The Challenge of Integrating UAVs into Mixed User Airspace

by *Air Commodore Neil Taylor*

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The success of unmanned aerial vehicles (UAV) used by US forces in Bosnia, Afghanistan and Iraq signals a demand for wider use of these systems, and militaries around the world are developing and buying them to incorporate them into their arsenals. Defence planners seek three primary missions from these aircraft: medium- and long-range extended surveillance and reconnaissance; tactical strike abilities; and miniature aircraft used by soldiers in the field for reconnaissance. They are a key component in US, UK, French and other western military plans to modernise forces under the Force Transformation banner. The goal is a broad and complex effort to use information technology to network every person, vehicle, ship and aircraft into a real-time system. Included in this is the introduction of new, lighter military hardware, such as UAVs, particularly suited to linking surveillance and intelligence gathering to guide weapons and firepower.

The evolving abilities of UAVs are also capturing attention in the civilian field, potentially opening a new and lucrative market. Future uses under development in the US include border and customs surveillance for the US Coast Guard and anti-terrorism intelligence for the Department of Homeland Security and local police authorities. As the systems become smaller there are, potentially, many other uses/user demands. US UAV programmes, for example, received $2.7bn from Congress in 2003–04, compared with the $2.3bn requested by the Pentagon. More than two-thirds of that money, $1.81bn, was used for research and development. The UK's Defence Export Services Organisation estimates a worldwide market for UAVs eventually worth about £3bn ($5.7bn) although this may be over pessimistic; others have put the figure at closer to £16bn ($30.4bn).

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US defence contractors are also working with the Pentagon to develop a futuristic unmanned combat strike aircraft. Such a craft would not fly around looking for targets, but would fly sorties to attack an objective. The Unmanned Combat Air Vehicles (UCAV) for the US Navy and Air Force include X–45 by Boeing, and Northrop's X–47 Pegasus. In addition, the US is exploring micro-UAV technology for use by individual soldiers in the field, such as backpack-sized drones. There is clearly potential for future collaboration and the UK MoD and the US Defense Advanced Research Projects Agency (DARPA), for example, have recently announced a collaborative programme to determine the military benefit of UCAVs for future coalition operations.

Airspace Use

With the proliferation of such systems it will be essential to open up the airspace to mixed use. To date, UAVs have been confined to segregated airspace as the regulatory authorities remain to be convinced that they are yet mature and safe enough to be allowed wider access. But UAVs are increasingly ranging outside restricted military airspace as demand for a persistent airborne presence grows; formal launch of a project to enable routine flights in US civil airspace has been agreed; a joint research agreement between NASA and the UNITE industry alliance has received formal legal clearance; and the Access 5 programme is focused on gaining routine airspace access for high altitude, long endurance (HALE) UAVs within five years.

The catalyst for commercialisation of UAVs is the US homeland security market. The task of patrolling America's borders and protecting its critical infrastructure is too immense to be accomplished without their use. But even paramilitary missions like border patrol require a level of routine access to civil airspace unavailable to UAVs today. While the momentum may be building fastest in the USA, other countries are paying increasing attention to their civil uses, but are somewhat lagging behind.

Australian company Aerosonde, meanwhile, believes it has more commercial UAV operating experience than any other company, and since 1995 it has logged 5000 hours of commercial operations in 10 countries. Aerosonde has its own air operator's certificate in Australia, which has reduced the time for filing a flight plan. Of particular note, the Civil Aviation Safety Agency (CASA) has certificated the company's mode of operations and not the vehicle itself.

Equal Access to Civil Airspace

There are echoes of the Australian

The General Atomics Aeronautical Systems Predator B has the capacity to conduct multiple missions simultaneously.

The Northrop Grumman Global Hawk is a high-altitude, long-endurance unmanned aerial reconnaissance system.

approach in US plans to secure equal access to civil airspace for UAVs, particularly in the emphasis on establishing operating policies and procedures rather than regulating vehicle technologies. The US plan is ambitious, with the ultimate goal of gaining airspace rights identical to piloted aircraft for UAVs providing safety performance equivalent to piloted aircraft.

Access 5 involves the Department of Defense (DoD) and US Federal Aviation Administration as well as NASA. Planners have laid out a four-step process to achieve routine airspace access. As envisaged, the four steps will take six years to complete at a total cost of around $360M:

- Step 1 allows experimental certification of the air vehicle and routine operations above 40,000ft (12,000m), accessed by climbing and descending in restricted airspace. UAV operators will be able to 'file to fly' above 40,000ft. The UAV takes off and climbs in restricted airspace to 40,000ft, where it enters Class A airspace. Air traffic control is able to command altitude, airspeed or route changes via the UAV control station which, in turn, communicates with the vehicle via line-of-sight or satellite link. For a normal landing or emergency recovery, the UAV descends through restricted airspace.
- Step 2 allows routine operations above 18,000ft – alongside commercial traffic – again accessed through restricted airspace, and establishes the type certification basis for UAVs. Additional capabilities include communications security enhancements and autonomous conflict avoidance with co-operating aircraft; recovery is again through restricted airspace.
- Step 3 requires special airworthiness certification of the vehicle, but allows routine operations above 18,000ft accessed from a UAV-designated dual-use airport through Class C, D and E civil airspace. Additional capabilities include onboard weather detection, autonomous conflict avoidance with non-co-operating aircraft (known as 'detect, see and avoid' and vehicle auto-land at a dual-use airport via Class C, D and E airspace.
- Step 4 – the end-state vision of Access 5 – reaches the goal of a standard airworthiness certificate for the air vehicle and adds the capability for emergency recovery via restricted airspace to a UAV-designated, dual use airport.

The Access 5 programme is aiming for a level of UAV safety that is equivalent to piloted aircraft. That might be achieved by validating functional 'equivalency' rather than insistence on certification of every part and tracking every serial number, although the concern from industry is about how to achieve increased levels of safety without making the cost prohibitive.

The European Position

At a European level, a joint task force has laid some groundwork in this area but, as yet, there is no equivalent to the Access 5 programme.

In the UK there is an attempt to achieve progress, and a programme called ASTREA, part of the Aerospace Innovation and Growth Initiative's demonstration programme for autonomous systems, will be launched this year to address UAV system integration into the airspace; the cost could be up to $153M over the next five years. Funding is reportedly being pursued in the form of grants from the UK Department of Trade and Industry and regional government agencies with a decision expected mid-year. If successful, the aim is to demonstrate routine UAV operations in non-segregated airspace in 2010. This could assist the European process and, if successful, it is estimated that integration could be achieved in Europe by 2012.

Safety

There are two major obstacles impeding the wider deployment of UAV systems. These are the problem of integrating routine UAV operations within the Air Traffic Management environment and lack of agreed certification standards.

Safety is clearly the major risk to an acceptable implementation of any UAV programme and one that is difficult to define and quantify accurately. However, we should be aware that other nations that have a less dense air-traffic environment, such as Australia, do appear to be making progress towards a regime that accepts the co-existence of manned and unmanned aircraft, albeit by using segregated airspace and special corridors.

The rules governing UAV operation in the UK are set out in two publications: for civil operations, CAP 722, and for military operations, JSP 550. Both state that the design criteria for a particular UAV system are to take into account its intrinsic safety, its mode of operation and the environment in which it operates. It is possible, CAP 722 states, that UAVs may need to be proven to be *safer* than manned aircraft to allow their integration into normal airspace. The rationale behind this statement is questionable, and meeting such a burden of proof would be extremely demanding and expensive. It is, without doubt, a major obstacle to both civil and military development of such systems in the European context.

While there is undoubtedly a requirement to achieve airworthiness certification, UAV employment should not be prohibited by the need to ensure that their design achieves total safety 'equivalency' with manned platforms; it may be technically impossible, or simply not cost-effective, to design and build UAVs to the same airworthiness criteria as manned aircraft. The consequence of this approach would be that the peacetime operation of UAVs could be limited to danger areas cleared from other air users and the general public. In other words, stringent operating limitations would be imposed to make up for perceived shortfalls in design integrity in order to achieve an overall acceptable level of safety.

Sense and Avoid

The term 'sense and avoid' for UAV operations is generally accepted as equivalent to 'see and avoid' for manned aircraft. Work on defining the minimum performance criteria for 'sense and avoid' systems is ongoing, but immature. The criteria will vary, no doubt, depending on the class of airspace used as well as on flight conditions. If the 'equivalency' principle is to be followed, minimum 'sense and avoid' criteria will have to be founded on solid analysis, research and, perhaps, trials of pilot capabilities in various categories of unmanned aircraft in various scenarios, including their interaction with Air Traffic Control. Currently, there are only three standardised acceptable systems available: Automatic Dependence Surveillance Broadcast (ADS–B), Tactical Collision Avoidance System (TCAS) and Traffic Information System Broadcast (TIS–B).

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It is axiomatic that an accurate and reliable 'sense and avoid' system requires the ability for the platform to be navigated within fairly precise parameters, for it to be able to accurately report its position and status, and for there to be either line-of-sight datalink and voice VHF links or an over-the-horizon satellite communications link. Again, there are internationally agreed standards for these although, as yet, there is no agreement on the standards required for a reliable Command and Control system.

A Way Ahead

UAVs offer an exciting range of potential solutions to meet future military and civil capability requirements, and priority must be placed upon the establishment of minimum UAV aviation safety criteria and associated sub-system requirements, with particular emphasis on collision avoidance. However, it is illogical to insist on the same level of design safety as that of a manned aircraft carrying 500 passengers, although the minimum safety criteria will, of course, have to take into account risk and the perceptions of other air users.

A step-by-step approach needs to be adopted now to introduce UAVs into a mixed peacetime manned and unmanned airspace, with progressive removal of the overly restrictive limitations that currently apply to their operation. Some of this, however, will depend on achieving agreements at the international level and, in some areas, time is critical. In the case of the high integrity links with the air vehicle and the provision of the radio frequency spectrum in which the systems can operate, for example, 2007 is the first opportunity to table proposals for a change to the international treaty known as the 'Radio Regulations' before the World Radio Conference. Failing that, the next opportunity would be 2010.

It is argued that UAV systems can perform tasks that have previously either not been possible or not cost-effective for manned platforms to undertake, and that they have the potential to deliver significantly higher levels of output for the same or less cost than their manned equivalents. For now, though, there are too few potential users who seem fully able to appreciate the capability on offer. ■