Paper to FAI Executive Board
by
FAI Navigation Expert Group (NEG) 15 June 2013

Executive Summary: *This paper covers the effect that UAVs may have on VFR traffic, and indicates likely future criteria for cockpit avionics in types of aircraft in which FAI has an interest such as Light GA and Sport Aircraft.*

On UAVs, the conclusion is that it is the mid-size ones that are of most concern to us. Large ones can easily be seen and are very expensive, well-controlled and supervised. Very small ones fly at low altitudes and have short range, and probably are little threat to FAI aircraft. Further work is recommended on the effect of UAVs of mid-size and weight, although the Regulatory and Air Traffic Authorities are both responsible and aware of the safety implications of UAV operations when in airspace mixed with manned aircraft.

On future cockpit avionics, the trend to the "glass cockpit" is noted, using flat screens instead of the traditional analogue instruments. In terms of expense, equipment with Regulatory Approval is more costly than non-certified equipment and the tests for Regulatory Approval can be expensive. Where equipment with Regulatory Approval becomes mandatory, FAI should work to ensure that it is not more expensive than it needs to be. For the Light GA and Sport Aircraft sector, the need for low cost and battery-powered equipment should be recognised by the Authorities, particularly in view of the many tens of thousands of such aircraft, sometimes 95% of the aircraft numbers licensed to fly in a given area.

The European SESAR and North American NextGen programmes for future Air Traffic management are noted, with their requirements for future avionics fit. Although this will be mainly for flight in Controlled Airspace, the fit may be required in other airspace and so is of interest to FAI. For NextGen the future is well-defined and requires GPS-based ADS-B avionics in the aircraft. The SESAR position is less clear and some intermediate position between the present and GPS ADS-B may be required in the short term, such as the continuing use of radar-based transponders.

Finally, future avionic requirements for Light GA and Sport Aircraft should not simply be repetitions of the Specifications for Commercial aircraft operating in busy terminal areas, but should be adjusted to be lower cost and easy to fit to the many small aircraft flying outside Controlled Airspace.

Task 1. Study "sense and avoid" technology for UAVs and the consequences for VFR traffic in terms of equipment needed. *The NEG report follows:*

1.1 Wording. The "sense and avoid" principle, compared to the more conventional "see and avoid" used in light GA and sport aviation, is not confined to de-confliction from UAVs. It implies that aircraft have to install a receiver system such as a radar transponder or GPS-based ADS-B receiver in order to sense other aircraft and compute an avoidance path. Furthermore, such a receiver and computing system will need approval from the relevant Regulatory Authority. The equipment itself and testing for Regulatory Approval have major cost implications.

1.2 UAV numbers and sizes. Forecasts predict high growth in UAV numbers both military and civil. The largest ones are military such as the Global Hawk which is larger and heavier than many aircraft [1]. However, there are many smaller UAVs including those that are hand-launched and some not much larger than butterflies.

1.3 Regulatory Authorties. Regulatory Authorities such as EASA in Europe and the FAA in the USA are responsible for air safety and de-confliction of aircraft (including UAVs) both inside and outside Controlled Airspace. Such Authorities are very conscious of the risks associated with UAV operations outside restricted airspace such as military range areas, and are actively developing rules and procedures to reduce risk. In some circumstances NOTAMS may be used

[1] Global Hawk has a wing span of about 130ft and a maximum weight of 36,000lb. There is a European version called the EuroHawk.

to warn pilots of some UAV activities outside restricted airspace, but with smaller UAVs operating at short range and low level, this is not possible.

1.4 Threats to FAI Aircraft.

1.4.1 Large UAVs. Large UAVs such as Global Hawk are closely controlled and regulated, and are very visible to other aircraft. Their size and sensors are such that they do not fly at low level. They are also very valuable, and the operator as well as the Regulatory Authority will strive to avoid incidents or accidents. They are therefore of little threat to other aircraft.

1.4.2 Small UAVs. Small UAVs are mainly for surveillance tasks varying from intelligence gathering to crop inspection using cameras, some with real-time data links. They are of low weight, short range, and limited in altitude. For these reasons small UAVs are of low threat to FAI aircraft unless they are flying at low altitude such as where gliders, hang gliders or microlights are ridge-soaring and there happen to be small UAVs in the area. A recent article in Aviation Week magazine [2] comes to a similar conclusion.

1.4.3 Other UAVs. The main threat to other aircraft is from UAVs of intermediate size and weight. Although this is primarily the responsibility of the Regulatory Authorities, this is worth further study.

1.5 Cost Implications for FAI Aircraft. Owners of FAI aircraft have more limited funds to fit expensive sensors and avionics compared to, for instance, the operators of business and commercial aircraft. Retro-fit to existing FAI aircraft is more expensive than the same fit at initial manufacture. Most FAI activities take place in VMC outside Controlled Airspace, and the principles of "see and be seen" and "see and avoid" apply. However, as pointed out in para 1, if "sense and avoid" technology is made compulsory in airspace used by FAI aircraft, the technology and Regulatory Approval process have major cost implications. See para 2 below.

Task 2. Establish criteria for future cockpit avionic equipment in GA Aircraft.

2.1 Future Avionics. This includes "glass cockpit" displays, equipment for instrument flying, specialist equipment for sport flying such as soaring instruments for gliders and hang gliders, and sensors to comply with Regulatory Authority programmes such as SESAR in Europe and NextGen in North America.

2.2 FAI Aircraft Categories. It is possible that normal category GA aircraft will implement new cockpit avionics at a slower pace compared to Experimental, Light Sport Aircraft (LSA) and Ultralights. This is because the latter have smaller instrument panels and less equipment that essentially requires Regulatory Approval.

2.3 Regulated and non-Regulated Avionics. For new equipment that requires Regulatory Approval, the costs for test and certification are high and can take some time. In contrast, the development and fit of non-certified equipment is much faster, prices are reasonable and competition between suppliers is high.

2.4 The Glass Cockpit. Flat-screen colour displays are now used for instrument and navigation information in the cockpit, obtaining information from a separate suite of sensors that can be remote from the cockpit in the most convenient place for the type of sensor. Unlike earlier analogue instruments such as altimeters and airspeed indicators which had sensors inside the instrument, screens can present information in a more versatile manner. Such flat screen displays are becoming lower in cost as time passes. Where Regulatory Approval is required, most of the initial cost is to allow for the expenses of testing and initial Certification. Most new GA aircraft are now offered with glass cockpit screens that feature many new functions, and companies such as Garmin specialise in such displays.

[2] Page 58 of Aviation Week magazine 27 May 2013, "Small UAVs pose no civil threat"

2.5 Future Regulatory Avionic Requirements. European SESAR and North American NextGen systems were mentioned in 2.1 above. These, and similar future systems in other parts of the world, are addressed in para 3.

2.6 Conclusion. Overall, the role for FAI in this field is to monitor the above developments and adapt to them. Lower cost systems should be encouraged.

Task 3. Provide suggestions for future navigation issues.

3.1 Background. The introduction of global satellite navigation systems (GNSS) has revolutionised aerial navigation. The current US GPS and Russian GLONASS systems offer highly accurate global navigation. Future GNSS include the European Galileo and Chinese Beidou 2 systems, to be operational later in this decade (Galileo) and in the 2020s (Beidou 2). The dependence on radar and aircraft-based transponders for future Air Traffic Management (ATM) will be reduced since aircraft can now transmit much more accurate GPS position [3] and other data through links to other aircraft and to ground-based air traffic centres. Such systems are called Automatic Dependent Surveillance (Broadcast) or ADS-B. The associated data links can transmit conventional transponder and radar data or, with much better accuracy, GNSS data from receivers in each aircraft.

3.2 Data Links for ADS-B and Other Systems. The ability of the data link between aircraft to aircraft and to ATM ground stations to cope with large data flows is important. The most common frequencies used are 1030 MHz for receive and 1090 MHz for transmit. The load in many parts of the world is already high and will become higher as GPS-based ADS-B becomes worldwide with its greater data capabilities to both aircraft and ground stations. Today, 1030/1090 MHz is used by systems such as secondary radar, Mode A, C and S transponders, and aircraft-to-aircraft collision avoidance systems such as TCAS. The question of future overload on 1030 and 1090 MHz is a worldwide problem and needs solving. The Universal Access Transceiver (UAT) system is being introduced in the USA for GA and sport aircraft flying at lower altitudes. This uses 978 MHz and a time-sharing principle for both transmit and receive. It has a more sophisticated architecture than the earlier 1030/1090 system and is capable of a higher data flow. However, due to frequency allocation limitations, it seems unlikely that the UAT/978MHz system will be available outside North America.

3.2.1 Future CAT Growth. Forecasts from Airbus and Boeing indicate that between now and 2030, each year there will be a need for an average of over 23,000 new commercial pilots and 1700 new CAT aircraft. Increases are forecast particularly for Europe, the Middle and Far East, and South America. This will increase any data link overload problems and also cause pressure on airspace volumes available for FAI aircraft.

3.3 Future ATM systems – NextGen, SESAR and other systems

3.3.1 NextGen. The FAA NextGen system for future ATM in North America has a positive plan until at least 2030. It relies heavily on GPS-based ADS-B fitted to aircraft and ATM ground stations. By the end of 2013, there are to be no less than 748 ADS-B ground stations between the Gulf of Mexico to Alaska. These are much simpler than radar stations and consist only of a receiver for aircraft data links, a transmitter linking to the same aircraft, and a relay to and from the appropriate ATM unit. The date for compulsory implementation of ADS-B in aircraft flying in North American Controlled Airspace is 2020. The major advantage is the increased accuracy of GPS, allowing a major reduction in aircraft separation and therefore a higher traffic density where this is needed at major airports and also in transit.

[3] Tests over many years by the FAI IGC GPS Committee give an average GPS position error of 11.5 metres from tests over accurately surveyed ground features

3.3.2 SESAR. The Single European Sky Advanced Research (SESAR) system is not as well developed as NextGen. There is no similar plan for new ADS-B ground stations, indeed when NEG member Strachan asked an EASA executive about this at an ATM conference, it was said that future ADS-B ground stations in Europe were a National responsibility. In view of the slower progress of SESAR compared to NextGen, FAI should monitor what is happening in Europe because it is out of step with progress in North America and other parts of the world such as Australia. This mis-match could involve extra expense to light GA and Sport Aircraft due to making systems such as Mode S transponders compulsory, before full GNSS-based ADS-B implementation inevitably follows what will have already happened in North America, Australia and elsewhere.

3.3.3 Other Nations and Regions. GNSS-based ADS-B has been in service in Australia for several years, and is also in use is parts of China and Russia. Due to its accuracy and the lack of need for expensive ground radars, it is clearly the world ATM system of the future.

3.4 Low-Cost Systems for FAI Aircraft. Regulatory and ATM Authorities are primarily concerned with high-end aviation such as Commercial Air Transport (CAT). The business aviation, CAT and military sectors have the resources to fit expensive new equipment when required. FAI aircraft have no such resources. Furthermore, many types of FAI aircraft have no engines (gliders, hang gliders, balloons) and some have limited electrical generator power (many microlights). Therefore, ADS-B systems are required that operate on battery power. Fortunately, ADS-B needs less power than radar transponders because it relies on data links rather than on a return signal to be picked up by secondary radar. Low cost is particularly important for light GA and sport aircraft because, in many parts of the world, these aircraft make up over 95% of the aircraft that are licensed to fly. This point should be constantly emphasised in contacts with ATM and Regulatory Authorities. The low-cost GPS-based FLARM (Flight Alarm) system should be noted which already gives proximity warning and collision avoidance over short ranges to FLARM-equipped aircraft. Some 20,000 FLARM units are already in service mainly in gliders and light aircraft. A longer range version called PowerFlarm is now available and is compatible with ADS-B data links, as are other relatively low-cost systems from companies such as Garmin. For all of these future systems, Regulatory Approval is essential if they are to be fully utilised, and Regulatory Authorities should not impose standards and costs appropriate to Commercial Air Traffic in busy Controlled Airspace, on the Light GA and Sport Aircraft sector operating outside Controlled Airspace.

3.5 Recommendations.

3.5.1 Low Cost ADS-B Systems. FAI needs to emphasise to ATM and Regulatory Authorities that for the hundreds of thousands of light GA and Sport Aircraft worldwide, in the future, low-cost ADS-B systems may be required, including models that are battery-powered.

3.5.2 Data Links. If no link other than 1030/1090 MHz is available outside North America, the data link will be overloaded, particularly with the large forecast future growth of worldwide Commercial Air Transport. A solution is needed before the situation becomes severe and costly to correct. As well as UAT/978, another possibility is the VDL4 system that is in service in Russia and Sweden and uses the aeronautical VHF radio band. These issues should be raised by FAI with appropriate Regulatory and ATM Authorities.

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