European Aviation Safety Agency

By Dave Haddon, Yves Morier, Willy Sigl & Filippo Tomasello

Development of European rules for civilian UAS

In the 9th century, after gunpowder was invented in China, fireworks become a reality. Later Genghis Kahn used "propelled weapons". They already were unmanned flying objects. Progress accelerated in XX century. The "Kettering Aerial Torpedo" (an Unmanned Aircraft ante-litteram) was flown in 1918. This, and similar inventions, led to Article 15 of Paris Convention (1919) covering "pilotless" aircraft.

While UAS technology evolved, also the concepts for management of air traffic evolved. Air Traffic Control (ATC) was initiated in 1930, while the first general purpose digital computer ("Zuse Z3") was developed in Germany in 1941. After WWII, rockets allowed to launch spacecraft (Sputnik; 1957) and Satellite Communications (Echo in 1960; Telstar in 1962). Computers paved the way to networks for digital communications. Gradually computers established their position in the air, in particular for Flight Management (one of the first on Boeing 737-300 in 1984) and in automation of ATC. The ICAO FANS Committee proposed in 1988 a vision of future aviation based on satellites, digitized information and Air Traffic Management (ATM) wider than tactical ATC. SESAR in Europe and NEXTGEN in the USA are building upon the FANS vision to shape aviation of the XXI century. In particular, SESAR postulates satellite navigation, massive interchange of data among aviation actors and negotiated 4D "trajectories" between the avionics and ATM.

In 1997 the principle of "separation" of safety oversight from provision of Air Navigation Services was agreed in Europe. it is now embedded into law of the European Union (EU) .

The converging developments recalled above, pose issues to the regulators. E.g. are all UAS "pilotless"? How to allow the flight of civilian UAS while minimising the risk for people on the ground? How to merge UAS into non-segregated airspace, while allowing ATM (composed by a ground part and by an airborne part; the latter comprising "detect and avoid") to minimise the risk of collision with other aircraft in flight? How to benefit from SATCOM for long range UAS, while ensuring safety? How to obtain synergism between the SESAR "postulates" and UAS?

European Entities Involved in UAS

EASA promotes highest and common safety in civil aviation in EU, working, as much as practicable, in coordination with other European Agencies, like the European Defence Agency (EDA). EDA and EASA mutually participate to respective projects. In particular EDA was involved in the Steering Committee of the EASA study on communications for UAS, while EASA is involved in EDA projects SIGAT (spectrum needs for UAS) and MIDCAS (development of "detect and avoid").

The European Space Agency (ESA) develops satellite-based technologies and services. In particular ESA is developing "Iris", i.e. a new generation satellite system for the Aeronautical Mobile Satellite Service, in the framework of SESAR. UAS of sufficient range, dimensions and power might use Iris services for ATM communications. In addition EDA and ESA are exploring the possibility of using satellites also for the command and control (C2) data link.

EUROCONTROL has established a «UAS ATM Integration Activity» with whom EASA has frequent interactions. The SESAR Joint Undertaking has been created to manage the development of ATM modernisation in EU. Their concept is based on trajectory management, which requires the exchange in real time of data concerning the progress and plan for a flight. SESAR concept will have to accommodate also UAS, although it is not in the SESAR mission to develop technologies specifically applicable to UAS. However UAS seem particularly suited for the SESAR digitized environment.

The competence of EASA is limited to unmanned aircraft (UA) with maximum mass of at least 150 Kg. For lighter UA the NL CAA launched the Joint Aviation Regulations of Unmanned Systems (i.e. JARUS), aiming at common airworthiness, air operations and crew rules. About a dozen EU Member States participate presently to JARUS. Also EASA is partner of the project in order to possibly achieve harmonisation, above and below the threshold of 150 kg, as would be desirable for industry.

Development of EASA Rules for Civilian UAS

<u>Airworthiness</u>
The competences of EASA, extended in 2008 and 2009 , cover:

- Airworthiness;
- Environmental protection;
- Pilots;
- Air operations including aerial work;
- Operations at civilian aerodromes;
- ATM, ANS and Air Traffic Controllers; and
- Safety of aircraft used by third country operators into, within or out of the EU.

The above includes the CNS equipment to be carried and used during the flight. As a consequence, all the civilian UAS operators residing in a non-EU country, should they wish to operate commercial aerial work in the airspace over the EU, will need a prior authorization from EASA (Article 9.2 B.R.) once the specific implementing rules would be available .

For airworthiness of UAS EASA had published the A-NPA 16/2005, followed by its CRD in 2007. Main findings where that:

- no new EASA specifications were required in the immediate for certification of UAS (e.g. CS-23 could be the starting point for the certification basis in many cases, taking into account the kinetic energy of the aircraft);
- the certification process will include the UA, the Control Station and the C2 link, as well as any other necessary element (e.g. launch devices).

The above is explained in detail in a certification "policy" , published in 2009, in order to guide industry. A number of applications have been accepted by EASA. Said policy has been extensively discussed with stakeholders, including EUROCAE WG-73. Normally the organisations designing and producing UAS will need a specific approval according to EASA rules . The approval process will culminate in a type certificate (TC) and a Certificate of Airworthiness (CofA) for each individual UAS. Alternative procedures are allowed, but in this case any deviation from the EASA essential requirements shall be compensated by operational restrictions. In the end "restricted" TC and restricted CofA may be the result.

The starting point of the approval process would be to choose from which EASA CS (e.g. 23, 25 or else) to start, as a function of the kinetic energy, should the UA suffer an uncontrolled crash. The CS will be "tailored" (e.g. eliminating non necessary requirements, like safety belts) and complemented by "special conditions", such as:

- Emergency recovery;
- C2 link;
- Level of autonomy;
- Human-machine interface;
- Control station;
- System safety analysis;
- Specific aspects linked to type of operations.

The "policy" uses some of the terms widely spread across the UAS community, including in ICAO and RTCA/EUROCAE. Once ICAO will publish guidance material on the subject (e.g. a specific UAS Circular in 2010) EASA will assess the need of producing a subsequent edition of the "policy", in order to align as much as possible the terminology to that suggested by ICAO.

Later, when sufficient experience will have been accrued, EASA may decide either to revise the "policy" (e.g. allowing separate certification of the station) or even to propose a Certification Specification for UAS. However, before proposing a CS-UAS, clarity is necessary on hazard severity definitions and related minimum acceptable probabilities. In fact, while a crash of a manned aircraft is always a catastrophe, this may not be true for UA. Since this issue is sensitive and controversial, while a consistent approach applicable world-wide is necessary, FAA and EASA have launched in 2009 a joint process for "Combined Regulators of UAS Safety". The aim is to establish a general standard applicable to all sizes and types of UAS, with a maximum weight of 150 kg or greater. The starting point would be rules 23.1309 and 25.1309 already applicable to manned aircraft, but which require adaptation for UAS. Of course industry is continuously consulted on the matter.

<u>Operations and Pilots</u>

EASA also needs rules and acceptable means of compliance (AMC) for the UAS crews and operations. The latter addressed to organisations operating the UAS. A multi-disciplinary rulemaking task (i.e. MDM.030) is included in the Rulemaking action plan . Current view of EASA is that requirements and responsibilities of the UAS operators shall be defined to establish and maintain high and uniform level safety in the EU with legal certainty. Three types of operations for remotely piloted aircraft have been identified:

- Commercial Air Transport (CAT) limited to cargo only;
- Commercial non-transport operations (COM), i.e. aerial work under contract;
- Non-commercial Corporate (non-recreational) operations, either cargo or aerial work (e.g. surveillance of pipelines, through UAS directly operated by the organization managing the same pipeline).

EASA will need to establish rules for any of these operations, even in the absence of ICAO guidance: in fact while ICAO is responsible for "international" aviation, EASA is responsible for "civil" aviation in the EU (i.e. even domestic).
Initially a single pilot station per UAS and a single PiC for the entire flight could be allowed. Later, the case of multi-pilot stations (and therefore handover from one PiC to a different one) may be included. Rules for operators will probably include the OPS manual, training requirements, composition of the flight crew and flight time limitations.

The major topics under consideration for instruments, data and equipment are "sense and avoid", replacement of the on-board pilot sensation, equipment of pilot station, C2 link, communications with ATC, forced landing, emergency recovery and fight data recorders.

The work will be carried out taking into account ICAO developments (e.g. proposed amendments to Annex 1 and 6) and through the applicable EASA rulemaking procedure, which includes public consultation of stakeholders .

ATM and SPECTRUM

EASA contracted QinetiQ for a study on UAS communications. The final report is on http://www.easa.europa.eu/ws_prod/g/g_sir_research_projects_miscellaneous.php#2008op08

Alternative communication architectures were evaluated. In particular the study identified, through preliminary hazard identification and risk assessment, 4 architectures from an initial list of 20. Importantly, this does not invalidate the other architectures, nor does it mean that the 20 candidate architectures represent the only architectures that might be deployed.

A broad cross-section of UAS stakeholders was engaged to understand the importance of the impacts associated with the architectures identified. Participation was sought throughout the EU and included selected countries outside the EU with active UAS programmes. The final phase analysed the results of the surveys.

The considered architectures included a wide range of features such as ATC relay, dedicated wired interface, C2 implementation using a dedicated terrestrial ground station, networked ground stations (GS) and GEO or LEO satellites. As a result of the analysis four "bounded" architectures emerged:

- AR2 - Networked terrestrial GS providing C2 and ATC Voice/Data Communications: i.e. an analogue VHF radio on board, like for manned aircraft. It had the lowest overall risk score, required no modification to present day ATC infrastructure and was seen as a logical solution as long as sufficient spectrum was available to permit ATC voice/data to be carried over the C2 data link;
- NR1 - Non-networked terrestrial for C2 and ground-based ATC Voice/Data COM equipment: i.e. the VHF radio on the UAS side will be installed on the ground. It had the lowest risk score of the non-ATC relay architectures, and was seen as being a practical and cost effective solution for small UAS operating within a confined geographical area (e.g. radio line of sight of the Control TWR);
- NR3 - C2 via GEO satellite and ATC Voice/Data via networked ground-based COM equipment: this is the lowest scoring (i.e. the safest) architecture with a satellite communications element and is seen as being cost effective and practical for medium/large UAS that need to operate over longer distances, or where there is no terrestrial C2 ground station coverage. By studying this architecture in more detail it was possible to explore issues to do with the use of Satellite communications for C2, and the use of a Communication Service Provider (CSP) to provide voice/data communications with ATC using

ground-based radio equipment;

- NR12 - ATC Voice/Data via CSP wired interface and C2 via networked terrestrial GS: Although this architecture does not have a particularly low (safety) score, it is considered to be a practical solution in the context of the SESAR 2020 timeframe. By studying this architecture in more detail it was possible to explore issues associated with the use of a CSP managed wired interface to the ATC voice/data network.

The analysis in the end indicated NR3 (C2 via satellite and ground-based ATC voice/data COM) as overall the most beneficial architecture out of those considered, closely followed by NR1 (single ground station). AR2 (networked ground station) had the lowest overall score. In practice, while all the three architectures were considered sufficiently safe and practical, the ones with the radio on the ground minimized cost and weight of the avionics, as well as need for electro-magnetic spectrum.

Satellite-based architectures in fact offer some unique and valuable attributes such as extensive coverage (particularly at low height), the ability to cross international boundaries and operate in areas devoid of terrestrial infrastructure. Furthermore, for many of the UAS applications identified, satellite communications is the only viable solution. Similarly, NR1 meets the needs of the significant proportion of UAS operators that operate small UAS over a short range. As well as not being able to carry physically large or heavy communications equipment, this type of activity is likely to be highly sensitive to cost, and this makes the use of a single COM ground station attractive.

Perhaps the biggest surprise was the consistently low score achieved by AR2, (ATC relay via a VHF radio on-board and the use of networked terrestrial ground stations). This can be explained by the combination of high infrastructure costs, high spectrum requirements and inferior interoperability performance (in terms of coverage at low heights and over remote/maritime regions).

In the end QinetQ recommended to EASA, inter alia, to consider mandating minimum performance of UAS communications (but not a specific technical solution) and to consider the possible certification of a COM SP which could provide at least connectivity between ATC and UAS. EASA will continue to work in close relationship with EUROCAE WG 73 (& RTCA) in order to develop the minimum performance requirements for the ATC COM infrastructure for UAS.

In the vision of EASA also ICAO should take into account the possibility of COM SPs to serve UAS needs. COM SPs are already legitimate by the EU “Single European Sky”. These providers, since supporting “safety and regularity of flight” are already covered by the ICAO definition (e.g. in Annex 10, Volume II), however no specific ICAO provisions on the COM SP are contained in said Annex.

Filippo Tomasello
European Aviation
Safety Agency