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ANSP Considerations for RPAS Operations

Foreword

Background

Until recently, Remotely Piloted Aircraft Systems (RPAS) have been used mainly in support of military and national security operations, largely in segregated airspace. However, RPAS operators are now seeking greater freedom of access to airspace and this will increasingly interact with the wider ATM system. RPAS come in a variety of shapes and sizes, and fulfill many diverse capabilities. They range in weight from a few grams to several tonnes and can operate at altitudes from near the surface to the edge of space. Some RPAS fly at slow speeds, while others are capable of very high speed and some can remain airborne for several days.

Accepting a large number of RPAS into the ATM system poses many challenges and, from an ANSP point of view, integration of RPAS in non-segregated airspace is of special interest. Their speed, manoeuvrability, climb rate, other performance characteristics, together with their avionic system equipage may differ substantially from conventional aircraft. Experience of RPAS operations and their interaction with the ATM system to date indicates that currently, while seamless integration is the eventual aim, they are unable to comply with many standard, routine ATM procedures. This has not prevented RPAS operations, but has limited their integration.

International regulations and standards require that any new system, procedure or operation that has an impact on the safety of ATM operations shall be subject to a risk assessment and mitigation process to support its safe introduction and operation. The goal of safely integrating RPAS seamlessly into the ATM system with other airspace users is subject to standard Safety Management System (SMS) principles. RPAS are classified as 'aircraft' and ultimately should comply with all the rules established for flying, certifying, and equipping aircraft. A key factor in safely integrating RPAS in non-segregated airspace is their ability to act and respond in an equivalent way to manned aircraft and there shall always be a pilot responsible for the RPAS operation.

Objectives

The objectives of this document are to:
— Raise awareness of RPAS operations with ANSPs
— Inform ANSPs how RPAS have been accommodated safely into Member State ATM systems to date, and
— Identify some of the issues that need to be addressed to safely achieve greater RPAS integration in the future

Scope

The audience for this document is ATM and ANSP policy makers, management and staff, including those specifically responsible for ATM procedures.

The focus of this document is on the IFR operation of in-service Medium Altitude Long Endurance (MALE) and High Altitude Long Endurance (HALE) remotely-piloted aircraft (RPA), operating in controlled airspace.

For the foreseeable future, only RPA will be able to be integrated into the international civil aviation system and therefore fully autonomous systems, without a 'human in the loop', are not considered.

Generic training material for Air Traffic Control Officers (ATCOs) is outside the scope of this document and will be produced separately.

It is recognised that technological solutions to address some of the challenges identified are under consideration or development, but this document does not address those activities.

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Abbreviations

Abbreviation	Definition
ASBU	Aviation System Block Upgrade
AIP	Aeronautical Information Publication
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Control Officer
ATS	Air Traffic Service
BLOS	Beyond Line of Sight (see VLOS)
C2	Command and Control
C3	Command, Control and Communications
CFIT	Controlled Flight Into Terrain
DAA	Detect and Avoid
DME	Distance Measuring Equipment
EASA	European Aviation Safety Agency
EET	Estimated En-route Time
ELOS	Equivalent Level of Safety (i.e. to manned aircraft)
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FCAS	Future Combat Air System
FDP	Flight Data Processing
FTP	Flight Termination Point
GCS	Ground Control Station
GPS	Global Positioning System
HALE	High Altitude – Long Endurance
HEMS	Helicopter Emergency Medical Service
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
MALE	Medium Altitude – Long Endurance
NVFR	Night Visual Flight Rules
OAT	Operational Air Traffic
PANS	Procedures for Air Navigation Services
PIC	Pilot In Command
R&D	Research and Development
RNAV	Area Navigation
RPA	Remotely Piloted Aircraft
RPAS	Remotely Piloted Aircraft System
RPS	Remote Pilot Station
RVSM	Reduced Vertical Separation Minima
SARPs	Standards And Recommended Practices
SES	Single European Sky
SESAR	Single European Sky ATM Research
SMS	Safety Management System
SSR	Secondary Surveillance Radar
TCAS	Traffic Collision Avoidance System
UAS	Unmanned Aircraft Systems
UASSG	[ICAO] UAS Study Group
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Air Vehicle
VLOS	Visual Line of sight (see BLOS)
VOR	VHF (Very High Frequency) Omni-directional Radio-range
VTOL	Vertical Take-Off / Landing

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Explanation of Terms

The following terms are taken from ICAO Circular 328, Unmanned Aircraft Systems (UAS) and are used in the context of this document. Except where indicated, they have no official status within ICAO and, where a formally recognised ICAO definition is included, it is noted with *.

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.

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.

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, organisation or enterprise engaged in or offering to engage in an aircraft operation.

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 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.

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

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.

3
Introduction

3.1 Generic RPAS Attributes and Examples of Applications

3.1.1   RPAS Components and Unique Characteristics

An RPA is an aircraft piloted by a licensed 'Remote Pilot' situated at a 'Remote Pilot Station' (RPS) 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 Air Traffic Control (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.

3.1.2   RPAS Configuration

An RPAS comprises a set of configurable elements including an RPA, its associated RPS(s), the required C2 links and any other system elements as may be required, at any point during flight operation.

The pilot controls the RPA from a RPS, linked by radio, which can either be in direct Radio (Frequency) Line of Sight (RLOS/FLOS), or Beyond (Frequency) Line of Sight (BLOS) using satellite or other relays. These links are used both for the C2 of the RPA and for communications with ATC and are potentially vulnerable to disruption. As radio communication is the critical mechanism for interaction between the RPA and pilot, their seamless operation in non-segregated airspace requires high availability of those communication links.

The diagrams on the next page show, in simplified terms, how RPAS C2 and ATC communications operate. As the remote pilot is not on board the RPA, considerations that need to be taken in the development of a supporting safety case for the operation include any latency between an instruction given by ATC, the remote pilot complying with that instruction and the RPA acting upon the instruction.

3.1.3   Examples of RPAS Applications
— Military:
   Intelligence, Surveillance, Reconnaissance (ISR); weapons platform; natural disaster support
— State (non-military):
   Border surveillance; police and security support; fire/rescue support; fisheries patrol; meteorological research and hurricane/typhoon monitoring; natural disaster support: land/forestry management; oceanic research; volcano monitoring; climate monitoring; Arctic/Antarctic monitoring
— Civil and support services:
   Advertising; aerial photography; agricultural monitoring; insecticide and fertiliser application; forest fire operations; cinema/media applications; magnetic surveys; wildlife census; critical infrastructure inspection; terrain mapping; oil and gas pipeline monitoring
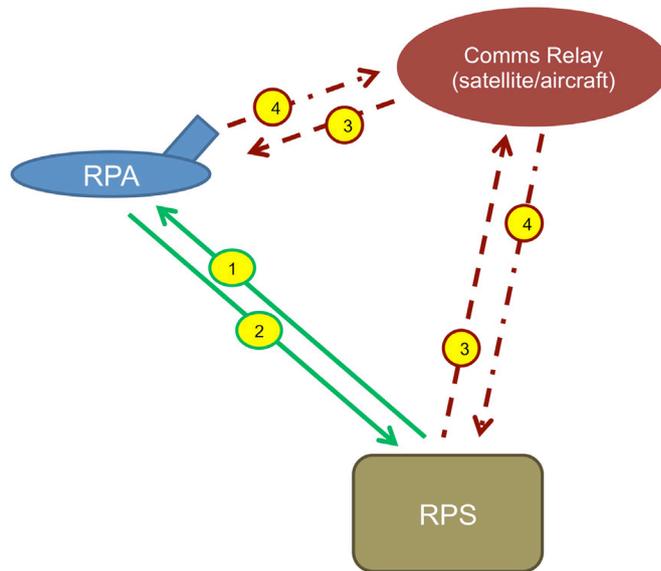
C2 radio communications in a RPAS
1. Uplink representing Line of Sight 'Command' in the C2 function
2. Downlink representing Line of Sight 'Control' in the C2 function
3. Relay of C2 communications from the RPS to the RPA
4. Relay of C2 communications from the RPA to the RPS
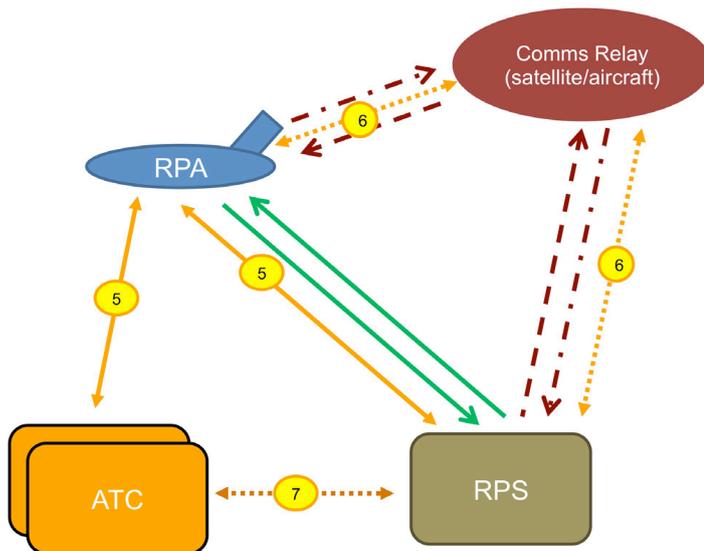
RPA radio communications related to ATC
5. ATC communications relayed between ATC, the RPA and the RPS
6. ATC communications relayed between ATC, the RPA, a satellite and the RPS
7. alternative direct link between ATC and the RPS

4
Conducting Routine RPAS Operations

4.1   General RPAS Requirements from an ANSP Perspective

Air traffic management (ATM) integration of RPAS will be safely achieved when routine access by RPAS operations into non-segregated airspace, is transparent to ATS providers. Therefore, the remote pilot will be required to respond to ATS guidance or requests for information, and comply with any ATC instruction (eg fly headings, altitudes, Navaids and Waypoints and comply with standard IFR approach and departure procedures), in the same way and within the same timeframe as the pilot of a manned aircraft.

Whilst specific procedures for RPAS should be kept to a minimum, experience shows that due to RPAS' unique attributes, such as the communications link and lack of an approved Detect and Avoid (DAA) system, at least some new or contingency procedures are required.

Visual Line of Sight (VLOS) RPAS operations need to be taken into account by ATM managers to assess and limit their impact upon the wider ATM system. For example, there may be restrictions on height/altitude of their operation, or their proximity to airports and aerodromes and ongoing manned aircraft operations. In most cases to date, Beyond Visual Line of Sight (BVLOS) operations have only been permitted in segregated airspace, although in some States authorisations are granted routinely e.g. Switzerland for military RPAS, or on a case by case basis e.g. USA. Furthermore, some BVLOS operations have been approved in non-segregated airspace, such as within the Arctic Circle, where the proponent has demonstrated, through a safety risk management process, that the probability of an incident is extremely improbable.

4.2   Separation

Currently, RPAS cannot operate VFR in the same way as manned aircraft, because an approved detect and avoid system is not available and, from an ATCO's perspective, they cannot comply with Visual Flight Rules (VFR) or visual separation requirements. However, RPAS can operate Instrument Flight Rules (IFR) in a similar way to manned aircraft and, from an ATC perspective can achieve IFR separation, unless otherwise specified there should be no difference between manned and unmanned aircraft in this regard.

4.3   Aerodrome and Terminal RPAS Operations

As described above, although it is an ultimate aim, RPAS currently operating are unable to interact seamlessly with the ATM system, because they are not equipped with a DAA capability, or with standard avionic equipment, or do not fit into a 'standard' aircraft category. This has not prevented RPAS operations, but has limited their integration. The list below, derived from research considered by the FAA, illustrates some of the challenges facing the integration of existing RPAS into the ATM system. Meeting these challenges could be translated into future RPAS-ATM requirements.

Most RPAS currently operating are unable seamlessly to:
— Conduct a visual approach, comply with visual sequencing in a visual traffic pattern, be instructed to "maintain visual separation" from another aircraft, including for dependent parallel runway operations, or conduct SVFR
— Fly a standard instrument approach or enter and hold in a standard holding pattern
— While taxiing:
    — Hold short of the ILS critical area
    — Follow an instruction to, for example, "Pass behind Cessna 172, then taxi across runway 28L"
    — Recognise and comply with aerodrome signs, markings and lighting

Note: For some RPAS, e.g. those equipped with surveillance equipment, compliance with ground taxi instructions is under development.
— Always make a controlled landing when beyond frequency line of sight
— Always perform standard, or half standard rate turns or arc about a NAVAID
— Operate within a complex traffic environment, requiring compliance with multiple ATC instructions
— Recognise visual signals (e.g. interception)
— Identify and avoid terrain
— Identify and avoid severe weather
Because RPAS are not yet categorised, they cannot:
— Conform to standard nomenclature for aircraft type identification
— Cannot be assigned to an aircraft approach category
— Apply wake turbulence criteria spacing on final approach or on departure
— Be used in same runway separation criteria
— Land and Hold Short Operations (LAHSO)

4.4 Special Handling

The factors listed above mean that, currently, RPAS operations must be subject to varying degrees of special handling by ANSPs to be able to operate safely outside segregated airspace. Below is a list of occasions where such special handling is currently required.

4.4.1 ATC phraseology

Ideally, RPAS would require no special handling from ATC and therefore would not require any additional ATC phraseology. However, the RPAS programme has not matured enough to be considered as normal ATC operations, especially for contingency operations because of the unique nature of individual RPAS. There is currently no approved, standard RPAS-related ATC phraseology and this will have to be developed and agreed prior to operations.

4.4.2 C2 Datalink

If the C2 datalink is operating via a satellite, there may be latency in the response to ATCO instructions. If the RPAS C2 datalink is operated by Radio Line of Sight, then the RPA may have minimum flight altitudes below which it cannot operate safely, as illustrated in Figure 1 below.

Figure 1 - Radio Line of Sight
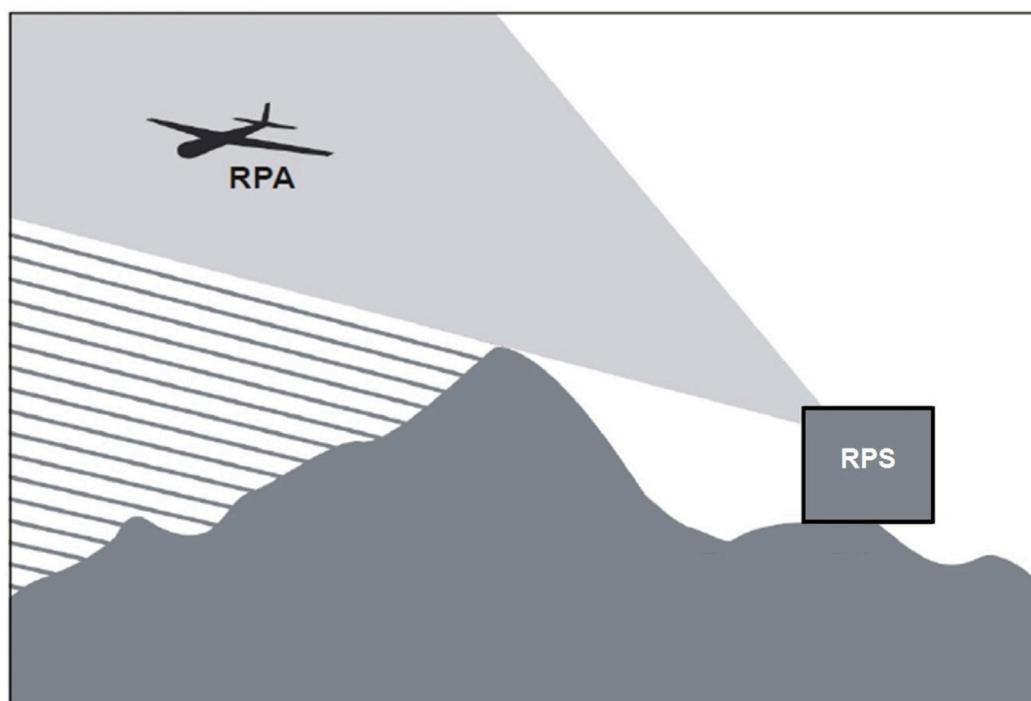
4.4.3 In-Flight Characteristics

The RPAS may also have different in-flight characteristics to manned aircraft, such as a slower than expected airspeed, a slow rate of climb or a preference to spiral climb rather than an en-route climb.

The flight profile of an RPAS may also be different to manned aircraft, which normally route from A to B via C, whereas the RPAS may take off and land at the same airport having conducted its mission, that is, from A to A, having orbited at C. Therefore, it will be important for ATC to establish whether the RPAS will be transiting through a sector, or remaining within a sector 'on task' either flying a race track or orbit.

4.4.4 Flight Data Processing (FDP) systems

FDP systems may have difficulty processing RPAS flight plans, due to elements such as the flight profile, duration of the flight, inability to specify 'zero' persons on board and alerting requirements. For example, the RPA may wish to complete a spiral climb from the aerodrome of departure or may remain airborne for more than 24 hours, both scenarios that would be difficult to define in a standard flight plan.

The accommodation of an RPAS by an FDP system may require 'work arounds' such as the submission of multiple flight plans or the issue of revised SSR/beacon codes. RPAS flight plans may need to be updated more frequently than others during their flight, due to long mission duration and operational mission needs, or changes requested by the PIC. Such flight plans may require more inputs as it may involve entering many route elements as latitude/longitude points as opposed to navigational aids, fixes and routes. Furthermore, there may be no national set of RPAS performance characteristics and such data would therefore not be available to the FDP system. The impact of RPAS operations on the FDP system may include software upgrades or adaptation, production of associated manuals, briefings and staff training, which will all have budgetary implications

and require ample lead times. This is an area that will require further development.

4.4.5 Alerting Services

Alerting Services are provided for all aircraft provided with air traffic control service, or that have filed a flight plan, or are believed to be the subject of unlawful interference. Current ICAO regulations do not differentiate between manned and unmanned aircraft; however some States are reviewing and considering adapting the application of alerting services for RPAS.

4.4.6 Utilisation of existing IFR Procedures

Most current RPAS are not fitted with standard, certificated avionics. This means that they cannot utilise existing civil published IFR approach procedures, e.g. ILS, VOR, DME or RNAV, or conduct a standard departure or fly en route procedures, including RVSM.

Nevertheless, most (if not all) RPAS are GPS-equipped and some may be able to conduct non-standard approaches or comply with an ATC instruction by flying via pre-arranged way points, or emulate existing procedures.

4.4.7 Detect and Avoid, Collision Avoidance

In manned aviation it is the pilot-in-command's responsibility to detect and avoid potential collisions and other hazards. The same requirement exists for RPAS. However, as there are currently no certified DAA systems available, alternative means for RPAS to comply with existing regulations 'see-and-avoid' in a manned aircraft may include:
— Primary or secondary radar surveillance from the ground, often referred to as Ground Based Sense and Avoid (GBSAA)
— Forward or side looking sensors which may be in a variety of spectra including electro-optic and infra-red
— Chase aircraft
— A combination of the above

4.5 Contingency and Emergency Operation Procedures

RPAS emergency procedures should mirror those for manned aircraft as far as practicable. However, because of their unique attributes (mainly, although not exclusively, because the pilot is not on-board), in some cases new procedures will have to be developed by ANSPs to accommodate RPAS. Importantly, ICAO recognises that ANSPs will need to review contingency and emergency procedures to take account of unique RPAS failure modes such as lost C2 link, stating:

"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

"ANSPs will need to review emergency and contingency procedures to take account of unique RPA failure modes such as C2 link failure, parachute emergency descents, flight termination, etc."

RPAS should have system redundancies and independent functionality to ensure the overall safety and predictability of the system. The operator must develop detailed plans for all operations to mitigate the risk of collision with other aircraft and the risk posed to persons and property on the ground in the event the RPA experiences a lost link, needs to divert, or the flight needs to be terminated. These plans must take into consideration all airspace constructs and minimise risk to other aircraft by avoiding published airways, navigational aids, and congested areas. In some States, in the event of a contingency divert or flight termination, the use of a chase aircraft is preferred if the RPA is operated outside segregated airspace. Contingency plans must address emergency recovery or flight termination of the RPA in the event of unrecoverable system failure. These plans should include the latitude/longitude of lost link points, divert/contingency points and

Flight Termination Points (FTP) for each operation, together with graphical representations plotted on aviation charts. If the RPA requires a precautionary landing, consideration should be taken for the system requirements (e.g. navigation and/or communication) at the divert location.

To put in place procedures to accommodate RPAS and meet an equivalent level of safety to manned aircraft operations will require a significant investment of time and resources by ANSPs and RPAS operators; the scale of this task should not be underestimated.

4.5.1 Loss of Radio Communication

A loss of ATC-RPAS radio communications is different to a lost link, which is described separately below. Procedures following a loss of radio communications for RPAS should be the same as for manned aircraft, as laid down in ICAO Procedures for Air Navigation Services Rules of the Air and Air Traffic Services (DOC 4444). RPAS may also have the advantage that, unlike the pilot of a manned aircraft, the remote pilot may have access to a backup communication link on the ground (e.g. a dial-up voice telephone service) that will allow him to contact the ATC unit directly. It will be important that ANSPs and RPAS operators develop procedures to take account of this additional means of communication e.g. would the remote pilot speak to the ATC Supervisor or direct to the controller?

4.5.2 Loss of C2 Link

The C2 link from the remote pilot in the RPS to the RPA can be considered equivalent to the linkage between pilot and the control surfaces in a manned aircraft. If the C2 link is lost, the remote pilot will be unable to maintain operational control of the RPA. There are many possible causes of a loss of C2 link between the RPS and RPA that include:
— Screening by terrain
— Weather interference
— Man-made interference, either unintentional (e.g. television broadcast) or

malicious (e.g. jamming)
— Out of range
— Equipment failures on the RPA, in the RPS or the network (e.g. satellite)
— Human error in the RPS (frequency setting, switches)

The ICAO (Circular 328) definition of lost link is:

"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."

In the event of a lost C2 link, the RPA should follow procedures and manoeuvres that have been pre-programmed prior to departure and coordinated with appropriate ATC facilities, to minimise their impact on ATC and other airspace users to the greatest extent possible. In the US, when considering contingency procedures, the Federal Aviation Administration (FAA) prescribes the following guidance for lost 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 a lost link."

The key motivator is to standardise ATM procedures for an RPA experiencing a lost link and to ensure that they behave in a transparent and predictable manner, even if that is not identical to the behaviour of a manned aircraft. Currently, there is no standardised lost link procedure and each manufacturer and operator agency may employ inconsistent procedures.

Once initiated, the RPA shall follow the appropriate lost C2 link procedure for the remainder of the flight or, in the event that the C2 link is restored, until such time as a revised flight plan can be negotiated and agreed.

4.5.3   Example of a Typical Lost Link Procedure

The generic lost link procedure that follows could be used as a basis for negotiation between ANSPs and RPAS operators, where agreement of the timescales between each stage of the process is of critical importance.

The following paragraphs relate, by number, to the diagram on the next page:

1. **Squawk 7400**
   When the RPA recognises that it has lost its C2 link with the remote pilot, after a predetermined time period, long enough to ensure the loss is not temporary, the RPA will automatically squawk its lost link code (e.g. 7400) to inform ATC of the RPA condition. This code selection will be displayed on ATC surveillance systems and will notify the lost link event to the Sector Controller.

2. **Remote Pilot Contacts ATC**
   The RPAS software should automatically alert the remote pilot to the event. The remote pilot will collect as much information as possible on the event and, via alternative (probably landline) communications, contact ATC to coordinate the lost control link manoeuvre and pass on any further relevant information. Whilst unlikely, it may even be the case that remote pilot to ATC communications may remain serviceable via the RPA in the event of a C2 lost link.

3. **RPA Maintains Assigned Altitude and Heading**
   Initially, the RPA should maintain its assigned altitude and heading, but the ATCO should now be aware that the RPA will soon execute its lost link manoeuvre and will be able to manage other aircraft under his control accordingly.

4. RPA Hold?

After another pre-arranged time period, which could be different depending on the RPA position or stage of flight, the RPA should initiate a lost link manoeuvre. Once again, whilst the ATCO will not be able to control the manoeuvre, he should know its headings, level and duration and thus be able to plan, sequence and separate other traffic under his control from the RPA. At this stage, it is anticipated that the RPAS crew and system will be attempting to re-acquire the C2 link.

5. RPA Manoeuvres to Destination

After a pre-determined period of time, which the remote pilot should be able to confirm to ATC via direct communication, the RPA will proceed to its destination to land which will be either (a) its designated alternate aerodrome or (b) return to base. In most cases to date, the RPA returns to base, that is its aerodrome of departure.

6. RPA Hold?

As the RPA manoeuvres to its destination, it could execute a number of turns or holds as part of its lost link procedure; these will all be known and predictable to the ATCO.

7. Flight Completion

The final stage of the procedure will either be for the RPA to land at its designated alternate or original base, or in rare cases, terminate the flight by controlled flight into terrain (CFIT) at a pre-determined point that is known to be unpopulated.

4.5.4 Flight Termination Procedures

RPAS should be equipped with system redundancies and independent functionality to ensure the overall safety and predictability of the system, including a Flight Termination System (FTS) that can be activated in rare cases by the remote pilot. Flight termination is the intentional and deliberate process of performing CFIT. This is a last resort when all contingencies have been exhausted and either further flight cannot be safely achieved, or potential hazards exist that requires the immediate end of the flight.
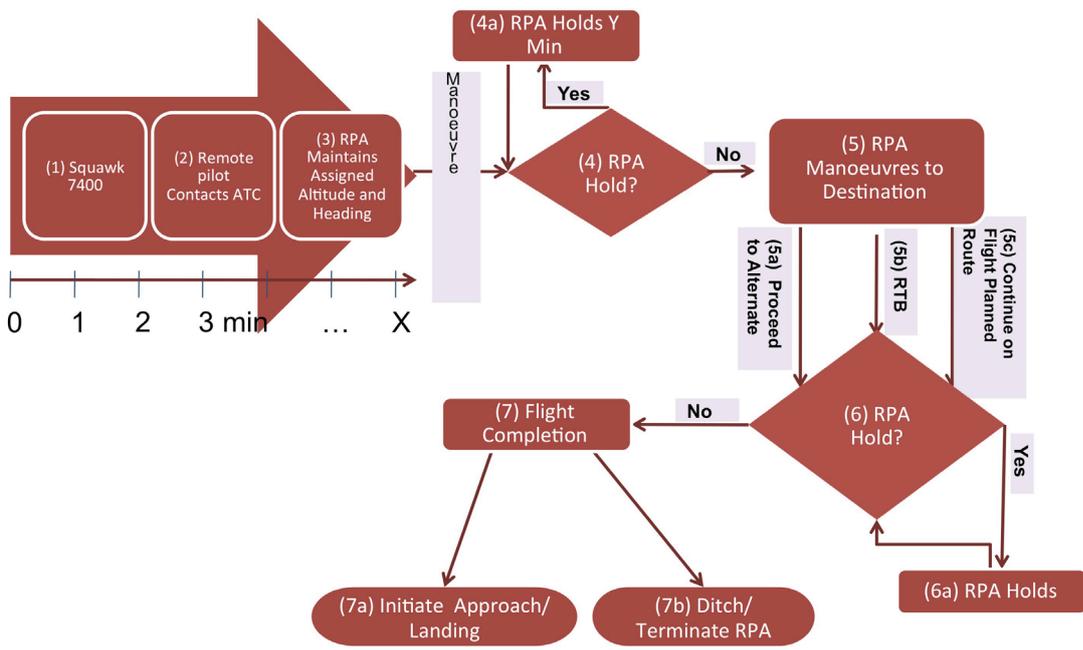
The operator must ensure sufficient measures are defined to accommodate flight termination at any given point along the route of flight. Flight termination points must be located in sparsely populated areas or over the sea away from any ground or maritime infrastructure. Where RPAS already operate routinely, flight termination points are planned in segregated airspace, on government-owned land, or offshore locations that are restricted from routine civil use and the operator retains full risk and all liability associated with the selection and use of all flight termination location.

5
Operations and Standards Guidance

5.1   Certification of RPAS (Air/ground), Airworthiness

There are currently no certification standards for RPAS that will require the provision of ATC services. It is imperative that ANSPs participate in the development of such standards to ensure that ATC requirements and concerns for airspace integration are incorporated. The ICAO UASSG is developing a UAS Manual for publication in 2014. Once released, it will provide more guidance and clarification to Member States, but will not define certification standards. It is expected that Standards and Recommended Practices (SARPs) will be developed once the Study Group is established as an ICAO Panel, which is expected to occur in 2014.

5.2   Personnel / Pilot Licensing and Training

For RPAS, pilot qualifications for flight in non-segregated airspace will be the same as those for manned aircraft. Currently, there are no specific pilot licences for civil RPAS operations. Many State authorities require RPAS pilots to be qualified in, and maintain currency in, manned aircraft that are equivalent to the RPA they fly (e.g. a single or multi-engine rating). Although the RPS will probably be different for each RPAS, the fundamental requirements for pilot licensing and training will remain the same.

6
Best Practice United States of America (USA): operation procedures RPAS Global Hawk

6.1   Background

6.1.1   The operation of Global Hawk (GH) in the National Air Space (NAS) in the USA is governed by a Certificate of Waiver or Authorisation (COA) issued to the Federal Government proponents presently operating GH airframes which include Department of the Air Force, Department of the Navy, and National Aeronautics and Space Administration (NASA) by the Federal Aviation Administration (FAA). This annex identifies the main ATM aspects of the arrangement.

6.1.2   In the USA, airspace is categorised as follows:

— Class A. Generally airspace from 18,000ft MSL up to and including FL600
— Class B. Generally airspace from the surface to 10,000ft MSL surrounding busy airports
— Class C. Generally airspace from the surface to 4,000ft above airport elevation surrounding airports that have an operational control tower and are serviced by radar approach control
— Class D. Generally airspace from the surface to 2,500ft above airport elevation surrounding airports that have an operational control tower
— Class E. Generally, if airspace is not Class A, Class B, Class C, or Class D, and it is controlled airspace, it is Class E airspace. Class E airspace extends upward from either the surface or a designated altitude to the overlying or adjacent controlled airspace. Unless designated at a lower altitude, Class E airspace begins at 14,500ft MSL
— Class G. Airspace not designated as Class A, B, C, D, or E

6.1.3   In the USA, Special Use Airspace (SUA) is airspace of defined dimensions wherein activities must be confined because of their nature, or wherein limitations may be imposed upon aircraft that are not a part of those activities. There are five types: Prohibited Area, Restricted Area, Warning Area, Military Operations Area, and Alert Area.

6.2   Relevant Airspace

6.2.1   The COA addresses the operation by GH in the NAS, outside of SUA and including oceanic controlled airspace under the jurisdiction of the FAA.

6.2.2   Though GH transits nearly all classes of airspace, normal GH mission profiles require that GH operates primarily SUA, Class A airspace and Class E airspace when above FL600.

6.3   De-confliction from Other Traffic

ATC facilities will provide separation services between GH and other IFR traffic in Class A airspace and Class E airspace (above FL600) on the basis of a filed IFR flight plan and related ATC clearances and instructions. The Department of Defense (DoD) responsible for GH operations is responsible for deconflicting GH from possible military traffic operating VFR in Class E airspace above FL600 through prior coordination.

6.4   Coordination Procedures

6.4.1   All routine flights into the NAS must be coordinated at least three working days in advance with the local FAA En-route Centre. The GH Mission Commander (MC) is responsible for coordination with all affected ATC facilities via the assigned FAA Service Center Operations Support Group (OSG) Specialist and FAA Headquarters assigned COA Processor to develop and/or ensure compliance with standard operating procedures. The MC is likewise responsible for coordinating with the relevant authority for the use of any special use airspace.

6.4.2   All routes will be coordinated with each affected ATC facility in advance. All flights will entail an IFR flight plan using standard navigational aids and five-letter identifiers and/or fix/radial/distances to identify the route of flight.

6.4.3   A list of telephone numbers for each ATC supervisory position responsible for airspace the GH is programmed to operate in will be prepared as part of the advance coordination action.

6.4.4   Contingency plans will be coordinated with ATC. Items should include possible landing sites enroute, phone numbers of GH pilot and ATC facilities, primary and backup frequencies to be used, and any other information deemed appropriate by the operator or ATC.

6.5   Contingencies

6.5.1   General

The GH flight management system is programmed, for each route segment, to automatically perform a specific contingency mission profile in the event of specified anomalies or system/subsystem failures. In addition to having been provided with planned contingency actions and routes within the pre-mission coordination documentation, during such an event, the affected ATC facility/facilities will be immediately notified of the contingency course of action that the GH will perform when a contingency route is executed.

6.5.2   Lost-Link Procedures

In the event of loss of the command and control data link between GH and the Launch and Recovery element or between the GH and the Mission Control Element, the GH will execute a pre-planned lost-link contingency mission plan and the GH transponder will automatically change to code 7600 (Code 7400 is still in development). As ATC voice relay may also be precluded whenever data links are lost, the affected ATC facility/facilities will be notified immediately via telephone of the contingency course of action the GH will

execute when voice relay is lost during a lost link occurrence.

6.5.3 Lost Voice Communication Procedures
If direct voice radio communications between the GH pilot and ATC are lost, the GH pilot will command GH's transponder to squawk code 7600. GH will then continue to operate along its programmed route. The GH pilot will also notify ATC by telephone that the GH has lost ATC voice capability.

6.5.4 Mission Abort Procedures
In the event of a malfunction that jeopardises the operational capability of a GH, the GH is programmed to automatically return to the departure airport or a pre-selected alternate landing site. The GH pilot will ensure that appropriate ATC facilities are notified of the emergency and return-to-base routing. If the emergency is flight critical and requires immediate recovery, the GH transponder will automatically change to code 7700.

6.6 Additional Special Provisions
6.6.1   The GH pilot will maintain 2-way radio communication with ATC in domestic airspace. In oceanic controlled airspace, the GH pilot will forward position reports to ATC via direct landline/telephone.

6.6.2   GH will operate external navigation and strobe anti-collision lights at all times. GH will operate with an operational transponder with Mode C altitude encoding set at the code assigned by ATC.

6.6.3   The proponent, and/or its representatives, is responsible at all times for collision avoidance with non-participating aircraft and the safety of persons or property on the surface during all phases of GH's flight. Special provisions for defining the ways and means to satisfy these responsibilities are written into the FAA issued

COA. If any phase of proposed flight operations is deemed to compromise these safety requirements, proper mitigations intended to reduce related risk to acceptable levels are developed, written into the COA, and provided for as part of the requirements to operate GH in the NAS.

6.6.4   The proponent will enter into a Letter of Agreement (LOA) with all affected ATC facilities for operations into and out of specific airports outside of SUA. The LOA will address operational and ATC requirements unique and specific to each location and/or airport.

7

Best Practice Switzerland: operation procedures ADS-95 RANGER

7.1 Background
The Swiss Air Force has operated RPAS in Switzerland in accordance with Operational Air Traffic (OAT) rules since 1988.

Currently, the Swiss Air Force is the only RPA operator flying in the Swiss ATM environment. The ADS95 RANGER RPAS was developed in Switzerland by the Swiss company RUAG Aerospace.

RANGER is used for military missions covering reconnaissance, real-time monitoring, target designation, fire control, and command/control. Additionally, the Swiss Air Force RPAS squadron supports civil operations including reconnaissance, border patrol, and search and rescue missions.

Today in Switzerland, OAT RPAS accompanied by a chase plane are normally operated without restriction. However in recent years, due to the increased need for airborne surveillance, and to release the RPAS from the limitations of operating in close formation with the chase plane, wider airspace access has been requested by both the Swiss Air Force and the Swiss Police (operating

in collaboration with the Air Force). To facilitate these applications outside restricted areas or segregated airspace, four different procedural implementations have been developed to support RANGER operations:

— NVFR-Flights in airspace class E and G (2005), which basically extends from GND up to FL100/130. During night time, most Swiss airports are closed and the total number of other NVFR traffic is very low, with all flights obliged to submit a flight plan and be in contact with ATC. RANGER will also publish a NOTAM, informing other pilots about the intended route and providing a contact telephone number.

— Unsegregated flights within MIL CTR/TMA (2007), based on separation towards any other traffic within this airspace volume.

— Quasi-segregated flights within the TMAs of international airports during night closure (2010). The major airports usually close down between 2330-0600 (LT) with occasional Helicopter Emergency Medical Service (HEMS) flights as the only remaining traffic. Mission times and locations are coordinated with the HEMS operators in advance and so RANGER can take advantage of this airspace, even though it is class C airspace.

— Since June 2013, RANGER is introduced into class C airspace within Switzerland on a 24/7 basis, for the time being restricted to IFR only.

The sequential approach and the experience gained over the past years enabled the last step; however, it must be noted that this introduction is strictly limited to the ADS-95 RANGER operated by the Swiss Air Force. Any other RPAS, actually even a different RANGER operator, would be subject to a new ops concept and safety assessment. Naturally, such an extension would be based on the existing procedures and require much less time than starting from the very beginning.[1]

7.2 Current Operations

The introduction into class C airspace is based on dedicated ATM procedures and several pivotal elements of the RANGER RPAS, such as:

— Limitation to IFR only
IFR in class C airspace ensures separation to any other traffic.

— Fixed Callsigns
Four discrete callsigns to facilitate recognition by ATCOs in case the RPA pilot fails to denote "unmanned" when establishing radio contact.

— Navigation
Apart from radar vectors, RANGER is able to navigate by reference to Navaids, Waypoints (5LNC) and geographical locations.

— Coordination
The RPAS operator must coordinate flights with the concerned ATC unit, including information about ETD, planned route to the mission area, EET and telephone number of the RPA pilot.

— Single Link Failure
Since RANGER is equipped with dual-links, no immediate emergency exists with a single link failure. However, in this event, in order to manage the increased risk of a dual-link failure, the mission is aborted and the RPA returns to the departure aerodrome under the control of the pilot and respects ATC instructions.

— Dual Link Failure
In case of failures, where the crew is unable to remain in positive control of the airframe but the RPA remains in flyable condition (e.g. dual-link failures), the RPA follows a pre-programmed autonomous flight profile back to the home air base.

Additionally, the RPA's transponder switches to power setting HIGH to maintain Mode S information transmission as long as possible. RTF is not affected as the radio equipment is ground-based.

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[1] Unsegregated and unaccompanied test flights of HERMES and HERON RPAS were enabled with six months lead-in time in 2012

From any point in space, the RPA joins a pre-programmed flight path at the closest point from its current position by carrying out a standard intercept. Once established on the route, it climbs or descends to the defined and indicated altitudes. The flight profiles are stored as radar maps and can be selected at any controller workstation.

— Parachute Landing

In case of malfunctions when the flight may not be continued (e.g. engine failure), the RPA autonomously deploys a parachute and slowly descends to ground level. The deployment of the parachute can also be manually triggered by the RPA pilot.

In both cases, the RPA immediately and autonomously squawks IDENT. Transmission of Mode S information is ensured for about 15 minutes after engine shut-down (battery backup).

7.3 Outlook

Switzerland is currently examining the possibility to have RANGER operate in airspace class E and G during daytime; however, with the current technical equipment and RANGER being a fairly old RPA, it appears unlikely to have a positive outcome. With the delivery of modern RPAS sometime in the future, this issue will most definitely be reconsidered, provided that successors to RANGER are fitted with autonomous sense-and-avoid systems, along with other technical improvements.

8

Future Considerations

ANSPs in several States have safely and successfully integrated RPAS operations outside segregated airspace. However, this has been achieved on a case by case basis and universally applicable procedures have not yet been developed. Experience shows that safe integration has been possible, but current RPAS do not have the capability to operate seamlessly with other air traffic and ANSPs have had to be flexible and imaginative to accommodate them.

It will be essential for ANSPs to work closely with RPAS developers, manufacturers and operators to safely, and more fully, integrate RPAS into the existing and future ATM system. Such cooperation will be required across ATM development programmes including:
— ICAO Aviation System Block Upgrade (ABSU) Framework
— Next Generation Air Transportation System (NextGen) in the USA
— Single European Sky Air Traffic Management Research (SESAR) in Europe

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