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of National Antarctic Programs

COVER SHEET / Notes to Versions

COMNAP Antarctic Remotely Piloted Aircraft Systems (RPAS) Operator's Handbook

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0.0 Minor editorial amendments; cover sheet creation and inclusion of the revision history within the cover sheet; addition of relevant paper under Other papers section.

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Antarctic Remotely Piloted Aircraft Systems (RPAS) Operator's Handbook

-prepared by the COMNAP RPAS Working Group[1]

Version 6, 15 September 2021

Purpose of this Handbook

The challenge for any national Antarctic program that utilizes RPAS technologies in the Antarctic Treaty region is to identify and manage risks associated with the technology and to develop guidelines that will enable safe and responsible RPAS use in differing circumstances and applications in order to reduce or mitigate those risks, and to plan and conduct any RPAS-related activity so as to limit adverse impacts on the Antarctic environment and dependent and associated ecosystems. This handbook may be used to develop a process for RPA deployment in the Antarctic Treaty Area and COMNAP encourages its Members to develop Standard Operating Procedures which acknowledge the specific circumstances in the area of operations.

The COMNAP RPAS Handbook should be viewed as a living document which, as RPAS technology evolves, and as published research on the use of and impacts, including environmental impacts, from RPAS in the Antarctic Treaty Area is made available and further developed in conjunction with SCAR and others, the recommendations and appendices are expected to evolve. Reviews of the Handbook will be regular, at least twice each year-at the end of the Antarctic summer season (including a review of reporting from national Antarctic programs) and before the start of each Antarctic summer season.

This COMNAP Handbook presents a summary of the discussions led by the COMNAP Remotely Piloted Aircraft Systems Working Group (RPAS-WG). The RPAS-WG is a subgroup of the COMNAP Air Operations Expert Group which recognises that the use of RPAS in the Antarctic Treaty region requires consideration of complementary issues within the Safety, Environmental Protection, and Science Facilitation Expert Groups; and also to a lesser extent within the Advancing Critical Technologies, and Marine Platforms Expert Groups. During the discussions, the RPAS-WG was composed of representatives from the:

- Australian Antarctic Division (AAD)
- Arctic and Antarctic Research Institute (AARI)/Russian Antarctic Expedition (RAE)
- Alfred Wegener Institute (AWI)
- British Antarctic Survey (BAS)
- Polar Research Institute of China (PRIC)
- French Polar Institute - Institut Polaire Français Paul Emile Victor (IPEV)
- Italy's National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA-UTA)
- Japan's National Institute of Polar Research (NIPR)
- Korean Polar Research Institute (KOPRI)
- Norwegian Polar Institute (NPI)
- Institute of Biochemistry and Biophysics Polish Academy of Science (IBB PAS)
- US National Science Foundation (NSF)

[1] Previously known as the COMNAP Unmanned Aerial Systems Working Group (UAS-WG)

SCOPE OF HANDBOOK
The RPAS-WG recognises that any use of RPAS must be safely integrated into the airspace of the Antarctic Treaty Area. It also recognises that RPAS are built in a variety of shapes and sizes and serve diverse purposes. Regardless of size and use, the responsibility to fly safely and within the environmental requirements of the Environmental Protocol applies equally to personned and unpersonned aircraft operations in the Antarctic Treaty Area.

But, because they are inherently different from personned aircraft, introducing RPAS into airspace is challenging. The COMNAP RPAS-WG recognises these challenges and the purpose of the RPAS-WG is to reduce risk to personned aircraft, to people and infrastructure on the ground, and to the environment in the Antarctic Treaty Area, while enabling, in situations where allowed, RPAS use in support of science, including logistics and operations, and for use in an emergency or in search and rescue situations.

This document represents the agreed information from discussions of the RPAS-WG and discussions by national Antarctic programs particularly in plenary sessions of the COMNAP Annual General Meetings, but also as a result of regular review, consideration of peer-reviewed state-of-knowledge and in consultation with SCAR. This information should assist national Antarctic programs with safe air operations in the Antarctic Treaty Area. Information exchange will also support national Antarctic programs in their development of their own guidelines or standard operating procedures for RPAS within their national Antarctic programs. National Antarctic programs may include additional information on RPAS deployment in their own guidelines or Standard Operating Procedures as they see fit and as required for their specific use and area of operations.

This Handbook is divided into three parts:
- **Part 1** includes introductory/general information.
- **Part 2** contains general recommendations and guidance in relation to environmental aspects of RPAS.
- **Part 3** contains appendices of various templates of common forms, such as communications plans and RPAS pilot logs. These templates are provided for use by national Antarctic programs and can be modified to suit a specific RPAS activity. They can then be incorporated into any national Antarctic program RPAS guidelines or Operating Manuals which are specific to their operations and situations.

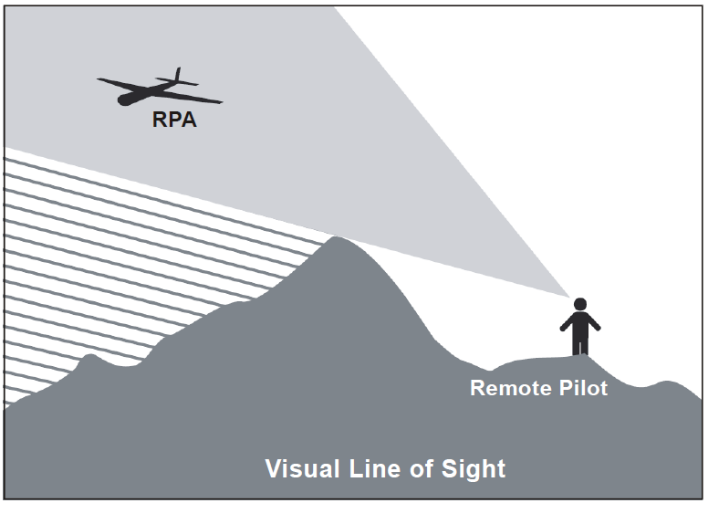
The COMNAP RPAS Handbook should be viewed as a living document which, as RPAS technology evolves, and as published research on the use of and impacts from RPAS in the Antarctic Treaty Area is made available, the recommendations and appendices are expected to evolve. The Handbook will be regularly reviewed, at least twice each year. Comments from any COMNAP Member organisation, on any aspect of this Handbook, would be welcomed.

LIST OF DEFINITIONS
COMNAP relies on the following terminology and definitions as per the ICAO (2015):

> ***Remotely piloted aircraft (RPA)*** – An unmanned aircraft which is piloted from a remote pilot station.
>
> ***Remotely piloted aircraft system (RPAS)*** – A remotely piloted aircraft, its associated remote pilot station(s), the required command and control links and any other components as specified in the type design.

Unmanned Aerial Vehicle (UAV) is considered an “obsolete term”.

LIST OF ACRONYMS



AGL – Above Ground Level
BRLOS – Beyond Radio Line-of-Sight
BVLOS – Beyond Visual Line-of-Sight
EIA – Environmental Impact Assessment
FIR – Flight Information Region
GPS – Global Positioning System
ICAO – International Civil Aviation Organization
IFR – Instrument Flight Rules
N/A – Not Applicable
NOTAM – Notice to Airmen
OM – Operator's Manual
PF – Pilot Flying
PIC – Pilot in Command
RC – Radio Controlled
RPA – Remotely Piloted Aircraft
RPAS – Remotely Piloted Aircraft System(s)
RX/TX – Receiver/Transmitter
SAR – Search and Rescue
SOP – Standard Operating Procedure
TOW – Take-Off Weight
VFR – Visual Flight Rules
VLOS – Visual Line of Sight

SIZE/CATEGORY

RPA can vary in size to those that are small (micro-), very light to light (mini-) and can be hand-launched, to those that are large to very large (major). Some countries have in place their own RPA classification system by size or weight of the unfuelled RPA component of the system and some countries have not yet agreed a classification system. States which have developed their own category systems and definitions use varying terminology and size/weight categories so that no two agreed systems are identical.

For the purposes of simplicity of this Handbook, COMNAP considers that there are only 3 categories of RPAS. Those with a RPA that is:

Small – Less than 2kgs
Medium – Greater than 2kgs but less than 25kgs
Large – Greater than 25kgs.

Most RPA deployed in the Antarctic Treaty Area in support of science, operations and logistics currently fall within the medium category and that category is the focus of the Handbook.

As countries prepare and agree on their national RPAS guidelines, national Antarctic programs will utilise the size categories/class terminology as per their national legislation.

PART 1

INTRODUCTION

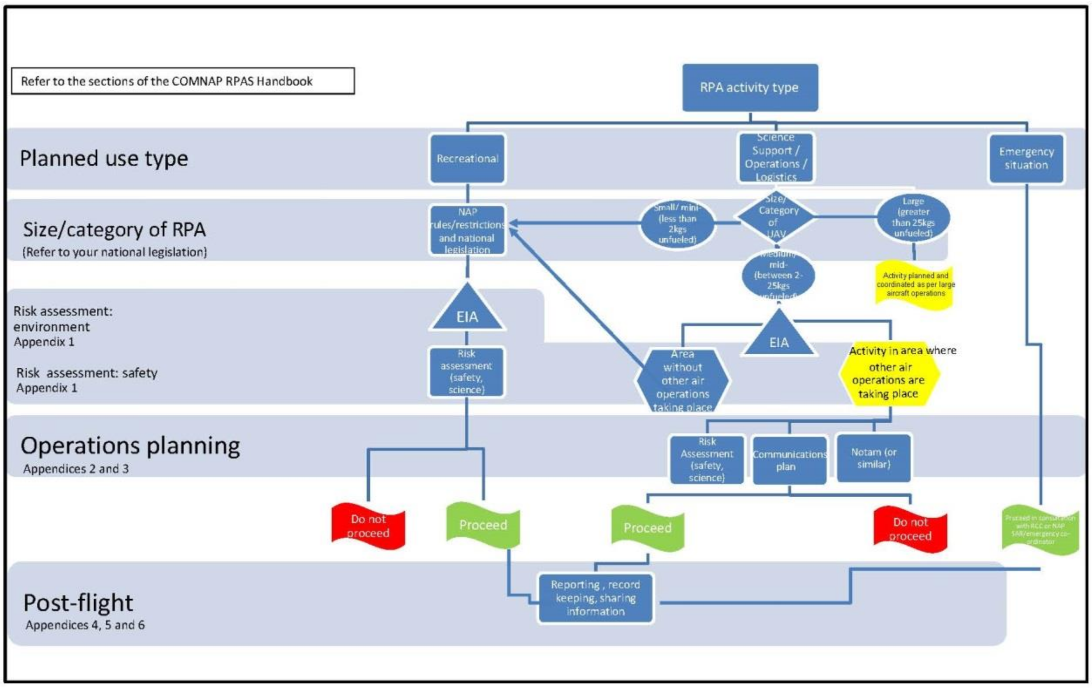
Technological advances have seen leaps in RPA capability and deployability. Most categories of RPA are now available at low cost, are lightweight and transportable. Technological advances will continue and soon any national Antarctic program, non-governmental organisation or individual will have the ability to operate a range of RPAS in the Antarctic Treaty region. This shifts aircraft operations from being only in the hands of licensed pilots who are fully aware of operational constraints, ATCM Recommendations and Measures, and best practice guidelines, to those who may have little or no awareness of these.

The principal objective of aviation regulatory guidelines is to achieve and maintain the highest possible level of safety. Against this background of safe air operations in the Antarctic region, there is also the fundamental consideration in the planning and conduct of all activities in the Antarctic Treaty Area as prescribed in the Environmental Protocol.

In the case of RPAS this means ensuring the safety of any other airspace user and of persons, environment, wildlife, infrastructure and equipment on the ground, including areas and equipment of scientific importance. Hazards and risks should be identified and assessed for each specific deployment as for any airborne object, advance notification and communications with other operators in any given region is essential to reduce risk of harm.

FLOW CHART FOR DECISION-MAKING

This flow chart may be used by national Antarctic programs as a tool to assist them with safe and environmentally friendly RPAS operations in a range of situations. It recommends appropriate steps to take in the pre-planning stages of the activity. As the Handbook is updated, so will the flow chart be updated. The decision to proceed or not to proceed with a particular RPAS operation is entirely a matter for the national Antarctic program.



FUTURE CONSIDERATIONS

With the lack of operational service history and certification experience with RPAS, this document does not yet provide specific guidance on procedures for things such as type design and airworthiness certification. Members are encouraged to establish best practice which should be shared, and which may be reflected in future revisions of this Handbook as such experience and service history is obtained.

Recognising that information specific to deployment of RPAS in the Antarctic Treaty Area has not been published to a great extent, consideration should be given to published information on RPAS in the Antarctic as it becomes available, including SCAR recommendations and advice on operating RPAS near wildlife. All relevant publications as they become available are shared by way of the COMNAP website and are listed at the end of this document.

Pilot training plays a major role in the safe responsible use of RPAS. Guidance on pilot training will be included in the Handbook and shared amongst the RPA-WG.

PART 2
GENERAL RECOMMENDATIONS and GUIDANCE RELATED TO ENVIRONMENTAL ASPECTS

Introduction
The COMNAP RPA Handbook contains guidance to ensure the safe operation of RPA and to minimize the risks and potential for environmental impacts from the operation of RPA in the Antarctic Treaty Area. They are based on the current state of knowledge in consultation with SCAR, and in view of the uncertainties that currently exist on impacts on wildlife and on the rapidly changing technology adopt a precautionary approach. Such guidance is intended to assist those who permit RPA operations including the national Antarctic programs themselves when they carry out their pre-flight risk assessments.

The guidance recognises the value of RPA use in the Antarctic Treaty Area as productive, while, at the same time wishes to serve as a reminder of the fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty Area.

Air operations in the Antarctic Treaty region are critical components of Antarctic activities in support of science and its associated operations and logistics. Air operations with personned aircraft are inherently risky to human life, costly and constrained due to the availability of ground-based infrastructure and the facilities necessary to support air operations in the Antarctic Treaty Area. Like personned aircraft, RPAS have environmental impacts; however, their use especially in place of personned aircraft also has significant environmental benefits. The unique characteristics of RPAS mean that science and science support operations can be completed with the use of RPAS which also reduces risk to human life, reduces costs and reduces impact to the Antarctic environment and dependent and associated ecosystems and wildlife. The extent of environmental impact and benefits will depend on the category and size of the RPA, the type and amount of fuel consumed, and the nature and location of the operation, among many other factors. RPA should be designed, built and operated, with this in mind.

Article 3 of the Environmental Protocol requires that activities in the Antarctic Treaty Area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment. In the context of RPA operations, the requirements of Annex II of the Environmental Protocol on the Conservation of Antarctic Fauna and Flora, and of Annex III on Waste Disposal and Waste Management may be particularly relevant.

ATCM Resolution 4 (2018) contains Environmental Guidelines for operation of Remotely Piloted Aircraft Systems (RPAS) in Antarctica. ATCM Resolution 2 (2004) which contains Guidelines for the Operation of Aircraft Near Concentrations of Birds in Antarctica may also contain general principles that are relevant to particular RPA operations. For all Antarctic Specially Protected Areas (ASPAs) entry is prohibited except in accordance with a permit. Specific reference to prohibition of RPA may be prescribed in ASPAs, Management Plans, in active airfield guidance found in the Antarctic Flight Information Manual (AFIM), in Notice to Airman (NOTAMS)[2] and in Historic Sites and Monuments (HSM) descriptions and designations.

Internationally, personned aircraft operations are heavily regulated. In the case of unpersonned aircraft, the international civil aviation community is currently working on the regulation of RPAS

[2] Notice to Airman (NOTAMS) can be found at https://notams.aim.faa.gov/notamSearch/ and at https://www.bas.ac.uk/polar-operations/sites-and-facilities/aircraft/pilots/

operations-some countries have developed and have in place regulation, while in other countries there is little regulation of unpersonned operations.

The RPAS-WG has made the following recommendations to assist with the activity in the Antarctic Treaty Area and provide guidance related to environmental aspects of RPA use in the Antarctic.

GENERAL RECOMMENDATIONS:

1. Recommends that national Antarctic programs inform their personnel that RPAS operations are prohibited without specific authorization/agreement to proceed from their program's head of operations/air operations manager/station manager.

2. Strongly recommends, that any RPA deployment be primarily for purposes in support of science, including science support, logistics and operations, and for use in an emergency and search and rescue situations.

3. Recognises that there are many regions within the Antarctic Treaty Area where no personned air operations take place. Likewise, there are areas, in particular around stations, where there is an active personned air operations program at certain times of the year. In the areas where there are personned air operations, advanced communication of planned RPAS operations, emplacement of RPAS restrictions (height and radius around personned air operations locations and facilities) or emplacement of technologies such as "geo-fences" may be appropriate. Any RPAS airspace restrictions around Antarctic airfields and other personned air operations should be noted in the COMNAP AFIM and documented in the NOTAM system.

4. Strongly recommends that every national Antarctic program wishing to deploy RPAs has an Operations Manual in accordance with their national regulations and in a manner that meets any applicable and relevant international provisions (as appropriate) to ensure the safest possible outcome of each RPAS deployment.

5. Where practical, all major components of any RPAS should carry identification marks, including any national registration and identification information, which may be required by the national Antarctic program's country, in order to identify the pilot and operator for record keeping or in the event of an accident, incident or near-miss. Any such marks, especially on medium and large RPA should be placed on the deployed aircraft in a manner that can be clearly visible during flight. Brightly coloured RPAs might be appropriate in Antarctic conditions for retrieval/recovery purposes.

6. Recommends national Antarctic programs take a common approach to safety risk assessment based on a recognised and commonly accepted air operations framework so that RPA operations can be carried out in as safe a manner as personned aircraft operations and not present a hazard to persons, property or the Antarctic environment that is any greater than that attributable to the operation of personned aircraft preforming the same or similar activity.

7. Strongly recommends that all RPAS deployment in the Antarctic Treaty Area should be notified. In areas with personned air operations, use of a communications plan and the NOTAM (or similar) system may be appropriate.

8. Recommends that the national Antarctic program ensure that each RPA pilot is appropriately trained in accordance with national regulations and in a manner that is

consistent with, for example, the provisions of Annex 1 to the Convention on International Civil Aviation (ICAO) *Personnel Licensing*, and provides proof of proficiency of training or competency for the specific category and type of RPA to be flown. If the pilot is flying their own manufactured RPA type-certification and airworthiness certification should be required.

9. Strongly recommends that as enabling technology develops, on attributes such as search and avoid capabilities or perception and avoidance systems, that national Antarctic programs consider routine integration of such technologies in RPAS deployments. A recent example of note is Automatic Dependent Surveillance–Broadcast (ADS–B)[3] transponders, such technology is very useful in some regions of the Antarctic Treaty Area to further support safe separation distances between personned and unpersonned vehicles.

10. Strongly recommends that all COMNAP national Antarctic programs routinely share operational and certification information and any documentation developed, in support of the sharing of best practices and to facilitate the establishment of national accreditation and operational programs.

GUIDANCE RELATED TO THE ENVIRONMENTAL ASPECTS OF RPA USE IN THE ANTARCTIC TREATY AREA:

Pre-flight Planning

1 General considerations

1.1 Consider the likely environmental impacts of the planned operations. If the planned activity can be carried out in areas away from wildlife, then do not operate RPA near or over wildlife. "Adopt the precautionary principle in lieu of evidence when using a RPA in the vicinity of wildlife."[4]

1.2 Follow your national Antarctic program operating procedures for preparing for any activity and any specific national Antarctic program guidance on RPA deployment. At a minimum, follow the COMNAP RPAS Handbook flow-chart for decision-making which includes environmental- and safety-risk assessment. Based on the assessment, adopt procedures to avoid and / or mitigate any impacts as far as possible.

1.3 Consider the state of knowledge available on wildlife impact, including, "that sensitivity to drone disturbance differs between species and even within species depending on the stage of the birds within its life cycle."[5]

1.4 Consider options carefully in regards to retrieval of a lost RPA in the event of a crash.

1.5 When planning to operate RPAS in the marine environment recognise the potential environmental impact from the loss of the RPA in the sea, on ice shelfs, and ice bergs and potential for interference with flying sea birds, which often follow ships. Make sure any pre-flight plans and assessments consider avoiding RPA flights near coastal Antarctic areas which are often the sites of wildlife habitats unless those areas or wildlife are the specific target of the research or the operations.

1.6 When possible, carry out pre-testing of specific RPA and related equipment in the home country before deployment to the Antarctic Treaty Area.

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[3] ADS–B is a technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked. The information can be received by air traffic control ground stations as a replacement for secondary radar and the technology is sometimes built-in to RPAs or a transponder can be attached to the RPA.

[4] Hodgson and Koh, 2016.

[5] Weimerskirch et al, 2017.

2 RPAS Characteristics

2.1 Peer-reviewed research indicates that low noise RPA have less impact on terrestrial wildlife given same conditions and corresponding height of fuel-powered RPA. As part of the risk assessment, give consideration to the type of RPA that is being considered for deployment and all characteristics being equal, give preference to electric-powered, low decibel output RPA over others.

2.2 Peer-reviewed publications suggest that some Antarctic wildlife exhibit a behavioural response which indicates they become disturbed from a resting behaviour to become vigilant or agonistic in response to some types of RPA. Select RPA for purpose and consider during the assessment any impact which can be avoided or mitigated by using RPA that do not closely resemble aerial predators. That is, consider ways to minimize stress on prey species and / or attacks by territorial species, if operating in areas where wildlife is likely to be present.

2.3 To reduce the risk of non-native species transfer on RPAS equipment, follow all guidance related to cleaning of equipment prior to shipment to the Antarctic Treaty Area and when using the same equipment intra-regionally. If applicable, consult the SCAR Code of Conduct for Activity Within Terrestrial Geothermal Environments in Antarctica, the SCAR Environmental Code of Conduct for Terrestrial Scientific Field Research in Antarctica, the SCAR/COMNAP Checklists for the reduction in the risk of transfer of non-native species and the CEP Clean-up Manual.

3 Policy & Legal requirements

3.1 National Antarctic program's must follow their procedures in relation to following the requirements of the Environmental Protocol, including, Annex II, Article 3, which prohibits harmful interference with native fauna and flora except in accordance with a permit.

3.2 National Antarctic program's must also follow their procedures in relation to following the requirements of the Environmental Protocol, including, Annex V, Article 4, which prohibits entry into an ASPA except in accordance with a permit. An ASPA may specifically prohibit air operations in the area.

3.3 If RPA operations are proposed to occur within an ASMA, consideration must be given to the Management Plan and any restrictions imposed within that plan. An ASMA may specifically prohibit air operations in the area. Some ASMA, by their very nature, are areas where activities pose risks of mutual interference or cumulative environmental impacts. Introduction of an RPA into a mutual use area should be taken into consideration and consultation with other users of the area is encouraged.

4 Operations near wildlife

4.1 Where the deployment of an RPA is not directly related to scientific research in relation to particular wildlife, avoid operation of RPA near any wildlife, unless for reasons of safety, in an emergency, or in a search and rescue situation.

4.2 Where operations of RPA near wildlife is necessary for scientific research, science support, operations and logistics purposes, "exercise minimum wildlife disturbance flight practices. Particular attention should be given to siting launch and recovery sites away from animals (out of sight if possible) and maintaining a reasonable distance from animals at all times during flight. Species specific protocols, including optimum flight altitude, should be developed and implemented wherever possible." [6]

4.3 "Animal responses should be measured during UAV operations (and before and after if possible). Monitoring stress response at a physiological level is encouraged, as is the use of tracking technology to quantify potential displacement. Operations should be aborted if

[6] Hodgson and Koh, 2016.

excessive disturbance results, especially in cases when quantification of UAV disturbance is not a research interest." [7]

4.4 Remember that "reaction of birds to horizontal flights and vertical approaches of an RPA vary extensively depending on the species, the status of birds and the altitude." For some bird species, when flying a RPA above that species at low altitudes, vertical flights cause a higher level of disturbance than horizontal ones. [8]

4.5 During any RPA operation around wildlife, pilots and any designated observers should watch for, and inform each other of, signs of wildlife disturbance, cease operations if necessary and record the particulars of the RPA flight, species and observations. Wildlife disturbance may not be a result of the RPA flight itself but may be due to human presence in the area. As with any human activity near any Antarctic fauna and flora modify your behaviour accordingly.

5 Operations over terrestrial & freshwater ecosystems

5.1 For RPA activity that is related to terrestrial scientific field research operations SCAR's Environmental Code of Conduct for Terrestrial Scientific Field Research in Antarctica provides good guidance.

5.2 Particular care should be taken when operating within or near geothermal environments, where the SCAR Code of Conduct for Activity within Terrestrial Geothermal Environments in Antarctica provides good guidance.

6 Human considerations

6.1 In permitting or allowing RPA operations as part of national Antarctic program operations, consideration should be given to all values that may be impacted by RPA operations in the Antarctic Treaty Area, including, scientific and wilderness values.

6.2 Avoid operating RPAS over HSMs, especially out of respect for the commemorative nature of HSM, to minimize disturbance to solitude associated with many of these historic sites and to minimize the risk of RPA accidents which may cause damage to or loss at these sites. Should retrieval of a failed RPA within an HSM be necessary, notify your national Antarctic program manager before retrieval as they may wish to contact the HSM authority for consultation and advice before undertaking any action.

Post-flight Actions

7 Actions in case of unplanned landing or accident

7.1 Consult the risk assessment plan and implement the steps to follow in case of accident.

7.2 In the event of an unplanned landing or crash, and mindful of the obligation under the Protocol on Environmental Protection to the Antarctic Treaty to remove waste from the Antarctic Treaty Area, retrieve, if safe to do so, the RPA and any component parts which have broken away, and in the case where the crash has created a fuel spill, remediate the site according to your national Antarctic program procedures.

8 Actions in case of planned end to operations

8.1 To reduce the risk of species transfer, ensure that the RPAS and all associated equipment and carrying cases are cleaned prior to use at another site in the Antarctic Treaty Area or prior to transfer out of the Antarctic Treaty Area.

9 Reporting

9.1 As per SCAR and COMNAP advice, national Antarctic programs are encouraged to record environmental aspects of RPA deployments and to share this knowledge with other national

[7] Hodgson and Koh, 2016.
[8] See Rümmler et al, 2016.

Antarctic programs and IAATO. National Antarctic programs are encouraged to provide support to scientific projects which will increase our understanding of environmental aspects of RPA use in the Antarctic Treaty Area.

9.2 The appropriate authorities should continue to receive advice from the scientific community about the potential impact and benefits of RPAS on the Antarctic environment, encourage further research to assist in decision-making and undertake regular reviews of the state of knowledge for the purpose of updating these guidelines so they reflect the best available scientific evidence.

9.3 Follow the COMNAP RPA Handbook and any national Antarctic program requirements to record environmental observations during all the stages of RPA deployment. "RPA specifications and flight practices should be reported accurately and in full. Thorough results should be reported to ensure findings can be integrated in future research. Notes of animal responses should be included in published studies to generate an evidence base for refined guidelines."[9]

[9] Hodgson and Koh, 2016.

PART 3
APPENDICES

This section of the Handbook contains guidance in the form of templates which national Antarctic programs may use in the development of their own RPAS Operator's Manuals and procedures.

National Antarctic programs should also refer to the flow chart on page 4 of this Handbook which refers to particular sections of Part 3.

Appendix 1: Risk assessment and management

Environmental considerations

From a general point of view, as pointed out by the CEP on several occasions, RPAS can be considered as excellent tools to minimise the environmental impacts related to monitoring activities (especially in ASPA) or other scientific and logistical uses. However, as with any activity undertaken in the Antarctic Treaty Area, an EIA should be used to determine the level of environmental impact a proposed activity is expected to have. Therefore, any national Antarctic program which is considering deploying RPAS as part of its Antarctic operations should include that activity in an EIA for assessment. That EIA should include waste management and recovery procedures for the safe recovery of any RPA that has crashed/experiences an unplanned landing, as well as details about wildlife avoidance and/or disturbance mitigation measures. As an overall evaluation, such an EIA should also outline the advantages, if any, of the RPAS use compared to other traditional approaches for the implementation of similar activities.

Safety of human life considerations

In many instances, RPAS use provides a safer alternative to personned aircraft operations. In RPAS operations, from the point of view of safety to human life, the most severe possible outcomes are those that result in injury or death to persons on the ground or persons in other aircraft.

Identification of hazards and assessment of risk related to deployment of RPAS in the Antarctic Treaty Area is a continuously applied process that is aimed at ensuring all risks are mitigated to a low rating. It also incorporates provisions that allow those risks which cannot be mitigated to be addressed. There are many examples of "Consequence-Probability", or "Cause-Consequence", or "Hazard –Risk" matrices available. The Example below is of a "cause-consequence" matrix, with severity classifications, likelihood of occurrence and related definitions.

Example of a cause-consequence matrix (Chart 1.1)

Severity/ Likelihood	No Safety Effect	Minor	Major	Hazardous	Catastrophic
Probable					
Remote					
Extremely Remote					
Extremely Improbable					

Table 1.1: Example of a cause-consequence matrix, which categorises risk based on four levels of likelihood of occurrence and five levels of potential severity. Green = low risk; Yellow = medium risk; and Red = high risk. (Chart from AMAP 2015, page 15).

Severity Classifications and Likelihood of Occurrence

Severity definitions related to occupants of an aircraft do not apply to an unpersonned system. In RPAS operations, the most severe possible outcomes are those that result in injury to people, either in another aircraft or on the ground. As a result of this, NASA (NASA 2007) has suggested hazard categories for RPAS as shown in Table 1.2.

Severity Level	Definition
Catastrophic	Failure conditions that are expected to result in one or more fatalities or serious injury to persons, or the persistent loss of the ability to control the flight path of the aircraft, normally with the loss of the aircraft.
Hazardous	Failure conditions that would reduce the capability of the RPAS or the ability of the flight crew to cope with adverse operating conditions to the extent that there would be the following: (1) A large reduction in safety margins or functional capabilities; (2) Physical distress or higher workload such that the RPAS flight crew cannot be relied upon to perform their tasks accurately or completely; or (3) Physical distress to persons, possibly including injuries.
Major	Failure conditions that would reduce the capability of the RPAS or the ability of the flight crew to cope with adverse operating conditions to the extent that there would be a significant reduction in safety margins or functional capabilities; a significant increase in flight crew workload or in conditions impairing flight crew efficiency; a discomfort to the flight crew, possibly including injuries; or a potential for physical discomfort to persons.
Minor	Failure conditions that would not significantly reduce RPAS safety and would involve flight crew actions well within their capabilities. Minor failure conditions may include a slight reduction in safety margins or functional capabilities or a slight increase in flight crew workload (such as routine flight plan changes).
No Safety Effect	Failure conditions that would have no effect on safety (that is, failure conditions that would not affect the operational capability of the airplane or increase flight crew workload).

Table 1.2: NASA Hazard categories for RPAs. (NASA 2007).

Probable	Anticipated to occur one or more times during the entire system//operational life of an item.
Remote	Unlikely to occur to each item during its total life. May occur several times in the life of an entire system or fleet.
Extremely Remote	Not anticipated to occur to each item during its total life. May occur a few times in the life of an entire system or fleet.
Extremely Improbable	So unlikely that it is not anticipated to occur during the entire operational life of an entire system or fleet.

Table 1.3: Four categories of likelihood of occurrence. Each level of likelihood has a qualitative and quantitative definition. This table shows the qualitative definitions (FAA 2000). The quantitative levels vary across aviation advisory material depending on the aircraft system in consideration.

Appendix 2: Communications plan

Any planned RPAS activity should be communicated. In areas where there is no or infrequent personned air operations then in-person or email communications to appropriate station or field personnel may be the most appropriate level of communications.

In areas where there are frequent or routine personned air operations or in areas where more than one national Antarctic program is carrying out operations and activities, a more exhausted communications plan may be appropriate. An example communications plan is provided in this appendix.

The communications plan should be completed by the RPAS operator/pilot, distributed within the national Antarctic program as per agreed programme standard operating practices and distributed to all other operators working in the same area as the proposed RPAS operations prior to any planned RPAS operations.

In the event of the cancelation of any planned RPAS activity a cancelation notice should be issued as soon as cancelation is confirmed utilizing the same distribution mechanism and list as the communications plan.

Example of **RPAS OPERATIONS & COMMUNICATIONS PLAN**

Pilot Contact Information
Phone:________________________________Email:_______________________________
Other telephone number:______________________________________
Other contact information:_____________________________________
(For Vessel Launches) Radio Call Sign: ___________ Vessel #:______Phone: ______________
VSAT:__________________________Iridium: ______________________________________

<u>7 days prior:</u> Distribute email, including authorization from appropriate authorities (if applicable), to air traffic service providers and appropriate government operators and any non-governmental operators in the area.

<u>7 days prior to 24 hours in advance:</u> Complete NOTAM template (Appendix 3) then contact: _________________ by phone:_________________ or email: _____________________ to request a NOTAM be issued for operation area.

<u>24 hours in advance:</u> Obtain and review operation area personned aircraft operator's schedule for the next day and weather forecasting information. By _________ (Local time) on day of flight, prior to flight, personned aircraft operators will confirm their daily flight plan(s). Review and alert all conflicts/possible conflicts. Reconsider RPAS operations in consultation with manager and air traffic service providers and taking into account weather conditions and weather forecasts.

<u>1 hour prior:</u>

- Operator files a flight plan through appropriate national Antarctic programme unit, following any operational procedures. [It is recommended that flight plans be submitted in accordance with Chapter 3 of ICAO Annex 2, Rules of the Air.]
- Receive and review weather briefing, review all NOTAMs, and determine if there are any other flight plans on file for the operating area.
- Contact appropriate air traffic service unit via telephone or other acceptable means to confirm that if any special use airspace or altitude reservation (ALTRV) is active.

10 minutes prior: In preparation for launch, broadcast a warning announcement on [Marine Common FM Ch 16] and appropriate local Air Traffic Control (ATC) VHF frequency. Use VHF Guard 121.5Mhz if no ATC local frequency is available. e.g., "RPAS flight operations are commencing from LAT/ LONG of research vessel or launch site." Maintain a listening watch on VHF______MHz and_______MHz for any area traffic.

During flight operations: Periodically broadcast a warning announcement on [Marine Common FM Ch 16] and VHF______MHz; e.g., "RPAS operations are in effect between the surface and _____feet within 10 nautical miles of LAT/LONG."

Lost Link/Lost Comms (Emergency Comms): Pilot will comply with the lost link/lost comms procedures stipulated in their operating procedures. Operator will immediately contact appropriate person via phone and report the Lost Link condition, time, and LAT/LONG. Immediately broadcast on [Marine Common FM Ch 16,], VHF______MHz, and VHF______MHz or other acceptable means; e.g., "RPA flight operations are commencing emergency return at ______feet Above Ground Level (ABL)."

Coordination with other operators: This information should be shared with all other operators in the area.

Appendix 3: NOTAMS (Notice to airmen) or similar notification

In some cases, a NOTAM (or similar) may be required to give notice to personned aircraft of planned RPAS operations. Below is an example of a NOTAM in such instances.

PART 1 : PILOT CONTACT DETAILS	
Contact Person	
Contact Telephone	
Contact Email	

** Your national Antarctic program Air Operations manager will complete a NOTAM for circulating to Antarctic operators from the information provided on this request form. The NOTAM will be posted on [website] and an approved copy returned by email to you.

PART 2 : NOTAM DETAILS			
NOTAM Type		New ☐ Cancel* ☐ Replace* ☐	
* If you selected CANCEL or REPLACE, please indicate the previous NOTAM number →			
A	Launch Location (long/lat)		FORMAT – Degrees Minutes Decimal Seconds
	Centre of flight location (long/lat)		FORMAT – Degrees Minutes Decimal Seconds
	Radius of flight (metres)		
B	Valid From Time	UTC	FORMAT – YYMMDD hhmm
C	Valid To Time	UTC	FORMAT – YYMMDD hhmm
D	Daily Schedule		
E	NOTAM Text	(includes details of platform and mission description)	
F	Lower and Upper Limit	FEET above terrain	

PART 3 : AUTHORISATION (to be completed by air operations)					
The information in this NOTAM request is declared as accurate/authorised for promulgation.					
Air Unit		Field/Ship Ops		Environmental	
Name					
Signature		Date			

On completion return to: ____

Guidance on completion of form

User/Pilot

1) Enter your contact information into Part 1.
2) In Part 2 select either new if new request, replace if updating or resubmitting request and cancel if no longer require that RPAS mission.
3) Enter in 2A location (longitude/latitude) of launch and centre of flying area in Degrees Minutes Decimal Seconds for centre of flying area and in NOTAM text add name of site [e.g. White Nunatak, Syowa Station, from SA Agulhas II vessel] and radius of flight (metres).
4) Enter in 2B/C/D the UTC date and time for when on location.
5) Enter in 2F maximum flying height above terrain in feet.
6) Enter in 2E any further relevant information that qualitatively describes the mission to be flown such as platform type and any particular flying characteristics [e.g. DJI's Flamewheel F550 hex rotor hovering over location at different points above the survey area].

Air unit/Station admin/Ship admin

1) Confirm with field ops/station leader that request for NOTAM is approved; [at this stage it may be required to contact environment office, air unit, ships or health & safety if appropriate no prior approval or permitting has been done for the operation of the RPA.]
2) If approved, transfer information on to NOTAM website and activate as required. If not approved await resubmission of approved NOTAM and do not fly.
3) Transfer information on to NOTAM form for circulation to other operators in the area.
4) Circulate NOTAM.

Appendix 4: Reporting, record-keeping and sharing of information-Pilot Record

In order to record the pilot history and particulars related to each pilot, a pilot should maintain a pilot log form which is a record of flights completed, including location, aircraft make and model, types of take-off and landings, and flight times. A pilot should carry this record with him/her at all times while operating RPAS in the Antarctic Treaty Area in hard copy or electronic format. A national Antarctic program or air operations unit manager may request to review the pilot record at any time.

Date	Time		Aircraft		Location		Mission	Pilot	Others
	Start	End	Make/model	Name/registration	Launch Lat/long	Flight radius			

		Flight duration		Type of piloting time		
Type of takeoff	Type of landing	VLOS	BVLOS	In command	Instructor	Signature

Appendix 5: Reporting, record-keeping and sharing of information-Flight Record

In order to record the flight history of all RPAS operations undertaken by national Antarctic programs in the Antarctic Treaty Area, a pilot should complete and submit a flight record report after the completion of each RPAS flight. The flight record is specific to the aircraft flown, the payload and the mission parameters. In order to continue to improve our knowledge of RPAS impact on Antarctic wildlife and the Antarctic environment, any comments on special observations on this issue is welcomed. When complete, flight records should be submitted to the air operations unit that had oversite of the operational planning.

Date	Time
Airplane	
Flights/hours since last major inspection	Flights/hours remaining until next major inspection
Power source: Fuel or battery	

Payload (instruments, comments)
Comms link(s) (type, comments)

Fuel weight	Payload weight
TOW	Without wings

PIC (start of flight)
Pilot
Other persons

Mission description (include whether VLOS, EVLOS, BVLOS and BRLOS)

Weather conditions

Wind	Temperature
Precipitation	Visibility
Air pressure	
Launcher	Pressure used
Takeoff location	Battery voltage
Control tower	Tower notified time start

Flight log

Takeoff time		Hand-overs
Takeoff type: vertical or horizontal		
Time	Incidence	Time/Role/Name
Landing time		Tower notified stop time

Landing location
Fuel consumed
Battery charge
Flight duration
Distance flown
Battery voltage
Environmental comments, including any observations in relation to wildlife
Notes

Signature(s)

Appendix 6: Reporting, record-keeping and sharing of information-Accident, Incident and Near-Miss Reporting

Any RPAS flight that is interrupted by an event which then causes an accident, incident or near-miss of any type, should be reported immediately to the air operation unit that had oversite of the operational plan, may require the completion of an accident, incident or near-miss reporting form as per the national Antarctic programs standard procedures.

Appendix 7: RPAS Concept of Operations (CONOPs)[10] Template

(example shared by the US Antarctic Program)

Due to safety of flight and potential medical cost rendered for personal injury, NSF requires for any RPAS activity the pilot to be FAA Part 107 (Drone Pilot License) certified (or other national equivalent) and be augmented by a visual observer. We also require the pilot provide a log certifying at least 10 hours flight time in the 180 days preceding deployment, with at least 2 hours in like-type aircraft within the 30 days preceding deployment date. NSF also requires a Concept of Operations (CONOPs) document which details the who, what, where, when, and how they plan to conduct operations. This plan is transmitted to Air Traffic Control authorities, who then incorporate the RPAS activity into the NOTAM system.

Deploying an RPAS CONAPs Proposal (please fill out 7.1 through 7.8).

7.1. Overview

7.1.1. Executive Summary – provide a high-level narrative of your plan.
7.1.2. Project Participants: include pilots and visual observers as a minimum.

7.2. Implementation Plan

7.2.1. Mission Planning
7.2.2. RPAS Platforms – ID make and manufacturer
7.2.3. RPAS Specifications – ID operational specifications

a. Material (Color, distinguishing features):
b. Overall dimensions:
c. Max TOGW (Takeoff Gross Weight): kgs or lbs
d. Ground clearance:
e. Service ceiling:
f. Max cruise speed:
g. Max endurance:
h. Rate of climb
i. Rate of descent
j. Radio transmission frequencies

7.2.4. Study Site(s)
7.2.4.1. Area A – include:

Proposed flight paths/patterns/altitudes/distances to accomplish goals.
These include latitude/longitudes, mission number (if any), call sign, pilot, visual observer, flight plan activation window (Proposed dates of deployment(s), altitudes, distances

[7.2.4.2. Area B, etc.]

7.3. Launch and Recovery

Prior to each mission a preflight procedure is defined to assure safe and reliable mission execution. These procedures include participant briefing, RPA testing and calibration,

[10] A Concept of Operations (CONOPs) document, when completed, describes the purpose of a proposed system or activity, the environment in which it will be operated, how it will be used, roles and responsibilities of users, resources required for its use, and other information stakeholders might need.

communication tests and weather checks. The RPAS launch zone is selected and prepared for operations by the pilot in charge. The aircraft will be launched from (describe proposed area). The pilot in charge will establish a communication plan with Air Traffic Control, communications facilities at nearest station, or ship authorities.

7.3.1. Pre-flight Protocol - Before the mission is initiated, the preflight protocol is validated by the pilot in charge and visual observer.

7.3.1.1. Team Briefing shall include:

a. Operating Conditions
b. Emergency procedures
c. Contingency procedures
d. Roles and responsibilities of each person involved in operations
e. Potential hazards

7.3.1.2. Environment Check / Conduct area assessment:

a. Local weather conditions and forecast check
b. Local airspace. Will also ID any flight restrictions including consideration of ASPAs and ASMAs and IBAs
c. ID locations of persons, infrastructure (including science equipment) and other assets on the surface
d. ID any wildlife in the area
e. ID other ground or flight hazards

7.3.1.3. RPAS Equipment Check – a preflight RPA visual inspection is required prior to every mission:

a. Airframe
b. Flight Controller
c. Imaging Camera/gimbal

7.3.1.4. Pre-flight Operation Check – to be accomplished prior to every mission to verify RPAS is in good working order:

a. Aircraft check
b. Battery/power check
c. Flight controller check
d. Aircraft compass calibration
e. GPS position acquisition check
f. Geo fence function test

7.3.2. Launch Procedure – describe launch procedures

7.3.3. Landing Procedure – describe landing procedures ***Warning**: Most RPAS injuries occur when recovering an airborne RPAS by hand. Any plan to recover a RPAS in this manner should be explicitly specified in this document and accomplished only by experienced operators.*

7.3.4. Airspace Management – describes how you will interface with Air Traffic Control (ATC), communications facilities at nearest station, or ship authorities.

WHO	WHAT	WHEN
SOPP	ATC issues standing NOTAM for the project and geographic footprint utilizing a latitude/longitude center point with radius covering the affected area with a ceiling based on vehicle's maximum service ceiling +2000ft.	Prior to commencement of season operations
SOPP	Issue airfield CTAF VHF frequency and include in NOTAM	Prior to commencement of season operations
Event Planner	Source air band radios	On arrival to MCM
PI (or designated representative	Confirms planned events with times for next day with FW Ops for inclusion to daily flight schedule	NLT 24 hours prior to planned mission
FW Operations / SOPP ATM	Deconflict daily schedule based on planned events. Clarify priorities with MCM NSF Rep as required.	Prior to daily flight schedule release
Remote Pilot / Pilot Operator / SOPP	Radio call to Mac Center / Send notification to advise appropriate users of planned commencement for UAS flight operations. Mac Center email: macctr@usap.gov	30 mins prior to first planned takeoff of the day
Remote Pilot / Pilot Operator	Establish communication via best means available with appropriate ATC location (Mac Center, Tower, etc)	Prior to powering up systems
Remote Pilot / Pilot Operator	Verify positive AFF with Mac Center (if installed)	Prior to taxi / takeoff
Remote Pilot / Pilot Operator	Verify airspace status, traffic with Mac Center. Include planned duration, estimated land time, planned are to operate.	Prior to taxi / takeoff
Remote Pilot / Pilot Operator	VHF CTAF / UNICOM calls commence for all events within 10NM of an existing airfield	Prior to takeoff, through landing
Remote Pilot / Pilot Operator	"Off-deck" call to Mac Center	When airborne
Remote Pilot / Pilot Operator	"Ops Normal calls to Mac Center	Every 30 mins while airborne
Remote Pilot / Pilot Operator	"On-deck" call to Mac Center, with estimated time to next take-off or terminating for the day	At completion of single flight or operations for the day are terminated

Table: Example RPAS Planning and Radio Call Matrix for planned RPAS deployment near US McMurdo Station.

7.4. Recovery Contingency Plan. Ensure environmental considerations are included.

7.5. Human Factors. Describe how ancillary people will be managed safely. These are the people not engaged in flight operations, but may be observers, either casual or associated with the project.

7.6. Pilot Certifications and Logbook. [For USAP-related RPAS Deployment: FAA Part 107 license (or other national equivalent) must be provided]:
7.6.1. Pilot A
[7.6.2. Pilot B, etc.]

7.7. References

7.8. Additional Information – please add any additional information needed for consideration of your work.

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