Abstract—Once adequate provisions have been produced to regulate the airworthiness, operation and pilot licensing aspects required for the safe integration of RPAs in non-segregated airspace, rules will also be needed to cover the Air Navigation Services aspects. Regulatory intervention in the field of ANS should focus on the double challenge raised by the operation of RPAs in non-segregated airspace, namely the need to ensure that ANS can effectively execute the tasks assigned to them in support to the safeguarding of States' airspace sovereignty and the proper technical and operational integration of RPAs in a new mixed civil ANS system, where ordinary aircraft share the airspace with remote piloted devices. Since RPAs are to be treated by ANS in the same way as "ordinary aircraft", RPAs integration is more a matter of technical ability to interface with ATNS than a matter producing new procedures. Without minimising the magnitude of the technological challenges and while recognising that massive regulatory action will be required in other fields, the need for regulatory intervention in the ANS domain should remain minimal. The analysis concludes that under the policy pursued by the aviation regulatory authorities the presence or not of a pilot on board should be largely irrelevant from an ANS perspective. Another consequence of the current focused regulatory policy is that the impact on the division of responsibilities between the (remote-)pilot and the air traffic controller, as well as on the liability exposure of ANS, should remain limited.

I. INTRODUCTION

Unmanned Aerial Systems (UAS)\(^1\) have been operating for many years. The early applications of such devices have been primarily for military purposes. UAS present particular safety risks, related to their particular technical features, and more specifically to the absence of a crew aboard the aircraft. These risks have until now been mitigated by the means of airspace restrictions in accordance with Art. 9 of the Chicago Convention which have limited UAS operations to segregated airspace\(^2\) sectors. However, newer types of UAS are being developed, which will serve civil uses and are intended to operate also in those parts of the airspace that are open to civil air transportation. The commercial potential of UAS applications are forecasted to be enormous.\(^3\)

The introduction of UAS in non-segregated airspace is now on the agenda of aviation authorities around the world. It forms part of the ICAO Global Air Navigation Plan and of the recently launched Aviation System Block Upgrade (ASBU) program. The foundation for the future regulatory framework is ICAO Circular 328. On that basis ICAO is expected to publish RPAs guidance material in 2014. At the regional level, the Federal Aviation Administration Modernisation and Reform Act of 2012 sets 30 September 2015 as a deadline for the safe integration of UAS into the national airspace of the USA. In Europe, various studies have been launched, in particular under the umbrella of the Single European Sky Air Traffic Management Research and development (SESAR) program, to investigate UAS operations in non-segregated airspace. The draft roadmap defined under the auspices of the European Commission is based on a 15 year strategy for the integration of UAS from 2016.

International and national aviation regulatory authorities have also acknowledged the fact that the integration of UAS in non-segregated airspace will require important adjustments to the international civil aviation regulatory framework. Three of the Annexes to the Chicago Convention have already been amended, based on the preliminary work performed by ICAO\(^4\) and EASA is working on a Notice of Proposed Amendment (NPA)\(^5\) specifically intended to define a common framework for

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1 Defined as "An aircraft and its associated elements which are operated with no pilot on board" (Unmanned Aircraft Systems (UAS), ICAO Document Cir 328-AN/190, 2011, hereinafter ICAO Cir. 328)
2 Defined as "Airspace of specified dimensions allocated for exclusive use to a specific user(s)" (ICAO Cir. 328).
4 Annexes 2 (Rules of the Air), 7 (Aircraft Nationality and Registration Marks) and 13 (Aircraft Accident and Incident Investigation).
5 Notice of Proposed Amendment (NPA) 2012-1.
the implementation of Amendment 43 to ICAO Annex 2 in Europe.

UAS is a generic category covering various types of unmanned devices. For the foreseeable future, regulatory authorities are concentrating their action on Remotely Piloted Aircraft (RPAs) only, excluding fully automated devices which operate without direct human control. Retaining the function of the pilot-in-command, albeit in a remote control mode, has significant consequences on the scope and extent of the amendments to be brought to the regulatory framework.

Most of the regulatory effort to this date has deliberately focused on areas such as airworthiness certification, pilot licensing, aircraft operations, rules of the air and aircraft operator liability, which will be most impacted by RPAs operations. But the introduction of RPAs in non-segregated airspace is also expected to have a significant impact on Air Navigation Services (ANS) and the regulatory initiative will need to extend to this field as well. The purpose of this paper is to investigate the regulatory impact of the integration of RPAs in the civil ANS system.

II. REGULATORY POLICY

The regulatory framework for Air Navigation Services has been increasingly criticised for its growing complexity over the past decades. The successful integration of RPAs in the ANS system will depend among other factors on the regulatory policy pursued by the competent authorities. The regulatory framework serves a double fundamental purpose. It is first meant to protect the general public from a variety of risks, in particular safety hazards, associated with air transportation. Second, it constitutes an essential tool to support the development of international aviation. Both objectives are not always easy to reconcile. An excessively heavy regulatory intervention is likely to unnecessarily slow down or hamper the evolution of the aeronautical industry, whereas too distant a regulator runs a risk of failing its protective mission. The challenge for the regulator is to strike the proper balance between both public interests. In order to be effective, the regulatory intervention that will support RPAs operations in non-segregated airspace will need to focus on the mitigation of the specific risks arising from such operations on the ANS system.

III. THE DOUBLE CHALLENGE OF RPAS OPERATIONS FOR ANS

From an ANS perspective, RPAs operations in non-segregated airspace raises a double regulatory challenge. The first one is of institutional nature and relates to the tasks that ANS providers (ANSPs) are required to perform in support to the safeguard of national sovereignty. The second is of operational and technical nature and pertains to the ability of RPAs to respond to clearances, instructions and information provided by Air Traffic Services (ATS).

IV. INSTITUTIONAL REQUIREMENTS

A. The ANS contribution to airspace sovereignty

Airspace sovereignty can be defined as a State's ability to retain full and permanent awareness of air navigation operations within its sovereign airspace, to ensure that all aircraft comply with applicable rules and to intervene at any location and moment within that airspace in case of infringement. Various regulatory requirements have been issued to allow States to effectively exercise their sovereign powers. For instance, civil aircraft crossing a national boundary are required to submit a flight plan and the entry of foreign State aircraft is subject to a diplomatic clearance. In case of doubts as to the status and intention of an aircraft, or in the event of a violation of applicable regulations Article 3 of the Chicago Convention states that “[e]very State, in the exercise of its sovereignty, is entitled to require the landing at some designated airport of a civil aircraft flying above its territory without authority... it may also give such aircraft any other instructions to put an end to such violations”.

The primary mission of ANS is related to the safety and efficiency of air navigation. This task is described in Annex 11 to the Chicago Convention and in the ICAO Procedures for Air Navigation Services. But, in most countries, ANSPs also play a key supporting role regarding the safeguarding of airspace sovereignty and more specifically for the purpose of implementing the provisions of Art. 3 of the Chicago Convention. ANS are required to maintain a permanent watch over the airspace under their responsibility, to report intrusions and violations of regulations and to act as an interface between aircraft subject to interception and the military authorities in charge of such operations. This additional task is not entrusted to ANSPs because it belongs to their statutory duties under ICAO regulations but because they are equipped to perform such a function. It is only partly addressed by ICAO regulations and is detailed in national provisions. In order for ANS to be able to fulfil their duties in respect of airspace sovereignty, two main requirements need to be fulfilled:

- ANS need to be informed of all aircraft crossing the national border into the airspace under their responsibility, in order to be able to report intrusions by unauthorised aircraft. That information must include diplomatic clearances issued to foreign State aircraft;
- In order to assist military authorities and airspace users for the purpose of implementing Art. 3 of the Chicago Convention, ANS need to be able to establish and maintain two ways communication with aircraft under their responsibility.

6 Defined as “Remotely piloted aircraft (RPA). An unmanned aircraft which is piloted from a remote pilot station.” Annex 2, Amendment 43.
8 “The integration of remotely piloted aircraft into the future air navigation system is one of the key challenges for aviation regulatory authorities and future air traffic control systems.” John PLUQUET, "Remote Control", Aerospace International, April 2013, p. 1
B. RPAs and State sovereignty

RPAs operations raise sensitive challenges from a State sovereignty perspective, that will also impact the ANS system. Historically, pilotless devices have been the cause of major concerns for States, since they have been widely used as weapons operating across national boundaries. For that reason, Article 8 of the Chicago Convention requires that "no aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State". The authorisation requirement is meant to guarantee that each State is aware and agrees to each flight performed over its territory by an unmanned aerial vehicle. The regime is particularly constraining. An authorisation must be granted even for flights within the boundaries of a single country. Then the use of the word "special" authorisation implies that the permission is delivered for each individual flight and not for a specified period or for a certain number of flights.

The emerging regulatory framework for RPAs builds on the principles outlined in both Article 3 and Article 8 of the Chicago Convention, since it is logically accepted that these vehicles qualify as "aircraft capable of being flown without a pilot". A historical interpretation of Art. 8 also indicates that, based on the technologies available at the time the Chicago Convention was drafted, aircraft flying without a pilot on board were primarily meant to refer to remotely piloted aircraft.

C. The Authorisation Regime

The caution expressed in Art. 8 of the Chicago Convention towards aircraft without a pilot on board still determines the regulatory approach pursued for the integration of RPAs in non-segregated airspace. The applicable regulations consequently require an authorisation to be obtained by RPAs prior to each flight. Considering the forecasted large scale deployment of RPAs against the rigid regime put in place under Art. 8, it could have been more advisable to establish an authorisation framework based on a more flexible and lighter interpretation of that article. But the provisions that have been developed in that respect reflect a literal application of Art. 8. ICAO has recently adopted procedures which detail the principle expressed under Art. 8 and were introduced by amendment 43 to ICAO Annex 2. These provisions confirm the constraining nature of the authorisation regime. They specify that an authorisation must be given by each individual State overflown, in the case of a flight crossing the airspace of more than one country. However, the authorisation "make take the form of agreements between the States involved". The regulatory material also confirms that the permission must be given delivered for each individual flight and for a limited duration. EASA is in the process of defining the precise prescriptions for the uniform implementation of amendment 43 in Europe and the preliminary material available indicate that the European aviation authorities are following a similar course.

For ANS to be able to execute their mission in support of national sovereignty, and more specifically to detect possible airspace intrusions, it will be essential that they are provided with all information related to the authorisations issued to RPAs. Thus, the authorisation prescribed under Art. 8 is very similar to the concept of diplomatic clearance required for foreign State aircraft to enter the airspace of other countries. The authorisation is not given for ATC purposes but to formalise the permission given to an RPA to enter the national airspace of the State by which it is delivered. The need for an authorisation is consequently different in nature from the requirement to file a flight plan or to obtain an ATC clearance. The delivery by a State of an authorisation will not relieve the RPAs operator from the separate obligation to file a flight plan for each flight subject to such a requirement under Annex 2 to the Chicago Convention.

Finally, when an RPAs plans to operate over the high seas, which by definition escape from the jurisdiction of any State, the formal State authorisation concept does not apply, but the RPAs operator must coordinate the flight with the ATS authority in charge of providing the service in the airspace sector concerned.

D. ANS and the application of Art. 3 Chicago Convention

It is accepted by ICAO that the principles expressed under Art. 3 of the Chicago Convention also extend to RPAs. But RPAs represent a particular challenge regarding its application. Some of the enforcement means available towards conventional aircraft are ineffective in the case of RPAs, for instance in the event of a communication failures whether between the remote pilot and ANS or between the remote pilot and the RPAs. In the absence of appropriate technical safeguards to substitute for the lack of a pilot aboard the aircraft, a risk exists that an aerial vehicle may operate within the airspace of a sovereign State, outside of any operational control and without any means for the sovereign State to enforce its sovereign prerogatives other than by destroying the aircraft. Further, whereas communication by the means of visual signals is possible between the pilot of a conventional aircraft and the pilot of an intercepting aircraft (or with an air traffic control tower operator in the case of an aircraft operating in the vicinity of an aerodrome) such substitutes for verbal communication are not necessarily available in the case of an RPAs.

Communication failures are even more critical when the remote crew is operating from across the boundaries of the State overflown, since RPAs operations are likely to multiply instances of cross-border activities. Operational and technical considerations often require that an ANSP established on the territory of one State, must extend its activities over the territory of a neighbouring country, in the sake of efficiency. In itself, the provision of cross-border ANS raises delicate institutional issues. The integration of RPAs in non-segregated airspace will unavoidably result in situations where a remotely piloted device will be flying over the territory of one State, while it is piloted from a crew located on the territory of a second country and provided with air traffic services from the territory of a third

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9 ICAO Circ. 328, § 4.2
10 An amendment of Art. 8 of the Chicago Convention seems both unnecessary and unrealistic.
11 Defined as "A person charged by the operator with duties essential to the operation of a remotely piloted aircraft and who manipulates the flight controls, as appropriate, during flight time." Annex 2 Amendment 43
State. Such situations are likely to further dilute the ability of the State overflown to exercise its regulatory, supervisory and enforcement competencies.

The lack of presence of a pilot aboard an RPAs, which presents a particular risk in respect of the application of Art. 3 must be compensated by technical contingency features, such as predictable automated control procedures which, in the event of a communication or remote control failure, will either lead the RPA to leave the airspace of a State or to land at a prescribed aerodrome.

V. OPERATIONAL REQUIREMENTS

A. The assimilation of RPAs to "ordinary" aircraft

The fundamental regulatory principle that will apply to the introduction of RPAs in the civil air navigation services system is that RPAs are to be treated like "ordinary" aircraft. ICAO Circular 328 insists in this respect that "Whether the aircraft is piloted from on board or remotely, the provision of ATS should, to the greatest practicable extent, be one and the same. The introduction of RPA must not increase the risk to other aircraft or third parties and should not prevent or restrict access to airspace. ATM procedures for handling RPA should mirror those for manned aircraft whenever possible."\(^{12}\)

This pragmatic regulatory approach has a number of fundamental consequences:

- The intention of the regulatory authorities is not to create a new category of air vehicles, subject to its own specific ANS regulations. RPAs fully qualify as "aircraft" as defined by ICAO and will be, as a rule, subject to the existing set of rules;
- The integration of RPAs into the ANS system is a matter of technical ability, more than one of producing new dedicated ATM procedures;
- The presence or not of a pilot on board should be (largely) irrelevant from an ANS perspective;
- The impact on the division of responsibilities between the (remote-)pilot and the air traffic controller should remain minimal.

B. Technical ability

In order to behave like ordinary aircraft, RPAs will need to be able to interface with the ATS system. According to ICAO, "Much of this ability will be subject to technology — the ability of the aircraft to be controlled by the remote pilot, to act as a communications relay between remote pilot and air traffic control (ATC)."\(^{13}\) The ability to be developed is essentially related to the need for RPAs to comply "... with directions and instructions provided by the air traffic services (ATS) unit..."\(^{14}\) regardless of whether the pilot sits on board the aircraft or not. It will be the responsibility of RPAs designers and manufacturers to take all practical measures to ensure that RPAs can effectively operate as any other aircraft.

Like for all other aircraft, the level of service provided by ATS, the operational responsibilities of the remote-pilots and the requirements for equipment (e.g. transponder, radio, datalink, etc.) will depend on the airspace class within which the RPA is operating and the type of flight rules selected.

In concrete terms, RPAs will need to be able to:

- Respond to ATC clearances and instructions;
- Avoid collision with other aircraft in accordance with the rules applicable;
- Integrate and respond in an appropriate manner to information provided by Flight Information Service (FIS). The scope of that information is very broad and not limited to data related to the presence and position of other aircraft. It includes terrain, clouds, weather phenomena, volcanic ash clouds, parachutes, obstacles, birds, etc.

The required technical ability will be easier to develop for flights operating under Instrument Flight Rules (IFR) for which navigation will rely on the use of a distant cockpit replicating the functions normally available aboard a regular aircraft. But a particular technical capability will also need to be available to RPAs flying under Visual Flight Rules (VFR). ICAO observes that "A fundamental principle of the rules of the air is that a pilot can see other aircraft and thereby avoid collisions, maintain sufficient distance from other aircraft so as not to create a collision hazard, and follow the right-of-way rules to keep out of the way of other aircraft. Integration of RPA may not require a change to the Standards, however, as RPAS technology advances, alternate means of identifying collision hazards will have to be developed with appropriate SARPs adopted."\(^{15}\) For that reason a "detect and avoid" capability will need to be developed to substitute for the lack of possibility for a full visual observation capability. The detect and avoid function is separate from airworthiness criteria and its sole purpose is to avoid collisions between RPAs and other aircraft as well as between RPAs themselves.

An important element is that a "detect and avoid" capability must not only be developed for RPAs operating under VFR, but also for those flying under IFR. It is accepted that the fact of navigating under IFR does not relieve the pilot-in-command of his duties to maintain a visual observation of the airspace around the aircraft, in particular to detect risks of collisions. In order for RPAs to be treated like ordinary aircraft, air traffic controllers will need to be able to assume that the (remote-)pilot of an RPA is able to show the same level of vigilance as the pilot of a regular aircraft.

Without minimising the magnitude of the technological challenges and while recognising that massive regulatory action will be required in other fields, the need for regulatory intervention in the ANS domain should remain minimal.

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12 ICAO Circ. 328, § 5.10
13 Ibid. § 2.13
14 Ibid, § 3.6.
15 ICAO Circ. 328
C. Target level of reliability

The integration of RPAs in the non-segregated airspace will require a solid level of confidence in the reliability of the technical features developed for RPAs to emulate the behaviours of ordinary aircraft. Appropriate targets levels of reliability will consequently need to be defined.

The philosophy adopted in respect of RPAs airworthiness is based on the principle of equivalent standards. It foresees that "[a] civil UAS must not increase the risk to people or property on the ground compared with manned aircraft of equivalent category" but airworthiness standards should not "penalise UAS by requiring compliance with higher standards simply because technology permits."16 ICAO suggests a similar philosophy for the level of reliability required for the interface between ATC and the remote pilot. ICAO Circular 328 states that "The exchange of control information between the aircraft and its remote pilot station will require an extremely high level of availability, reliability, continuity and integrity" and that "the information exchange between ATC and the remote pilot will likely require the same levels of reliability, continuity and integrity, referred to as QOS, that are required to support operations with manned aircraft in the airspace in which a UA is intended to operate".17

However, the airworthiness standards are "primarily targeted at the protection of people and property on the ground",18 because of the absence of persons on board. Whereas the "detect and avoid" capability is also meant to avoid secondary damage on the ground, as a collateral consequence of a collision between two aircraft, it is primarily intended to protect occupants of other aircraft. The social acceptability of a mixed environment comprising aircraft operating without the presence of a pilot aboard could require higher standards of reliability for the equipment used for the interface between RPAs and ATC.

D. Areas requiring regulatory attention

The principle in accordance with which RPAs are to be treated like ordinary aircraft implies in particular that the ATM procedures applied in respect of RPAs must be the same as those used for regular aircraft.19 Preliminary work performed within the European Commission confirms that "RPAs... must not require changes to ATM procedures".20 This view is largely shared within the aviation academic community.21 As emphasised in ICAO Circular 328, "[w]hether the aircraft is piloted from on board or remotely, .... ATM procedures for handling RPA should mirror those for manned aircraft whenever possible..."22 Further, for the exchanges between air traffic controllers and remote pilots "for RPA, communications procedures will likely be based upon current practices applicable in the airspace classes in which the RPA operate."22

The application of same operational procedures is not limited to ATS purposes, but extends to all services covered by the ATM functions. This includes in particular Air Traffic Flow Management (ATFM) measures in the sense that where an ATFM slot is required, RPAs will need to request and obtain one.24

The regulatory policy pursued by ICAO consequently implies that whether there is a pilot aboard an aircraft or not should be largely irrelevant to the air traffic controller. However, the assimilation or RPAs to ordinary aircraft cannot be absolute and finds its limits in the specificity of these devices. For that reason, the RPA status cannot be ignored by air traffic controllers. Separately from the data provided to satisfy the requirement to obtain a State authorisation, which serves a different purpose, of institutional nature, the RPA status should ideally appear under the flight plan information provided for the needs of ATC.25 In addition, whereas the assimilation principle must be pursued to the farthest extent possible, the development of limited specific complementary procedures appears necessary and unavoidable to address those particular features of RPAs which are genuinely unique to that category of aircraft and cannot be addressed by the means of technical measures, or only at a prohibitive cost.26 From that perspective there are two domains which will require regulatory attention. The first is linked to the specific flights characteristics of RPAs and the second to the need for particular contingency procedures.

RPAs exist in a large variety of forms and sizes. The weight of these devices will range from less than a kilogram to that of a large aircraft. The flight performance of RPAs will also show significant differences, with some vehicles hovering at very low speed and others flying at supersonic speeds. RPAs operations will introduce new models for aerial missions. While conventional aircraft normally fly across airspace sectors following the most direct route, RPAs may be engaged in missions which will require them to remain stationary for very long times over a particular location. Air traffic controllers will consequently need to adapt to a new environment where very
slow moving RPAs share the airspace with high speed conventional aircraft and where they will need to guide aircraft around RPAs in stationary flight. Happily, the regulatory answers to these new operational challenges are already to be found in the existing regulatory framework, which can offer strong references that can be applied by analogy. First, ATC procedures are already accustomed to manage conventional aircraft with very different flight characteristics operating in the same airspace. Light single engine propeller aircraft do not perform in the same way as large jet passenger aircraft and are treated differently by the ANS system. Particular routes and ATC procedures are implemented to account for the different flight performance of different aircraft categories. The separations applied between aircraft to mitigate the risk associated with wake turbulences vary depending on the weight of the aircraft.

Second, inspiration can also be found in the ATC procedures that apply in respect of unmanned free balloons, which also present the characteristic of remaining at the same geographical location for long periods of time. RPAs have a different status than unmanned free balloons, which are treated as "obstacles" from an ANS perspective. Contrary to unmanned free balloons, RPAs should enjoy no particular priority over other aircraft. However, RPAs are treated similarly under the Rules of the Air. Whereas air traffic controllers will guide air traffic around unmanned free balloons, they will expect RPAs to be able to manoeuvre clear of other aircraft in the same way as ordinary aircraft.

Part of the challenge arising from the introduction of RPAs in the civil ANS system arises more from an expected increase of mixed performance air traffic than because of the lack of pilot on board, which characterises these vehicles. The regulatory answer to this challenge consists in the categorisation of RPAs in such a manner that the ATCOS can anticipate the flight performance of a particular device and in the application of conventional procedures for mixed flight performance environments.

But most RPAs present unique characteristics that are related to their unmanned status that need to be accounted for by the ATC system, when applying separation or providing flight information. It is conceded that "There will be some instances where the remote pilot cannot respond in the same manner as could an on-board pilot (e.g. to follow the blue C172, report flight conditions, meteorological reports). ATM procedures will need to take account of these differences." Therefore, "ATM provisions may need to be amended to accommodate RPA, taking into account unique operational characteristics of the many aircraft types and sizes as well as their automation and non-traditional IFR/VFR capabilities..." 27

Finally, the risk of a loss of control link between the remote-pilot and an RPA will cause operational issues. In such a situation, a risk exists that the vehicle flies astray and constitutes a collision threat for other aircraft, because of the absence of any external control on its flight path. Article 8 of the Chicago Convention specifies that "[e]ach contracting State undertakes to insure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft". The nature and extent of the control required includes both the requirement for a remote pilot, for ordinary control procedures and contingency control measures, in the event of a technical failure. Whereas a contingency autonomous navigation system may allow the vehicle to continue its flight and land at a suitable location, that fall-back system may be ineffective to detect the presence of other aircraft and to take appropriate action to avoid a collision. Air traffic controllers will need to be prepared to the possibility of a technical failure in the event of a loss of control by the remote pilot on the RPAs, and more specifically in case of failure of the command and control link (C2). Air traffic controllers must therefore be informed of the RPAs status of an aircraft and of the contingency procedure to be followed in case of a communication failure in order to maintain adequate separation between the RPA concerned and other aircraft.

RPAs specific procedures should however be strictly limited to situations objectively dictated by the particularity of such devices. Some experts have expressed the views that exceptions should be reserved in respect of ATC separation and have suggested that "[i]n airspace, where all traffic is subject to control, one may consider an increased separation for UAV from other traffic". However, such specific provisions should not be promulgated, in order to avoid an excessive operational complexity and technical measures should instead be developed to ensure the level of performance required for the application of standard separations.

E. Division of responsibilities between the remote pilot and the air traffic controller

One of the main consequences of the assimilation of RPAs to ordinary aircraft is that the division of responsibilities between the (remote-)pilot and the air traffic controller will remain unchanged.

The most fundamental rule in this respect is the principle of the final authority of the pilot in command. This principle is expressed in § 2.3.1 of ICAO Annex 2, which states that "The pilot-in-command of an aircraft shall, whether manipulating the

27 "Fully autonomous aircraft operations are not being considered in this effort, nor are unmanned free balloons nor other types of aircraft which cannot be managed on a real-time basis during flight". ICAO Circ. 328, § 2.2.

28 "A remotely piloted aircraft shall be operated in such a manner as to minimize hazards to persons, property or other aircraft and in accordance with the conditions specified in Appendix 4" and "[a]n unmanned free balloon shall be operated in such a manner as to minimize hazards to persons, property or other aircraft and in accordance with the conditions specified in Appendix 5", ICAO Annex 2, Amendment 43, § 3.1.9 and 3.1.10.

29 ICAO Circ. 328 § 5.10.

30 Ibid. § 5.9.

31 "Air navigation service providers will need to review emergency and contingency procedures to take account of unique RPA failure modes such as C2 link failure, parachute emergency descents and flight termination" (ICAO Circ. 328, § 5.9). The document also refers to the procedures enacted by the United States in respect of C2 link which require that "In all cases, the UAS must be provided with a means of automatic recovery in the event of a lost link. There are many acceptable approaches to satisfy the requirement. The intent is to ensure airborne operations are predictable in the event of lost link", ibid. §17.

32 Kaiser, op. cit. note 7, p. 167.
controls or not, be responsible for the operation of the aircraft in accordance with the rules of the air…”

From a legal perspective the principle of the final authority of the pilot-in-command finds its justification in two assumptions:

- First, the ICAO approach for the allocation of responsibilities is risks based and the system recognises that the primary decisional authority should rest with the actor who generates the aviation risk. That person is the person who operates the aircraft;

- Second, it is assumed that the physical location of the pilot-in-command, in the aircraft's cockpit, puts him in the position to acquire a full situational awareness. Many elements concerning the immediate surroundings of the aircraft (weather, air traffic, terrain etc.) may be visible to the pilot, that are not apparent to other actors. The final responsibility as to the operation of the aircraft therefore rests with the pilot.

The second justification for the principle of the final authority of the pilot-in-command may lose part of its validity, as the remote-pilot of an RPA will no longer sit aboard the aircraft, but will control the device from a distance. The remote-pilot will lose a considerable number of contextual clues that contribute to the construction of a full situational awareness and the pilot will lose his privileged position.

However, regardless of this important change in the position of the pilot-in-command, ICAO Circular 328 makes it clear that the principle remains "... true whether the pilot is on board the aircraft or located remotely." Further "[t]he pilot-in-command of a manned aircraft is responsible for detecting and avoiding potential collisions and other hazards. The same requirement will exist for the remote pilot of an RPA. Technology to provide the remote pilot with sufficient knowledge of the aircraft’s environment to fulfil the responsibility must be incorporated into the aircraft with counterpart components located at the remote pilot station."34

The corollary of the retention of the principle of the final authority of the pilot in command is that the operational duties of the air traffic controllers will remain largely the same. Whereas, specific procedures will be necessary to reflect the technical specificity of RPAs, air traffic controllers will provide the same service, based on the same operational procedures, regardless of the presence on board or not of a pilot.

It is important to note that, whereas none of the pilot's responsibilities will be transferred to the air traffic controller, these responsibilities will not be transferred to the technical equipment either. The current responsibilities of the pilot-in-command will be transferred integrally to the remote-pilot. ICAO Circular 328 explains that “Under no circumstances will the pilot responsibility be replaced by technologies in the foreseeable future.”35 This was the justification for ICAO to focus on remote-piloted aircraft only, as opposed to fully automated aircraft, which would have required a fundamental reform of the operational framework currently founded on the pilot-in-command, by effectively removing the latter and by transferring the direct operational responsibility to the aircraft operator.

VI. LIABILITY ASPECTS

The launch of RPA operations will obviously have a number of major implications at the level of legal liability. But this impact will be primarily measurable at the level of the aircraft operator and manufacturer and not at the level of ANS.

The expected developments in the field of liability are primarily related to the automation of flight functions. At the level of the aircraft operator, RPAs operations will induce a shift from fault based liability to product liability. Fault based damages related to human errors will remain as long as unmanned vehicles are not fully automated, but the area of product liability will increase with automation, as the probability of a technical failure over a human error will increase. As a result, it is to be expected that a regime of strict liability will be imposed to RPAs operators, for damages arising from a technical malfunction.36

The impact of RPAs on the liability of ANS, however, is expected to be marginal. Legal liabilities follow legal responsibilities. Since it is assumed that RPAs will not challenge the current division of responsibilities between the (remote-) pilot and the air traffic controllers, there is no reason to expect any significant change in the liability exposure of ANS.

However, despite the existence of clear principles such as that of the final authority of the pilot-in-command, there is never a clear cut division line between the duties of the various actors involved, which are always deeply intertwined. In court, the allocation of legal liabilities is always determined on a case by case basis, depending on the specific circumstances of the event. RPAs events will introduce new contextual elements that will need to be accounted for in case of a liability case involving RPAs. When deciding ATC liability cases, courts take the view that ATC clearances and instructions are mandatory and that the pilots are legitimated to assume that, if followed, they will ensure the safety of the aircraft. However, a number of landmark decisions37 have ruled that "the pilot, after his clearance has been given remains primarily responsible for the movement of his aircraft" and is "required to follow his clearance, not blindly, but correlative with his duty to exercise care for his own

33 ICAO Circ. 328, p. 15
34 Ibid. § 5.2
35 Ibid. § 3.1
36 “[T]hird party liability for damage caused by RPAS should be developed on the basis of the principles for manned aviation. Automation creates an additional level of complexity to the question of responsibility and liability. However, legal experts concluded that strict liability will fall on the operator of the RPAS… The responsibility for accidents, liability claims and the obligation to take insurance for a RPAS falls generally on the operator of the system.”European Commission, Commission Staff Working Document, “Towards a European strategy for the development of civil applications of Remotely Piloted Aircraft Systems (RPAs).”37 Most of the court case decisions are from US Courts, but as they rely on universal ICAO regulations and based on past judicial experience, it can be assumed that jurisdictions in other regions of the world would follow a similar reasoning.
This principle has been used to delineate the respective responsibilities of the pilots and the air traffic controllers. Even when subject to ATC, pilots are expected to maintain visual observation to identify dangers which are visible to them. Courts have decided in that respect that "[f]light crew members have a continuing duty to be aware of dangers which they can perceive with their own eyes. Pilots cannot fail to use their own eyes and ears to be aware of danger. Pilots are charged with a duty to see that which is plainly visible" and that "[t]he pilot has a continuing duty to be aware of dangers which are discernible with his own eyes and instruments." In the case of RPAs, even with the introduction of technical capabilities intended to allow RPAs to behave like ordinary aircraft, the scope of what is "plainly visible" to the pilot may differ from what can be observed directly from the cockpit. Elements that would have been used by courts to absolve ATC from any liability, or to reduce its liability, may no longer be available in a case involving RPAs. Such developments could result in a slight increase of liability exposure on the side of ATC.

VII. CONCLUSION

Once adequate provisions have been produced to regulate the airworthiness, operation and pilot licensing aspects required for the safe integration of RPAs in non-segregated airspace, rules will also be needed to cover also the ANS aspects. The successful integration of RPAs will depend to a large extent on the regulatory policy pursued by the regulatory authorities. Because of the novelty of the RPAs concept, these authorities enjoy a rare opportunity in this respect. As a rule, regulatory intervention must focus on those areas where legal uncertainties exist and on those elements that cannot be left to the discretion of the aviation industry stakeholders. Regulation should be performance oriented, in the sense that it must serve the purpose of maintaining and enhancing the safety, operational efficiency, economic effectiveness and environmental efficiency of air transportation. The challenge for the regulatory authorities is to allow the regulatory framework to evolve in such a manner that it supports the development of international air transportation, without jeopardising the public interests that that framework is intended to protect and without leading to excessive complexity.

The need for regulatory intervention in the field of ANS should focus on those particular challenges that are genuinely unique to RPAs. Regulatory intervention should address the double challenge raised by the operation of RPAs in non-segregated airspace, namely the need to ensure that ANS can effectively execute the tasks assigned to them in support of States airspace sovereignty and the proper technical and operational integration of RPAs in a new mixed civil ANS system, where ordinary aircraft share the airspace with remote piloted devices.

The policy in accordance to which RPAs are to be treated by ANS in the same way as "ordinary aircraft" implies that adjustments to the regulatory framework for ANS are expected to remain of marginal extent. For both the institutional and operational challenges raised by RPAs, the solution is more a matter of technical ability to interface with ATS (and more specifically the development of a "detect and avoid" capacity and of contingency measures in the event of a remote control failure) than a matter producing new procedures. Whereas neither the technological challenge involved nor the regulatory impact on many sides of the industry (e.g. airworthiness, aircraft operations, pilot licensing) should be underestimated, the need for regulatory adjustments in the ANS domain should remain minimal. The analysis presented above concludes that under the policy pursued by the aviation regulatory authorities the presence or not of a pilot on board should be largely irrelevant from an ANS perspective. Another consequence of the focused regulatory policy is that the impact on the division of responsibilities between the (remote-)pilot and the air traffic controller, as well as on the liability exposure of ANS, should remain minimal.

There are nevertheless two areas where regulatory intervention will be required to account for particularities which are unique to RPAs. The wide range of flight characteristics shown by RPAs and new types of missions involving long stationary operations will require a categorisation of RPAs and specific ATS procedures. But strong regulatory inspiration can be found in existing provision governing the provision of ANS in mixed flight performance environments and the treatment of unamend free balloons. The lack of a pilot on-board will also require contingency procedures to manage losses of communication between the remote-pilot and the RPA under his control.

Finally, the manner in which the development of RPAs technical capability will need to fit properly in the broader roadmap for the evolution of the global and regional ANS systems. ANS stand on the threshold of a major technological revolution, at global level under the ICAO ASBU programme, and in several key regions such as Europe (SESAR initiative) and North America (NextGen). These offer both an opportunity and a challenge in respect of RPAs development. These program constitute a framework within which the required technical ability can be developed and implemented in a consistent manner. But, in addition, the other main elements of these programs (e.g. 4D Trajectory-based Operation, and System-Wide Information Management (SWIM)) will need to account for the deployment of RPAs from the very outset.


41 Single European Sky Air Traffic Management Research and development.