Cir 328
AN/190

Unmanned Aircraft Systems (UAS)

Approved by the Secretary General
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FOREWORD

Civil aviation has to this point been based on the notion of a pilot operating the aircraft from within the aircraft itself and more often than not with passengers on board. Removing the pilot from the aircraft raises important technical and operational issues, the extent of which is being actively studied by the aviation community. Many of these issues will be identified in this circular.

Unmanned aircraft systems (UAS) are a new component of the aviation system, one which ICAO, States and the aerospace industry are working to understand, define and ultimately integrate. These systems are based on cutting-edge developments in aerospace technologies, offering advancements which may open new and improved civil/ commercial applications as well as improvements to the safety and efficiency of all civil aviation. The safe integration of UAS into non-segregated airspace will be a long-term activity with many stakeholders adding their expertise on such diverse topics as licensing and medical qualification of UAS crew, technologies for detect and avoid systems, frequency spectrum (including its protection from unintentional or unlawful interference), separation standards from other aircraft, and development of a robust regulatory framework.

The goal of ICAO in addressing unmanned aviation is to provide the fundamental international regulatory framework through Standards and Recommended Practices (SARPs), with supporting Procedures for Air Navigation Services (PANS) and guidance material, to underpin routine operation of UAS throughout the world in a safe, harmonized and seamless manner comparable to that of manned operations. This circular is the first step in reaching that goal.

ICAO anticipates that information and data pertaining to UAS will evolve rapidly as States and the aerospace industry advance their work. This circular therefore serves as a first snapshot of the subject.

Comments

Comments from States on this circular, particularly with respect to its application and usefulness, would be appreciated. These comments will be taken into account in the preparation of subsequent material and should be addressed to:

> The Secretary General
> International Civil Aviation Organization
> 999 University Street
> Montréal, Quebec, Canada H3C 5H7

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ABBREVIATIONS/ACRONYMS

ACAS	Airborne collision avoidance system
ADS-B	Automatic dependent surveillance — broadcast
AM(R)S	Aeronautical mobile (route) service
AMS(R)S	Aeronautical mobile satellite (route) service
ARNS	Aeronautical radio navigation service
ARNSS	Aeronautical radio navigation satellite service
ATC	Air traffic control
ATM	Air traffic management
ATS	Air traffic services
C2	Command and control
C3	Command, control and communications
CAA	Civil Aviation Authority
CPDLC	Controller-pilot data link communications
EASA	European Aviation Safety Agency
EUROCAE	European Organisation for Civil Aviation Equipment
HF	High frequency
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ITU	International Telecommunication Union
PANS	Procedures for Air Navigation Services
QOS	Quality of service
RPA	Remotely-piloted aircraft
RPAS	Remotely-piloted aircraft system
RTCA	RTCA, Inc.
SAR	Search and rescue
SARPs	Standards and Recommended Practices
SATCOM	Satellite communication
SMS	Safety management system(s)
SSP	State safety programme
UA	Unmanned aircraft
UAS	Unmanned aircraft system(s)
UAV	Unmanned aerial vehicle (obsolete term)
UOC	UAS operator certificate
VDL	VHF digital link
VFR	Visual flight rules
VHF	Very high frequency
VLOS	Visual line-of-sight
VMC	Visual meteorological conditions
WRC	World Radiocommunication Conference

GLOSSARY

Explanation of Terms

*Note.— The terms contained herein are used in the context of this circular. Except where indicated, they have no official status within ICAO. Where a formally recognized ICAO definition is included herein for convenience, this is noted with an *. Where a term is used differently from a formally recognized ICAO definition, this is noted with an **.*

Aircraft*. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Aircraft — category*. Classification of aircraft according to specified basic characteristics, e.g. aeroplane, helicopter, glider, free balloon.

Autonomous aircraft. An unmanned aircraft that does not allow pilot intervention in the management of the flight.

Autonomous operation. An operation during which a remotely-piloted aircraft is operating without pilot intervention in the management of the flight.

Command and control link. The data link between the remotely-piloted aircraft and the remote pilot station for the purposes of managing the flight.

Commercial operation. An aircraft operation conducted for business purposes (mapping, security surveillance, wildlife survey, aerial application, etc.) other than commercial air transport, for remuneration or hire.

Crew member*. A person assigned by an operator to duty on an aircraft during a flight duty period.

Detect and avoid. The capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action to comply with the applicable rules of flight.

Flight crew member*. A licensed crew member charged with duties essential to the operation of an aircraft during a flight duty period.

Flight recorder**. Any type of recorder installed in the aircraft for the purpose of complementing accident/incident investigation. In the case of remotely-piloted aircraft, it also includes any type of recorder installed in a remote pilot station for the purpose of complementing accident/incident investigation.

Flight time — aeroplanes*. The total time from the moment an aeroplane first moves for the purpose of taking off until the moment it finally comes to rest at the end of the flight.

Flight time — helicopters*. The total time from the moment a helicopter's rotor blades start turning until the moment the helicopter finally comes to rest at the end of the flight, and the rotor blades are stopped.

Flying pilot. A person who operates the flying controls of an aircraft and is responsible for the flight trajectory of the aircraft.

Handover. The act of passing piloting control from one remote pilot station to another.

Instrument flight time*. Time during which a pilot is piloting an aircraft solely by reference to instruments and without external reference points.

Lost link. The loss of command and control link contact with the remotely-piloted aircraft such that the remote pilot can no longer manage the aircraft's flight.

Operational control*. The exercise of authority over the initiation, continuation, diversion or termination of a flight in the interest of safety of the aircraft and the regularity and efficiency of the flight.

Operator*. A person, organization or enterprise engaged in or offering to engage in an aircraft operation.

Pilot (to)*. To manipulate the flight controls of an aircraft during flight time.

Pilot-in-command*. The pilot designated by the operator, or in the case of general aviation, the owner, as being in command and charged with the safe conduct of a flight.

Radio line-of-sight. A direct electronic point-to-point contact between a transmitter and a receiver.

Remote crew member. A licensed crew member charged with duties essential to the operation of a remotely-piloted aircraft, during flight time.

Remote pilot. The person who manipulates the flight controls of a remotely-piloted aircraft during flight time.

Remote pilot station. The station at which the remote pilot manages the flight of an unmanned aircraft.

Remotely-piloted. Control of an aircraft from a pilot station which is not on board the aircraft.

Remotely-piloted aircraft. An aircraft where the flying pilot is not on board the aircraft.

Note.— This is a subcategory of unmanned aircraft.

Remotely-piloted aircraft system. A set of configurable elements consisting of a remotely-piloted aircraft, its associated remote pilot station(s), the required command and control links and any other system elements as may be required, at any point during flight operation.

RPA observer. A remote crew member who, by visual observation of the remotely-piloted aircraft, assists the remote pilot in the safe conduct of the flight.

Segregated airspace. Airspace of specified dimensions allocated for exclusive use to a specific user(s).

Unmanned aircraft. An aircraft which is intended to operate with no pilot on board.

Unmanned aircraft system. An aircraft and its associated elements which are operated with no pilot on board.

Visual line-of-sight operation. An operation in which the remote crew maintains direct visual contact with the aircraft to manage its flight and meet separation and collision avoidance responsibilities.

REFERENCES

ICAO DOCUMENTS

Annex 1 — *Personnel Licensing*
Annex 2 — *Rules of the Air*
Annex 3 — *Meteorological Service for International Air Navigation*
Annex 6 — *Operation of Aircraft*
  Part I — *International Commercial Air Transport — Aeroplanes*
Annex 7 — *Aircraft Nationality and Registration Marks*
Annex 8 — *Airworthiness of Aircraft*
Annex 10 — *Aeronautical Telecommunications*
  Volume II — *Communication Procedures including those with PANS status*
  Volume IV — *Surveillance and Collision Avoidance Systems*
Annex 11 — *Air Traffic Services*
Annex 13 — *Aircraft Accident and Incident Investigation*
Annex 14 — *Aerodromes*
  Volume I — *Aerodrome Design and Operations*
Annex 16 — *Environmental Protection*
  Volume I — *Aircraft Noise*
  Volume II — *Aircraft Engine Emissions*
Annex 18 — *The Safe Transport of Dangerous Goods by Air*

Doc 4444 *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM)
Doc 7300 *Convention on International Civil Aviation*, signed at Chicago on 7 December 1944 and amended by the ICAO Assembly
Doc 8643 *Aircraft Type Designators*
Doc 9284 *Technical Instructions for the Safe Transport of Dangerous Goods by Air*
Doc 9854 *Global Air Traffic Management Operational Concept*
Doc 9863 *Airborne Collision Avoidance System (ACAS) Manual*
Doc 9869 *Manual on Required Communication Performance (RCP)*

OTHER DOCUMENTS

RTCA, DO-304, Guidance Material and Considerations for Unmanned Aircraft Systems
Issued 03-22-07 • Prepared by SC-203

This document addresses all Unmanned Aircraft Systems (UAS) and UAS operations being considered for realistic implementation in the United States National Airspace System (NAS) in the foreseeable future. It is intended to educate the community and used to facilitate future discussions on UAS standards. It provides the aviation community with a definition of UAS, a description of the operational environment, and a top-level functional breakdown. The guidance material provides a framework for developing standards through RTCA Special Committee 203.

EASA, Policy Statement – Airworthiness Certification Policy of Unmanned Aircraft Systems (UAS)
Doc E.Y013-01 • Issued 25-08-2009

This policy establishes general principles for type-certification (including environmental protection) of an unmanned aircraft system. The policy represents a first step in the development of a comprehensive civil UAS regulation. This policy statement is an interim solution to aid acceptance and standardization of UAS certification procedures in Europe.

Chapter 1

INTRODUCTION

BACKGROUND

1.1 On 12 April 2005, during the first meeting of its 169th Session, the Air Navigation Commission requested the Secretary General to consult selected States and international organizations with respect to: present and foreseen international civil unmanned aerial vehicle (UAV) activities in civil airspace; procedures to obviate danger to civil aircraft posed by UAVs operated as State aircraft; and procedures that might be in place for the issuance of special operating authorizations for international civil UAV operations.

First informal ICAO meeting on UAVs

1.2 Subsequent to the above, the first ICAO exploratory meeting on UAVs was held in Montreal on 23 and 24 May 2006. Its objective was to determine the potential role of ICAO in UAV regulatory development work. The meeting agreed that although there would eventually be a wide range of technical and performance specifications and standards, only a portion of those would need to become ICAO SARPs. It was also determined that ICAO was not the most suitable body to lead the effort to develop such specifications. However, it was agreed that there was a need for harmonization of terms, strategies and principles with respect to the regulatory framework and that ICAO should act as a focal point.

Second informal ICAO meeting on UAVs

1.3 The second informal ICAO meeting (Palm Coast, Florida, January 2007) concluded that work on technical specifications for UAV operations was well underway within both RTCA and EUROCAE and was being adequately coordinated through a joint committee of their two working groups. The main issue for ICAO was, therefore, related to the need to ensure safety and uniformity in international civil aviation operations. In this context, it was agreed that there was no specific need for new ICAO SARPs at that early stage. However, there was a need to harmonize notions, concepts and terms. The meeting agreed that ICAO should coordinate the development of a strategic guidance document that would guide the regulatory evolution. Even though non-binding, the guidance document would be used as the basis for development of regulations by the various States and organizations. As regulatory material developed by States and organizations gained maturity, such material could be proposed for inclusion in the ICAO guidance document. The document would then serve as the basis for achieving consensus in the later development of SARPs.

1.4 The meeting felt strongly that the eventual development of SARPs should be undertaken in a well-coordinated manner. Because this was a newly emerging technology it was felt that there was a unique opportunity to ensure harmonization and uniformity at an early stage and that all ICAO efforts should be based on a strategic approach and should support the emerging work of other regulatory bodies. The meeting had also suggested that from this point onwards, the subject should be referred to as unmanned aircraft systems (UAS), in line with RTCA and EUROCAE agreements.

1.5 Finally, it was concluded that ICAO should serve as a focal point for global interoperability and harmonization, to develop a regulatory concept, to coordinate the development of UAS SARPs, to contribute to the development of technical specifications by other bodies, and to identify communication requirements for UAS activity.

PURPOSE OF THE CIRCULAR

1.6 The purpose of this circular is to:

a) apprise States of the emerging ICAO perspective on the integration of UAS into non-segregated airspace and at aerodromes;

b) consider the fundamental differences from manned aviation that such integration will involve; and

c) encourage States to help with the development of ICAO policy on UAS by providing information on their own experiences associated with these aircraft.

1.7 Unmanned aircraft (UA) are, indeed, aircraft; therefore, existing SARPs apply to a very great extent. The complete integration of UAS at aerodromes and in the various airspace classes will, however, necessitate the development of UAS-specific SARPs to supplement those already existing.

DOCUMENT STRUCTURE

1.8 UAS issues span all of aviation, and as such, it is an ongoing challenge to determine the most effective and efficient means of addressing the broad scope of topics. This document is organized to reflect the three traditional areas of aviation: operations, equipment and personnel. This systems approach will facilitate a comprehensive view of the issues, as well as better align the discussions with the appropriate disciplines.

Chapter 2

ICAO REGULATORY FRAMEWORK

PILOTLESS AIRCRAFT

> **Article 8** of the *Convention on International Civil Aviation*, signed at Chicago on 7 December 1944 and amended by the ICAO Assembly (Doc 7300) (hereinafter referred to as "the Chicago Convention") stipulates 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 and in accordance with the terms of such authorization….

2.1 The *Global Air Traffic Management Operational Concept* (Doc 9854) states "An unmanned aerial vehicle is 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 understanding of UAVs was endorsed by the 35th Session of the ICAO Assembly.

2.2 The regulatory framework under development by ICAO is being shaped within the context of the above statement. All UA, whether remotely-piloted, fully autonomous or a combination thereof, are subject to the provisions of Article 8. Only the remotely-piloted aircraft (RPA), however, will be able to integrate into the international civil aviation system in the foreseeable future. The functions and responsibilities of the remote pilot are essential to the safe and predictable operation of the aircraft as it interacts with other civil aircraft and the air traffic management (ATM) system. 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.

2.3 Integrating remotely-piloted UA into non-segregated airspace and at aerodromes can likely be achieved in the medium-term. The premise behind the regulatory framework and the means by which contracting States will be able to grant special authorizations is that these UAS will meet the identified minimum requirements needed to operate safely alongside manned aircraft. The remotely-located pilot with the fundamental responsibilities of pilot-in-command is a critical element in reaching this status. It is possible that States may be able to accommodate UA which are not remotely-piloted through use of special provisions or in segregated airspace; however this accommodation is not equivalent to integration.

MODEL AIRCRAFT

2.4 In the broadest sense, the introduction of UAS does not change any existing distinctions between model aircraft and aircraft. Model aircraft, generally recognized as intended for recreational purposes only, fall outside the provisions of the Chicago Convention, being exclusively the subject of relevant national regulations, if any.

FUNDAMENTALS

2.5 ICAO recognizes many categories of aircraft, among them balloons, gliders, aeroplanes and rotorcraft. Aircraft can be land, sea or amphibious. Whether the aircraft is manned or unmanned does not affect its status as an aircraft. Each category of aircraft will potentially have unmanned versions in the future. This point is central to all further issues pertaining to UA and provides the basis for addressing airworthiness, personnel licensing, separation standards, etc.

2.6 To the maximum extent possible, all terms in common use in ICAO documents will remain unchanged by the introduction of UAS. The definition of "operator" remains unchanged from existing use while "controller" equates only to "air traffic controller". With regard to "pilot", the function of this position remains unchanged despite the person or persons being located other than on board the aircraft. To distinguish those pilots who conduct their piloting duties from other than on board the aircraft, the term "remote pilot" will be applied. Consideration of the applicability of the terms "pilotless" and "flown without a pilot", as contained in Article 8 of the Chicago Convention, is elaborated in Chapter 4.

2.7 Another fundamental of the assessment undertaken by ICAO is that a UA will not, for the foreseeable future, have passengers on board for remuneration. This point relates directly to many of the existing SARPs contained in Annex 6 — *Operation of Aircraft* and Annex 8 — *Airworthiness of Aircraft* such as use of seatbelts and safety harnesses by crew members during take-off and landing, pilot windshield features and emergency equipment. While recognizing that there may come a time in the future when passengers are transported on UA, development of SARPs for that scenario will only be addressed as and when required.

REGULATORY FRAMEWORK

2.8 The principal objective of the aviation regulatory framework is to achieve and maintain the highest possible uniform level of safety. In the case of UAS, this means ensuring the safety of any other airspace user as well as the safety of persons and property on the ground.

2.9 Identifying the commonalities and differences between manned and unmanned aircraft is the first step toward developing a regulatory framework that will provide, at a minimum, an equivalent level of safety for the integration of UAS into non-segregated airspace and at aerodromes. Technical specifications to support airworthiness, command and control (C2), detect and avoid, and other functionalities are being addressed by various industry standards-development organizations around the world. ICAO's focus will remain on the higher-level performance-based standards, e.g. specifying minimum performance requirements for communications links, rather than how to achieve said requirements, along with harmonizing terms and definitions needed to support this activity.

2.10 Development of the complete regulatory framework for UAS will be a lengthy effort, lasting many years. As individual subjects and technologies reach maturity, the pertinent SARPs will be adopted. It is envisioned that this will be an evolutionary process, with SARPs being added gradually. Non-binding guidance material will often be provided in advance of the SARPs for use by States that face UAS operations in the near term. Therefore close adherence to the guidance material will facilitate later adoption of SARPs and will ensure harmonization across national and regional boundaries during this development phase. It is to be noted that elements of the regulatory framework for UAS certainly already exist inasmuch as UA are aircraft and as such major portions of the regulatory framework applicable to manned aircraft are directly applicable.

2.11 Data collection is critical to the development of SARPs. This process requires time and inherently serves as a prelude to a robust understanding of the unique characteristics of UAS. Therefore, every effort should be made amongst contracting States to collect data in a coordinated manner and share it openly to expedite the development of international civil aviation standards.

CASE FOR HARMONIZATION

2.12 To date, most flights conducted by UAS have taken place in segregated airspace to obviate danger to other aircraft. Current UA are unable to integrate safely and seamlessly with other airspace users, the reasons for which are twofold — the inability to comply with critical rules of the air, and the lack of SARPs specific to UA and their supporting systems.

2.13 A key factor in safely integrating UAS in non-segregated airspace will be their ability to act and respond as manned aircraft do. 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), the performance (e.g. transaction time and continuity of the communications link) as well as the timeliness of the aircraft's response to ATC instructions. Performance-based SARPs may be needed for each of these aspects.

2.14 Personnel licensing provides harmonization within a single airspace as well as across national and regional boundaries. The remote pilot of a UAS and the pilot of a manned aircraft have the same ultimate responsibility for the safe operation of their aircraft and therefore have the same obligation for knowledge of air law and flight performance, planning and loading, human performance, meteorology, navigation, operational procedures, principles of flight and radiotelephony. Both pilots must obtain flight instruction, demonstrate their skill, achieve a level of experience, and be licensed. They must also be proficient in the language used for radiotelephony and meet medical fitness levels, although the latter may be modified as appropriate for the UAS environment.

2.15 The lack of an on-board pilot introduces new considerations with regard to fulfilling safety-related responsibilities such as incorporation of technologies for detect and avoid, command and control, communications with ATC, and prevention of unintended or unlawful interference.

2.16 Technologies are continuously evolving in both manned and unmanned aviation. Automation plays an ever increasing role, particularly in transport category aircraft. Automation systems are already capable of operating the controls, keeping the aircraft on course, balancing fuel use, transmitting and receiving data from various ground facilities, identifying conflicting traffic and providing resolution advisories, plotting and executing optimum descent profiles and in some cases even taking-off or landing the aircraft. All of these activities are, of course, being monitored by the pilot.

SAFETY MANAGEMENT

> ***Safety.*** The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management.

2.17 Aircraft operating without a pilot on board present a wide array of hazards to the civil aviation system. These hazards must be identified and the safety risks mitigated, just as with introduction of an airspace redesign, new equipment or procedures.

2.18 The term "safety management" includes two key concepts. First is the concept of a State safety programme (SSP), which is an integrated set of regulations and activities aimed at improving safety. Second is the concept of a safety management system (SMS) which is a systematic approach to managing safety, including the necessary organizational structures, accountabilities, policies and procedures.

2.19 States are required to establish an SSP to include safety rulemaking, policy development and oversight. Under an SSP, safety rulemaking is based on comprehensive analyses of the State's aviation system. Safety policies are developed based on safety information, including hazard identification and safety risk management, while safety oversight is focused on the effective monitoring of the eight critical elements of the safety oversight function, including areas of significant safety concerns and higher safety risks. As operators introduce UAS into operation, the State's SSP should support analysis of the potential effect on safety of the air navigation system, the safety of the UAS itself and of third parties. It should also determine what role, if any, “equivalent level of safety” and “acceptable means of compliance” will have.

2.20 Operators and service providers are responsible for establishing an SMS. States are responsible, under the SSP, for the acceptance and oversight of these SMS. Assuring the safe introduction of UAS into the aviation system will fall under the responsibility of the State in accordance with Annex 6 — *Operation of Aircraft*, Annex 11 — *Air Traffic Services* and Annex 14 — *Aerodromes*, Volume I — *Aerodrome Design and Operations*. It is envisaged that Annex 6 will be expanded to include UAS at which point the SMS requirement will become applicable for the UAS operator. Detailed analyses will need to be conducted to determine what risks are likely to be encountered. Analysis may need to include, inter alia, the type of UA involved, the construct and location of the remote pilot station, if any, and its ability to interface with the UA, and the location and type of operation being proposed.

2.21 Safety levels are established by States based on many criteria. Proper application of SARPs, PANS and guidance material assists States in maintaining the agreed level of safety. UAS present a new dilemma for the airworthiness authority to consider. In most respects, UAS will be required to comply with existing regulations; however, there will be aspects which must be addressed differently as a result of not having a pilot on board the aircraft. For these cases, the authority will have to determine if an alternate means of compliance is possible to achieve the same safety level.

Chapter 3

OVERVIEW OF UAS

GENERAL CONCEPT OF OPERATIONS

3.1 UAS will operate in accordance with ICAO Standards that exist for manned aircraft as well as any special and specific standards that address the operational, legal and safety differences between manned and unmanned aircraft operations. In order for UAS to integrate into non-segregated airspace and at non-segregated aerodromes, there shall be a pilot responsible for the UAS operation. Pilots may utilize equipment such as an autopilot to assist in the performance of their duties; however, under no circumstances will the pilot responsibility be replaced by technologies in the foreseeable future.

3.2 To better reflect the status of these aircraft as being piloted, the term “remotely-piloted aircraft” (RPA) is being introduced into the lexicon. An RPA is an aircraft piloted by a licensed “remote pilot” situated at a “remote pilot station” located external to the aircraft (i.e. ground, ship, another aircraft, space) who monitors the aircraft at all times and can respond to instructions issued by ATC, communicates via voice or data link as appropriate to the airspace or operation, and has direct responsibility for the safe conduct of the aircraft throughout its flight. An RPA may possess various types of auto-pilot technology but at any time the remote pilot can intervene in the management of the flight. This equates to the ability of the pilot of a manned aircraft being flown by its auto flight system to take prompt control of the aircraft.

3.3 RPA is a subset of unmanned aircraft. Throughout this document, “unmanned aircraft” or “unmanned aircraft system” will be used as all-encompassing terms, whereas “remotely-piloted aircraft” or iterations thereof will refer only to the piloted subset.

3.4 The roles of RPA will continue to expand as technologies and performance characteristics become better understood. Long flight durations, covert operational capabilities, and reduced operational costs serve as natural benefits to many communities, such as law-enforcement, agriculture and environmental analysis.

3.5 As technologies develop, mature and become able to meet defined standards and regulations, RPA roles could expand to include operations involving carriage of cargo and eventually — possibly — passengers. In addition, domestic operations will likely expand to trans-border flights subject to pre-approval by the States involved.

3.6 RPA may have the same phases of flight — taxi, departure, en-route and arrival — as manned aircraft or they may be launched/recovered and/or conduct aerial work. The aircraft performance characteristics may be significantly different from traditional manned aircraft. Regardless, the remote pilot will operate the aircraft in accordance with the rules of the air for the State and airspace in which the RPA is operating. This will include complying with directions and instructions provided by the air traffic services (ATS) unit.

RECENT GLOBAL DEVELOPMENTS

3.7 The potential of RPA for civil use has long been evident and is now beginning to be realized. Migrating current military RPA types into civilian roles and applications is actively being considered. Meanwhile newer designs are being tailored specifically for the civil market. Additionally, while military RPA are State aircraft and therefore not subject to the Chicago Convention and its SARPs, States face a dilemma when attempting to integrate military RPA in airspace and at aerodromes also used by civil aircraft. The regulatory framework being developed for civil application may therefore carry the added benefit of facilitating operations for its military counterpart.

RPA SYSTEM CONCEPT

3.8 The remotely-piloted aircraft system (RPAS) comprises a set of configurable elements including an RPA, its associated remote pilot station(s), the required C2 links and any other system elements as may be required, at any point during flight operation. Other features might include, inter alia, software, health monitoring, ATC communications equipment, a flight termination system, and launch and recovery elements.

3.9 The system, in many cases, will not be static. An aircraft can be piloted from one of many remote pilot stations, during any given flight or from one day to another. Likewise, multiple aircraft can be piloted from a single remote pilot station, although standards may dictate a one-aircraft-at-a-time scenario. In both of these cases, the configuration of the system in operational use changes as one element or the other changes on a real-time basis.

3.10 This RPAS concept introduces many challenges for the airworthiness and operational approvals that are required. These challenges are described in Chapter 6.

3.11 Payload on RPA is not a factor considered within this document except as it pertains to dangerous goods. Likewise, any communications/data link requirements for the payload are not addressed herein.

UAS POTENTIAL MOST SUITED TO CIVIL OPERATIONS

3.12 UAS are popularly commended as being well suited to civil applications that are dull, dirty or dangerous, in other words, tasks that entail monotony or hazard for the pilot of a manned aircraft. However, there is a far broader potential scope for UAS, including, inter alia, commercial, scientific and security applications. Such uses mainly involve monitoring, communications and imaging.

3.13 Typical monitoring and surveillance tasks include border and maritime patrol, search and rescue, fishery protection, forest fire detection, natural disaster monitoring, contamination measurement, road traffic surveillance, power and pipeline inspection, and earth observation. Moreover, the ability of some UAS to keep station for days, weeks or even months makes them particularly well suited for use as communication relays. Other UAS are already being exploited for commercial imaging purposes such as aerial photography and video.

EXPECTED EVOLUTION OF THE UAS CIVIL MARKET

3.14 A civil market already exists for UAS. This market will likely remain limited until appropriate regulatory frameworks are in place. Any significant expansion will also depend upon the development and certification of technologies required to enable the safe and seamless integration of RPA into non-segregated airspace.

3.15 The demand for small civil RPA flying visual line-of-sight (VLOS) (see Figure 3-1) for law enforcement, survey work, and aerial photography and video will continue to grow. Larger and more complex RPA — able to undertake more challenging tasks — will most likely begin to operate in controlled airspace where all traffic is known and where ATC is able to provide separation from other traffic. This could conceivably lead to routine unmanned commercial cargo flights.

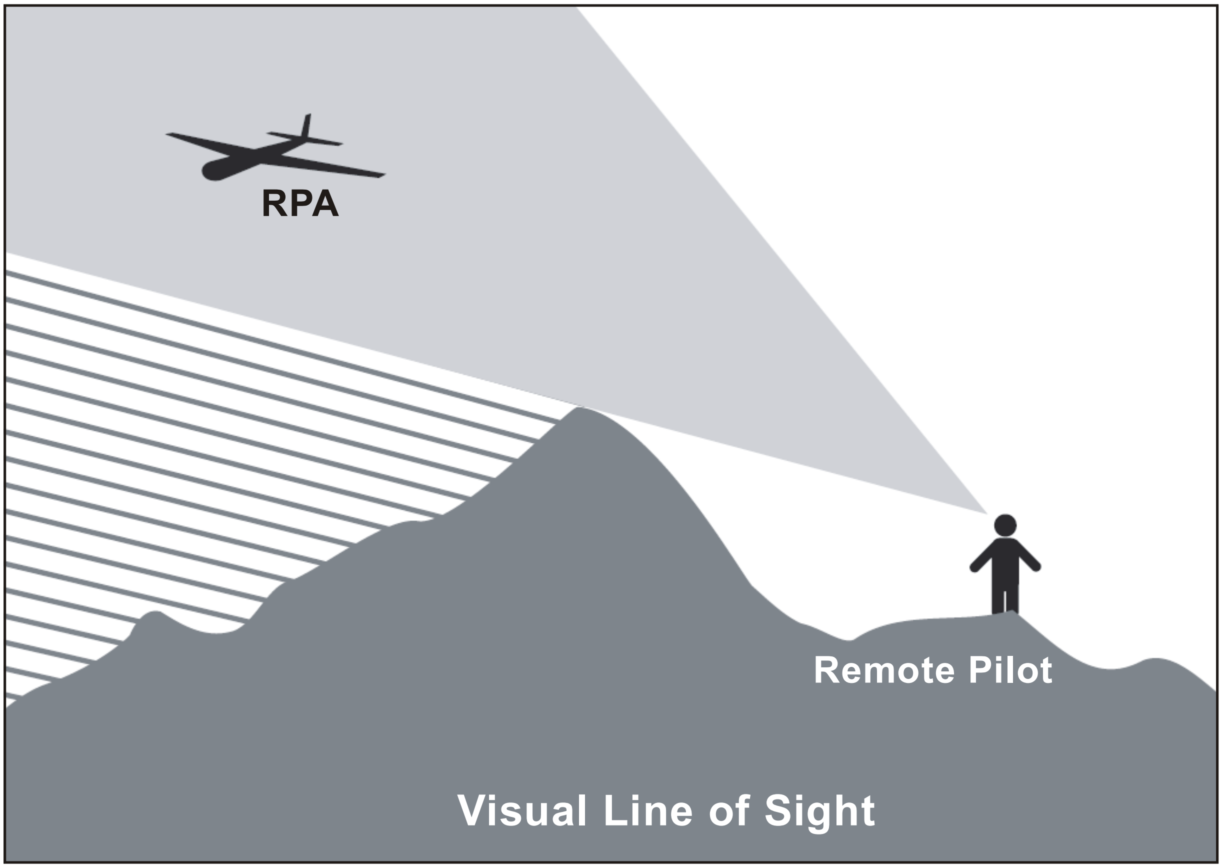

Figure 3-1. Visual line of sight

3.16 Paradoxically, the benefits of RPA to conduct visual surveillance/observation missions, which typically occur in visual meteorological conditions (VMC), are far more challenging due to the need to avoid collisions without benefit of separation service provided by ATC. activities as diverse as gliding, ballooning, parachuting, leisure flying, military training and law enforcement operations are likely to occur under the same conditions. Technology to support the pilot in meeting the collision avoidance responsibilities is not yet in place; hence the civil market for RPA operating outside controlled airspace could possibly be the slowest to evolve.

3.17 In cooperation with the scientific community, civil aviation authorities are working on the means to permit use of RPA in support of research on climate change, meteorological forecasting, and wildlife monitoring, among others. Many, if not most, of these flights cannot be conducted by manned aircraft due to the remote locations, harsh conditions, or altitudes at which the flights need to operate.

3.18 The RPA civil market is expected to develop incrementally, with usage increasing as confidence in RPA safety and reliability grows, as SARPs and technical specifications are developed, and public and industry confidence grows.

HIGH SEAS OPERATIONS

3.19 Operators must have approval from the State of the Operator before conducting operations in high seas airspace. They must likewise coordinate their operations with the ATS provider responsible for the airspace concerned.

ENVIRONMENTAL CONSIDERATIONS

3.20 Like manned aircraft, UA operations will have an impact on the environment, the extent of which will depend on the category and size of the UA, the type and amount of fuel consumed, and the nature and location of the operation, among many other factors. It is critical that as UA are designed, built and operated, their environmental footprint, noise and gaseous emissions, are compliant with the applicable standards. Environmental issues are further addressed in Chapter 6.

Chapter 4

LEGAL MATTERS

INTRODUCTION

4.1 Specific rights and obligations have been agreed by the contracting States in order that international civil aviation may be developed in a safe and orderly manner and that international air transport services may be established on the basis of equality of opportunity and operated soundly and economically. These rights and obligations will, in principle, apply equally to both manned and unmanned civil aircraft. Where new measures must be developed for UAS operations, or existing requirements met using alternative means, they will be identified herein and addressed according to the Chicago Convention.

SPECIFIC ARTICLES AND THEIR APPLICABILITY TO UAS

Article 3 *bis*

b) The contracting States recognize that every 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.

c) Every civil aircraft shall comply with an order given in conformity with paragraph b) of this Article….

4.2 Contracting States are entitled, in certain circumstances, to require civil aircraft flying above their territory to land at designated aerodromes, per Article 3 *bis* b) and c). Therefore the pilot of the RPA will have to be able to comply with instructions provided by the State, including through electronic or visual means, and have the ability to divert to the specified airport at the State's request. The requirement to respond to instructions based on such visual means may place significant requirements on certification of RPAS detection systems for international flight operations.

Article 8

Pilotless aircraft

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 and in accordance with the terms of such authorization. Each 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.

4.3 Article 8 details conditions for operating a "pilotless" aircraft over the territory of a contracting State. To understand the implications of this Article and its inclusion from the Paris Convention of 1919 (Article 15) into the Chicago Convention of 1944, the intent of the drafters must be considered. Remote-control and uncontrolled aircraft were in existence at the time, operated by both civil and military entities. "[A]ircraft flown without a pilot" therefore refers to the situation where there is no pilot on board the aircraft. As a consequence, any RPA is a "pilotless" aircraft, consistent with the intent of the drafters of Article 8.

4.4 Second, emphasis was placed on the significance of the provision that aircraft flown without a pilot "shall be so controlled as to obviate danger to civil aircraft", indicating that the drafters recognized that "pilotless aircraft" must have a measure of control being applied to them in relation to a so-called "due regard" obligation similar to that of State aircraft. In order for a UAS to operate in proximity to other civil aircraft, a remote pilot is therefore essential.

4.5 More recently, the Eleventh Air Navigation Conference (Montréal, 22 September to 3 October 2003) endorsed the global ATM operational concept which contains the following text: "[a]n unmanned aerial vehicle is 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."

4.6 Standards to facilitate application and processing of the mandated requests for authorization will be contained in an Appendix to Annex 2 — *Rules of the* Air. In all cases, the safety of other civil aircraft will have to be considered. It is envisaged that once the broad range of SARPs are adopted for each of the Annexes affected, contracting States will be able to facilitate and foster international operations of RPA to a similar extent as that being enjoyed by manned aviation.

Article 12

Rules of the Air

Each contracting State undertakes to adopt measures to insure that every aircraft flying over or maneuvering within its territory and that every aircraft carrying its nationality mark, wherever such aircraft may be, shall comply with the rules and regulations relating to the flight and maneuver of aircraft there in force. Each contracting State undertakes to keep its own regulations in these respects uniform, to the greatest possible extent, with those established from time to time under this Convention. Over the high seas, the rules in force shall be those established under this Convention. Each contracting State undertakes to insure the prosecution of all persons violating the regulations applicable.

4.7 The rules of the air apply to all aircraft, manned or unmanned. Furthermore, they oblige contracting States to maintain national regulations uniform with ICAO Standards, to the greatest possible extent, and to prosecute all persons violating them. This is the basis for international harmonization and interoperability, which is as essential for unmanned as manned operations to be conducted safely.

4.8 In accordance with Article 12 and Annex 2, the pilot-in-command is responsible for the operation of the aircraft in compliance with the rules of the air. This also extends to having final authority as to disposition of the aircraft while in command. This is true whether the pilot is on board the aircraft or located remotely.

4.9 RPA operations may involve the pilot and all associated responsibilities being handed over while the aircraft is in flight. The remote pilots may be co-located or situated thousands of kilometres apart, e.g. for an oceanic flight of a long range RPA, handover of piloting responsibilities to a remote pilot situated in Asia from a remote pilot situated in North America or between an en-route remote pilot and a local (terminal) remote pilot. Handover may also occur as a result of routine shift work of the remote pilots. Changes will be required to address the handover of such responsibilities between different remote pilots. Adding to the complexity of this scenario is the possibility that the remote pilots and their stations may be located in different States.

Article 15

Airport and similar charges

Every airport in a contracting State which is open to public use by its national aircraft shall likewise, subject to the provisions of Article 68, be open under uniform conditions to the aircraft of all other contracting States....

4.10 This provision applies equally to UA. Contracting States remain free to permit civil UA operations only to/from designated aerodromes, providing that no discrimination is introduced with respect to national or foreign registration of the aircraft.

Article 29

Documents carried in aircraft

Every aircraft of a contracting State, engaged in international navigation, shall carry the following documents in conformity with the conditions prescribed in this Convention:

a) Its certificate of registration;

b) Its certificate of airworthiness;

c) The appropriate licenses for each member of the crew;

d) Its journey log book;

e) If it is equipped with radio apparatus, the aircraft radio station license;

f) If it carries passengers, a list of their names and places of embarkation and destination; and

g) If it carries cargo, a manifest and detailed declarations of the cargo.

4.11 Regarding Article 29, every aircraft of a contracting State engaged in international navigation shall carry the specified documents on board the aircraft. For an RPA, carrying paper originals of these documents may be neither practical nor appropriate. Use of electronic versions of these documents may be considered. The requirement for certain documents to be carried on board the aircraft will be reviewed to determine if alternative means can be developed for RPA.

Article 31

Certificates of airworthiness

Every aircraft engaged in international navigation shall be provided with a certificate of airworthiness issued or rendered valid by the State in which it is registered.

4.12 Article 31 applies equally to unmanned aircraft engaged in international navigation; however there may be differences in how airworthiness will be determined. These differences are explored in Chapter 6. Until such time as SARPs for Certificates of Airworthiness are adopted in Annex 8 — *Airworthiness of Aircraft*, a gap will exist in how States issue these certificates.

Article 32

Licenses of personnel

a) The pilot of every aircraft and the other members of the operating crew of every aircraft engaged in international navigation shall be provided with certificates of competency and licenses issued or rendered valid by the State in which the aircraft is registered.

4.13 Remote pilots and other members of the remote crew are not subject to Article 32 which was drafted specifically for those individuals who conduct their duties while on board aircraft. Despite this, remote pilots and other members of the remote crew must be properly trained, qualified and hold an appropriate licence or a certificate of competence to ensure the integrity and safety of the civil aviation system. Until such time as SARPs for remote pilot licenses and certificates are adopted in Annex 1 — *Personnel Licensing*, a gap will exist in how States issue, render valid or recognize such licenses and certificates.

> **Article 33**
>
> *Recognition of certificates and licenses*
>
> Certificates of airworthiness and certificates of competency and licenses issued or rendered valid by the contracting State in which the aircraft is registered, shall be recognized as valid by the other contracting States, provided that the requirements under which such certificates or licences were issued or rendered valid are equal to or above the minimum standards which may be established from time to time pursuant to this Convention.

4.14 Article 33 is the basis for mutual recognition of certificates and licences; however, it should be noted that significant differences will exist in how UAS certificates will be considered. As with manned aircraft, the UA must possess a Certificate of Airworthiness. The other elements comprising the system which allows the RPA to operate (remote pilot station, C2, etc.) will also have to be addressed.

4.15 Assembly Resolution A36-13, Appendix G, Certificates of airworthiness, certificates of competency and licenses of flight crews (clause 2) resolves that States shall recognize the validity of certificates and licenses issued by other States when international standards for certain categories of aircraft or classes of airmen have not (yet) been developed. While ICAO is developing SARPs for RPAS, States are encouraged to develop national regulations that will facilitate mutual recognition of certificates for unmanned aircraft, thereby providing the means to authorize flight over their territories, including landings and take-offs by new types and categories of aircraft. An update to Assembly Resolution A36-13 may be necessary to include mutual recognition of licenses of remote pilots and other members of the remote crew.

Chapter 5

OPERATIONS

RULES OF THE AIR

5.1 Annex 2 — *Rules of the Air* constitutes Standards relating to the flight and manoeuvre of aircraft within the meaning of Article 12 of the Chicago Convention. Over the high seas, therefore, these Standards apply without exception. In addition, Annex 2 is applicable to aircraft bearing the nationality and registration marks of a contracting State, wherever they may be, to the extent that the marks do not conflict with the rules published by the State having jurisdiction over the territory overflown.

COLLISION AVOIDANCE

5.2 The pilot-in-command of a manned aircraft is responsible for detecting and avoiding potential collisions and other hazards (see Figure 5-1). 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. As stated in Annex 2, paragraph 3.2:

> *Note 1.— It is important that vigilance for the purpose of detecting potential collisions be exercised on board an aircraft, regardless of the type of flight or the class of airspace in which the aircraft is operating, and while operating on the movement area of an aerodrome.*

5.3 Paragraph 1.5.3 of the *Airborne Collision Avoidance System (ACAS) Manual* (Doc 9863) states that: "ACAS II was not designed with the intent of being installed on tactical military (e.g. fighter aircraft) or unmanned aircraft. As such, there are technical and operational issues that must be addressed and resolved prior to installing ACAS II on these types of aircraft." The nature and extent of the technical and operational issues will have to be assessed before any determination can be made as to the applicability of ACAS II for the RPA.

5.4 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. Regardless, the right-of-way rules will remain essential for the safe operation of aircraft, with or without a pilot on board. Likewise, for the surface movement of RPA in the aerodrome environment, it is necessary that RPA operations be conducted safely and efficiently without disrupting other aircraft operations.

5.5 Aircraft pilots are required to observe, interpret and heed a diverse range of visual signals intended to attract their attention and/or convey information. Such signals can range from lights and pyrotechnic signals for aerodrome traffic to signals used by intercepting aircraft. Remote pilots will be subject to the same requirements despite not being on board the aircraft, necessitating development and approval of alternate means of compliance with this requirement.

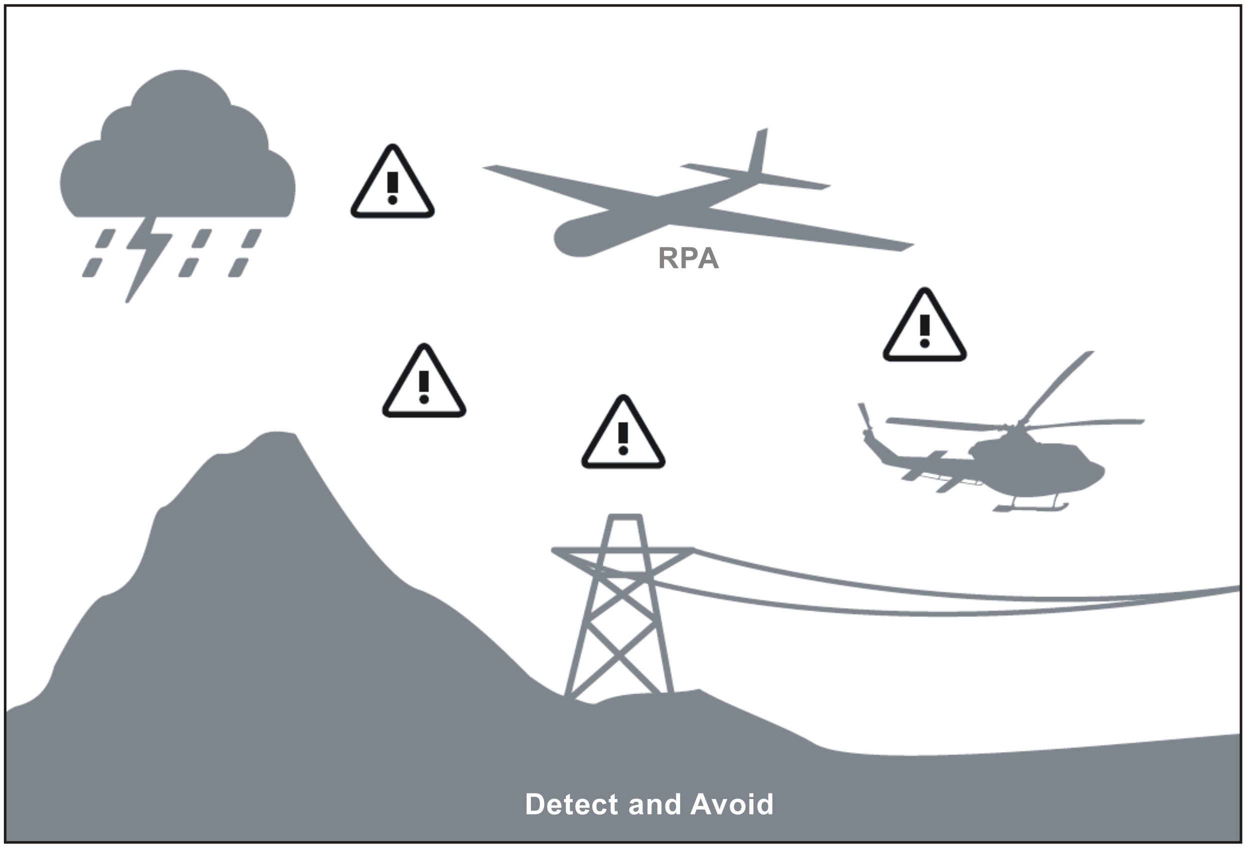

Figure 5-1. Detect and avoid

5.6 Considering each of the above, RPAS detect and avoid solutions will be required to meet specified performance requirements related to flight crew responsibilities. Both the aircraft and the remote pilot station will need to incorporate aspects of this functionality to achieve the complete technical solution required as part of the RPA operational approval. Depending on the type and location of the operations the RPA will conduct, these could include the ability to:

a) recognize and understand aerodrome signs, markings and lighting;

b) recognize visual signals (e.g. interception);

c) identify and avoid terrain;

d) identify and avoid severe weather;

e) maintain applicable distance from cloud;

f) provide "visual" separation from other aircraft or vehicles; and

g) avoid collisions.

5.7 The aerospace industry will continue to face a major challenge in the development of cost-effective solutions meeting RPAS detect and avoid performance requirements. It is possible that initial detect and avoid solutions which may not meet all performance requirements could nevertheless be accommodated on the basis of restricted or limited operational approvals and/or permits to fly as a function of associated safety assessments. Typically such restrictions or constraints would relate to airspace classifications, flight rules or specific geographical areas and associated traffic densities.

AIR TRAFFIC SERVICES

5.8 Annex 11 — *Air Traffic Services* relates to the establishment of airspace, ATS units and services necessary to promote a safe, orderly and expeditious flow of air traffic which, together with Annex 2, is intended to ensure that flying on international air routes is carried out under uniform conditions designed to improve the safety and efficiency of air operation.

5.9 For RPA, the following specificities need to be addressed:

a) 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; and

b) 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.

5.10 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. 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.

5.11 *Wake turbulence*. As RPA enter into routine service, there may be a need to review the current aircraft wake turbulence categories and any associated separation standards or procedures.

5.12 *Flight plans*. ATC must receive pre-flight notification/application that an aircraft is remotely-piloted. The *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) will likely be amended to include a specific flight plan annotation for this purpose. *Aircraft Type Designators* (Doc 8643) will certainly be amended to incorporate RPA type designators.

EQUIPMENT

5.13 All applicable equipment mandated in the Annexes, both for airworthiness and for operation, will be required for the RPAS, either directly or through an alternative (e.g. a digital compass instead of a magnetic compass). The difference will be that the equipment will be distributed over the RPA and remote pilot station. In addition to the equipment already required, there will be new equipment introduced to allow the RPAS to operate as a system. This may include, but is not limited to:

a) detect and avoid technologies; and

b) command and control systems to provide the connection between the RPA and remote pilot station.

ATS/REMOTE PILOT COMMUNICATIONS

5.14 ATS/remote pilot communication requirements must be assessed in the context of an ATM function, taking into account human interactions, procedures and environmental characteristics. An SMS approach should be employed to determine the adequacy of any communications solutions.

5.15 Current telecommunication procedures ensure voice and data messages are composed in a standardized format for both air-to-ground and ground-to-ground communications. For RPA, communications procedures will likely be based upon current practices applicable in the airspace classes in which the RPA operate.

5.16 Any requirements on type and level of interaction RPA must be capable of achieving with other users and service providers will need to be fully addressed prior to RPA integrating with manned aircraft. Topics such as situational awareness will require a deeper understanding of RPA's benefits and problems. Benefits that have been coincidentally achieved within manned aviation will need to be specifically charted for RPAS as they may not be automatically available in future designs (e.g. remote access to electronic aeronautical information). In addition, other new ATS features such as 4-dimentional trajectories must be reviewed for RPA use and adoption.

5.17 As with manned aviation, current communication technologies for RPA must continue to be supported with clear and proven procedures. Novel techniques may need to be employed to support the use of current technologies for ATS/remote pilot communications. Several technical solutions are available (addressed in Chapter 6), however it will be vital that any such solution which is not the norm for the particular ATS unit will have been approved by the ATS authority prior to the flight/operation. (See Figure 5-2.) Essential considerations include but may not be limited to volume of traffic, type and location of operation, ease of access to the communications method and its reliability.

5.18 Technical and operational interoperability with manned aircraft must be maintained. A prerequisite for this is compliance with the provisions of Annex 10 — *Aeronautical Telecommunications*, Volume II — *Communication Procedures including those with PANS status*. In the case of RPAS, the provisions dealing with loss of communication will most likely require special technical solutions.

5.19 *Transaction time*. The air-to-ground communication links may prove to be inadequate if there are substantial transmission delays between ATC and the remote pilot. This may have implications for future technological solutions to be used for direct controller/pilot communications.

5.20 The traditional requirement for a pilot to monitor an assigned ATC frequency channel for analogue radiotelephony must be assessed. Aside from the obvious need to respond to ATC, there is a collateral benefit in that pilots gain situational awareness by listening to the voice traffic, particularly regarding the intentions and positions of other aircraft.

5.21 *Phraseology*. To increase the situational awareness of air traffic controllers and other pilots on the frequency, remote pilots may be directed to prefix their call signs with "remotely-piloted" or something similar, possibly only on the first call, during voice communications between ATC and the remote pilot station.

5.22 Chapter 3 introduced the concept of more than one remote pilot station being utilized for a single flight (see Figure 5-3). Technical protocols and operational procedures will be required to support the handover of piloting functionality between the remote pilot stations. The aircraft must be under the piloting control of only one remote pilot station at a time. The system should be capable of supporting the automatic transfer of C2 data link authority between designated remote pilot stations using digital data interchange. Remote crew procedures would verify the link and ensure the "relief" crew briefing was complete prior to terminating the C2 data link with the transferring remote pilot station. An analogy exists with controller-pilot data link communications (CPDLC) in the technical protocols used for transferring data link authority from one ATC facility to another as an aircraft approaches a transfer-of-control point.

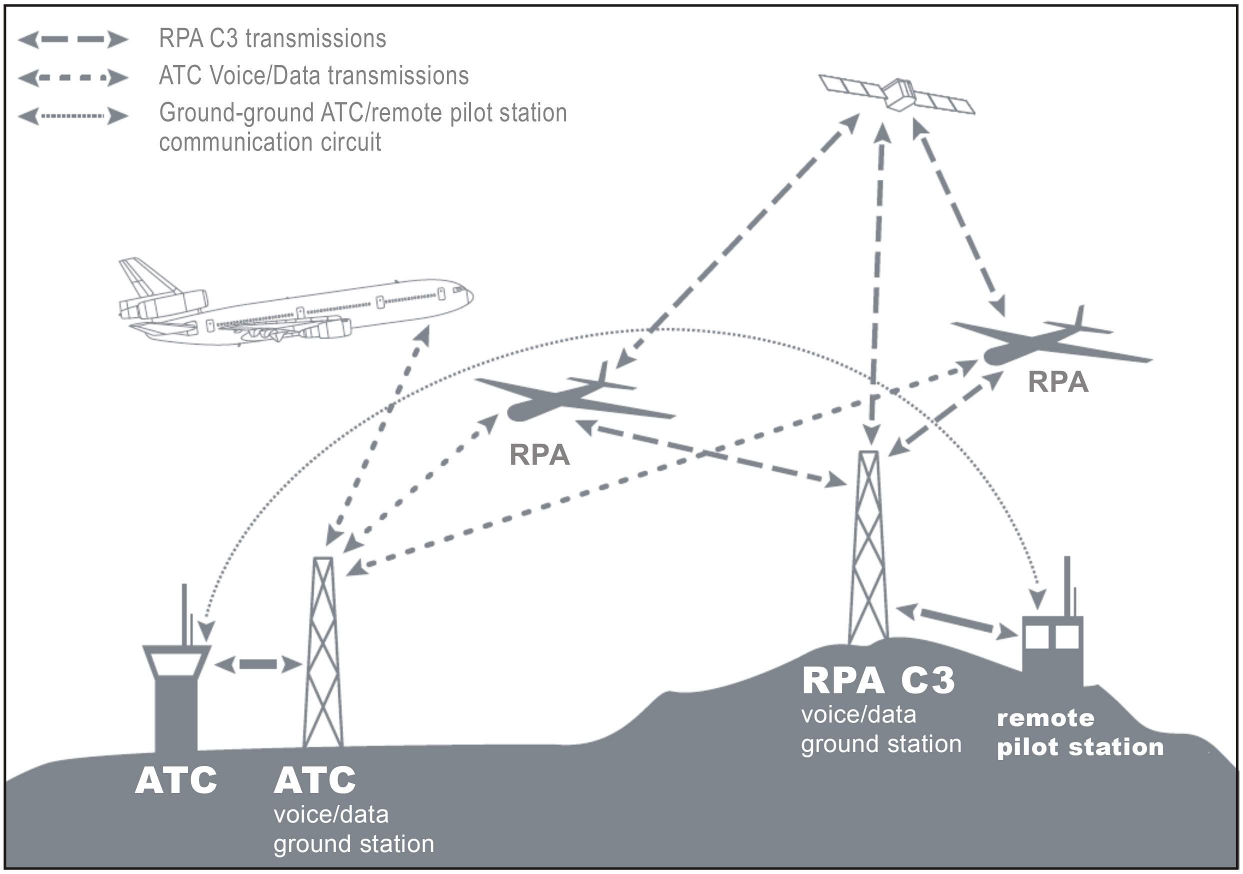

Figure 5-2. Communication links

AERODROMES

5.23 It is generally recognized that integration of RPA into aerodrome operations will prove to be among the greatest challenges. At issue are provisions for the remote pilot to identify, in real-time, the physical layout of the aerodrome and associated equipment such as aerodrome lighting and markings so as to manoeuvre the aircraft safely and correctly. RPA must be able to work within existing aerodrome parameters. Aerodrome standards should not be significantly changed, and the equipment developed for RPA must be able to comply with existing provisions to the greatest extent practicable. Moreover, where RPA are operated alongside manned aircraft, there needs to be harmonization in the provision of ATS.

5.24 Consideration may be given to the creation of airports that would support RPAS operations only. Current provisions regarding aerodrome design, construction and operations would continue to apply, however some amendments or additions may be necessary to accommodate unique RPAS issues.

5.25 Annex 14 sets forth the minimum SARPs that prescribe the physical characteristics and obstacle limitation surfaces to be provided for at aerodromes, and certain facilities and technical services normally provided. It is not intended that these specifications limit or regulate the operation of an aircraft. The Annex does provide for the accommodation of current types of manned aircraft and, therefore, should equally address the same or comparable types of RPA. However, changes may be necessary to the Annex should unique issues arise that cannot be addressed with the current provisions.

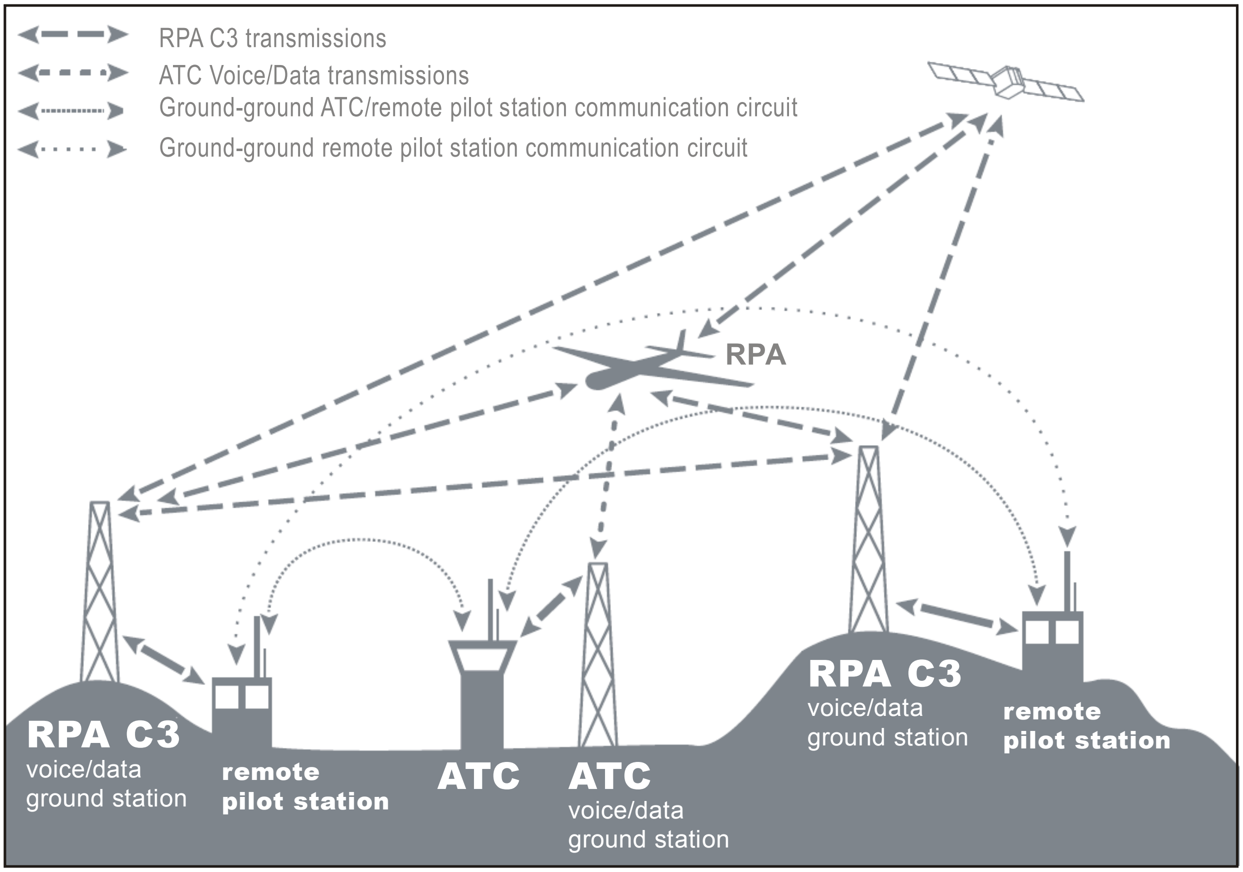

Figure 5-3. Communication links

5.26 The unique characteristics of RPA that would affect aerodrome operations will need to be considered to facilitate the integration of these aircraft. Some of the areas to be considered are:

a) applicability of aerodrome signs and markings for RPA;

b) integration of RPA with manned aircraft operations on the manoeuvring area of an aerodrome;

c) issues surrounding the ability of RPA to avoid collisions while manoeuvring;

d) issues surrounding the ability of RPA to follow ATC instructions in the air or on the manoeuvring area (e.g. “follow green Cessna 172” or “cross behind the Air France A320”);

e) applicability of instrument approach minima to RPA operations;

f) necessity of RPA observers at aerodromes to assist the remote pilot with collision avoidance requirements;

g) implications for aerodrome licensing requirements of RPA infrastructure, such as approach aids, ground handling vehicles, landing aids launch/recovery aids, etc.;

h) rescue and fire fighting requirements for RPA (and remote pilot station, if applicable);

i) RPA launch/recovery at sites other than aerodromes;

j) integration of RPA with manned aircraft in the vicinity of an aerodrome; and

k) aerodrome implications for RPA-specific equipment (e.g. remote pilot stations).

METEOROLOGICAL SERVICE

5.27 Meteorological information plays a role in the safety, regularity and efficiency of international air navigation and is provided to users as required for the performance of their respective functions. Meteorological information supplied to operators and flight/remote crew members covers the flight in respect of time, altitude, and geographical area. Accordingly, the information relates to appropriate fixed times, or periods of time, and extends to the aerodrome of intended landing. It also covers meteorological conditions expected between the aerodrome of intended landing and alternate aerodromes designated by the operator.

5.28 Meteorological services are critical for the planning, execution and safe operation of international aviation. Since the remote pilot is not on board the aircraft and may not be able to determine meteorological conditions and their real-time effects on the aircraft, obtaining meteorological information from appropriate sources prior to and during flight will be especially critical for the safe operation of these aircraft.

5.29 Annex 3 — *Meteorological Service for International Air Navigation* has a requirement for aircraft on its registry operating on international air routes to make automated routine observations, if so equipped. RPA may not be so equipped. Likewise, there is a requirement for all aircraft to make special observations whenever severe turbulence, severe icing, severe mountain wave, thunderstorms, hail, dust, stone and volcanic ash are encountered during a flight. However, RPA may not be able to comply with these provisions as the pilot is remote from the aircraft, and the aircraft may not have the sensors to detect these phenomena.

5.30 Conversely, the RPA specifically equipped for such purposes may in fact be used to monitor meteorological conditions, relaying information back to ground sensors. These aircraft could potentially be used in conditions and locations where manned aircraft cannot safely operate such as in hurricanes, convective weather or in the vicinity of volcanic ash/gases.

5.31 Besides natural turbulence, there is also the problem of wake turbulence. Wake turbulence information is critical for the planning and execution of safe operations of all aircraft and especially RPA which may be unusually light in comparison to manned aircraft. The wake turbulence separation minima may need to be amended as very small RPA are much more sensitive to wake turbulence than larger and heavier manned aircraft. Near-term measures in this area, including implementation of dynamic wake vortex separations and wake vortex avoidance systems, will need to be reviewed for application to RPA.

SECURITY

5.32 Security is a vital issue for RPA with aspects that are both similar and unique when compared with manned aircraft. As a remote pilot station is similar in purpose and design to a cockpit, it must likewise be secure from sabotage or unlawful malicious interference. Chapter 13 of Annex 6, Part I — *International Commercial Air Transport — Aeroplanes* contains SARPs to secure the flight crew compartment. However, due to the fixed and exposed nature of the remote pilot station (as opposed to the restricted nature of a commercial aeroplane where the intrusion and use of heavier weapons is less likely) further consideration should be given to the potential vulnerability of the premises against unlawful interference.

5.33 Similarly, the aircraft itself must be stored and prepared for flight in a manner that will prevent and detect tampering and ensure the integrity of vital components. The *Aviation Security Manual* provides further details concerning protection of aircraft.

5.34 Systems for controlling access to the remote pilot station should be at least of equal standard to those already in place in the commercial aviation industry. In that regard, ICAO publishes information on procedures to be followed and systems to be implemented to ensure the security of the flight crew compartment, and this may be used as general reference material when addressing the unique nature of the remote pilot station. Identification technologies such as the use of biometrics for access control systems may offer a higher degree of security. Furthermore, distinction in access control level may be considered between the remote pilot station itself and the premises wherein it resides.

5.35 Remote pilots should be subjected, at a minimum, to the same background check standards as persons granted unescorted access to security restricted areas of airports (Annex 17 — *Security* – Standard 4.2.4). Further details concerning background checks can be found in the *Aviation Security Manual*.

5.36 The software and data/communications link provides functions as vital as traditional wiring, control cables and other essential systems. These links may utilize diverse hardware and software that may be provided and managed by third parties. Safety and security of these links and services are equally important as those for the aircraft and remote pilot station. They must be free from hacking, spoofing and other forms of interference or malicious hijack.

SAFE TRANSPORT OF DANGEROUS GOODS BY AIR

5.37 Article 35 of the Chicago Convention addresses cargo restrictions, specifically regarding the carriage of munitions or implements of war and other dangerous goods. The provisions of Annex 18 — *The Safe Transport of Dangerous Goods by Air* further govern the international transport of dangerous goods by air. The broad provisions of this Annex are amplified by the detailed specifications of the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284) and its supplement, *Supplement to the Technical Instructions for the Safe Transport of Dangerous Goods by Air* (Doc 9284SU). Most of the dangerous goods carriage requirements contained in Article 35 and within the third edition of the Annex are considered applicable to RPA as written. While there are references to crew, these relate to the crew being informed about the dangerous goods or informing other parties. Again, operators of RPA would be expected to comply with the requirements.

5.38 At such time as civil RPA are utilized for the transportation of goods internationally, the provisions of Annex 18 and Article 35 of the Chicago Convention will be applicable.

AIRCRAFT ACCIDENT AND INCIDENT INVESTIGATION

5.39 The safety of UA operations is equally important to that of manned aircraft. Third party injury and damage to property can be equally severe, whether caused by a manned or unmanned aircraft. Proper investigation of each accident or serious incident is necessary to identify causal factors and/or contributing factors in order to prevent recurrences. Similarly, the sharing of safety information is critical to reducing the number of accidents and serious incidents globally.

5.40 An amendment to Annex 13 — *Aircraft Accident and Incident Investigation* has already been adopted to bring UA accidents and serious incidents under the same umbrella as those of manned aircraft. The following revisions became applicable on 18 November 2010:

CHAPTER 1. DEFINITIONS

. . .

Accident. An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

. . .

Note 3.— The type of unmanned aircraft system to be investigated is addressed in 5.1.

. . .

Serious incident. An incident involving circumstances indicating that there was a high probability of an accident and associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down.

CHAPTER 5. INVESTIGATION

. . .

5.1 The State of Occurrence shall institute …

. . .

Note 3.— In the case of investigation of an unmanned aircraft system, only aircraft with a design and/or operational approval are to be considered.

5.41 Although the amendment to Annex 13 for investigation of UA accidents and serious incidents covers only those with a design and/or operational approval, it is recommended that within contracting States the investigation of UA accidents be undertaken regardless of UA certification status. Data collected by these investigations should be shared to the extent practicable with the other States.

SEARCH AND RESCUE

5.42 Article 25 of the Chicago Convention states that "Each contracting State undertakes to provide such measures of assistance to aircraft in distress in its territory as it may find practicable, and to permit, subject to control by its own authorities, the owners of the aircraft or authorities of the State in which the aircraft is registered to provide such measures of assistance as may be necessitated by the circumstances. Each contracting State, when undertaking search for missing aircraft, will collaborate in coordinated measures which may be recommended from time to time".

5.43 By definition, search and rescue (SAR) is based on the idea that the main purpose of "search" is to ensure that assistance is rendered to persons in distress. This is most often seen as rendering assistance to persons who were on board the aircraft, but includes third parties as well. Assuming that the number of persons on board an aircraft, if any, will already be determined through the use of current provisions, these same provisions may need to be reviewed to reflect any assumptions regarding potential injuries to those on the ground or otherwise.

5.44 As mentioned in Chapter 3, RPA may fulfil roles in SAR activities due to their ability to operate for extended duration even in remote and hazardous environments and their usefulness in providing communication relay platforms. Provisions for RPA and the remote pilots to undertake these activities within the SAR framework of ICAO and the International Maritime Organization will need to be developed.

FACILITATION

5.45 Under Article 22 of the Chicago Convention, each contracting State accepts the obligation "to adopt all practicable measures, through the issuance of special regulations or otherwise, to facilitate and expedite navigation by aircraft between territories of contracting States, and to prevent unnecessary delays to aircraft, crews, passengers and cargo, especially in the administration of the laws relating to immigration, quarantine, customs and clearance." This obligation would apply to UA as well.

5.46 Any UA which departs from and lands in two different States will have to satisfy the facilitation requirements of the States involved. There may be a need to address current definitions, types of operations, documentation and remote pilot station requirements to support routine international operations of UA.

Chapter 6

AIRCRAFT AND SYSTEMS

CERTIFICATION

6.1 RPA are integrating into a well-established certification system and are subject to demonstrating compliance in a manner similar to that of manned aircraft. The fact that these aircraft cannot operate without supporting system elements (remote pilot station, C2 data links, etc.) brings new complexities to the subject of certification. One cannot assume that a single RPA will always be flown from the same remote pilot station using the same C2 data link. Rather, it is likely that each of these system elements will be changeable. It is even likely that for long-haul operations, the remote pilot station and C2 data links will be changed during flight and that as a remote pilot station is released from one aircraft it can then be used for another in real time.

6.2 Taking this new concept one step further, it is also likely that components will be located in different States. The long-haul flight operating from one region of the world to another will face increasing C2 and communications performance issues as the aircraft travels further from its remote pilot station. While the performance (e.g. data link transaction time, availability) may not be detrimental in the oceanic and remote en-route environments, it will be different in the congestion of the continental and aerodrome environments. To address these issues, it may be necessary to handover piloting control from the "home" remote pilot station to one in the destination locale. Legal issues related to certification, licensing and the recognition of documents in this new scenario would have to be addressed.

6.3 The remote pilot station, particularly looking at possible future scenarios, could be operated as a commercial enterprise by a "remote pilot station operator". This remote pilot station operator would be responsible for obtaining approval from the State Civil Aviation Authority (CAA) to operate and maintain the remote pilot station. Among the factors to be considered would be specific aircraft types that can be piloted from the remote pilot station. It should be noted that the State of the remote pilot station operator would not necessarily be the same as the State of the Operator of the RPA. Complex legal issues and agreements between States would have to be addressed prior to this scenario becoming feasible.

6.4 From an operational point of view, it is desirable to have maximum flexibility in using remote pilot stations when conducting a flight. Implementing this concept would lead to a flexible operational system configuration. Two possibilities envisaged to facilitate this flexibility are described in 6.5 and 6.6.

6.5 The first option envisaged is that the certification of the RPAS is documented with the Type Certificate issued to the RPA. The configuration of the RPAS as a whole would be included in the Type Certificate of the RPA, under the responsibility of one unique Type Certificate holder. The remote pilot station associated with the aircraft would be a separate entity, likely to be treated in a manner similar to engines and propellers in that it could have a Type Certificate issued by the remote pilot station State of Design. The configuration of RPA and remote pilot station(s) would be certified in conjunction with the RPA by the State of Design of the aircraft and documented in the Type Certificate data sheet. The remote pilot station then is "part" of the RPAS. This would give the RPA State of Design responsibility for the overall system design. The RPA State of Design would also have responsibility for providing any mandatory continuing airworthiness information. The State of Registry would have responsibility for determining continuing airworthiness of the RPAS in relation to the appropriate airworthiness requirements. More than one remote pilot station could be associated with the RPA as long as the configuration is described in the Type Certificate. A Certificate of Airworthiness would be issued for the RPA, and it would remain the responsibility of the operator to control the configuration of the RPAS (RPA, remote pilot station and data links). SARPs for the design standard of the remote pilot station would have to be developed for Annex 8 — *Airworthiness of Aircraft.*

6.6 The second option envisaged would require not only new SARPs to be developed for Annex 8, but also new certificates comparable to the existing Type Certificate and Certificate of Airworthiness for the remote pilot station(s). This option diverges significantly from the traditional approach in that the design configuration of the RPAS would be defined separately for the RPA and remote pilot station. This means that the airworthiness of the RPA and the comparable certification for the remote pilot station would be dealt with individually. An RPAS designer would have responsibility for verifying the RPA, and remote pilot station(s) could be configured into an "airworthy" system. It is not clear yet what the exact RPAS design process approval (similar to what is currently called Type Certificate) and RPAS production process approval (currently called Certificate of Airworthiness) would be, but they would require a fundamental change to the approach to certification provided in Annex 8.

6.7 The aircraft must, of course, have a Certificate of Airworthiness. In the first option the remote pilot station associated with the aircraft will be linked to the RPA Certificate of Airworthiness, either through the Certificate of Airworthiness directly or through configuration control mechanisms per flight (e.g. RPA logbook). In this option, only the RPA will be registered. In the second option, the remote pilot station will have a separate certificate, similar to the RPA Certificate of Airworthiness, and there must be an operator-controlled system document with which the RPAS (i.e. RPA and remote pilot station) configuration is controlled. In this option, requirements for registration of the RPAS elements will have to be explored.

6.8 In both options, a method will need to be developed to certify the adequacy of the connection between the remote pilot station(s) and the RPA. Traditionally, the equipment only is certified; the data link(s) are not. In this new scenario, the data link replaces the traditional cables connecting flight controls to control surfaces. As such, the appropriate State authority will need to consider the data link performance as part of the RPA/RPAS certification process.

6.9 Due to the unique characteristics involved in UAS operations, a new UAS operator certificate (UOC), similar in nature and intent to the existing air operator certificate, is envisaged. This UOC would authorize the operator to conduct UAS operations in accordance with the operations specifications. Issuance of the UOC would be dependent upon the operator demonstrating an adequate organization, method of control and supervision of flight operations, and training programme as well as ground handling and maintenance arrangements consistent with the nature and extent of the operations specified. The operator would have to demonstrate arrangements for use of approved remote pilot stations and voice and data links that will meet the quality of service (QOS) appropriate for the airspace and the operation to be conducted. Furthermore, the operator's SMS will have to be approved by the State authority.

AIRWORTHINESS

6.10 All aircraft, whether manned or unmanned, share a large degree of commonality with regard to airworthiness. A majority of UAS assessments will likely rely on what is already prescribed for manned aviation. Interestingly, the small number of areas unique to UAS that are not addressed in current ICAO documents are more critical because of the potential magnitude of their impact. Review of these areas will likely result in dramatic changes to technology growth, international infrastructures, regulations and standards, and operational procedures.

6.11 Many existing SARPs are applicable to UAS; others may require interpretive or innovative solutions. Relief from regulations may be possible given the policy that should a condition not exist, then the requirement(s) do(es) not apply. As an example, the absence of the flight crew and passengers from the on-board environment will provide relief from seat belt requirements, life vests and life rafts. Conversely, while the pilot windshield becomes irrelevant, the necessity for an undistorted field of vision may still have to be addressed in some way.

6.12 Article 31 of the Chicago Convention requires that every civil aircraft engaged in international aviation be issued a Certificate of Airworthiness by the State of Registry.

6.13 Article 33 states Certificates of Airworthiness must be based on compliance with at least the minimum international (airworthiness) Standards established by Annex 8. Where there is a failure to comply with international airworthiness requirements, the Certificate of Airworthiness must be properly annotated on those areas of failure.

6.14 Annex 8 requires the following:

a) that the State of Design provide evidence of an approved type design by issuing a Type Certificate;

b) that an aircraft be produced in a controlled manner that ensures conformity to its approved type design;

c) that a Certificate of Airworthiness be issued by the State of Registry based on satisfactory evidence;

d) that the aircraft comply with the design aspects of the appropriate airworthiness requirements; and

e) that the State of Design, State of Registry and the type certificate holder collaborate in maintaining the continuing airworthiness of the aircraft.

6.15 The following is a general (non-inclusive) summary of the different design aspects contained in Annex 8 for manned aeroplanes and helicopters, engines and propellers:

a) unsafe features or characteristics;

b) flight characteristics;

c) structural strength and other characteristics;

d) design and construction;

e) powerplant and installation;

f) rotor and power transmission (for helicopters);

g) instruments;

h) systems and equipment;

i) operating limitations and information;

j) systems software;

k) crashworthiness and cabin safety;

l) operating environment and Human Factors;

m) tests and inspections; and

n) security (for large aeroplanes only).

6.16 Airworthiness and certification are based on a well-established airworthiness design standard provided in Annex 8. However, performance standards currently in use for manned aviation may not apply or satisfactorily address UAS operations. The following UAS-related issues will have to be addressed:

a) SARPS are limited to aircraft over 750 kg intended for carriage of passengers or cargo or mail;

b) SARPS for remote pilot stations; and

c) provisions for C2 data links.

6.17 Current categorization of manned aircraft certification standards may not adequately support new UAS technology. A few areas to be addressed may include:

a) new types of airframes and powerplants;

b) non-traditional construction methods; and

c) technologies and methods for detect and avoid, operational communications, C2 data links (including infrastructure, protected spectrum and security), etc.

6.18 Contingency situations (emergencies) where the pilot is no longer able to manage the flight will require additional on-board systems, which in turn will require new performance-based SARPS and/or PANS. This includes loss of C2 data link, loss of ATC communications and flight termination, among others.

REMOTE PILOT STATION(S)

6.19 Remote pilot stations will require regulatory oversight as do other safety-critical elements of the aviation system. Details of how this will be achieved by the appropriate State authority are to be determined.

6.20 Traditional operational positions for manned aviation are confined to a single cockpit environment. The presence of the flight crew within the airframe plays an integral role in the overall certification of the aircraft and development of flight procedures. By removing the cockpit environment from the aircraft, interactions between the remote crew and their operational positions will pose new complexities, the extent of which is not yet identified. Flight procedures will have to be amended to accommodate this scenario.

6.21 Airworthiness and certification considerations require many airborne systems to be provided in a redundant configuration for manned aircraft. Achieving a similar level of redundancy for an RPAS involves the RPA, remote pilot station and the connecting C2 data links. For an RPAS, all systems and their constituent components[1] may necessitate the same degree of redundancy or greater than those in manned aircraft. This will be subject to further study. Likewise, many supporting systems will require a similar or greater level of redundancy, one example being flight recorders, which might be required for both the RPA and the remote pilot station.

6.22 As discussed in certification above, remote pilot stations involved in the operation of the RPA must be certified for such purpose in line with standards yet to be developed. This presents special opportunities and challenges in developing new work environments and determining implications on the Type Certification of the RPA. New designs and standards will need to be developed to support functions, such as assuring the dedication of the data link connecting the remote pilot station to the aircraft, and the ability to handover the data link between remote pilot stations,

1. In the case of RPAS, the link between the remote pilot and ATC may comprise a link between ATC and the RPA and a link between the RPA and the remote pilot station.

along with many more. Situations like these will involve technology and equipment not traditionally assessed in the current airworthiness process.

6.23 Regarding the subject of continuing airworthiness, the remote pilot station should be treated similarly to the RPA. Additionally, due to the operational nature of the RPAS on long-haul flights, the option of "In Flight Maintenance" should be studied. It can be foreseen that the remote pilot station intended for later stages of the flight could be taken out of service after the RPA has initiated its flight, a situation which would not necessarily prevent the RPA from continuing. If the remote pilot station can be returned to service or an alternate one used, the flight may be unaffected.

NATIONALITY AND REGISTRATION MARKS

6.24 Annex 7 — *Aircraft Nationality and Registration Marks*, specifies the minimum Standards for the display of aircraft marks to indicate appropriate nationality and registration. It is important for UA to comply with aircraft marks so the UA can be identified in cases where they come in close proximity to other aircraft, are intercepted, or land at aerodromes other than the designated landing site.

6.25 Some UA may have difficulty meeting the readily identified mark requirement as well as the height requirements for both lighter-than-air and heavier-than-air aircraft as the airframe may be too small. Exemptions for marks or alternative systems, such as labelling already used for aircraft parts that adequately allow identification may be required for small UA. Requirements for changes to Annex 7 SARPs as regards to their applicability to UA will be considered in due time.

RADIO NAVIGATION AIDS AND AIRBORNE NAVIGATION EQUIPMENT

6.26 As a general statement, all aircraft, whether manned or unmanned, must meet the navigation performance requirements for the specific airspace in which they will operate.

6.27 RPA that utilize VLOS as the basis for navigation would not require an on-board means for determining position or the ability to fly an instrument approach. Operations of these aircraft are usually conducted under VMC to ensure the remote pilot can maintain continuous and direct visual observation of the RPA and its surrounding environment.

6.28 RPA that traverse several airspace volumes may operate for the most part under IFR. Such RPA will have to meet the communications, navigation, and surveillance requirements and have an appropriate aircraft operational certification associated with the airspace.

6.29 In cases where small RPA have a requirement to fly beyond VLOS, they will need a means to meet navigation capabilities for the airspace within which they are operating. This could involve an alternate means of achieving the navigation performance.

SURVEILLANCE SYSTEMS

6.30 Unless exempted by the appropriate authorities, all UA will likely be required to be equipped with pressure-altitude reporting transponders which operate in accordance with the relevant provisions in Annex 10, Volume IV — *Surveillance and Collision Avoidance Systems*.

6.31 Additionally, other means of surveillance (automatic dependent surveillance — broadcast (ADS-B) or other derived positional information) may enable UA to meet the ATS surveillance requirements to the same level as mandated for manned aircraft.

6.32 Smaller, lighter transponders are being developed which may allow small UA to be appropriately equipped.

AERONAUTICAL COMMUNICATIONS

6.33 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.

6.34 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. The determination of required communication performance and associated QOS levels will be based on functionality considering the level of ATS being provided.

6.35 The handover of piloting functionality will require the development of technical protocols to support this. These protocols must also support the operational procedures for the handover of piloting responsibility.

6.36 The time taken for a controller or pilot to transmit a message and receive an answer varies considerably depending on the communications medium used. In oceanic airspace it may be acceptable to transmit a request and receive a reply within a matter of minutes (e.g. HF or SATCOM) whereas operations in terminal areas and congested en-route airspace require instantaneous radiotelephony response times (e.g. VHF). The RPA has increased time built-in to any communication transaction as a function of the message being retransmitted from the aircraft to the remote pilot (or vice versa) and back along the same route to ATC. This transaction time could cause increased blocked transmissions and unacceptable delays in receiving and reacting to ATC clearances and instructions.

6.37 ATM requirements associated with acceptability (or otherwise) of such transaction times are expected to be the subject of specific communication performance requirements which will be vested in the RPA airworthiness certification and operational approvals.

6.38 To operate in controlled airspace, the remote pilot must have not only a C2 data link with the aircraft, but also a voice and/or data link (as appropriate for the airspace/operation) between the remote pilot station and the relevant ATS unit. Studies have demonstrated that different technical solutions may exist, taking into consideration the envisaged operation, altitude and range of the RPA. In most cases, the ATS communications are relayed through the aircraft, making use of a voice/data link between the RPA and the remote pilot station. In other cases, the connection with ATC can be established via a ground wired interface between the ATS unit and the remote pilot station, relayed through ground-based radio stations or via satellite. The options are spelled out below:

a) In order for the RPA/remote pilot station to comply with the current infrastructure and communicate with service providers via air-to-ground, several issues will need to be addressed regarding additional equipage, transaction times, contingency capabilities, security, procedures, etc. Standards may need to be developed for the new equipment and the spectrum they will operate within. Some of this work has now been initiated within the International Telecommunication Union (ITU) with a request for the accommodation of aeronautical safety type (AM(R)S, AMS(R)S, ARNS) spectrum to support this function. A methodology has been adopted which focuses on analysing and defining the problem and presenting a recommendation at the WRC-2012. The adopted approach was selected as the one which has the least impact on the service providers as communication will be mostly transparent to manned aviation.

b) In the second approach, remote crews have the unique opportunity to take advantage of ground-to-ground infrastructures to communicate with the ATS provider. This approach presents a complex issue for both the users and the service providers in that current ground-based systems do not support this type of communication for routine services. If this approach is utilized, Standards would need to be developed for the equipment that will manage the communication pathway between the remote crew and the air traffic controller. Likewise, new procedures will need to be developed alongside the introduction of any new equipment. The telecommunications service providers would have to develop new systems and communication infrastructures. UAS operators would need to furnish remote pilot stations with appropriate equipment to link with this new infrastructure, as would the ATS providers.

6.39 Due to the nature of aeronautical VHF communications, the VHF frequency is shared by all aircraft within range. The common audio supports a limited but beneficial level of situational awareness for flight crews and remote crews. This is a feature of the first approach.

6.40 Rather than mandating a specific technical solution using a specific communication architecture, the efficacy of the design chosen must be demonstrated by the applicant when requesting an airworthiness certification. Furthermore, approval to operate in any given airspace would have to consider whether the communication architecture meets the needs of the ATS provider.

6.41 Either of the two approaches given above will, in all likelihood, be affected by the medium-term planning of the NextGen (United States) and SESAR (European Union) modernization efforts, which rely heavily on an integrated network for digital communications. It is possible that this combined effort may provide efficient solutions for both air-to-ground and ground-to-ground communications between the remote crews and ATS providers.

6.42 Small UA may have difficulty carrying a VHF radio to support ATS communication and to meet the requirements for emergency services and communications at outlying locations. In some cases, these communications can be achieved with the remote pilot utilizing a portable radio for communications, if agreement is reached with the designated authorities to permit this solution. These radios would still likely have to meet Annex 10 spectrum and frequency requirements, despite not being carried on the aircraft.

6.43 It may be difficult or even impossible for small RPA to continuously monitor the aeronautical emergency frequency 121.5 MHZ when operating in areas where this requirement exists, the implications of which are currently being assessed.

AERONAUTICAL RADIO FREQUENCY SPECTRUM

6.44 It is essential that any ATC communication relay between the RPA and the remote pilot meet the performance requirement applicable for that airspace and/or operation, as determined by the appropriate authority. As with manned aviation and to reduce the potential of external interference, this will necessitate the use of designated frequency bands, i.e. those reserved for aeronautical safety and regularity of flight under AM(R)S, AMS(R)S, ARNS and ARNSS allocations as defined in the ITU Radio Regulations. These regulations dispose that these bands require special measures to ensure their freedom from harmful interference. As such they are not available for non safety-related activities, with few exceptions.

6.45 Furthermore, it is essential that any communication between the remote pilot station and RPA for C2 meet the performance requirement applicable for that airspace and/or operation, as determined by the appropriate authority. This too necessitates use of the designated frequency bands reserved for aeronautical safety and regularity of flight.

6.46 Long-range high altitude long endurance RPA can cover great distances and cross national boundaries during their missions. These aircraft will need VHF voice/data radios meeting spectrum requirements to talk or transmit data with ATS. They will also need very long-range communications, such as SATCOM, between the aircraft and remote pilot who may be thousands of kilometres away. SATCOM may be an appropriate solution for these operations, although there may be a need for a redundant means of communications to be in place, in particular for those circumstances where SATCOM shadows exist, precluding effective real-time communication capability. There may be an additional requirement for frequencies and spectrum for these long-range communications.

AERONAUTICAL CHARTS

6.47 Additional symbology pertinent for UAS operations may be needed. Remote pilots may have greater dependency on aeronautical information conveyed on charts to maintain their situational awareness of the airspace in which they are operating or on the aerodrome surface movement areas. As experience is gained in this arena, the full subject of aeronautical information as it pertains to UAS operations will be considered.

ENVIRONMENTAL PROTECTION

6.48 Annex 16 — *Environmental Protection*, Volume I — *Aircraft*, defines the requirements for aircraft noise as applicable to aircraft which are issued with a Certificate of Airworthiness and are engaged in international operations.

6.49 The UA may or may not be operated out of traditional airports where compliance with noise standards would be required. Operations may occur in ad hoc or semi-prepared locations that are away from populated areas, giving argument to whether noise requirements would apply.

6.50 Noise requirements for current aircraft categories will apply to UA assuming similar airframes and propulsion systems are used.

6.51 Engine emission standards as specified in Annex 16, Volume II — *Aircraft Engine Emissions* apply to UA assuming similar products are used. As new products and aircraft come into use, it may become apparent that additional noise and emission standards are necessary.

Chapter 7

PERSONNEL

PERSONNEL LICENSING

7.1 Annex 1 — *Personnel Licensing*, establishes the minimum training, operation and licensing standards to be met by aviation personnel involved in international air navigation.

7.2 The issuance of licences in accordance with Article 32 of the Chicago Convention provides the State of Registry a measure of control over whom may be involved, and under what conditions, as flight crew or in the maintenance of manned aircraft operating internationally. The introduction of RPA operations brings new dimensions to licenses for remote pilots and other members of the remote crew in that they are outside the scope of Article 32. First among these is a question as to whether the remote pilot is affiliated primarily with the RPA or the remote pilot station. If the decision is made that the primary relationship is between the remote pilot and the remote pilot station, the conclusion may be reached that the State of the remote pilot station rather than the State of Registry of the RPA, if different, would grant the licence. The implications of this new dimension will have to be assessed in detail before a decision can be reached. In either case, the RPA and the remote pilot station would be considered as a unit by the designated licensing authority.

7.3 Licensing authorities and medical examiners will have to consider the location and configuration of the remote pilot station (e.g. in a building, vehicle-based, ship-based, airborne, handheld, large suite) when issuing remote pilot licenses. The type of RPA (e.g. aeroplane, helicopter, powered-lift) a remote pilot is authorized to pilot and any related privileges the license holder may exercise will have to be stipulated.

7.4 Unusual Human Factors, including sensory deprivation or motions inconsistent with the aircraft being piloted, may place unique physical or mental demands on the remote pilot. Some remote pilots may only be required and trained for take-off/launch and landing/recovery. Other remote pilots may only need to be trained for en-route flight responsibilities excluding take-offs and landings.

7.5 With reference to the present definition of "aircraft certificated for single-pilot operation", a similar definition for "aircraft certificated for remote pilot operation" may be considered for RPA operations.

7.6 The RPA operating internationally is distinct and different from the operation of manned aircraft in a number of significant ways. For example, the remote pilot licence will be issued to an individual who will not be with the aircraft as it arrives in a foreign State. Authorities in the destination State will not have direct personal contact with the remote pilot or members of the remote crew.

7.7 A major change to current provisions in Annex 1, which envisions aircraft with the pilots on board, is the addition of a remote pilot station and its links with the aircraft. The principal factors which must be considered are remote pilot skill, knowledge, training and medical fitness to ensure they are commensurate with the particular license or rating being sought by the pilot candidate.

LICENSING AND TRAINING FOR PILOTS AND OTHER MEMBERS OF THE REMOTE CREW

7.8 Remote pilots and other members of the remote crew shall be trained and licensed in accordance with Annex 1.

7.9 Licensing and training requirements will be developed similar to those for manned aviation and will include both the aeronautical knowledge and operational components. Specific adjustments may be needed considering the particular and unique nature and characteristics of the remote pilot station environment and RPA applications (from both a technical and flight operations perspective, e.g. VLOS or beyond VLOS) as well as aircraft type (e.g. aeroplane, helicopter). In that context, qualifications for certain categories of remote crew (e.g. VLOS helicopter) may be significantly different from those pertaining to the traditional qualifications pertaining to manned aviation.

7.10 On the basis of the foregoing, current and previous notional designations for personnel piloting RPA will need to be replaced with applicable terms as contained in Annex 1, appropriately modified to indicate their position being external to the aircraft, such as “remote pilot”, “remote navigator” and/or “remote engineer”, each of which is a member of the remote crew. A new crew position unique to some VLOS operations is “RPA observer”, an individual who, by visual observation of the RPA, assists the remote pilot in the safe conduct of the flight. Additional crew positions unique to remote pilot station/RPA operations may be identified over time. These new positions will need to be incorporated into Annex 1 for international standardization.

LICENSING AND TRAINING FOR AIR TRAFFIC CONTROLLERS

7.11 Licensing of air traffic controllers will not be affected by UAS. However, when UAS are introduced within an ATC environment, additional training requirements specific to different types of UAS characteristics could be required for ATC personnel including, inter alia, performance, behaviour, communication, operating limitations and emergency procedures.

Appendix

EXAMPLES OF STATE/REGIONAL UAS INITIATIVES

GENERAL

1. This Appendix provides examples of policy and current practices being used by various CAAs at the regional[1] or national level. These examples are relevant to this circular and may provide guidance to other CAAs when drafting their own regulations or guidance material.

LEGAL

2. A number of CAAs have adopted the policy that UAS must meet the equivalent levels of safety as manned aircraft. UAS operations must be as safe as manned aircraft insofar as they must not present a hazard to persons or property on the ground or in the air that is any greater than that attributable to the operation of manned aircraft of equivalent class or category. In general, UAS should be operated in accordance with the rules governing the flight of manned aircraft and meet equipment requirements applicable to the class of airspace within which they intend to operate. UAS must be able to comply with ATC instructions.

3. It is United States policy that introduction of UAS into the national airspace system (NAS) does not harm nor put undue burden on the existing system and users of the system, and the inability of UAS, with current technology, to comply with basic requirements such as the need to see and avoid other traffic means that UAS access to the NAS is necessarily very limited.

4. In the United States, the process for acquiring an Experimental Airworthiness Certificate for UAS operations is specified in FAA Order 8130.34 and in Interim Operational Approval Guidance Document 08-01.

5. A group of national authorities (JARUS) under the leadership of The Netherlands and in cooperation with EASA are developing harmonized operational and technical regulations for “light” (i.e. less than 150 kg) UAS. The group dealing with technical requirements is focusing on establishing certification specifications for various types of aircraft, starting with light unmanned rotorcrafts. A group is also working on licensing requirements.

6. For civil UA above 150 kg, a Type Certificate issued by EASA is normally required in the EU based on the applicable policy Doc E.Y013-01 (issued 25-08-2009). Furthermore, EASA plans to propose common EU rules for operations and flight crews of these UAS by 2014.

7. *EUROCAE WG-73* is recognized as the European UAS expert group to propose technical inputs to EASA for additional airworthiness criteria and/or special conditions that have not been detailed in the earlier rule-making proposals.

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1. For example, the European Aviation Safety Agency (EASA) in the European Union (EU).

8. *RTCA SC 203* is recognized as the United States UAS expert group to propose technical inputs to the FAA for additional airworthiness criteria and/or special conditions that have not been detailed in the earlier rule-making proposals.

9. The NATO UAV Flight in Non-Segregated Airspace Working Group (FINAS WG) recommends and documents NATO-wide guidelines to allow the cross-border operation of UAVs (sic) in non-segregated airspace. To date, the FINAS WG has provided NATO Standardization Agreements (STANAGs) on Recommended Guidance for the Training of Designated UAV Operators [pilots] and UAV System Airworthiness Requirements[2] (USAR). The latter is intended primarily for the airworthiness certification of fixed-wing military UAVs with a maximum take-off weight between 150-20 000 kg.

ENVIRONMENTAL CONSIDERATIONS

10. No reviews have been conducted for determination for the need for noise and emissions control with respect to UAS. However it is generally accepted that the existing noise and emissions standards for manned aircraft should be applied to UAS.

11. UA can be made lighter and smaller than the aircraft currently being used for many operations thus making them more fuel efficient, producing less carbon dioxide emissions and less noise.

12. Comparisons between a small single-engine, manned aeroplane and a small UA show that the UA will, on average, use a tenth of the fuel, produce a tenth as much CO_2, have noise levels 6 to 9 dB lower and operate five to ten times as long.

13. The link below shows a comparison between a Cessna Skylane and a UA with a 10 kg payload:

    http://www.barnardmicrosystems.com/L4E_environment.htm

RADIO NAVIGATION AIDS AND AIRBORNE NAVIGATION EQUIPMENT

14. The United States has established the policy that UAS operations must be transparent and seamless. This implies that UAS will meet navigation performance specifications for the type of operation and for the airspace in which it will be operated. Consequently, RTCA, in collaboration with EUROCAE, is developing minimum aviation system performance standards (MASPS) for UAS operations.

SURVEILLANCE AND COLLISION AVOIDANCE

15. In the United States, large UA that are allowed access to non-segregated airspace are required to have a transponder on board. These UA do not have ACAS systems, or if they are equipped, are prohibited from being used. Smaller UA are generally required to fly line-of-sight from the pilot. These UAS do not normally have transponders and usually have a separate visual observer to accomplish detect (see) and avoid and collision avoidance responsibilities.

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2. STANAG 4671

16. Russia has developed equipment and carried out test flights for surveillance and control of UAS (take-off weight of 350 kg, single engine turbojet, speed of 700 km/h, and ceiling of 9 km). Surveillance operations, based on ADS-B and C2 based on CPDLC were carried out using VHF data link Mode 4 transponders. Russia is considering the use of ADS-B and VDL Mode 4 as a means to manage UAS flights in civil airspace.

AIR TRAFFIC SERVICES

17. The United States prescribes the following guidance in determining procedures for loss of C2 data link: "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". ATC/pilot voice communication continues to be required for UAS in all airspace and operations, as appropriate, and in a manner transparent to the controller.

18. CAP 772, the United Kingdom UAS policy and guidance document, recognizes that specific ATS integration issues do exist and that operational procedures will need to be developed to facilitate the provision of ATS to UAS. Notwithstanding, unless special provision is made with the ATS unit handling the UAS activity, the provision of a service to a UAS must be seamless for both air traffic controller and pilot. In other words, the same communications methods, rules and procedures apply. Accordingly, UAS must be able to comply with instructions from the ATS provider applicable to the class of airspace within which they intend to operate, and within a timescale comparable to that of a manned aircraft.

AERODROMES

19. According to the United Kingdom CAA CAP 722, the aerodrome license holder is required to demonstrate how the safety of those aircraft requiring the use of a licensed aerodrome will be assured when UAS operations are permitted at that aerodrome. The aerodrome license holder should provide an operating manual or other documents pertaining to the operation of UAS at that aerodrome, to ensure that risks from all aspects of the intended UAS operation are assessed and mitigated. Finally, it is essential that those managing UAS operations be familiar with the relevant rules and procedures applicable at the aerodrome from which they operate.

20. Australian CASA Regulations (CASR Part 101) consolidate the rules governing all unmanned aeronautical activities into one body of legislation. Whilst the focus of the regulations is not entirely UAS-related, Subpart 101.F covers the operation of a large UAS and the operation of a small UAS for purposes other than sport or recreation. This is supported by advisory circulars which provide guidance to controllers and manufacturers of UAS in the operation and construction of UAS and the means whereby they may safely and legally operate UAS within Australian airspace.

AERONAUTICAL TELECOMMUNICATION PROCEDURES

21. Currently within the United States unmanned aircraft operating in controlled airspace on an IFR clearance are required to maintain communications with the appropriate ATC facility. Where UAS are not able to accommodate traditional air-to-ground communications with ATC, alternate methods are developed and required as part of the authorization.

22. Additionally, communication among the flight crew, including with those having visual observer responsibilities, is also mandated. This replicates the communication that occurs among the flight crew for manned operations.

23. Current navigation systems that rely on ground-based aids are not utilized because the weight of the on-board equipment cannot be accommodated by most unmanned aircraft designs. GNSS or direct pilot visual observances are predominantly used.

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