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ATM & U-Space Services to support the Urban Air Mobility Airspace Integration Challenges

Giancarlo Ferrara [*]

Innovative Air Mobility & Urban Air Mobility

- Due to the lack of a set of specific definitions at the end of 2022 EC and EASA have developed the notion of Innovative Aerial Services (IAS).
- IAS correspond to the set of operations and/or services that include both the transportation of passengers and/or cargo enabled by a new set of airborne technologies.
- IAS are further divided into "Aerial Operations" (surveillance, inspection, imaging, …), and a new emerging market called "Innovative Air Mobility" (IAM) that is including international, regional and urban air mobility.
- The concept of Innovative Air Mobility (IAM) is to accommodate operations offering a new air mobility of people and/or goods, particularly in congested (urban) areas, based on an integrated air and ground-based infrastructure.
- IAM describes a diverse array of aircraft types (such as manned and unmanned), whose designs are enabled by ongoing innovations (hybrid and electrification of propulsion systems, digitalization, automation etc.) along with the development of new airspace management constructs, operational procedures and shared services to enable an innovative type of transport network.

[*] EUROCONTROL Innovation Hub – U-space R&I Work Programme Manager.

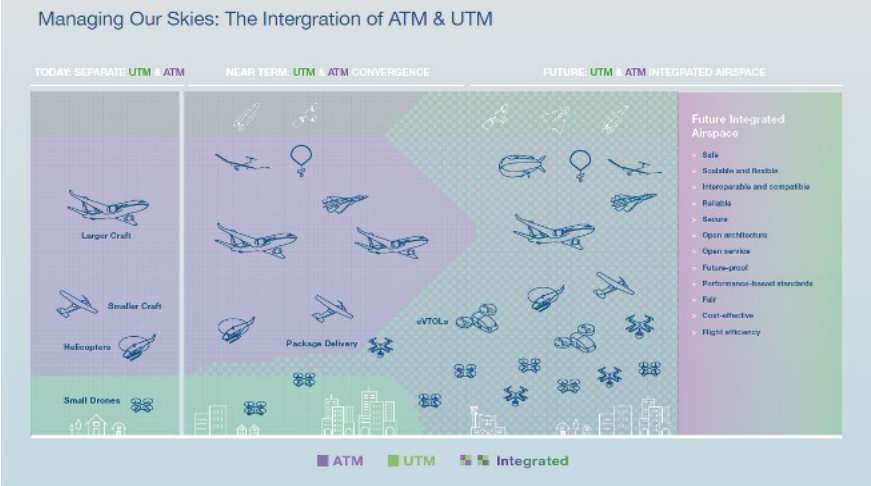
Urban Air Mobility Operations

- Urban Air Mobility (UAM) is a term used to describe an ecosystem that enables on-demand, highly automated, passenger or cargo air transportation services in scarcely populated areas as well in the more challenging and complex suburban (such as the port areas) and urban areas with vehicles ranging from small drones to passenger aircrafts.
- The UAM/AAM operations involves new vehicle designs, new system technologies, the development of new airspace management constructs, new operational procedures and shared services to enable an innovative type of transport network.
- Governments and technology companies have started to look at UAM as a viable option for the passenger and/or cargo transport.
- OEMs and startups are currently racing to deploy the first electric Vertical Take-Off and Landing (eVTOL) operations by 2025/2026.

What is Urban Air Mobility in practice?

- **Nothing new:** regional airline travel and helicopter service are current/historical forms of AAM already in service today.
- **Everything new:** electric aircraft could make AAM safer, quieter, greener, and more economical than ever before.

- **Areas of Operation:**
  - City Center
  - Suburbs to City
  - Edge City to (Edge) City
  - Rural Access
  - Hub Airport Access
- **Types of Operation:**
  - Shuttle/Cargo
  - Last Mile Delivery
  - Air Metro
  - On Demand (air taxi)
  - Airport Shuttle
  - Emergency Services



UAS/UAM Most relevant Use Cases

Goods & cargo delivery

Emergencies

Surveillance & inspections

People rescue

Medical parcel delivery

Media

Support to first aid operations

AIR TAXI

People Air Transport

Urban Air Mobility – Market Forecast

- There are a number of related R&I projects around the world already experimenting various type of services with aerial prototypes or full-scale eVTOL demonstrators.
- Meaningful innovation fuelled by a significant amount of capital investment in eVTOL prototypes and IAM/UAM services development is opening a new frontier for mobility and cargo services also connecting airports and ports with the city center as well as other relevant hubs.
- As with any mass market, the demand for IAM/UAM services - both cargo and human transport - will increase as the price becomes competitive against ground-based transport options and as consumers gain confidence and trust that relevant mobility services are safe, environmentally sustainable, convenient and efficient.
- If this happens, IAM/UAM along with relevant vertiports could become part of the smart-cities and airports/ports infrastructure and services.

Urban Air Mobility – Expectations

- The Urban Air Mobility (UAM) market is expected to grow quite rapidly during the period 2026-2035.
- The need to increase operational efficiency, reduction of human intervention for intra/intercity transportation are key factors expected to drive the market growth.

- Europe and North America are investing in these technologies and the growth of many startups and initiatives in both regions has made UAM important markets for the industry.
- UAM main operational challenges to be addressed are referring to airspace operations integration, separation management, contingency management, demand–capacity balancing, scheduling, spacing, etc.
- The initial regulations referring to the UAM industry are currently being to be published. An EU strategy has been also defined for bringing the UAM into commercial service in the next 2-4 years.

Urban Air Mobility – The Air Taxi Challenges

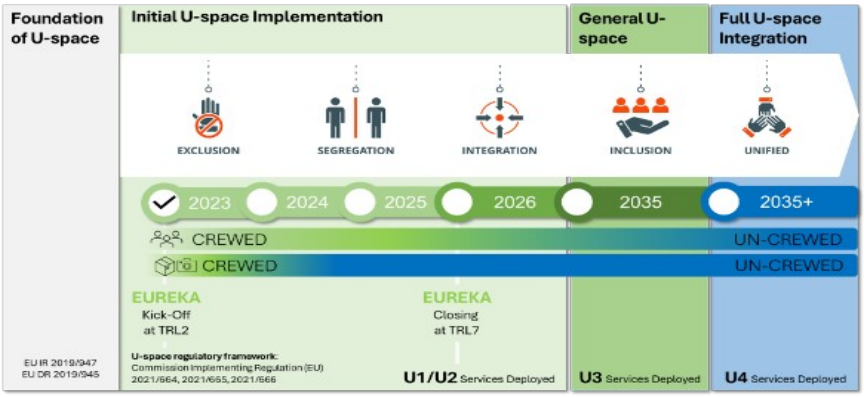
UAM includes:

- new vehicle technologies/operations
  - electric power
  - vertical take off / landing
  - GND – 6000 Ft AMSL
  - sub/intra-urban & inter urban areas
- new airspace management constructs
- new operational procedures
- High degree of automation and *"digitalization"*
  - Vehicle and relevant capabilities
  - U-space services development

The UAM challenges can only be met through:

a. An evolutionary development process
b. Advanced and interoperable U-space services (including the so called vertiports)
c. Integrated low-cost infrastructures & technologies
d. Appropriate procedures to mitigate the expected operational risks

U-space Roadmap



Urban Air Mobility & Air Taxi: Dream or Reality?

The dream

- Air Taxi operations
- Land / Take-off anywhere
    - Rooftops, Open spaces
- Rapid (no traffic jams!)
- Acceptable cost
    - Autonomous aircraft
    - eVTOL should be cheap
        - Mechanically simple
- Social acceptance
    - Low noise (?)
    - Low risk

Some realities

- Battery powered aircraft have very limited endurance.
    - This is not improving as fast as some were expecting.
    - Many recent eVTOL designs have wings
- Costs are not so low
    - Aircraft are not consumer electronics
- There is more to UAM than just vehicles

- The cost of an urban vertiport is significant
- Social acceptance is difficult

- The economics of UAM work best with no pilot on board.

UAM Infrastructures additional considerations

Existing Transportation

- What first- and last- mile connections are needed?
- How will high volume vertiports impact public transport networks?

Land use / Zoning

- What defines the area where we want to place UAM ground infrastructure?
- How do we integrate vertiports into nearby infrastructures?

Built Infrastructure

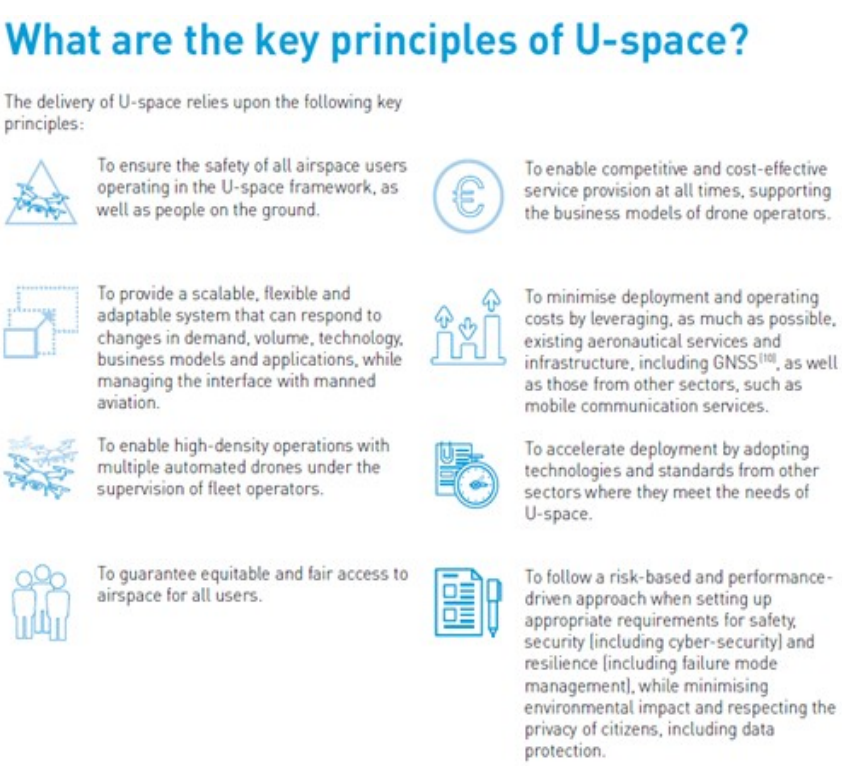
- What types of infrastructure need to be re-purposed, renovated, or redeveloped to support UAM?
- How much space do we need to accommodate eVTOL vehicles, parking, passenger facilities for future scaled operations?

Energy

- What are the anticipated forms of fuel – electricity, hydrogen, etc.?
- What capacities are needed, now and in the future, for generation, transmission and storage?

What is the U-space?

- U-space is the European term indicating the eco-system that is being developed to manage UAS and part of the UAM operations too.
- More specifically, U-space is a set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of UAS and UAM operations.
- As such, U-space is an enabling framework designed to allow a large series of simultaneous UAS/AAM missions, in the relevant classes of airspace and types of environment while addressing an appropriate interface with manned aviation and Air Traffic Control.
- The first step of establishing U-space is to define and designate U-space airspaces. These are volumes of airspace where, as a minimum, mandatory U-space services will be provided.



UAM and U-space / UTM

European Approach:

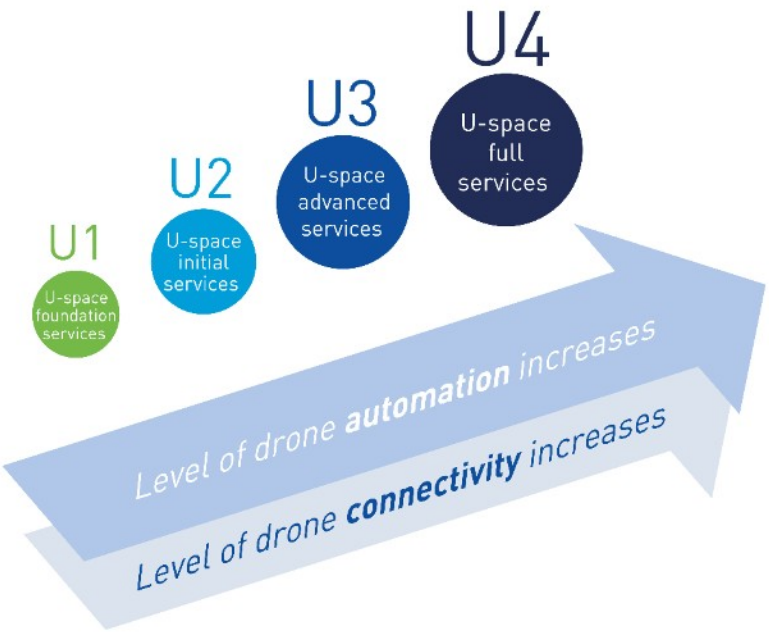
- UAM are UAS, with higher risk
- U-space can work for UAM, if built to an appropriate standard
    - Research is testing this hypothesis
- Initial operations will have pilot on board. Automation comes later.
- Initial operations could be VFR or SFVR
    - Or even IFR

American Approach:

- Advanced Air Mobility is something like the European UAM concept
    - NASA
      https://nari.arc.nasa.gov/aam-portal/
- There is yet another traffic management system
- It may turn out to be like UTM
- *but*
- Passenger carrying vehicles fly IFR
- Initial operations will have pilot on board. Automation comes later.
    - 6 UAM Maturity Levels foreseen

ATM/U-space Integrated Operations

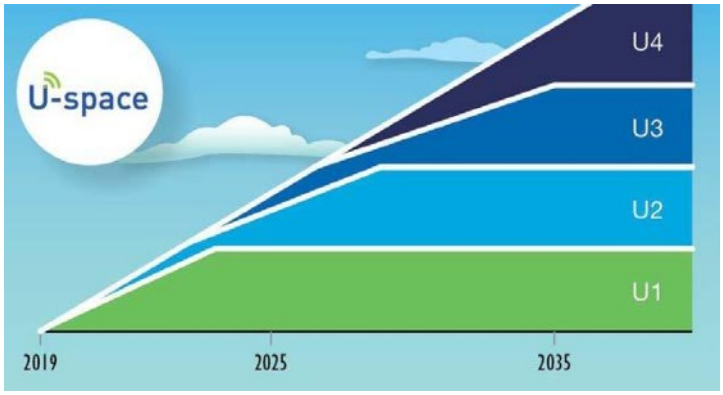
- UAM will operate in both U-space and airspace managed by traditional ATM including airspace adjacent to commercial manned aviation (e.g. airports) and sub-urban/urban areas.
- UAM operations will be also performed in an airspace where several classes of users - such as military/police, helicopters, UAS and general aviation (GA) - are already operating.
- A safe and equitable integration of current and future operations is essential especially in the urban airspace and close to airports, where traffic density and ground risk are expected to be higher.
- An evolutionary development process of innovative U-space services and the development of smart, automated, interoperable, and sustainable traffic management solutions will be key enablers for achieving this high level of integration.
- U-space shall also address a variety of constraints to meet the requirements of "priority aviation" such as security or emergency service helicopters.


U1
U-space foundation services
U2
U-space initial services
U3
U-space advanced services
U4
U-space full services
Level of drone automation increases
Level of drone connectivity increases

U-space Services and Capabilities Roadmap

- The SESAR R&D and VLD projects completed recently demonstrated the U-space services required for U1 and U2 as described in the SESAR Consolidated SESAR U-space R&D results document.

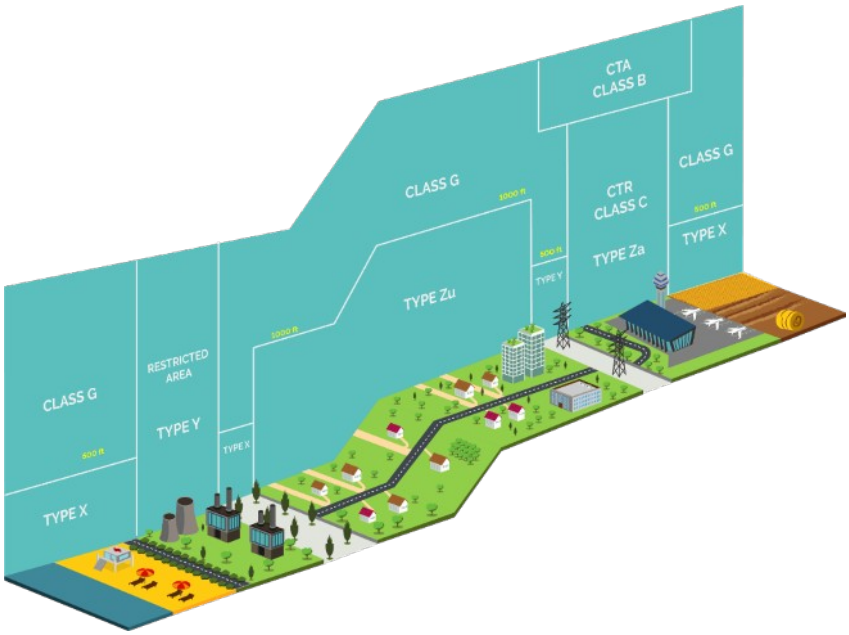
- Further developing and maturing the required U3 and U4 services is the focus of the next SESAR activities as well as the recently S3 ER02 projects.
- Further R&I is needed to deploy U-space services and UAM operations in areas of high complexity, high traffic density and integrated with manned aviation.



The initial set of U-space Services for UAS/UAM

U-space Airspace Types (ConOps Ed. 3 & 4)

1.1 Focus on Very Low Level
1.2 All VLL is divided into
1.3 X, Y and Z volumes
1.4 **X** = low risk
1.5 **Y** = higher risk
1.5.1 Access only with approved operation plan
1.5.2 Specific technical requirements per volume
1.6 **Z** = highest risk
1.6.1 Access only with approved operation plan
1.6.2 Za = ATC controlled airspace
1.6.3 Zu under U-space



Airspace Volumes and Conflict Resolution

X = not a geographic zone as per 2019/947:
No conflict resolution service
Enables VLOS
Pilot remains responsible to remain well clear
Y = **U-space Airspace** as 2021/664,5,6:
Approved flight plan required for all flights
Conflict resolution before take off
Position reporting required "Network Identification"
Information given to pilot during flight
Geo-awareness
Traffic information
Conformance Monitoring
Weather

Z *not currently mentioned in EU law*
Conflict resolution before flight **and** in flight
Requires tracking
Separation 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 could provide conflict resolution during flight, from the ground

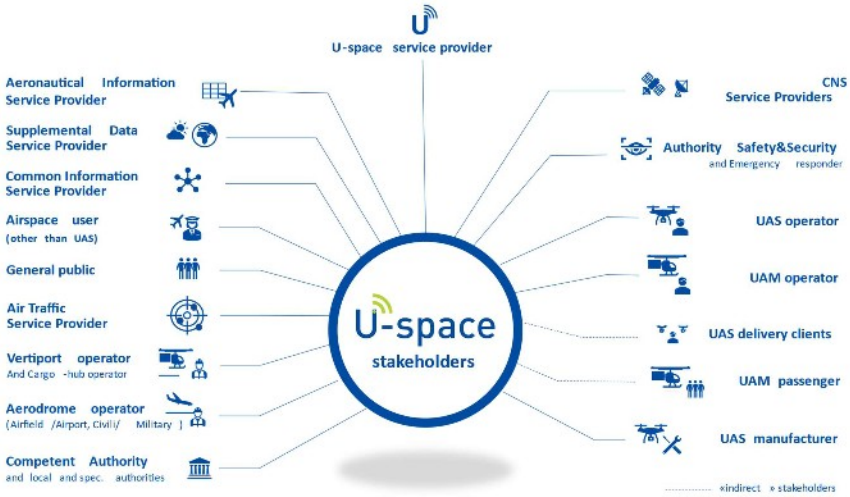
Note: Reg. 2019/947 does not refer to U-space services while the Reg. 2021/664 refers to some U-space services for sUAS operators. Further work will be required to develop the set of the U4 Full Services in parallel with the evolution of the relevant requirements and operations demand.

ATM/U-space Integrated Concept of Operations

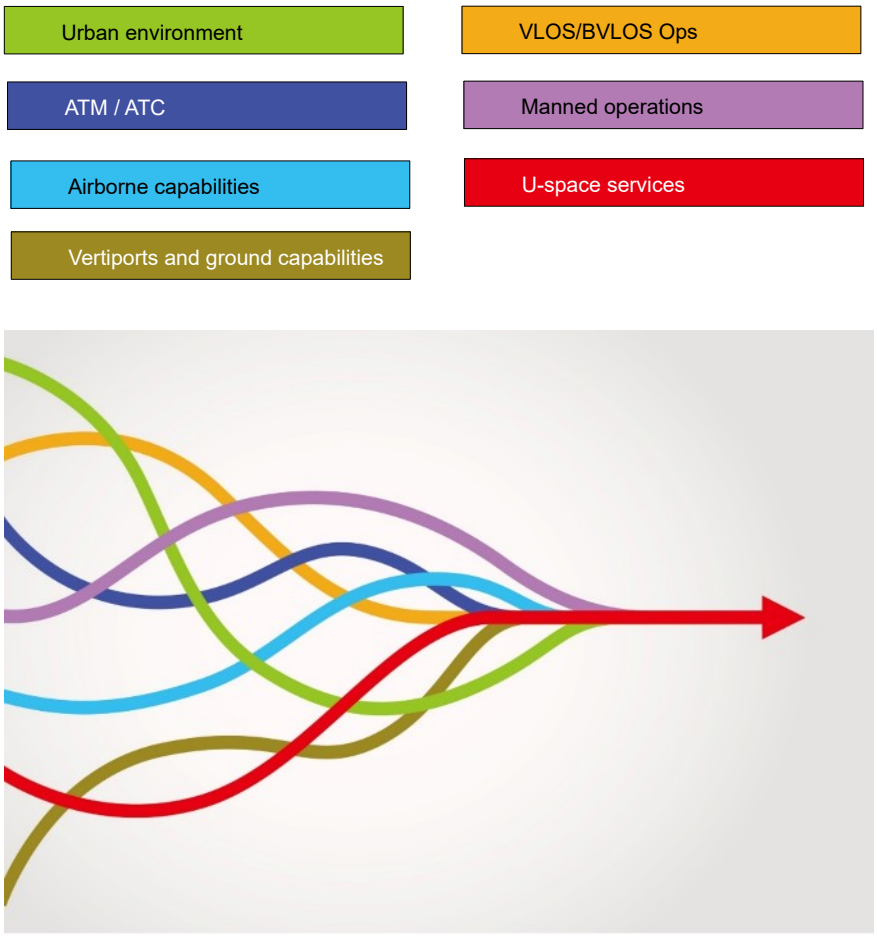
- The U-space ConOps must enable the safe integration of UAM and UAS into airspace managed by U-space and Air Traffic Control and alongside manned aviation operations.
- UAM is including some of the most demanding / challenging use cases for U-space services and capabilities and it will require an extensive set of R&I and validation activities before its deployment.
- To meet this challenge, integrated flight operations of both unmanned and manned aircraft shall be demonstrated / validated along with advanced forms of ATM/U-space interaction through digital information and data exchange.
- It should be particularly explored how to ensure a proper interface with ATM/ANS (Air Navigation Services), with a particular focus on airport scenarios, as well as with all relevant airspace operations.

USPs and U-space Services

- The U-space services within the U-space airspace are provided by U-space service providers (USPs).
- Unlike the provision of ATC service where only one provider can be responsible for a particular volume of airspace, there may be multiple U-space service providers serving the same U-space airspace.
- U-space service providers must:
  - establish arrangements with the ATS providers to ensure adequate coordination of activities and exchange of relevant operational data.
  - exchange any information that is relevant for the safe provision of U-space services amongst themselves.
  - handle air traffic data without discrimination.



Current Research & Innovation Focus



- Advanced services
- Urban Air Mobility
- U-space & ATM Interoperability

U-space and AAM R&D/VLD on-going activities

- U-space overview & consolidated R&D results can be found at
  https://www.sesarju.eu/U-space
- In 2021 SESAR launched ten additional projects to address AAM/UAM airspace integration enabled by U-space services. Further U-space R&I looking at enabling UAM integrated operations is currently going to be concluded soon:
  - PJ34 – AURA (IR project on interfacing U-space and ATM),
  - DACUS (U-space Demand Capacity Balancing),
  - BUBBLES (U-space Separation Management Services),
  - ICARUS (U-space Common Altitude Reference System).
- In parallel, six Very Large Demonstrations were launched on how to integrate UAM operations in various scenarios:
  - CORUS-XUAM (www.corus-xuam.eu),
  - SAFIR-MED (https://www.safir-med.eu/),
  - GOF-2 (https://gof2.eu/project/),
  - AMU-LED (https://amuledproject.eu/),
  - TINDAIR (https://tindair.eu/),
  - U-space4UAM
    (https://www.sesarju.eu/node/3760).

A flight rule for U-space and UAM

- ICAO airspace classes A to G are defined in terms of flight rules and services.
- UAS in U-space are not currently considered as flying any of VFR, SVFR, IFR. Due to this
    - U-space airspace is a sort of restricted area for the manned aviation
    - UAS cannot fly among VFR, SVFR or IFR flights
- In order to have integration, we need to either:
    - Fly UAS/UAM following an existing flight rule
    - Devise new flight rule for UAS/UAM and understand how manned aircraft can fly it or fly with it.
    - We are working on the idea of a new flight rule. Two approaches look promising
    - VFR – like: with U-space providing situational awareness to UAS/UAM and supporting visual situation awareness for manned aircraft
    - IFR – like: UAM with different equipment carriage requirements and U-space providing a separation service.