

# U-space CONOPS and research dissemination conference

1 October 2019

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## SESSION 2 PRESENTATIONS



 U-space



# U-space CONOPS and research dissemination conference

1 October 2019

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GOF USPACE  
Maria Tamm & Thomas Lutz  
EANS & Frequentis AG



 U-space







# GOF USPACE

Finnish-Estonian "Gulf of Finland" very large U-space demonstration 2019



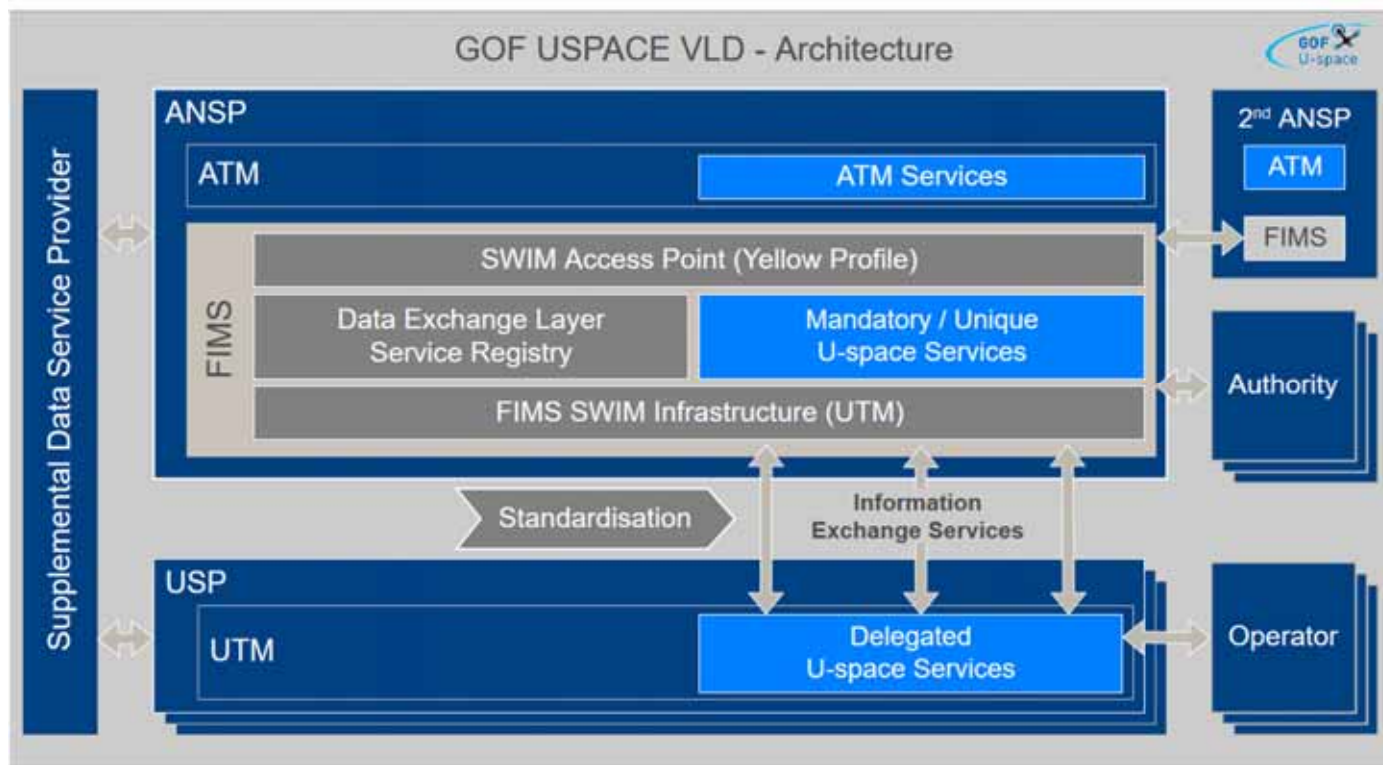
## Project outcomes summary

- Flight Information Management System (FIMS) was established to enable collaboration between:
  - 2 ANSPs
  - 3 U-space Service Providers
  - 1 Supplemental Service Provider
  - 8 Drone Operators (including police)
  - 2 Manned Aircraft operators
- Successfully applied SWIM principles in setting up the architecture for demonstrations;
- Highlights from 7 live trials:
  - 1<sup>st</sup> international drone flight with ATC collaboration, observed in both ATM and UTM;
  - 1<sup>st</sup> drone Taxi flight at Helsinki Int'l airport with integration to both UTM and ATM;
  - 1<sup>st</sup> in Estonia to mix manned and unmanned aircrafts in SAR exercise;
  - Public authority collaboration showed priority access to U-space in several trials;
  - Dynamic geofencing and tactical U2 & U3 deconfliction demonstrated;
  - Safe integration of drone and aircraft in both controlled and uncontrolled airspace;
- Tracking from different data sources (GCS, mobile network trackers, FLARM, ADS-B, SSR);
- Some lessons learned:
  - Tracking solutions need significant additional work;
  - U-space services must be resilient to poor mobile network coverage

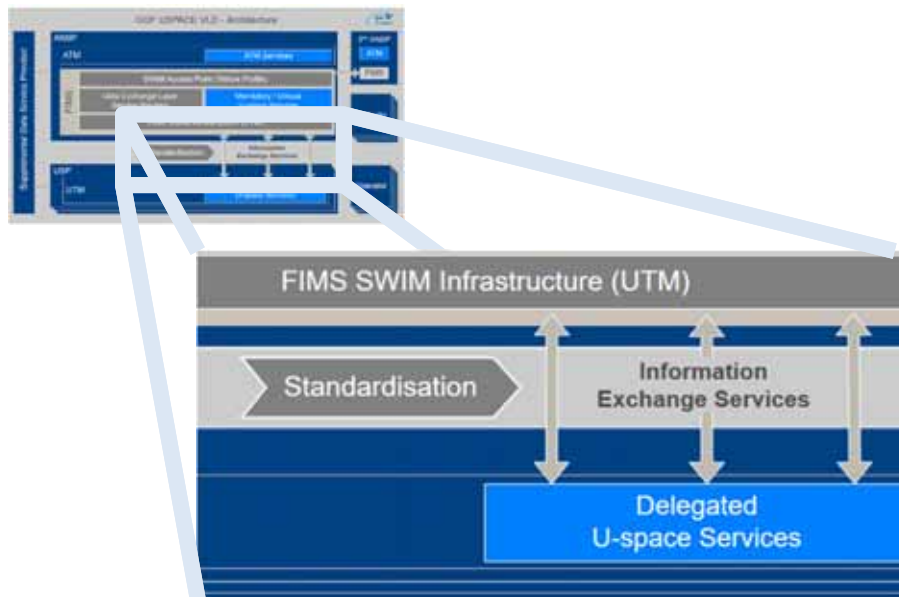
## GOF USPACE Architecture – Based on SESAR Principles



- Service Registry & SWIM based FIMS
- Information Exchange Services
- 3 USP, 2 FIMS
- Enhancements added during trials
- Common Situational View established



## Interoperability is key – achieved in a 2-step approach ... based on SWIM principles



### *Output-driven objectives*

- Advanced use cases shaped requirements

### *Step 1. Common Understanding*

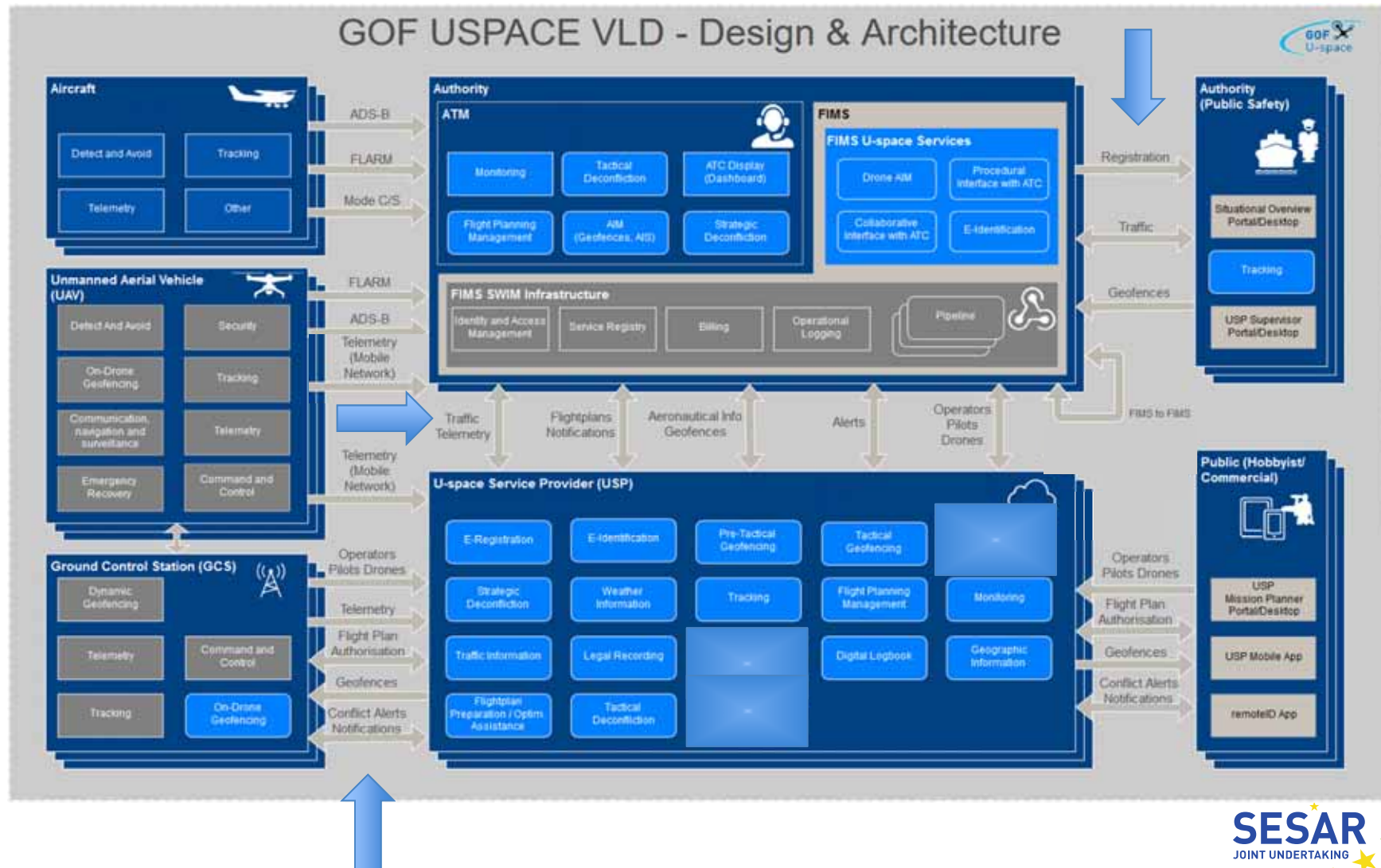
- Analyse Data Flow
- Identify Information Exchange Services
- Describe (without technology)
  - Context
  - Model
  - Interface
  - Behaviour

### *Step 2. Technical Interfaces & Integration*

1. Map existing technical interfaces
2. Test integration

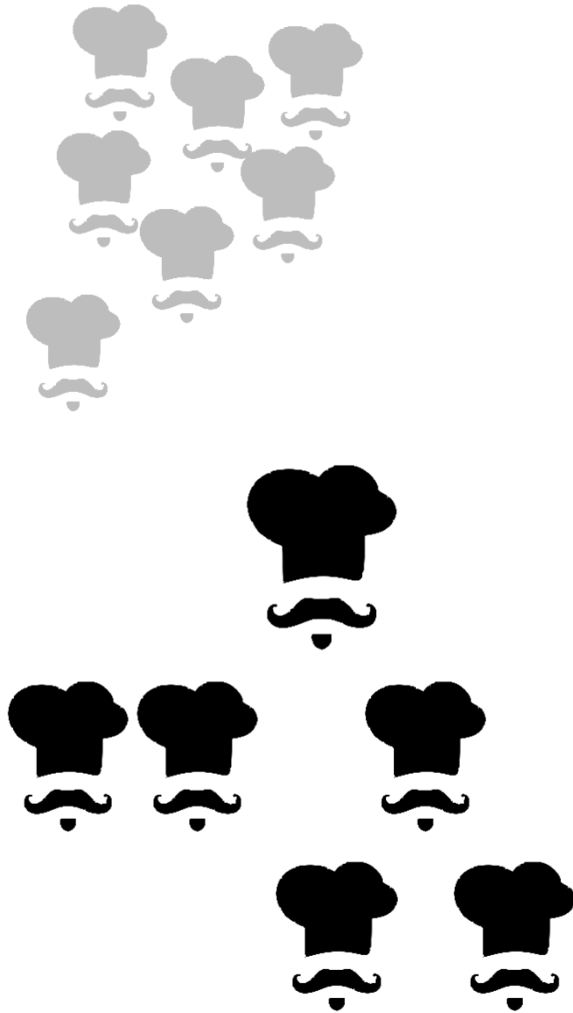


# Data exchange – Information Exchange Services in GOF USPACE





## System of Record – *Common Situational Overview*



- Services of same service type can be made available concurrently by different partners
- Some services need to be centrally managed by one process or system per region (unique service)
  - AIM / Geofences
  - Flight approval
  - ...
- Identical situational overview requires same telemetry feeds for all (single source of truth)
- Clear and well-defined responsibilities are necessary to make a system of systems work – GOF showed that rigorous testing against well-documented standard interfaces are a must to move the industry forward

There can be many services connected to a dataflow, most dataflows require one authoritative service – a single source of truth for a region.

Stay in touch with us



GOF USPACE

<https://www.sesarju.eu/index.php/node/3203>

Main contact for project communication:

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Speaker:

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Thomas Lutz ([thomas.lutz@frequentis.com](mailto:thomas.lutz@frequentis.com))



This U-space project has received funding from the SESAR Joint Undertaking under the European Union's Connection Europe Facility (CEF) programme under grant agreement SJU/LC/343-CTR



# SAFIR

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SAFIR  
Koen Meuleman  
UNIFLY



U-space



# Project SAFIR



SAFIR

Safe And Flexible Integration of Initial U-space  
Services in Real Environment

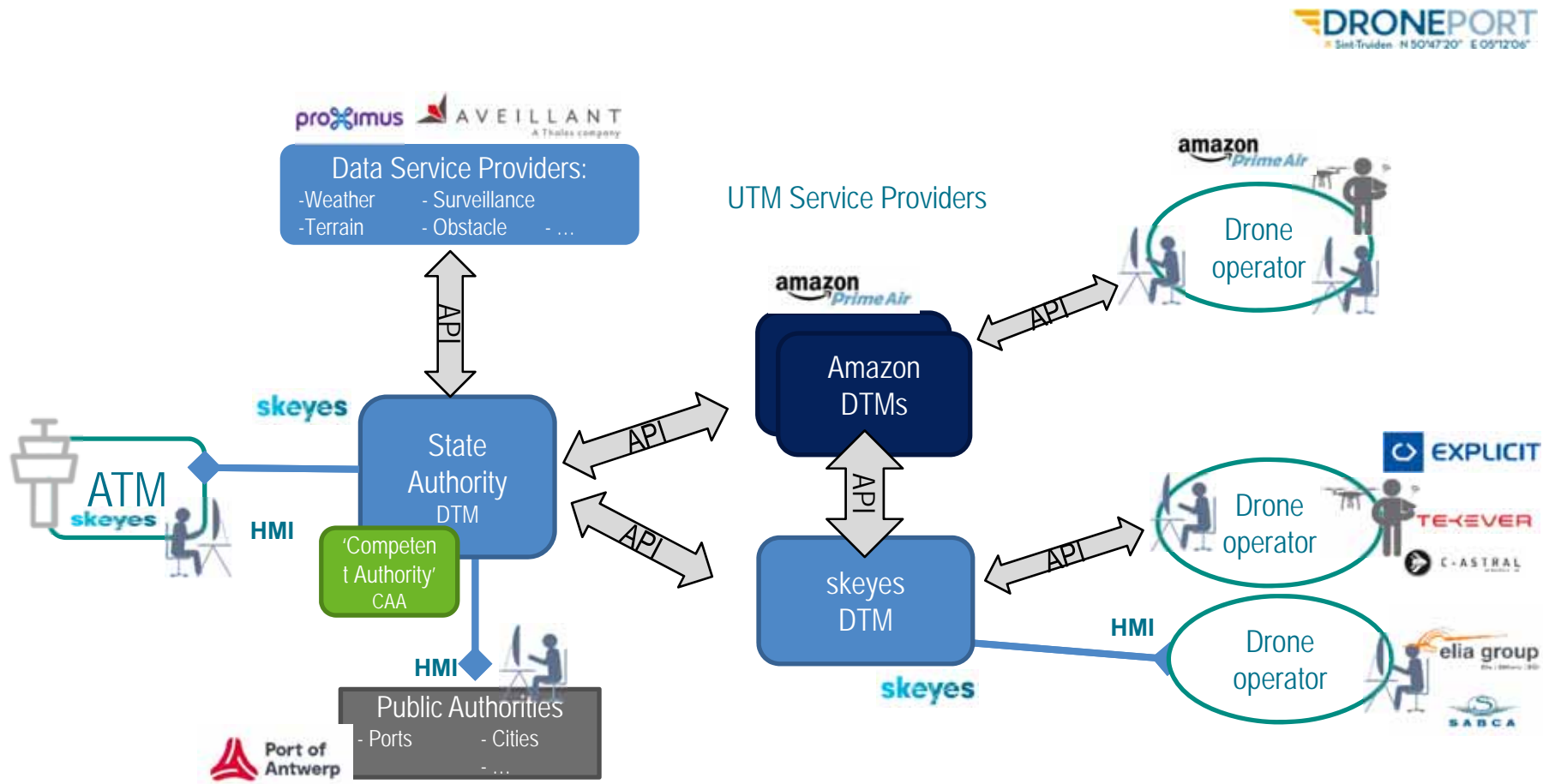
- An ambitious demonstration project demonstrating several U-space services through the deployment of a multitude of UAS and simultaneous deployment of several U-space service providers covering a complex operational airspace







## SAFIR: roles, architecture and consortium





### Interface with ATC & manned aviation/ Should U-space services be part of ATC

- UTM and ATM should be '*integrated*' especially in controlled airspace
- Uncontrolled airspace: interface/information exchange between drones and manned aviation will become mandatory

### Contingency procedures

- 'Independent' tracking device
- Radio communication between operators and direct communication to the tower

### Priority rules

- Currently manned aviation always has priority above unmanned !?

### Does airspace need to be restricted?

- U-space should be everywhere, not only restricted to certain dedicated area's

### Conflict management (collision avoidance, separation management)

- Current separation rules can't be maintained... → special VFR report submitted!
- Collision warning successfully tested, though rules needed on

### Need for single truth

- No doubt possible. (Drone-)AIM data can only come from a single (and or approved source ensuring consistency

### Interoperability/ interfaces

- Interoperability between U-space service providers successfully demonstrated → which standards?
- Common altitude reference framework needed

### Architecture principles

- Federated architecture has been tested → to what level of complexity?
- Discovery rules/standards/procedures to be clarified

## SAFIR preliminar obervations/conclusions 3/3

### Importance of the geofencing

- Dynamic geofencing and according actions (automatic re-routing, loitering) by operators successfully demonstrated
- The tool for local authorities to work with

### Societal issues

- Societal issues are not neglectable. Involvement of cities, local authorities (police, fire brigade,....)

### Mobile network performance

- Connectivity is a backbone for UTM. SAFIR relied on LTE network connectivity → network stability and coverage need to be improved.

### How you link to the CONOPS or not.

- CONOPS was not considered

# VUTURA

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VUTURA  
Henk Hesselink  
NLR



 U-space





# Dedicated to innovation in aerospace



## VUTURA & Urban Air Mobility

SESAR Dissemination Day  
1 October 2019



Dedicated to innovation in aerospace

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## VUTURA

VUTURA = Validation of U-Space by Tests in Urban and Rural Areas

Project members are NLR (Coordinator), TUDelft, Municipality of Enschede, UAVI, AirHub, LVNL, Unifly, AirMap, UniSphere, Robor Electronics



## VUTURA U-space tests

### DELFT

- » URBAN AREA
- » FIVE DRONES
- » TWO U-SPACE SERVICE PROVIDERS
- » ROTTERDAM CTR
- » B-VLOS

**NRTC:** Agriculture inspections  
**Delft:** Surveillance/Counter drones  
**Enschede:** Package delivery



### NRTC

- » RURAL AREA
- » THREE DRONES
- » TWO U-SPACE SERVICE PROVIDERS
- » B-VLOS

### ENSCHDE

- » URBAN AREA
- » FIVE DRONES
- » TWO U-SPACE SERVICE PROVIDERS
- » SMART CITIES
- » B-VLOS

## VUTURA U-space demonstrations

Marknesse 27 June 2019      20 external visitors

Delft 2 July 2019              20 external visitors

Enschede 29 August 2019      120 external visitors

External participants from The Netherlands, SESAR and EUROCONTROL:  
IenW, ILT, SESAR SJU, Eurocontrol, RWS, LVNL, Communities, manned  
aviation, RAI, Universities, Police, Medical Services, ANWB,  
Airports, Logistics, Drone Manufacturers, Drone Users, .....

## Some impressions of the demo-days





## Visitors & team @ NRTC





## Visitors & team @ Delft





## Visitors & team @ Enschede



## Most important VUTURA objectives

Demonstration of U-space; dealing with many drones simultaneous

Cooperation between USPs

Prioritization of drones, including de-confliction

How to coordinate this?

How to give access to autonomous systems?

How to give the operator freedom to plan its flights?



## VUTURA's Achievements

SORA with ILT – Several risks mitigated for approval of the highly complex scenarios

Demonstration of the use of U-space

Cooperation between USPs

Multiple drones simultaneously

B-VLOS up to 3.8 km

Over cities: Delft and Enschede

Priorities for emergency services



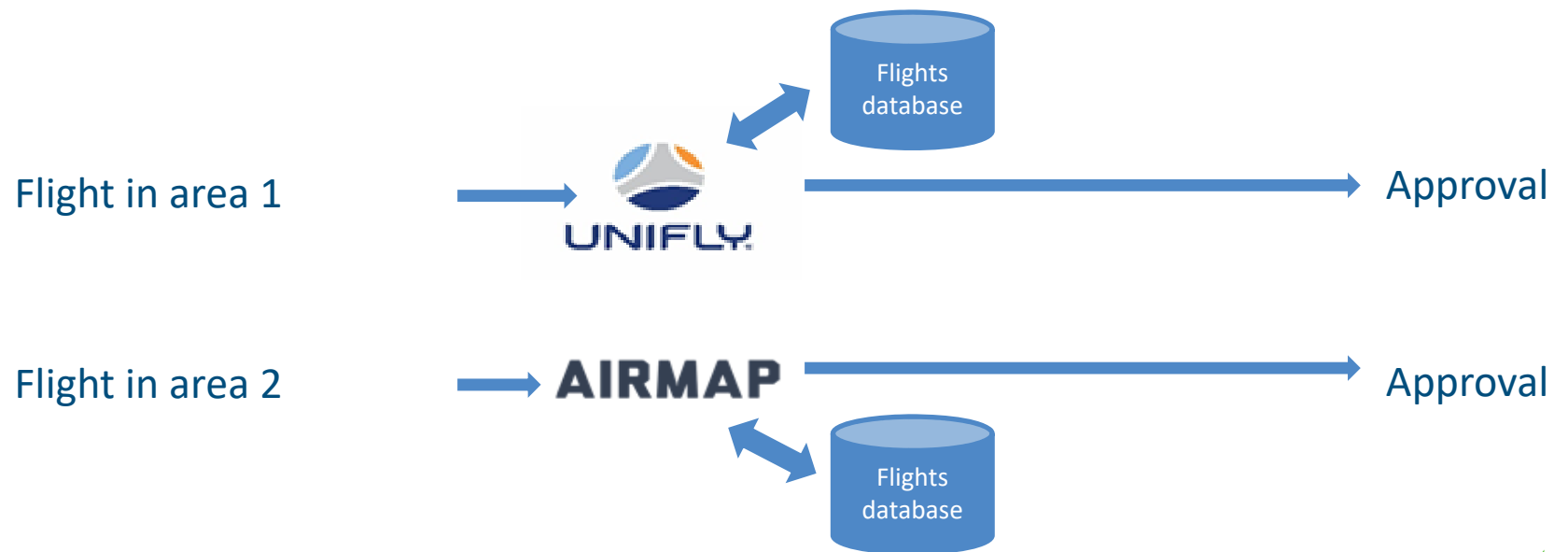
NLR Adviescommissie AO, 17 September 2019





## Operational flight within one airspace

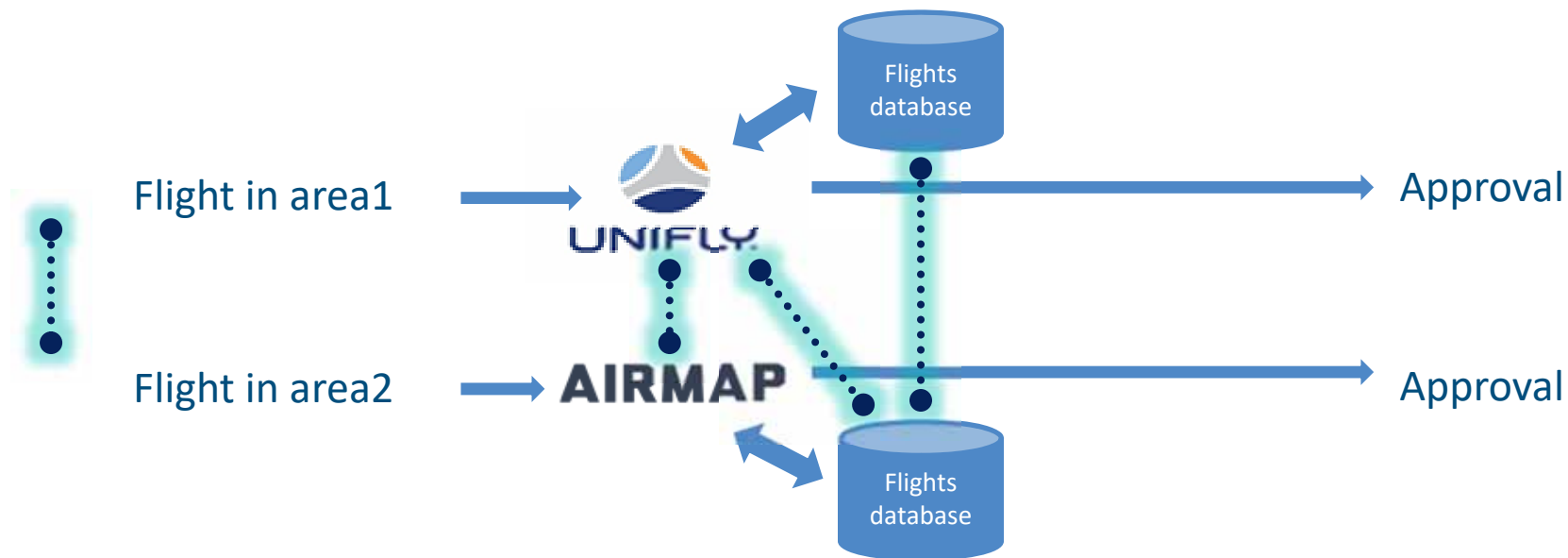
Register with the appropriate Service Provider (USP)  
USP manages the coordination with other flights in the country



## Flight from one airspace to another

Central coordination, like in manned aviation

Or: register and plan in one country; USP will coordinate this





## Cooperation between USPs

Shared airspace or cross border (U1)

USPs cover the same airspace

- e-Registration with both USPs?
- e-Identification with both USPs?
- Sharing of geo-fenced areas

USPs cover adjacent areas

- e-Registration/e-Identification with both USPs: yes

Shared airspace or cross border (U2)

USPs cover the same area

- Flight planning needs very good alignment

USPs cover adjacent areas

- Flight planning for cross-border flights needs decisions (file with USP of first flight leg or arbitraty USP or centralised service)?

## Push + Pull (Urban) Air Mobility through VUTURA





Dedicated to innovation in aerospace

# Fully engaged

Royal Netherlands Aerospace Centre



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# EURODRONE

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EURODRONE  
Vaïos Lappas  
UNIVERSITY OF PATRAS



 U-space





# SESAR | U-SPACE

Efficient and secure access to airspace

EURODRONE

[eurodrone.upatras.gr](http://eurodrone.upatras.gr)

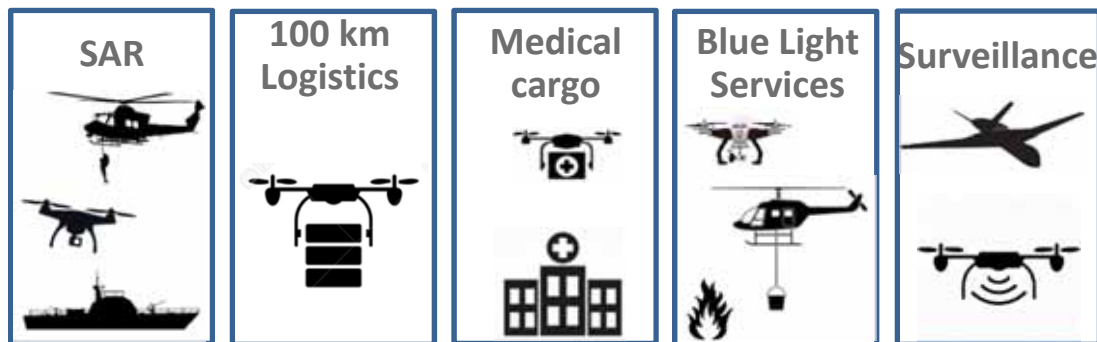


Funded by  SESAR



# A European UTM testbed for U-space

## First UTM Testing in South East Europe



UAV Demonstrations and Applications



DRONSYSTEMS



ASLOGISES

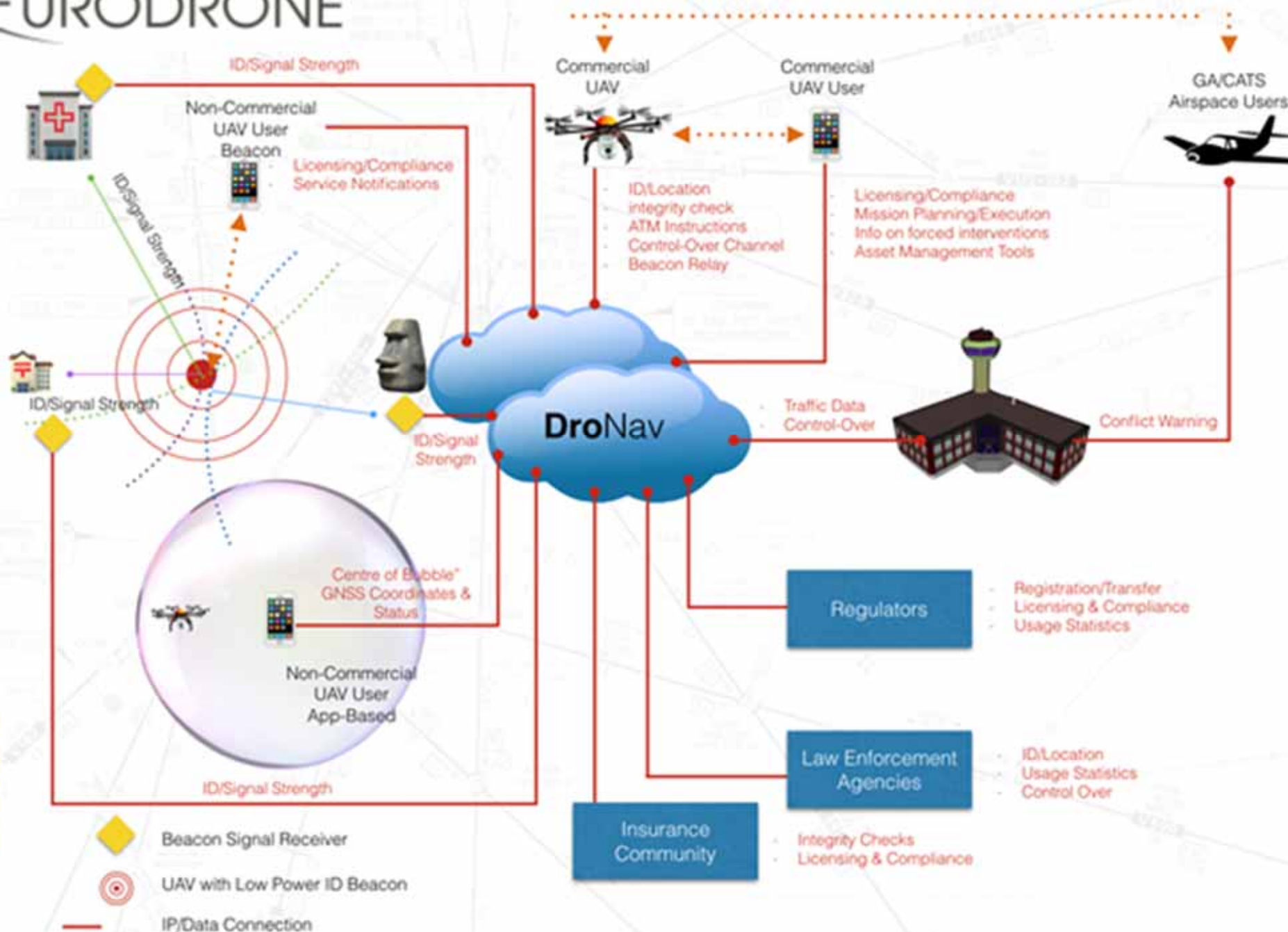


[www.aml.eurodrone.upatras.gr](http://www.aml.eurodrone.upatras.gr)



# EURODRONE

DRONSYS



## Key Innovations/Technologies

1. Automated cloud based UTM system connected to a miniature, intelligent transponder/processing board on drones with full authority flight mission planning
2. Innovative vehicle to infrastructure link (V2I), integrated to a self learning UTM platform, with a capability to share flight information in real time
3. Demonstration of end to end UTM applications focusing on VLOS/BVLOS logistics and blue light services
4. Advanced autonomy, logistics applications



**Flight Schedules and Status**  
Check approval status and approved start time

Mission Name	Drone	Start Time	Local Start Time	Mission Status	Approval Status	Action
EURODRONE-1-001-01	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Reserved	Mission fully approved	<a href="#">View</a>
EURODRONE-1-001-02	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Ready	Approved	<a href="#">View</a>
EURODRONE-1-001-03	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Ready	Approved	<a href="#">View</a>
EURODRONE-1-001-04	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Completed	Approved	<a href="#">View</a>
EURODRONE-1-001-05	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Completed	Approved	<a href="#">View</a>
EURODRONE-1-001-06	EURO	2019-07-24 10:00:00	10:00:00 Europe/Paris	Completed	Approved	<a href="#">View</a>





# Testing 24/7 to 29/7/19 – Phase I



VLOS, long range testing in Patras area, verify UTM functions



DRONSYSTEMS



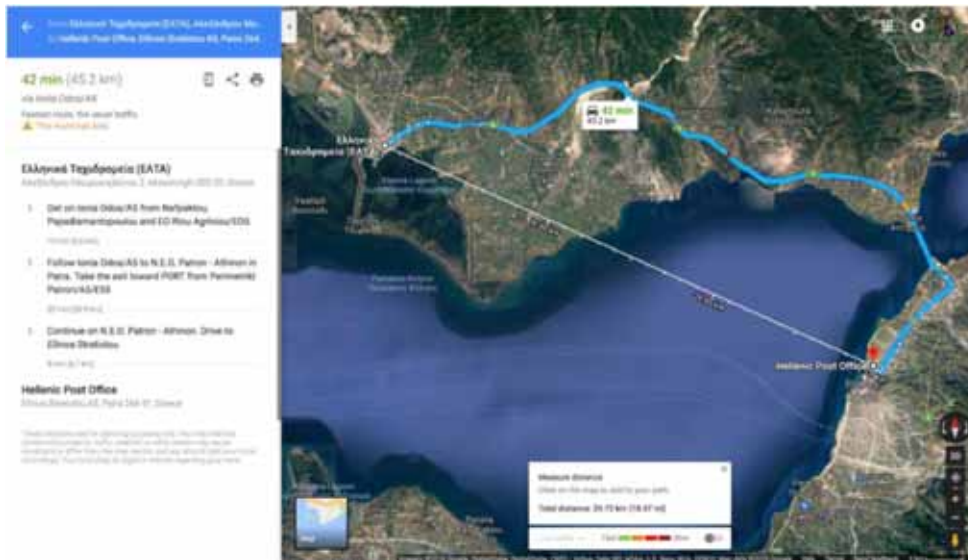
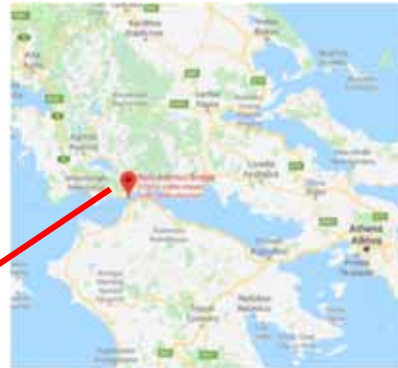
ASLOGIC



# Testing 13/9 to 20/10/19 – Phase II



BVLOS, long range (50+ km) testing in Patras area



DRONSYSTEMS



ASLOGIC



CIVIL AVIATION AUTHORITY October 2019



## Novel Results, Achievements to Date

1. First end to end UTM demonstration in South East Europe/Mediterranean Region
2. Successful LOS UTM coordination and operation with ATC, commercial aviation
3. Technical/Operational innovations:
  - i. V2I and V2V Communications
  - ii. Detect and Avoid (DAA) Algorithms and operations
  - iii. 10+ km flights (LOS) with medical cargo
  - iv. End to end, safe, robust UTM cloud operations



UNIVERSITY OF  
PATRAS



DRONSYS

Brussels, 1 October 2019



EATA



ASLOGIC







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ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΑΣ



DRONSYSTEMS



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Contact Information

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Applied Mechanics Lab

University of Patras  
Brussels, 1 October 2019

U-space

SESAR

EURODRONE

[www.aml.eurodrone.upatras.gr](http://www.aml.eurodrone.upatras.gr)

# IMPETUS

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IMPETUS  
Pablo Sánchez-Escalonilla  
CRIDA



 U-space





## 1 Scope of the project

Organization of **invariant information needs** into a coherent drone operations lifecycle that reveals how drones will operate, what information is needed and why and how it might be produced.



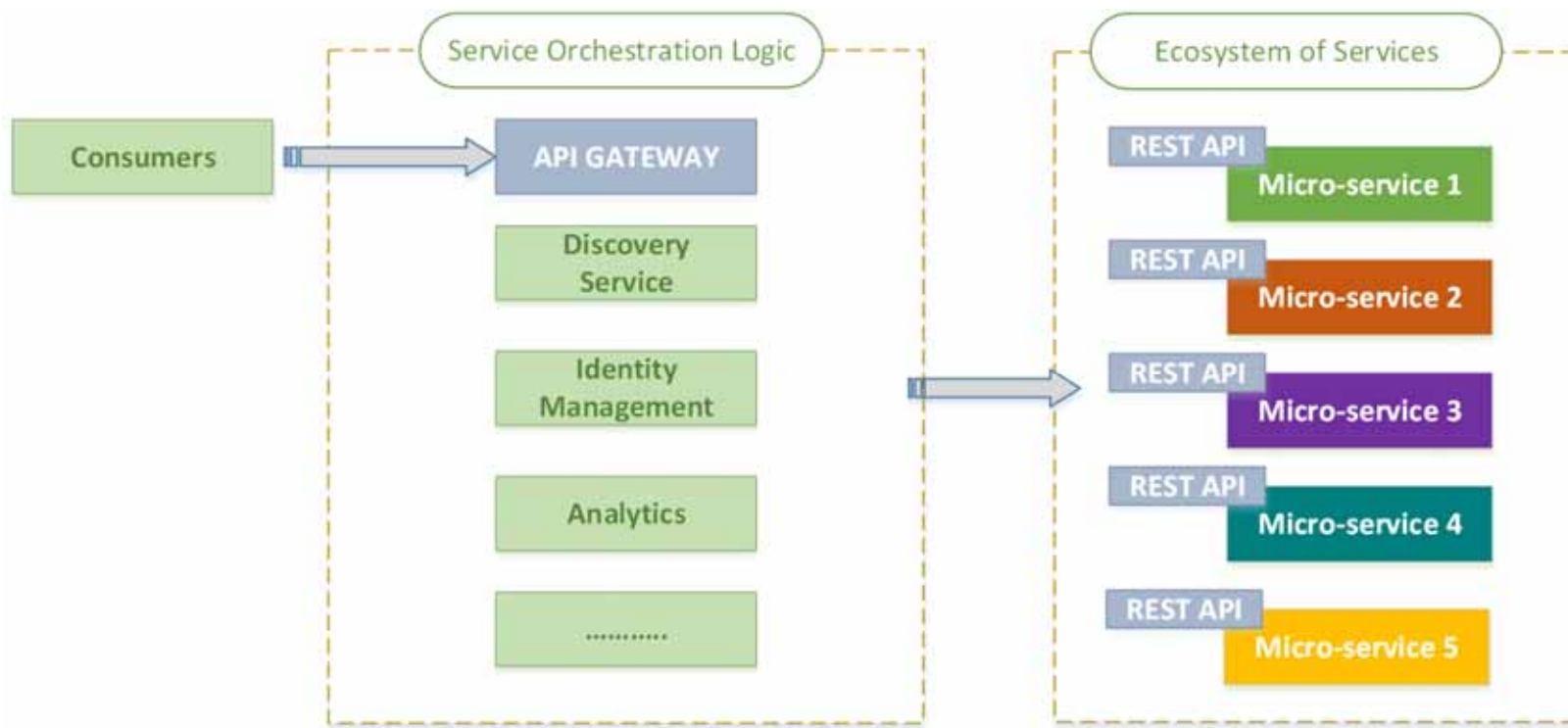
Definition and validation of an **architectural solution** which should be scalable, measurable, cost-efficient and fully automated to support the entire drone operational lifecycle.



## 2

## The architectural solution – microservice paradigm

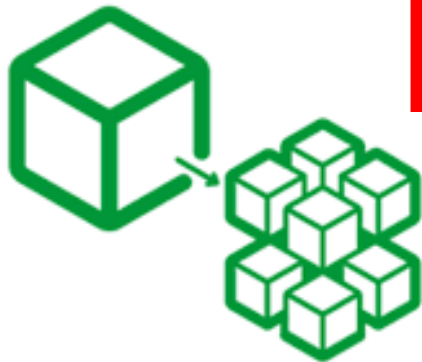
The entire system is divided in lightweight self-contained microservices, with a **clearly defined functionality** (focused on a specific business capability) and simple interactions managed through a **Service Orchestration Logic**.



## Benefits

The ability for services to be independently deployed, will provide the **flexibility required for rapid and agile increments** of the overall U-Space capability.

- Diverse technologies according to the service requirements.
- No need of common standards for design and development.
- Continuous deployment of the service is made possible.



## Challenges

- Maintaining **data consistency** across multiple services as microservice architecture is characterised by the decentralised data management.
- Management of **failure modes** and mechanisms for the real-time monitoring.

Prototyping several **cloud-based environments** which integrates **several micro-services** in order to test:

1. The technological feasibility of the architecture.
2. Also specific challenges of envisioned U-space services.

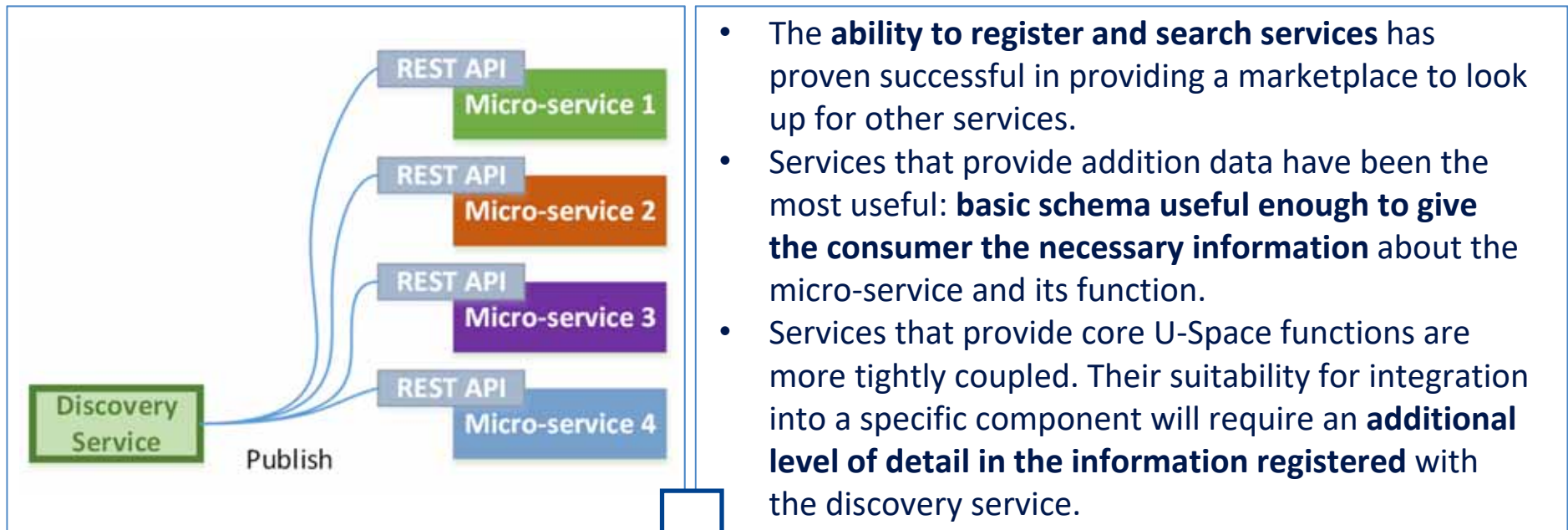
**Drone-specific weather provision** that considers the uncertainty to improve the trajectory-based decision making process

**Flight planning management** process to comply with the mission targets and trajectories' deconfliction

**Monitoring and traffic information** provision to process information from and to multiple users or systems

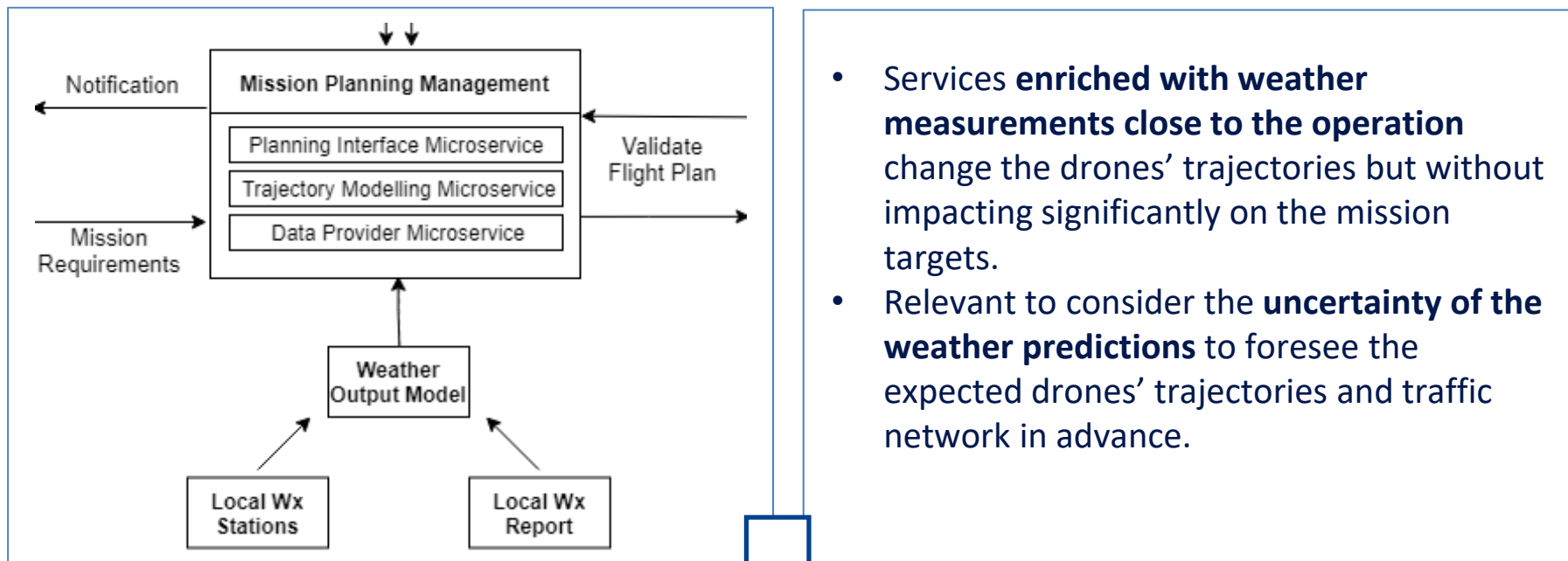
**Dynamic Capacity management** and interdependencies with **tactical deconfliction** to dynamically manage the airspace

What are the **interoperability principles** in the micro-service based architecture?





How **weather uncertainty** is impacting the traffic management processes?



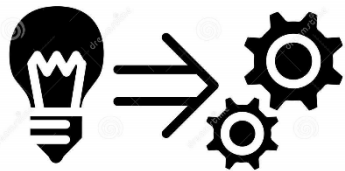
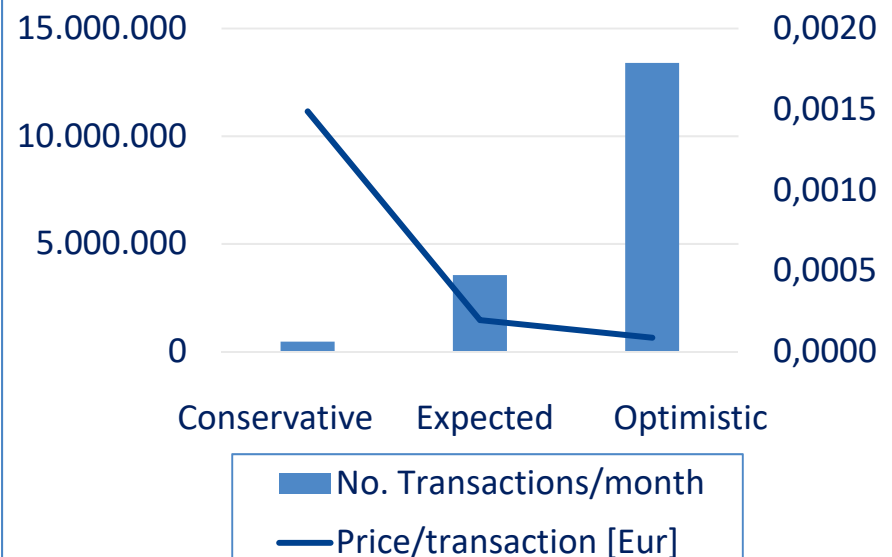
### **“Reasonable Time to Act” (RTA)**

Time period far enough before flight that a disturbance to the operation has minor repercussions.



Can the microservice-based approach facilitate  
**billing according to the use of U-Space resources?**

1. Up to 5 typical **Flight Planning Management** requests were considered.
2. **Different mission types** require different computational resources.
3. No. of requests based on **official forecast (2025)** considering 3 scenarios ((conservative, expected, optimistic).
4. Estimated **deployment costs** in cloud environment.



### **Feasibility of the U-space implementation**

Definition of the different business model  
and impact on the final users

## 8 Outcomes summary and next steps

Up to 35 drone operations  
information entities and  
numerous of their key  
challenges

Architecture,  
dependencies and  
requirements of  
services

Evidence of  
performances and  
technical feasibility

**Workshop on IMPETUS results**  
**CRIDA/ENAIRe headquarters, Madrid, 12/11/2019**



### Links

[impetus-research.eu](http://impetus-research.eu)

[Linkedin.com/groups/13574098](https://www.linkedin.com/groups/13574098)

### Contact

[info@impetus-research.eu](mailto:info@impetus-research.eu)

[psescalonilla@e-crida.enaire.es](mailto:psescalonilla@e-crida.enaire.es)

# DOMUS

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DOMUS

*Demonstration Of Multiple U-space Suppliers*

Daniel García-Monteavaro

ENAIRE



 U-space



## DOMUS Consortium



ENAIRe 



indra



AIRMAP

EARTH NETWORKS



ineco

55

enai re. es





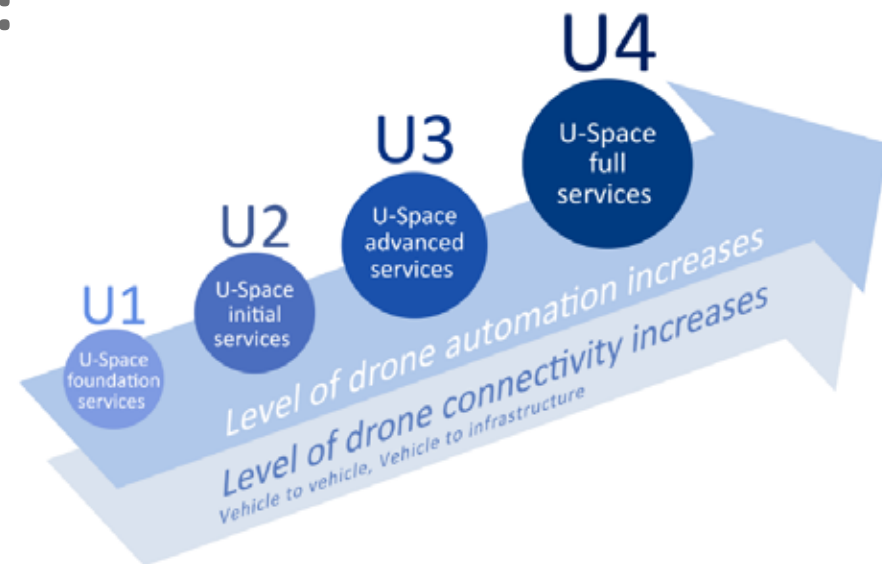
## DOMUS: scope of the project

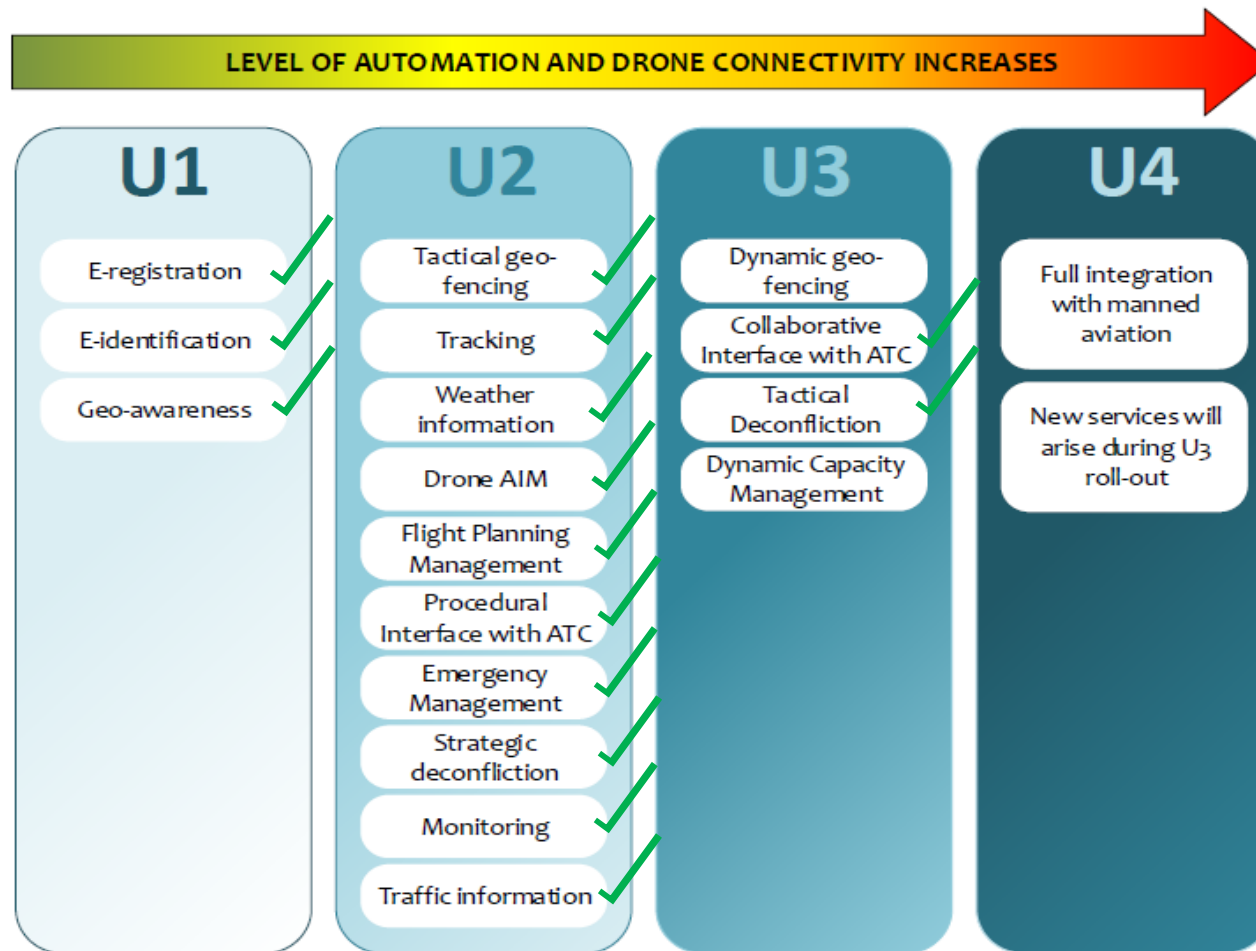
### U-space initial services (U1 and U2)

### Some specific U3 services:

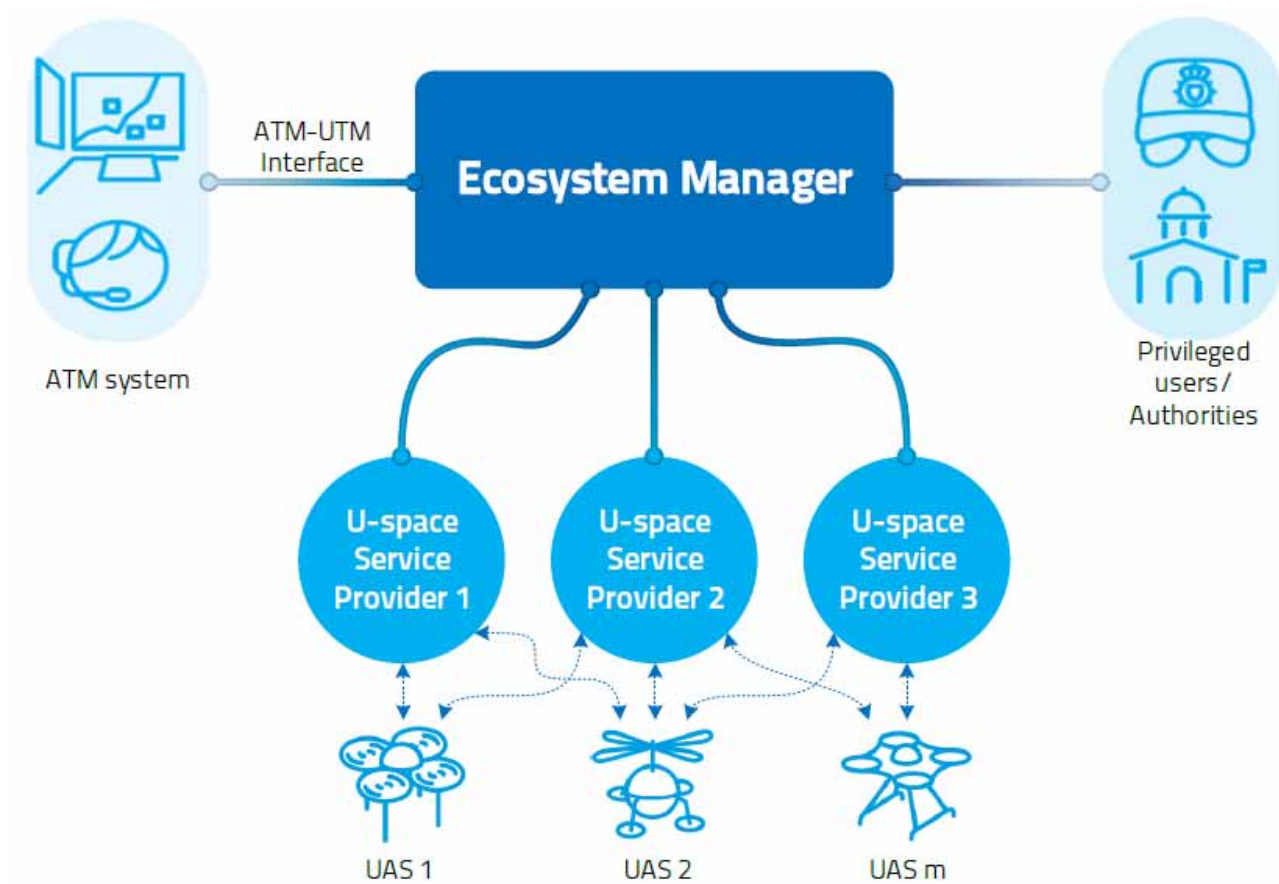
- Tactical Deconfliction
- Collaborative ATM

### Smart City use cases

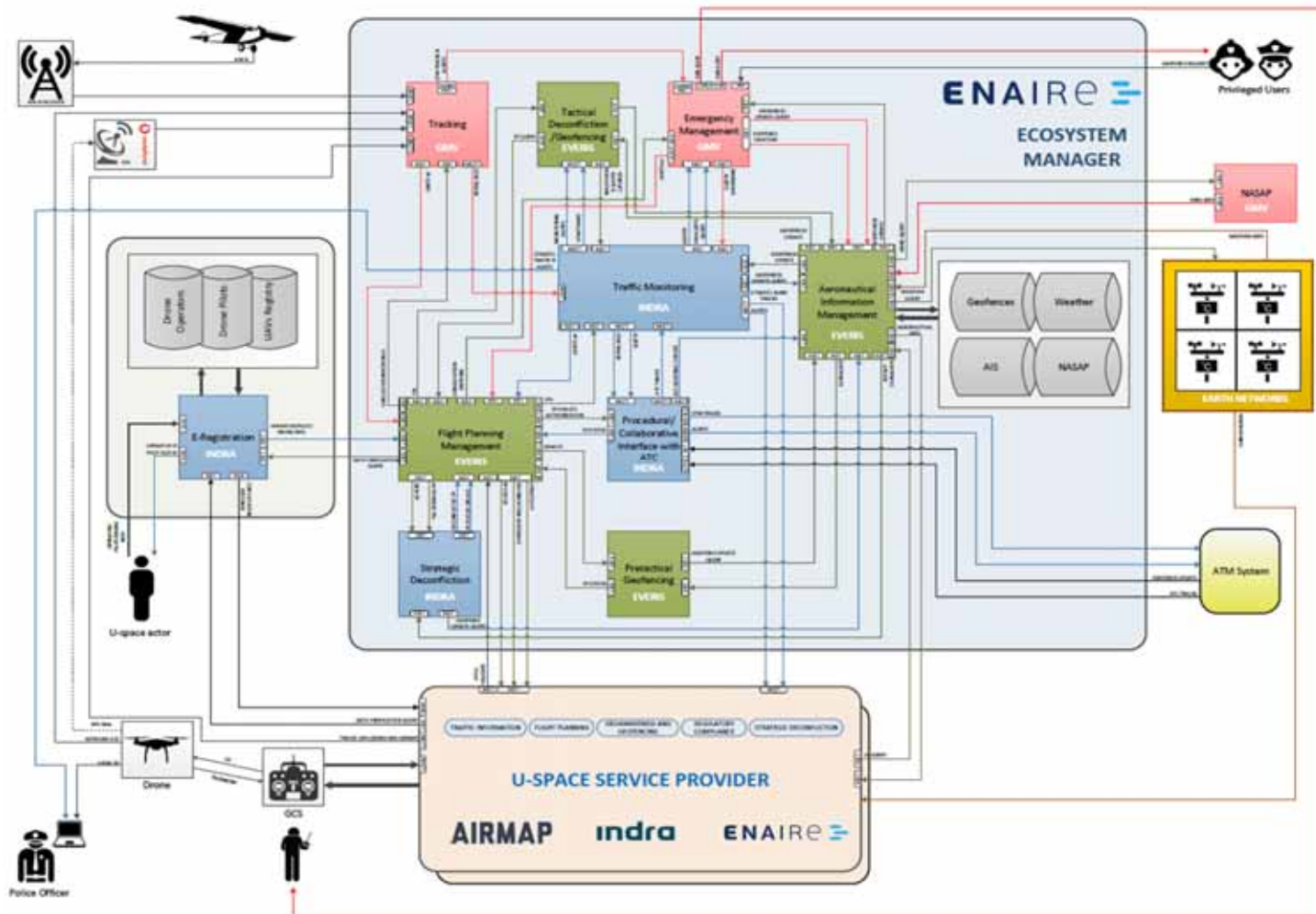




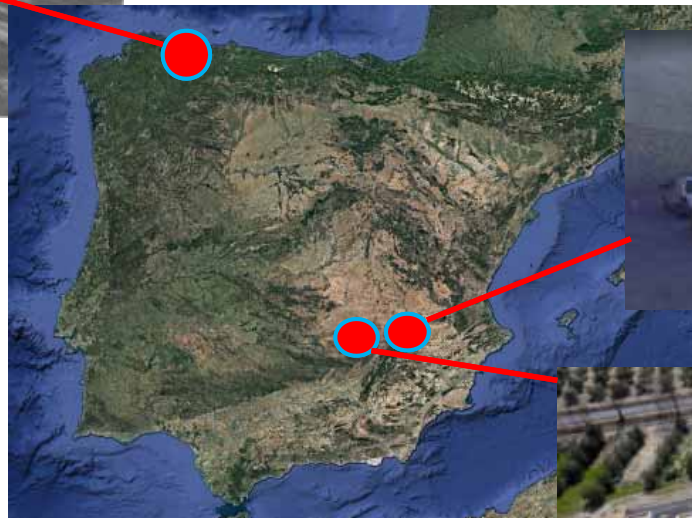
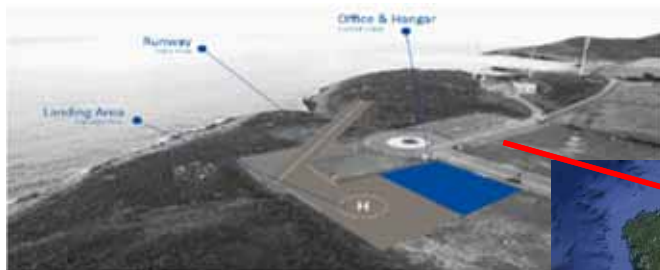
## Architecture U-space



## Architecture U-space

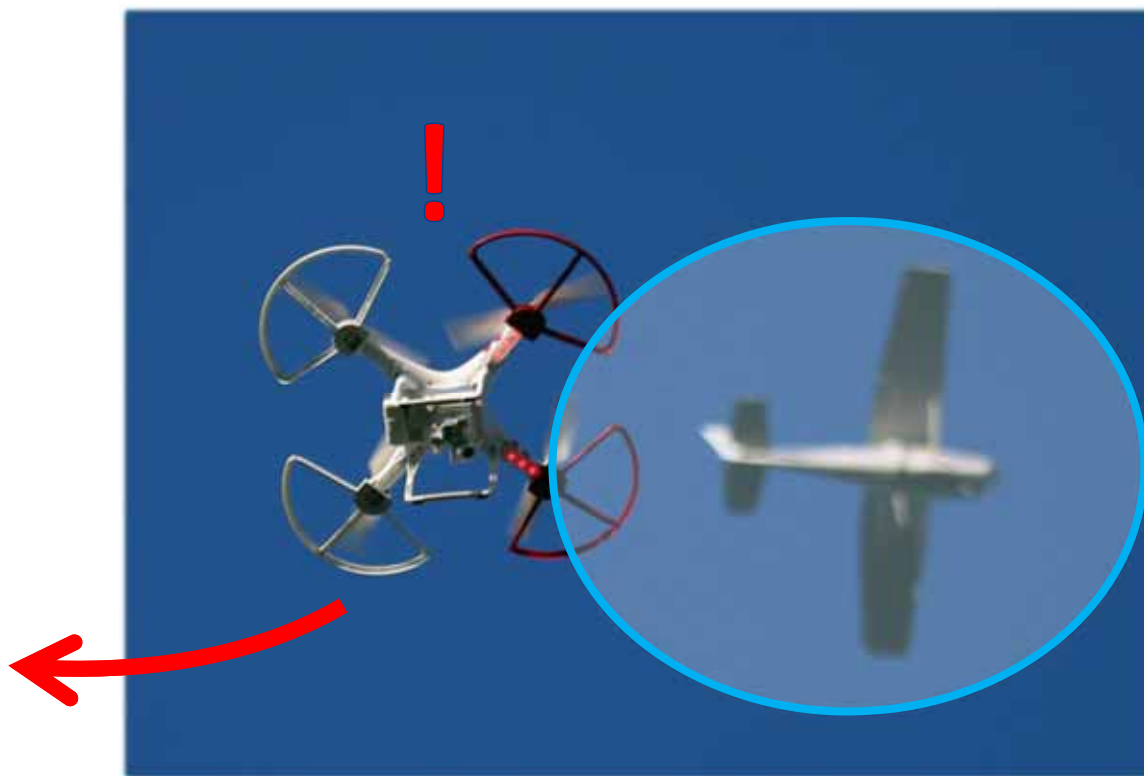


## DOMUS Demonstration Place

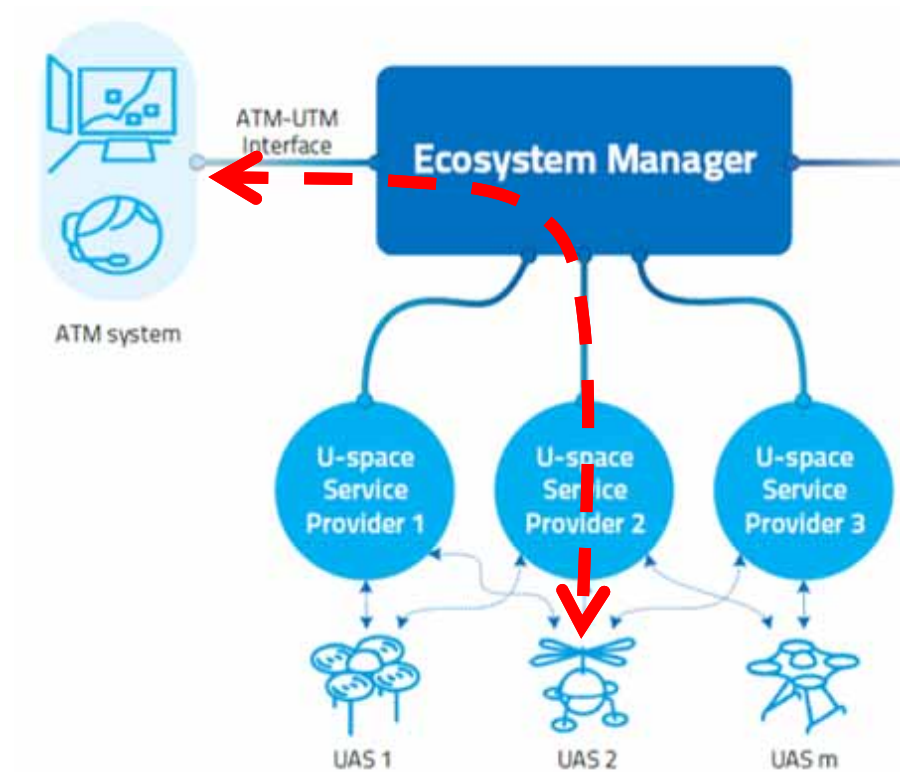
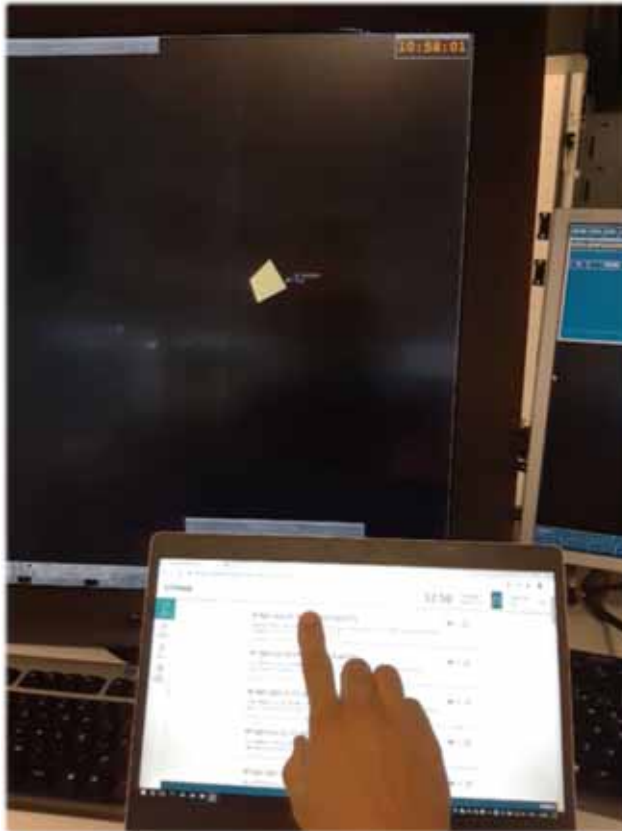




## Manned Aviation (Emergency Management)



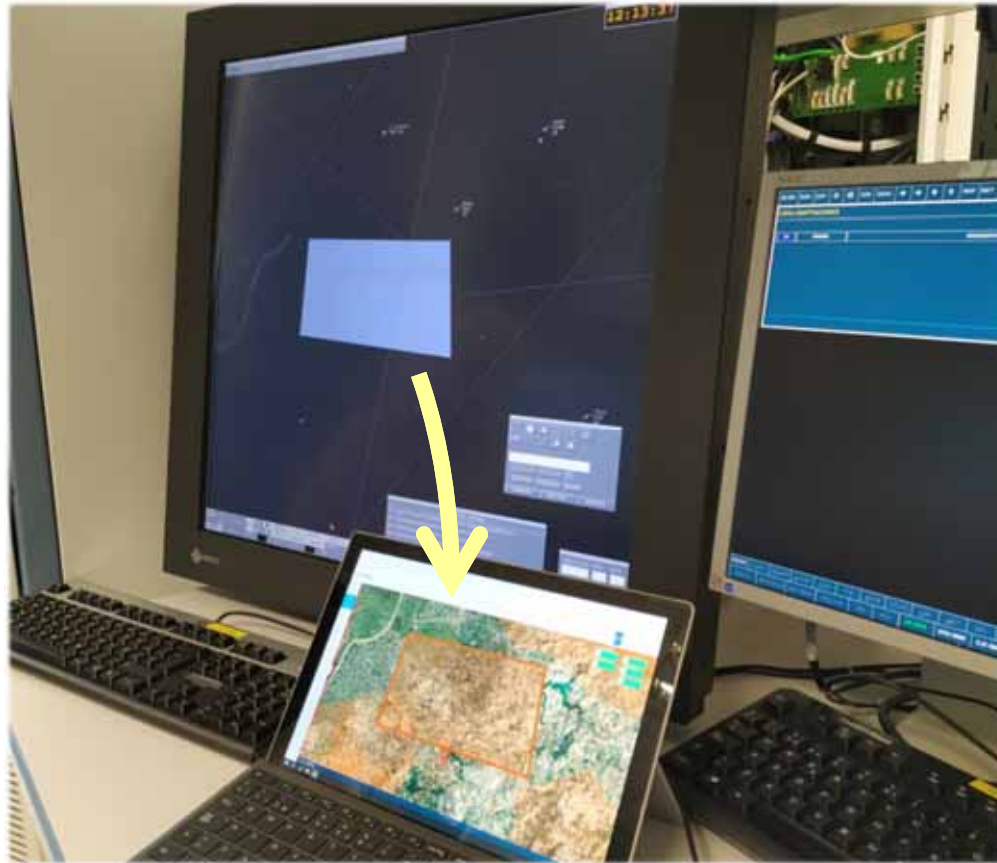
## Procedural Interface ATC : ATC Approval



## Colaborative interface ATC (1/2): Traffic Information

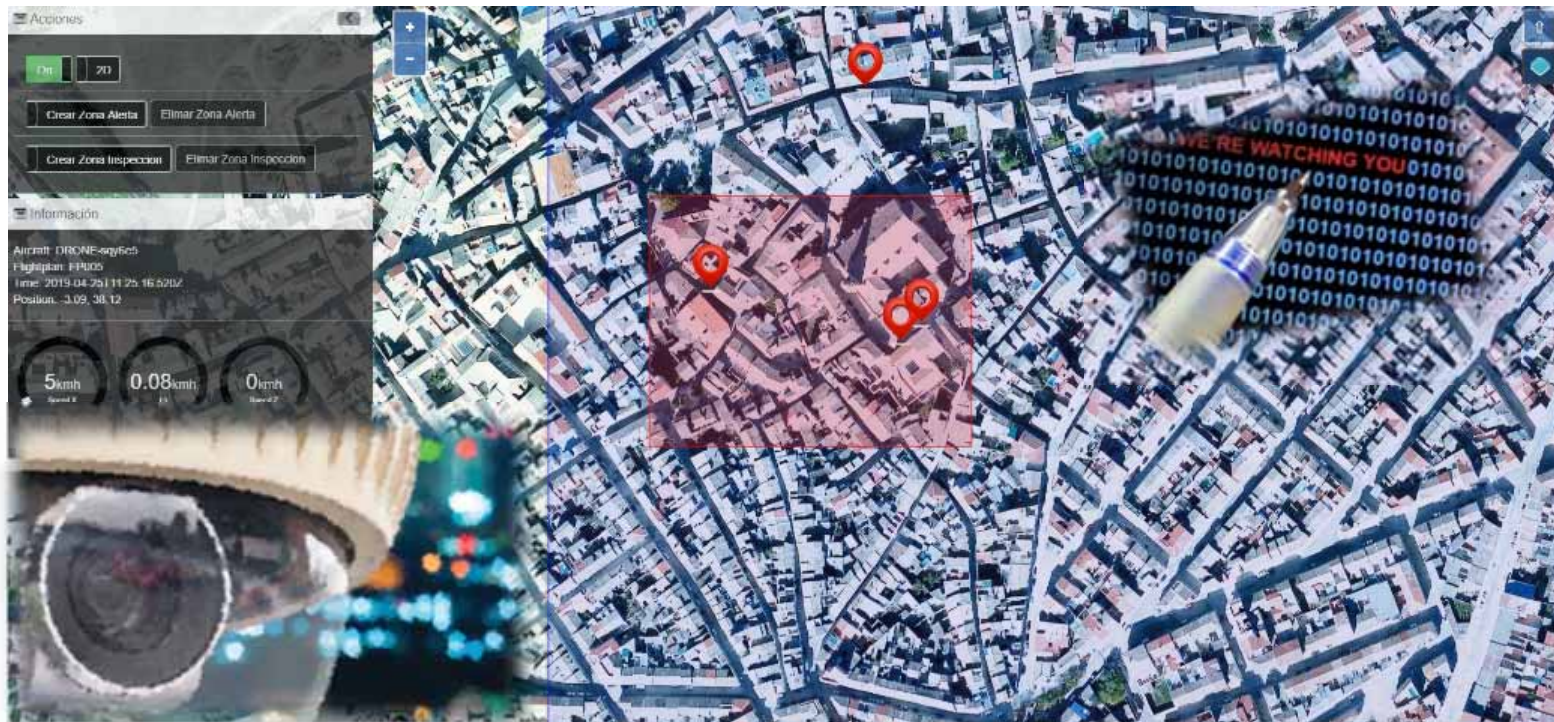


## Colaborative interface ATC (2/2): Geofence Creation





## U-space & Smart City Interaction





## Strategic Deconfliction



## Strategic Deconfliction

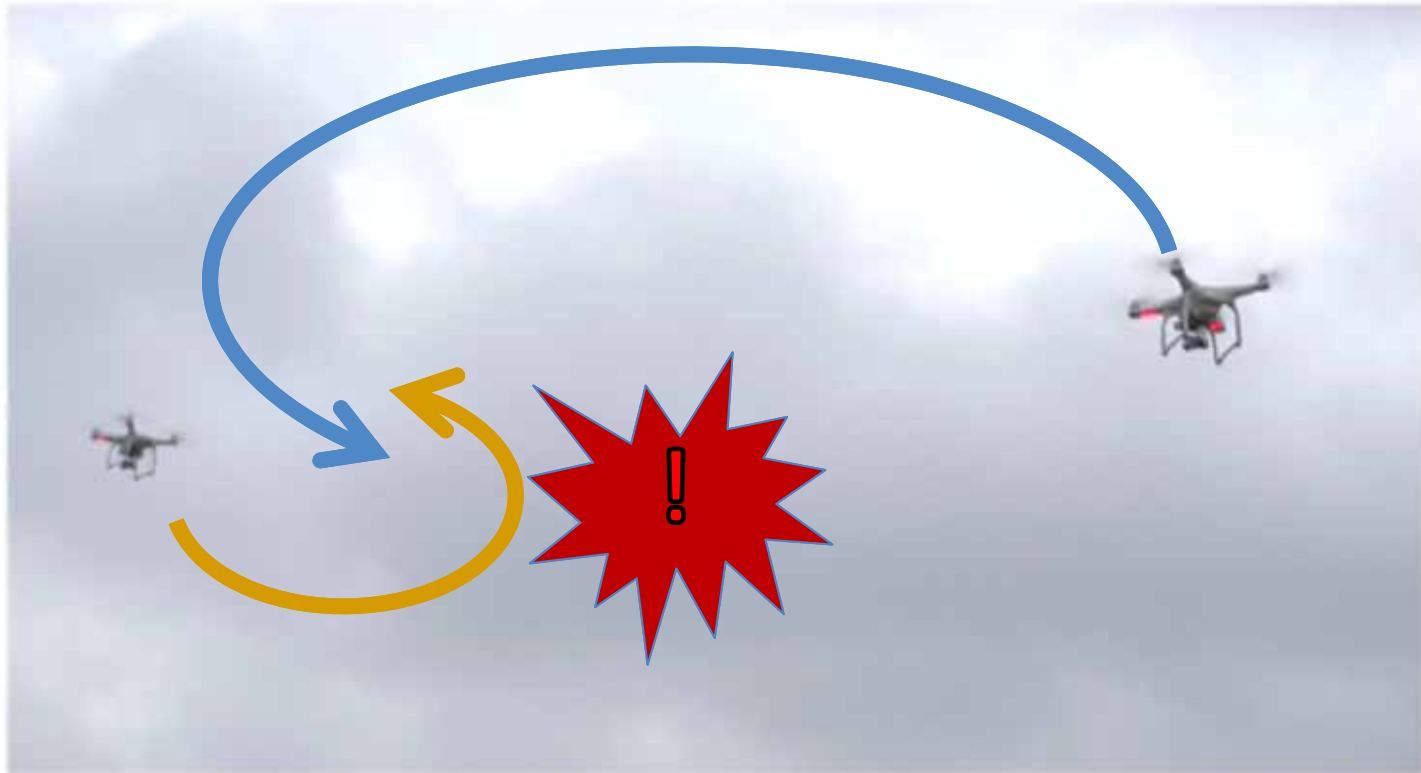




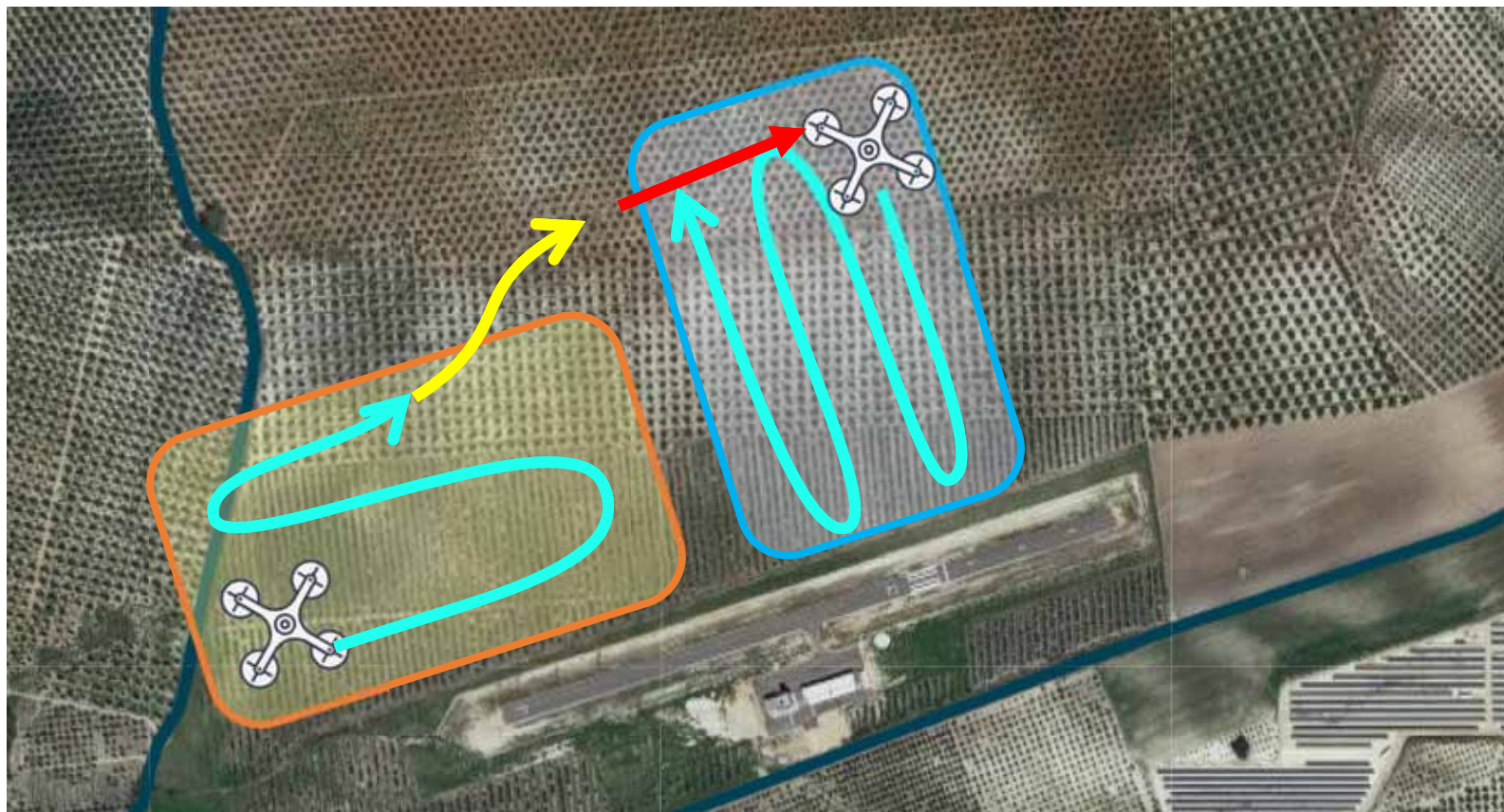
## Trial #2: Priority Flight Plan (Flight plan management)



## Tactical Deconfliction (U3)



## Tactical Deconfliction (U3)

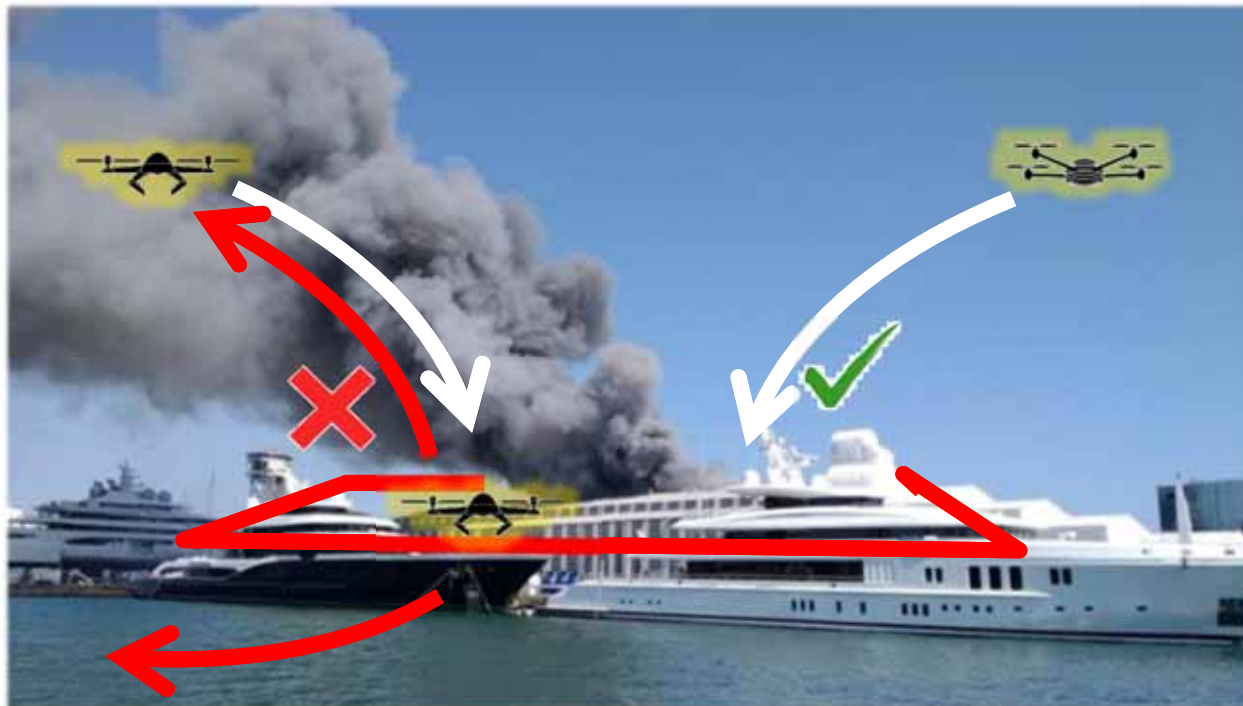




## Tactical Deconfliction (U3)



## Tactical Geofencing & Emergency Delivery



## The core of DOMUS (Demonstration Of Multiple U-Space Suppliers)



- **DOMUS Ecosystem Manager (ESM):**

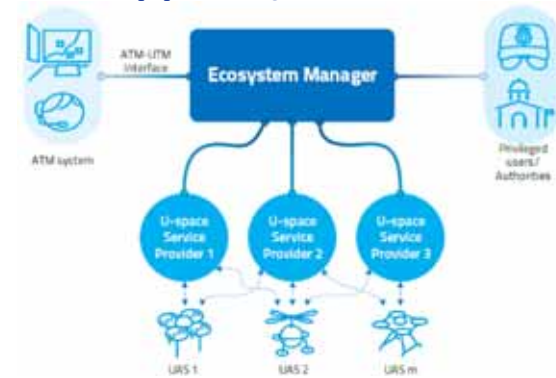
- facilitates the **orderly and efficient simultaneous operation of Multiple USPs** via:

- hosting the common core critical functionalities for the U-space community
    - providing for needed operational data exchange for all users;
    - interfacing with manned ATM system as single point of access;
    - providing for data integrity to all users as single point of truth;
    - ensuring interoperability and conformity among U-space Service Suppliers;
    - harmonizing the upgrade and entrance of new functionalities

- ensures **safety, security, privacy and secrecy of the data** down the stream

- facilitate the performance of **Governmental operations**

## The core of DOMUS (Demonstration Of Multiple U-Space Suppliers)



- USPs:
  - do serve directly to operators being their **gateway to U-space**;
  - **ensure drone operations are safely performed** according to filed flight plan drawing upon the common core critical functionalities provided by the ESM;
  - **compete each other** to offer the **most suited added value services** serving their operators by covering their specific different needs (best operation profiles, fleet management, log records,..).

## The core of DOMUS – the rationale behind

**Why** the DOMUS Federated Architecture approach:

- provides for a **central legal entity bearing responsibilities and liabilities**
- because of neutrality and hosting of critical functionalities of ESM, **USPs are guaranteed equal and fair access**;
- requires **less effort for USP certification** which do away with costly processes and access barriers thereof
- by **core investment being made by the ESM** avoids multiplication of investment and brings cost-efficiency gains to the system.



As a consequence:

- **A USP Open Competitive Market is fostered and secured for the benefit of the operators** and other U-space users, **mitigating risks for a potential scenario of dominant position** by one or more undertakings.



## DOMUS – More information in...

### Links

<https://www.sesarju.eu/node/3201>

17<sup>th</sup> Sept Demostration available @ENAI Channel (youtube)

### Contact

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**Thank you for your attention**

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