Investigate operational use of Unmanned Aerial Vehicles
Presented by TOC

1. Introduction

1.1. There is a proliferation of Unmanned Aerial Vehicles (UAVs) taking place on a global basis. IFATCA does not currently have any policy established with regard to UAV operations.

1.2. The development and manufacture of UAVs is currently the largest growth area in the aviation industry.

1.3. It is because of this dramatic growth in the actual and potential use of UAVs that IFATCA requires policy to be developed regarding UAV operations. Several international organisations, including ICAO, JAA, EUROCONTROL and EASA, are formulating regulatory policy regarding UAV operations.

2. Discussion

2.1. Background Information on Unmanned Aerial Vehicles

2.1.1. The term UAV, as the name Unmanned Aerial Vehicle suggests, refers to pilot less aerial vehicles. Indeed, the definition of an UAV is “An aircraft which is designed to operate with no human pilot onboard”.

2.1.2. The shape and size of UAVs is very varied. UAVs range from hand launched micro aerial vehicles, weighing a few kilos, to aircraft similar in size to a Boeing 737, such as the Global Hawk. UAVs are not just fixed wing either, and there are numerous rotorcraft UAVs either in use, or being developed, as well as some lighter-than-air UAV concepts.

2.1.3. More than 30 nations are developing or manufacturing more than 250 models of UAVs. More than 40 countries already operate more than 80 types of UAVs that have a wide range of system performance concerning speed, altitude, mission duration, and payload capability. The entire spectrum of aviation companies and research institutes, both small and large, are developing and operating UAVs, as well as forwarding their related technologies.

2.1.4. In 2000, the world market for UAV systems exceeded one billion US $ in terms of annual revenues, with a continued compound annual growth rate forecast of approximately 7 percent for forthcoming years.
2.1.5. Civil UAV applications have been relatively slow to take advantage of potential applications, especially when compared to the rate of proliferation of military applications. This is due, at least in part, to the lack of a regulatory framework. Many potential civil missions, such as global monitoring of the environment and security applications, can only be achieved if UAVs are able to fly seamlessly amongst other air traffic within national or international airspace. However, there are many scenarios where existing regulations cannot currently accommodate civil UAVs. It is these areas that the proponents of UAVs are focusing upon to develop the regulatory framework to enable civil UAV operations on a widespread basis. The technologies and procedures that are essential to enable civil UAV operations are being developed and demonstrations are underway to show how UAV civil applications can be introduced in a safe manner. Where regulatory arrangements are already in place for civil UAV applications it is expected that operators will rapidly identify and exploit UAV technologies, particularly if UAVs can demonstrate a cost benefit compared to manned aircraft.

2.1.6. UAVs are being proposed for a variety of civil applications. The major drivers for the use of civil UAVs are unique flight performance, such as High Altitude, Long Endurance (HALE), and their suitability of use for “dull, dirty and dangerous missions”. Potential uses include endurance missions for surveillance, such as customs enforcement of coastlines, border patrols and fisheries protection. However, surveillance missions aren’t limited to remote areas and there is consideration being given to the use of UAVs for surveillance of urban areas. For instance, rush hour traffic could be monitored by UAVs that could loiter over potential hotspots. UAV operations are even being considered to replace the use of helicopters in monitoring the perimeter of international airports.

2.1.7. Other civil applications include the use of UAVs for environmental work (such as gathering scientific data from the atmosphere); communications (e.g. the relaying of live data); and even agricultural (e.g. crop spraying).

2.1.8. Within the 2004-2007 timeframe, the applications are:
- border and coastal patrol,
- environmental research (e.g. gathering scientific data from the atmosphere);
- communications (e.g. relaying of live data);
- agricultural (e.g. crop spraying);
- digital mapping and planning;
- fire fighting; and
- energy infrastructure/monitoring.

2.1.9. From 2008-2012, civil applications are expected to include law enforcement, search and rescue, maritime traffic control, hazardous materials monitoring and crisis management.

2.1.10. From 2013 onwards, applications may include surrogate satellites, communication and broadcast services, transportation and urban law enforcement.
2.1.11. One of the main catalysts for commercialisation of UAVs is the USA homeland security market. The task of patrolling America’s borders is immense and the use of UAVs is being promoted as a means of achieving this requirement. However, such missions will require a level of routine access to civil airspace. And such roles for UAVs extend beyond the USA. For example, Australia is seeking to use the general atomics mariner UAV for civil maritime surveillance.

2.1.12. There is considerable effort being undertaken by potential civil UAV operators to resolve the issues associated with operating in civil airspace. For instance, the formation of the UNITE group has been successful in obtaining a budget of US$101 million for work, known as Access 5, to be carried out over the next few years. The aim is to have a ‘file and fly’ capability for aircraft whose main operation is above 18,000 feet. The focus is on HALE aircraft.

2.1.13. Whilst the growth of civil UAVs and their potential operations is impressive, the civil UAV market is dwarfed by the vast military demand for UAVs. There are a huge range of potential military uses for UAVs. UAV operations range from reconnaissance, close air support, battle damage assessment to strike missions flown by Uninhabited Combat Aerial Vehicles (UCAVs) and Unmanned Combat Armed Rotorcraft (UCARs). The scale of proposed military operations range from individual lightweight micro UAVs, hand-launched by a single infantry soldier, to formation flights of UCAVs being controlled from a “mother ship”.

2.1.14. UAVs are now routinely used in military operations. The on-going operations in Iraq have been a proving ground for many types of UAV and mission. It is already public knowledge that UAVs have been used in a strike capability. The growth in the military use of UAVs is likely to continue unabated for years to come.

2.1.15. The aggregated military UAV expenditure for 2003-2012 (for USA and Europe) is expected to be 25 billion Euros. Around 84% of this spending will be directed towards HALE, MALE and UCAV applications. Out of this total, US $11 billion is forecast to be spent on procuring reconnaissance and surveillance UAVs. This sum will purchase approximately 6,000 UAVs.

2.1.16. Research & Development on UAVs is forecast to be US $2.5 billion in 2005, rising to US $4.5 billion by 2015. Combined expenditure on R&D in the USA and Europe will probably exceed 25 billion Euros over the next 10 years.

2.2. Types of UAV operation

2.2.1. A significant increase in both civil and military UAVs flying, is anticipated, most of which will require access to all classes of airspace if it is to be both operationally effective and/or commercially viable. To achieve this, UAVs will have to be able to meet all existing safety standards, applicable to equivalent manned aircraft types, appropriate to the class (or classes) of airspace within which they are intended to be operated.
2.2.2. In essence there are two types of UAV operations; those that take place in segregated airspace and those that take place in non-segregated airspace. Segregated airspace is a volume of airspace that has been set aside specifically for use by UAVs. Such a piece of airspace is therefore segregated from General Air Traffic (GAT). At present, most operations in the civil domain take place in segregated airspace. It is typical for a cylinder of airspace to be established around the airfield or launch site of the UAV. The UAV will get airborne and will climb within this cylinder of segregated airspace to reach a further piece of segregated airspace in which it will operate. Once the mission is complete, the UAV would return to the cylinder and fly a spiral descent and recover into the airfield or landing site.

2.2.3. Operations within segregated airspace are becoming common place. Such flights, due to the fact that they are operating in airspace that is specifically reserved for such operations, are not normally subject to Air Traffic Control (ATC).

2.2.4. It is the proposed onset of operations in non-segregated airspace that is the area that needs to be examined in detail. The proponents of civil UAVs wish for full access to all airspace by UAVs. However, it is realised that a phased approach to this desired end goal is required. For example, the Access 5 programme has identified 4 steps to enabling UAV operations in non-segregated airspace. Step One proposes routine operations above 40,000 ft in Class A airspace, with ATC being able to command altitude, speed, heading and route changes. Access to this high level Class A airspace would be achieved through the use of restricted airspace. Step Two would lower the base of operations to 18,000 ft enabling UAV operations alongside commercial traffic. Access is still provided through restricted airspace. Step Three still envisages operations above 18,000 ft, although access would be achieved through Class C, D and E civil airspace. Step Four proposes the use of UAVs in civil airspace at all levels, with UAV operations integrated with conventional commercial traffic.

2.2.5. Levels of UAV autonomy may considerably vary. At one extreme, the UAV pilot may have direct control of the UAV. The UAV in this case can be referred to as a remotely piloted vehicle, similar to existing model aircraft. At the other end of the scale is the fully autonomous UAVs, where the UAV operates autonomously using 'sense and avoid' principles. Many UAVs have the capability of autonomous flight control and navigation or capability of controlled flight out of the direct vision range of a human operator. For autonomous operations, there is no permanent control link and the UAV commander only intervenes in the management of the flight in special cases. Most types, with the possible exception of light UAVs, are expected to have some limited autonomy capability. The UAV pilot is still given the possibility to monitor and intervene, for example, to perform corrective actions in case of failure.

2.2.6. The class of airspace that the UAV is being operated in will determine the interaction that ATC will require with the UAV. In uncontrolled airspace, such as Class G, autonomous UAV operations using the 'sense and avoid' principles would probably enable UAVs to mix with other air traffic operating in this environment. UAVs operating in this non-segregated, but uncontrolled environment, would need to be capable of adhering to the ICAO rules on collision avoidance.
2.2.7. These ICAO rules stipulate how to avoid collisions between aircraft in terms of "right of way" and evasive manoeuvring. An aircraft that is obliged by the rules to keep out of the way of another shall avoid passing over, under or in front of the other, unless it passes well clear and takes into account the effect of aircraft wake turbulence. The aircraft that has the right-of-way shall maintain its heading and speed, but the pilot-in-command of an aircraft shall always take such action as will best avert collision.

2.2.8. UAV operation is expected to be transparent to ATS providers. The UAV operator will be required to comply with any air traffic control instruction or a request for information made by an ATS unit in the same way and within the same timeframe that the pilot of a manned aircraft would. These instructions may take a variety of forms and, for example, may be to follow another aircraft or to confirm that another aircraft is in sight.

2.2.9. There are specific ICAO requirements that would need to be adhered to by UAVs. For example those specified in ICAO Annex 2 requiring that all aircraft in flight shall display anti-collision lights and navigation lights, from sunset to sunrise. If there is clear evidence that displaying these lights also during daytime enhances an aircraft's visibility significantly, then it may be considered a requirement for UAVs to carry such lights 24 hours a day.

2.2.10. Some additional factors that will need to be considered to enable UAVs to operate in a safe manner environment are listed below:
   a) Ability to comply with the rules of the air;
   b) Airworthiness;
   c) Control method, controllability and manoeuvrability;
   d) Flight performance;
   e) Communications procedures and associated links;
   f) Security;
   g) Emergency actions, reversionary or failure modes in the event of degradation of any part of the UAV and its associated control and/or relay stations;
   h) Actions in the event of lost communications and/or failure of onboard 'sense and avoid' equipment;
   i) Ability to determine real-time meteorological conditions and type of terrain being overflown;
   j) Nature of task and/or payload;
   k) Autonomy of operation and control;
   l) Method of sensing other airborne objects;
   m) UAV operator level of competence;
   n) ATC communications, procedures and links with control station;
   o) Means of launch/take-off and recovery/landing;
   p) Reaction logic to other airspace objects;
   q) Flight termination;
   r) Description of the operation and classification of the airspace in which it is planned to be flown; and
   s) UAV physical characteristics.
2.2.11. UAVs, given suitable equipment and procedures, such as those detailed above, can be operated in full alignment with ICAO regulations. There is one exception, notably separation by direct visual reference to other aircraft, obstacles and the surface, which may be the only means for collision avoidance.

2.2.12. By their nature, UAVs do not carry pilots and are not able to ‘see and avoid’ in the traditional manner. UAVs can however ‘sense and avoid’ other aircraft. Such an ability requires the carriage of specific equipment that supports the avoidance of collisions, such as:
• Altitude alerting system
• Airborne Collision Avoidance System (ACAS)
• Ground Proximity Warning System (GPWS)
• Terrain Awareness and Warning System (TAWS).

2.2.13. If the UAV industry is to produce UAVs capable of operating in non-segregated airspace, it is essential that ‘sense and avoid’ issues be addressed. Without a means of ensuring equivalence with manned aircraft, UAV operations will be severely limited and subject to the restrictions of segregated airspace. If every intended UAV flight needs to rely on using segregated airspace then it is highly unlikely the UAV industry will progress and grow at the rate it desires. It is doubtful whether sufficient segregated airspace could be made available to meet UAV demand.

2.2.14. UAV operations outside of non-segregated airspace must not increase the risk to existing users and must not deny airspace to them. To enable this, an equivalent level of safety as that enjoyed by manned flight must be achieved. This will require all the fundamental pillars of a safe system, airworthiness, operations, ATM, security and certification, to have been addressed.

2.2.15. Operations in controlled airspace will require UAVs to be able to comply with ATC instructions. In these cases, autonomous operations are not suitable as a human will need to be included in the loop so as to be able to interact with the Air Traffic Controller. Remotely piloted UAVs, on the other hand, enable ATC to exchange voice communication with the UAV pilot, and the pilot will respond to all ATC instructions in the same way as a piloted aircraft would respond.

2.2.16. In order to provide the transparency required by ATC for UAV operations and ensure that ATC does not have to apply special handling criteria to UAVs, it is essential that UAV operations in non-segregated airspace are conducted in full accordance with all ICAO requirements.

3. Conclusions

3.1. ATC should not have to apply different rules or work with different criteria in order to handle UAVs. From the air traffic controller’s perspective, the provision of ATS to a UAV must be transparent. This includes all stages of the flight from pre-notification to landing. There should be no difference in R/T, landline communications or transponder data procedures nor should the controller have to apply different rules or different criteria.

3.2. Routine operations of any UAV in non-segregated airspace must not increase the risk to other airspace users and should not deny the airspace to them.
3.3. UAVs must be able to fully comply with ATC instructions and with equipment requirements applicable to the class of airspace within which they intend to operate.

3.4. The problem of detecting, sensing and avoiding other aircraft during flight is a crucial challenge that must be overcome before civil aviation authorities permit UAVs to fly in unrestricted civil airspace.

4. Draft Recommendations

It is recommended that;

4.1. IFATCA Policy is:

4.1.1. All Unmanned Aerial Vehicles operations in non-segregated airspace must be in full compliance with ICAO requirements.

4.1.2. Air Traffic Controllers must not be expected to handle a UAV in a different way from any other aircraft for which they are providing a service.

And be included in the IFATCA manual on page 3 2 1 20

4.2. TOC be assigned a work item to study how UAV operators intend to deal with “see and avoid” requirements.

5. Reference Documentation

- CAP722 Unmanned Aerial Vehicles (UK CAA)
- JAA UAV Task Force Final Report (07/05-16 JN-04-015L)
- Civil Military Interface Standing Committee (CMIC 19/04/06)

6. List of Acronyms

ACAS  Airborne Collision Avoidance System
ATC   Air Traffic Control
ATCO  Air Traffic Control Officer
ATS   Air Traffic Services
GPWS  Ground Proximity Warning System
HALE  High Altitude Long Endurance
MALE  Medium Altitude Long Endurance
R&D   Research and Development
RPV   Remotely Piloted Vehicle
TAWS  Terrain Awareness and Warning System
UAV   Unmanned Aerial Vehicle
UCAR  Unmanned Combat Armed Rotorcraft
UCAV  Unmanned Combat Aerial Vehicle

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