Integrating Activities for Advanced Communities

D8.1 - Drone Workshop Report

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the Consortium (including the Commission Services)	
CO	Confidential, only for members of the Consortium (including the Commission Services)	

Table of Contents

Publishable Executive Summary

This document aims to provide the reader with a summary of the drone workshop that was arranged in Svalbard on October 24th 2017 for the 83 Arctic station managers engaged in INTERACT (International Network for Terrestrial Research and Monitoring in the Arctic).

The drone workshop was devoted to the researchers with the objective to teach them more about how drones and sensors could be utilized in the demanding Arctic environments they are operating in. The venue for the drone workshop, was at and near The University Center in Svalbard, UNIS, in Longyearbyen. UNIS is the center for all of Svalbard's education and polar research.

During the workshop, the participants learned basic knowledge about drone technology as well as some more advanced examples of how the technology can be used in Arctic environments. There was also a Round Robin station system with discussions on sensor technologies, future and desirable applications, and two stations that allowed all the participants to test fly different drone models on the market, both inside the warehouse at UNIS and outdoors.

The participants showed great enthusiasm during the entire workshop and a lot of excitement during the drone test flying sessions. The feed-back from the participants afterwards was very positive on how surprisingly easy they thought the drones were to operate. For some of the researchers it was the first time to operate a drone. Several new ideas were born in the break-out sessions on how technology and environmental research can benefit from each other in the future. Drone legislation was also covered in one of the sessions during the workshop.

The result from the drone workshop is presented in this report and will be developed further in Guidelines for drone usage in Arctic environment (D8.5). A drone pocket guide was developed especially for this occasion and was distributed during the workshop.

Acronyms

AGL	Above Ground Level
ATC	Air Traffic Control
BVLOS	Beyond Visual Line Of Sight
CAA	Civil Aviation Authority
CTR	Controlled Traffic Region
EVLOS	Extended Visual Line Of Sight
FPV	First Person View
GNSS	Global Navigation Satellite Systems
MTOM	Maximum Take-Off Mass
NPA	Notice of Proposed Amendment
RPAS	Remotely Piloted Aircraft System
SDR	Special Drawing Rights
UAS	Unmanned Aerial System
UAV	Unmanned Aircraft/Aerial Vehicle
VLOS	Visual Line Of Sight

1. Introduction

1.1. Background

The Swedish small-medium size enterprise Umbilical Design, is the leader of WP8, and the main organizer of the drone workshop that was arranged for station managers in Svalbard October 24th 2017. Umbilical Design is contracted by the European Space Agency, ESA, and is also working with NASA. Umbilical Design's assignment from the ESA is to oversee the transfer of technology from the space sector to industry with the overarching objective to stimulate business opportunities by exploiting the materials, technologies, methods and concepts from the space sector. Umbilical Design's partner in WP8 is ÅF. ÅF is the largest Swedish technical consultancy combining cutting-edge expertise in IT, product development, infrastructure, engineering and energy.

There are large potential benefits with using drones in Arctic research, such as efficiency in data collection and increased personal safety. Drones may also be used for transport of goods and assisting tasks.

One important aspect of arranging a drone workshop within INTERACT was to allow the researchers to exchange knowledge with industry (Umbilical Design and ÅF) to both learn of the potential of drones in environmental research, and to share ideas on future requirements to the industry to meet actual needs. The overall purpose is to see how drones can support Arctic researchers in their work. The drone workshop in Svalbard was an important milestone in WP8 in particular since it focuses on the researchers' needs and challenges they encounter in the extreme Arctic environment.

1.2. Purpose of document

This document aims to provide the reader with a basic overview of the different sessions in the drone workshop that was arranged in Svalbard on October 24th 2017. Another purpose with the document is to compile the results from the workshop.

1.3. Disclaimer

Regarding the legislation, a more extensive text is found in the Drone legislation guide (D8.2) and its referenced material. The translation of legal terms in this document is not certified as accurate by any authority and should subsequently not be used for any purpose other than guidance.

2. Basic drone knowledge

This chapter defines different kinds of drones and acronyms which were presented at the workshop and that you might encounter in the following chapters. Figure 1 illustrates some examples of the types of drones that you might encounter.

Figure 1. *Three different types of drones. From left: rotor helicopter, multirotor, and fixed-wing.*

2.1.Drone technology

A rotor helicopter usually has one single lifting rotor with two or more blades. Helicopters are generally manually controlled and usually difficult to fly.

A multirotor is a drone with more than one rotor, generally four to eight rotors. The multirotor needs an internal flight controller, a computer that makes it easier to fly the drone. It simply would be too difficult to control the thrust of all the individual rotors in order to maintain the center of gravity meanwhile controlling the different tracks and movements in all axis.

The flight controller takes all the inputs from different sensors, such as altimeters, gyroscopes, magnetometers, etc. and combines it with the input from the operator. The flight controller can also be programmed to perform an automatic flight pattern without any involved operator.

A fixed-wing aircraft must have air moving over their wings to generate lift. This means they must stay in forward motion and cannot hover in one spot in the way a helicopter can. Usually the fixed wing will give you a longer flight time for less energy. Fixed wings will generally withstand stronger wind than multirotors.

2.1.1.Make sure your equipment is in order

Batteries will lose much of their capacity when exposed to cold climates. This may result in a sudden drop of power to the motors without prior notice, resulting in a crash. Keep batteries warm until the second of take-off. Batteries can be stored inside a pocket of clothing or in insulated boxes or pouches that also might be equipped with extra heating to keep the temperature at a suitable level.

Your UAV will use a compass to navigate. The compass is particularly important for a multirotor, as it will hover in one position. High latitudes, which are common for many INTERACT stations, will alter the angle between the geographical and the magnetic north pole, which may influence the compass and sensors in your UAV. A fixed wing will maintain a continuous motion and can therefore navigate using GNSS.

Reception from the GNSS satellites can be less accurate in the polar region than in other places around the globe, but usually it should be sufficient to allow position lock. Make sure that your UAV can lock to the GNSS before take-off.

2.1.2.How to decide what drone is suitable for my tasks

In general, large drones can cost a lot of money while small drones will be cheaper. Large drones will lift heavy equipment while small ones will not. Everything is a trade-off and it is difficult to give any specific recommendations on what to choose. First of all, start by finding an answer to the question "what do you want to do"? This will hopefully tell you what type of sensor or equipment you want to carry.

Many of the commercial off the shelf drones will come with a camera and will have specific features for using it. This may not be optimal for the type of work you would like to do. Carrying of other sensors might need other types of drones that are custom made for that reason or mission.

Another aspect to consider is the redundancy required for your mission. Depending on your sensors or in what type of environment you are going to fly, different drone types can give you a better redundancy. Technically, this can be achieved by increase the rotors on a multirotor. Four rotors will not give any redundancy in an event of a rotor failure and the drone will crash. A six or eight rotor aircraft will continue to fly with one or even more rotor failures. A fixed wing will also give a sufficient redundancy to perform a controlled emergency landing without any motors as it will take advantage of the generated lift of the wings as long as it stays in a forward motion.

Flying your drone might also require a certain amount of training and even crashing.

In the end you might realize that buying a drone expert service rather than buying your own equipment is the way to continue.

2.1.3.Payload

As a very rough rule of thumb, on a multirotor drone, one gram extra weight of payload will reduce the flight time by one second.
Small drones will not be able to carry any payload apart from small light devices.

2.2.Drone vocabulary

Here follows a list of some frequently used expressions and acronyms that may require further explanation.

Visual Line Of Sight (VLOS)

VLOS means keeping the drone in visual-line-of-sight at all times. This means that you cannot fly the drone into clouds or fog, behind trees, buildings or other (even partial) obstructions. VLOS also means un-aided vision, except for prescription glasses or sunglasses, and not having to use binoculars, telescopes or zoom lenses to see the drone. Maximum VLOS is typically set to no more than 120 m vertically and 500 m horizontally. (Australian Certified UAV Operators Inc., 2014)

Extended Visual Line Of Sight (EVLOS)

This is the operating method whereby the Remote Pilot in command (PIC) relies on one or more Remote

Observers to keep the drone in visual line of sight at all times, relaying critical flight information via radio and assisting the Remote Pilot in maintaining safe separation from other aircraft (manned or unmanned). (Australian Certified UAV Operators Inc., 2014)

Beyond Visual Line Of Sight (BLVOS)
This means flying a drone without the Remote Pilot having to keep the drone in visual line of sight at all times. Instead, the Remote Pilot flies the aircraft by instruments from a Remote Pilot Station (RPS). (Australian Certified UAV Operators Inc., 2014)

First Person View (FPV)
This refers to a Remote Pilot operating a drone by reference to an on-board video camera, providing the Remote Pilot on the ground with a live ‘cockpit-view’ from the drone. (Australian Certified UAV Operators Inc., 2014)

Special Drawing Rights (SDR)
The SDR is an international reserve asset created by the IMF to supplement other reserve assets. It is often used as a “reference currency” (note that it is not a currency) for international transactions. The SDR’s value is calculated daily using a basket of five major currencies: the U.S dollar, Euro, Japanese yen, pound sterling, and the Chinese renminbi (IMF, 2017)
The currency value of the SDR is used by companies providing insurances for drones.

3. Preparing for a drone mission

The following generic checklist applies to all drone missions and was presented at the workshop. It is advised to follow this checklist as a general step in the process of preparation for flying drones.

Please note that this is an oversimplification of the procedure required to operate a drone legally. For more detailed information please see Deliverable D8.2.

Insurance	Most countries require operators to have an insurance that covers any damage or injuries that might occur as a result of a flight operation. A minimum coverage sum is usually specified
National CAA	Drone operations generally fall under the jurisdiction of a local Civil Aviation Agency, which usually provides online information about rules and permits. In cases where information is sparse or unavailable in the desired language, direct contact may be the best approach.
Restricted Areas	Obtain information on the restricted areas of the relevant region. Restricted areas usually include airports, military bases, national parks, nature reserves and densely populated areas. Acquiring aeronautical charts (or digital alternatives) is recommended.
Local Rules	Each region has its own rules and regulations regarding the use of drones. These rules must be studied and understood before engaging in any flight activities. National legislations of all countries hosting INTERACT research stations are summarized in deliverable D8.2.
Shared Rules	Formal unified rules exist to some extent; in the EU, drones with a MTOM of over 150 kg are subject to EASA rules in addition to national rules. In the near future, new EASA rules will replace national legislations in all EU member states. These rules are described in deliverable D8.2.
Commen sense	Aside from following rules and regulations, the operator must always use her/his best judgement to avoid endangering people, animals, nature and property. Avoid unsafe situations through careful planning and rigorous preparation.

3.1.Frequently occurring rules

Frequently occurring rules, found in the legislations of most countries and territories, were presented at the workshop and summarised below.

Never fly nearby an airport

Manned airports will establish a controlled airspace, which extends from surface to a specified upper limit together with positions in longitude and latitude, forming a protective "box" around the airport. This box is called Controlled Traffic Region (CTR) or control zone in US airspace class D. The CTR is controlled by the air traffic control (ATC) which will coordinate all aircrafts in that airspace. You need to coordinate with and get permission from the ATC in order to fly in a CTR. Unmanned airports usually don't have any ATC and you need to coordinate directly with any manned aircrafts and pilots that are going to use that airport. This can be all from local private licenced pilots to commercial helicopter companies providing air services.

Essential things prior to flight

Get yourself an aeronautical chart. There are online charts or apps that will show no-fly zones but you can also buy a traditional paper printed aeronautical chart.

AIP, Aeronautical Information Publication, is an essential publication, issued by or with the civil aviation authority of state which contains important information about airports, regulations, procedures and so on. Basic information like opening hours or telephone number as well as more advanced information can be found in here.

The AIP can usually be found on CAA internet homepage for the specific country.

NOTAM, Notice to Airmen, is also important information to keep track of. A NOTAM is created by government agencies and airport operators and contains for example changes in aeronautical facilities, hazards and restrictions. The NOTAM can usually also be found in the CAA internet homepage.

Insurance

Accidents involving aircrafts can be costly. An insurance covers damage to third party property or persons. Some countries legislation demands a mandatory insurance when operating drones commercially. It is important to sort this out prior to your flight.

Permission from authorities

In many countries, flying a drone for a scientific or commercial business might need a permission from civil aviation authorities (CAA). Make sure that you follow the procedures to obtain a valid license or permission. The authorization sometimes comes with a requirement to maintain a log for all flights performed.

Keep a safety distance

Rotating propellers, even on a small aircraft, may cut off your fingers. Place the drone a few meters away from people, animals or property before take-off.

Fly in a wide and open area away from people, animals and property

A falling or flying aircraft will have a lot of energy in the event of an impact.

Fly within safe altitudes

The height limits in the airspaces nearby INTERACT field stations may differ but usually no flights above 120m/400ft should be performed as this will interfere with regular, manned air traffic. Despite this, many INTERACT field stations do have regular helicopter or aircraft connectivity flying on low altitudes near ground.

Fly within line of sight (LOS)

Make sure you can see the drone with your eyes at all times. Generally, no regulatory framework on any INTERACT field station allows flying beyond visual line of sight (BVLOS), without a special permission or license.

Follow local rules and regulations

Local rules can apply to national parks, restricted areas, animal preservation areas, military areas, etc. Some of these areas can be marked in an aeronautical chart but some information needs to be obtained from elsewhere. In some countries and stations, there are exceptions for using drones for scientific research within restricted areas, which will make your life a bit easier. Just don't forget to apply for that permission.

4. Drone workshop agenda – short summaries of each session

4.1. Presentation of INTERACT WP8

Introduction of WP8 and presentation of the organizers from Umbilical Design and ÅF was given by Annelie Sule, Cecilia Hertz, Tomas Gustafsson, Tor Ericson, Maria Ader and Eskil Bendz. Annelie Sule and Tomas Gustafsson presented and guided the audience through the workshop agenda. A short inspirational video clip of what drones can be used for (a train movie) was shown.

4.2. User studies: drones in Arctic research

Some of the station managers had prior to the drone workshop responded to an online drone survey, conducted by ÅF, on use of drones in Arctic research. Maria Ader presented the outcome of the survey which was then used as input for one of the breakout sessions.

4.3. Drone facts & overview

Tomas Gustafsson presented and defined different kinds of drone models and acronyms that you might encounter when flying drones (see section 2 and 3 above). A checklist that applies to all drone missions was shared as well as a 3 minutes crash course on how to operate different drones, as a preparation for the afternoon sessions on actual test flying of drones.

4.4. Drone exhibition

Different drone models were displayed during the coffee break. The models shown in the exhibition were a few of the common available small to medium size drones from the commercial market:

- DJI Spark (https://store.dji.com/)
- DJI Phantom 4 (https://store.dji.com/)
- 3DR Solo (https://3dr.com/solo-drone/)
- a custom-made carbon fibre drone with a total wing span of about 600 mm

In addition to the drones, some of the accessories needed when flying drones were shown. During the coffee break several interesting discussions and questions were raised. There were curious questions on everything between technical details to applications on how to use the drones. The drone exhibition drew large interest and could easily have been extended in order to let all participants participate with their thoughts. Figure 2 illustrates the drone exhibition at UNIS.

Figure 2. *The indoor drone exhibition was visited by many interested INTERACT Station Managers.*

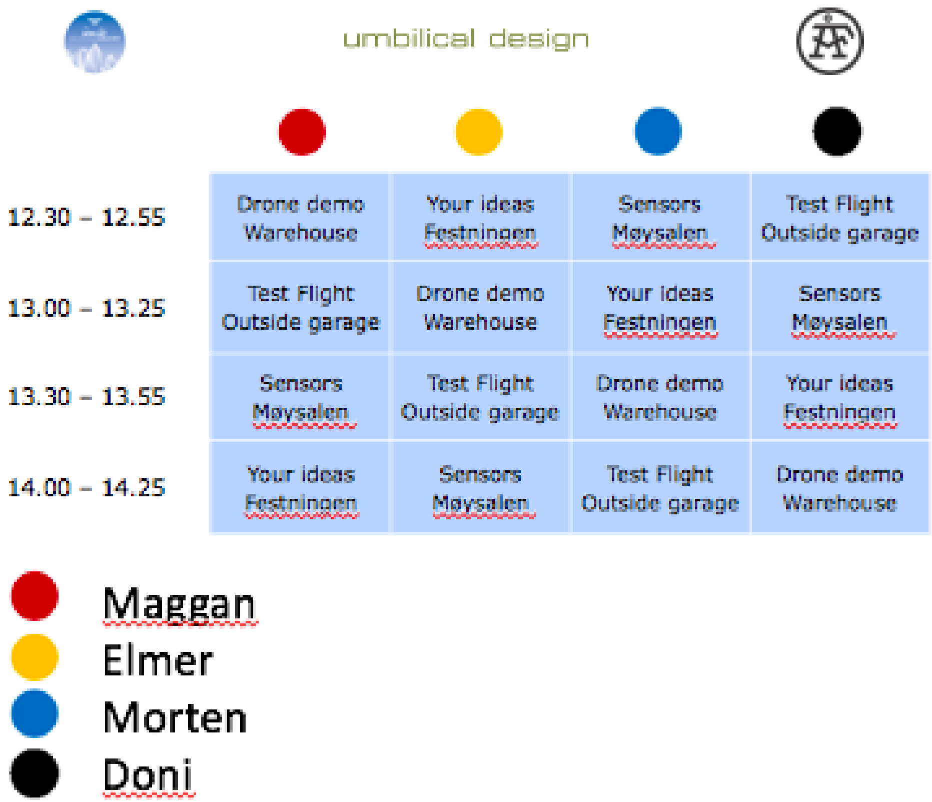
4.5.Reference case from researchers who uses drones in Arctic environments

Sara Mollie Cohen from UNIS, Svalbard, shared an inspiring presentation on the use of drones in Svalbard, and perspectives from UNIS, touching upon her and other researchers experience from flying in Svalbard, as well as showcased various very interesting projects with challenges encountered and future goals for UNIS regarding drones. In Svalbard, drones are for example used for meteorological observations, structure for motion, digital elevation models, height differencing and mapping. Drones can also be crucial out of a safety perspective, for spotting polar bears, which otherwise can be very difficult to see, in particular when there is snow or when travelling by boat or a snow mobile.

One of the challenges of operating a drone in an Arctic environment such as Svalbard is also that battery life can be cut by more than half in cold temperatures, and the drone can shut down at cold temperatures. Sara also mentioned that technical challenges might occur when operating in an Arctic environment, with resources far away, repairs, replacements, lack of WIFI and even losing GPS connections for example.

4.6.Round Robin session

Maria Ader gave Round Robin instructions and explained the activities for the different stations, also checking that everybody knew where to go. The participants were advised that the drone test flight station would be open during coffee break. Four group leaders among the participants that had been asked to take on this role prior to the drone workshop were announced. The group leaders appointed were; Margareta Johansson, Elmer Topp-Jørgensen, Doni Bretharte, and Morten Rasch. The intention with group leaders was to stimulate discussions in the groups at the different stations and also to team build among the participants, which they successfully did. Figure 3 illustrates the Round Robin scheme the participants followed, divided into four groups, each with their own group leader.



12.30 – 12.55	Drone demo Warehouse	Your ideas Festningen	Sensors Møysalen	Test Flight Outside garage
13.00 – 13.25	Test Flight Outside garage	Drone demo Warehouse	Your ideas Festningen	Sensors Møysalen
13.30 – 13.55	Sensors Møysalen	Test Flight Outside garage	Drone demo Warehouse	Your ideas Festningen
14.00 – 14.25	Your ideas Festningen	Sensors Møysalen	Test Flight Outside garage	Drone demo Warehouse

Figure 3. *Round Robin scheme including four stations (see section 4.6.1-4.6.4 for more details).*

4.6.1 Round Robin, Drone demo and flight simulator

Sara Mollie Cohen demonstrated different drone models in the warehouse at UNIS. All participants were given instructions on how to operate the drones and also the possibility to fly the drones. The exercise was much appreciated by the participants, who enjoyed operating the drones. The drone models used in the Warehouse was a Parrot AR Drone and a Parrot Bepop 2. Figure 4 illustrates test flying in the Warehouse, led by Sara Mollie Cohen from UNIS.

Figure 4. *INTERACT station managers testing drones under the supervision by Sara Mollie Cohen from UNIS.*

4.6.2 Round Robin, Test flight of drones – time to try yourself

Annelie Sule and Tomas Gustafsson guided the researchers through the test flying station outdoors, outside of UNIS. The participants got to fly two DJI Sparks and a DJI Phantom 4 and showed lots of enthusiasm and curiosity for their mission.

Although the flights were conducted in a relatively civilized area near the training facility, several of the challenges that might occur when flying drones in these environments was indeed present, including a harsh climate, and magnetic interference on navigation systems. Further the test flying was conducted within a restricted area for a commercial airport, hence coordination in the airspace was required, and a close contact was maintained with the flight tower in Longyearbyen to respect all the rules. Figure 5 and 6 illustrate the test flying outside of UNIS, led by Tomas Gustafsson and Annelie Sule.

Figure 5. *Morten Rasch, Copenhagen University, test flying a drone, model DJI Phantom 4, outside of UNIS.*

Figure 6. *Picture taken by the DJI Phantom 4, operated by Wlodek Sielski, Institute of Geophysics, Polish Academy of Sciences, outside of UNIS.*

4.6.3 Round Robin, What can you do with drones? Sensors and samplers.

This session was conducted by Eskil Bendz and Maria Ader, and focused on examples of types of drone missions that can be carried out. The purpose was to give the researchers an insight into different types of drones and samplers in order to have the researchers think about specific applications within their own field of research.

The session included the following topics:

- Standard cameras. Take photos that can construct 3D models, count animals, keep a record.
- Smart eyes. Combine stereo camera with AI to make categorize items and take immediate actions.
- Lidar. Use laser to scan an area or object and create highly detailed 3D models.
- Radar. Use radar to detect items in harsh weather conditions. Construct 3D models with Synthetic Aperture Radar. Make measurements on ice layers, snow layers, biomass, ocean currents, lake levels etc.
- Sensors under water. Apply sensors under water and have drones read out the data utilizing hydro acoustic communication.
- Water sampling. Have drones do water sampling in e.g. remote or inaccessible lakes.
- Tailoring a system of sensors. Combine miniaturized sensors on a single drone platform for e.g. measuring temperature gradients, pressure, gases etc.

4.6.4 Round Robin, What do you want to do with drones? Group discussion.

Tor Ericson hosted the group discussions around this session. Below is a summary and some fundamentals of the areas discussed.

Some opportunities of research with drones

It is important to remember that research stations in INTERACT differ a lot from each other, both in types of terrain and environment but also in what research focus they have. WP8 is called “drones in Arctic environments” but this is not one type of environment. The environments in most cases are typically Arctic with cold, snow, ice, but on Iceland for example, there are hot water spring. Some stations have forest while others do not, types of vegetation is different and so on. This causes different research questions. The following list of opportunities is therefore not shared by all research stations but some examples presented.

Opportunities shared of more than 50% of all research stations included:

- Detailed 3D mapping - Some examples were shown at the conference. Some considered a good 3D map of the environment as a future basic property of each research station. No one really disagreed but some did not have this as their highest priority.
- Count animal populations - To use a lot of images and then count animals such as reindeer, birds (in air, at cliffs, nesting etc.), seals etc. or plants where of interest for many.

- Snow coverage - Measuring snow coverage was an important feature. This could be combined with 3D mapping and also give you some snow depth. Snow density and layers of snow was only prioritised by a few.
- Vegetation mapping - Vegetation mapping and to monitor trends is of great importance for many research managers.
- Temperature measurements - In air, in water (or in the ground) on different levels
- Recurrent measurements and upscaling - The opportunity to do the measurements with drones frequently and scale up some precision instrument results in one place and see the changes, was mentioned by many.

Opportunities shared of more than 25% of all research stations:

- Collect samples of air, water, soil/mud/gravel and trees - Drones can make non-invasive sampling possible and introduce less impact on the environment, they introduce the possibility to access hard-to-reach places such as the middle of a lake, mountain slopes, air 30m up etc. Water samples seem to be the most interesting, air less and mud/gravel/soil (approx. 30ml) and tree samples was only mentioned by a few, likely because it is obviously a little bit harder to achieve with a drone.
- Mount/place sensors in places difficult to access for humans - There are problems today with placing sensors but also with fetching data from sensors placed on mountain slopes etc. Drones could be adapted to place the sensors but also to wirelessly receive sensor data and bring it back home.
- Spectral measurements - Mainly for vegetation mapping
- Radar measurements - Mainly ground radar measurements are done today but other types of radar applications were discussed, for example inspecting a glacier.
- Measure greenhouse gas fluxes - There are a lot of different gases that are measured today. Among them CO_2.
- Heat camera
- Safety - See the scene or inspect dangerous places, look out for polar bears, send rescue material.
- Marketing videos - Drones give you a good overview of the scene, the research area and more.

Other opportunities that were mentioned in the discussions:

- Follow tagged animals or find equipment - An example with fish that have radio tags was mentioned, as well as problems with small equipment placed in difficult surroundings (especially in water), those could be difficult to find. Example given with small optical sensors in water with a small floating device. The ice can make this whole setup change position when you try to find it.
- Measure water salinity
- Measure (changing) “bottom” of water streams
- Laser emitting light and sensor measuring fluorescence created
- Send or receive goods to teams out in the field
- Send drone to see what students are doing instead of going there yourself ;-)
- Monitor snow avalanche
- High mountain slope morphology

- Topoclimate in relation to relief
- Micro-topography changes due to climate change
- GHG fluxes
- Flooding – high resolution aerial photograph

Do you use drones today?
There were very few stations that used drones today for scientific purposes. Several stations (approx. 1/3) had an enthusiast using a standard drone for photography/video and similar.

Challenges experienced within INTERACT community?
- Know-how of how to use drones
- Where to invest the money - What type of kit is best to start with. How should we plan for drone usage?
- Do not want to lose the money - How big are the risks that we lose our investment. Drones crash….
- Regulations - These limit what you are allowed to do, but since we do not know today what the rules are, we do not use drones.
- GPS problems - We have heard about a lot of strange behaviours close to the poles. Likely due to poor GPS coverage and magnetic compass problems but also the tough environment.
- Short flying time /area coverage - A standard quadcopter has a short flying time and fixed wings are more difficult to handle today. Are the drones good enough for us? How much area will we cover in 15 minutes?
- Things look different from the air - Plants, vegetation etc. looks different from the air than from the ground. This is an opportunity because you can see more but also a problem to interpret pictures.
- Overall, how to train an object recognition system?
- If goods are sent, how will they be received and how can the flight be controlled?
- Could it be a problem that some people use drones for hunting and scaring animals?
- How to handle all the data - OK, we have a lot of data from the drones. How shall we manage that data?
- Software that handles the data can be too expensive. These can be double the price of the drone.

Identified needs from the INTERACT Community
- Overview – How to get started with using drones for research purposes. We need an overview, step by step guide to start using drones including:
  - Some standard drone setups for some purposes
  - Management of drone data
- Standards for sensors (weight, connection, power etc.) - Many scientists are good at making their own sensors. But what are the requirements for such a sensor to fit to a typical drone.
- What standard sensors are available? A list of some standard sensors that fits some drone platform would be very good.

4.7. Recap activities

Tor Ericson and Tomas Gustafsson summarized take away messages and other inputs in plenum from the different stations.

4.8. Drone legislation

Maria Ader presented the session on drone legislation (see Section 3). Almost all countries have laws and regulations concerning the use of drones. It is crucial to be aware of local regulations before engaging in any drone operations. Regarding the legislation, a more extensive text is found in the Drone legislation guide (D8.2).

The general procedure:

- Most countries require drone operators to have insurance.
- Drone operators must follow the rules of a national Civil Aviation Agency as well as other authorities, such as the European Aviation Safety Agency.
- It is also important to always practice common sense, especially regarding safety, even in the absence of rules.

Some general rules that are shared by many countries and regions:

- Never fly nearby an airport or other restricted areas.
- Keep a safe distance to people, animals and property.
- Fly within safe altitudes, usually below 120 m/400 ft.
- Fly within visual line of sight.

The amount of information available, and the intelligibility of that information, varies greatly between different countries. Some countries provide user-centered websites in multiple language (such as Finland), while others do not provide a clear overview of rules or certificate processes, or do so in just one language (Poland, Russia).

One identified obstacle for applying drones in research activities is the general and local legislation related to flying drones. Laws and regulations differ between countries and thus it might be troublesome for a researcher from one country to be aware of and prepare for applicable legislation in another country where research is about to take place.

4.9. Reference case from Russian station

Tatiana Kolesnikova, Manager of BioClimLand Centre of excellence, National Tomsk State University, shared her and the station’s experience from operating drones in Russia. Tatiana also highlighted the importance of trans-disciplinary research. The presentation focused on the use of drones to enhance transdisciplinary, and producing society-relevant knowledge.

4.10.ESA Business applications

Cecilia Hertz presented funding opportunities through ESA Business Applications who has a “Kick-start activity”, themed: Arctic and Sub-Arctic regions, and Commercial Climate Services, where interesting funding opportunities could arise for station managers in INTERACT. More information and details on these funding opportunities are available under Business applications on the website of European Space Agency, ESA (www.esa.int/ESA).

4.11.Wrap-up summary & next step

Annelie Sule wrapped-up the drone workshop day and advertised for the upcoming TA user Drone webinar due 30th January 2018. It was also highlighted that this drone workshop that was very well attended by many INTERACT Station Managers (Figure 7) also had attracted global attention from North America and Europe, from other researchers and drone enterprises, which could lead to interesting synergies and new collaborations in the future. The aim for a next step is to create value and innovation for Arctic research and facilitate the researchers' important work in the Arctic region.

Figure 7. *Drone workshop participants outside of UNIS.*

Tomas Gustafsson also highlighted the drone operator education in Ljungbyhed which could be an interesting collaboration opportunity for the participants, as the students will have at least one period with several weeks of workplace practise. This means that there might be an opportunity for researchers to use the students' practical knowledge during 2018 and onward. Detailed information about this opportunity is provided by ÅF.

A handy document, Drones pocket guide; where to start and how to continue, was compiled for this drone workshop, and was distributed to all the participants, which easily summarizes both technology and laws that might be useful to look through before a drone flight.

The drone workshop organizers were very pleased with the outcome of the workshop (Figure 9).

Figure 8. *A Drones pocket guide were produced for the workshop and provided to all participants.*

Figure 9. *The drone workshop organizing team. From left: Eskil Bendz, Tor Ericson, Tomas Gustafsson, Cecilia Hertz, Maria Ader and Annelie Sule.*

5. References

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