Leonardo Aircraft Division UAS flight testing experience capabilities and future developments

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ABSTRACT

Leonardo Aircraft Division has been a pioneer in UAS design, development and testing, starting its commitment in early 90s with the participation in all major European research teamed with Academia and other industrial stakeholders.

Leonardo Aircraft Division built its own technology and operational demonstrators with Sky-X and Sky-Y achieving significant results:

- *Sky-X, was built and operated to mature technology and competence in the unmanned vehicle flight autonomy and the ability to gather, process, synthesise and deliver information. SKY-X, first flight in 2005, was the first UAV to fly in Europe in its weight category.*
- *Sky-Y programme allowed developing technologies for a MALE such as surveillance technologies demonstration, autonomous take-off and landing, mission management system, sensor exploitation, full Mission system testing, data exploitation and dissemination, fully automatic night landing and extended range clearance. Sky-Y, first flight 2007, proved to be a surveillance asset capable of supporting monitoring and control of a wide range of events.*

In the field of UCAV, Leonardo Aircraft Division played an important role in the Neuron programme, let by Dassault as prime contractor. The activity encompassed the integration of electrical generation, the development of the low observable air data system and the attack mission system for both Air segment and Ground Segment including the design, manufacturing and integration of the A/C weapon bays doors.

Leonardo Aircraft Division is also supporting the development and certification activities of the Falco Xplorer RPAS of Leonardo Electronic Division, by participating with a dedicated team in the flight test of the prototype.

Leonardo Aircraft Division is currently involved in the Euro MALE RPAS program. One of the 3 prototypes will be managed and flight tested in Italy for the experimentation of the Airborne Mission System and of the Armament System.

Leonardo Aircraft Division has the necessary expertise including exploited organization and robust flight test processes in synergy with Italian MoD Authorities and facilities, with experiences matured across several test programs.

1 LDV distinctive vision on UAS

Leonardo started many years ago dealing with UAS, developing its proper vision on UAS development, testing and certification activities.

Studies and research began in early ’90s with the participation in all major European research teamed with

Leonardo Aircraft Division (LAD) built its own technology and operational demonstrators with Sky-X (first flight in 2005) as UAV technologies demonstrator and Sky-Y (first flight 2007) as MALE & Surveillance technologies demonstrator achieving some significant results.

Since the first stage of activities LAD focuses on:

- Design, produce and operate medium to large sized drones
- Find out the best strategy to safely conduct test and qualification of these flying machines
- Demonstrate the capability to install and operate remotely state of the art or innovative technologies
- Integrate complex mission system capabilities.

1.1 Participation in major European and International research and operational program

Leonardo Aircraft Division decides to participate to a number of international program to strengthen its capabilities or to share experience and vision with:

- Dassault for Neuron advanced UCAV demonstrator
- Skydweller, medium-altitude pseudo satellite capable of carrying heavy payloads at long range and persisting overhead indefinitely
- Leonardo Electronic Division (LED) Falco XPlorer light MALE
- Piaggio AS for the P1HH RPAS.

1.1.1 Neuron

The contribute of LAD in the Neuron Program was targeted to the achievement of important technological targets like:

- Low Observables technologies
- Aerodynamics/Aeroacoustics
- Weapon internal carriage and release from a bay
- Combat capability with internal E/O sensor
- Modular avionics, hardware and software
- Autonomy and Automatic flight.

1.1.2 Skydweller

LAD is involved in Skydweller program with a team of design and test engineers located in Madrid. Skydweller is a US-Spanish aerospace company developing solar powered aircraft solutions capable of achieving perpetual flight with high payload capacity.

The aircraft fly at altitude by an electric thruster powered by solar-powered accumulators that collaborate with extremely advanced aerodynamics that takes shape on a light structure.

1.1.3 Falco Xplorer

LAD is participating at Falco XPlorer program with a Flight Test Team in support of the development and certification Test Campaigns, basing on proper experience and skill on Test techniques and associated established procedures for manned aircraft. In addition, a collaboration in engineering task is in course for:

- Support for Structural Coupling analysis and Structural Testing SCT/GVT
- Support to aeroelastic testing in flight
- Lightning Protection
- Bridge Test Campaign on composite materials
- Wing Full Scale fatigue test
- Bird Strike Analysis and Test
- Support to Certification activities with the Compliance Verification Engineer (CVE)

1.1.4 Piaggio P1HH

An assignment in development, integration and qualification of an Armament System fit for the use on the Piaggio P1HH UAS was agreed between Piaggio and Leonardo.

The P.1HH is a remotely piloted aircraft developed starting from the fuselage of the Piaggio P180 characterized by thrusting propellers and its characteristics made it fall into the MALE category.

In particular, the development and qualification of the Armament System and Weapon Aiming, comprehensive of flight test support, was part of a complete “vertical” work package assigned to LAD.

1.2 Contribute of Leonardo global approach to UAS enabling technologies

Some examples of the LAD contribute/experience to UAS enabling technologies are presented hereinafter.

Mission planning were developed and tested using SKY-Y as a platform such a testing new logic design for automatic definition of routes on the basis of EOST pre-planned capabilities.

A new functionality of EO Intelligence Surveillance and Target Reconnaissance (ISTAR) were developed implementing an off track cruise mode capability, called “Direct Steering” (DS), that was the autonomous capability in driving SKY-Y towards a point of interest located outside of the programmed route for recognition purposes.

Another significant step in the field of autonomous flight plan capability was achieved with the conclusion of the Sky-X flight test campaign in Amendola Air force base performing automatic Join Up flight using C27J aircraft as cooperant and a video tracking system for auxiliary.

The mission was based on Automatic Rendez-Vous and Automatic Close Formation Flight.

The data source was an integration of optical and GPS data for a fully automated 4D autonomous rendez-vous mission with real time re-planning, fully automated pre-contact in-flight refuelling simulation & formation flight. The mission was called "Join-Up", that is, the ability, in a completely automatic way, to reach a Joining area at a predefined point and time, orbit the area by establishing instrumental contact with the mother aircraft (C27J) and then use this information to approach and maintain stable contact with the aircraft.

To equip the aircraft with the capabilities necessary for carrying out the mission, the avionics system was integrated with a Mission Management System and an optical tracking system.

Figure 1-1: Sky-X Join-Up

In the field of autonomous replanning capabilities, a significant experience was made on Neuron program where Leonardo was in charge of the development of the SIWB (Smart Integrated Weapon Bay) that allow to demonstrate in flight important technologies like:

- Automatic detection and recognition
- Target designation sent to GCS
- Automatic trajectory update
- Autonomous re-plan of detection and recognition mission with or without intervention of GCS operator.

An-experimental FCS mode for command and control for UAS was performed using Sky-Y as test bench: a dedicated architecture allowed through an Uplink Switch to evaluate in flight, in dependence of phases of flight, different control laws and a new experimental Data Link (narrow + wide band data link) by direct comparison of flight behaviors. For this task a new tactical Control Station was developed and joined to the basic one in use.

In the field of new technologies, within Neuron program, Leonardo was in charge of ~~an~~ airdata system providing both low-observable equipment and the algorithm embedded in the flight control laws to produce aircraft information.

An important activity for the identification of architectures and standards for the S&A (sense and avoidance) of unmanned aircraft was part of the MIDCAS project aimed at demonstrating technological solutions that allow the use of UAS systems in non-segregated airspace.

Detect and Avoid is the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action. This capability aims to ensure the safe execution of an RPA flight and to enable full integration in all airspace classes with all airspace users. This project was part of a vast program which saw the participation of 13 partnerships including 5 Italian companies.

MIDCAS logic was based on forecasted intruder trajectory breaching a predefined volume around the SKY-

Y. Two phases were activated to avoid the collision:

- Self-Separation Phase (Traffic Avoidance TRA) - Pilot in Control.
- Collision avoidance (CA) – S&A in control: active when Intruder is predicted to breach CA Volume.

MIDCAS system was installed on SKY-Y and a flight test campaign was carried out using different encounter scenarios and a company aircraft as intruder to validate high level requirements such as: provide situational awareness, provide separation maneuver, provide collision avoidance, abort collision avoidance maneuver, provide interface with data link, detect intruder, prioritize intruder.

After Clear of Conflict a Recovery manoeuvre started, bringing back the UAV to straight & Level flight with a commanded final heading. When S&L flight condition was reached, S&A asked pilot to revert back in command.

2 Demonstrators development, deployment and testing experience

2.1 Technology and operational demonstrators

2.1.1 Sky-X

Leonardo's experience, at the time Alenia Aeronautica, in the field of UAV technology research aiming at developing a family of UAV technical demonstrators, date back at the end of 2003 when it was launched the technology demonstration program Sky-X, being this program the first Alenia effort in the field of UAV technology research.

The aim of the Sky-X program was to acquire kwon-how in the unmanned vehicle, and in particular on the development of a platform dedicated to the testing of the so-called enabling technologies for unmanned systems. Another purpose of the project was to increase the degree of autonomy of the air vehicle and its ability to gather, process, synthetize and deliver information, make the uninhabited system a high added-value tool in the military and civil operational scenarios.

The Sky-X flight segment was a high wing, single jet, Vee tail, tricycle landing gear aircraft, all-electric controls aircraft, with the only exception of the brakes, which were powered by a hydraulic system. The engine was a 965 lbs thrust jet turbojet. The electric system was powered by the generator mounted on the engine shaft and by a battery that provided both a backup in case of generator failure and the adsorption of power peaks requests. The heart of the system was a highly integrated Flight Control Computer (FCC) including an air data, inertial and magnetic sensor suite, a GPS, and a computing unit processing the sensors data and the commands coming from the GCS providing the inputs to the flight control actuators: 2 ailerons, 2 ele-rudders (Vee tail), 2 airbrakes and the steering. The servo actuators were substantially identical. The FCC, together with a differential GPS and a radar-altimeter, performed also the navigation computer function. The aircraft could be operated in different flight Modes (Basic and Navigation flight modes), each of these managed by the FCC.

The Ground Segment included a Video-Tracker that was a laser-optical device able to give aircraft position and distance information to the ROS operator. It was placed at the end of the runway and it was used as landing aid. The Video tracker was a COTS, but the integration with the GCS was performed by the Flight Test Department.

The maiden flight was performed at Vidsel air base in Sweden in 2005 and it was the first UAV to fly in Europe in its weight category.

The Sky-X program has been characterized by a short developing time, relying to the greatest extent on the know-how and resources already available in the company. Moreover, a simplified Qualification Process was adopted in order to maintain the traceability of requirements and obtain a ‘Permit to Fly’ from two different Airworthiness Authorities (FMV in Sweden and ENAC in Italy).

In this research program the Flight Test Department played a new and important role. In fact, in addition to the traditional flight testing task, the Department had the responsibility of designing and developing the Ground Control Station and the Data Link System exploiting the experience in the field of telemetry and real time software.

Auto take off and auto landing functionalities were fine-tuned using an Auto Tracker Video Optical System

The main achievement of this program were:

- Data source integration – optical and GPS data
- Fully automated 4D autonomous rendezvous mission with real time re-planning
- ATOL based on ground video/laser tracker
- Automatic Rendezvous
- Automatic Close Formation Flight
- Fully automated pre-contact in-flight refuelling simulation & formation flight.

□ Length/wing span: about 7 m / 6 m

- Max TO weight: 1200 kg
- Max speed: 350 KCAS
- Cruise speed: 260 KCAS
- Propulsion: Microturbo TRI60-268 jet engine
- Ceiling: 35000 ft
- Maximum load factor: 5
- TO and landing run: about 900 m

Figure 2-1: Sky-X

2.1.2 Sky-Y

Sky-Y was a Medium Altitude Long Endurance (MALE) Technologies Demonstrator, intended as a dedicated platform for validating several key enabling technologies for a surveillance UAS to be used in either a military and civil operational scenario.

These technologies included: innovative carbon fiber composite construction, heavy fuel/JP-8 engine (automotive diesel derivative), advanced datalinks, surveillance sensor (EO/IR, Hyperspectral, Synthetic Aperture Radar) and mission management system able to relevant data treatment, elaboration, fusion and distribution by means of an interoperable Tactical Control Station.

As far as concerning surveillance capability a demonstration program for Regione Piemonte called "Sistema Monitoraggio Avanzato del Territorio" (SMAT) was carried out. The purpose of the SMAT project was to study and demonstrate a surveillance system capable to support prevention and control of a wide range of events (e.g. fires, floods, landslides, traffic, pollution, cultivations).

Three UAV systems were involved in this project: Sky-Y, Falco and C-Fly; the objective of this project was to integrate 3 different platforms in a single operative contest well defined. One of the task was to develop advanced functionalities of mission planning and replanning within SMAT program.

Effective teamwork is a must for UAS operations nowadays. Distributed sensors combined with intensive digital information exchange can provide an up-to-date "picture" of the environment. This can give the individual operator, and the team, the information necessary to successfully complete complex and dynamic missions.

Rapidly changing mission environments require teams to constantly adapt the way they operate and collaborate. Joint and combined operations are the norm nowadays. Also, unmanned systems are teaming up with manned aircraft and helicopters. This requires operators with a variety of backgrounds, training and experience to work together.

Dimensions	
Length	9.725 m
Span	9.937 m
Weights	
MTOW	1200 kg
OEW	850 kg
Fuel	200 kg
Payload (*)	150 kg
Performances	
LOS Radius	70+nm
Range	500 nm
Altitude	25.000 ft
Endurance	14 h
(* Typical)	

Figure 2-2: Sky-Y

3 Developing UAS Flight Test philosophy

Facing for the first time the in-flight experimentation of unmanned aircraft, Leonardo relied on the consolidated experience in flight tests of piloted aircraft, trying to transpose the test techniques on this new kind of machines. The test and evaluation was initially platformcentric, that means it was aimed at developing the air vehicle and proving its airworthiness as a platform. But since from the first experiences the need for an operational test and evaluation approach to validate the effectiveness and suitability of the UAV system was highlighted.

At the beginning the driver in the development process was to keep the development risk at minimum, by using at the greatest extent as possible resources, experience and equipment already available or used on different programs and to limit the development of new system/equipment. As examples, the first GCS was derived from an existing Control Station used for the telemetry monitoring, the engine, the servo-actuators and FCC were COTS, or modified COTS.

In this contest the Flight Test Department was in charge of the development of the Ground Control Station and the Data Link, relying on the great experience matured during the years in other programs on the telemetry and data processing applications.

3.1 Flight test process: Leonardo experience on UAV

The process followed for UAV flight test activities is in Leonardo the same adopted for manned aircraft, with the necessary tailoring due to the ground-flight parts of the system.

The flight preparation phase includes the normal Test Procedures on the aircraft plus the integration testing with GCS in the loop.

Importance of the EME testing, the loss-of-comunication backup strategy has been duly take into consideration.

Training of the crews, risk mitigation actions and approach, hazard assessment in each phase must be considered at higher level for UAS testing: consider that for size, speed and dimensions the LAD managed drones could be considered in the medium to large categories.

In general, the flight test planning with unmanned aircraft do not differ much from planning manned flights. The objectives and constraints for the flights are documented and collected. Some constraints are permanent which are imposed by the official regulations of the country where the test is performed like restricted ground and air space, some other are project limitations like endurance of the vehicle, usable flight envelope due to systems limitations or limitations of the vehicle imposed by a sensor payload. Test procedures, test execution and test report are part of the process that allow for flight clearance by the governing authority.

3.1.1 Ground test phase: what is different w.r.t. manned aircraft

Before starting any Flight Test program many stakeholders have to plan and prepare teams and test setup in proper way: particularly for an UAS project.

Correct modelling, off-line and on-line simulation, system integration test is a must.

Ground test phase on UAV has to be considered as a System Integration Test because it should include the Ground Control Station, Air Vehicle, Data Links, Recovery Systems, and any other subsystems required to execute the mission.

Quality ground testing is essential not only to reduce the risk of mishap, but also to ensure that the system is technically ready for the flight testing to follow in all its components.

The ability to force the system into a simulated flight mode with a high fidelity (preferably a six degree of freedom) model residing in the GCS, facilitates quality ground testing and improves risk reduction. It also reduces the time and effort required to find and fix problems by allowing isolation to the message containing the error.

The key words that characterized the testing approach during the development phase was ‘synergy and integration’ between the involved Engineering departments, and sharing of the various Ground Test Facilities.

The development phase, and in particular the testing activity, saw a strict and highly integrated collaboration among the Flight Test Department, the Simulation Department and Avionic RIG. As a first step each department firstly developed its own Ground Test Facilities in order to accomplish the testing necessary to develop the system under its own responsibility.

During System Integration Testing a thorough test of the data link, both primary and back up is necessary. By attenuating the output power of these systems and monitoring the received signal strength, it is possible to determine whether the links will provide the range and margin determined in the design analysis. This “range” check has to be conducted in the intended flight test environment. It is also extremely important to verify the procedures by which the backup data link assumes control in the event of a primary failure. In many cases this operation is completely automatic and requires no operator intervention or action.

A more difficult phase of the control transfer may be required when the control of the air vehicle is transferred not from the primary to backup data link, but from one ground control station to another.

Electro-Magnetic Effects – Electro-Magnetic Interference and Compatibility testing are very important in UAV systems due to the fact that UAV rely on Radio Frequency (RF) transmissions for all operator control inputs, and all operator displays. There are no mechanical backup systems when the air vehicle is in flight. So test site characterization is a very important feature. These systems should be extensively tested in the intended operational environment that includes close range emissions from surface and air traffic radar systems and communications equipment.

Five different test site were assessed for the trials of Leonardo program and a big effort to characterize each site has been necessary.

3.1.2 Flight test phase: what is different w.r.t. manned aircraft

The flight test activity to be executed derives from an engineering requirement which is discussed and agreed with Flight Test Department who is in charge of the preparation of Flight Test Plan. This document details the procedures to be followed for achieving the objectives of the trials and establish the criteria for validation of testing. A special attention is dedicated to the assessment of risk and a dedicated session to discuss the mitigation required for the accomplishment of the test with all the stakeholders involved in the program constitutes an essential step.

In general, many aspects of UAV or UCAV test planning and execution are not significantly different from manned aircraft testing. Attention to the same risk factors is required, and much of the data to be collected is very similar. There are however, unique requirements and differences that need to be understood in order to develop effective and successful test programs

If the UAV can be kept within approved boundaries with fail-safe or flight termination systems, loss of the air vehicle may become an acceptable risk. This is diametrically opposed to the entire philosophy of manned aircraft Risk Management.

The major difference between manned and unmanned testing is a necessary requirement to have a fail-safe ability to terminate the flight.

So, in addition to the failure mode analysis of engine, avionics, flight control system, servos, and generators a new aspect to consider is the communications signal uplink and downlink.

In case of Data link loss, a flight termination after a predetermined time is required. From a flight safety and operability standpoint it is necessary to know air vehicle position, altitude, heading and speed at all times. In addition to real time navigation requirements, it is necessary that flight planning capabilities exist to translate terrain topology and survey grid requirements to provide optimal data link coverage for the control telemetry.

Flight termination boundaries will correspond to the area of operations described in the NOTAM and it is also dependent on the test range constraints.

A consideration that must prevail over all is to protect personnel and property in the event that a major system failure does occur so the safety assessment for the test range choice must take into account air vehicle size and weight, aircraft performance, system complexity, redundancy of critical systems and flight termination.

In some cases, where navigation computers and GPS allow to know the relative position of the UAV and control room, autonomous return to base logic can be considered in case of lost link. But this depend from range constrictions.

In some other cases a flight termination system completely independent of the UAV system may be required. Such systems may also be required if the UAV system cannot satisfy range safety requirements.

These systems may simply disable the air vehicle engine, cause departure from controlled flight, emergency parachute, or even cause the airborne destruction of the vehicle.

Another important point that has to be particularly considered is the training. Pilot or operator training is often underestimated as a critical path to UAV testing.

Human factors with respect to the ground station man-machine interface should also be considered early in the design process. A fundamental and unique aspect of UAV operation is the complete lack of the multitude of feedback provided to the pilot of a manned aircraft. Wind noise, engine vibration, peripheral cues, and feel of acceleration on the human body are all missing for the UAV pilot. The safe operation of a UAV requires intense concentration on exclusively visual feedback.

For this reason, a well-designed cockpit and GCS lay out is crucial. Communications between flight crew members need to be clear. Use of high quality headsets and microphones is mandatory, switch functions clearly marked and guarded with adequate separation between switches to prevent inadvertent activation, visual displays with critical information need to be well allocated for pilot’s view as well as the video downlinked from UAV camera, status of critical parameters should be easily observable by the entire test team.

So training of the entire team is essential to reduce risk. Hardware in-the-loop simulations were used to provide crew with realistic training and practice opportunities as well as to simulate anomalies and failures.

Situational awareness involves the remote pilot being aware of what is happening in the vicinity of the RPA, in order to understand how information, events and the remote pilot’s own actions will impact the mission. Whether conducting IFR or VFR operations, the remote pilot’s situational awareness is dependent on a combination of support from the Detection and Avoidance capability, flight instruments and/or external contributors (ATC instructions, flight preparation).

The Flight Simulator for Leonardo programs was brought to each test area essentially to give the pilot the opportunity to train and to check each flight before actually fly it. It revealed to be a very useful tool to check the feasibility of each proposed flight in terms of number of planned test points and manoeuvres. It was also important to optimize the position of the two emergency loiter points. The entire team was engaged in reviewing and updating the emergency procedures.

Test team organizational structure is a major element in the success and efficiency of any test team. A dedicated flight test team was deployed for the two Leonardo UAV programs distributed with well-defined roles in the GCS (Ground Control Station) and TCS (Tactical Control Station) during the execution of flight test activities.

The GCS team was composed by:

- one Test Conductor with the role of point of contact with the crew during the flight. It is his responsibility to initiate the testing and he also may abort it. He is responsible that the flight test runs and coordinates the flight test activities.
- three Flight Test Engineers (air vehicle, general systems, mission system) for monitoring of the systems and test point validation
- one Data Link Operator for monitoring of Data Link quality and eventual switch on back up data link in case of signal degradation

- one Ground Station Operator for monitoring of HW and SW of each station in use and control of communication between GCS and TCS.

The TCS team was composed by:

- one Experimental Test Pilot with the role of PIC
- one Co-pilot or a LFTE to assist the pilot in normal and emergency procedures
- one Mission System Operator who is responsible that the payload is working during mission. He synchronizes its operation with the flight test and gathers the information needed for the scope of testing
- one TCS operator for HW and SW efficiency monitoring

Another important difference between manned and unmanned process is relative to the Permit To Fly. The Remotely Piloted Aircraft (RPA) are certificated by the issuance of a Type Certificate, which includes all the associated components required for controlled flight. Operation of an RPA requires that the remote pilot have the ability to manage the flight on a real-time basis through use of a C2 (Command and Control) link. Therefore, the C2 link is necessarily part of this safe flight principle, and must be addressed in the certification process. The C2 link is not a “product”, therefore it will not be independently type certificated. There are two forms of operation related to the C2 link: within RLOS and beyond BRLOS. In either case, the link forms part of the overall type design and as such it will need to be defined and fully addressed within the certification process.

Even in the flight manual some differences have to be underlined. The RPA flight manual should contain all necessary information for operation of the RPAS. In addition to those required for manned aviation, the following procedures should be included:

- RPA handover procedures from one Remote Pilot Station to another;
- C2 link specifications and procedures to respond to interruption or loss of the C2 link;
- flight termination procedures;
- security procedures unique to RPAS (e.g. Remote Pilot Station security, C2 link).

4 Testing manned and unmanned AS

When dealing with testing of a new category of flying machines, different approaches can be adopted: a brand new, revolutionary one, with relevant risks and advantages, or a modified, improved, evolutionary one, based on lessons learned, achievements and experienced gained by the organization or consortiums.

Past experience, history, culture, dimension and attitude of the test organization play a role in this doing: the new and the old has to be evaluated in testing UAS.

The evolutionary approach bases on some solid arguments:

- The flying machine often is a derivative of an existing one or has “classic” design: legacy or state-of-the-art power plant and general systems, integrated avionics and nav/id
- Mission system integration is felt as a process very similar on manned and unmanned AS
- Basic airworthiness testing, envelope expansion and H&P quite similar or even of lower effort wrt frontline manned aircraft

On the other hand, you have to encompass some aspects that make new the business:

- The interaction between the human being and the machine is remote, either if the pilot is on ground or some degree of autonomy (little to full) is reached on the AS
- This impact in the design of the system, ground and flight for the UAS, and in the design of the associated testing
- Rules and regulations vary according to type, size, destination (military, civil), country and aviation authority involved
- Scope and logistics of the activities may require a change in the standard test set up
- New technologies deployed all together in a new AS require a revision in the safety approach of the test.

To mitigate most of these challenges, some practices are already in place:

- Anticipate most of the activities at an early stage of the design: analysis tools, simulation, system and integrated rigs, test benches, iron bird, global benches and so on. The continuous feedback to the previous stage allow for validate and improve the prediction capabilities
- Use of innovative technologies, like digital twin or rapid prototyping, can make more efficient the development process
- Train every part of the system, human or machines, since the beginning
- Integrated planning of multi-asset, multi-tasking, multi-resources programs with some degree of automatics and some degree of freedom of adjustment.

Some parts of the activities require more attention:

- Safety of operations and risk assessment/mitigation
- Activities authorizations and limitations, in all phases of testing: proof of concept, demonstration, development, certification, in service.

One may argue if, for testing an UAS, is necessary an established organization or a new one: it largely depends on the nature of the machine and on the history/experience/culture of the organization: normally large companies test dept. rely on well-established and staffed team, with procedures, regulations and approval gained in long years of test campaigns. New organizations are nevertheless more agile and result-oriented: a blend of the two approach could be considered, but requires solid technical and program knowledge. At the end the only consideration must be: Safety first.

5 Future developments

LAD is engaged in the Euro MALE RPAS Joint Development Program for the Next Generation European MALE. The aim is to establish an independent European UAS capability by developing an advanced MALE RPAS able to fulfil future European requirements through a joint high level European Governments and Industrial initiative launched by Airbus D&S, Leonardo Aeronautics Sector and Dassault Aviation. The new system will give to Europe a full sovereignity and indipendence, in terms of ownership of technology, ability to enhance the system through the life-cycle, management of operations and information. Moreover, the certification basis will be agreed among the airworthiness authorities, to allow the system to insert in the European non-segregated airspace.

LAD will act as a Major Sub-Contractor according to the following contract scheme:

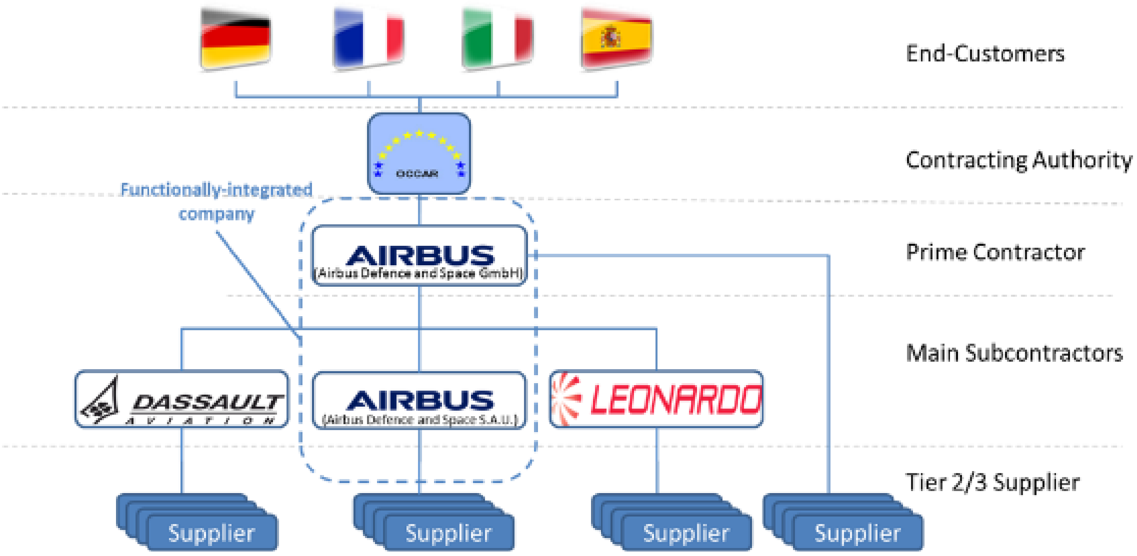

Figure 5-1: Euro MALE contract scheme

As far as the flight test is concerned, one of the 3 prototypes will be managed by LAD, according to the following rules:

- Test Requirements, level I schedule will come from a Synthesis Team (lead ADS).
- Level II scheduling, task distribution will be responsibility of the FT Management Team (lead ADS)
- The responsibility for Permit to Fly obtaining, III level scheduling, ground and flight test conduction with the assigned prototype will be in charge of the Main subcontractor (LAD).

The Major Sub-Contractor shall do its best effort to achieve a reasonable flight test frequency, taking into account the external constraints it may face.

The Major Sub-Contractor shall perform all the flights test that will be defined in collaboration between Prime and Major Sub-Contractor.

LAD is acting to manage with the National Military Authorities the way to implement the euro MALE Italian test activities, both for regulatory, logistic and operational aspects.

The "Italian" Euro MALE prototype will be mainly dedicated to mission systems and armament development and qualification.

Figure 5-2: Euro MALE

6 Conclusions

Unmanned systems with current intelligence, surveillance and reconnaissance technologies, combined with high level of endurance, no risk of loss of on-board life could increase their potential use to become independent also in an unknown environment and in operational situation where complex judgements are needed.

In order to enlarge their application UAS should increase safe operation to overcome the restrictions on flying over people.