Towards a Performance Based Regulation for the Integration of Drones in the Civil Aviation System

If Technology is Right then Regulation is Light

Dr. Francis SCHUBERT
skyguide, Swiss Air Navigation Services Ltd
Geneva, Switzerland
francis.schubert@skyguide.ch

Abstract— **The proliferation of drones will fundamentally change the face of aerial activities. This development need not, however, been perceived as a threat to civil aviation but as a unique opportunity to implement in practice the still relatively abstract concept of a performance based regulatory approach. The main argument developed in this paper is that, in a performance based model, technology should and can be used as a substitute for hard regulation. Further the exploding drones sector offers the welcomed opportunity to develop and validate innovative air navigation solutions that can later be exported into the airspace open to civil aviation with the promise of a massive improvement of the performance of the legacy ANS system.**

Keywords: Drones, RPAS, Performance based regulation

I. Introduction

The unmanned aerial vehicle sector is facing a massive expansion, from all points of view. The number of drones put in operation is exploding, with several millions devices produced annually in the recent past years. The range of devices is expanding from micro-drones weighing a dozen of grams to large machines of the size of a passenger aircraft. Once reserved to specific military operations, drones are now used or planed for use for an increasingly wide number of civil applications. Considering the pace of development, the numbers involved and the apparently unlimited possibilities offered by drones technology, there is no doubt that unmanned aerial devices will fundamentally change the face of the air transportation industry.

This phenomenal development has generated a sense of confusion and helplessness, if not panic, within the civil aviation sector, faced with the prospect of millions of drones asking to share the world's airspace. The launch of drones operation is largely mature from a technology perspective, but remains slowed down, if not frozen, in particular in the airspace open to civil aviation because of the lack of an appropriate regulatory framework. The regulatory authorities face a triple challenge. First, the regulatory framework for the deployment of drones operations, and in particular where such activities are to interfere with the operation of civil aircraft needs to remain as light as possible, in order not to further raise the level of complexity of the aviation regulatory framework. Second, the civil aviation regulators will need to cope with the fact that the gap between technology and regulations is doomed to increase as technology evolves faster than the regulatory measures, in a sector of activity which is known for the low speed of its regulatory processes. Finally, there is a need to dissipate the thick veil of confusion arising from a lack of understanding of the real impact of drones operations on the civil aviation sector.

In spite of the apparent magnitude of the challenge facing regulators, two positive observations should be highlighted. First, because of its novelty, the regulation of the drones sector offers a unique opportunity for regulators to steer their effort in the right direction from the beginning, with the goal of establishing a framework which is both light and performance oriented. Second, an assessment of the preliminary work undertaken by the main regulatory bodies concerned, mainly ICAO, the FAA and EASA, tends to indicate that the preliminary regulatory effort reflects the spirit of a performance oriented framework.

The purpose of this paper is to define the outline of a European regulatory strategy which can ensure that regulations applicable to the drones sector remain light, proportionate and performance based. While recognising that the advent of the age of drones raises many regulatory challenges, this paper focuses more specifically on issues related to safety and security regulation[1]. The main argument developed in this paper is that technology should and can be used as a substitute for hard regulation.

II. Regulatory framework

The future regulatory framework for the integration of drones is being developed mainly by ICAO, at the global level and EASA at the regional level.[2] The main elements of the still tentative regulatory framework consist in the Manual on

[1] The protection of privacy is another sensitive domain, which is not discussed in this paper.

[2] The FAA has also produced important regulatory material for unmanned aerial systems which offer a valuable source of inspiration with a view of a regulatory framework which must be consistent across the globe.

Remotely Piloted Aircraft Systems published by ICAO[3] and an EASA Advance Notice of Proposed Amendment on the "Introduction of a regulatory framework for the operation of drones"[4].

Unmanned aerial vehicles cover a wide range of devices that can be distributed among various categories. In ICAO's terminology, the generic category encompassing all such systems is knows as Unmanned Aerial Vehicle (UAV) and is defined as "a pilotless aircraft, in the sense of Article 8 of the Convention on International Civil Aviation, which is flown without a pilot in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous". This generic category is currently known in EASA's regulatory material as "drones", defined as “an aircraft without a human pilot on board, whose flight is controlled either autonomously or under the remote control of a pilot on the ground or in another vehicle.”[5] Both ICAO and EASA's approach divide the generic category in two distinct sub-categories: autonomous aircraft[6] and remotely piloted aircraft (RPA)[7].

ICAO's tentative regulatory framework differs from EASA's approach as far as their respective scope are concerned. The effort of ICAO focuses exclusively on those devices which are meant to operate in airspace open to civil aviation, and more specifically Remote Piloted Aircraft Systems (RPAS), leaving aside the vast majority of devices, including model aircraft, which are not expected to interfere with civil aviation. EASA's regulatory approach, on the contrary, covers the full range of drones, including the operation of devices outside of civil aviation airspace and fully autonomous vehicles. But only those devices which will share the airspace with civil aviation aircraft will be regulated under the EU aviation regulatory system. Other drones operations, which will constitute the vast majority of activities, are to be regulated outside of that framework.

EASA's regulatory approach distributes drones among 3 specific categories:

- The "open" category, which constitutes the overwhelming majority of devices. These are drones, mainly light devices, which are expected to fly at low altitude, below and outside of airspace reserved for civil aviation. They will normally not interfere with civil aircraft except for some low flying helicopters. Application of such drones include recreational activities, parcel delivery, surveillance and monitoring, etc.
- The "specific operation" category comprises particular types of activities which may interfere with civil aviation activities. Such operations require coordination measures which are arranged on a case by case basis under the responsibility of the operator for the purpose of a particular activity.
- The "certified" category includes those devices which will share the airspace with ordinary manned aircraft.

Although there are measurable differences between the respective scopes of ICAO and EASA's regulatory approaches, both initiatives are largely consistent as far as their underlying regulatory principles are concerned. First, from a legal perspective, UAVs and drones are all defined as aircraft, with all the consequences that this status entails in respect of applicable regulations. Second, both regulatory approaches wisely treat these devices in the same manner, regardless of their commercial or non-commercial purpose. Then the framework will apply irrespective of the weight of the unmanned aircraft. Earlier proposals to limit the scope of applicable regulations to devices above a certain mass have been dropped, although different rules may apply depending on the weight of a given craft. Finally the main common assumption supporting the global and European approaches is the condition that the integration of drones in the civil aviation airspace must have no negative impact on the safety of aviation.

III. Performance based regulation

Among the many opportunities offered by the rise of drones is a possibility to put some flesh on the much touted by still relatively abstract concept of performance based regulation. In a performance based environment, the regulations define performance objectives that need to be met instead of prescribing a comprehensive set of detailed rules governing all parameters of the activity. The way to best meet the mandatory regulatory objectives is left to the sector's stakeholders. In an environment strongly driven by technology, such as the drone manufacturing domain, a performance based regulatory approach offers in particular an important room for the development of industry standards.

In practice, the essence of a performance based regulatory framework for the integration of drones could be based on the following basic principles:

- Drones which are unable to behave like ordinary aircraft or to maintain full autonomous separation from ordinary aircraft and from each other, are to remain segregated from civil aviation traffic or be subject to control

[3] Manual on Remotely Piloted Aircraft Systems (RPAS), ICAO Doc 10019, AN/507, 1st Edition 2015 [hereinafter ICAO Doc 10019].

[4] Introduction of a regulatory framework for the operation of drones, EASA Advance Notice of Proposed Amendment 2015-10, 31 July 2015 [hereinafter EASA ANPA 2015-10].

[5] EASA ANPA 2015-10. Concerned about the proliferation of terms with identical meaning, EASA is hinting that they might drop the term "drone" in favour of the more common "unmanned aircraft". The American terminology seems to prefer the use of the term Unmanned Aerial System (UAS).

[6] Defined as "an unmanned aircraft that does not allow pilot intervention in the management of the flight" (ICAO Doc 10019).

[7] Defined as "an unmanned aircraft which is piloted from a remote pilot station". ICAO also uses the term Remotely Piloted Aircraft System (RPAS) to designate "a remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design" ICAO Doc 10019.

measures under the responsibility of their remote pilot practices;

- In order for drones to operate within the airspace open to civil aviation, they must be certified to behave like ordinary aircraft or to perform fully autonomous separation.

The implementation of these basic principles is to be achieved primarily by:

- Technical standards, that can be developed by the drone manufacturing industry in conjunction with the ATM industry in order to be able to reconcile technology choices where relevant;
- Exceptional specific operational procedures to mitigate the particular aspects of drones which cannot be resolved by technology alone.

IV. Safety regulation methods

Various regulatory methods can be deployed to mitigate the safety risks associated with the integration of drones.

A. Segregation

The method which has been applied historically is airspace segregation, where unmanned aircraft are simply required to remain outside of the airspace open to civil aviation. When a need arises for a drone to operate within the latter, a dedicated airspace volume is defined for the duration of the activities within which the device will be authorised to fly. The limits of the reserved airspace sector will be communicated to Air Traffic Services (ATS) and displayed on surveillance displays. ATS personnel will be required to give instructions to aircraft under their responsibility in order to prevent these aircraft to enter the limits of the reserved airspace. The main purpose of a regulatory framework for drones is however to remove the need for segregation.

B. Visual Line of Sight operations

Basic measures can be taken with a view of taking a first step towards integration, in the form of Visual Line of Sight (VLOS) operations[8]. This method, which applies specifically to Remote Piloted Aircraft Systems (RPAS) consists in requiring the remote pilot to retain permanent visual contact with its aircraft and to take any necessary action to avoid a collision between the latter and ordinary aircraft or other drones. While this strategy allows RPAS to fly closer or even into airspace open to civil aviation, it constrains drones operations to a relatively short radius around the position of the RPAS operator.

C. Beyond Visual Line of Sight

Beyond Visual Line of Sight (BVLOS) operations are based on methods which allow both RPAS and autonomous aircraft to fly, including within civil aviation airspace, without the need for a human operator to retain permanent visual contact with the drone.

V. Regulatory strategy

The main safety challenge regarding the integration of drones arises from the need to keep drones separated from ordinary aircraft as well as from each other. The ultimate objective should be to achieve an environment where drones operation do not require any human attention, in the sense that these devices are capable of detecting themselves the presence of other flying objects, whether ordinary aircraft or other drones, and to take appropriate measures to avoid any collision.[9]

A. Open category

The open category, which will comprise the vast majority of unmanned aerial vehicles. In a first step, the avoidance of collisions between these drones and ordinary aircraft will be achieved by the means of airspace segregation. These devices, for the foreseeable future are meant to operate at low altitudes, below the airspace sectors used for civil aviation purposes and maintaining a safe distance from airspace reserved for airport operations. VLOS operations can support drones activity close to or even within airspace sectors open to civil aviation (such as aerodrome control zones).

B. UAS Traffic Management (UTM)

It is however becoming apparent that some sort of infrastructure will need to be deployed to ensure the safety of drones operations also outside of the airspace open to civil aviation. The purpose of such an infrastructure would be primarily to keep drones separated from each other, but also from the few aircraft such as low flying helicopters with which they may need to share the airspace. That infrastructure should also integrate a function preventing drones to enter airspace sectors where their operation is prohibited.

The concept of UAS Traffic Management (UTM) which is being considered in the USA responds to such a need. At first sight, it could be tempting to import existing practices developed for the purpose of Air Traffic Control into the open sector category, as a basis for the shaping of the future UTM. However, a reverse strategy should be pursued. The legal ATM system is the product of a long historical development which can hardly serve as a model for the management of a highly innovative domain such as drones. In particular it is self-limited by the fact that many promising technologies are already available (and sometimes mandated) which are not used to support efficient operations.

In addition, the future UTM will differ fundamentally from the legacy ATM system in place in the civil aviation airspace. The number of drones expected to operate in the open sector is so high that it appears unrealistic to imagine an infrastructure operating on the basis of human intervention. The regulatory

[8] Defined as "an operation in which the remote pilot or RPA observer maintains direct unaided visual contact with the remotely piloted aircraft" (ICAO Doc 10019).

[9] This is in line with ICAO's own vision which states that “the integration of RPA in non-segregated airspace will be a gradual process that builds upon technological advances and development of associated procedures. The process begins with limited access to airspace, and while some RPA may eventually be able to seamlessly integrate with manned flights, many may not.” ICAO Doc 10019.

arrangements and procedures developed for the purpose of preliminary tests conducted in some countries, for instance for the delivery of postal parcels, may be adequate to validate the technological solutions proposed and the feasibility of the operational concept, but will prove to be fully inadequate for large scale operations. For instance, requirement for a NOTAM or coordination with Air Traffic Services for each individual drone flight beyond VLOS, or constraining drones in the open category to a fixed network of authorised trajectories does not appear to be a viable model. In the open sector numbers speak for automation. The UTM infrastructure should consequently capitalise on a technical service using automated traffic detection and separation functions.

The open category offers a unique opportunity to serve as a laboratory where solutions which are difficult to test in the civil aviation environment can be developed and validated, before being introduced in the civil aviation environment to improve the performance of the legacy air navigation system. It should also be noted that existing drones are highly sophisticated devices. The technology already exists to support autonomous collision avoidance in the open sector. The challenge is consequently no longer to develop technical solutions, but to agree on common standards and to have these validated for use in the civil ANS system.

C. Specific category

A similar strategy should be pursued to regulate special purpose operations into civil aviation airspace. Until drones are capable of assuring their own separation from other aircraft, airspace segregation and VLOS operations will remain the primary means to ensure separation.

D. Certified category

The certified category comprises those drones which are expected to operate on a routine basis within the airspace open to civil air navigation. The civil ATM system is presently excessively complex both from an operational and a regulatory perspective and the primary objective must be to achieve integration without adding another layer of complexity.

Presently, drones are kept separated from ordinary aircraft by the means of temporary or permanent airspace segregation. Specific arrangements authorise RPAS to enter civil airspace subject to mitigations measures such as VLOS processes, for instance requiring the drone to be accompanied by a chase aircraft retaining visual eye contact on the drone, and which stays in radio contact with the appropriate ATS authority. From within the chase aircraft, the remote pilot will manoeuvre the drone as required for ATS purposes. But such practices are of exploratory nature and do not make full use of the drone capability. They are not sustainable for future large scale operations and are meant to remain of temporary nature until a more mature operational model is in place. That model require the capability for an RPA to behave like an ordinary aircraft to the farthest extent possible. This emulation capability applies to both equipment requirements (communication, navigation and surveillance) and to operational procedures. Under this regulatory strategy, the unmanned status of an aircraft should become ideally irrelevant to the air traffic controllers, who will treat them in the same manner as ordinary aircraft.[10] The remote pilot remains in contact with the appropriate ATS unit and interacts directly with the air traffic controllers. The absence of a pilot on board should be mitigated by other means, supported by technological functions such as a "detect and avoid" capability[11] to compensate for the lack of visual contact. That model has already been tested on a small scale in some countries.

This idealistic philosophy however finds its limits in some specific operational features of unmanned aircraft and must recognise that the integration of drones will require some additional regulations. But these will need to be introduced by exception only. Such exceptional regulations will need to be developed for instance to address new types of operations, such as very long endurance drone activities where unmanned devices will remain airborne for long periods of time and performing stationary flights at high altitudes resulting *de facto* in the creation of high altitude obstacles. Speed differentials and unusual rates of turns may also require new particular ATS procedures. Contingency procedures will need to be developed to implement standard behaviours and manoeuvers to address failure of the critical C2 link. Finally ATC personnel will need to be trained to treat airspace infringements.

VI. Security regulation

The regulatory framework should recognise that the most serious challenge raised by the introduction of drones is not related to cooperative devices. All the technology required for the integration of drones (even in the airspace open to civil aviation) already exists that would allow an RPAS to behave like an ordinary aircraft in the ANS system. Technology would even allow an environment where drones are capable of detecting and avoiding all other devices in a fully autonomous manner. The work to be done remains significant but relates mainly to agreeing a common operating concept, validating the model, developing common technical standards and certifying the various equipment. The greatest risk posed by drones relates to non-cooperative systems. Nevertheless, the regulatory framework must not be developed on the assumption that drones will be used, wilfully or not, for unauthorised purposes. The regulatory framework must by default assume compliance, but must integrate adequate measures to mitigate exceptional unauthorised operations. In this domain, the technology required to mitigate that risk also already exists, for instance in the form of specific geo-fencing software which automatically trigger a

[10] According to ICAO "in order for RPA to be integrated into non-segregated controlled airspace, the RPA must be able to comply with existing ATM procedures. In the event that full compliance is not possible, new ATM procedures should be considered... Any new ATM procedures should be kept as consistent as possible with those for manned flights to minimize disruption of the ATM system… In order for RPA to be integrated into non-segregated uncontrolled airspace, the RPA will need to be able to interact with other airspace users, without impacting the safety or efficiency of existing flight operations." (ICAO Doc 10019)

[11] Defined as "the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action" (ICAO Doc 10019).

manoeuver away from predefined sensitive airspace sectors or from other aircraft. Safeguards allowing law enforcement authorities to override the control of drones in case of necessity, or to force the landing or diversion of such devices can be embedded by the manufacturers as a mandatory functionality.

VII. Conclusions

There is no doubt that the proliferation of drones will fundamentally change the face of aerial activities. This development need not, however, been perceived as a threat to civil aviation. First of all, the main impact of this phenomenon will be to open sectors of the airspace which are currently only marginally used for aerial activities. The early regulatory effort is in the process of clarifying the actual extent of the impact of drones on civil aviation and emphasising that, contrary to widespread fears, the overwhelming majority of drones put into operations will never interfere with traffic engaged in civil aviation operations, at least for the foreseeable future. Second, subject to the condition of a light handed performance based regulatory framework, the impact of any interference between these new entrants and legacy airspace users should remain minimal and will not impact the safety of air navigation. Finally, and probably above all, the exploding drones sector offers the welcomed opportunity to develop and validate innovative air navigation solutions that can later be exported into the airspace open to civil aviation with the promise of massive improvement of the performance of the legacy ANS system.

Technology is the key to a light handed but performance oriented regulatory framework. The integration of drones in the international civil aviation system should be an evolutionary process where full integration is achieved by the means of technology developments rather than by regulations. In a performance based regulatory spirit, the regulations will define objectives, such as requiring that drones must first acquire the ability to behave like ordinary aerodrome and later to avoid collisions in a fully autonomous manner, before they can operate in the airspace open to civil aviation. How drones acquire this capability is for the manufacturing industry to determine. The drone manufacturing industry is well ahead of the thinking of the civil aviation regulatory authorities and the gap is still widening. Functionalities have already been developed which could respond to most of the legitimate safety and security concerns arising from the operation of drones. The immediate challenge relates to the need to agree on common choice for particular technologies, to develop the associated industry standards and, finally to validate these solutions and certify the relevant equipment in an aviation regulatory environment where such processes are particularly heavy and complex.