Antarctic Unmanned Aerial Systems (UAS) Operator's Handbook

-prepared by the COMNAP UAS Working Group

Purpose of this Handbook

The challenge for any national Antarctic programs that is beginning to utilize UAS technologies in the Antarctic Treaty region is to identify and manage risks associated with the technology and to develop guidelines that will regulate UAS use in differing circumstances in order to reduce or mitigate those risks. This handbook may be used to develop a process for UAS deployment in the Antarctic Treaty area.

The COMNAP UAS Handbook should be viewed as a living document which, as UAS technology evolves, and as published research on the use of and impacts, including environmental impacts, from UAS in Antarctica is made available and further developed in conjunction with SCAR and others, the recommendations and appendices are expected to evolve.

RELEASE NOTES AND RECORD OF AMENDMENTS

Version 31 March 2016

This COMNAP Handbook presents a summary of the discussions led by the COMNAP Unmanned Aerial Systems Working Group (UAS-WG). The UAS-WG is a subgroup of the COMNAP Air Expert Group which recognises that the use of UAS in the Antarctic Treaty region requires consideration of complementary issues within the Safety, Environment, and Science Expert Groups; and also to a lesser extent within the Energy & Technology, Training, and Shipping Expert Groups. During the discussions, the UAS-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)
- Institute of Biochemistry and Biophysics Polish Academy of Science (IBB PAS)
- US National Science Foundation (NSF)

SCOPE OF HANDBOOK

The UAS-WG recognises that any use of UAS must be safely integrated into the airspace of the Antarctic Treaty area. It also recognises that UAS 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 manned and unmanned aircraft operations in the Antarctic Treaty area.

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

This document represents the agreed information from discussions of the UAS-WG. 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 UAS within their national Antarctic programs. National Antarctic programs may include additional information on UAS deployment in their own guidelines or standard operating procedures as they see fit and as required for their specific use and area of operations.

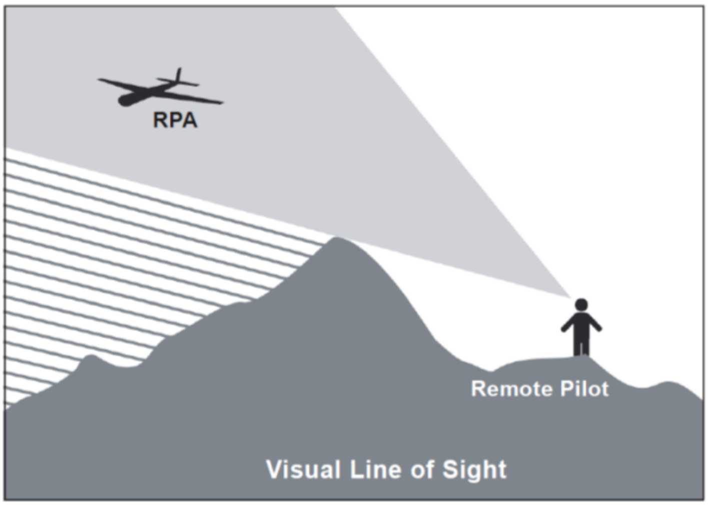
This Handbook is divided into three parts:

- **Part 1** includes introductory/general information.
- **Part 2** contains recommendations of the UAS-WG.
- **Part 3** contains appendices of various templates of common forms, such as communications plans and UAS pilot logs. These templates are provided for use by national Antarctic programs and can be modified to suit a specific UAS activity. They can then be incorporated into any national Antarctic program UAS guidelines or Operating Manuals which are specific to their operations and situations.

The COMNAP UAS Handbook should be viewed as a living document which, as UAS technology evolves, and as published research on the use of and impacts from UAS in Antarctica is made available, the recommendations and appendices are expected to evolve. Comments from any COMNAP Member organisation, on any aspect of this Handbook, would be welcomed.

LIST OF ACRONYMS

AGL – Above Ground Level
BRLOS – Beyond Radio Line-of-Sight
BVLOS – Beyond Visual Line-of-Sight
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
UAS – Unmanned Aircraft System(s)
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 UAS 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 UAS. Those with a RPA that is:

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

Most RPAs deployed in Antarctica 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 their national UAS guidelines, national Antarctic programs will utilise the size categories/class terminology as per their national legislation.

PART 1

INTRODUCTION

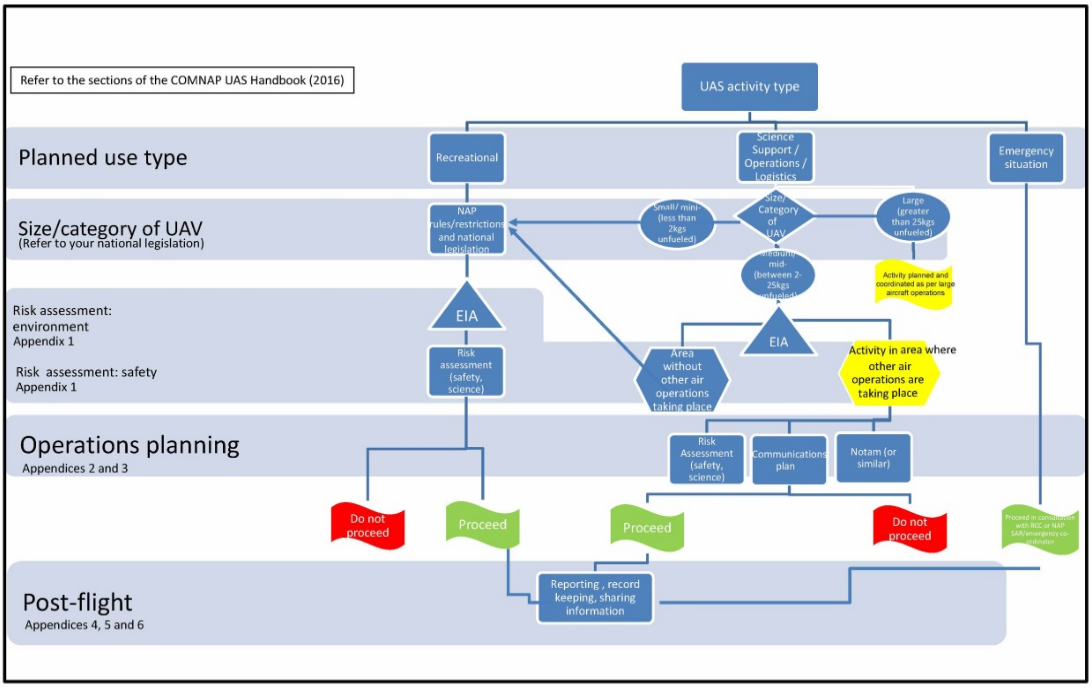
Technological advances have seen leaps in UAS capability and deployability. Most categories of UAS are now available at low cost, are lightweight and transportable. Technological advances will continue and soon any national Antarctic program, non-governmental organisation or individual will have the ability to operate a range of UAS 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 principle 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 UAS 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 UAS 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 regularly. The decision to proceed or not to proceed with a particular UAS operation is entirely a matter for the national Antarctic program.



FUTURE CONSIDERATIONS

With the lack of operational service history and certification experience with UAS, 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 UAS in the Antarctic Treaty area has not been published to a great extent, consideration should be given to published information on UAS in the Antarctic as it becomes available, including SCAR recommendations and advice on operating UAS near wildlife.

PART 2

RECOMMENDATIONS

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 manned 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. The unique characteristics of UAS mean that science and science support operations can be completed with the use of UAS which also reduces risk to human life, reduces costs and reduces impact to the Antarctic environment.

Internationally, manned aircraft operations are heavily regulated. In the case of unmanned aircraft, the international civil aviation community is currently working on the regulation of UAS operations- some countries have developed and have in place regulation, while in other countries there is little regulation of unmanned operations.

The UAS-WG has therefore made the following recommendations to assist with the activity in the Antarctic Treaty area recognising that as countries develop their own UAS regulation, national Antarctic programs must act in a manner that does not contradict their national rules and regulations.

The COMNAP UAS-WG:

1. Recommends that national Antarctic programs inform their personnel that UAS 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 UAS 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. Notes that, as with any human activity undertaken in the Antarctic Treaty area, consideration must be given to the environmental impact of the proposed UAS activity, as per the Environmental Protocol, ATCM Measures and Recommendations, and any provisions in relevant Antarctic Specially Managed Areas (ASMAs).

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

5. Strongly recommends that every national Antarctic program wishing to deploy UAS 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 UAS deployment.

6. Where practical, all major components of any UAS 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.

7. 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 manned 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 manned aircraft preforming the same or similar activity.

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

9. 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.

10. Strongly recommends that all UAS operations and all national Antarctic programs' Operations Manuals contain provisions for safe and appropriate retrieval of waste in the event the UAS suffers an accident as part of its operations.

11. 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 UAS deployments.

12. 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.

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 UAS 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
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 plans on deploying UAS as part of its Antarctic operations should include that activity in an EIA. That EIA should include waste management and recovery procedures for the safe recovery of any RPA that has crashed.

Safety of human life considerations
In many instances, UAS use provides a safe alternative to manned aircraft operations. In UAS 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 UAS in the Antarctic area is a continuously applied process that is aimed at ensuring all risks are mitigated to a low or equivalent 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	(green)	(yellow)	(red)	(red)	(red)
Remote	(green)	(green)	(yellow)	(red)	(red)
Extremely Remote	(green)	(green)	(green)	(yellow)	(red)
Extremely Improbable	(green)	(green)	(green)	(green)	(yellow)

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 unmanned system. In UAS 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 UAS activity should be communicated. In areas where there is no manned 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 manned 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 UAS 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 UAS operations prior to any planned UAS operations.

In the event of the cancelation of any planned UAS 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 **UAS 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 manned aircraft operator's schedule for the next day and weather forecasting information. By _________ (Local time) on day of flight, prior to flight, manned aircraft operators will confirm their daily flight plan(s). Review and alert all conflicts/possible conflicts. Reconsider UAS 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 VHF_____MHz ; e.g., "UAS 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., "UAS 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., "UAS 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 manned aircraft of planned UAS 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 UAS 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 UAV.]
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 UAS in the Antarctic 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

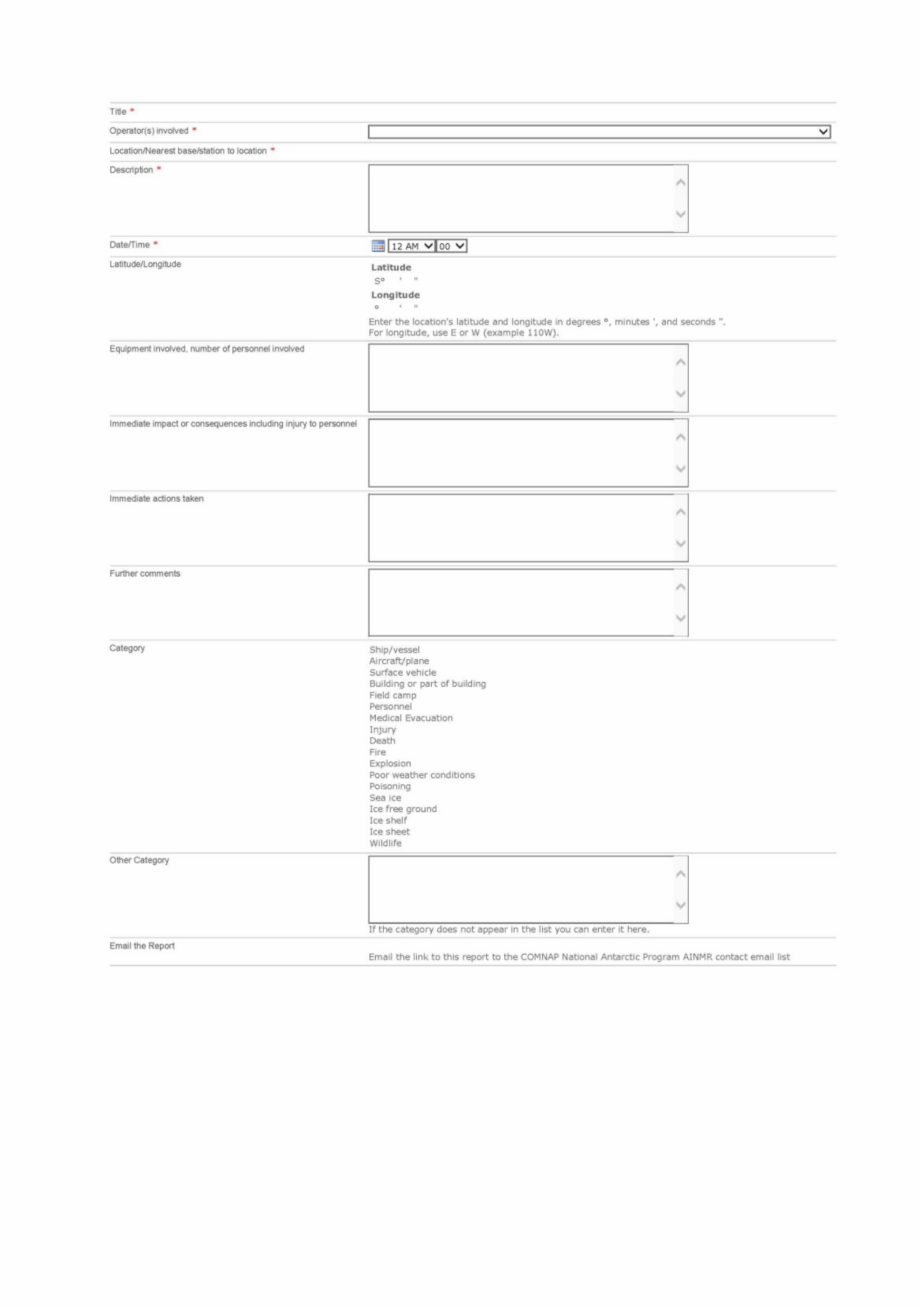
Appendix 5: Reporting, record-keeping and sharing of information-Flight Record

In order to record the flight history of all UAS operations undertaken by national Antarctic programs in the Antarctic Treaty area, a pilot should complete and submit a flight record report (Appendix 5) after the completion of each UAS flight. The flight record is specific to the aircraft flown, the payload and the mission parameters. 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
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
Time	Incidence	Time/Role/Name
Landing time		Tower notified stop time
Landing location		
Fuel consumed		
Battery charge		
Flight duration		
Distance flown		
Battery voltage		
Notes		
Signature(s)		

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

Any UAS 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 and should be considered for entry into the COMNAP AINMR system:
(https://www.comnap.aq/membersonly/AINMR/SitePages/Home.aspx).



Title *	
Operator(s) involved *	
Location/Nearest base/station to location *	
Description *	
Date/Time *	12 AM 00
Latitude/Longitude	Latitude S° ' " Longitude ° ' " Enter the location's latitude and longitude in degrees °, minutes ', and seconds ". For longitude, use E or W (example 110W).
Equipment involved, number of personnel involved	
Immediate impact or consequences including injury to personnel	
Immediate actions taken	
Further comments	
Category	Ship/vessel Aircraft/plane Surface vehicle Building or part of building Field camp Personnel Medical Evacuation Injury Death Fire Explosion Poor weather conditions Poisoning Sea ice Ice free ground Ice shelf Ice sheet Wildlife
Other Category	If the category does not appear in the list you can enter it here.
Email the Report	Email the link to this report to the COMNAP National Antarctic Program AINMR contact email list

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