

UNIVERSITÀ DEGLI STUDI DI NAPOLI
FEDERICO II



DIPARTIMENTO DI
INGEGNERIA
INDUSTRIALE

SEZIONE
INGEGNERIA AEROSPAZIALE

UNINA AEROSPACE SYSTEMS GROUP: UAS RESEARCH AND COLLABORATIONS



- Staff and Research Themes;
- Recent UAS-Related Projects;
- Collaborations and International Activities;
- Overview of main research projects.



UNINA-DII Aerospace Systems Group:

- 1 Full Professor;
- 3 Associate Professors;
- 2 Assistant Professors ;
- 2 Post-doc Research Assistants;
- 3 PhD Students.

Research themes

- Airborne and Spaceborne Remote Sensing Systems
- Avionics
- Air Traffic Management and Control
- **UAS/RPAS**
 - Sense and Avoid
 - Integrated Surveillance Systems
 - Cooperative Small UAV Swarms
 - Sensor fusion
 - Autonomous landing
 - Situational awareness and autonomous flight in complex environments
 - Vision-aided Guidance and Navigation
- Distributed Space Systems
- Satellite Attitude Sensors
- GNC for space and re-entry applications



UAS-related National Collaborations





UAS-related International Collaborations/ Activities





- All-Time All-Weather Multi-sensor Tracking System to provide UAS with Autonomous See and Avoid capabilities (Project **CIRA-TECVOL**);
- GN&C system and a video-link for a miniUAV to be integrated in a Netcentric C2 system (Project **SELEX-SI - SISTS**);
- GNC Technologies for cooperative micro UAVs (project **STAR i-TEAMS**);
- Real-time navigation system to assist Autonomous UAV Takeoff and Landing (Project **CIRA-ATOL**);
- “1st” small UAV platform for airborne remote sensing of fire hazards (In cooperation with **AMRA Excellence Center**).



Other UAS-related Research Projects

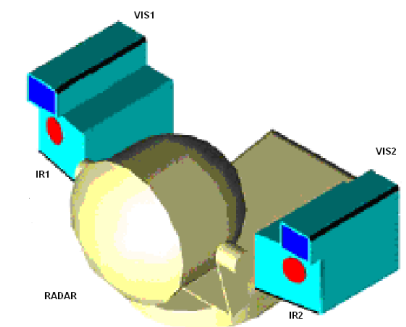
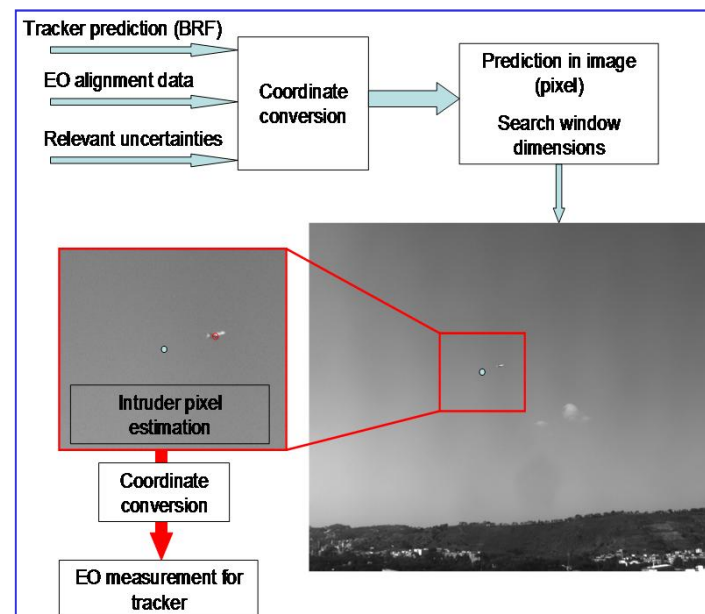
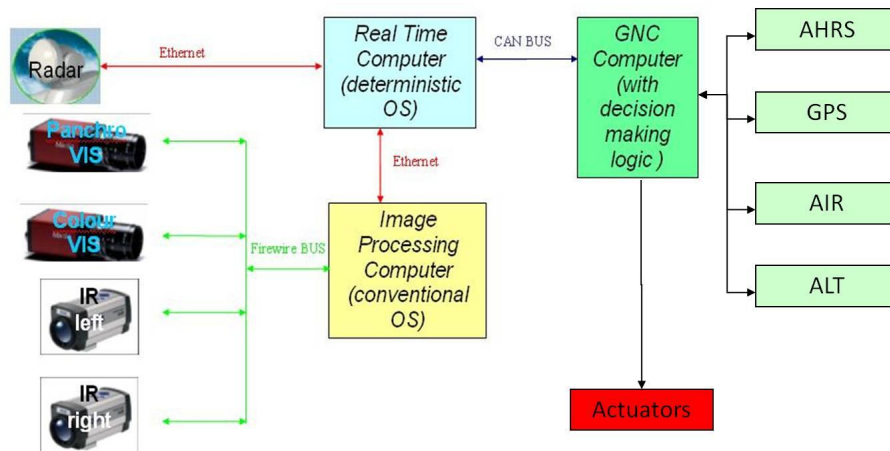
- Development of a compact airborne SAR named miniSAR able to operate on-board a small aerial platform (In cooperation with CoRiSTA);
- Advanced CDGPS/INS test system for measuring AHRS performance (with GMA Axitude s.r.l.);
- Development of a low cost collision avoidance system for small aircraft (project CIRA-LASA, in cooperation with **MITRE** Corporation);
- Advanced Data Fusion Methods for Airborne Obstacle Tracking (funded by **EUROCONTROL** in the network HALA!);
- Study on Hybrid Airborne and Spaceborne Bistatic Radar System for UAS navigation (funded by **ESA**);
- RF Systems (Data Link, Collision Avoidance) for UAS (project SIRENA, with **MBDA**);
- Vision-based guidance and navigation algorithms for UAS (project WISCH, with **MBDA**);
- Autonomous flight in complex environments (research in collaboration with **Cranfield University**).



SENSE AND AVOID

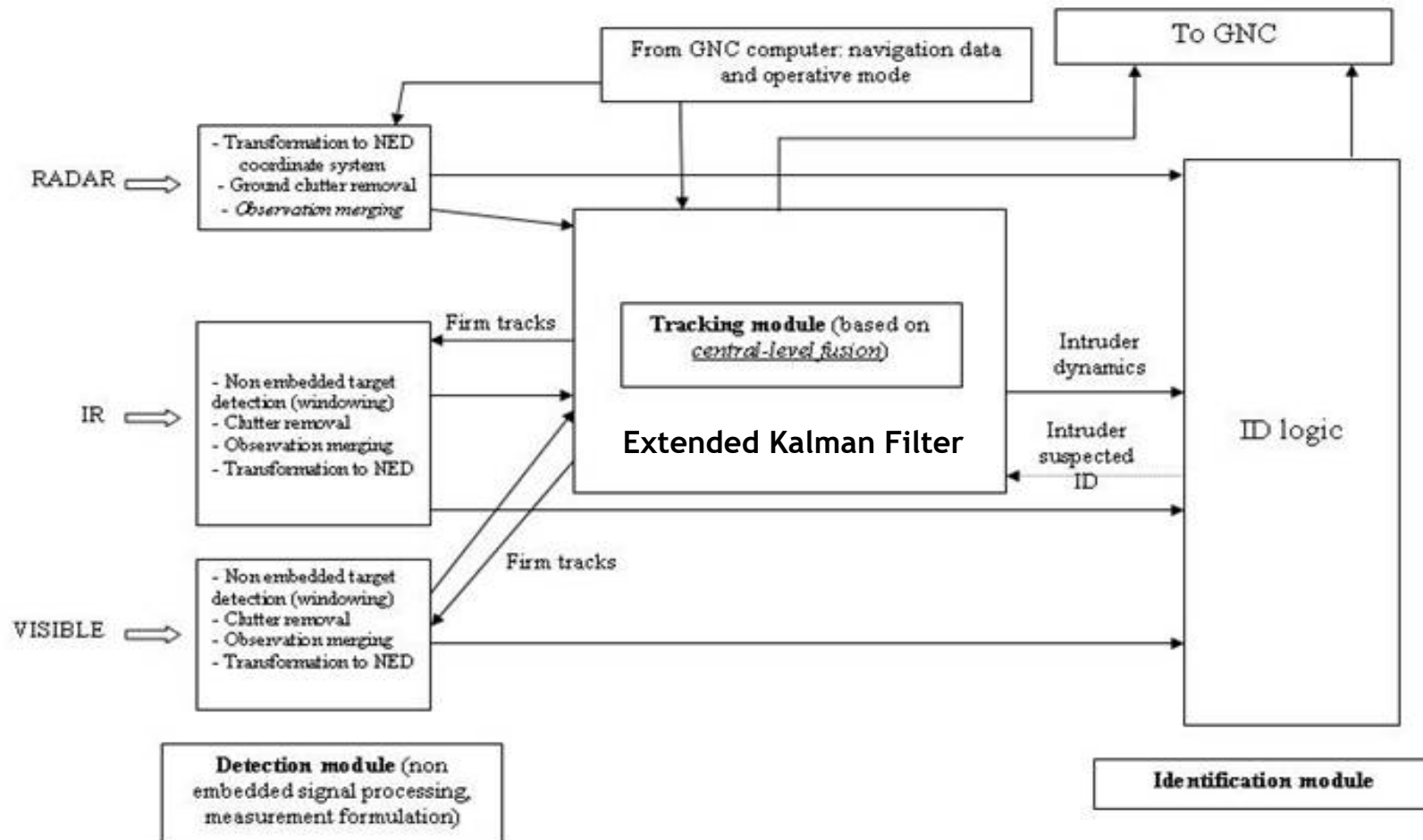


UAS Sense and Avoid





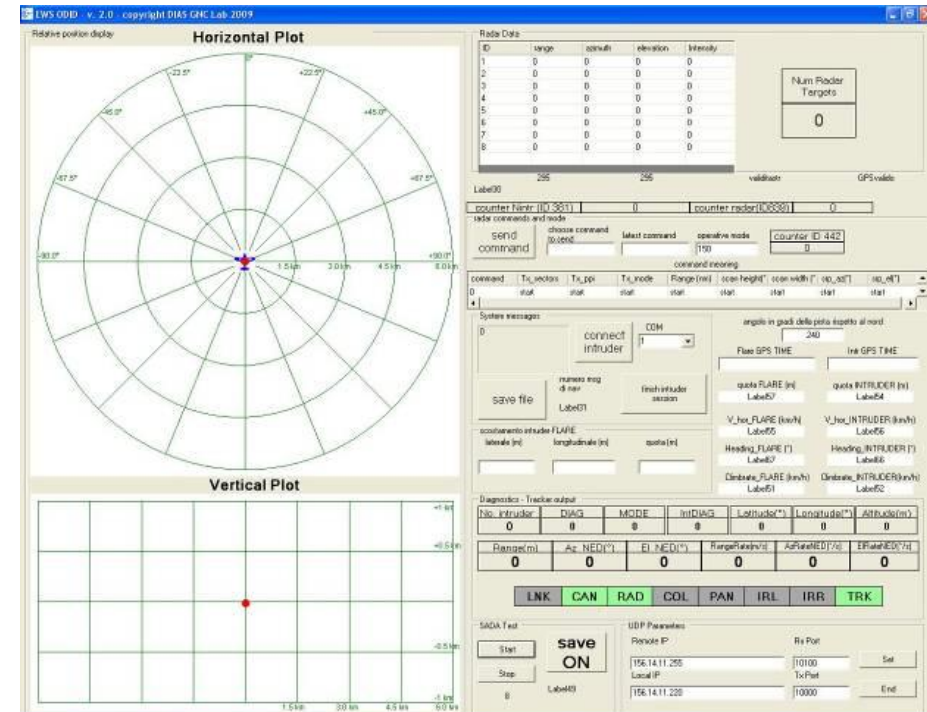
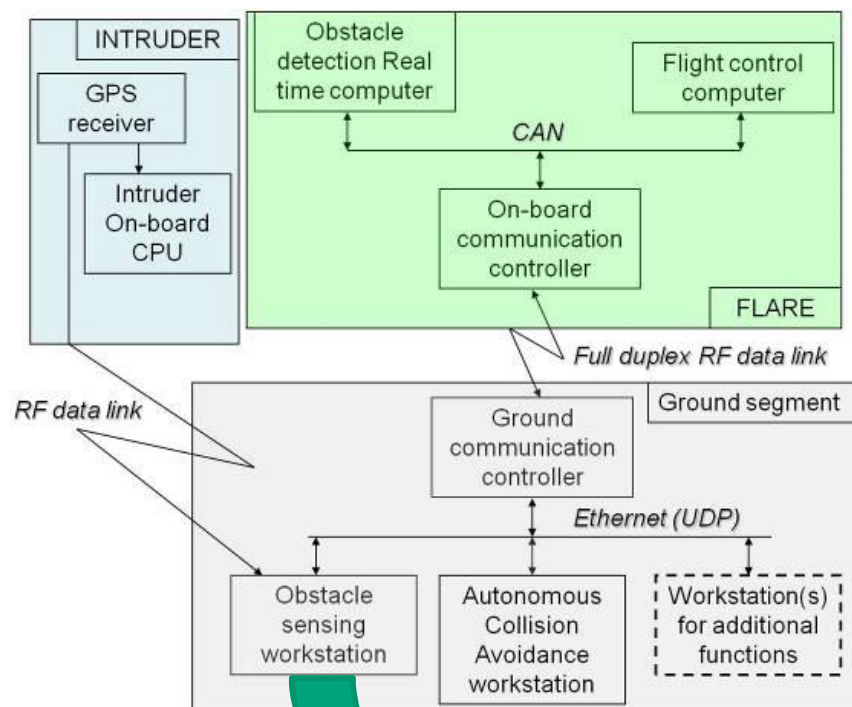
Sense and Avoid: Multi-sensor Data Fusion



Tracking is based on an Airborne EKF model

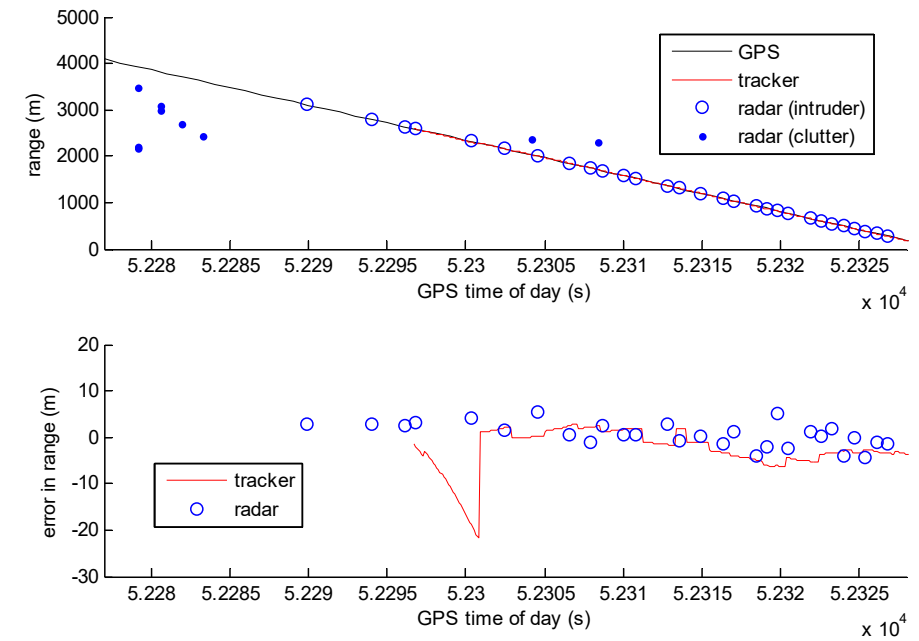


Sense and Avoid: Flight Testing Architecture



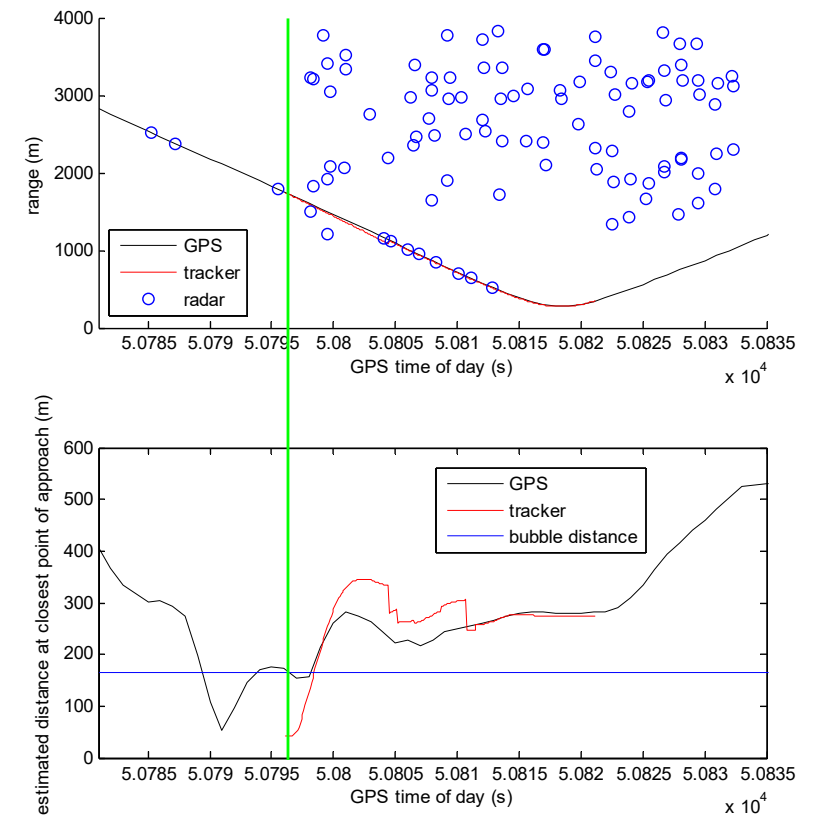
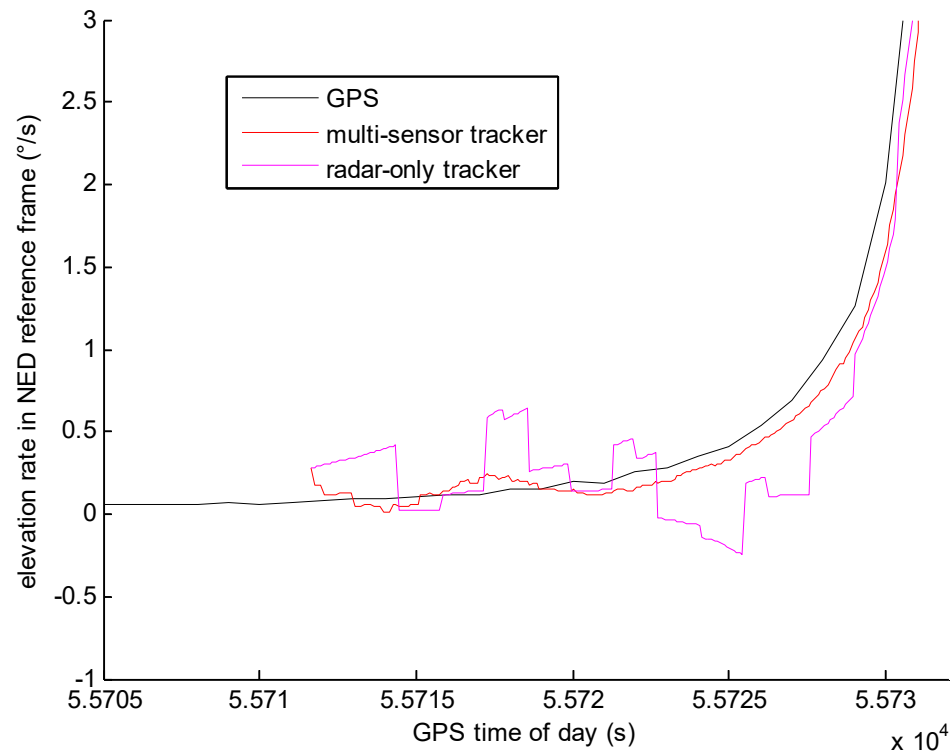


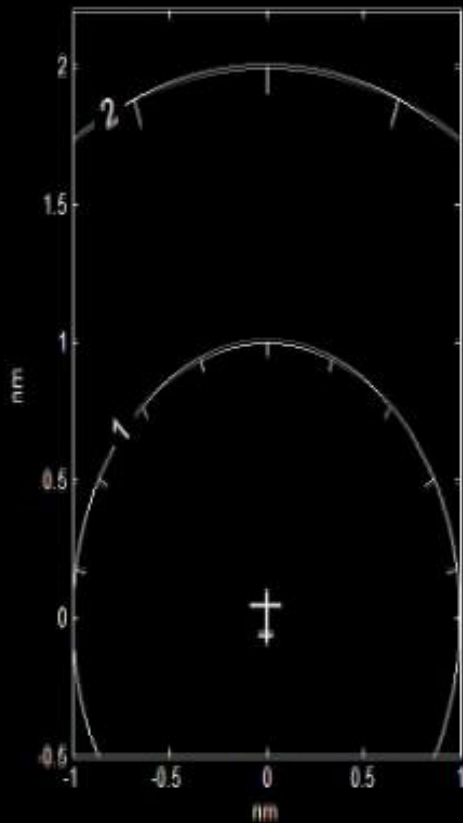
Sense and Avoid - Flight results





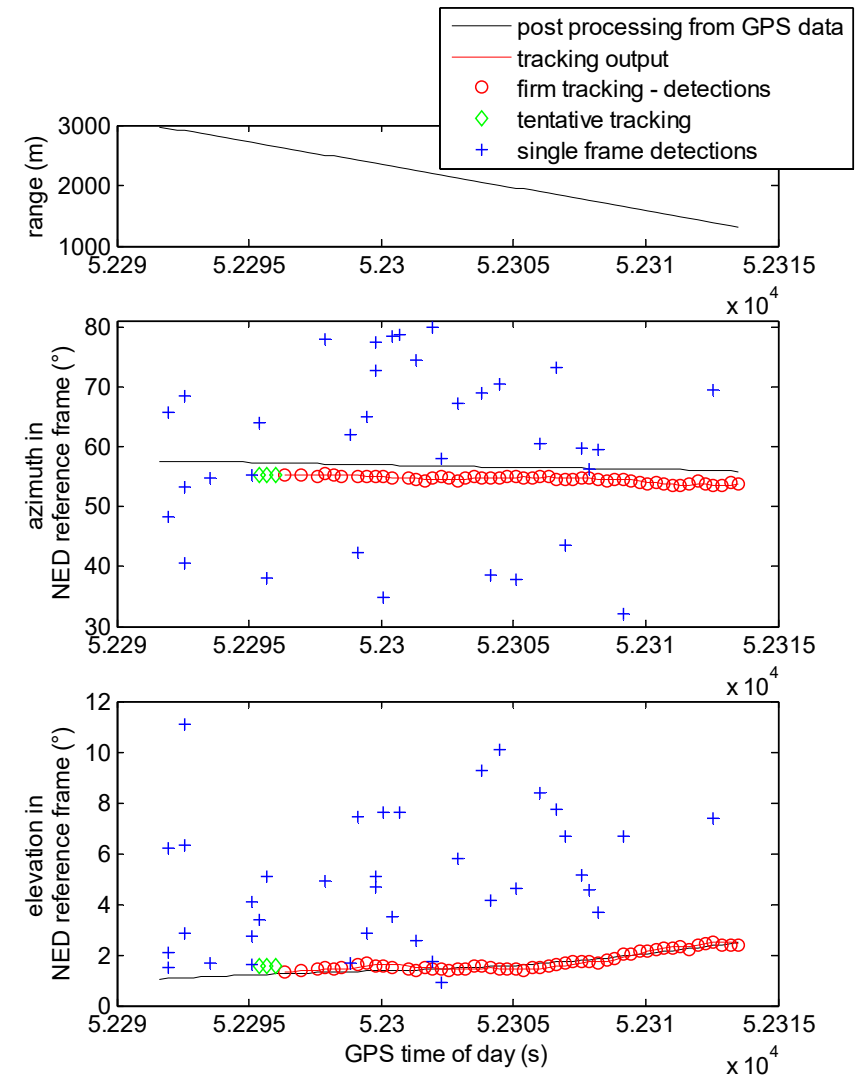
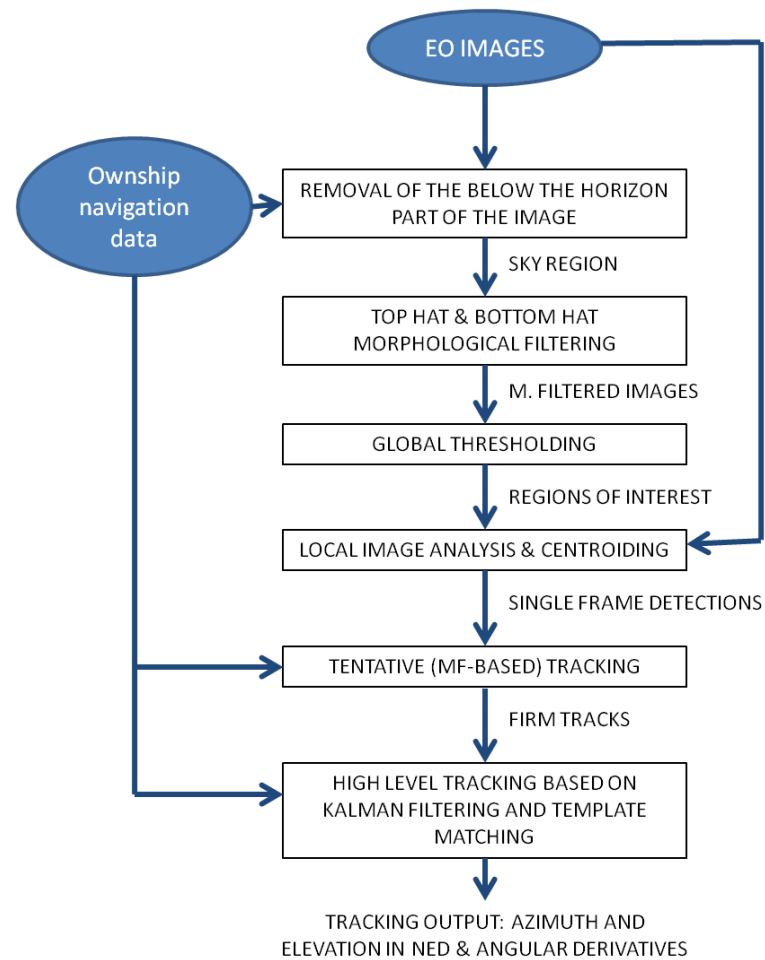
AVOIDANCE MANEUVER INITIATED

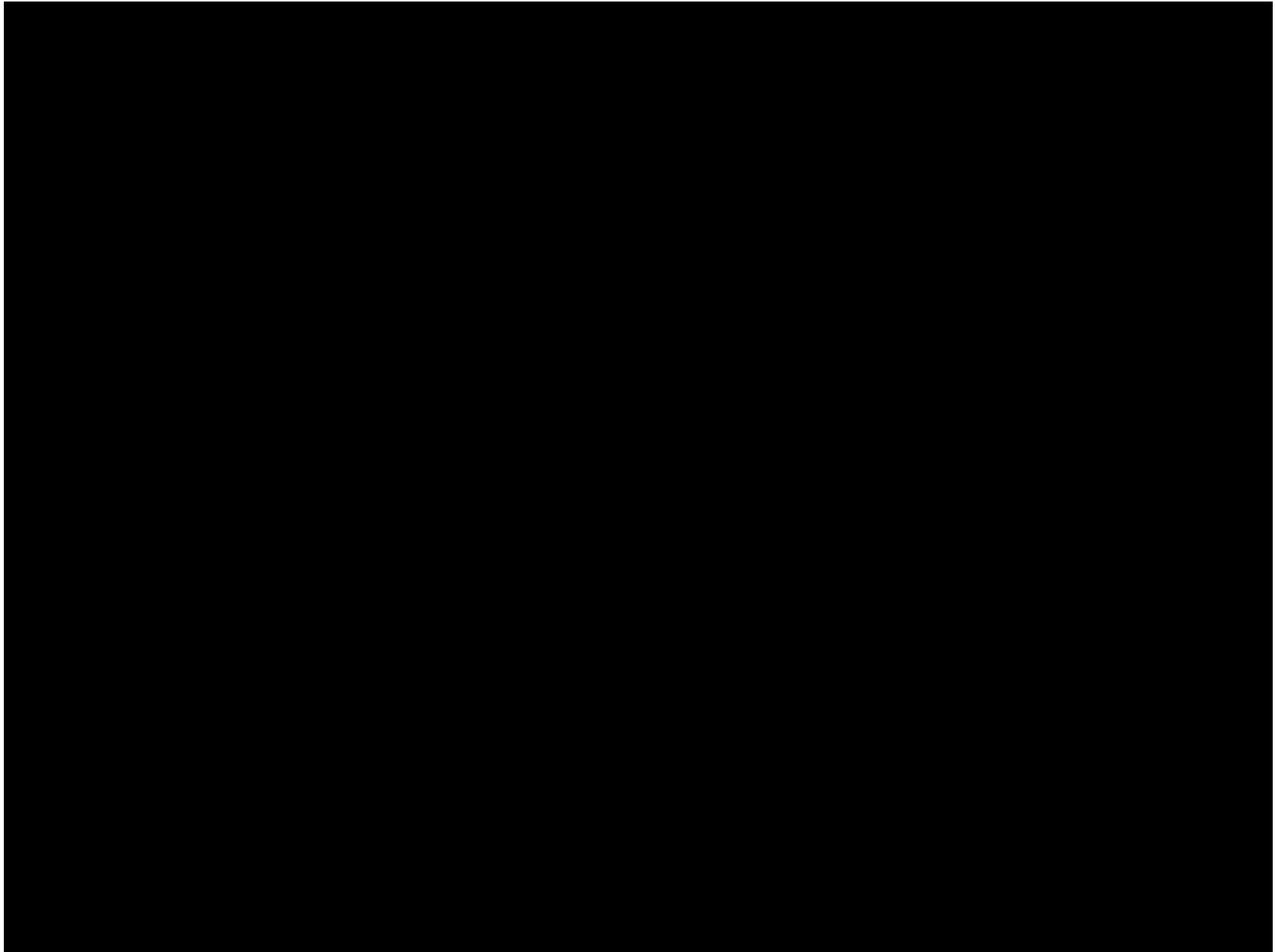






Vision-based Sense and Avoid







AEROSPACE AMERICA 2008

Citation in “A year in review” article

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December 2008

AEROSPACE A M E R I C A



2008 The year in review



A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

INFORMATION AND LOGISTICS SYSTEMS

Sensor systems

Variety was the trend this year in sensor systems, which used new technologies, attached themselves to new platforms, and were applied to new mission objectives. This was apparent in the application of sensor systems to UAVs, Earth observation, Mars exploration, and the

This suite of sensors allows the Global Hawk, from a 60,000-ft cruising altitude, to provide the necessary information to support ground combat forces, air-to-air combat, and missile defense.

The ScanEagle UAV, with a takeoff weight of 40 lb, requires the miniaturization of sensor systems. This UAV has already been deployed with a miniaturized SAR system for operation in desert conditions. This year Boeing, Goodrich, and In Situ demonstrated the ability to integrate a shortwave infrared (SWIR) system for this platform. The SWIR system, which allows visual identification, uses a lightweight, low-power imaging system, based on indium gallium-arsenide technology, to allow imaging in low-light conditions.

As UAV sensor systems become more sophisticated, there is increasing interest in removing the need for a remote pilot. Two parts of this large problem were solved this year. Researchers at the Institute of Aerospace Systems at the Technische Universität Braunschweig in Germany demonstrated that simple lightweight cameras could be integrated into autonomous visual range-finding, allowing camera-guided autonomous flight of UAVs weighing below 5 kg. Researchers at the University of Naples, working with the Italian Aerospace Research Center, showed that radar and visual sensing could be integrated into a sophisticated UAV collision avoidance system, increasing the ability of autonomous UAVs to operate in complex environments such as urban areas.

UAVs for climate measurement

Not all of the new applications of UAVs are military. One of the most challenging problems for

autonomous flight of UAVs weighing below 5 kg. Researchers at the University of Naples, working with the Italian Aerospace Research Center, showed that radar and visual sensing could be integrated into a sophisticated UAV collision avoidance system, increasing the ability of autonomous UAVs to operate in complex environments such as urban areas.

mounted on three mutually orthogonal gradiometer axes.

Program (MP-RTIP) developed by Northrop Grumman. This sensor suite, which incorporates SAR (synthetic aperture radar) ground imaging and GMTI (ground moving target indicator) into the same package, is designed to function on both the conventional E-8 aircraft and the Global Hawk UAV. This year the Global Hawk team successfully flight tested MP-RTIP.

The Proteus test aircraft flies over Southern California carrying the Global Hawk variant of the Multi-Platform Radar Technology Insertion Program radar system.

by Michael James Martin
Wai-Jen Su
Corey Hernandez
Timothy L. Howard



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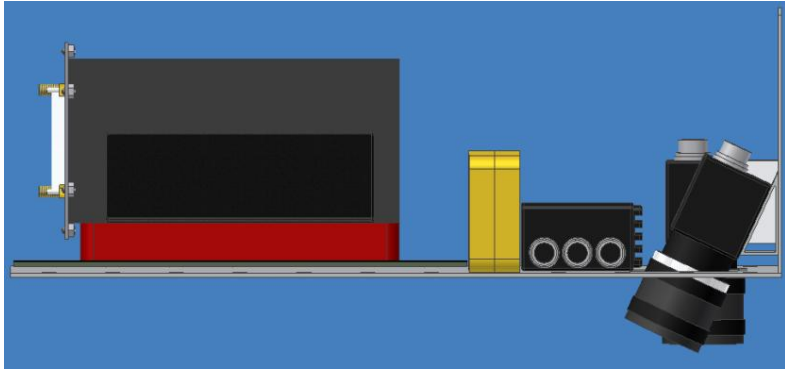
PROJECT SELEX-SI SISTS



- This project aims at performing an in-flight demonstration of system that is capable of transmitting a video stream captured by an UAV to a remote Control Center by exploiting a mobile Ground Station as transponder for Satellite Communications.
- UNINA Group is involved in the project and in the integration process of the autonomous UAV GN&C unit and the Electro-Optical payload. UNINA will also support flight testing.
- This project is owned by SELEX-SI and it is funded by the Italian Ministry of Defense.



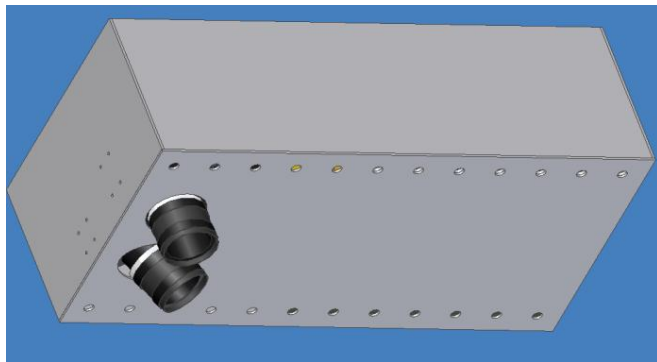
SISTS Onboard Unit



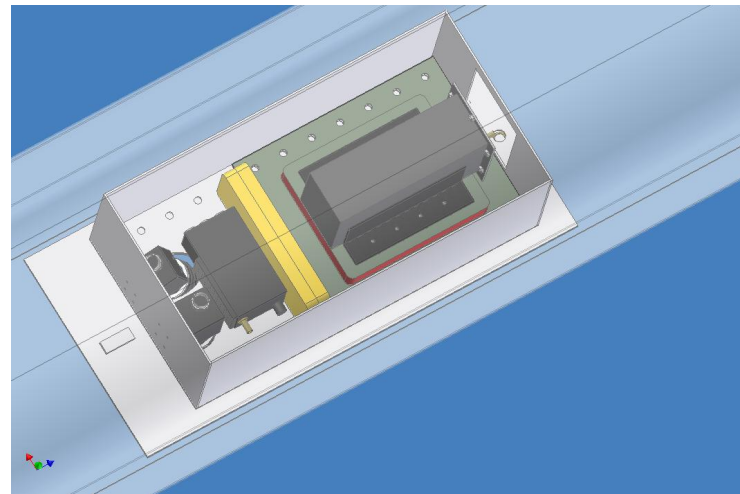
Lateral view of GN&C system and payload



Lateral view of UAV fuselage with GN&C system and payload installed



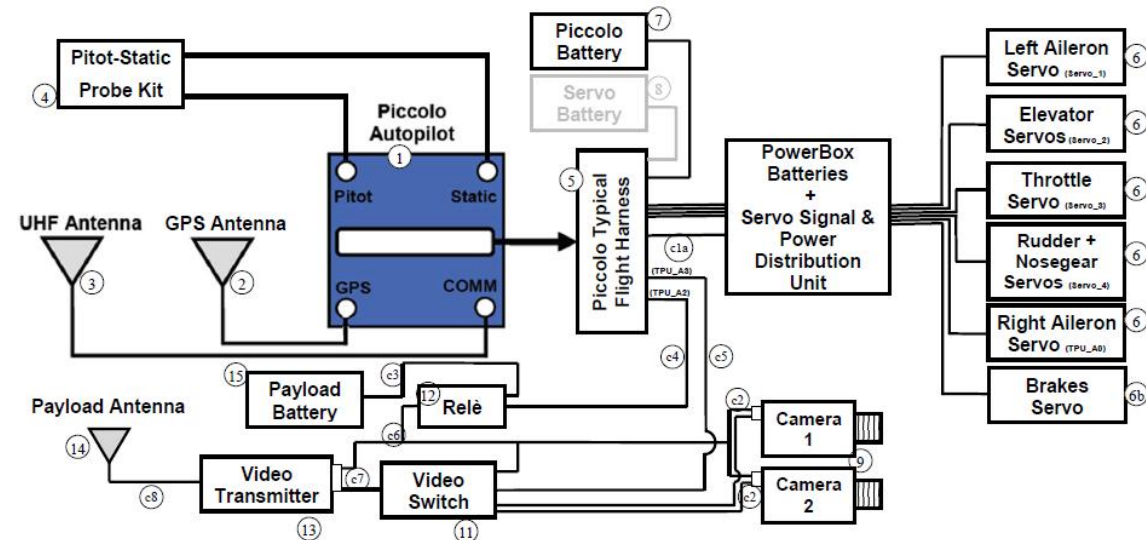
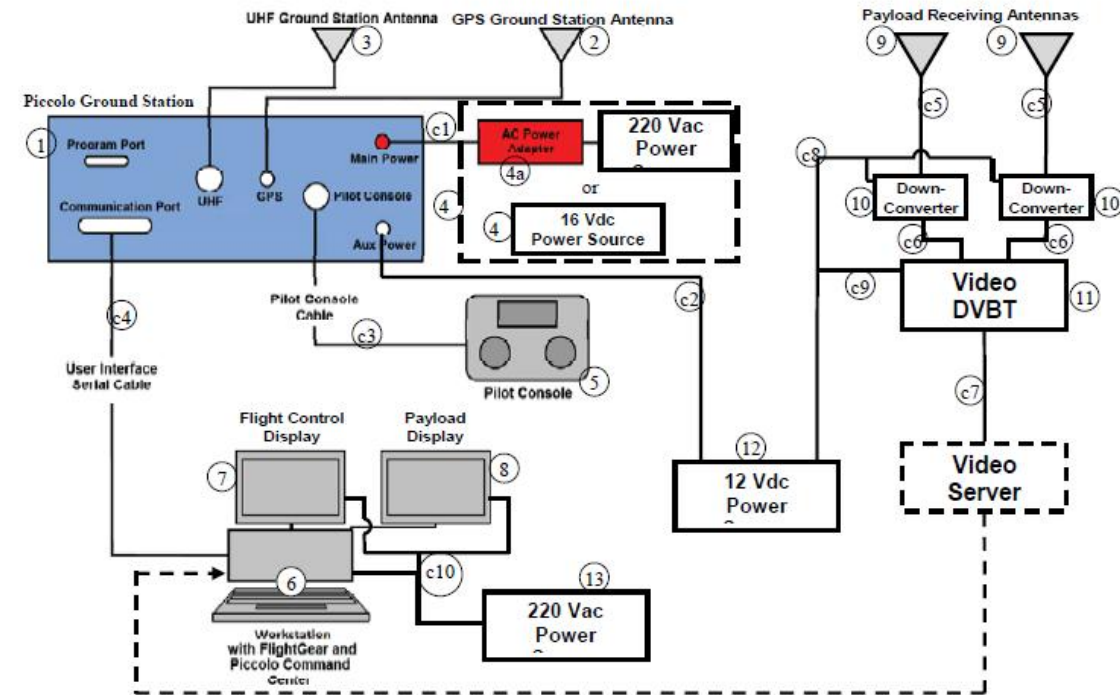
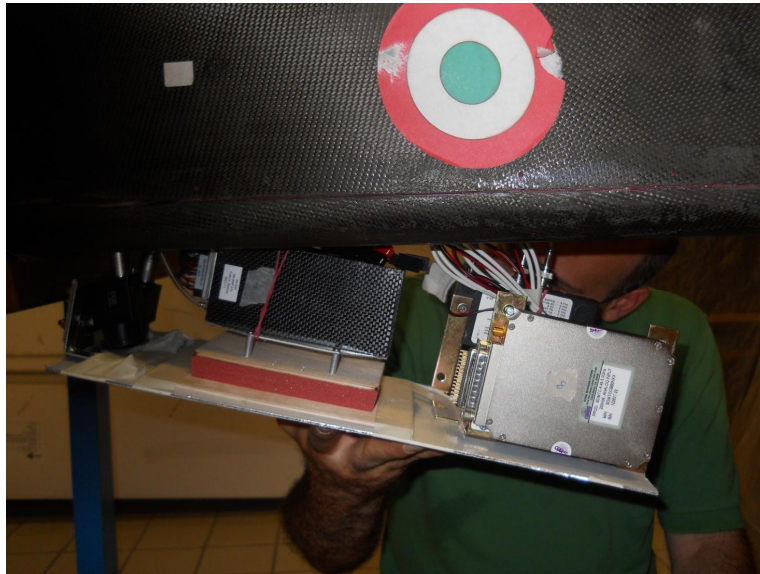
Payload enclosure



GN&C system and payload enclosure installed into UAV fuselage



System Architecture





UV 100



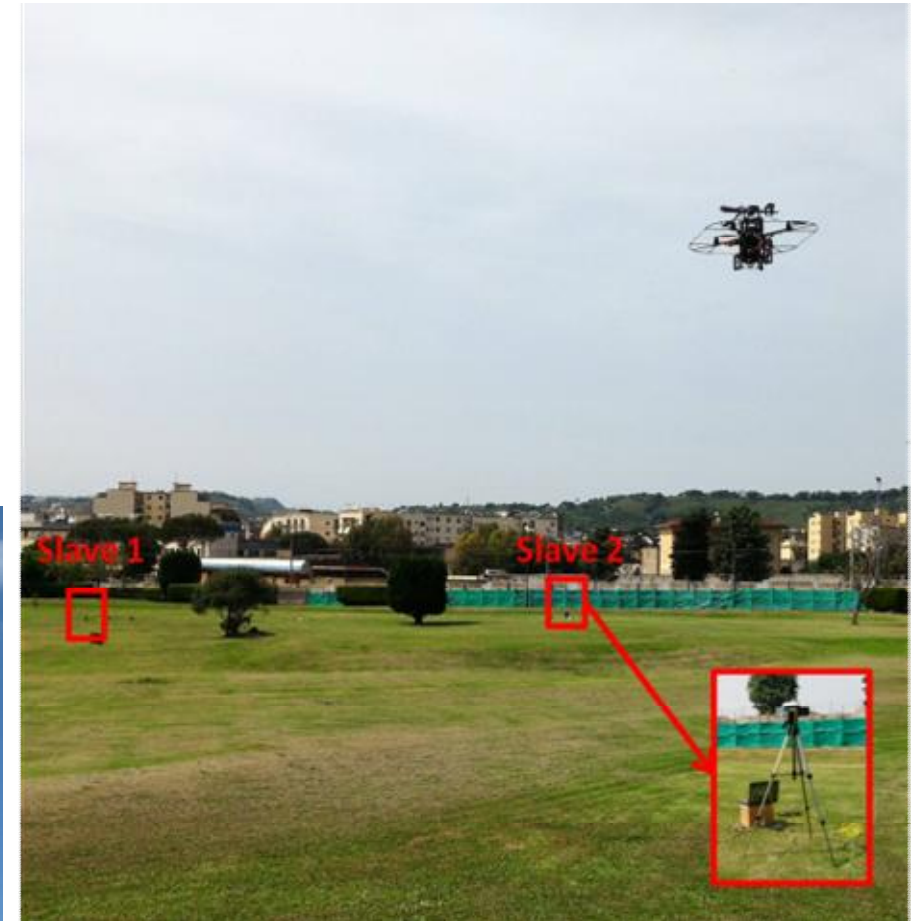
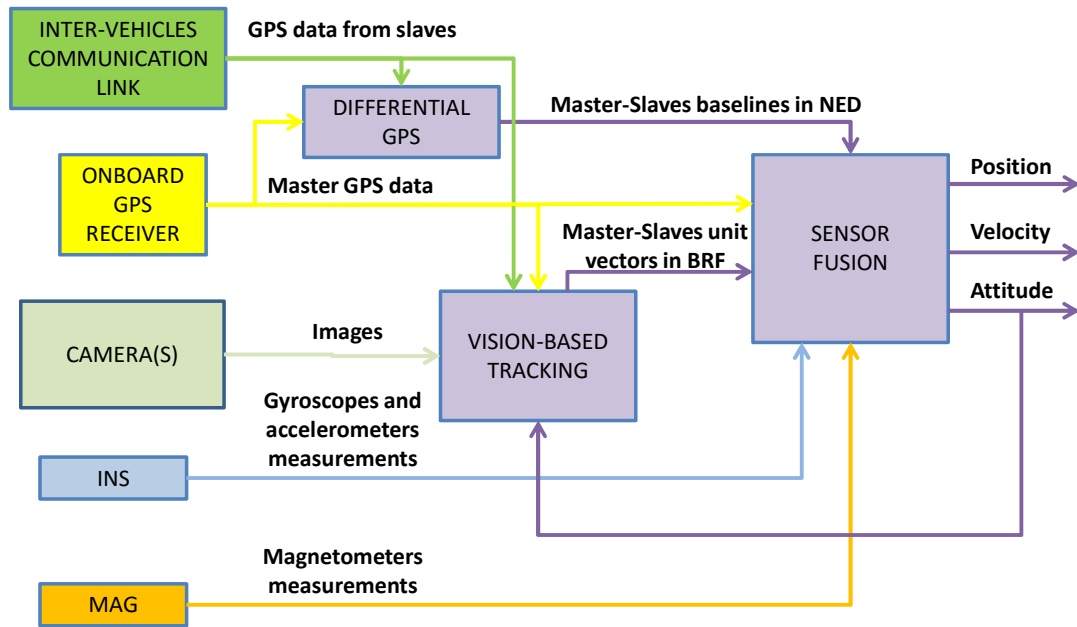




PROJECT I-TEAMS

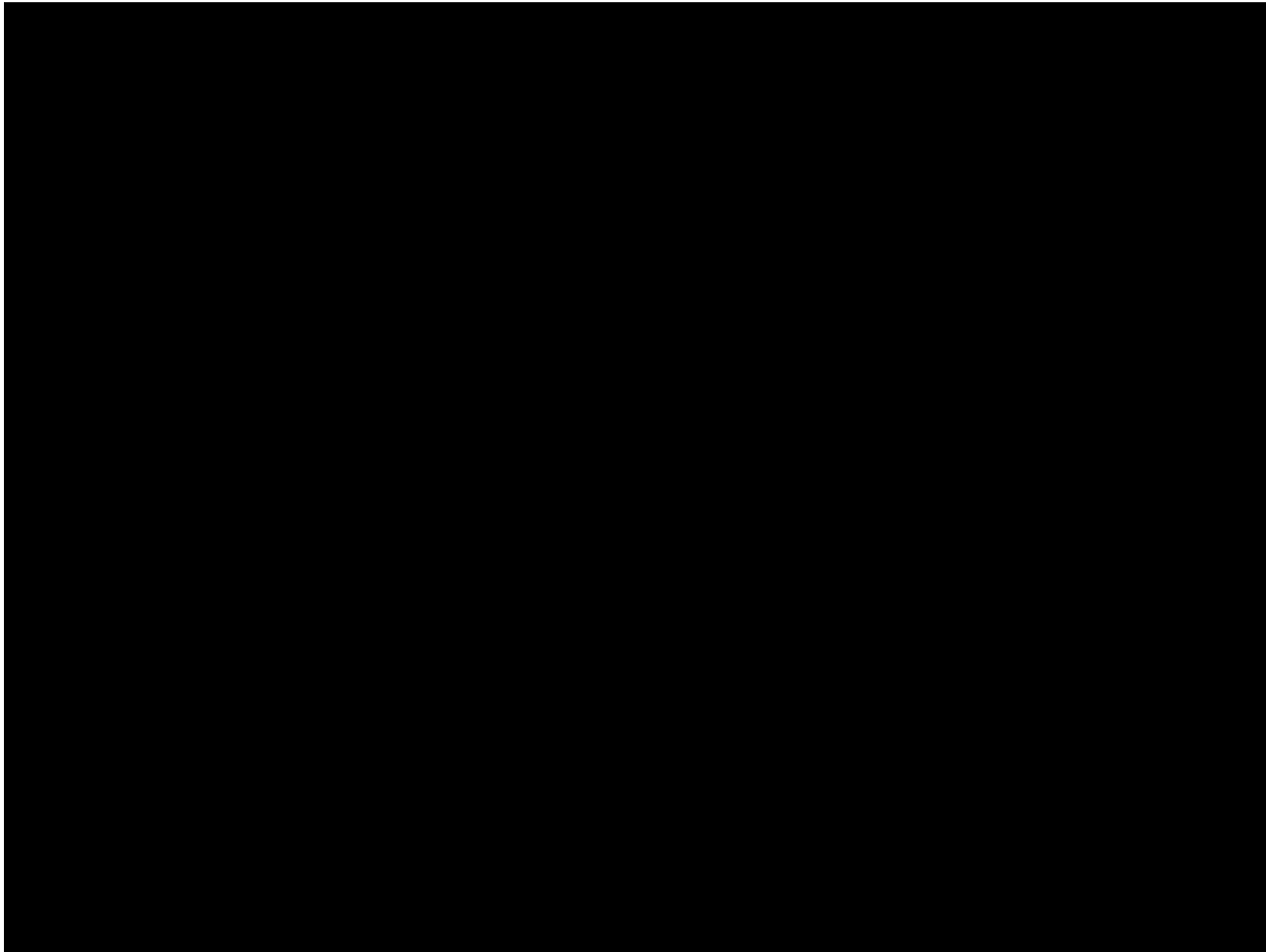
- Funded after successful peer review-based evaluation in the framework of the STAR Program supported by Università di Napoli "Federico II" with the financial contribution of Compagnia di San Paolo and Istituto Banco di Napoli - Fondazione
- The project aims at developing new architectures and technologies for distributed guidance, navigation, and control, with particular emphasis on the concepts of cooperation and autonomy





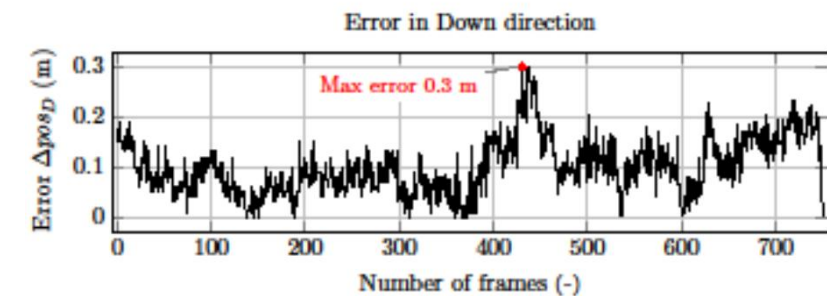
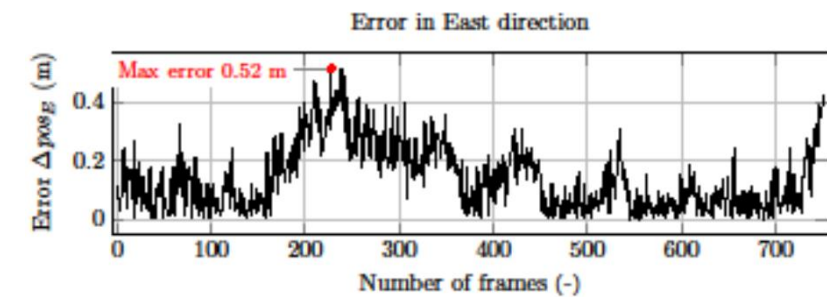
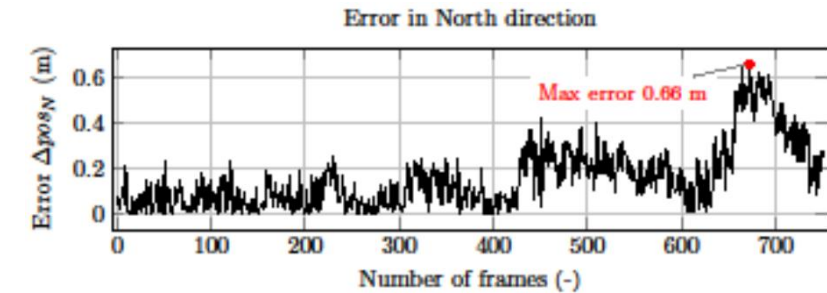
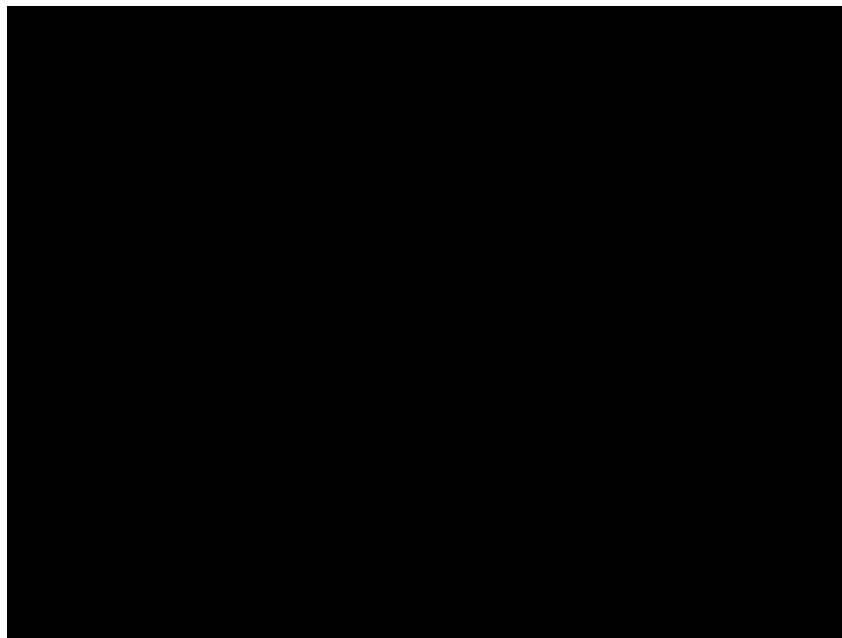
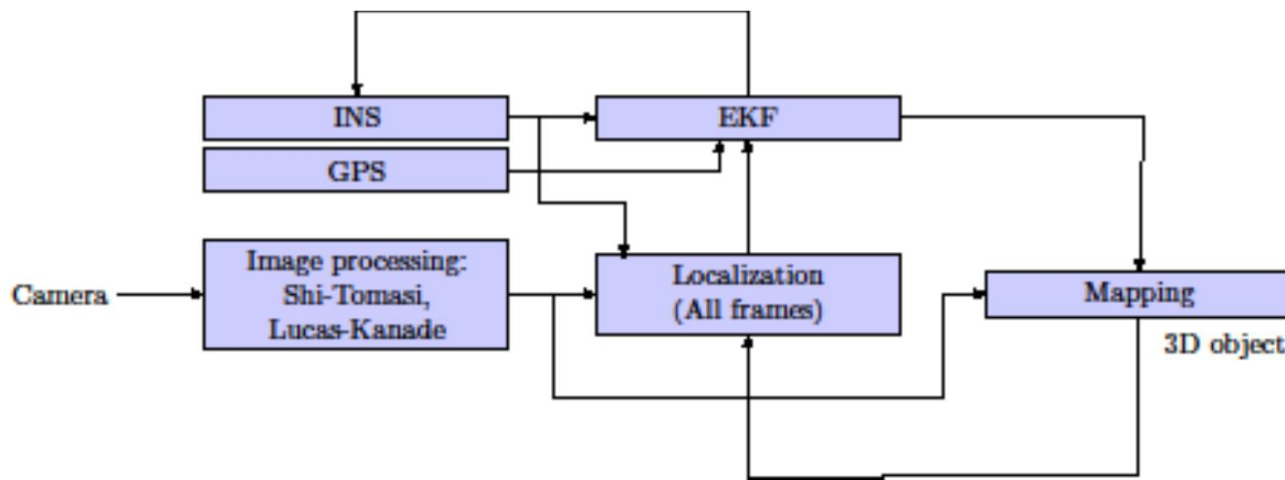


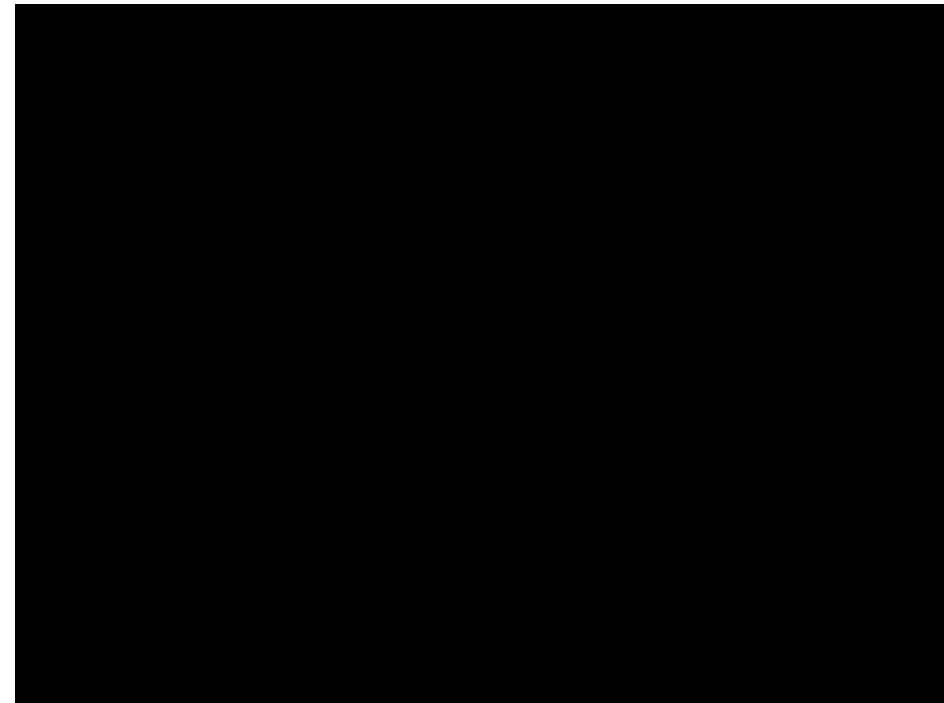
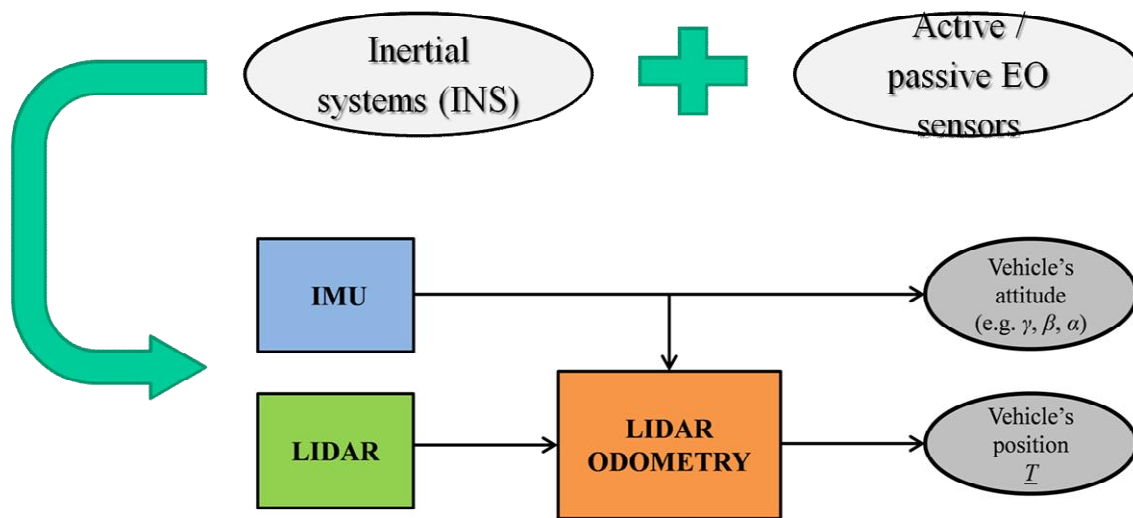
GNSS/Vision based attitude estimation





Vision-aided navigation

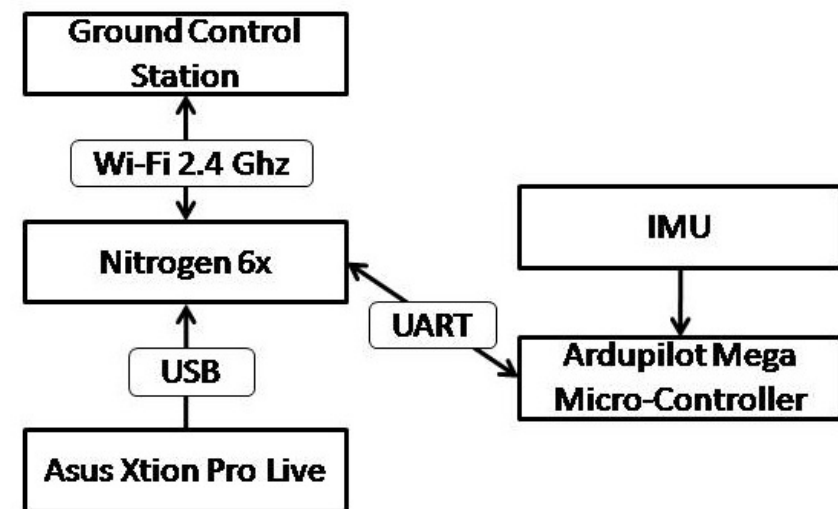
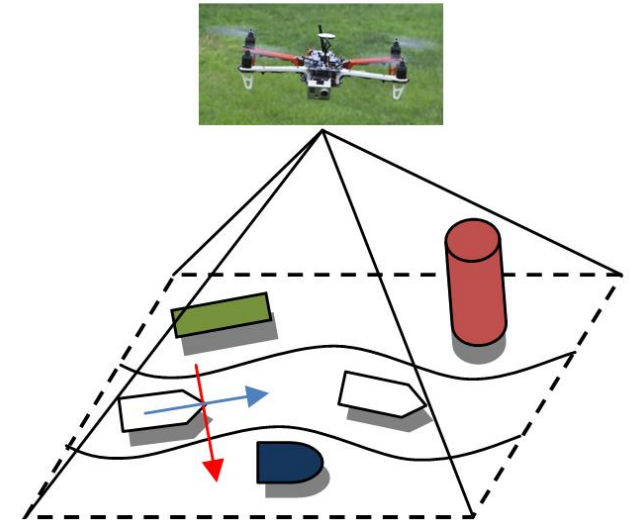
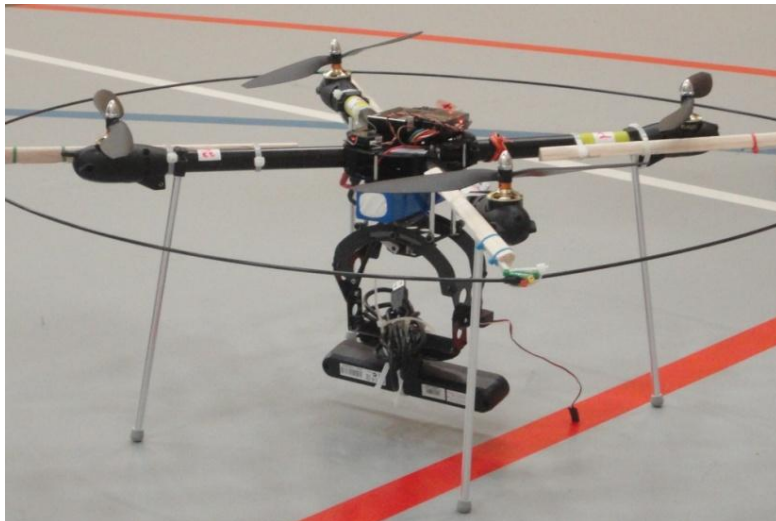




RGB-Depth
Data

Automatic Target
Detection and
Recognition

Pose Estimation

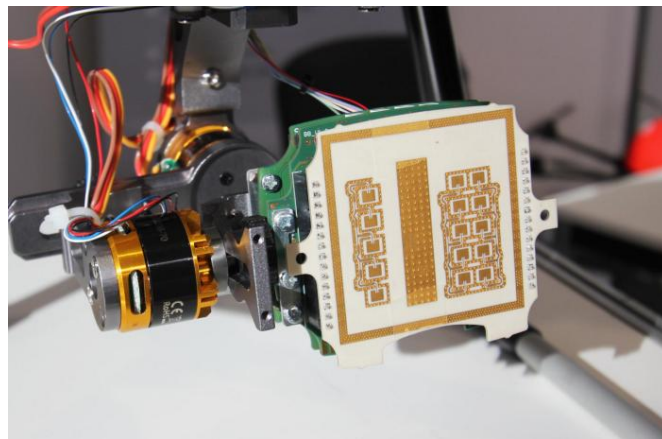




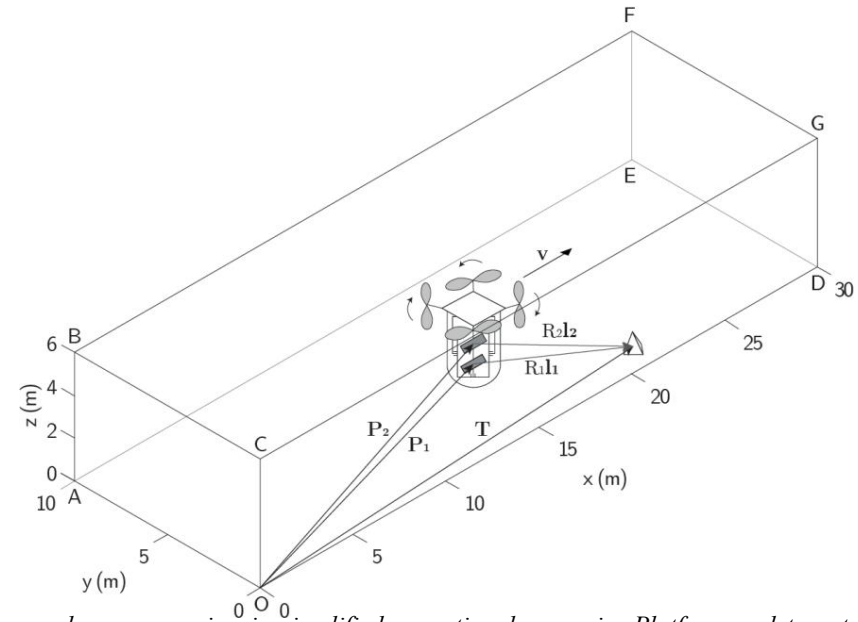
Miniaturized MMW Radar-aided navigation



Artistic view of an operational scenario for envisaged radar system embarked on a small UAS.



Gimbaled radar sensor (front-end and patch antenna) mounted on small UAS.



Platform and sensor moving in simplified operational scenario. Platform and target position vectors, line of sight unit vector, velocity vector, and target distance to antennas are depicted, too (not to scale for clarity).

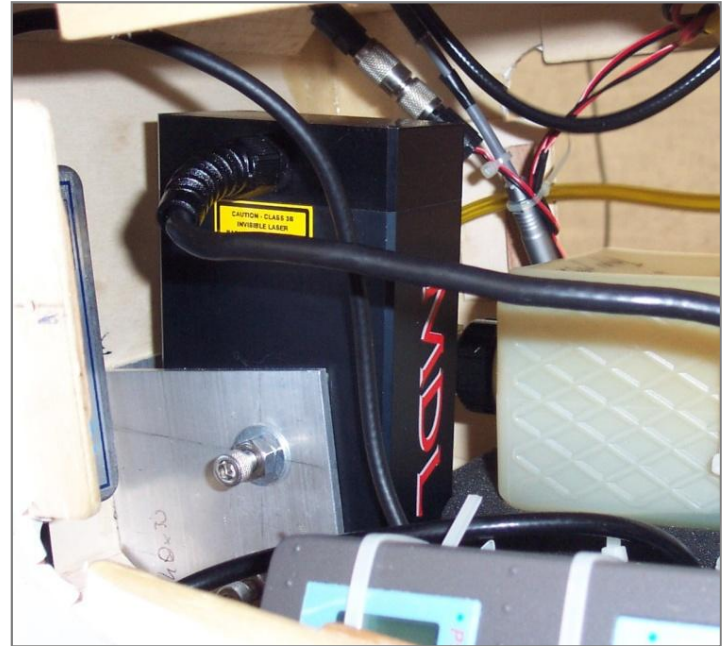
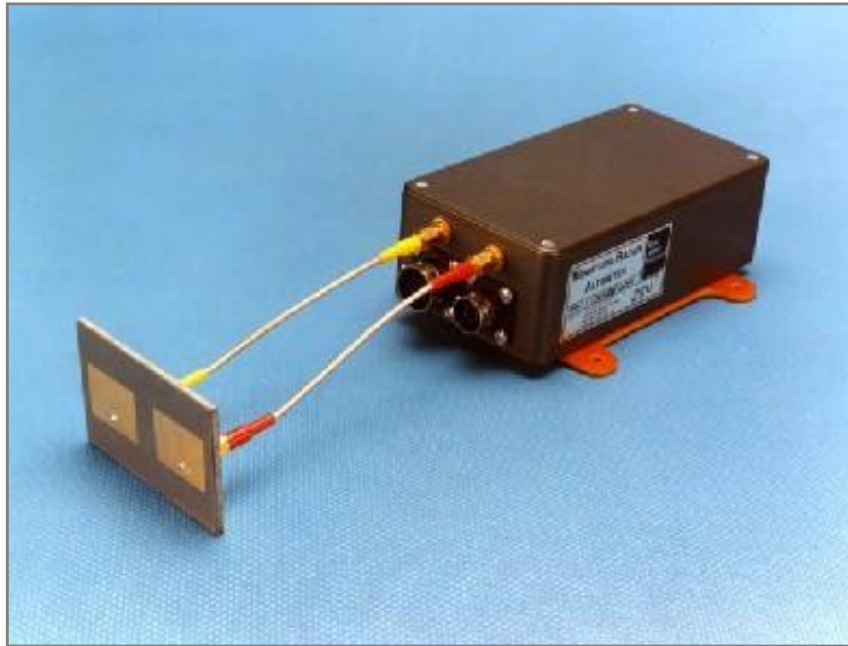
Main Constraints	
Mass	<1kg
Size	<1500cm ³
Maximum dimension	<20cm
Power consumption	<10W
Real-Time on-board processing	
Expected Performances	
3D mapping without ground truth	
3D resolution	10-20cm
Operation in presence of smoke and fire	
Technical Solutions	
SAR	
Millimeter Wave Radar	



UAV AUTONOMOUS TAKEOFF AND LANDING

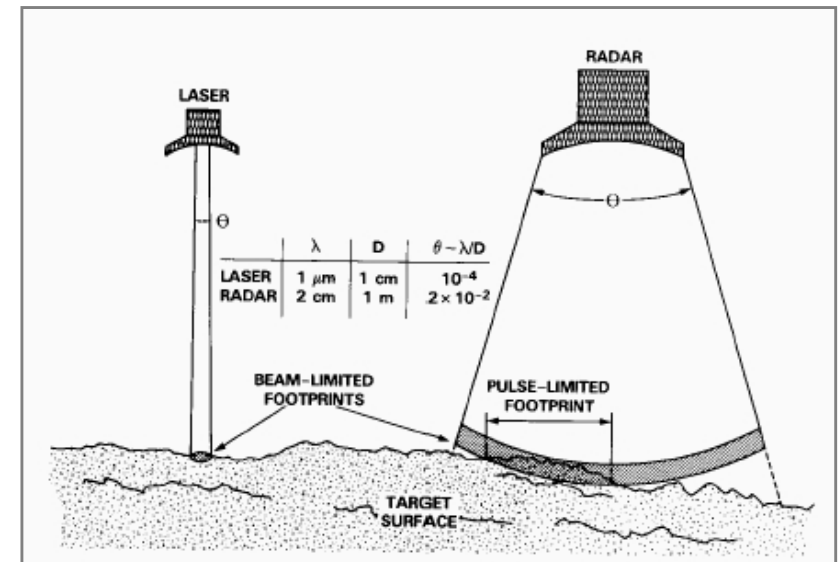


- The UNINA- DII (former DIAS) Aerospace Group supported CIRA for its Autonomous Take Off and Landing (ATOL) project;
- The project involved flight testing an Autonomous Flight Control System for UAVs onboard a small platform;
- UNINA supported CIRA in the following activities:
 - Selection of altimetric sensors (in cooperation with CoRiSTA);
 - Developement of a real time Integrated Navigation System based on sensor data fusion by Kalman Filtering;
 - A study on GPS accuracy applied to UAV landing requirements.



The Aerospace System Group at UNINA and CoRiSTA supported CIRA in the following activities:

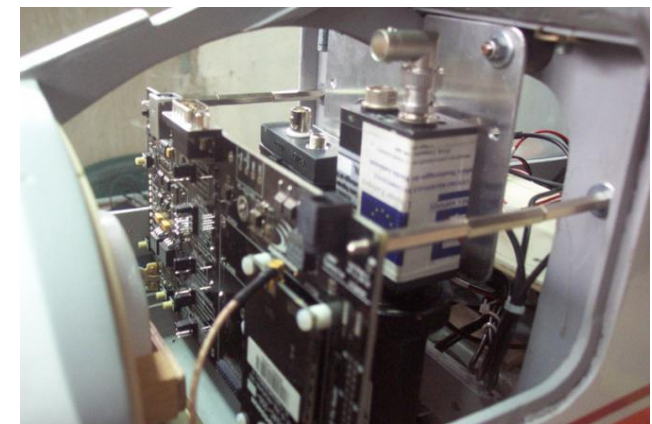
- Selecting a radar altimeter and a laser altimeter adequate to be installed onboard a small UAV;
- Developing real time software to extract ground altitude from raw sensor data;
- Performing an error budget analysis of sensor output.





PROJECT 1ST

- 1st:
autonomous Flyer for Integration of Remote Sensing Technologies and guidance, navigation, and control aimed at monitoring environmental risk
- mini-UAV platform, equipped with:
 - integrated avionics for autonomous navigation and autopilot for flight control
 - payload of electro-optical sensors with multi-band and hyperspectral observation capability, conceived for forest fire risk monitoring
 - communication subsystem for telemetry/telecommand (distinct bands for GNC and Payload)





1st UAV platform & GNC avionics

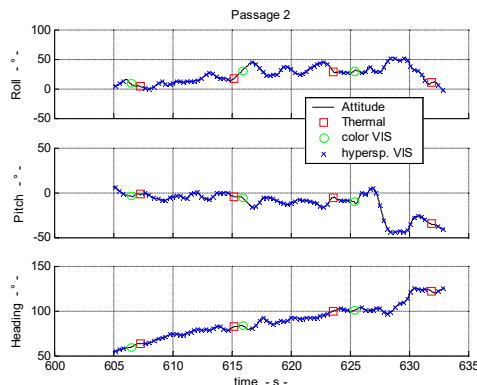
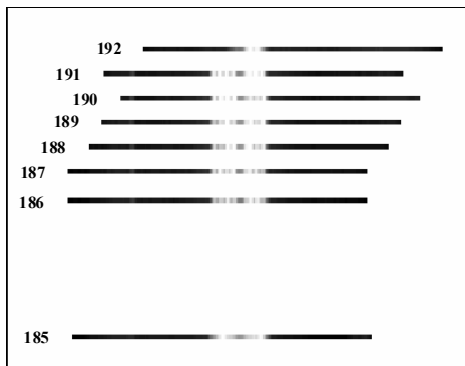
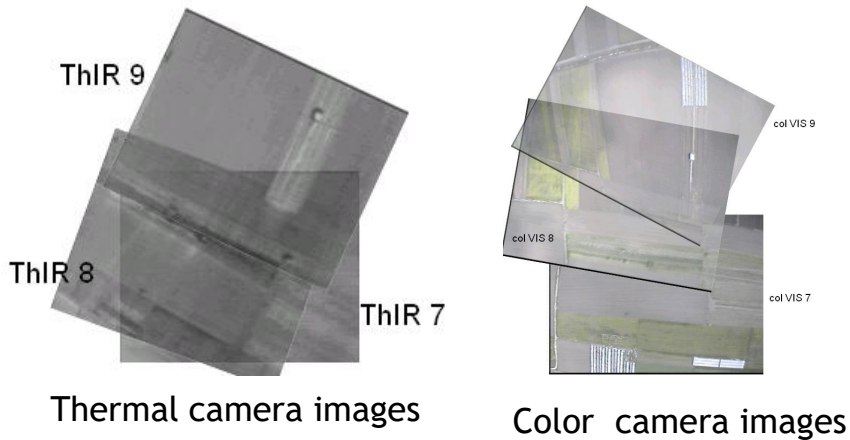


DIMENSIONAL SPECIFICATIONS	
Wingspan	2.75m
Wing Area	0.46m ²
Length	1.20m
Weight	< 3kg
Airfoil	Symmetrical
ENGINE	
Model	OS BGX 35cc
Swept volume	35cm ³
Propeller	20x10cm

- GCN on-board sub-system based on commercial units by Crossbow Technology:
 - navigation board (12-ch GPS receiver, inertial sensor set + magnetometer, ADS sensor) with MEMS sensors
 - 400-MHz RISK processor board
 - I/F to R/C receiver and servomotors
 - Transceiver for a bi-directional radio link @ 400 MHz (navigation telemetry downlink & command uplink)



1st Electro-Optical Payload



EO sensors	<ul style="list-style-type: none"> -Thermal (7.5-13.5 μm) -VNIR hyperspectral (60 bands in 400-900nm) -Low-res (VIS) color camera <p>Pushbroom Operation</p>
Power / Mass	<3.6W / < 0.9kg
CPU	pc104 format, 400MHz Celeron, 256MB RAM, RS-232/422/485, LAN, and USB1.1 ports, compact flash and solid state disk
Frame grabber	-4-ch (mux) analog frame grabber
Power / Mass	< 20 W / < 0.5 kg
RF communication	Aerocomm AC 5124 transceiver
RF data rate	882 kbps (max)
Carrier	2.4 GHz
Power	< 2.4W (100%Tx)
Mass	< 0.2kg
Total power	< 26W
Total mass	<2.6kg (incl. battery)



Contact information and research publications can be found at

<http://www.dii.unina.it/index.php/it/ricerca/gruppi-di-ricerca/280-aerospace-systems-team>

<http://www.dii.unina.it/index.php/it/ricerca/laboratori-di-ricerca/281-aerospace-systems-laboratories>