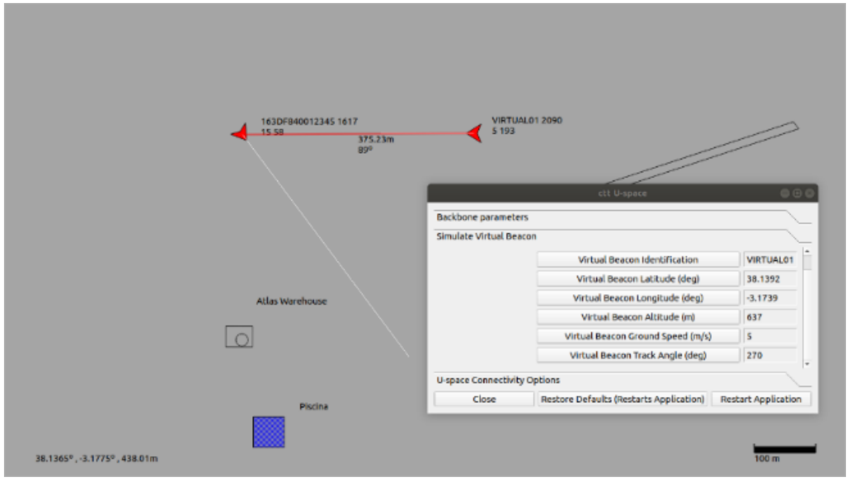


Backbone server

This block aims to centralize the information distribution between the U-Space system and the other building blocks, simplifying the data transmission and allowing an easier integration.

Developed by PildoLabs, this block will provides:

- Data reception/transmission through different comms. protocols.
- Data processing features to adapt the information's structure/format at client level.
- Local data storage for post-processing and assessment.
- Features for simulating data transmission.
- GUI for user awareness.



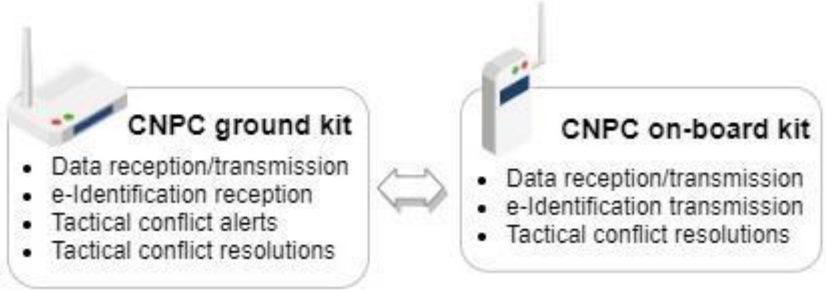
CNPC Ground/On-board Kits I/II

These two blocks consist on the required equipment to establish a radio communication channel from ground with the UA with the following objectives:

- To receive on-board tactical deconfliction instructions sent by U-Space system; and
- To transmit UA's information to the ground to feed U-Space system for tactical deconfliction detection.

The CNPC ground/on-board kit will be developed by PildoLabs and Collins, based on the following systems that are already operational:

- **CNPC-5000E**: Prototype radio implementation of DO362 standard developed by Collins.
- **Radio Navigation Unit (RNU)**: A dedicated portable system developed by Pildolabs gathering multiple navigation and processing equipment for data collection/assessment on-board any UAs.



CNPC Ground/On-board Kits II/II

Weight	≈ 2kg
Volume	25 x 16 x 7.5 cm
Power input	15 - 30VDC
Consumption	42W (nom), 62W (max)

CNPC antenna connector	SMA F
GNSS antenna connector	SMA F
Power connector	LEMO EGG.0B.302.CLL
Ethernet data connector	LEMO EGG.0B.304.CLL
USB data connector	LEMO EGG.0B.304.CLL
Video/audio connector	HDMI F

Ground Monitoring Station

This block is formed by a ground monitoring station, a system equipped with GNSS and ADS-B receivers, which intends to be deployed in the area of interest to:

- collect local data;
- assess the GNSS signal performances; and
- detect ADS-B collaborative nearby traffic.

This information will be used as input for traffic detection and tactical deconfliction services.

The ground monitoring station, developed by PildoLabs, is based on the PildoBox Premium, a monitoring device used as an access point for a set of GNSS and/or ADS-B PildoLabs' data related services.

Control and Non-Payload Communication (CNPC)

Reliable Line of Sight Safety link for exchanging Command and Control Information with unmanned platform

- Defined by RTCA DO362A standard and TSO C-213
- Allows integration of UAV in non-segregated airspace
- Optimized for non payload communication:
  - Very narrow bandwidth (205kHz max) for optimal spectrum utilization and link robustness
  - 50ms Time Division Duplexing between uplink and downlink allowing low latency communication
  - Optimized for ATC voice, DAA and weather data

- Designed to cope for strong interference from other UAs/Ground stations
- Operate in 5030-5091 MHz band allocated for UAS C2 Safety Services

Collins CNPC5000 is a prototype implementation of DO362A standard used as a validation platform for the MOPS

4. Demonstrations

- Use Cases
- Demonstrations objectives
- Vehicles & Timing

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4. Demonstrations

Use Cases

Vittorio Sangermano– Human Factors & Safety researcher
- Issnova

November 10th 2021

Overview

1. Use Cases Approach
2. Use Case 1
3. Use Case 2
4. Use Case 3
5. Use Case 4
6. Assumptions

Use Cases Approach

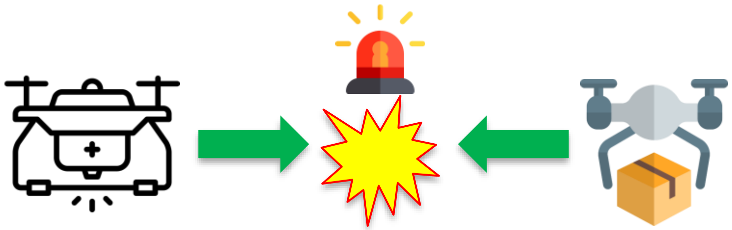
- Definition of a workflow table for each use case:

Main Use Case:
Step 1: Define two flight plans and associated trajectories: one flight to deliver medicine from airport to hospital and another one returning to the airport warehouse.
Step 2: Flight 1: no constraints, Flight 2: trajectory with conflict with Flight 1 on the way back, in the middle of the trajectory
Step 3: At strategic level, the UTM platform proposes alternative trajectory to solve conflict
Step 4: During flight execution, new guidance order is sent to Flight 2 in order to generate separation infringements with Flight 1 at one point of the not overflown part of the trajectory.

- Definition of roles and responsibilities of the actors involved in demonstration plan through a task analysis;
- Definition of different flight phases:
  - Pre-flight phase;
  - In-flight phase;
  - Post-flight phase;

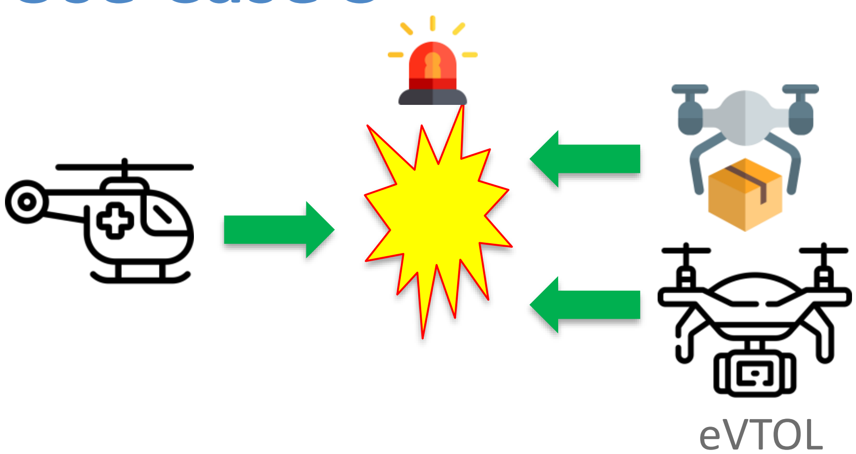
Use Cases Approach

Use Case 1

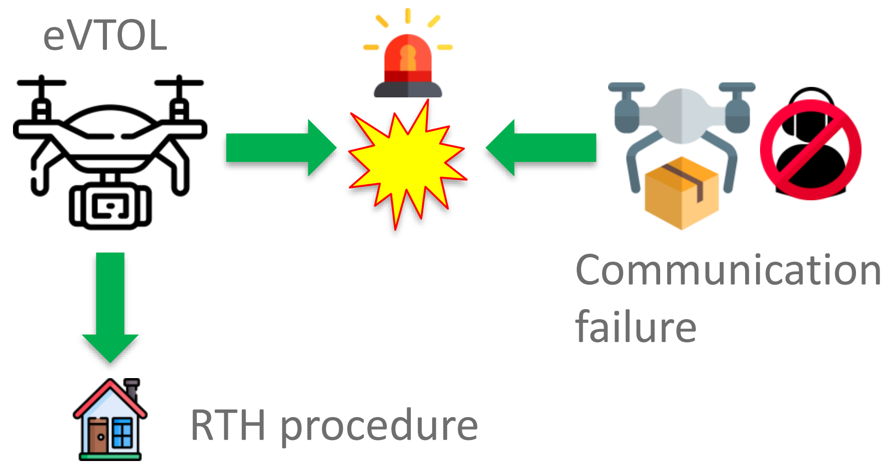


Use Case 2

Use Case 3



Use Case 4



Use Case 1

- Title: Autonomous drones flight management;
- Description and scope: Medical link between a specialized clinic and a delivery point located at 11Km. De-confliction management between two drones on similar trajectories (imposed air corridor);

Main Use Case:
Step 1: Define two flight plans and associated trajectories: one flight to deliver medicine from airport to hospital and another one returning to the airport warehouse.
Step 2: Flight 1: no constraints, Flight 2: trajectory with conflict with Flight 1 on the way back, in the middle of the trajectory
Step 3: At strategic level, the UTM platform proposes alternative trajectory to solve conflict
Step 4: During flight execution, new guidance order is sent to Flight 2 in order to generate separation infringements with Flight 1 at one point of the not overflown part of the trajectory.
Step 5: Immediately the ground command system identifies the future conflict and proposes resolution order to the drone traffic supervisor
Step 6: At the same time, the air situation display of the UTM platform shows the potential conflicts through an alert to the drone operators of the Flight 1 and Flight 2
Step 7: On resolution advice acknowledgment by the drone traffic supervisor, resolution advice is sent and displayed in the air situation of the drone operator of the concerned flight.
Step 8: Drone operator of the concerned flight acknowledges the good reception of resolution advice and modifies flight trajectory according the conflict resolution advice and sent it back to drone.
Step 9: The air situation display deletes the conflict alerts and displays the new safe trajectories.
Alternative Use Case:
Identical steps till 7 as main use case.
Step 8: The drone operator concerned by the resolution order did not acknowledge the resolution advice within the time tolerance window.
Step 9: The Ground control system raises an alert to the Drone supervisors
Step 10: Drone supervisor phones to Flight 2 drone operator to stop the mission immediately
Step 11: Drone operator of flight 2 sends an RTH order to its flight.
Step 12: Flight 1 ends its mission safely

- 2 Use Cases: Main Use Case and Alternative Use Case;
- 4 Solutions: 3 Main Use Case and 1 Alternative Use Case

Use Case 1,3,4 – Pre-flight phase

During the Pre-flight phase a set of procedures shall be accomplished in order to carry out the operation. Of course, starting from the first stage, the drone pilot/operator shall register the drone(s) on the USSP platform. The e-registration service is a basic service that enables many functions of the U-Space and it is a digital implementation of the requirements.

Phase	Drone Pilot/ Drone operator	USSP system	ANSP/USSP
1. Registration	1.1 Send Registration information	1.2 Check registration information	
2. Validate registration		2.1 Validates registration information	
3. Registration accepted	3.2 Receive registration information	3.1 Send Registration	
4. Flight Planning definition	4.1 Flight planning is originated	4.2 Flight planning is designed	
5. Flight Planning validation		5.1. Transfer flight planning to ANSP/USSP	5.2. flight planning is validated
6.Request/elaborate authorization	6.1 Requires authorization to mission	6.2 Receive and transfer the request	6.3 Receive and elaborate the request
7. Elaboration/provision of authorization	7.2 Receive the operational authorization	7.3 Receive and transfer the operational authorization	7.1 Provides operational authorization
8. Execution of pre-flight check	8.1 Pre-flight check.		

Use Case 1 – In-flight phase

The In-flight phase starts when the drone take-off.

Phase	USSP Supervisor	Drone Pilot	Other users (another drone)	USSP system
1. Take-off		1.1 Take-off and moves from airport	1.3 Starts his mission	1.2 Track drone
2. Flight phase		2.1 Report drone position	2.1 Report drone position	2.2 Acquires drone positions
3. Traffic Information	3.2 Receive traffic information	3.2 Receive traffic information	3.2. Receive traffic information	3.1 Provides traffic information
4.Flight Information elaboration	4.2 Detect Strategic/Tactical conflict			4.1 Display flight information
5. Monitoring	5.1 Detect Strategic/Tactical conflict	5.1 Monitor drone's flight and check the drone status	5.1 Monitor drone's flight and check the drone status	5.1 Monitor drone's flight
6. Warning	6.2 Receive warning	6.3 Aware of the warning	6.3 Aware of the warning	6.1 Provides warning
7. De-confliction	7.2 Receive de-confliction information and confirm the orders	7.3 Receive de-confliction information	7.3 Receive de-confliction information	7.1 Suggest and transfer de-confliction information
8. Conflict solved	8.1 Detect Strategic/Tactical conflict	8.2 Follow the flight plan	8.2 Return on the previous flight plan	8.3 Stop warning
9. Regular landing	9.2 Aware of landing	9.1 safe landing	9.1 Continues his flight plan	9.1 Track drone

Use Case 1,2,3 – Post-flight phase

The mission is terminated and the drone has accomplished his mission. The drone stops the engines and the drone operator closes the flight plan.

Phase	USSP Supervisor	Drone Pilot	USSP system
1. Close Flight Plan	1.3 Stop tracks the drone	1.1 Close flight plan	1.2 Records flight plan closes
2. Unloading		2.1 unload the payload	
3. Flight Check		3.1 Perform flight check	
4. Produce report		4.1 Produce report	4.2 support users to produce report
5. Mission report		5.2 Receive a mission report	5.1 Generates a log of the flight

Use Case 2

- Title: Autonomous drones + eVTOL flight management;
- Description and scope: Flight in a segregated area with the use of an eVTOL + drone. Mixed traffic with one merchandise delivery with transportation of one simulated person

Main Use Case:
Step1: Define two flight plans and associated trajectories: one flight (Flight 1) to deliver merchandise from airport to one warehouse from a vertiport to another one (Flight 2).
Step 2: Flight 1: no constraints, Flight 2: trajectory with conflict with Flight 1 at some point of the trajectory
Step 3: For Flight 2, UTM platform proposes alternative trajectory (2D route deviation) to solve this conflict at strategic level
Step 4: During flight execution, the Flight 2 is forced to change its 2D route in a way that generates separation infringements with Flight 1 at one point of the not overflown part of the trajectory.
Step 5: Flight 2 communicates to the drone traffic supervisor the new route.
Step 6: Ground supervisor updates the route path of the Flight 2 in the ground command centre.
Step 7: The Ground command centre recomputes the forecast trajectory of the Flight 2 and identifies the future conflict and proposes resolution order to the drone traffic supervisor
Step 8: At the same time, the air situation display of the UTM platform shows the potential conflicts through an alert to the drone operators of Flight 1 and Flight 2
Step 9: On resolution advice acknowledgment by the drone traffic supervisor, resolution order is sent to the Flight 1.
Step 10: Drone operator of the Flight 1 acknowledges the good reception of resolution advice and modifies flight trajectory according the conflict resolution advice and sent it back to drone.
Step 11: The air situation display deletes the conflict alerts and displays the new safe trajectories.
Step 12: Flight 1 add 2 end their flight/mission safely.

- 1 Main Use Case
- 3 Solutions

Use Case 2 – Pre-flight phase

Phase	eVTOL operator/pilot	USSP system	ANSP/USSP
1. Registration	1.1 Send Registration information	1.2 Check registration information	
2. Validate registration		2.1 Validates registration information	
3. Registration accepted	3.2 Receive registration information	3.1 Send Registration	
4. Flight Planning definition	4.1 Flight planning is originated	4.2 Flight planning is designed	
5. Conflict detected		5.1 Conflict with delivery drone detected	
6. Alternate route	6.2 Accept the alternate route	6.1 Stategic de-confliction service proposes an alternate route	
7. Flight Planning validation		7.1 Transfer flight planning to ANSP/USSP	7.2 flight planning is validated
8.Request/elaborate authorization	8.1 Requires authorization to mission	8.2 Receive and transfer the request	8.3 Receive and elaborate the request
9. Elaboration/provision of authorization	9.2 Receive the operational authorization	9.3 Receive and transfer the operational authorization	9.1 Provides operational authorization
10. Execution of pre-flight check	10.1 Pre-flight check.		

Use Case 2 – In-flight phase

The In-flight phase starts when the drone take-off.

Phase	USSP Supervisor	Drone Pilot	eVTOL	USSP system
1. Take-off		1.1 Take-off and moves from airport to warehouse	1.1 Starts his mission from vertiport to another vertiport	1.2 Track drones
2. Flight phase		2.1 Report drone position	2.1 Report eVTOL position	2.2 Acquires drone positions
3. Traffic Information	3.2 Receive traffic information	3.2 Receive traffic information	3.2. Receive traffic information	3.1 Provides traffic information
4.Flight Information elaboration	4.2 Detect Strategic/Tactical conflict			4.1 Display flight information
5. Monitoring	5.1 Detect Strategic/Tactical conflict	5.1 Monitor drone's flight and check the drone status	5.1 Monitor eVTOL flight and check the drone status	5.1 Monitor drone's flight
6. Warning at strategic level	6.2 Receive warning	6.3 Aware of the warning	6.3 Aware of the warning	6.1 Provides warning
7. Strategic de-conflict	7.2 Aware of the strategic de-conflict			7.1 proposes alternative trajectory (2D route deviation) to solve this conflict at strategic level
8. Maneuvering phase		8.3 Follow the flight plan	8.2 eVTOL change his route following the strategic de-confliction proposed by UTM system	8.1 Provides a new route to the eVTOL
9. New route	9.2 Receive the communication of the new eVTOL's route		9.1 Communicate to the USSP supervision the new route to be followed	
10. Route updated in the USSP system		10.2 Follow the flight plan	10.1 Update the new route in the USSP system	
11. Conflict warning	11.2 Aware of the future conflict	11.2 Aware of the future conflict	11.2 aware of the future conflict	11.1 Detect a future conflict
12. De-confliction	12.2 Receive and transfer de-confliction information	12.3 Receive de-confliction information	12.3 Receive de-confliction information	12.1 Suggest de-confliction information to USSP supervisor
13. Conflict solved	13.1 Detect Strategic/Tactical conflict	13.2 modifies flight trajectory according the conflict resolution advice and sent it back to drone	8.2 Follow the flight plan	8.3 Stop warning
14. Regular landing	14.2 Aware of landings	14.1 safe landing	14.1 safe landing	14.1 Track drones

Use Case 3

- Title: Autonomous drones + eVTOL + helicopter flight management;
- Description and scope: Flight in a segregated area with the use of a helicopter + eVTOL + drone. Mixed traffic with one merchandise delivery with transportation of one simulated person and manned medical emergency

Main Use Case:
Step1: Define 3 flight plans and associated trajectories: one flight (Flight 1) to deliver merchandise from airport to one warehouse, another one for public transportation from a vertiport to another one (Flight 2) and a third one for emergency medical transport (Flight 3).
Step 2: Flight 1 and Flight 2 are created with two crossing trajectories but separated in time in such a way they are not conflicting.
Step 3: Flight 1 and Flight 2 start their flights/mission.
Step 4: During flight execution, an emergency flight plan is created for emergency medical transport with one helicopter with conflict with the Flight 1.
Step 5: To simulate the flight plan transmission between ATM system and Ground control system, the drone traffic supervisor created a filled flight plans (pop-up flight) for the helicopter.
Step 6: The Ground control system creates the Flight 3 (AFIL flight) and computes its new trajectory.
Step 7: The Ground control system identifies the conflict between the Flight 3 and the flight 1 and proposed a resolution advice to be applied by the Flight 1 (priority given to the general aviation flight). The ground control system has considered the potential conflict between Flight 1 and Flight 2 so the resolution advice does not produce a conflict between them.
Step 8: The Drone Traffic Supervisor acknowledges the resolution advice for Flight 1
Step 9: Resolution order is sent to Flight 1
Step 10: The Drone operator of the Flight 1 acknowledges the good reception of resolution advice and modifies flight trajectory according to the conflict resolution advice and sends it back to his/her drone.
Step 11: The air situation display deletes the conflict alert and displays the new safe trajectories.
Step 12: Flight 1/2/3 end their flight/mission safely.

- 1 Main Use Case
- 2 Solutions

Use Case 3 – In-flight phase

Phase	USSP Supervisor	Drone Pilot	eVTOL	Helicopter	USSP system
1. Take-off		1.1 Take-off and moves from airport to warehouse	1.1 Starts its mission from vertiport to another vertiport	1.1 Starts its mission from vertiport	1.2 Track drones
2. Pop-up flight	2.1 Create and transfer to the USSP system a filled flight plan for the helicopter				2.2 Receive the filled flight plan for the helicopter
3. New route		3.1 Aware of the emergency flight	3.1 Aware of emergency flight		3.2 Track drones and helicopter
4. Flight phase		4.1 Report drone position	4.1 Report eVTOL position	4.1 Report helicopter position	4.2 Acquires drone positions
5. Traffic Information	5.2 Receive traffic information	5.2 Receive traffic information	5.2 Receive traffic information	5.2 Receive traffic information	5.1 Provides traffic information
6.Flight Information elaboration	6.2 Detect tactical conflict				6.1 Display flight information
7. Monitoring	7.1 Detect Strategic/Tactical conflict	7.1 Monitor drone's flight and check the drone status	7.1 Monitor eVTOL flight and check the drone status	7.1 Follow the flight plan	7.1 Monitor drone's flight
8. Warning	8.2 Receive warning	8.3 Aware of the warning	8.3 Aware of the warning	8.3 Aware of the warning	8.1 Provides warning
9. de-conflict	9.2 Receive and check if de-confliction information are suitable to the drones	9.3 Receive de-confliction information	9.3 Receive de-confliction information	9.3 Follow the flight plan	9.1 Suggest and transfer de-confliction information
10. Maneuvering phase	10.1 the information are suitable	10.2 drone update its flight plan following the de-confliction	10.2 eVTOL update its flight plan following the de-confliction	10.2 Follow the flight plan	10.1 Provides a resolution informationto the drone and eVTOL
11. Conflict solved	11.1 Detect Strategic/Tactical conflict	11.2 Return on the previous flight plan	11.2 Return on the previous flight plan	11.2 Follow the flight plan	8.3 Stop warning
12. Regular landing	12.2 Aware of landings	12.1 safe landing	12.1 safe landing	12.1 safe landing	12.1 Track drones and helicopter

Use Case 4

- Title: Emergency landing;
- Description and scope: Flight in a segregated area with the use of drones. The purpose of this use case is to assess a de-confliction action involving an emergency landing

Main Use Case:
Step1: Define two flight plans and associated trajectories: one flight for public transportation from a vertiport to another one flight (Flight 1) and another one flight to deliver merchandise from airport to one warehouse (Flight 2).
Step 2: Flight 1 and Flight 2 have well-separated trajectories.
Step 3: Flight 1 changes its planned route in a way that generates conflict with Flight 2
Step 4: on detection of route deviation of the Flight 1, the Ground control system extrapolates its new trajectory and identifies a potential conflict with Flight 2.
Step 5: The Ground control system computes a resolution advice for the Flight 2 and send it to the pilot.
Step 6: to simulate a loss of communication, the Flight 2pilot does not acknowledge the good reception of the resolution order
Step 7: After a predefined time, parameter, the ground control system raises an alert of loss of communication and an order for emergency landing is sent to the drone operator of the Flight 1.
Step 8: the drone operator of the Flight 1 sends an emergency order (RTH) to its drone.
Step 9: as soon as the conflict is detected as resolved (through computation of new trajectory of the Flight 1), the ground control system stops the alert
Step 10: The Flight 1 lands emergently and safely and the Flight 2 ends its flight safely too.
Alternative Use Case:
Step 1: only one flight including an eVTOL flying taxi.
Step 2: during flight execution, eVTOL pilot simulates an on-board emergency and asks to the ground control system the most appropriate landing site.
Step 3: The Ground control system determines the closest available vertiport and sent it back to the eVTOL pilot
Step 4: the eVTOL pilot acknowledges the good reception of the alternative vertiport and changes its route towards it.
Step 5: the eVTOL flight lands safely in the alternative vertiport.

- 2 Use Cases: Main Use Case and Alternative Use Case;
- 3 Solutions: 2 Main Use Case and 1 Alternative Use Case

Use Case 4 – In-flight phase

Phase	USSP Supervisor	Drone Pilot	Other users (another drone)	USSP system
1. Take-off		1.1 Take-off and moves from airport	1.3 Starts his mission	1.2 Track drone
2. Flight phase		2.1 Report drone position	2.1 Report drone position	2.2 Acquires drone positions
3. Traffic Information	3.2 Receive traffic information	3.2 Receive traffic information	3.2. Receive traffic information	3.1 Provides traffic information
4.Flight Information elaboration	4.2 Detect Tactical conflict			4.1 Display flight information
5. Monitoring	5.1 Detect Tactical conflict	5.1 Monitor drone's flight and check the drone status	5.1 Monitor drone's flight and check the drone status	5.1 Monitor drone's flight
6. Warning	6.2 Receive warning	6.3 Aware of the warning	6.3 Aware of the warning	6.1 Provides warning
7. De-confliction	7.2 Receive and check if the de-confliction information are suitable	7.3 Receive de-confliction information	7.3 Don't receive de-confliction information due to loss of communication	7.1 Suggest and transfer de-confliction information
8. Loss of communication	8.3 Aware of the emergency	8.3 Receive the alert of communication loss of the drone 2	8.1 Loss of communication procedure	8.2 Raises an alert of communication loss with the drone 2
9. Stop mission 1		9.2 Receive the order		9.1 Send an order to stop the mission for drone 1
10. Conflict solved		10.1 Stop his mission	10.2 Follow the flight plan	10.2 Stop Alert
11. Regular landing	11.2 Aware of landing	11.1 mission stopped	11.1 safe landing	11.1 Track drones

Use Case 4 – Post-flight phase

Phase	USSP Supervisor	Drone Pilot	USSP system
1. Close Flight Plan	1.3 Stop tracks the drone	1.1 Close flight plan	1.2 Records flight plan closes
2. Unloading		2.1 unload the payload	
3. Flight Check		3.1 Perform flight check	
4. Incident Analysis		4.1 Perform the incident analysis	4.2 Receive the incident analysis
4. Produce incident report		4.1 Produce report	4.2 support users to produce report
5. Mission report		5.2 Receive a mission report	5.1 Generates a log of the flight
6. Transport to home base		6.1 Perform the transport to home base	
7. Planning and execution of corrective measures		7.1 Perform and plan corrective measures	

Demonstration Assumptions

Identifier	Title	Description	Justification
ASM-VLD-TINDAIR-001	Use of dedicated airspaces	The demonstration will be performed in dedicated airspaces well separated from all other airspace users not participating in the project (e.g., general aviation, commercial flights, …).	During VLD, the system will only consider flights involved into the demonstration exercises. To prevent any safety risk with other air operations, the demonstration flights shall be contained in a dedicated airspace.
ASM-VLD-TINDAIR-002	Drone operator / pilot registration	The drone operators and pilots have previously made their required registration. The registration includes identity, contact information, pilot training certificate and any information useful for identification of their drones.	The network identification service requires the registration to be done in advance to ensure the Direct Remote Identification. Moreover, the registration is required for authorities too.
ASM-VLD-TINDAIR-003	Flight authorizations	Before performing demonstrations flights, the corresponding operation plans have previously been sent to involved authorities which have sent back the flight authorizations.	These authorizations may take few days to be obtained that's why the flight plan declaration must be done beforehand.
ASM-VLD-TINDAIR-004	Drone CNS equipment	All aircraft involved into demonstrations have all the Communication, Navigation and Surveillance (CNS) equipment required	The system is based on the reception and the consolidation of aircraft position to perform the tracking. Moreover, it must send orders to aircraft in case of conflict resolution. Thus, aircraft must be able to communicate their positions, to receive orders and navigate by their own.
ASM-VLD-TINDAIR-005	Deconfliction resolution	The deconfliction messages transmitted by the system will be received by the drone and its remote pilot. However, the remote pilot will be responsible of commanding the deconfliction measures manually into the drone.	For safety reasons, and in order to ease the integration of demonstration equipment on-board each drone, the CNPC on-board kit will not have any interface with the avionics or autopilot.

4. Demonstrations

Demonstrations Objectives

Valentin Courchelle– R&D engineer – Innov'ATM

November 10th 2021

Demonstration objectives

<u>Main objective:</u> develop a system to ensure safe flights inside the U-space

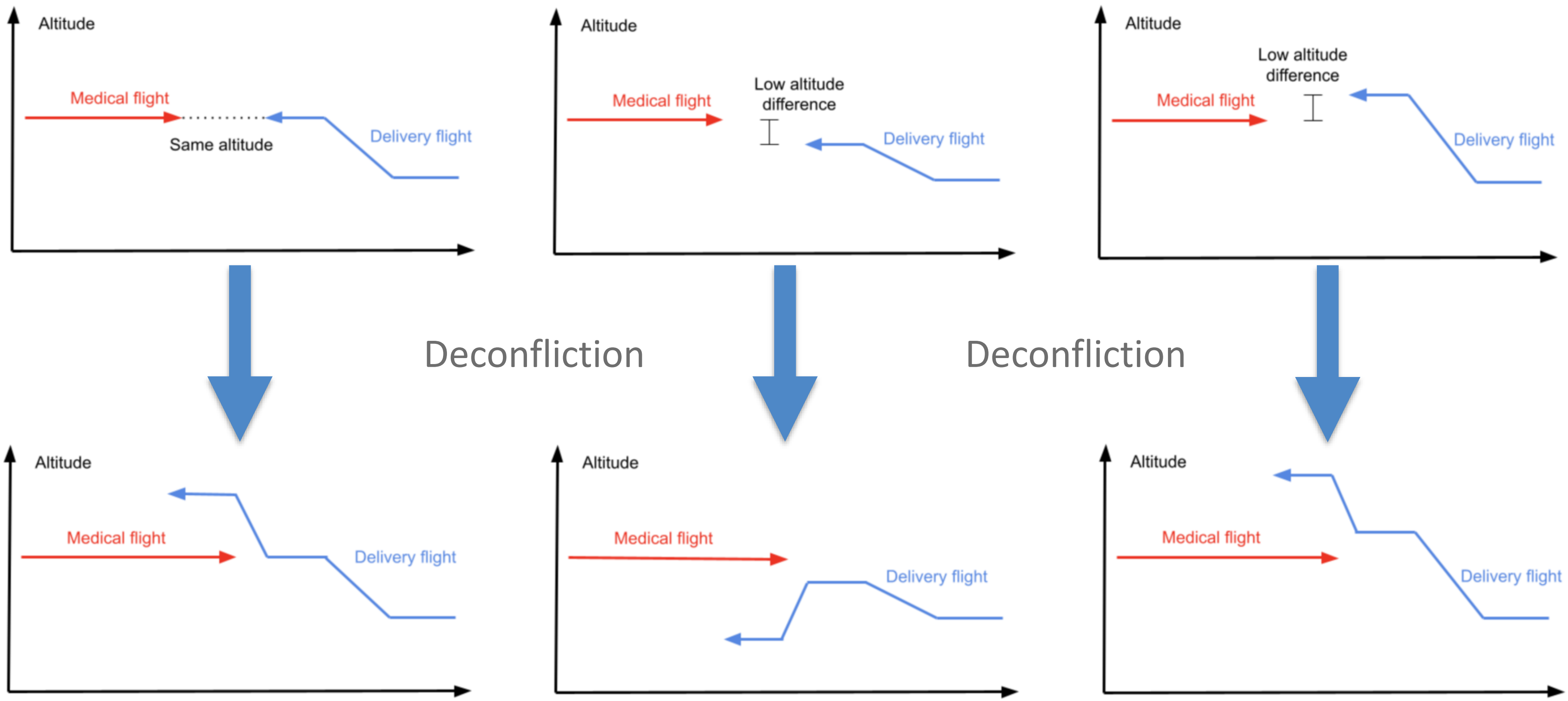
Service	Objectives
Strategic deconfliction	• Detect any conflict resulting from a flight plan edition • Resolve all conflicts through minimized flight plan modifications under constraint.
Aircraft identification	• Every operated aircraft are identified by the system • Aircraft operator/pilot’s contact is available
Geo-awareness provision	• Flight restriction areas are visible and considered by the system
Tracking	• Operated aircraft are continuously tracked as soon as they take-off until they land.
Monitoring	• Each operated flight is associated to a flight plan • Detect and alert at any flight plan deviation
Tactical deconfliction	• Detect any conflict occurring in the near future • Resolve all conflicts through minimized flight plan modifications under constraint. • Send manoeuvres to pilot and update flight plan accordingly
Traffic information	• Provide to pilots a restricted air display centred around their flight
Emergency management	• Detect loss of connection with pilots and raise alert • Receive emergency status from pilots and raise alert

Demonstration exercises

Exercise 1 scenario 1: two facing drone flights

Scenario particularity:

Demonstrate the system ability to adjust the deconfliction solution according to the conflict configuration in case of two facing trajectories

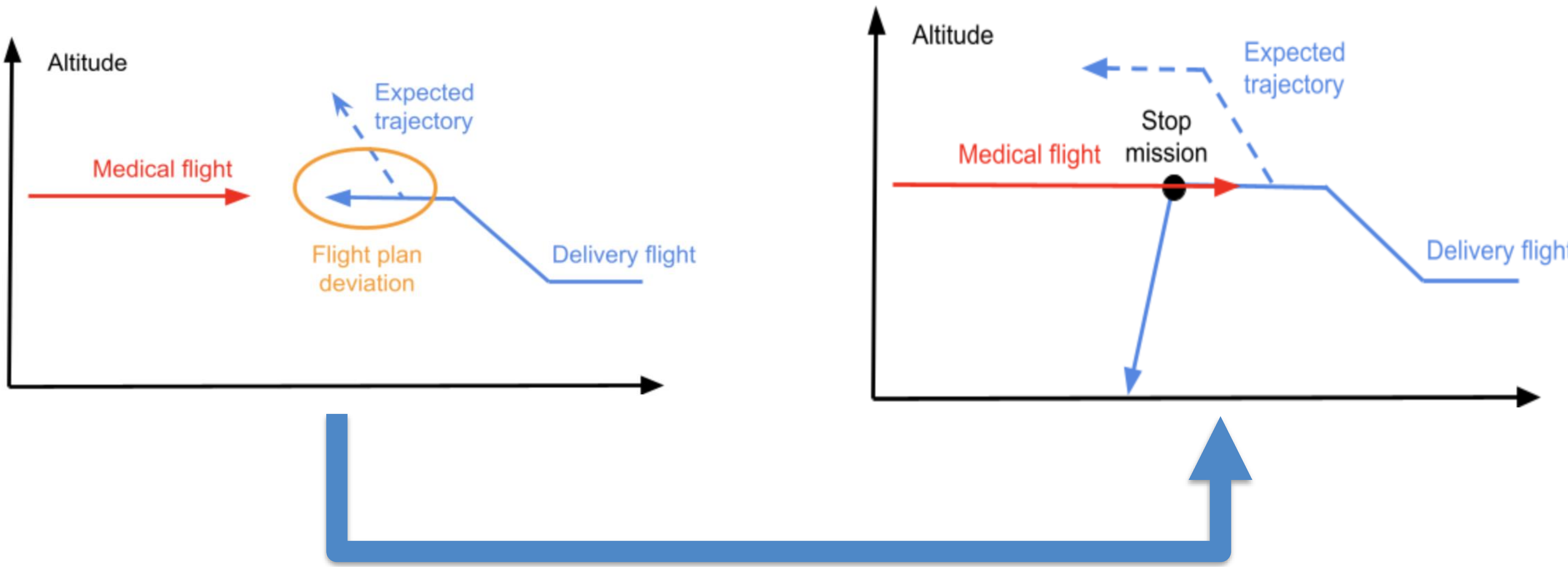


Demonstration exercises

Exercise 1 scenario 2: monitor conflict avoidance manoeuver

<u>Scenario particularity:</u>

Demonstrate the system ability to detect flight plan deviations and to raise an alert accordingly



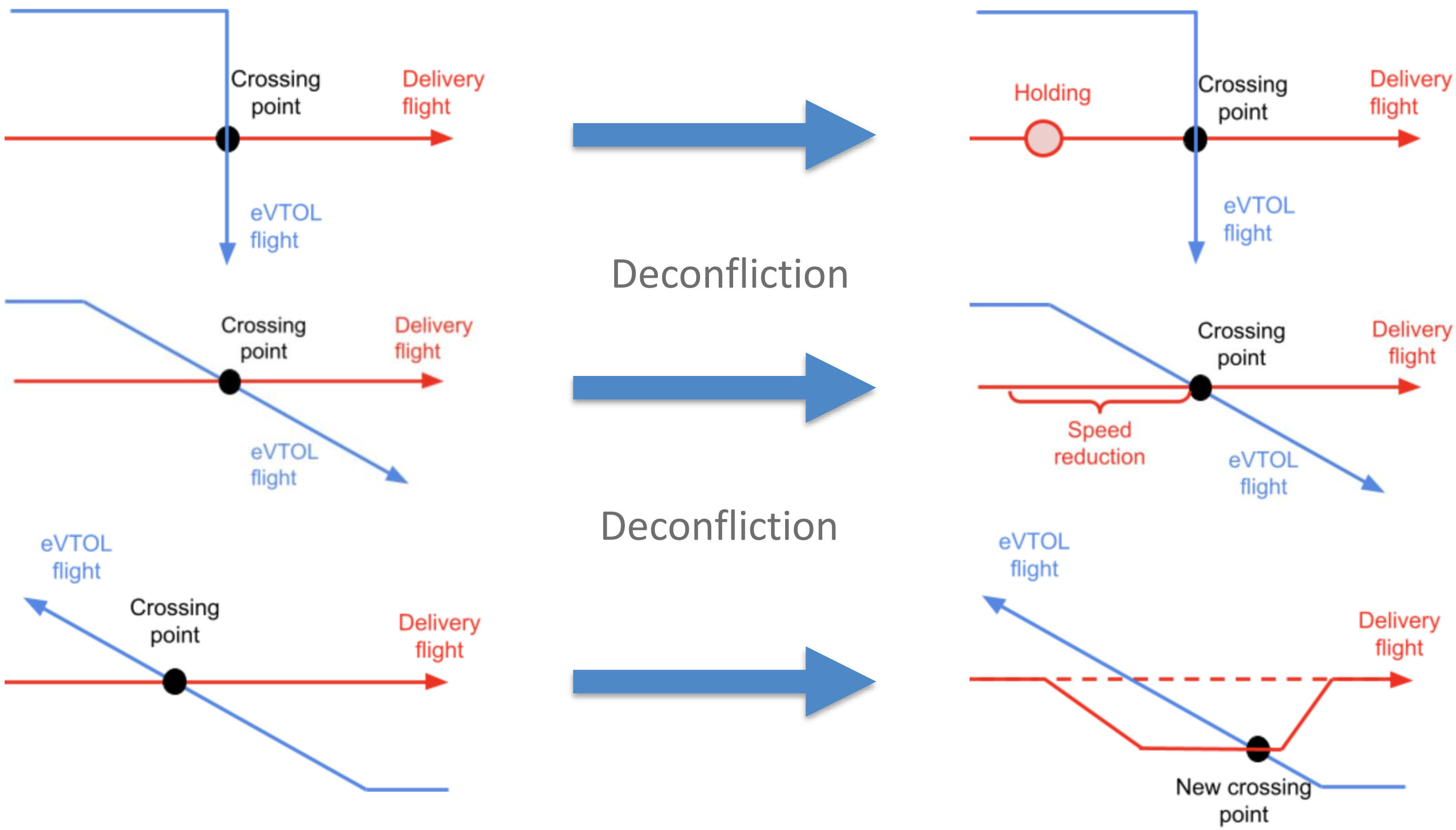
Flight plan deviation alert + USSP supervisor stop mission order

Demonstration exercises

Exercise 2: two crossing drone trajectories

Scenario particularity:

Demonstrate the system ability to adjust the deconfliction solution according to the conflict configuration in case of two crossing trajectories



Demonstration exercises

Exercise 3 scenario 1: helicopter and drone flight

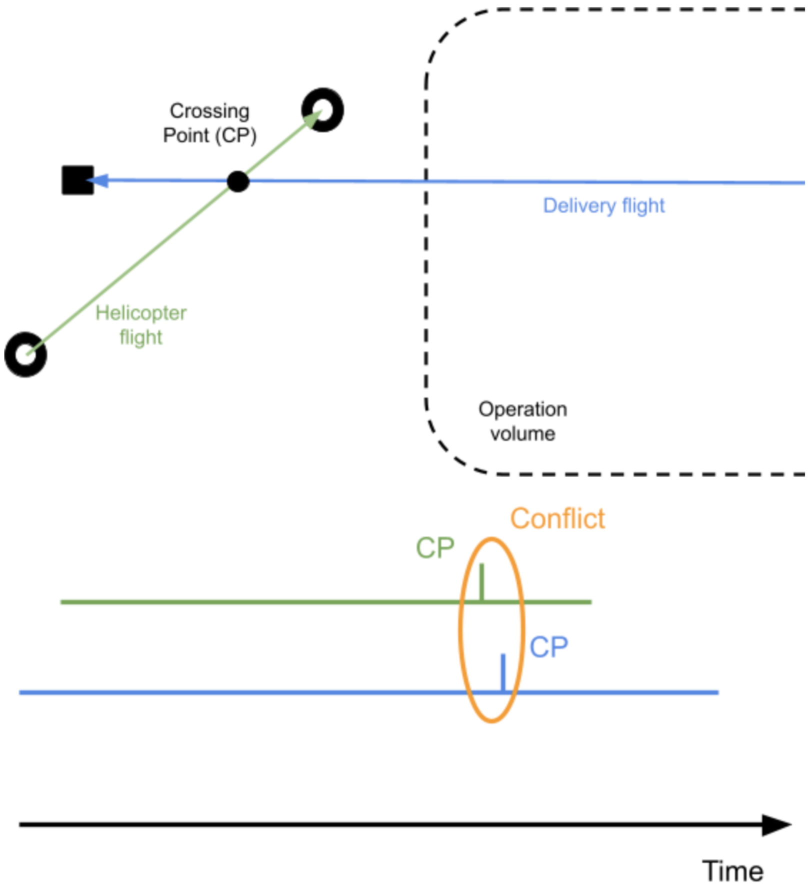
Scenario particularity:

Demonstrate the application of higher separation minima required by manned aviation

Assumption:

Delivery flight is planned to cross the helicopter trajectory but it will never exit the operation volume during demonstration

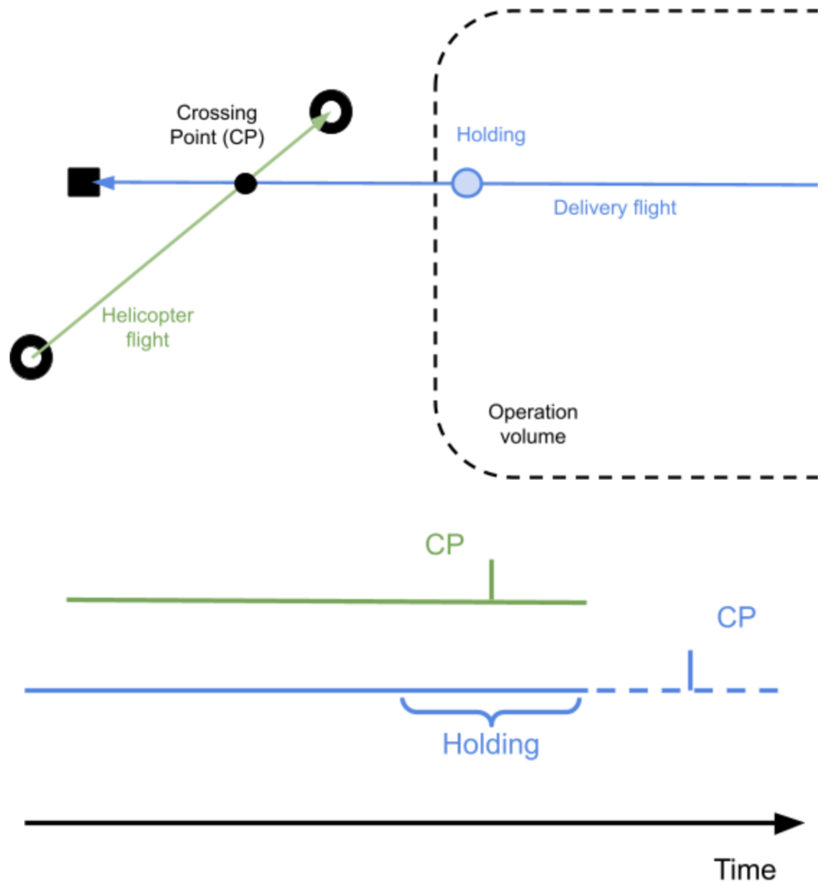
Trajectories before conflict resolution



Demonstration exercises

Exercise 3 scenario 1: helicopter and drone flight

Trajectories after conflict resolution



Scenario particularity:

Demonstrate the application of higher separation minima required by manned aviation

Assumption:

Delivery flight is planned to cross the helicopter trajectory but it will never exit the operation volume during demonstration

Demonstration exercises

Exercise 3 scenario 2: helicopter and two drone flights

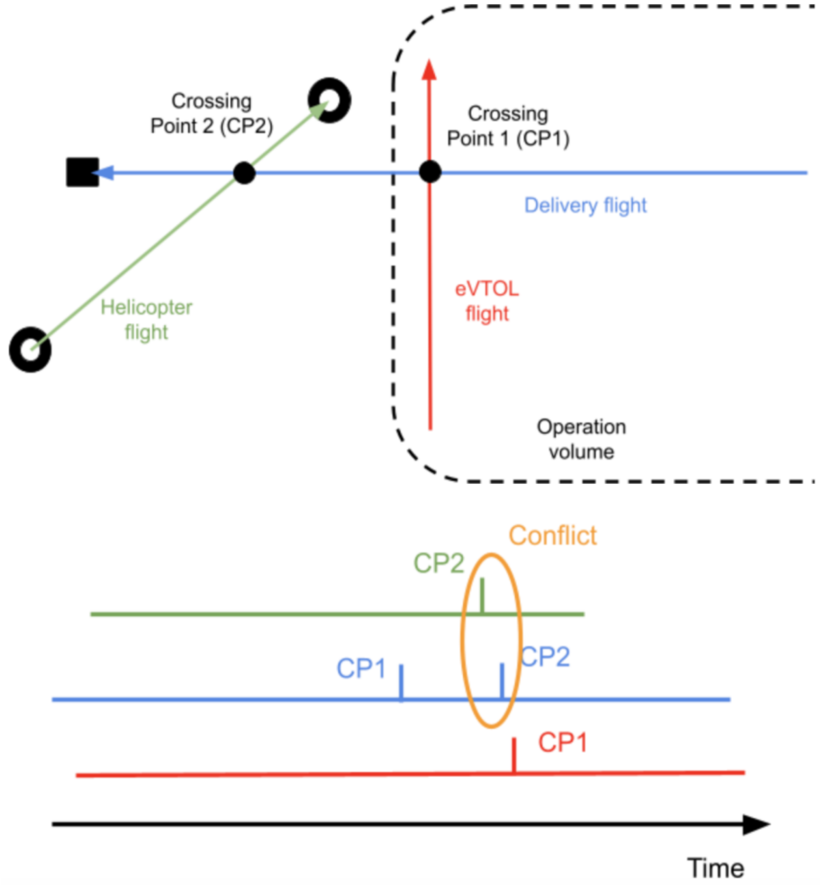
Scenario particularity:

Demonstrate the consideration of the whole traffic in deconfliction solution computation

Assumption:

Delivery flight is planned to cross the helicopter trajectory but it will never exit the operation volume during demonstration

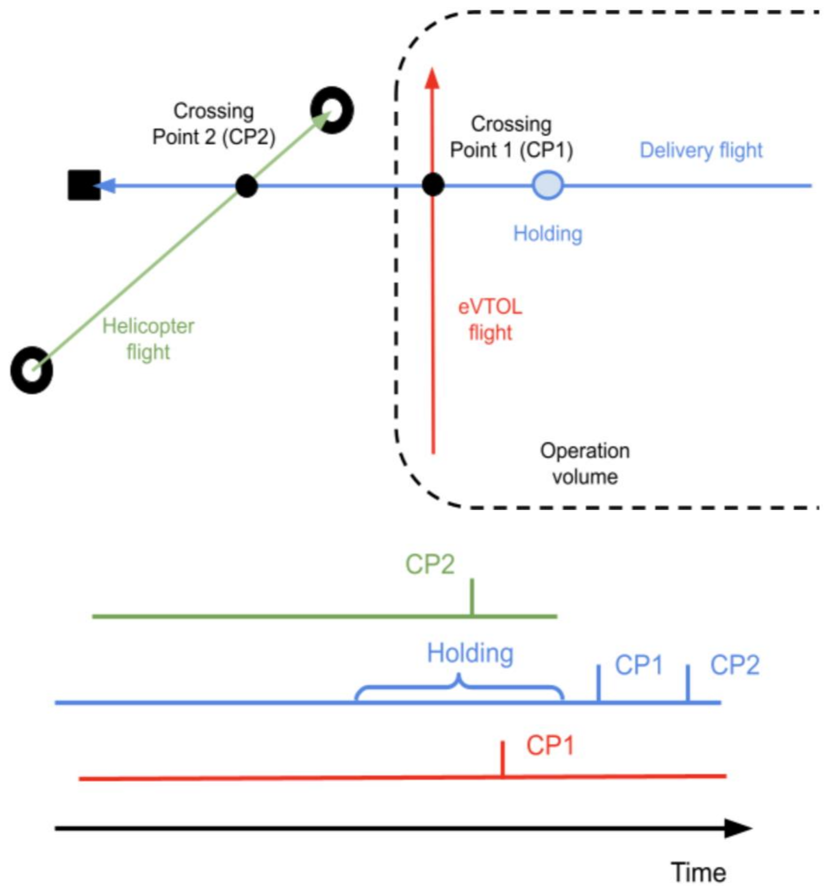
Trajectories before conflict resolution



Demonstration exercises

Exercise 3 scenario 2: helicopter and two drone flights

Trajectories after conflict resolution



Scenario particularity:

Demonstrate the consideration of the whole traffic in deconfliction solution computation

Assumption:

Delivery flight is planned to cross the helicopter trajectory but it will never exit the operation volume during demonstration

Demonstration exercises

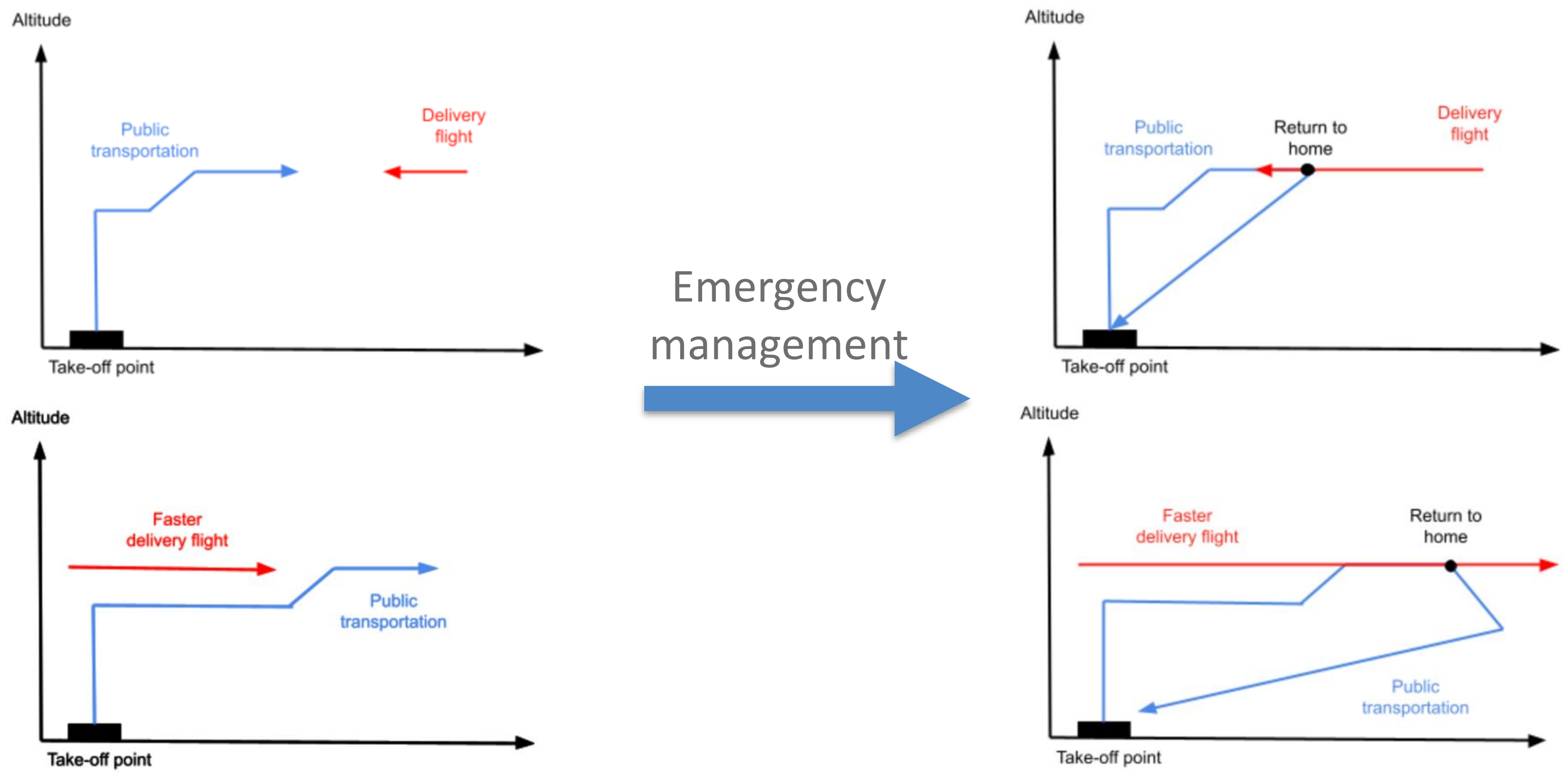
Exercise 4 scenario 1: loss of connection emergency

Scenario particularity:

Demonstrate the deconfliction ability to order a suitable return to home in case of loss of connection emergency

Scenario assumption:

The loss of connection will be simulated



Demonstration exercises

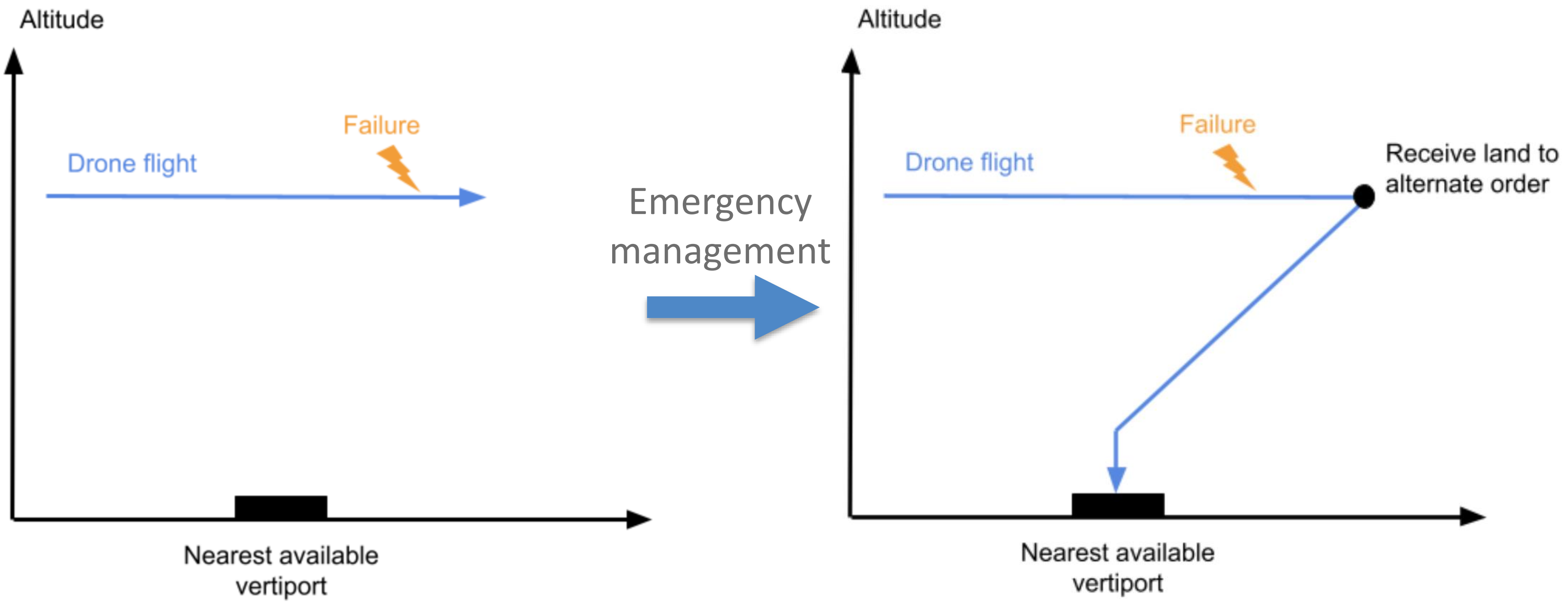
Exercise 4 scenario 2: emergency management due to failure

Scenario particularity:

Demonstrate the system ability to manage an emergency resulting from an aircraft which has sent a distress message

Scenario assumption:

The alternate vertiport is declared in the flight plan beforehand



4. Demonstrations

Vehicles & Timing

Ugo Martinez– Aerospace engineer– Skybirdsview

November 10th 2021

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UAV Platforms

A set of 5 different platforms :

- Different capabilities & flight characteristics
- Limitations inherent to each platforms will have to be accounted for to deconflict the trajectories

Representative of UAV diversity and different UAV use cases :

- Swoop : Last mile delivery
- FUS35 : Delivery/inspection/surveillance
- FazerMax : Test bed/agricultural/surveillance
- UMILES Concept 2 air taxi : Suburban/urban transportation
- Manned helicopter : Transportation/medevac



Timing of the demonstrations & Flight authorizations

Updated demo timing :

WP7.1 - Autonomous drones flight management	ONERA	22/5/15	22/6/15
WP7.2 - Autonomous drones + eVTOL flight management	TECNALIA	22/6/15	22/7/15
WP7.3 - Autonomous drones + eVTOL + Helicopters flight management	SKYBIRDSVIEW	22/8/15	22/9/23
WP7.4 - Emergency Landing	SKYPORTS	22/7/01	22/7/31

Flight authorizations

- Location of the flight demo & CONOPS to be decided by December (in accordance to air & ground risks constraints)
- SORA to be performed and sent to DSAC for approval 3 month prior to each demo
- ZRT request to be sent 2 month prior to each demo
- ARCEP frequency authorization to be sent 2 month prior each demo

5. Next Steps

- Human Factors and Social acceptance assessments
- Safety and Security Assessment
- Project Schedule

November 10th 2021

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5. Next Steps

Human Factors and Social acceptance assessments

Gabriella Duca - President, Head of Human Factors & Ergonomics Lab - Issnova

November 10th 2021

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Objectives of Human Factors and Social Acceptance assessment

- to set up and execute HF investigation, relying on data available from human actors' involvement in the flight demo campaign
- to involve society stakeholders in order to elicit their needs, perspectives, and priorities about the proposed use cases, allowing to early detect concerns and barriers to the successful deployment of envisaged use cases
- the involvement of Human Factors and Stakeholders has the final objective to build a clear framework of technical, environmental, regulatory and social issues relevant for the UAM future implementation and full deployment

Approach to the Human Factors assessment

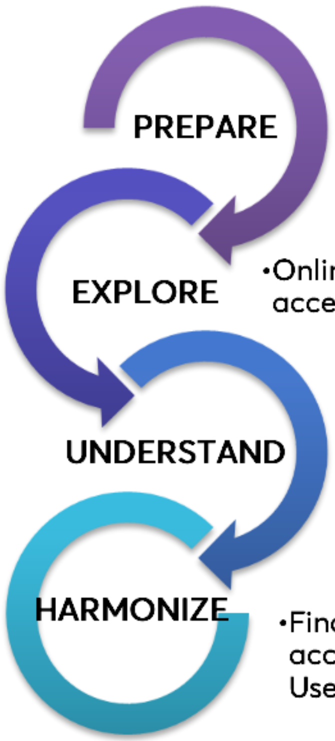
To assess TindAIR solutions under the HF perspective, the project is

- formulating a series of hypotheses on Human Factors issues that might arise from implemented scenarios
- defining specific Human Performances validation objectives with related indicators and metrics (subjective and objective) for the human actors involved in the scenario
- preparing the data gathering tools (i.e. check lists for post-flight debriefings/focus groups, post-flight questionnaires, final questionnaires, final semi-structured interviews).

Approach to the Social Acceptance Assessment

To assess the social acceptance of TindAIR Use Cases, the project has

- defined the rationale for the social acceptance assessment
- set up its Advisory Board as consultory body on social acceptance, including representatives of
    - local/regional administration
    - End users acting in the topic of infrastructure monitoring
    - EU network acting in the topic of UAM, Sustainable Urban Mobility Plan
    - governmental organization acting in the topic of sustainability
    - Industrial research in the field of drone technologies and mobility
    - Industry in the field of drone technologies and services
    - Regulatory organization
    - Research in the field of drones and aeronautics, innovation acceptance, sustainability, multimodal transport, transport financing
- Defined the methodology and timing for the social acceptance assessment



- Setting the AB and the TindAIR circle
- Online survey on UAM social acceptance
- Interview on social acceptance topics related to TindAIR Use Cases
- Final workshop for social acceptance assessment of TindAIR Use Cases

5. Next Steps
Safety & Security assessment

Raphael Blaize – Head of Innovation lab – Apsys

November 10th 2021

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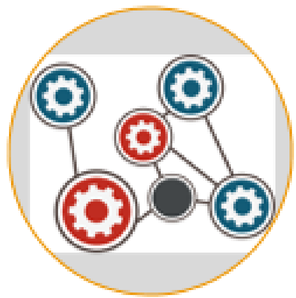
TindAIR Security Concept

System security Assessment

Security preliminary assessment are necessary to ensure consistency of development security activities.

Security context and security targeted acceptable level defined during this assessment



System secure Design

Based on preliminary assessment outcomes, design drivers should be given through security requirements.

Those requirements shall ensuring best possible ad equation with functional objectives

Security Evaluation

Security evaluation provides additional confidence in the system security level. Evaluation can be divided into 2 types of activities :

- System design vulnerabilities identification and evaluation
- Offensive security tests

Maintain in operational conditions

Security threats evolution needs to be considered during the entire lifetime of the product. As a consequence dedicated security activities needs to be implemented such as:

- Continuous vulnerability management
- Log management
- System correctives patch development

Cyber risk taken into account

- **Direct attacks on onboard data and code or through installation of toxic components**
  - **during maintenance, storage and operation**
  - **during manufacturing and delivery**
  - **→ loss of survivability, remote control possible, compromise of**
    tactical and passenger data
- **Wireless attacks**
  - **Uses wireless communication channels to target onboard systems and data**
  - **With knowledge of the protocol and breaking the security of command**
    and control
- **Sensor attacks (Radar, sonar, LIDAR, GPS, camera or IR sensors)**
  - **Malicious exploitation of these sensors**
  - **Manipulation of sensor inputs or functions to transfer malware**
  - **Misguidance of the process**
  - **Generation of misbehavior, denial of service, or fail safe mechanisms**

TindAIR

5. Next Steps
Project Schedule

Sophie Althabegoïty– Project coordinator – Innov'ATM

November 10th 2021

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Next steps

December 2021
Integration activities

February / March 2022
Project Review

Summer 2022
Demonstrations in Toulouse & Bordeaux areas

End 2022
Publication of recommendations

Thank you very much for your attention!

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017677