# The Integration of UAVs in Airspace

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*The growth of UAV industry is greatly dependent on the way an entire range of technical, airworthiness, operational and regulatory issues related to UAV integration in airspace will be solved. The present article reviews the most significant related airworthiness and operational issues as viewed by an UAV manufacturer, IAI-MALAT, strengthened by the more than 80 000 hours of in-service experience accumulated by its whole range of UAV products.*

During the past few years, with astonishing proliferation, European and international UAV working groups have been drafting regulatory materials and guidance papers related to the issuance of UAV certification. Even if these activities have not as yet led to concrete results, the trend is clearly apparent: sooner or later, the UAV industry and its users will have to get ready to enter the "world" of airworthiness, airspace integration and certification.

## Challenge and issues

An increasing number of military UAVs – especially when used for peacetime training operations and potentially for para-civil applications – are facing a difficult time with having been strictly confined to restricted portions of airspace by the ATC authorities. And, as per the Biblical prophecy (Isaiah II, 4), whereby "they shall beat their swords into plowshares…", the military technology is now being progressively used for peaceful purpose: indeed, civil and commercial applications for Unmanned Air Vehicles have great potential.

The "adoption" of UAVs by the international aviation community requires the fulfillment of the two following interrelated conditions:

- UAV design must be shown to be safe and reliable in order to receive authorization to fly above populated areas of possibly high density. Generally, this is usually dealt with during the 'airworthiness certification' process and is mostly related to safety design criteria;
- UAVs should be safely operated, considering the envisaged kind of operations within possibly ever increasing portions of airspace. This is usually dealt with during the 'operational certification' process, relating to airspace management issues, operator qualification, maintenance and continued airworthiness.

Dealing appropriately with the above issues, especially within the framework of European airspace constraints is crucial. It is, undoubtedly, a prerequisite condition for the growth of the commercial UAV industry in particular and, probably also, for the growth of the whole UAV industry in general.

## IAI-MALAT ongoing experience

It is well known that accumulated in-service experience on one hand and the introduction of new technologies on the other hand have always triggered the update or the establishment of airworthiness and aviation standards.

During the past twenty-five years, IAI-MALAT (Israel Aircraft Industries, Malat Division) has accumulated considerable operational experience while in parallel continuously and smoothly introducing new technologies. Throughout this time IAI-MALAT has had to deal with UAV airworthiness and operational issues. True, they were not always formally expressed as such and, in most of the cases, the official "certifying" bodies remained within the military context. However, such experience can provide – and has already provided – fruitful inputs to various outstanding rule-making processes.

### IAI-MALAT UAVs "Airworthiness" approvals

"Airworthiness" approvals have been generally dealt with within the framework of the system requirements. This includes System Qualification and First Article Test Inspection procedures as well as the Compliance Demonstration process with specification requirements which often "hide" design airworthiness and safety requirements. Such a process was, for instance, successfully performed for IAI-MALAT UAV systems like the US SR-Hunter (*figure 1*), French F-Hunter and worldwide sold Searcher.

The Ranger System (produced by a consortium consisting of Oerlikon Contraves as Prime Contractor, IAI-MALAT as overall technical responsible and the Swiss Aircraft and Systems Company) has been procured by the Swiss Armed

*Figure 1. The Hunter UAV.*

Forces and was recently purchased by the Finnish Armed Forces (*figure* 2). It has gone through a qualification and certification process carried out under the Defence Procurement Agency of the Swiss Federal Department of Defence as the responsible authority.

The B-Hunter System, contracted to the EAGLE Consortium (consisting of IAI-MALAT as technical system responsible, and SONACA, SAIT and Thomson-CSF Electronics Belgium and Thomson-CSF Systems Belgium) by the Belgian Ministry of Defence, is undergoing a formal airworthiness certification process based upon JAR VLA type requirements and specific UAV system requirements specified within the scope of the contract.

### IAI-MALAT UAVs "Operational" approvals

The respective military authorities also gave operational approvals of the IAI-MALAT products mentioned above. In most cases, the reserved portions of airspace used by the UAV are under the full control of the military Air Traffic Control (ATC) Authority, which ensures the necessary coordination with the civil ATC wherever required. For instance, in the case of the F-Hunter, a step-by-step process is being applied. After an appropriate confidence level was reached, based on the high-level reliability and in-service record of the system, the F-Hunter was progressively allocated dedicated corridors to fly from one reserved portion of airspace to another one. This allows the creation - on the basis of still existing restricted areas - of larger portions of airspace open to the UAVs, while minimizing the need for additional airspace. Most recently, in the frame of an exercise conducted for the French Navy, F-Hunter was authorized to take-off from a "mixed" civilian – military airport and to fly under radar control within the Terminal Control Area of Toulon-Hyères in the South of France. Such a step was achieved through perfect coordination between civilian and military authorities.

In the United States, a demonstration of the Firebird 2001, *figure 3*, (from the Eyeview family) was carried out in the State of Montana (forest fire surveillance application and assistance to fire brigades). IAI-MALAT went through the currently applicable procedure of receiving a special FAA certificate of flight authorization, designated as a "waiver" procedure. Technical information relating to the air vehicle and airborne systems, with emphasis on safety features, including autonomous flight management and flight termination capabilities, was presented to the FAA. Details of the intended flight plan and related airspace categories were also submitted and early coordination with the local ATC was performed. A "Certificate of Waiver or Authorization" (FAA form 7711-1) was finally issued by the Manager of the Air Traffic Division of the FAA Northwest Mountain Region. The authorization for the IAI Firebird 2001 to fly was granted during specified time frames based upon special safety provisions attached to the Certificate, including required ATC coordination with the local Approach Control (an ATC transponder was installed on Firebird 2001) and direct communication between the FAA controlling agency and the UAV Ground Control Station.

## Airworthiness aspects

### Lessons learned from in-service experience

More than 80 000 flight hours of operational experience accumulated by IAI-

*Figure 2. The Ranger UAV.*

*Figure 3. The Firebird 2001 UAV.*

MALAT products have been converted into airworthiness lessons learned. Analysis of statistics of UAV events served as an input into design efforts invested in new IAI UAV products (*figure 4*) in order to continuously improve failure handling and redundancy management of flight critical systems.
Human errors are also an important factor in the cause of UAV events. Interestingly, one finds an approximate ratio of 1/5, similar to that found for manned aircraft. The remedy for this is increased automation and improved man-machine interface within the Ground Control Station based upon the use of modern display technologies as is the case with the new IAI-MALAT Advanced Ground Control Station (*figure 5*).
The propulsion system is also a critical factor and efforts should be made to provide engines certificated or tested in accordance with manned aircraft engine procedures (including FAR/JAR 33 endurance tests).

### Defining an overall approach and most significant criteria

First, one must consider and view the UAV system as a whole system consisting of the Air Vehicle, the Ground Control Station and related Man-Machine Interface and the Communication Data Link. Each of these elements, separately and in conjunction, one with each other, may affect the airworthiness level of the entire system.
Secondly, airworthiness and safety criteria must be considered from the early stages of design and continue throughout the development process. In some cases, manned aircraft regulations, e.g.: JAR VLA, FAR/JAR 23, according to the type of UAV) can be used as a reference, but not blindly applied. They need to be tailored taking into account the leading particular and specific features of the UAV while keeping in mind the kind of operations envisaged.
Due to its considerable impact on the design and architecture of the system, the safety objective should be subsequently determined. Approaches such as the "FAR/JAR 25.1309", based upon fail-safe design principles and linkage of the severity of failure conditions to their probability of occurrence, are most appropriate,

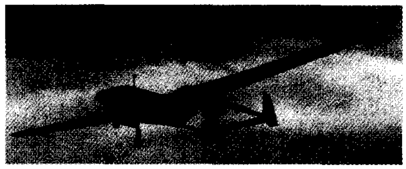

**Figure 4.** *The IAI-MALAT new Heron UAV.*

provided they are carefully tailored and adjusted to UAV applications.
A classical issue is, for instance, the definition of an UAV Catastrophic Event. Unlike the case of manned aircraft, it cannot be limited to the loss of the Air Vehicle due to the absence of passengers on board. Such an event should be defined as resulting from a failure condition that leads to an uncontrolled UAV landing or crashing and subsequently creating fatal injuries and/or severe damage on the ground. (The issue of air collision is dealt with under the operational certification process). The subsequent acceptable risk level can then be derived, considering various mitigating factors including the envisaged flight profile. Assessing such risk and minimizing it constitutes one of the key activities of the airworthiness process.
Finally, as for manned aircraft, the outputs of the airworthiness demonstration process should be converted into well-defined operational procedures and limitations, considering the handling of both normal and abnormal situations resulting from potential failure scenarios. It may also lead to the identification of safety maintenance tasks to maintain the level of airworthiness during in-service operations.

## Operational and airspace integration aspects

### General considerations

Operational aspects cover a broad range of issues, including integrated logistics support, maintenance capability of the operator and personnel qualification, which cannot be reviewed within the scope of this article.
Airspace integration aspects are crucial for the growth of UAV operations and

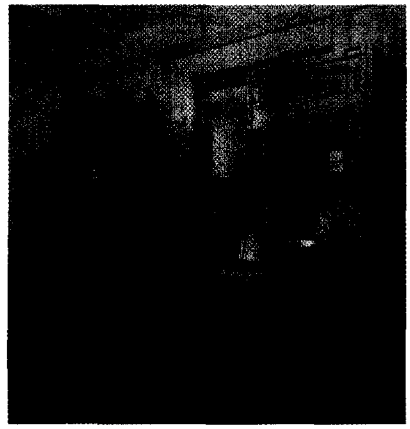

**Figure 5.** *The IAI-MALAT new Ground Control Station.*

also call for the application of sane ground rules. Among them are:

- as a prerequisite condition, the UAV system should be duly approved as airworthy according to the approach and criteria discussed above;
- UAV operators must be qualified and familiar with ATC technical and "cultural" environments;
- a step-by-step approach should be applied. Here, one must adequately tailor the issues according to the type of airspace actually required to be used as follows:
  - restricted areas (including military airspace areas);
  - allocated corridors from and to restricted areas;
  - outside restricted areas / civil airspace environment;
- preflight risk analysis should be carefully performed and emergency procedures, including flight termination into predefined landing areas, should be identified and duly coordinated with ATC authorities;
- in any case, close cooperation with ATC authorities is required, whereby the UAV must be able to communicate with ATC controllers and comply with their instructions.

### The "see and avoid" issue

The risk of air collision between an UAV and manned aircraft, if and when sharing the same portions of airspace, is often presented as the most crucial issue. Sometimes, as if it was the only one! Considering the absence of a pilot onboard, the requirement for the UAV system is to provide a means to "see and avoid" so as to cope with the risk of air collision in a manner equivalent to the manned aircraft. One must not forget that in many instances of manned flight, including IFR operations, pilot's eyes are not enough to avoid air traffic collisions. Therefore, it is also important to tailor the issue as a function of several operational, legal and technological factors listed below:

- the envisaged class of airspace required for UAV applications and the kind of operations (VFR/IFR);
- the legal onus for "see and avoid", is traditionally upon the operator. Nevertheless, future airspace environment and Air Traffic Management, based upon an automated data link, could well bring about some revolutions in the mentalities and in the sharing of the responsibilities;
- considering UAV specificity and technological considerations, the "see and avoid" requirement may in fact be met by "detect and avoid" means.

### Operational UAV design features

Typical, current, operational, design features necessary to cope with step-by-step integration of the UAV in the airspace include: an IFF/ATC Transponder providing continuous information to the ATC on an UAV flight, a Voice Relay (VHF) for two-way communication between the GCS and the ATC Control Station via the Air Vehicle, (with the possibility of direct communications between the ATC and the Ground Control Station as alternate means), anti-collision Strobe Lights, Forward Vision Camera and/or an Electro-optic Infrared Sensor.

Depending on the above mentioned "see and avoid" related factors and future Air Traffic Management trend and environmental contexts, various technologies are currently under investigation to enhance the UAV "detect and avoid" capability. This includes onboard systems, based either upon cooperative technologies (ADS, TCAS) or non-cooperative technologies (e.g. radar proximity sensors).

## Concluding thoughts

The ultimate challenge that the UAV industry and its users are facing is one that the international aviation community has been facing continuously during its history. As always, it is a matter of finding the "golden path" which means the establishment of appropriate safety standards to ensure that the required safety level is met and that public trust is gained while at the same time promoting technological development without unnecessary economic burden. For UAV developers, it requires maturity and experience, an airworthiness "cultural background", well-proven design features, system flexibility and a growth potential capability to implement future requirements and technological improvements. In this respect, IAI-MALAT does not only take advantage of being a division of a larger aerospace industry, it also enjoys an unique and considerable in-service experience based on its whole range of UAV products. As such, IAI-MALAT is ready to face this "old-new" challenge. ■

***About the author:***

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