VERY-LONG ENDURANCE SOLAR POWERED AUTONOMOUS UAVS: ROLE AND CONSTRAINTS FOR GMES APPLICATIONS

G.Romeo*, E.Cestino*, F.Borello*, M.Pacino*
***Dept of Mechanical and Aerospace Eng., Politecnico di Torino**
giulio.romeo@polito.it

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Abstract

The wide range of applications for civilian UAVs, will open up a variety of markets for potential sales and economic growth. The Scientific Community could benefit in many ways from employing UAVs in the civilian sphere. Within the EC funded project TANGO "Telecommunications Advanced Networks for GMES Operations", a three-year European Commission (EC) programme with the aim to develop, integrate, demonstrate and promote new telecom services dedicated to GMES (Global Monitoring for Environment & Security) requirements, a multicriteria comparison between different UAV configurations has been implemented and different configurations have been assessed regarding a lot of representative scenarios (Risk & Crisis, Maritime, Security, Land cover, Humanitarian Aid). Almost all these scenarios can be performed with success by UAVs. Nevertheless, the civil market for the use of UAVs will remain difficult to develop until operational regulations for the use of UAVs in non segregated airspace are developed and approved by ATM authorities. Two different configurations were developed in details:1) A Solar powered HALE configuration was designed and a 1:3 scaled prototype (24m wing span) was manufactured and tested up to failure load to show reliability of technological process & theoretical analysis 2)The flying model SESA (Small Electric Solar Unmanned Airplane) was manufactured within the EC funded projects CAPECON and TANGO, to carry out several experimental flight test with a small UAV and to demonstrate some critical technologies and applications. The UAV was positively introduced in a TANGO demonstration where a flight test was prepared for final integration in cooperation with Iridium satellite system.

1 Introduction

The total UAV market is growing at a rapid pace and it is imperative that the European community should make a serious effort to attain a significant segment of this market. The utilization of UAVs for border and costal patrol, homeland security, maritime surveillance, forest fires mapping, real-time monitoring of seismic-risk areas, volcanoes eruption, etc, "Eye-in-the-sky" surveillance, will allow better law-enforcement in the protection of citizens and integrity of the borders and will assure the public is aware of imminent disasters and can prepare for their occurrence. In Sept. 2010, the Boeing Company signed an agreement with the U.S. DARPA to develop and fly the SolarEagle unmanned aircraft for the Vulture II demonstration program. Under the terms of the $89 million contract, SolarEagle will make its first demonstration flight in 2014. "SolarEagle is a uniquely configured, large unmanned aircraft designed to eventually remain on station at stratospheric altitudes for at least five years. "That's a daunting task, but Boeing has a highly reliable solar electric design that will meet the challenge in order to perform persistent communications, intelligence, surveillance and reconnaissance missions from altitudes above 60,000 feet." (Pat O'Neil, Boeing Phantom Works).

Under the coordination of the first author, a research is being carried out since 1996 aiming at the design of Very-Long Endurance Solar Powered Autonomous Stratospheric UAV (VESPAS-UAV) and manufacturing of solar powered prototype. This could play the role of pseudo-satellite, with the advantage of allowing more detailed land vision, due to the relative closeness to the land, with continuous earth observation and at a much lower cost than real satellites (Fig. 1). Several satellite systems used for earth observation are useless for continuous real-time border surveillance because of their limited spatial resolution.

Fig.1 VESPAS-UAV border surveillance

All the Mediterranean Sea border, from Turkey to Spain could be controlled by 8-9 platforms from a high altitude (17-20 km), with very-long endurance (4-6 months) stratospheric UAV (payload up to 150-200 kg, power available for payload up to 1.5-2kW). It is essential to control who and what enters European countries in order to prevent the admission of terrorists and instruments of terror across borders, along coastlines and harbours. Continuous (24h by 24h) border monitoring would be guaranteed and service costs and tedious work would be drastically reduced. A 300km diameter area would be monitored by each of these platforms. UAVs are less expensive (800-1000 €/flight hour) than other manned aircraft used for the borders surveillance (8.000 €/flight hour) drastically reducing service cost and tedious work. The main advantage of VESPAS-UAV is that this system has less climb and descend events, important when considering interference with the aviation traffic. Any other high-altitude UAV configuration for border surveillance has a very limited endurance (24-48 hours) that would drastically increase any potential collision risk with civil aviation traffic. A double number of UAVs would be requested to guarantee the surveillance service, highly increasing the System Total Life Cycle Cost. MALE UAVs has the disadvantage that a much higher number of UAVs are requested to continuously cover all the Mediterranean Sea, since the covered area is decreasing with the square value of the flying altitude increasing tremendously the cost. POLITO (Coordinator Prof. G. Romeo) is carrying on, since several years, one of the few existing world projects on solar powered aerodynamic stratospheric platforms. After a preliminary funding by the Italian Space Agency, a very great push to the project has indeed been obtained by the financial support received by the European Commission in the field of stratospheric platform (HeliNet, Capecon, Enfica-FC, Tango) **[1-4]**. The possibility of medium-long endurance (4-6 months) for a stratospheric platform can be realized with the application of an integrated Hydrogen-based energy system. It is a closed-loop system: during daytime, the power generated by thin high efficiency solar cells that cover the aircraft's wing and horizontal tail supply power to electric motors for flying and to an electrolyser which splits water into its two components, hydrogen and oxygen. The gases are stored into pressurized tanks and then, during night-time, used as inlet gases for fuel cells stack in order to produce electric DC power and water to be supplied to the electrolyser. Since fuel cells represent the promise of clean and efficient power generation, they are a suitable alternative to conventional energy sources.

The GMES (Global Monitoring for Environment & Security) services are currently being developed to support public policy makers' needs in the domain of environment and security, and rely on a comprehensive Earth observing system, using space borne and in situ techniques. The civil market for the use of UAVs will remain difficult to develop until operational regulations for the use of UAVs in non segregated airspace are developed and approved by ATM authorities. Potential users have interests to deploy UAS in non segregated airspace. Recent technological and operational improvements give reason to believe that UAS safety and performance capabilities are maturing. UAS, together with satellite telecommunications will be a key component of the future GMES architecture. In this framework, the European Commission has selected the TANGO Project "Telecommunications Advanced Networks for GMES Operations" to develop, integrate, demonstrate and promote new telecom services dedicated to GMES requirements. The present paper presents results of an high level analysis with comparison between various platforms in performing different TANGO missions through the development of a multicriteria tool in which inputs from performances characteristics of reference aircrafts are compared to requirements from mission typology. The last phase of the TANGO Project demonstrated, trough a real experimental phase, the ability to integrate land monitoring existing systems with monitoring aircraft systems based on a small UAS platform, with high range and endurance capabilities, powered by alternative energy sources based on solar cells, batteries and fuel cells in order to develop a more effective monitoring system with the introduction of a local air component with low environmental impact.

2 Description of the procedure

The implementation of a multi-criteria analysis for the identification of suitable applications for different classes of UAVs within TANGO thematic (Risk & Crisis, Maritime, Security, Land cover, Humanitarian Aid) has been subdivided in four parts:

- Definition of applications requirements.
- Assessment of the Capabilities & Performance of various UAVs
- Analysis of capabilities versus user needs through a multi-criteria analysis.
- Identification of suitable TANGO applications

2.1 Definition Of Applications Requirements

Several scenarios (e.g. oceanic Observations, fire fighting, oil spills, boarder surveillance etc…), has been identified in term of payload typology (Infrared, EO, SAR, Lidar etc.), characteristics of various payloads (mass, power consumption, volume, data link etc.) and requirements of the mission (all weather capabilities, day/night operation, endurance, altitude, flight speed etc.). Data about missions requirements has been collected through data sheets aimed to the identification and description of specific applications in term of payload main characteristics, operational needs, advantages and benefits compared to existing implementations. For each scenario a weight index is included in order to describe main missions performance requirements. A high weighting index means the criterion is very important for the mission, a low weighting index means the criterion is not very important for the mission. These weights indices are used in the multicriteria method to give the final ranking.

Table 1

Mark	Meaning
10	Capability is extremely important for the mission
6	Capability is one of the more important parameters for the mission.
2	Capability is not very important for the mission and a low performance is sufficient to perform the mission.
0	Capability is not critical for mission

The weight scale used to characterize missions is reported in Table 1. It should be noted that in case the mission includes some minimum or maximum required performances the weight indices measure the importance to overcome the basic requirement, or if the mission include some optimal requested value, weight indices

measure the importance to be closer to the optimal value.
The algorithm implemented is based on inputs from performances characteristics of the aircrafts (Ji) and requirements from mission typology, it analyze each aircraft considering some weight indices given to the missions (Wi) and shows a final score for each aircraft and for each mission excluding those UAVs that are not able to complete the specified mission. The comparison algorithm takes in consideration the gap between the lowest and the highest value of single requirements and considers how near is the aircraft from the best value, then it applies the weight indices required by specified mission and give the global score (Fig 2).

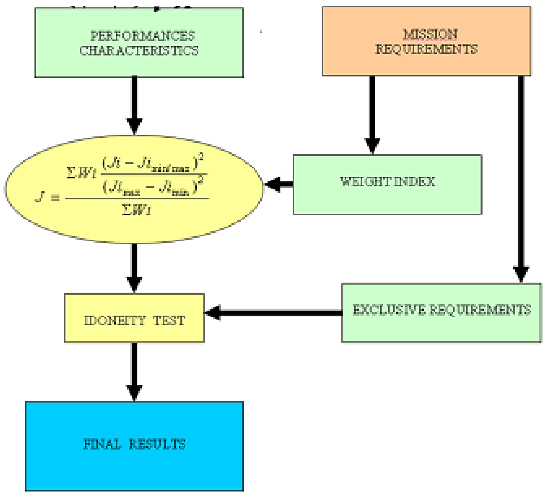


Fig.2 Multi-criteria analysis

2.2 Assessment Of The Capabilities & Performance Of Various UAVs

On the technical side, the UAV system can be characterized by an air system and a ground system, interconnected by data links, control links, and integrated into a technical and decision-making environment. Civil UAVs are also categorized as a function of weight and operational altitude **[8]**. During the work presented, the assessment of the Capabilities & Performance of various UAV systems has been made starting from some reference configurations mainly derived from Heliplat and CAPECON projects **[5,6,7]** and used here only as a performance baseline of the different UAVs categories. Solar HALE configuration and Small Solar configuration are described in details in the following paragraphs.
In order to evaluate and compare the aircrafts selected, the performances criteria shown in Table 2 have been chosen **[8]**. Some of these criteria are exclusive like "Vertical takeoff", "HOGE" and the "All weather capability". The value for these characteristics can be 1 if the aircraft is able to perform them or 0 if not.

Table 2

Capability	Description
Vertical Take Off	capability to perform vertical take off and landing typical of helicopter.
HOGE	capability to perform hovering out of ground effect typical of helicopters.
All weather capabilities	ability to flight in every adverse weather conditions.
Range	maximum flight range to perform the mission expressed in meters
Range of controllability:	distance of the UAV from the ground control station
Maximum velocity:	maximum velocity that can be reached in level flight expressed in m/s
Climb rate	the altitude expressed in meters that can be achieved in one second, it express the ability to reach the desired altitude quickly
Ceiling	maximum flight altitude in meters
Payload weight	maximum admitted weight of the operative payload expressed in kg.
Manoeuvrability	ability to perform short range manoeuvres, the value is the turn radius expressed in meters.
Minimum velocity	minimum flight velocity in level flight before stalling in m/s.
Landing length	distance necessary to land expressed in meters.
Take off length	distance necessary to take off expressed in meters.
Noise on flight	noise produced during the flight operations caused by engines and rotors expressed in dB.
Minimum altitude	Minimum flight altitude correlated to the airspace categorization.
Loiter velocity	cruise speed on level flight expressed in m/s. a suitable aircraft should have a loiter velocity as close as possible to the optimal value required by the specific mission.

Other characteristics are dimensional characteristics that give a high score as higher they are (Range, Endurance, Range of controllability, Maximum velocity, Climb rate, Ceiling and Payload weight). Finally others criteria are dimensional characteristics that give a high score as lower they are (Maneuverability, Minimum velocity, Landing length: Take off length, Noise on flight, Minimum altitude, Loiter velocity).

2.3 Results For Selected Missions

Several scenarios in each TANGO thematic has been considered for the analysis.
Below are shown results related to few thematic of the five main scenarios considered during the project.

<u>Maritime Thematic</u>

- *Maritime Patrol*

Marine surveillance and tracking missions have the main purpose of detection and localization of sea moving targets (ship imaging and classification, man in life raft, oil tankers…); sea pollution monitoring: detection of oil spills, position, thickness and extent of the oil surface. The aircraft would fly from one sea region to the next and track targets (different ships categories) or loiter at speeds of about 50m/s in a region for a period of time. A long endurance not less than 8hr as well long range mission not less than 1000km are the two main mission parameters. The vehicle management system should allow for direct control or flight path re-direction from a ground station so a high manoeuvrability is requested for the mission. Payloads will consist of various sensors including detection and tracking of ships. Sensor data from the UAV must be available real-time. OTH network communications for command and control of the UAV are required. For these reasons mission require a high payload weight capacity not less than 90kg and better if it is higher. In this case the use of very long endurance HALE UAVs seems the best solution. Results are shown in Fig 3.

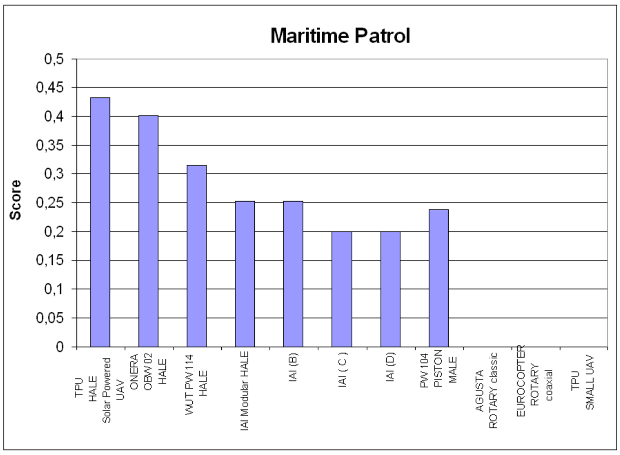


Fig. 3 Example of Results for Maritime Patrol

This mission is an additional support for the previous mission and may include the deployment of a platform in closer proximity to suspicious vessels, the HOGE capability could give a contribution to the success of the mission but is not an excluding requirement. The platform would be released low altitude less than 5000m and in some case a very low fly altitudes is requested so the capability to fly at very low altitude is weighted with an high value.
The mission require low turn radius that means high maneuverability in order to fly around the vessel under suspicion. The analysis results shown high rates for Rotary and for small UAVs (Fig 4).

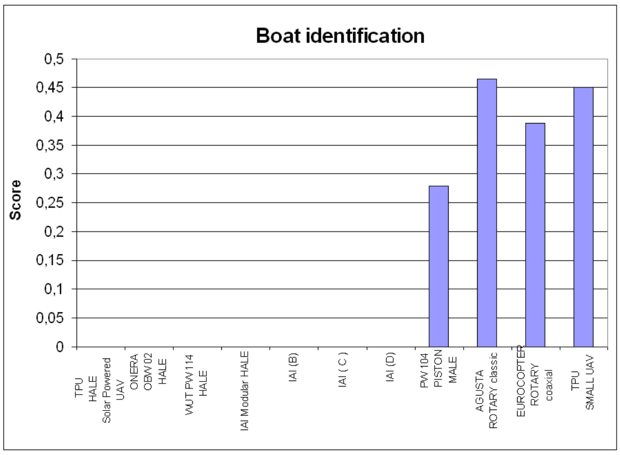


Fig. 4 Example of Results for Boat Identification

- *Boat Identifications*

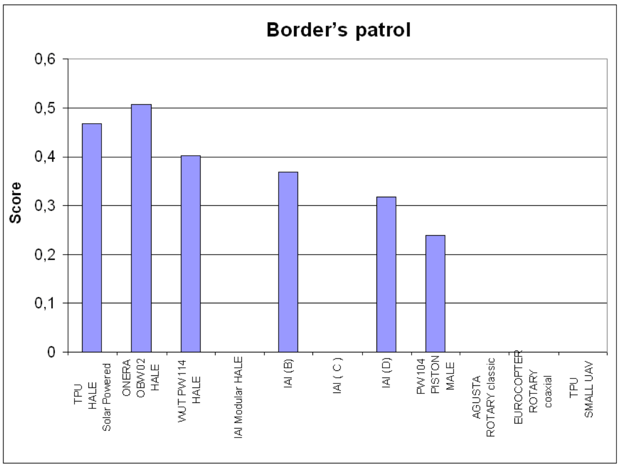


Fig. 5 Example of Results for Archaeological observations

<u>Security thematic</u>

- Borders Patrol

The UAV flies along the border conducting surveillance, and detecting cross-border activity and informs personnel at the Border Patrol Regional Command Centre. An area supervisor dispatches resources and re-tasks the UAV(s), as appropriate. Once on station, the UAV serves as a communications node and identifies border violators. Desired attributes for the platform include multi-day endurance (>24h weight=6), and the ability to carry multiple payloads (>40kg weight=5). High altitude flight is desirable (weight=7) as it increases platform's covertness. The ability of the sensor package to "steer" the platform to a target of interest is highly desirable (maneuverability=5). The results show that the Solar powered and blended HALE configurations have the best result for this mission (Fig 5).
Similar results have been obtained for scenarios included in other thematic like Risk&Crisis, Land Cover and Humanitarian Aids **[8]**.

3 Description of HALE Solar powered UAV

The full scale HeliPlat® UAV (Fig. 6) was designed by using the most advanced tools for obtaining an endurance of several months (4-6) and being operable in almost all typical environment conditions (wind jet up to 140km/h) at stratospheric altitude (17-20 km). **[5,6,9,10]**. A computer program was developed for designing the platform capable of remaining aloft for very long period of time. The project of the platform was completed up to a quasi-final detail design. A numerical aerodynamic analysis was performed to obtain the highest efficiencies of the whole wing and airplane. Several experimental tests were carried out on Low-Speed-Low-Turbulence Wind-tunnel, obtaining a very good correlation between analytical and experimental results. A first configuration of Heliplat® was worked out, as a result of the preliminary design study. The platform is a monoplane with 8 brushless motors, twin-boom tail type, horizontal stabilizer and two rudders. The design procedure followed in the analysis was based on the energy balance equilibrium between the available solar power and the required power for flying; the endurance parameter has in particular to be fulfilled to minimize the power required for a horizontal flight. Main characteristics for a flight at 38°N latitude and design altitude of 17 km are: Total weight: 8500N; Wing Area: 176m2; Span:73m; Required Power: 7500W; Aspect ratio=33; Cruise Speed = 71 km/h.

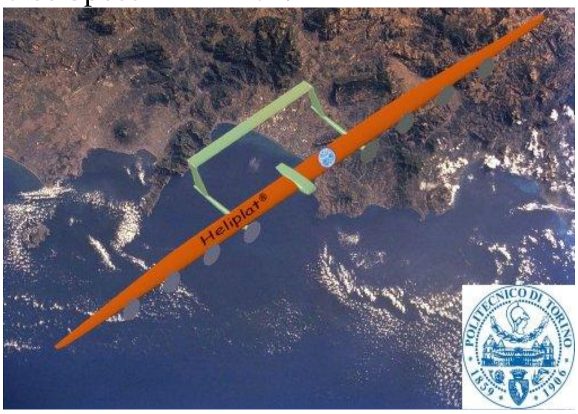


Fig.6 HeliPlat ® Configuration

A payload up to 100kg, with available power up to 1500W, could be installed on board for several global monitoring of environmental and security applications (GMES). A numerical aero-dynamic analysis was performed to obtain the highest efficiencies of the whole wing and airplane including propellers by using VSAERO software, at the flight Reynolds numbers **[5,6]**.
A 1:3 scaled size prototype (wing span 24m, length 7 m) was built in advanced composite material (high modulus CFRP) in order to show the technological feasibility (Fig. 7).

Several shear/bending/torsion static tests on the whole manufactured scaled-size prototype were per-formed in our laboratory up to failure load (7.5g) finding a very good correlation with the in-house developed numerical analysis and FEM analysis (Fig. 7-8).

Fig. 7 – 1:3 Scaled-size HeliPlat® UAV

The results obtained in the CAPECON project **[2]**, confirmed the feasibility of a solar powered stratospheric UAV (SHAMPO) satisfying the requirements of a long endurance stationary flight. A detailed aerodynamic and structural design, the flight mechanics and the electric systems was completed by the Politecnico di Torino up to a quasi-final design (Fig. 9) **[5]**. A greater aerodynamic and structural efficiency was obtained allowing an higher payload mass (150 kg) and power (1.8 kW).

Fig. 8 - 1:3 Scaled-size HeliPlat® UAV – Shear/Bending and Torsion Tests

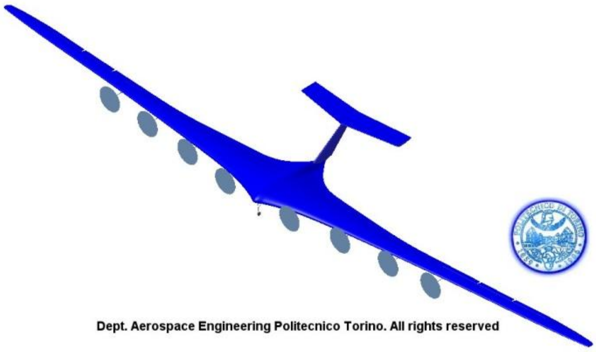


Fig. 9 – CAPECON SHAMPO Configuration

4 Description of SESA

The SESA (Small Electric Solar Aircraft) UAV was designed and manufactured by the Polytechnic of Turin within CAPECON and TANGO European projects (Fig.10). The aim was to have a technological demonstrator to investigate experimentally the technologies required by a HALE Solar powered UAV and to demonstrate the applicability of UAV platforms in a satellite global network for GMES operations as proposed in TANGO project.
SESA is a 7m wing span platform weighting 35 kg maximum at the take-off with 5-6 kg of payload. The propulsion is a solar powered brushless electric motor with LiPo batteries as secondary power source; the piloting is manual remote and autopilot switchable with both direct and satellite data-link communications. The fuselage and wing structure were manufactured in fiberglass with carbon-fiber spar and enforcements by Archemide Advanced Composite company in order to accomplish the required 3.8 limit load (Fig.11).

Fig.10 SESA UAV

The UAV was utilized for testing the photovoltaic technology and developing the electronic devices for the solar power management in order to increase the endurance. Then the autopilot implementation assessments, occurred for the control-law calibration, and the direct data-link footprint measurements.
Finally Low Earth Orbit (LEO) satellite communication system was installed for testing the BLOS (Beyond Line Of Sight) command & control communication capability.
After the technologies experimentation the UAV was used for demonstrate monitoring purposes mission efficacy as proved in the TANGO demonstration described in the next chapter.

Fig.11 SESA structure

4.1 Electric System

Since SESA is a completely electric solar UAV, the electric system is responsible for both the flight power and the avionic and payload power supply.

Flight power

The UAV is equipped by a brushless electric motor of 2 kW maximum power with a direct joint to the two blade propeller. The main power supply of the motor for the flight power is made by the solar-cells array displaced on the 2m^2 wing surface. The array is made of high efficiency mono-crystalline silicon solar-cells with a nominal efficiency of 21% made of a thin and flexible structure able to cover the airfoil curvature. A MPPT (Maximum Power Point Tracker) is responsible to the solar array voltage and current balancing to grant the maximum power production, then a DC-DC booster was designed to obtain the right range of voltage required by the motor (Fig.12). Such a system is able to keep in flight the UAV for 6-7- hours during June July. In addition, LiPo battery packs have been installed as secondary power source in a redundant displacement. In particular situations an additional amount of energy is required: for the take off, climb and in case of clouds obscuring the sun, then the battery packs supply the gap of power. Moreover that reserve of energy grants a safety backup in case of main source or electronic devices failure.

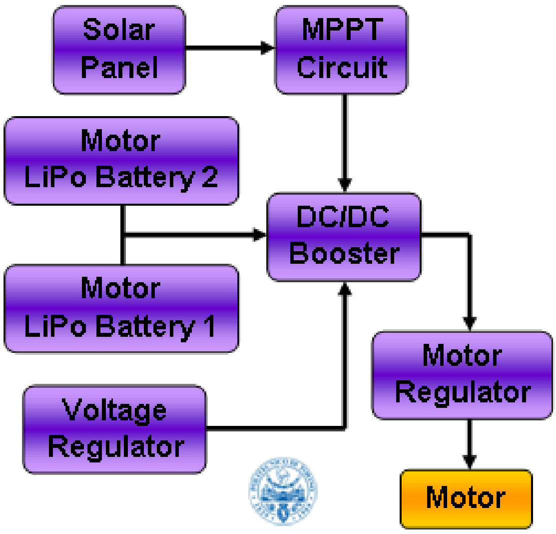


Fig.12 Flight power electric system

Avionic and payload power supply

Separate from the flight power batteries, two others battery packs have been allocated to supply the command & control system and the payload each with a double redundant displacement.

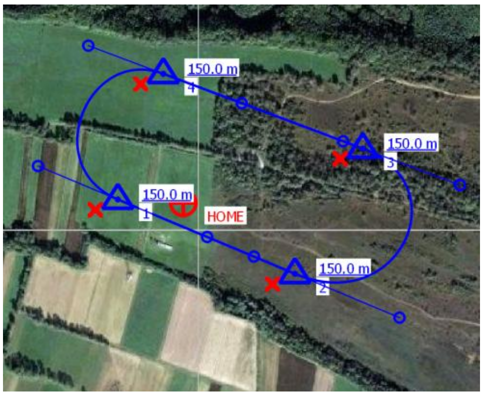
4.2 Command & control

SESA command & control is mainly managed by an autopilot system providing a completely autonomous navigation based on spline-connected waypoints (Fig.13). That system operates with two separate data-link, one direct in Line Of Sight with the GCS and the second satellite-based for a Beyond Line Of Sight transmission. Both the links are able to transmit and receive re-planning information and telemetry data.

In addition a manual control can operate by overriding the autopilot with a direct radio connection. This is required during the critical flight phases: take-off & landing or emergency. The 2.4GHz on-board R/C receiver is connected to the autopilot and a safety switching mechanism allow the autopilot to be overridden by the remote control at any time, as long as the remote control transmitter is within the aircraft range. That fact does not represent a limitation, the transmitting range in fact is about 2 km, which is a suitable range also for the visibility of the manual pilot on the ground. In this way, any possible malfunction of the autopilot or telemetry system is overcome and flight safety is increased to great extent.

The ground control station is basically composed of the LOS data-link and Iridium transceivers, a PC, and the ground control software which is the user interface to the SESA UAV system for mission planning and runtime control. All the mission planning & re-planning work can be done by just one operator on an underlying map. The waypoints position, altitude and the flight speed can be easily modified also during the flight. This allows a very flexible flight path design. Moreover a check with respect to the aircraft performance is automatically done and remarked to ensure a realistic and safe flight planning.

Then for the payload data acquisition an additional PC and data-link receivers are used with directive antennas for increasing the receiving range.



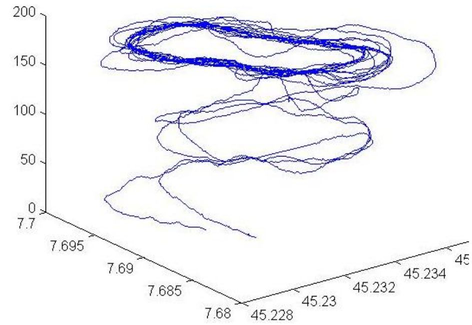


Fig.13 Autopilot route planning and flight assessment results

4.3 Autopilot specifications

The Autopilot system consists of three main parts:

1) The TrIMU Sensor Block containing a complete 3-axis Inertia Measurement Unit (IMU) and two pressure sensors for barometric altitude and airspeed determination. It generates up to 12 independent servo control signals.

2) The Navigation Core hosting a sophisticated navigation filter for GPS/IMU data fusion which enables precise and long-term stable determination of the position, velocity and the Eulerian angles and to obtain a reliable attitude determination.

3) The Satellite Navigation Receiver. 16 channel GPS receiver with high sensitivity and integrated ceramic patch antenna.

The on-board autopilot system communicates with Ground Control via a dedicated, direct bidirectional data link, using a radio modem which operates in the European 868 MHz band. The A/P periodically sends data (GPS time, position, Eulerian angles, flight speed, etc.) to the GCS at a rate of 4 Hz, and health monitoring data (battery voltage, electric motor current) but with a lower data rate.

For the Beyond Line Of Sight command & control capabilities an Iridium L-Band Transceiver weighting 650g, with less than 1 second latency provides the satellite connection with the control station.

4.4 Payload

In order involve the SESA platforms in GMES operations, the UAV has been equipped with 2 wireless cameras transmitting at 1.2GHz, in a range of about 1.5 km. Two configurations have been tested:

1) A colour CCD camera with a resolution of 720x576 pixel and remotely-controlled 40x zoom, and an infra-red thermo-camera 160x120 pixel (Fig.14), both pointing downward for fire detection purpose;

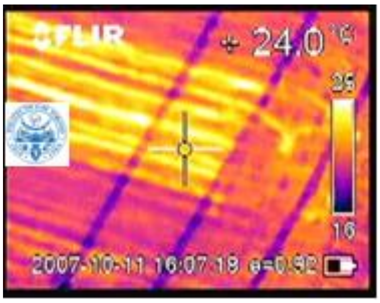


Fig.14 Thermal image

2) The colour camera pointed forward for see & avoid compliance (Fig.15) and a downward monitoring photo/video-camera with remotely-controlled clicking mechanism.

Fig.15 Forward image

The second configuration has been chosen for the TANGO demonstration demo flight.
The ground segment have been equipped with a specific PC acquiring the real-time images for monitoring purposes, images acquisition, and referencing pictures with the UAV position.

5 The use of the SESA UAV in the TANGO demonstration

The multicriteria analysis showed out that the small Politecnico UAV represents a good solution for boat identification missions. So a demo application within TANGO project was realized about such scenario.
The Italian CAA concerning flying the UAV showed some safety issue to take into account. Since the SESA weight is less then 35kg and since it shall be used for research and scientific purposes, an EASA certificate is not necessary. Nevertheless, the following items shall be pursed:

a) See & Avoid system on board;
b) Flight over a non populated area (although the Maximum kinetic energy of 95 KJ shall not be reached);
c) Direct visual manual control, necessary to obtain a safe flight and to avoid double-triple redundancy. The SESA shall be always followed by a pilot in direct-link range for any UAV emergency remote control. If necessary the R/C can override the A/P control at any moment.
d) No catastrophic failure condition shall result from the failure of a single component; the allowable Quantitative Probabilities (per 1 flight hour) is less than 10^{-6}.

So, in order to accomplish the second CAA requirement, the demo flight was planned in Tarquinia Lido where the airfield is just close to the sea. All the flight has been performed completely over a non populated sea area.
The task of the mission was integrating the small UAV activities in a network involving satellite monitoring and detection. When an undeclared boat would be detected in a maritime area by satellites, the coordinates would be sent to the GCS that would direct the UAV over that area for investigating with closer high resolution picture the vessel origin and intentions.

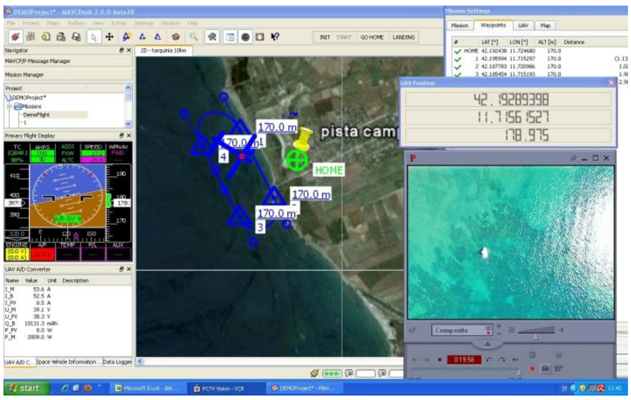


Fig.16 GCS software and downward camera image acquisition during the demo flight

To simulate this scenario a GCS was equipped near the Tarquinia airfield and a sailboat was involved to figure as an illegal boat (Fig.16,17). After a simulate advise from the satellite the coordinates of the monitoring area have been set on the GCS route planner and sent to the UAV both with direct and BLOS data-link. The pilot operate the take off in manual control, then switched the control to the autopilot autonomous navigation.

Arrived over the operating area the vessel was detected and followed. At that time the GCS operator was able to take pictures of the boat and remark its exact position. At the same time the pilot was asked to monitor the forward camera to note eventual obstacles on the flight trajectory and to keep under check the telemetry parameters to be ready to operate in case of failure.

After the boat images acquisition its position was determinate for advising the competent authorities .

All the flight parameters have been recorded in the autopilot logger and at the same time sent to GCS both with LOS and Iridium satellite data-link (with a lower rate Fig. 18). The reverse connections was used for the up-link re-planning commands.

At the end of the mission was planned the flight back to the airfield and then a manual handover occurred for the landing procedures.

Fig.17 TANGO demo flight illegal boat identification

6 Conclusions

The following conclusion should be issued as result of the many years of research in the field of solar powered UAV:

- Today’s technology allows to define and produce different types of UAVs, for a high number of potential GMES applications.
- A multi-criteria analysis, which compares the mission requirements with the performance of different UAV configurations has been developed as a decision support for future end-users. The limits of the proposed algorithm mainly are the difficulty of taking into account additional criteria such as costs and level of risk introduced by a specific UAS configuration.

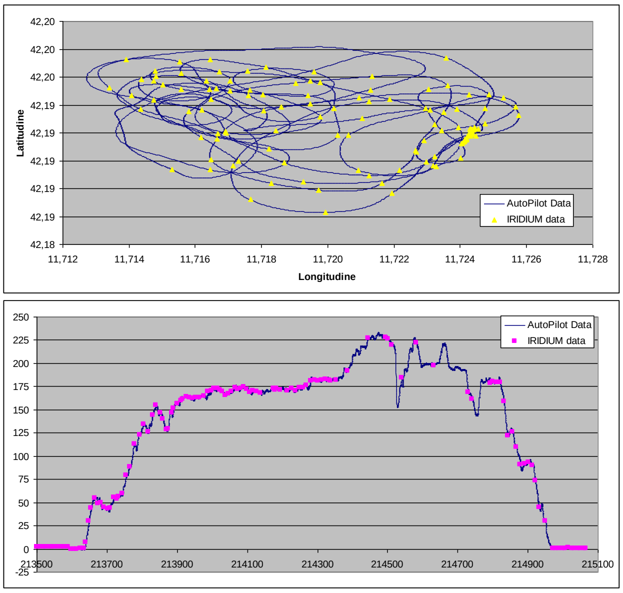


Fig.18 Direct link and Iridium positioning data correlation

- Possible realization of VESPAS-UAV at least for low latitude sites in Europe and for 4-6 months continuous flight.
- Forest Fire Early detection, Border Patrol and Fishery monitoring would be possible at much cheaper cost and higher resolution than actual systems, and it would be obtained continuously.
- Showed feasibility of very light CFRP structural elements. Good correspondence between experimental, analytical and FEM analysis.
- The experimental tests successively validated several critical technologies for high altitude very long endurance flight: high efficiency solar cells, electric brushless motor, controllers, video and thermo camera image transmission, telemetry system, Solar Power production and control, Wireless transmission
- Autonomous flight control of UAV as by autopilot as well as by satellite communication.
- The feasibility of an UAV system, integrated with a satcom system was shown,

to achieve Fisheries patrolling in a faster, accurate and more reliable manner.

- For small UAV limited in payload weight, it should be necessary to improve the image compression system to transmit the required images by satcom system.

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