The Challenges of an Open Access UTM

by

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Outline

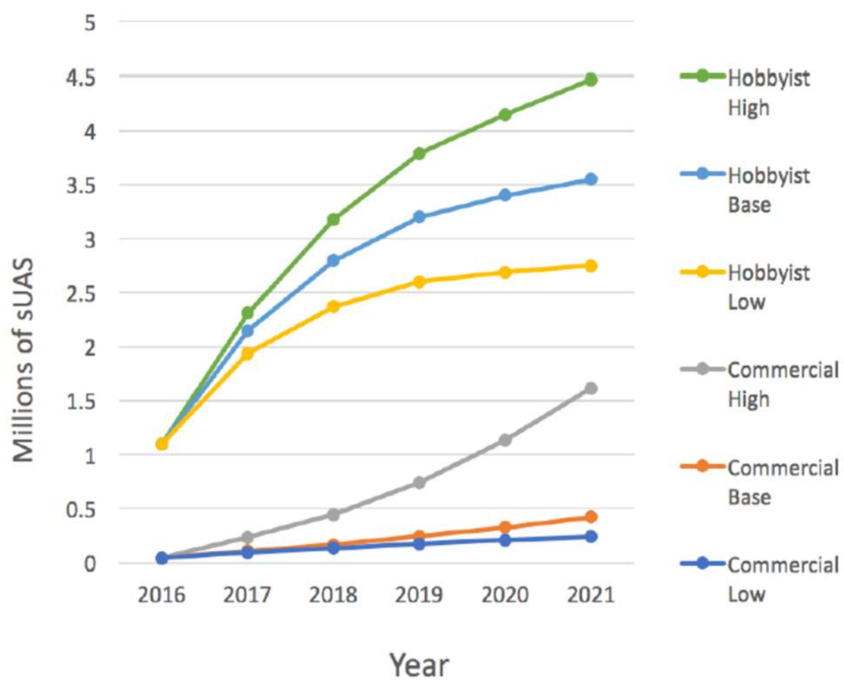
- The UTM definition and architecture;
- Worldwide activities;
- Issues and Solutions for Open Access UTM;
- Conclusion.

Definition and Architecture

- UTM definition and need
- UTM Architecture
- Main Concerns

UTM definition

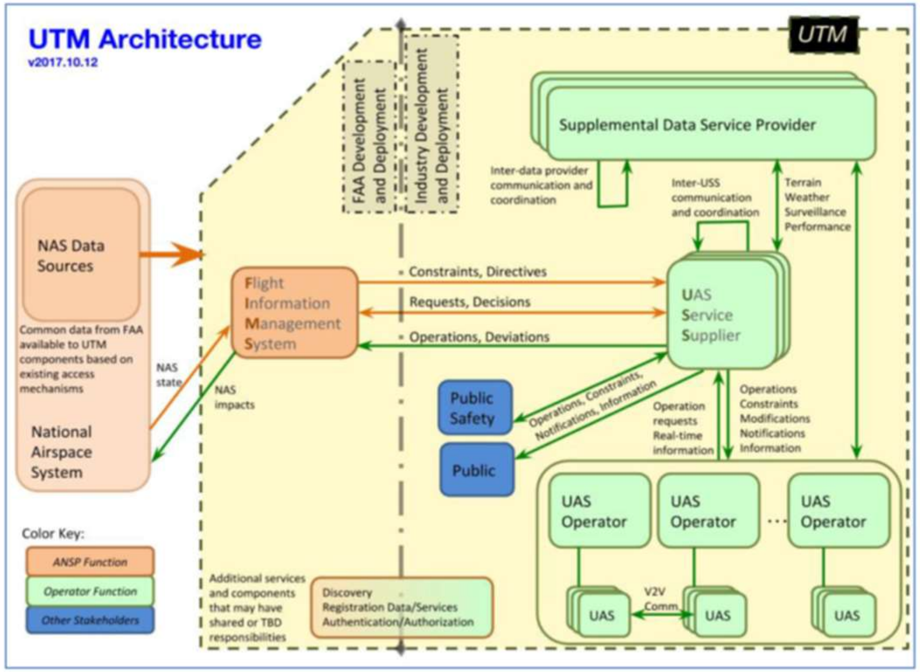
- Unmanned Traffic Management UTM is “a set of federated services and an all-encompassing framework for managing multiple UAS operations at Very Low-Altitude Level (class G airspace below 400ft AGL in low populated areas and 1000ft AGL in cities).” (NASA UTM Conops v1.0, 2018, CORUS Conops, 2018);
- UTM would not require human operators to monitor every vehicle continuously. The system could provide to human managers the data to make strategic decisions related to initiation, continuation, and termination of airspace operations.
- Need for UTM is determined by the large increase in UAS systems expected in next years (see figure);



Source: NASA UTM Conops v.1.0

UTM Architecture from ConOps

- Guideline to develop UTM services (NASA UTM Conops, 2018):
  - Safety;
  - Security;
  - Equity.
- Operators ask for Performance Authorization to authorities;
- Level of authorization depends on the level of capabilities of UAS onboard equipment;
- The capability to be Open Access means that each user can access within a short time since it decided to fly by performing a digital agreement of flight plan with UTM management system.



Source: NASA UTM Conops v.1.0

Main Concerns about Open Access UTM

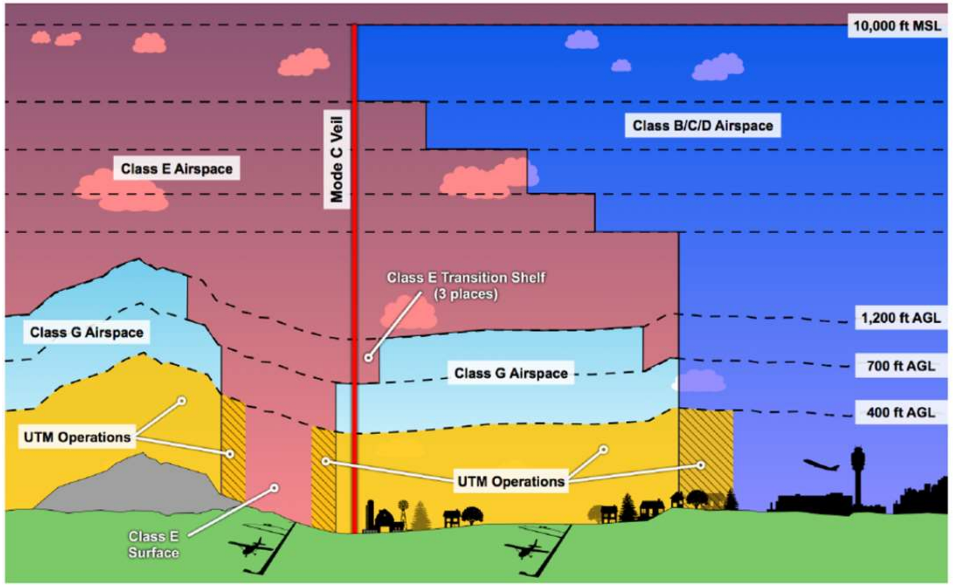
- Safety of people, living beings, and objects;
- Safety of Conventional Air Traffic;
- Privacy;
- Environmental impact (noise, plastic parts, batteries).

Worldwide Activities

- USA;
- European Union;
- UK;
- Japan;

UTM Worldwide Development (1/2)

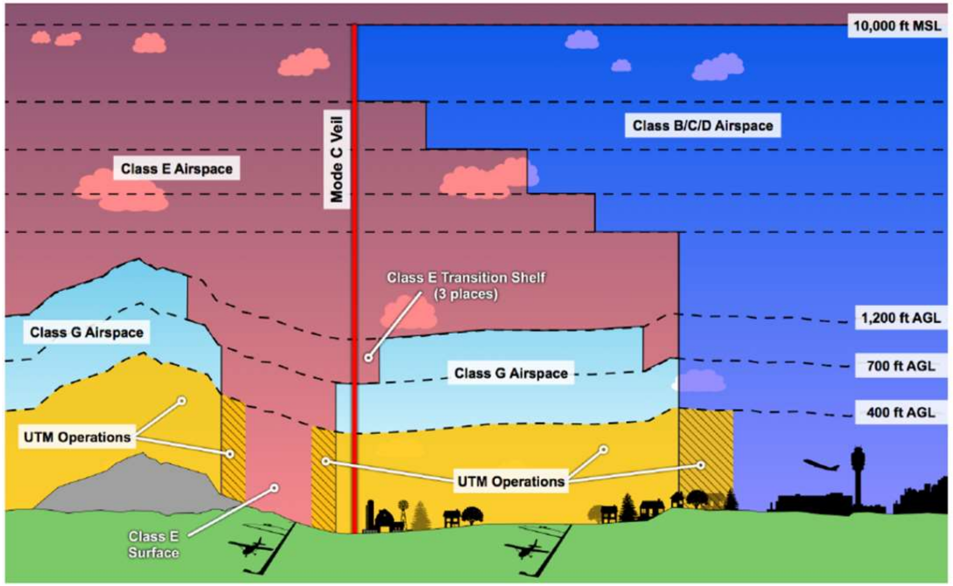
- US
  - Original UTM developer;
  - Owner: NASA on behalf of FAA;
  - Project name: UTM;
  - Status
    - Conops v.1.0 released;
    - Demonstration up to TCL 3 completed (TCL 4 ongoing).
- European Union
  - Owner: Eurocontrol on behalf of European Commission;
  - Project name: U-Space (within SESAR2020);
  - Status
    - Draft Conops released (Corus project);
    - No coordinated demonstration plan developed (single projects).



Source: NASA UTM Conops v.1.0

UTM Worldwide Development (2/2)

- UK
  - Operation Zenith supported by NATS. Demonstration of feasibility of UAS airspace integration by developing eight reference scenarios.
- Japan
  - Aerial Industrial Revolution project owned by JAXA on behalf of Japan Civil Aviation Bureau;
  - Large experience from unmanned helicopters used for agriculture;
  - Focus on packet delivery;
  - Important cooperation with US NASA UTM.



Source: NASA UTM Conops v.1.0

Issues and Solutions for Open Access UTM

- Authentication
- Geofencing
- CNS –BVLOS operation in GPS impaired conditions
- See and Avoid – Manage fixed and in motion obstacles
- Wind and Weather Conditions Management
- Management of flight termination for nominal and contingency conditions
- Interaction with ATC and VFR
- Availability of Reliable Aircraft

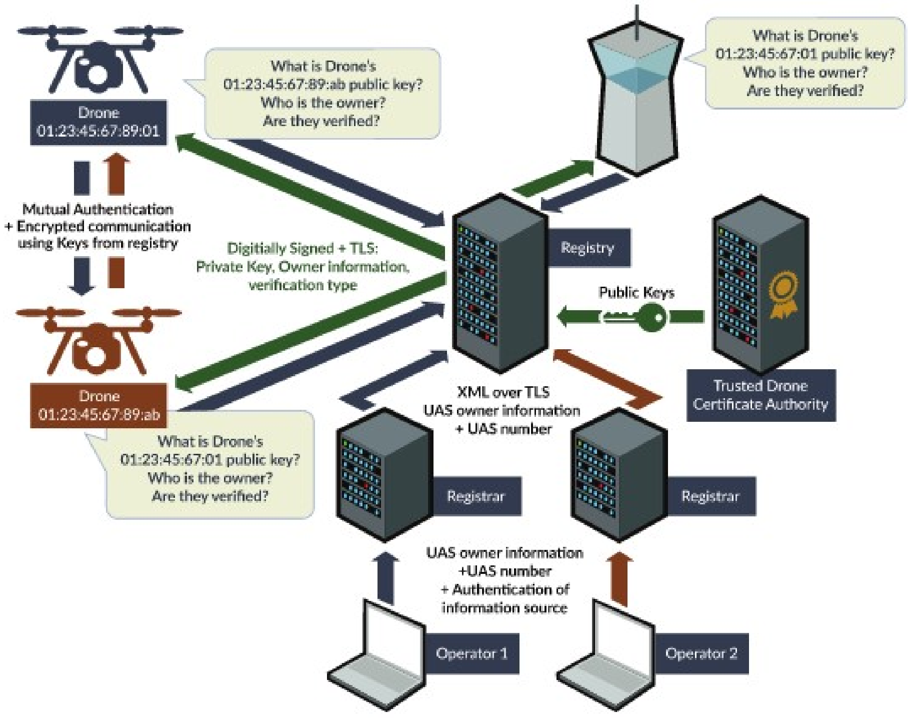
Authentication

Issues

- Authentication is the “entrance” to UTM system, UAS shall be securely authenticated during mission in order to provide identification feature to UTM for tactical level orders;
- Proper digital flight plan authorization shall be granted by UTM before flight. Authentication will allow for real-time identification of unauthorized or rogue UAS. It will reduce the risk that hackers take control of UAS;
- UAS shall be equipped with transponder-like equipment to allow automatic authentication process with UTM. UTM shall have the capability to transmit digital orders to UAS and receive digital reports;
- Authentication will be used also to define the level of authorization for drone flight standing the capabilities of onboard equipment. Orders shall be executed by manual and automatic control;
- Automatic authentication will allow for real-time Open Access to UTM

Solution

- Protocol layer: use cryptography and certificates to provide proper authentication and identification process.
- Communication Network layer: 5G and WiMax are considered as proper means of communications with UTM system because of their intrinsic reduced latency.



Source: DIY drones

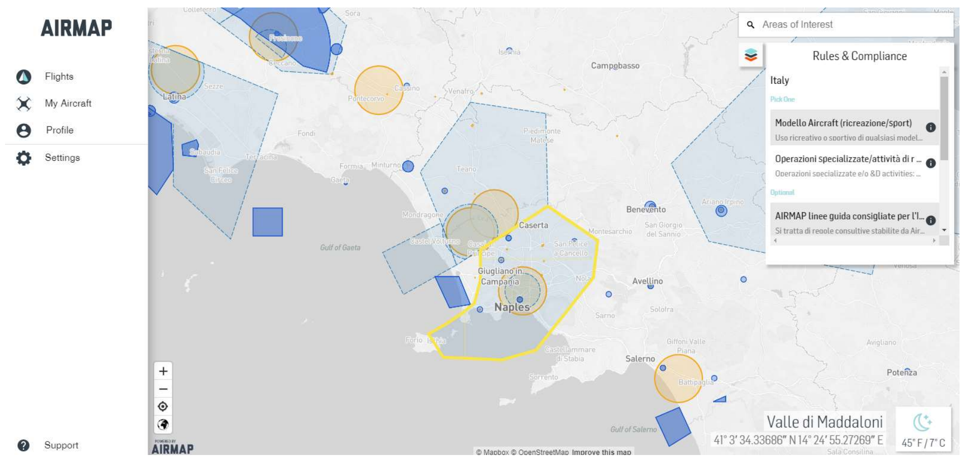
Geo-fencing

Issues

- This function is carried out by comparing the planned UAS trajectory with digital maps that identify NOTAMs and any type of forbidden volumes for UAS operation;
- Two levels of geo-fencing functions shall be provided by UAS
    - Strategic level geo-fencing that can be performed before flight is executed;
    - Tactical level geo-fencing that can be performed after flight is executed.
- UAS operated BVLOS shall be provided with autonomous tactical level geo-fencing capabilities.

Solutions

- Need for onboard processing space for real-time 3D geo-fencing map update;
- Efficient UAS trajectory control management to prevent violation of boundaries.



Source: Airmap

CNS

Issues

- The UTM will need persistent communication, navigation, and surveillance (CNS) coverage to ensure monitoring conformance to the constraints.
- Operation BVLOS in urban conditions is the most challenging task. Challenge is handling GPS impaired conditions;

Solutions

- Communications
  - C2 link with remote pilot
    - 2.4 GHz – 5.8 GHz ISM for LOS operation;
    - 5G for BVLOS (5G has reduced latency with respect to 4G/LTE).
  - Payload data link;
  - UTM data link to transmit reports and receive orders;
  - VTV data link with UAS traffic and other forms of traffic to transmit proximity information.
- Navigation
  - Multi sensor integration including MEMS based inertial unit, visual cameras, air data, magnetometer;
  - Need for integrity, i.e. proper error distribution models and integrity figure of merit shall be developed.
- Surveillance
  - Cooperative surveillance
    - Infrastructure derived traffic data;
    - VTV traffic information;
    - ADS-B air traffic information;
  - Non-cooperative surveillance
    - Visual cameras;
    - Small microwave systems.

See and avoid

Issues

- See and avoid is considered the last barrier before a collision is determined. It is equivalent to the capability of an human pilot onboard to avoid collision after visual detection of an intruder.
- Several types of collisions shall be prevented
  - Other UAS flying;
  - Fixed obstacles;
  - Other forms of transport systems, including aircraft flying in standard airspace;
  - Terrain;
  - Humans and other living creatures.

Solutions

- Sensing solutions available
  - Visual and IR cameras;
  - Small microwave systems;
  - Acoustic sensors;
  - Support from ground and airborne observers;
  - VTV cooperative information.
- Efficient data fusion framework shall be developed to derive the best assessment of collision threat.

Trajectory and separation management

Issue

- Provide trajectory and separation management to avoid congestion.

Solutions

- Trajectory management
  - Define trajectory at strategic level, i.e. flight plan;
  - Update trajectory at tactical level;
  - Trajectory prediction to assess future risk of separation violation. Proper models are needed such as the one provided by Eurocontrols'BADA^{TM} for ATM.
- Separation management
  - Perform surveillance of traffic;
  - Evaluate risk of separation violation within next 10 minutes (CORUS Conops, 2018);
  - Transmit trajectory update orders to skip separation violation.

Wind and Weather Conditions Management

Issues

- UAS shall be provided with information to terminate flight in case of wind and weather conditions will overcome pre-defined minimum acceptable level of operation;
- Wind and weather conditions must be properly monitored in real-time by UTM infrastructure. Winds in “urban canyons” are a primary source of interest (CORUS Conops, 2018);

Solutions

- Accurate forecast must be provided to allow for prompt and timely realization of countermeasures. Typical time frames are 1 hour and 15 minutes;
- Wind conditions can be autonomously estimated by onboard UAS systems in order to provide real-time high-resolution redundant estimates with respect to the ones provided by UTM infrastructure.

Management of flight termination for nominal and contingency conditions

Issue

- Provide safe termination for nominal and contingency operation

Solutions

- Flight termination for nominal conditions
  - Generate maps of UAS landing areas;
  - Update landing area status in case of unavailability;
  - Define take-off, approach and landing procedures.
- Flight termination for contingency conditions
  - Define criteria to select contingency landing sites;
  - Define models for real-time assessment of the spatial distribution for risk of crash;
  - Identify failure modes and relevant recovery strategies.

Other Issues

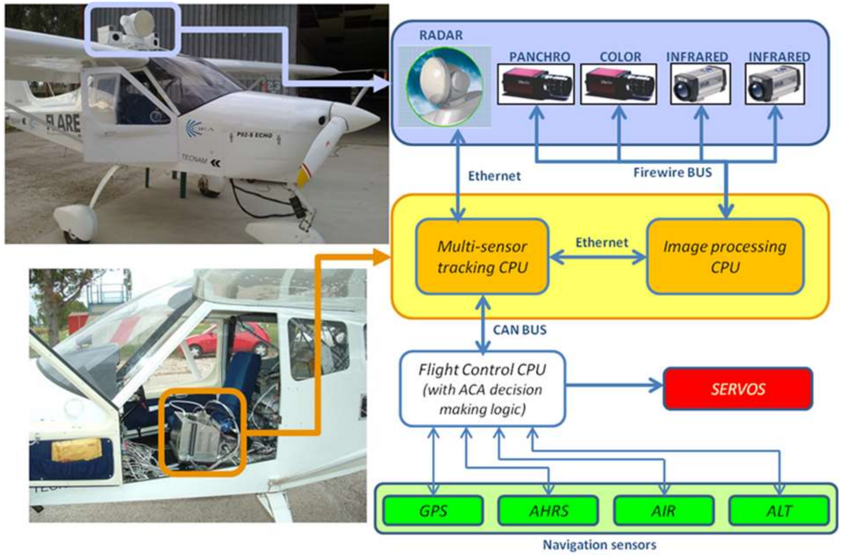
- Interaction with ATC and VFR
  - Some aircraft can penetrate UTM volume, such as helicopters used for emergencies;
  - High-level drones shall be equipped at least with ADS-B In enabled receivers to detect aircraft incoming and generate proper evasive manoeuvres, including fast landing.
- Interaction with wildlife
  - Negative interactions with birds shall be prevented.
- Availability of Reliable Aircraft
  - As impact kinetic energy risk increases, drones shall be manufactured taking into account manufacturing processes and component that ensure proper levels of reliability, such as it happens for standard aviation systems.

UTM-related Research Projects at UNINA

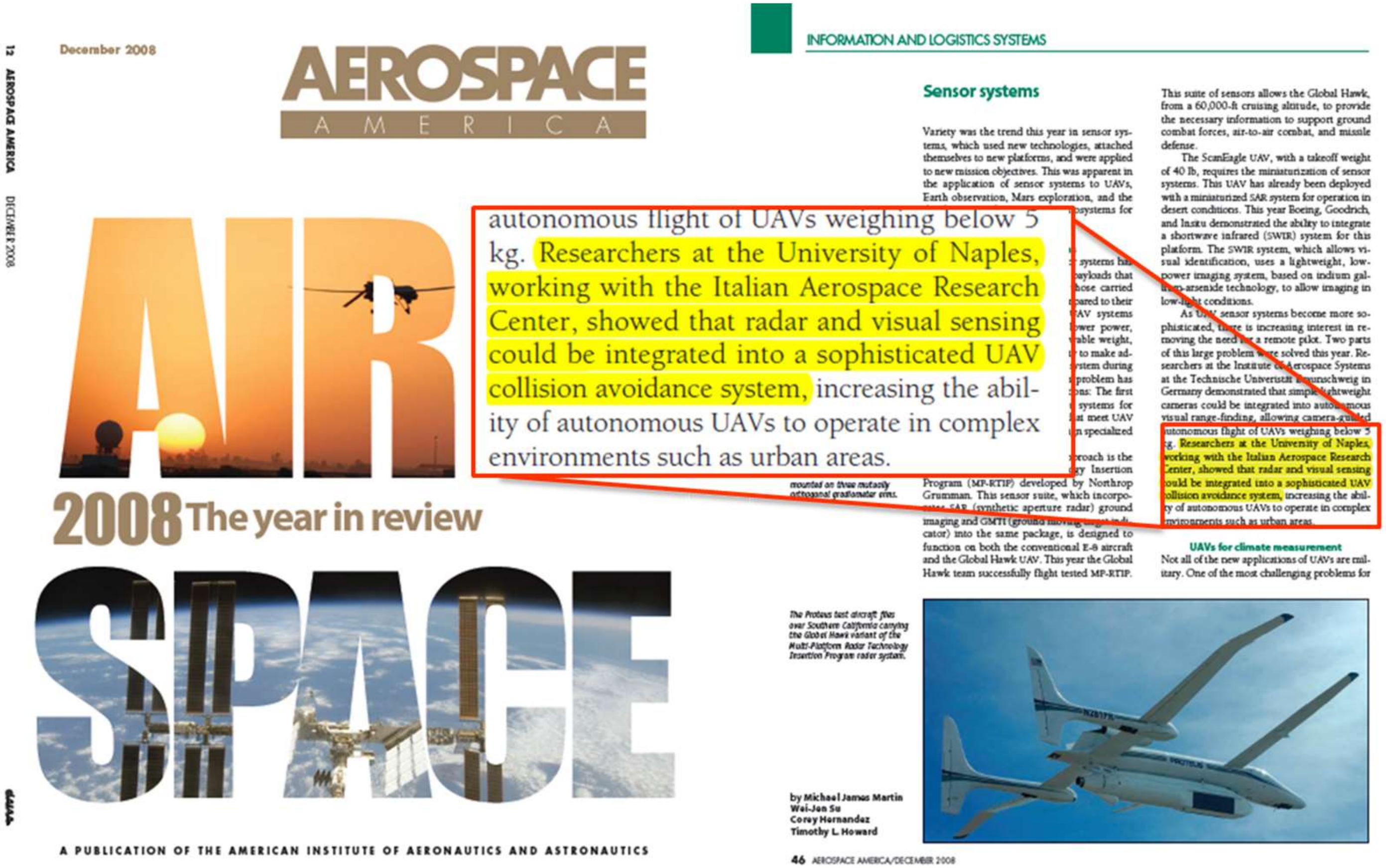
TECVOL: See and Avoid by Multi-Sensor System

Project TECVOL funded by Italian Aerospace Research Centre CIRA

- Original radar/EO data fusion architecture
- Successful flight demonstration (optionally piloted aircraft) of:
  - Real time radar-based detection and tracking
  - Real time multi-sensor-based detection and tracking
  - Autonomous non-cooperative collision avoidance (100 % success rate)
  - Vision-based detection and tracking (off-line based on flight data)
- Running activities on small UAS Sense and Avoid



Aerospace America – The Year in Review 2008

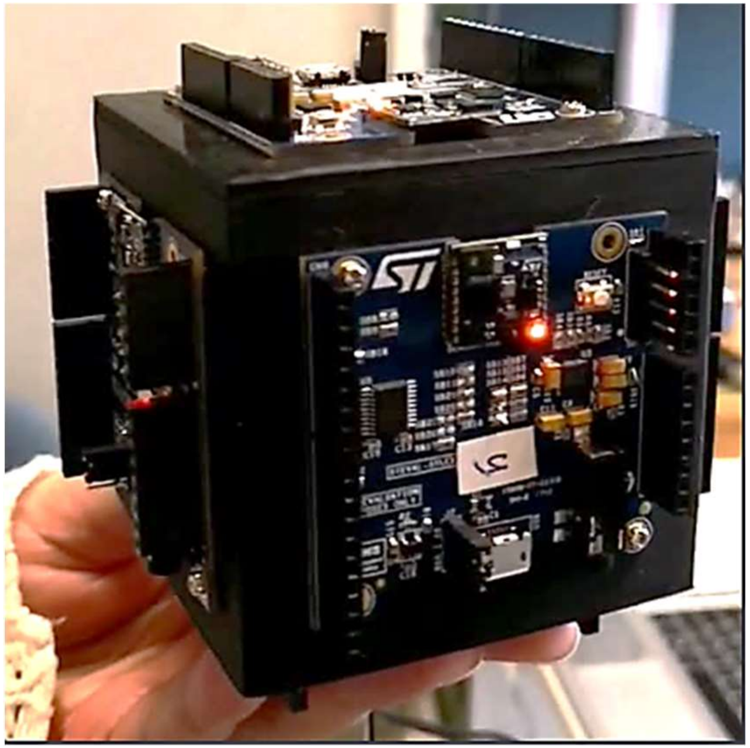


UV100: Development of UAS to be Integrated into C2 Framework

- Fixed-wing UAS System developed by UNINA (composite frame and onboard systems) to be integrated into C2 mobile unit developed by Leonardo Company™.
- Funded by the Italian Ministry of Defense;
- Final tests in a military facility with runway developed on purpose.

PolyTile: Inertial Unit based on Low-cost Redundant MEMS Sensors

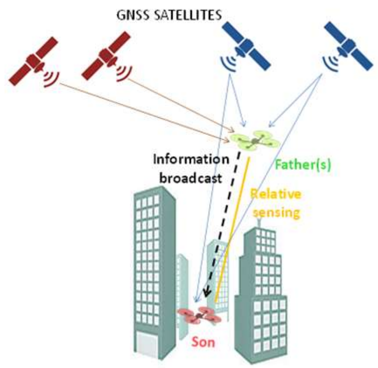
- MEMS sensors are available in low-cost board-level solutions;
- Redundant configuration will help improve error performance by mutual cancellation of biases and noise reduction by averaging measurements;
- Proper low-cost accurate alignment procedure developed (AIAA/IEEE DASC, 2018);
- Field testing by ZUPT and GPS/INS integration (AIAA Scitech, 2019);
- Activity supported by ST Microelectronics.

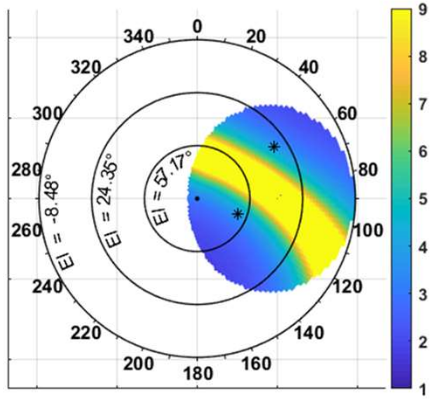


Cooperative Multi-UAV Systems

- Development of new architectures and technologies for distributed GNC and situation awareness

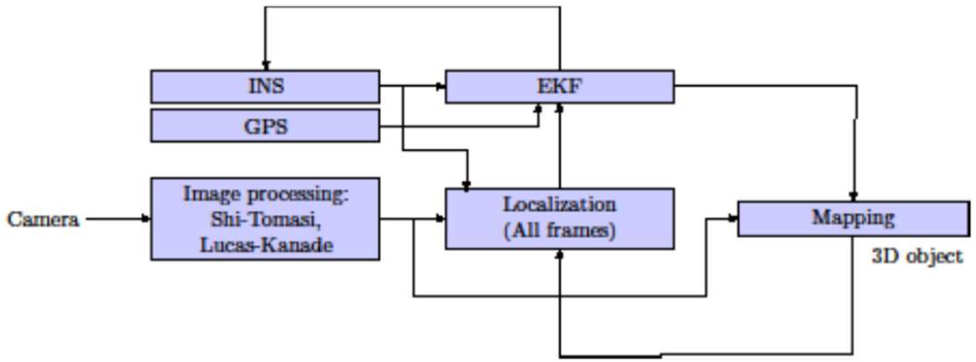
- Areas of activity:
  - Cooperative guidance and navigation in challenging environments
  - Cooperative navigation for accurate attitude/pointing
  - UAV-UAV detection and tracking
  - Path planning for autonomous swarms

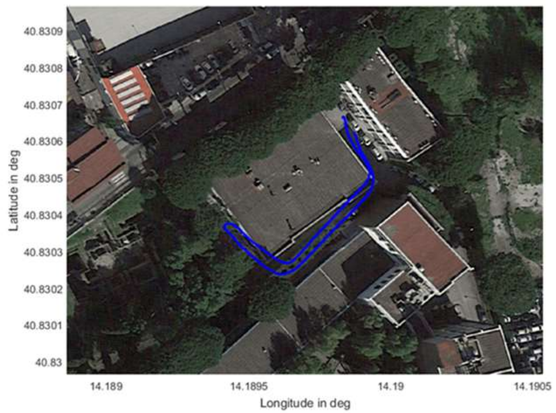




Autonomous Flight In Complex and/or GNSS-Challenging/Denied Environments

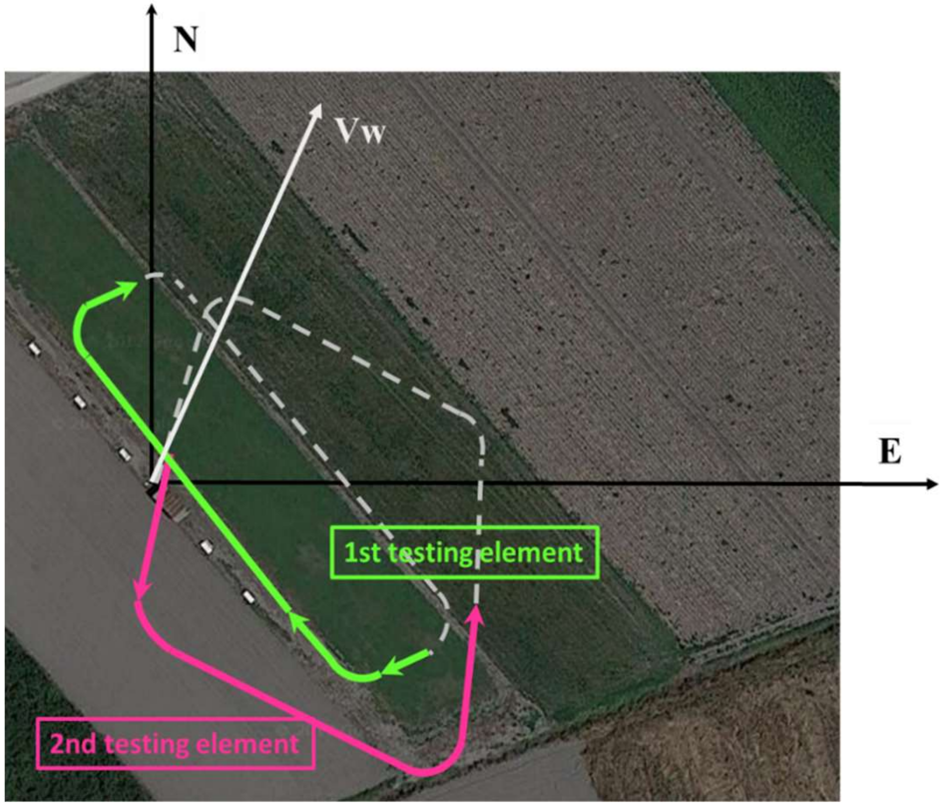
- Vision-aided navigation
- Vision-aided autonomous take off and landing
- LIDAR-aided navigation





UTMTraj: UAS Trajectory Prediction Exploiting Artificial Intelligence

- A method that exploits Backpropagation Neural Networks BNN to predict the travel time over specific trajectory segments was developed (Scitech, 2018);
- The method exploits experimental data collected during flight tests and can handle different wind conditions;
- The use of BNN supports the real-time use in UTM traffic processors performing trajectory prediction;
- The method exploits similar strategies as the one adopted for standard ATM in owned joint patent with Italian company Leonardo™.



FOCUS: Mitigation of Negative Interaction with Seagulls

- Project developed in cooperation with Unina Department of Veterinary and Public Health in cooperation with three local SME;
- Project funded by local authorities, i.e. Regione Campania, with funds by European Union;
- Guidelines were derived to realize service for negative interaction mitigation that is also compliant with wildlife regulations;
- Good option also to reduce bird strike risk in proximity of airports.

Competence Center medITech: Drone Applications for Industry 4.0 Framework

- Funded by Italian Ministry of Industry.
- Headquarters: Naples.
- Apulian venue in Bari.
- Members
  - 8 Universities;
  - 41 Companies.
- medITech academic members include all Universities from Campania and Apulia performing technical curricula.
- Reference market: Italian Companies interested in *ICT & Industry* paradigm with focus on Mediterranean area.
- In this framework several companies are interested in developing industrial activities with drones.
- My responsibility is related to Aerospace Manufacturing segment.

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Conclusion

- The UTM system need is a consequence of the large increase in the number of small UAS flights at Very Low Altitude;
- Autonomy, multi sensor fusion, and fast data exchange are crucial to provide service to a large number of users with overall limited budget;
- Some initial regulation are available, mainly to define proper LOS operation;
- Future UTM systems will require advanced additional features for safe BVLOS operation, such as authentication, geo-fencing, see and avoid, and management of contingency.

References

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