

GARTEUR 50th Anniversary

UAM Exploratory Group plan

by

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Outline of the presentation

- What is UAM ?
- Why UAM ?
- UAM Conditions
- Aircraft for AAM/UAM
- UAM Challenges
- UAM Activities within GARTEUR
- Proposal for a multidisciplinary project

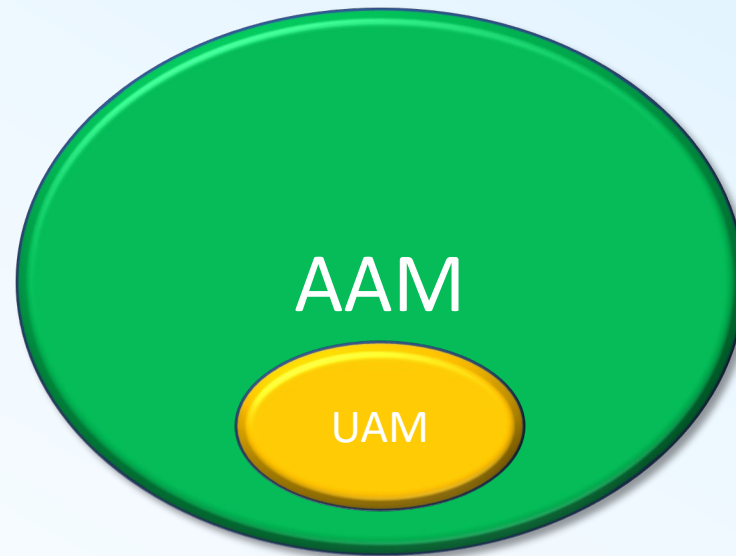
What is Urban Air Mobility (UAM) ?

- **EASA vision (EU):** UAM is *“an air transportation system for passengers and cargo in and around urban environments.”*
- **UIC2* vision (EU):** UAM is *“Very-low altitude airborne traffic, above populated areas, at scale, that is sustainably integrated with surface mobility systems.”*
- **FAA vision (US):** *“Urban Air Mobility (UAM) envisions a safe and efficient aviation transportation system that will use highly automated aircraft that will operate and transport passengers or cargo at lower altitudes within urban and suburban areas. UAM will be composed of an ecosystem that considers the evolution and safety of the aircraft, the framework for operation, access to airspace, infrastructure development, and community engagement.”*
- **NASA vision (US):** *“Our vision of UAM is a safe, efficient, convenient, affordable, and accessible air transportation system for passengers and cargo that revolutionizes mobility around metropolitan areas. This vision includes everything from small package delivery drones to passenger-carrying air taxis that operate above populated areas.”*

* UAM Initiative Cities Community

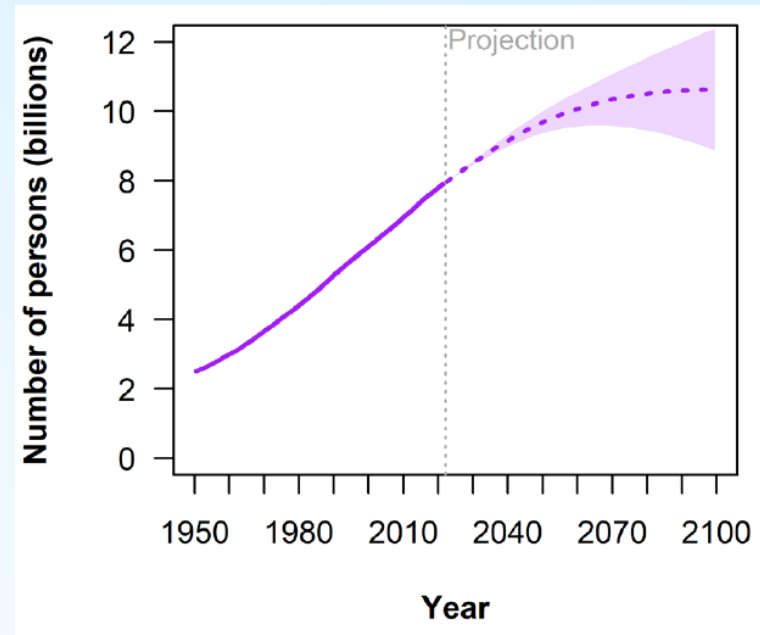
AAM vs UAM

- The term AAM (Advanced Air Mobility) is also in common use. With respect to UAM, it extends the aerial missions to urban, regional and interregional areas
- As such, UAM can be regarded as a subset of AAM. It covers aerial missions in and around urban environments



Why UAM ?

- The number of persons living on the planet Earth is increasingly growing. Recent projections of the United Nations estimate a global population of 10 billion persons in 2050, 70% of which living in big, highly congested cities
- Cities and metropolitan areas are powerhouses of economic growth contributing about 60% of global gross domestic product (GDP). However, they also account for about 70% of global carbon emissions and over 60 per cent of resource use, thus representing a threat to a sustainable way of life



United Nations: World Population Prospects 2022

Why UAM ?

- Smart living, or enhanced quality of life, includes mobility services that contribute to citizen's welfare in a sustainable manner.
- UAM is a transportation system which aims at overcoming these problems by making use of the largely untapped low-altitude air space above urban landscapes, and by using electric propulsion that is safer, cleaner, and quieter than conventional engines.
- Urban Air Mobility (UAM) is expected to create environmental benefits as well as advantages for citizen and businesses – related to commercial as well as emergency use cases



UAM conditions

- UAM is a complex system demanding the simultaneous fulfilment of a set of conditions, intimately interconnected, to guarantee its successful implementation (“**Market Viability**”)

Sustainable

Accessible

Affordable

Societal acceptable

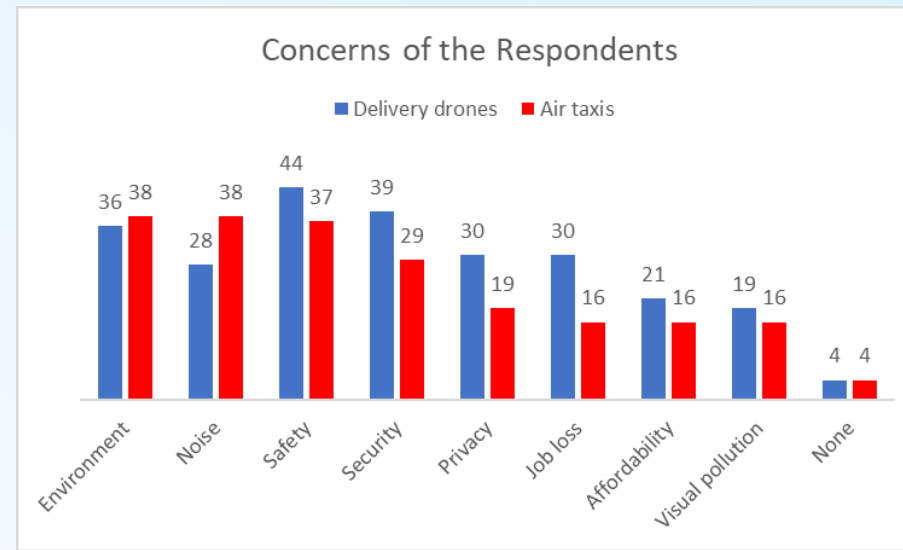
Efficient

Safe & Secure

UAM Societal acceptability


- UAM relates to the passengers and cargo mobility and is implemented in three different use cases. Societal acceptability ranks the usefulness of UAM use cases as follows:
 - Emergency (mainly medical) use cases
 - Drone delivery of supplies, groceries and goods
 - Passenger transport

- The overall results were reported for the following 9 main concerns:



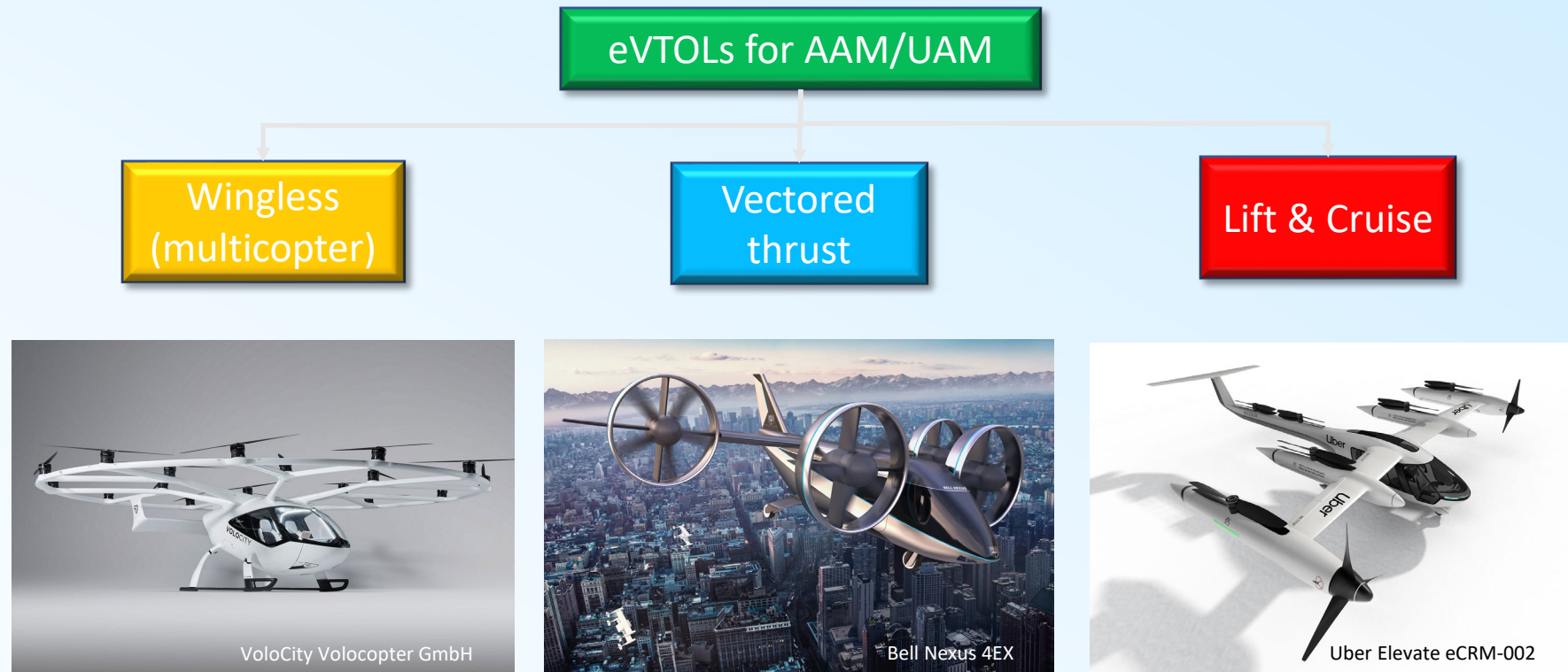
EASA - Study on the societal acceptance of Urban Air Mobility in Europe," May 2021

Aircraft for AAM/UAM missions - 1

- UAM missions are carried out in and around urban environments, which can be considered as confined areas, i.e. regions of space where the flightpath is limited in some directions by the presence of obstacles.
- This implies that the aircraft must take-off and land vertically (Runway Independent Aircraft – RIA). In addition, capabilities of hovering flight are required.
- For these reasons, the aircraft must be of a rotary-wing category, i.e. a rotorcraft
- The use of an electric propulsion system is required for sustainability reasons. It is also more flexible as it can be integrated with the propeller or airframe structures. It also enables distributed electrical propulsion, which opens up new system configurations for lower noise, greater efficiency and improved safety.
- The UAM aircraft must be lightweight, having low mechanical complexity, low-noise, efficient  conventional helicopters are excluded

Aircraft for AAM/UAM missions - 2

- This category of aircraft is called eVTOL and can have different configurations, which are categorized as:



Aircraft for AAM/UAM missions - 2

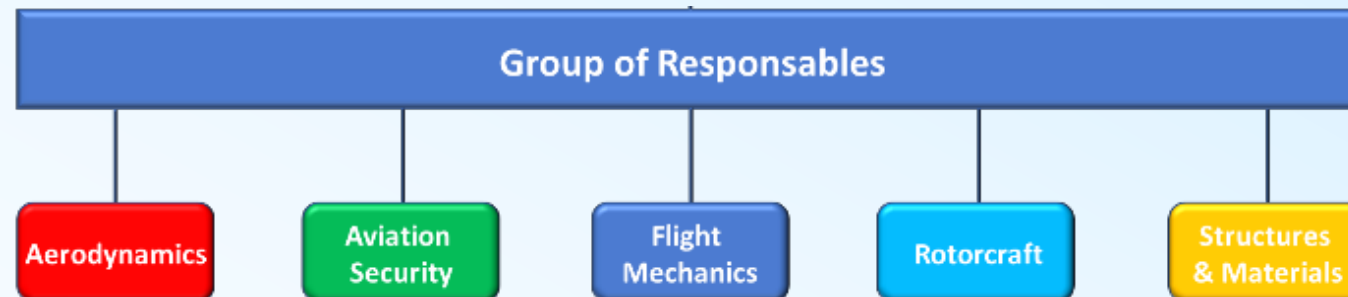
- The selection of the suitable configuration depends on several factors:
 - Mission: UAM/AAM intra-city, inter-city, regional,
 - Use case: Emergency; Cargo transport; Passenger transport
- **Vectored thrust** architecture is better suited to longer-distance flights, as the system is more efficient but more complex than the other concepts
 - ➔ Best suited for Passenger transport (e.g. Air Taxi)
- **Lift & Cruise** architecture is suited to shorter distance flights than vectored thrust, but to longer distances than wingless. It is potentially easier to certify than vectored thrust because the propulsion systems are separate
 - ➔ Best suited for Cargo transport (e.g. Deliveries)
- **Wingless multicopter** architecture offers the shortest flight distances and is overall the simplest concept, as it is avoiding any unnecessary movable parts.
 - ➔ Best suited for Emergencies (e.g. Medical, Firefighting, etc.)

UAM challenges

- Technological Advances: Aircraft; Propulsion system: Energy storage (Batteries, Hydrogen (Fuel-cell)); Autonomous flight (sensors, AI); Connectivity; GNC
- Infrastructures: Digital (for UTM); physical (Vertiports, Service stations, Distribution hubs, etc.)
- Societal acceptance
- Certification, Regulatory requirements
- Air Traffic management

UAM Activities within GARTEUR

- Not all UAM-related activities can be carried out within GARTEUR.
- Only those:
 - Low TRL (1-3) numerical & experimental activities
 - Self funded
 - Technological aspects, mainly platform-oriented (Rotorcraft), related to the competences of the five Group of Responsables:



RC GoR-related UAM activities

TOPIC	UAM CONDITION
Interactional aerodynamics of multirotor configurations (AG25);	Efficiency; Sustainability; Safety
Aeroacoustics of multirotor configurations (AG26)	Sustainability; Public Acceptance
Gust resilience of VTOL aircraft (EG40);	Safety
Vortex Ring State (NI);	Safety
Icing & De-icing (NI);	Safety, Sustainability
Noise propagation in urban environment	Public Acceptance

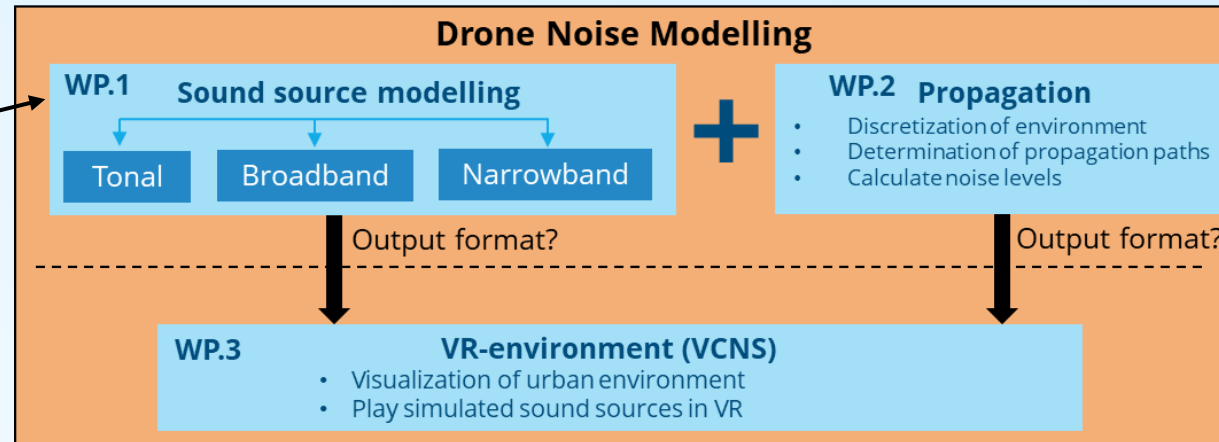
SM GoR-related UAM activities

TOPIC	UAM CONDITION
Characterization and optimization of shock absorbers for industrial applications: crashworthiness of UAM/AAM configurations (AG37)	Safety
Noise reducing structures (e.g. shielding concepts) and silent rotor blades.	Sustainability; Public Acceptance

UAM Activities within GARTEUR

Aeroacoustics of multirotor configurations (AG26)

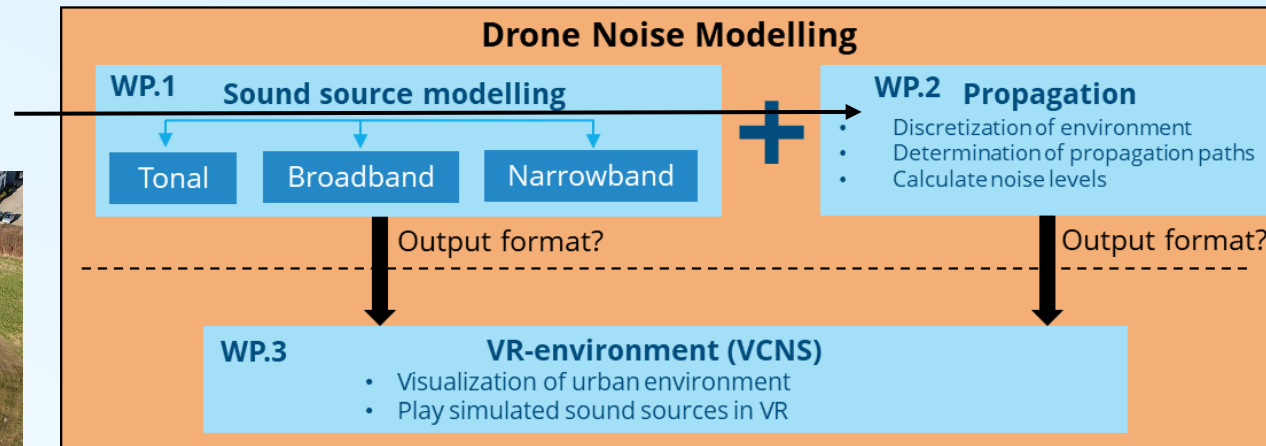
The DJI Matrice 600 is chosen as case study



UAM Activities within GARTEUR

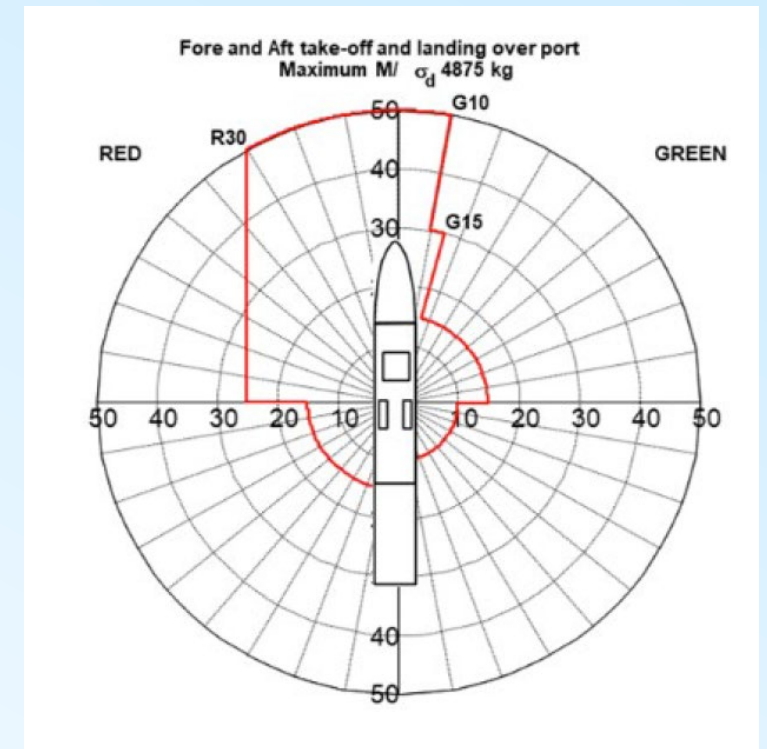
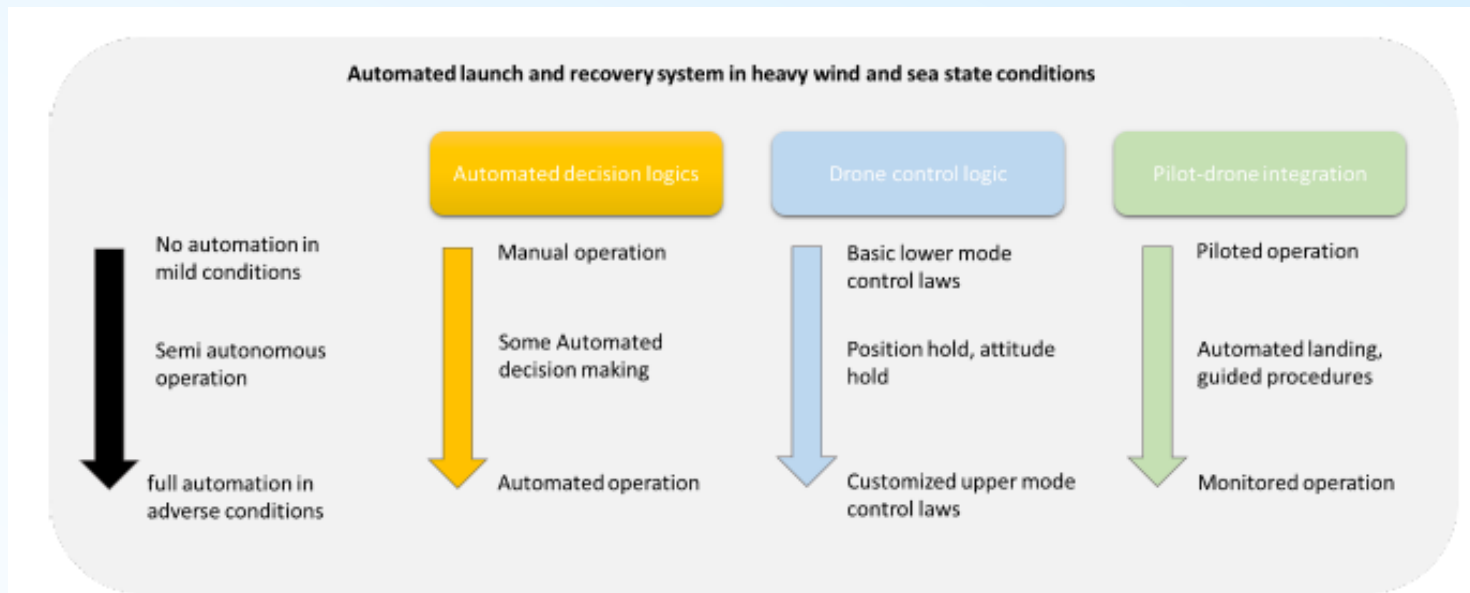
Noise propagation in urban environment

As case study the DigiCity at NLR is selected



UAM Activities within GARTEUR

Gust resilience of VTOL aircraft (EG40)



In-flight icing on UAM

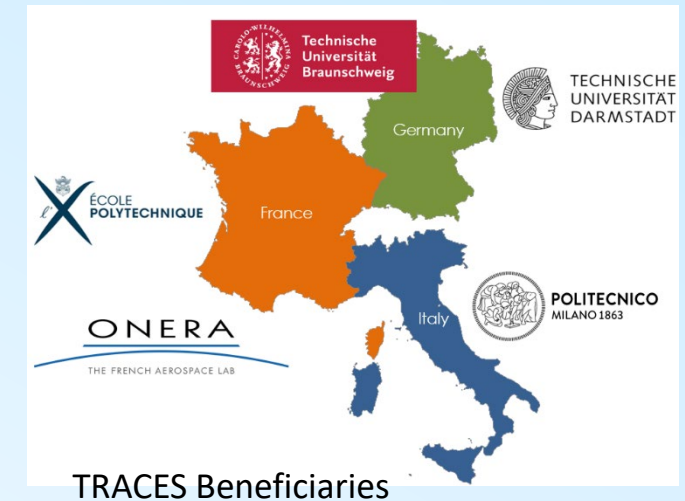
- Low altitude (< 3000 m), higher probability of supercooled water droplets and snow
- **Glaze** ice for T just below T_{freezing} -> thrust reduction
- Low Reynolds, low rotational speed, ducted structures -> severe accretion, no shedding
- Smaller and lighter vehicles more susceptible to drastic **performance losses**
- Adverse snow and ice conditions during a **non-negligible flight time**
- **Limited power** available for anti or de-icing systems
- Icing avoiding strategy: **grounding** or mission-path modification
- **Certification**: regulation gap, high cost

Numerical methods for better performance degradation predictions, more efficient IPS design, and virtual certification

In-flight icing research at DAER-PoliMi

TRACES: TRAINing the next generation iCE researchers

- MSCA DN 2021, with PoliMi as coordinator
- Deliver a new generation of high-achieving DRs in the diverse disciplines necessary for mastering the complexity of ice accretion and its mitigation
- Combination of hands-on research training, non-academic placements at major EU aviation industries, courses, and workshops on scientific and soft skills
- **Team Design & Certify exercise**, assessed by EASA and FAA.



<https://traces-project.eu/>

In-flight icing on UAM at DAER-Polimi

- Numerical simulations of ice accretion on UAM geometry
- Validation of simulation tools as a means of compliance for the certification of UAM in icing conditions
- Virtual certification tools and procedures for in-flight ice accretion and IPS
- Robust design of a multi-level ice detection system based on acoustic signature
- Robust design of a 3D thermal ice protection system
- Multi-physics simulation of electro-mechanical de-icing system

Transfer the expertise in numerical simulation of ice accretion on helicopter rotors and tailor icing prediction tools to UAM vehicles



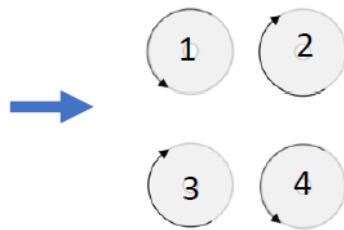
A possible multidisciplinary project



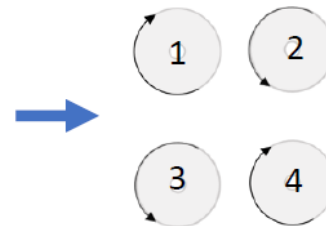
Whirl flutter

- Aircraft FEM model required
- Analysis of the whirl flutter induced by different propeller layouts such as, for example:
 - single propeller vs coaxial propellers for each arm of the quadrotor configuration;
 - Bearhug vs breaststroke configuration

2) Square bearhug front



3) Square breaststroke front

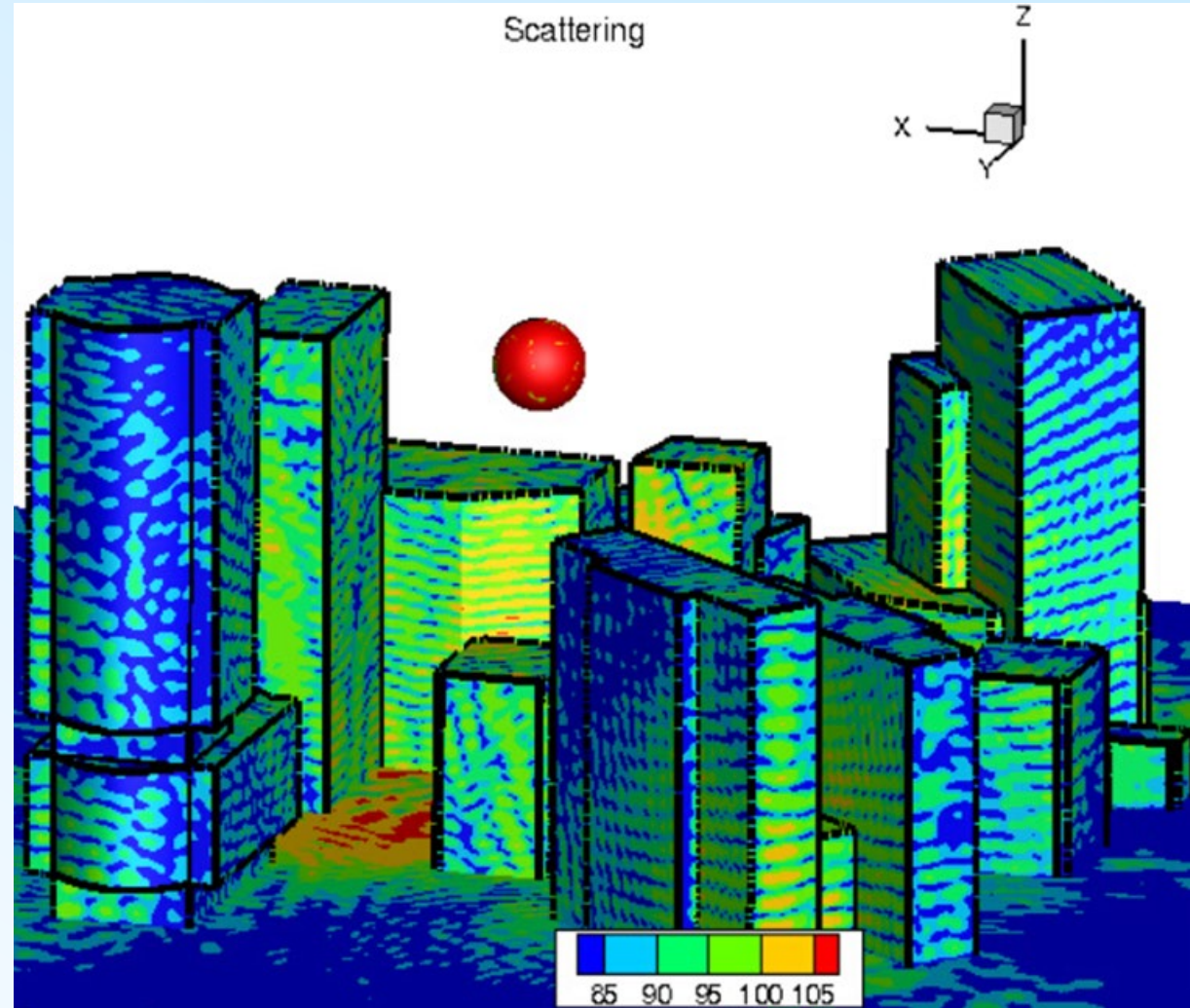


Noise near field

- Effect on noise of the different quadrotor configurations
- Effect of the application of noise reducing structures
- Effect of the application of materials/layouts for silent propeller blades

Noise scattering

- The idea is to have $N > 1$ aircraft (red ball) in the same flight conditions but at different altitudes and flight direction
- To evaluate the aggregate contribution of the building scattered aircraft noise propagation to ground



Thank You for
your
attention