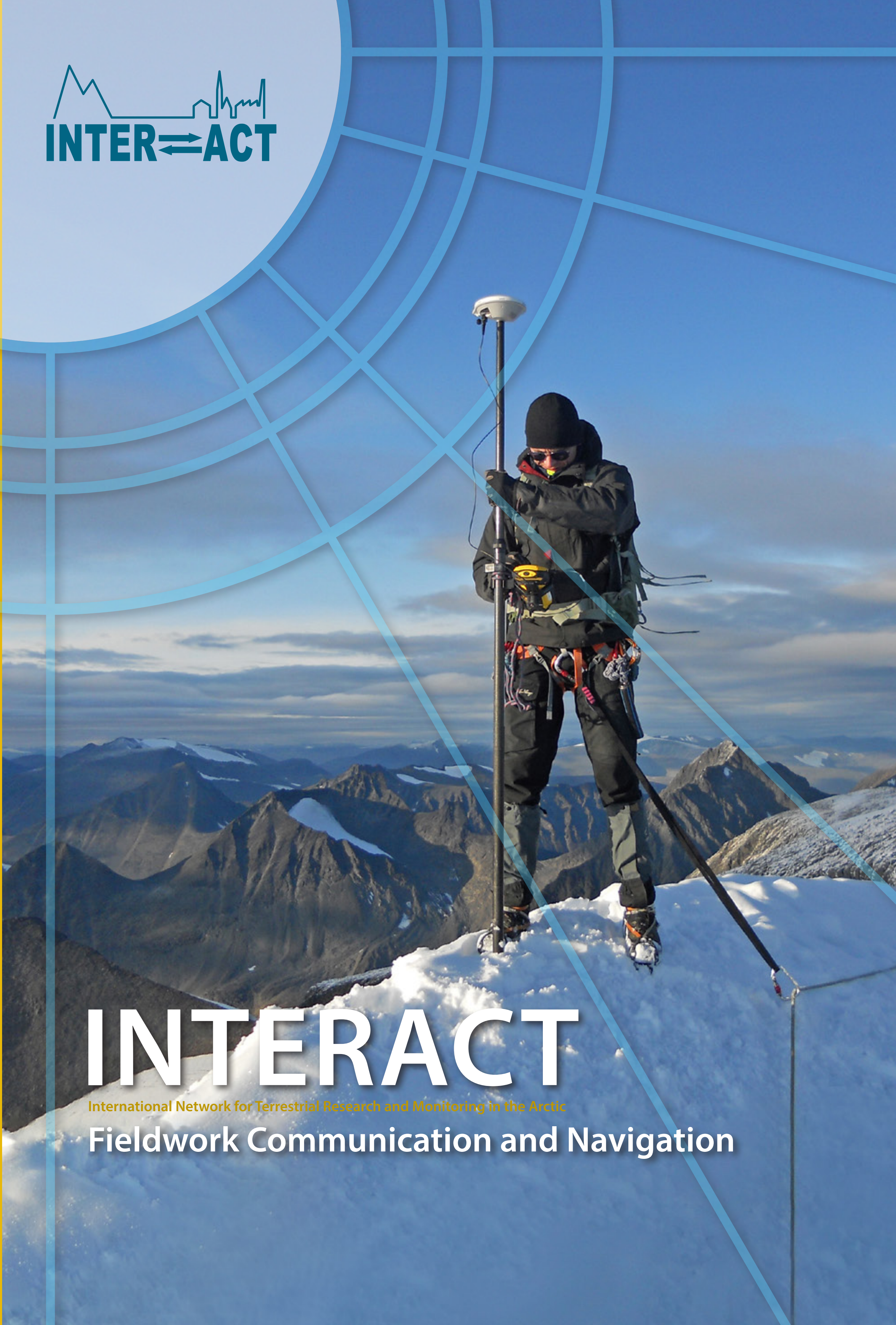

INTERACT

International Network for Terrestrial Research and Monitoring in the Arctic

Fieldwork Communication and Navigation

INTERACT Fieldwork Communication and Navigation

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Eds.: Andrea Schneider *et al.*

INTERACT

Fieldwork Communication and Navigation

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INTERACT

Photo: Lisa Grosfeld

Contents

About this guidebook

When preparing for fieldwork, there is a wealth of things to keep in mind and to make decisions about. Communication and navigation are essential elements of conducting science in cold and remote areas of the world. Therefore, INTERACT and APECS have joined forces to initiate a collection of recommendations and handy tips. This guidebook aims at increasing your understanding of fieldwork-related communication and navigation to make your fieldwork experience safe and successful.

In this guidebook, we compare different types of devices to ease equipment choices and match them with individual researcher needs. This includes comparisons of advantages and disadvantages of the different devices, and recommendations about which device works best in which situations. We also offer an overview of parameters such as estimated costs, coverage range, portability, reliability, accuracy, ease of use and much more that can be useful when choosing the right communication and navigation equipment.

The primary target group for the book is scientists working out of arctic research stations. The book can however also be of help to other scientists working in the Arctic, to tourist guides and to more adventurous travelers. Most of the information is not only relevant for the Arctic but also for Antarctica and mountainous areas around the globe.

The guidebook is closely linked with other INTERACT publications such as the *INTERACT Management Planning* handbook, the *INTERACT Fieldwork Planning Handbook* and the *INTERACT Practical Field Guide*.

Disclaimer: *This book is not intended to replace proper training. Its purpose is solely to serve as a handy resource to remind you about communication and navigation aspects related to fieldwork in arctic and alpine regions. INTERACT and APECS take no responsibility for its content or for actions that you may take as a result. In case you discover any discrepancies between the advice provided in this book and possible safety regulations stipulated by your workplace you should always follow the rules of your workplace.*

1 Importance of communication and navigation

Photo: Andrea Schneider

Due to the harsh physical environment and remoteness of the Arctic, small issues can rapidly escalate into serious and dangerous situations. Being able to make good decisions is important to staying safe. Good equipment choices and adhering to established procedures, guidelines and checklists are essential to minimise the risk of accidents and potential expensive Search and Rescue (SAR) operations (see *INTERACT Management Planning* handbook, p. 35). That is why good communication and navigation practices are crucial in the Arctic.

Box 1.1 Be cautious

Consider behaving as you would do if you did not have any communication and navigation technology to rely on while in the field. Do not take safety for granted or rest on thoughts like '*Things only go sideways for others*' or '*Nothing ever happened to me during past field projects*' or '*The others will know, they have been here/done this before*'. Instead, develop a mentality of "*Stop, Think, Plan*" before you act.

HANDY TIP

You can find more information on first aid procedures, emergency protocols, practical equipment lists and safety in the *INTERACT Practical Field Guide*. Chapter 3 of the *INTERACT Fieldwork Planning Handbook* gives you valuable information on risk assessment and on how to develop your 'fieldwork mindset' and situational awareness.

Why is communication important?

Safety aspects

Fieldwork can be challenging or even dangerous, especially in remote areas with limited infrastructure. For safety reasons, it is crucial that team members and host stations have up-to-date information about e.g. weather, challenging terrain and changes to fieldwork plans. Communication between station staff and field teams before, during and after fieldwork is therefore crucial. It is needed for the field teams to plan their activities, for the stations to provide the support needed to ensure the safety of teams in the field and as feedback to help prepare future outings.

While communication is essential to prepare for potential hazards and changing conditions, it is also essential to resolve incidents. If something happens, it is important to communicate clearly to station staff or rescue personnel what happened, where the group or person affected currently is located (geographical coordinates), and what kind of help is needed. Station staff and SAR personnel often have in-depth knowledge of the local environment and can provide life-saving recommendations. It is therefore important that field teams are capable of realising when they need assistance and that they are not too proud to make contact. Time is a crucial factor for staying safe in the Arctic.

Work efficiency

Before heading out, all team members should be aware of the fieldwork plans, the potential hazards they may encounter and how to mitigate these.

While in the field rely on up-to-date information to make decisions about fieldwork plans and safety aspects. This relates to the whereabouts of a group and regular check-ins, but it can also relate to more complex situations. For example, communication is helpful for any unforeseen issues such as polar bear sightings, damage or loss of equipment, sudden weather changes or terrain being very different from what was expected.

Good working relationships

Good communication is important for keeping everyone safe, ensuring productivity as well as maintaining good working relationships. Lack of communication and awareness may translate into safety issues, poor work progress, unmotivated team members and disagreements. It is much easier to prevent such things from happening than to resolve situations arising from poor communication. Hence, it is important for research stations and their visiting scientists to establish and follow simple, clear and regular communication procedures. It is also good practice and a matter of courtesy to have good communication in the field – among team members, between the team and the host station, and other contacts outside the field.

Inherent in arctic fieldwork is people being in places and situations that are new to them, such as staying at a remote place for weeks to months with long working days in changing weather conditions and without having the comforts of home and the support of family and friends. This can be challenging for everyone. Good communication is open, honest and non-judgmental. It can help prevent or overcome all sorts of challenges, help team members in adjusting to everyday fieldwork life, and help maintain a positive mood to ensure you make good memories for life whilst yielding productive outcomes.

It is important to communicate with your team members and/or the host station or other support personnel about:

- Changes in the weather.
- Changes to your field schedule (time/location).
- Differences to expected terrain conditions (e.g. river level, snow volumes, avalanche risks, crevasses, etc.).

- Loss or failure of any instrument or equipment, including safety equipment.
- Important wildlife sightings (polar bears or their traces, injured or dead animals).
- Environmental impacts (chemical or fuel spills, uncontrolled fire, etc.).
- Changes in the health condition of any team member.

Talk in advance about the different roles in the team and who possesses relevant skills in the team? For example, who is making sample lists, who takes care of scheduled communication and who shares polar bear guarding. It is also good to know who has special skills or experiences that exceed the common fieldwork preparation (e.g. climbing experience, river crossing, special snow knowledge or avalanche rescue training, more advanced first aid training, firefighter training, local language, etc.). The roles of the group leader and co-leader, and special skills or experiences of team members should be known and agreed upon early in the fieldwork planning phase.

Box 1.2 Good and poor communication

Poor communication can create unsafe working conditions, create an unnecessary sense of urgency, lower productivity and decrease the quality of work, lead to unsatisfied team members and cause tension and stress. It can also cause you to be overworked and to make potentially unsafe decisions. Poor communication can create a sense of distrust among team members, while poor communication with your home station or other support personnel outside the field can cause confusion, reduced work efficiency, irritation and disagreements. Poor communication includes:

- Not really listening.
- Passive-aggressive communication and sarcasm (appearing to have listened, but not doing the agreed task).
- Aggressive communication (hostile communication, such as name-calling and belittling team members, attacking someone's personality or character).
- One-way communication (not allowing others to have their say).
- Too little communication (not providing enough information).
- Controlling communication (giving commands instead of engaging in meaningful exchanges).
- Disrespectful communication (ignoring team member's feelings).


Photo: Konyaev Sergey

Good communication ensures that everyone feels as part of the team, works well together, are happy, amenable and bears no grudges. This translates into a safe work environment, a productive team and a positive mood. Good communication requires:

- Engaged listening, i.e. listening and making the other person(s) feel heard and understood.
- Paying attention when someone is speaking with you. Asking for clarification if something is unclear.
- If an important topic is brought to you while you are busy with another task, agree on a suitable time and place to take up the topic.
- Being empathetic and seeing (or trying to see) your team member's point of view. Being open minded is important.
- Encouraging your team members to voice their concerns in open debate that is free of criticism, judgement and ridicule.
- Taking an interest in your team members' lives, but remember to remain professional.
- Remaining friendly and respectful when someone else is speaking.
- Paying attention to body language. Non-verbal cues are as important as verbal communication (but do not expect that people can always interpret your body language – it is better to speak up).
- Asking (clarifying) questions when something is not clear to you or to others in the team to seek a common understanding.
- Communicating clearly and being willing to compromise.

Why are good navigation practices important?

At a remote location, communication and navigation go hand in hand. While communication helps to inform, discuss and find solutions, navigation helps us to know where we are, where our 'home' during fieldwork is and where our study sites are. A range of navigation devices and methods supports us in doing so. Knowing about different navigation tools and their advantages and disadvantages helps to select the best option and spend our time learning to use them. Training on how to use and maintain the devices is of vital importance, as it contributes to effective communication and safe navigation.

Figure 1.1 Different devices for communication and navigation. Upper row from left to right: VHF radios, InReach, Iridium phone, Personal Locator Beacon and GPS. Lower row: Map and and ruler, compas and mobile phone. Photo: Morten Rasch.

Finding the best and safest route requires navigation skills and knowledge of the local environment. Knowing where you are and how to get to your destination is essential for all fieldwork in the Arctic and crucial if something goes wrong. If you are not able to make it to a safe place and you need assistance, you must also be able to communicate your exact location to station staff and/or support/rescue personnel.

HANDY TIP

- You must rely on yourself when in the field – do not rely on others and do not rely completely on battery-powered technology (always bring a map and a compass and know how to use it).
- It is a good idea to always know where you are, and where you are going. You need to know where your base is in relation to your study site(s) and how to navigate back 'home' (for example by entering your home base and your study sites as waypoints in your GPS and on your physical map).
- Not all communication systems and navigation devices will work equally well everywhere – know which works the best in your fieldwork area.
- Similarly, you need to know how to navigate across unfavorable terrain and in unfavorable weather conditions. This kind of navigation requires an up-to-date knowledge of the specific area, relevant skills among team members and appropriate navigation devices.

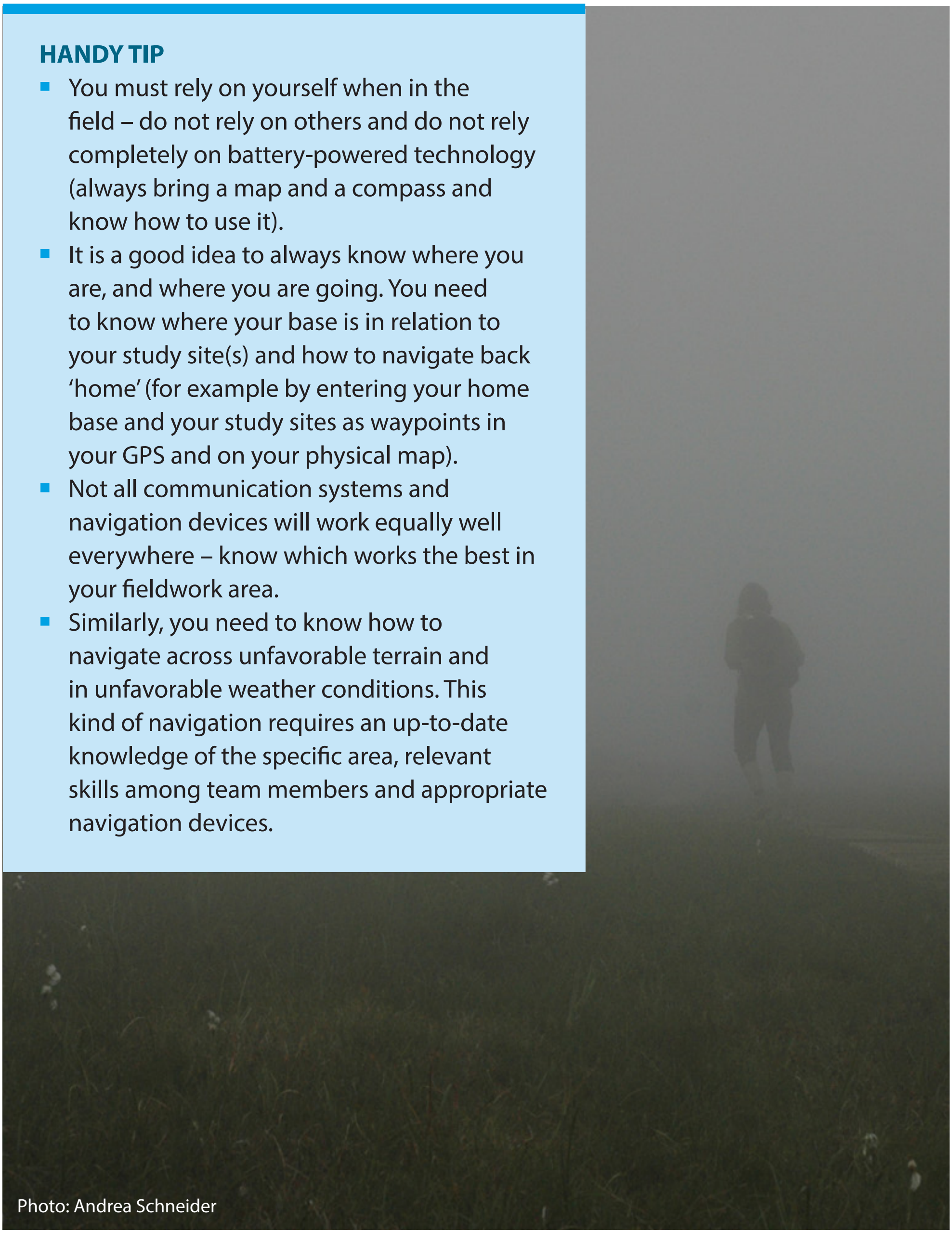


Photo: Andrea Schneider

Communication and navigation challenges at high latitudes

Knowing of the challenges related to communication and navigation in the Arctic is important when selecting appropriate devices. Geographical location, weather, remoteness and limits of available technology require field teams to assess their needs and the specifications of communication and navigation technologies.

- Rough weather (e.g. low temperatures, frequent storms with high wind speeds, snow storms) can lead to reduced visibility/poor contrast and/or elevated avalanche risk on a previously safe route after e.g. a heavy snowfall. Read more on rough weather in Box 1.3.
- Difficult to traverse terrain may change the planned travel route (e.g. crevasses on a glacier, river crossings, frozen lakes or sea, steep rocky or snowy terrain, swamps/bogs). This means that you might need to find and agree on a new safe route. Always let your host research station know about your changes of route.
- Poorly mapped areas and unknown terrain are normal in some parts of the Arctic. This may require an unexpected change in your travel route.
- Darkness and snowy weather may reduce visibility.

Photo: Andrea Schneider

- You might need to wear bulky, heavy and unfamiliar clothing. It is important that your clothing fits well and you get used to wearing it and know your limits (you may get tired faster than usual).
- Batteries consume much more energy in the cold, dramatically reducing battery life. Hence, it is a good idea to keep all batteries warm (e.g. close to your body) and bring spares. Batteries rely on chemical reactions, and cold temperatures can slow or even stop those reactions, making your battery unusable. **Handy tip**: Do not attempt to recharge a frozen battery. You can cause irreparable harm to it by doing so. Wait until you are in a warm area, where the battery can be warmed up to room temperature.
- Touch screens and gloves do not always cooperate well. You could consider 'screen gloves' that are made of special material at the fingertips, allowing you to keep your gloves on while using a touch screen.
- Not all communication and navigation devices will work everywhere – know which do in your study area and be aware of any potential limitations.
- Remote areas with large distances and poor or missing road infrastructure makes emergency response operations more resource and time-consuming. Reliable communication and accurate positioning are therefore crucial for SAR operations.

Box 1.3 Arctic climate and weather

Arctic climate

- Air temperatures in the Arctic are characterised by very high regional and seasonal variability.
- Very low temperatures may be reached during winter. For instance, the January mean air temperature is less than –40°C in some regions in Siberia and ranges from –32°C to –25°C over the Central Arctic Ocean.
- Although summer temperatures are milder, they can be relatively harsh in some places. The July mean air temperature normally ranges from 10°C to 20°C over land without snow cover, whereas it is close to 0°C above the Central Arctic Ocean.
- The cold you actually feel is a combination of the actual air temperature and the cooling effects of wind and air humidity. You should therefore always bring a Wind Chill Factor Chart as part of your field equipment.

Weather hazards

Weather in the Arctic can be local and unpredictable, and if you are away on fieldwork you must therefore pay close attention to any changes in the weather conditions. Weather hazards in the Arctic include strong winds, heavy snow showers, blizzards, freezing rain, icing and fog. Some meteorological phenomena associated with severe weather are:

- **Cyclones** (also known as migratory low pressures) develop in the Arctic all year round, although the frequency of cyclones varies with the season and the region. Cyclones can be associated with very strong winds. For instance, the east coast of Baffin Island can experience winds speeds of more than 160 km/h, i.e. 45 m/s.
- **Polar lows** are short-lived intense maritime cyclones of between 200 and 1,000 km in diameter. They are associated with strong winds (more than 55 km/h, i.e. 15 m/s), which can reach hurricane force, result in large waves and heavy snow showers. Calm weather can turn into strong winds. In less than 10 minutes, horizontal visibility can decrease to less than 100 m. There is a high risk of icing on ships, and large amounts of snow increase the avalanche risk.
- **Katabatic winds** Areas near ice sheets and large glaciers in Greenland experiences katabatic winds, which are downslope winds flowing out from cold surfaces, larger glaciers and the Greenland Ice Sheet. Similar winds can occur around larger ice caps in e.g. Iceland. Along the south-eastern coast of Greenland, these winds are known as 'Piteraqs'. This phenomenon is associated with strong winds, which can reach hurricane-force (> 33 m/s wind speeds), with a temperature drop and icing on ships.
- **Föhn winds** (also known as Chinook) are very strong and warm winds, starting very fast. A typical Föhn situation will result in a rise in temperature of ten degrees or more and wind speeds of more or much more than 20 m/s. Föhn winds will often lead to extensive snow melt and increase the risk for snow avalanches.

2 Fieldwork communication

Photo: Katrine Raundrup

Before Fieldwork

Fieldwork plans

Provide a fieldwork plan and ensure that the station, or other local contact(s), your home institute and your group are fully aware of it. Such a plan should include names of the group members involved, planned fieldwork locations and travel route, means of transportation, expected time of departure and return, communication plan, risk assessment, a list of communication and navigation equipment as well as safety and emergency equipment.

If you do not have a local contact, leave your fieldwork plan at your last accommodation and inform someone at your home institution to react if you do not follow an agreed communication schedule. It is crucial that you report back to your local contact, home institute or the like when you return from fieldwork to avoid Search and Rescue (SAR) to be set in motion.

Checklists

Checklists are often used in stressful situations (e.g. aviation, military) to reduce errors and/or to remember important things. They can also be used to share procedures among people, e.g. you and your research team. As a busy scientist under time pressure to collect all your samples and data in an environment different from home, you may also benefit from such lists. The *INTERACT Fieldwork Planning Handbook* and the *INTERACT Practical Field Guide* have good standard checklists for equipment and other things to remember.

Daily briefings

Start every fieldwork day with a briefing led by the group leader or another experienced person. If you are working out of a research station, daily briefings are often part of the routines, and the station manager or other staff is likely to lead the briefings. It is critical that all members of your group take part in the briefing, so they know the plan for the day and understand the challenges involved. It is important that they are given the opportunity to ask any questions. Never assume everyone is on the same page.

If you start the fieldwork day very early, a detailed briefing can be made during the evening before the fieldwork, e.g. when the group comes together around dinnertime. However, you should still reserve time for a short briefing at the start of the next day, as weather forecast or other relevant information may have changed overnight.

Figure 2.1 It is always a good idea to gather the group for a short meeting about the plans for the day before heading out. Photo: Guido Grosse.

Discussion points for daily briefings:

Plan for the day:

- Discuss the route to your destination and back, including approximate distance and potential terrain challenges (crevasses, river crossings, steep terrain, sea ice, etc.).
- Discuss what incident necessitates a change of plans and who is responsible for taking the decision.
- Discuss what to do in case of an emergency.

Equipment:

- Make sure that you bring all relevant safety and emergency equipment, and make sure that everyone knows who carries what equipment.
- Ensure that every member of the group brings along extra warm clothing, sufficient food and drinks and any special equipment if needed (e.g. sea ice spikes, gloves and/or helmet).
- Ensure that all necessary scientific equipment is prepared and packed.

Communication:

- Ensure that all group members are aware of where to find contact information for the designated local contact(s) and emergency contact(s).
- Identify one or two team members responsible for keeping track of scheduled routine calls, e.g. the group leader and a co-lead, and reporting relevant news back to the group.
- Identify one person responsible for emergency calls, and have alternatives if this person is incapacitated. Make sure that all team members know relevant communication devices and what should be communicated in case of emergencies, i.e.:
    - Who are you?
    - Where are you?
    - What has happened?
    - What kind of help do you think you need?
    - Be ready to answer any questions station staff or rescue personnel may have.

Weather:

- Always keep an eye on the weather conditions and forecasts. Keep in mind that the weather may be highly variable throughout the day and pack accordingly.
- Remember that the closest weather station may be some distance away, and therefore may be experiencing quite different conditions to where you are.
- Agree on the weather conditions that will make an end to the fieldwork for the day.

Fieldwork risks:

- Before heading out, you should make a risk assessment. This should be done together with station staff or others familiar with the local landscape and hazards.
- Inform team members about relevant potential hazards before heading to the field site. The *INTERACT Fieldwork Planning Handbook* and the *INTERACT Practical Field Guide* summarise the best practices and recommended equipment for working in challenging environments, such as on sea ice, in steep terrain, on glaciers with crevasses, in cold weather, in polar bear risk areas, etc.
- Agree on when to use toolbox meetings, i.e. short meeting in the group before doing something challenging, see page 19.

Group whereabouts: Sign out/in procedures

Local sign in/out procedures are slightly different at different INTERACT stations and at other accommodation facilities. Make sure you understand the local procedures and adhere to them. The most important points to note are:

- The names of all team members.
- The departure time.
- Where you intend to go.
- What time you expect to return.
- If possible, relevant information about how to contact you.

Remember to sign in again when you get back.

HANDY TIP
Read more about communication with visitors at research stations and find practical examples in the *INTERACT Management Planning* handbook, p. 63 (general information on communication with visitors at stations), p. 112-113 (example and discussion points for a fieldwork preparation meeting and communication in the field) and p. 138-141 (example of health af safety policy for Research Station Samoylov Island, Russia).


Photo: Morten Rasch

During fieldwork

Briefings
Upon arrival to the field site, the group should be gathered for a briefing. This is the perfect opportunity to check that all team members are feeling well and warm enough after travel.

It is then important to remind the group of the plan for the day, including an overview of the tasks, any planned breaks, planned routine calls, polar bear watch schedules, anticipated time of departure and another overview of the potential risks.

Toolbox meetings
Toolbox meetings are short consultations that can be used before specific tasks that may be risky, e.g. glacier or sea ice crossing on snowmobiles, traversing a steep slope or moving through avalanche terrain. The purpose of toolbox meetings is to make everyone in the group aware of the upcoming tasks, risks, responsibilities and procedures. They are used to refresh everyone's memory, cover last minute safety checks and exchange information with more experienced members of the field party.

Here is an example of what a toolbox meeting could include:
- Gather your group.
- Explain the tasks, risks, responsibilities and procedures.
- Put on safety gear if relevant (e.g. helmets, ropes, etc.).
- Remind the group about who carries safety and emergency gear.
- Explain what to do if something goes wrong.

- If the group splits up or moves one by one across difficult terrain, agree on a meeting place to gather after passing the difficult terrain.
- Give everyone a chance to speak up, ask questions and/or mention doubts.

Routine calls

It is important to have a method for checking in with the research station or other primary contacts on a regular basis to be agreed upon with them beforehand, e.g. as part of the fieldwork plan. Schedule your calls at specific time(s) every day, upon arrival at a site, when leaving a site, etc. Appointing two people, e.g. the group leader and a co-lead, who keep track of scheduled routine calls is a good idea. Routine calls are a good time to receive updates about weather and snow conditions, polar bear sightings, etc. Remember to communicate relevant news to other team members.

Non-scheduled calls

Non-scheduled calls are used to inform your contact person of changes in plans or other questions:

- If you need assistance for safety or medical reasons.
- Delays in scheduled arrival due to deteriorating weather or other unforeseen events.
- Deviations from the planned travel route for any reason.

Emergency calls

In the event of an emergency, the team should follow an agreed emergency protocol (see the inner book flap of the *INTERACT Practical Field Guide* for an example).

When the risk of further injuries has been prevented, the team leader(s) should get an overview of the situation, gather relevant information and immediately contact relevant emergency contact(s), e.g. station staff, SAR personnel or Police.

In phone calls, be prepared to answer questions like:

- Who are you?
- Where are you?
- What happened?
- Are people injured?
- What type of injuries have occurred?
- What help do you think you need?

You may want to have team members around you to help answer questions and follow instructions.

The Phonetic Alphabet

You can use a phonetic alphabet to clarify communication. It ensures that letters are clearly understood, even when speech is distorted or hard to hear. This can be a great asset in the field, when communication channels are poor, when you find yourself in much background noise or when you talk with someone with a strong accent. Using a phonetic alphabet can help to prevent miscommunication issues.

In order to communicate with the phonetic alphabet you simply spell out each word you are saying letter by letter and by using the code words as shown below. The alphabet below (Table 2.1) is known as the NATO phonetic alphabet, and it is used to spell out the English alphabet. Table 2.2 shows how you would spell out numbers phonetically. As using the phonetic alphabet takes time, you may choose to use it only for single words or numbers being especially important in relation to the message you want to get through.

Table 2.1 The NATO Phonetic Alphabet and associated code words.

A	Alpha (AL-FAH)	N	November (NO-VEM-BER)
B	Bravo (BRAH-VOH)	O	Oscar (OSS-CAR)
C	Charlie (CHAR-LEE)	P	Papa (PAH-PAH)
D	Delta (DELL-TAH)	Q	Quebec (KEH-BECK)
E	Echo (ECK-OH)	R	Romeo (ROW-ME-OH)
F	Foxtrot (FOKS-TROT)	S	Sierra (SEE-AIR-AH)
G	Golf (GOLF)	T	Tango (TANG-GO)
H	Hotel (HO-TELL)	U	Uniform (YOU-NEE-FORM)
I	India (IN-DEE-AH)	V	Victor (VIK-TAH)
J	Juliet (JEW-LEE-ET)	W	Whiskey (WISS-KEY)
K	Kilo (KEY-LOH)	X	X-Ray (ECKS-RAY)
L	Lima (LEE-MAH)	Y	Yankee (YANG-KEY)
M	Mike (MIKE)	Z	Zulu (ZOO-LOO)

Table 2.2 Numbers spoken phonetically.

1	One (Wun)	7	Seven (Sev-en)
2	Two (Too)	8	Eight (Ait)
3	Three (Tree)	9	Nine (Ni-ner)
4	Four (Fa-war)	0	Zero (Zee-ro)
5	Five (Fife)	100	Hundred (Hun-dred)
6	Six (Six)	1000	Thousand (Tou-sand)

If communication takes place by VHF radio or a similar communication device only allowing for one speaking at a time, it is a good idea to use a proper radio communication protocol, such as 'OVER' or 'GO' to indicate that you are done speaking, 'Affirmative' to indicate 'Yes', 'R' or 'Roger' to indicate OK, and 'Negative' or 'N' to indicate 'No'. When you call someone, use the sentence: '[Name of the person you call], [Name of the person you call], [Name of the person you call] this is [Your name]'. End conversation with an 'Out' followed by your name. Wait for the same from the one you communicate with before you turn off the radio. See Appendix 1 concerning *Radio protocol and etiquette*.

After fieldwork

When returning to camp, research station or other accommodation facility

Ensure your safe arrival to the station/accommodation facility/field camp is communicated to all relevant parties such as sub-teams (when staying in field camps), research station staff, local contact or home institution. Make sure that everyone has arrived safely back and make sure that everyone is signed back in when returning to the research station or other accommodation facility.

At the end of each day, it is a good idea to have a debriefing meeting to summarise the experiences and results of the day, and to discuss potential plan adjustments and preparations needed for the next day. Following the last fieldwork day, the debriefing can also be used to allocate responsibilities for post-fieldwork tasks, such as cleaning equipment, processing samples and preparing for transport, data management, etc.

You may also want to think about a personal routine to get you ready for the next day, such as downtime to write a private diary or a short walk to "digest" an eventful day.

After returning to your home

You may have to prepare a field report/summary for the research station. The report requirements differ between stations, so it is important to check and comply with the procedures of the relevant station. Some likely tasks include:

- Writing a field report or log; including team members, time in the field, location(s) visited, manipulations and sample collections, travel route(s), weather conditions, details of any incidents.
- Processing samples and/or logging data.

It is always a good idea to write such a report short after your fieldwork while you still have things in fresh mind. Consult the *INTERACT Fieldwork Planning Handbook*, Chapter 5, for more details.

3 Communication devices

Photo: Allan Juhl Kristensen

What are your needs?

There are several considerations that need to be given attention to when choosing the type of communication devices to be used during fieldwork.

Do you need one-way or two-way communication?

The first consideration is the type of communication needed – for example, one-way or two-way communication. One-way communication is where information is communicated in one direction and no response is possible. Two-way communication is where information can be communicated back and forth. One-way communication is often quicker, cheaper and easier than two-way communication, but it has a limited use.

Who should you be able to communicate with?

When conducting fieldwork, you may need to be able to communicate with different entities. You therefore need to consider what devices are suitable for communicating with e.g. the research station, your home institution and SAR operators. If you work in sub-groups in the field, you may also need communication devices that let you communicate across sub-groups.

How remote will you be?

The remoteness of an area that a group will move into can limit the choice of communication devices based on its coverage range.

What is the physical environment like?

The physical environment where fieldwork will be undertaken also needs to be accounted for when choosing fieldwork communication devices. Atmospheric conditions (e.g. temperature extremes) and local topography can all affect the operability of communication devices in the field. These factors will be discussed in the following sections.

What will be your main mode of transport and how much distance will you travel?

The equipment often needs to be transported over long distances, so weight can be an important factor to take into account when selecting the most suitable communication device.

Legal requirements and limitations

Prior to fieldwork, you need to be aware of legal requirements, e.g. mandatory permits and certificates for device use, and of areas where communication for one or another reason may be restricted, e.g. near military areas and airports.

In some countries, satellite phone and emergency beacon use may be either illegal, under governmental restriction and/or require registration of the device(s) or a specific permit. Some jurisdictions may assess costs for rescue operations that you will have to cover if you initiate a Search and Rescue (SAR) mission. This may require a bank guarantee or an insurance that will cover the estimated costs. The user of each device carries the responsibility to find out about the limitations before going into the field.

Note that registration, permits and documentation of insurance coverage may take weeks, if not months. If you work out of a research station, station staff can often help you identify relevant legal requirements.

Beacon (emergency signal sender, see p. 48) regulations for all arctic countries can be found here: http://www.cospas-sarsat.int/en/documents-pro/beacon-regulations-handbook.

Box 3.1 Radio Silence around Ny-Ålesund, Svalbard

Ny-Ålesund on Svalbard is a radio silent area. Radio transmission in the 2–32 GHz frequency band is not allowed within a 20 km radius from Ny-Ålesund because sensitive research instruments at Norway's geodetic laboratory need radio silence to function optimally. Radio silence is also introduced to avoid electromagnetic pollution in the pristine arctic environment around Ny-Ålesund.

Radio transmission in the 2–32 GHz frequency band is not allowed within a 20 km radius from Ny-Ålesund on Svalbard. Map: Norwegian Polar Institute.

Box 3.2 Check your device

Make sure that you know how to operate the devices before leaving home. You might even ask an experienced user to give you an introduction. Make a copy of the user manual and bring it along.

Visual and sound signals

Visual signals

An advantage of arctic and alpine landscapes with their relatively sparse vegetation is that one can see far, presuming that visibility is clear. This invites to use visual communication via bright colours from clothing and materials and light or smoke, to make yourself well visible over longer distances. This is a simple and effective way to pinpoint your location to your field colleagues and to rescue personnel in emergency situations.

During everyday fieldwork, prioritise using red-coloured tents, jackets, backpacks and helmets. Orange and yellow are also suitable signal colours. Brightly coloured and firmly fixed flags can help you to mark field locations or can be used in bad weather to mark your way around the camp. This is common practice in Antarctica, where strong winds and snow obscure vision, and where it is even possible to get lost on the way to the kitchen or bathroom tent.

Figure 3.1 Tent and flagpoles in storm at Trident, Antarctica. Photo: Anne Elina Flink.

The most simple way to achieve awareness, if the ones you want to get in contact with are not too far away, is simply by shouting and waving your arms above your head. On a greater distance you might use a piece of bright-coloured clothing and wave that over your head. Notice, that also people who wants to get in contact with you would probably do the same. Therefore, if you see someone nearby acting different than you would assume, always check up whether they are OK.

You can use bright-coloured flags tied to firmly placed poles or large and heavy objects, such as large stones, or boxes filled with sand/gravel/rocks (they need to be closed at the top) for marking a suitable landing place for a small aircraft or helicopter. Remove bigger stones from the area. For a helicopter you should mark a square with four corners. For a fixed-winged aircraft you should mark an airstrip with at least three markings at each side – and preferably more. The DeHaviland DHC-6 (Twin Otter) is the most common fixed winged aircraft for rescues of field teams in the Arctic. It can land on an airstrip down to 200 meters, preferably more than 350 meters. If possible, align the airstrip with

Figure 3.2 The tents have strong colours and are therefore easily recognised.
Photo: Ruth Vingerhagen.

the most common wind direction. Be considerate to make markings that can withstand the pressure produced by the aircraft – and still will not damage the aircraft in case of collision. On a new airstrip, the pilot will always make a low pass to check the conditions before landing. For both landing strips for helicopters and fixed winged aircrafts, it will be appreciated by the pilot if you place a small flag (a walking stick with a piece of clothing or similar) to indicate the wind direction.

Another visual tool is light from your headlamp, flashlight or the mirror in your compass that can be used to indicate your position on sunny days (the compass mirror) or during darkness (lamps). With different lamp types and a mirror, you can make signals to employ the International Morse Code. It is essentially a sign language that encodes the 26 English letters A through Z, some non-English letters, the Arabic numerals and a small set of punctuation and procedural signals (prosigns). The most important signs that you need to remember are the signals for SOS, i.e. • • • ▬ ▬ ▬ • • • .

Figure 3.3 The sign language of the International Morse Code.
Image source: Rhey T. Snodgrass & Victor F. Camp 1922.

Visual Morse Code communication can also be made with signal flags, but that is beyond the scope of this book.

For emergency situations, bright light and colours can be used to indicate distress and to pinpoint your location to approaching rescuers. Examples are pyrotechnic flares or fire.

Pyrotechnic flares to shoot into the air are internationally recognized distress signals. Flares are shot either from a flare gun, otherwise used for polar bear protection, or are separate handheld flares. There are three main types, which differ in colour:

- White-coloured flares to pinpoint positions.
- Orange smoke flares to pinpoint positions in daylight. They are NOT visible at night.
- Red-coloured flares are used in situations of grave and imminent danger.

All these flares burn for about 60 seconds when being shot into the air or released and handheld. Use them when you know rescue teams are very close, e.g. when you can hear an approaching helicopter or aircraft or you can see its lights. Smoke flares are only visible in daylight and are particularly helpful for air rescues, as they help indicate the surface wind direction. Light flares can be difficult to see in strong sun light.

How to use a flare:

- Check beforehand that the flares are up to date and not expired.
- Use gloves, a straight raised arm and a firm grip (when deploying a handheld flare).
- Turn your back to the wind.
- Fire or hold the flare away from you and other people, buildings or aircrafts.
- Never look directly at a flare when it is lit.
- Make sure your team knows how to use flares before an emergency arises.
- Store pyrotechnic flares dry and easily accessible.

If wood is available, consider lighting a fire to mark your position, when expecting a rescue team to arrive in darkness. Try to light the fire shortly before the rescue teams expected time of arrival, so that it lights up your location at the time when they are approaching you.

In an emergency, rescue authorities will often search for you with aircrafts. Make signs that are visible from high altitude, for example a cross made by wide red ribbons (e.g. by putting red clothing together) or an SOS written with stones differing in colour from their surroundings.

Sound

Another light and simple tool to call for attention or attract awareness of nearby rescuers is a whistle (or alternatively the more heavy signal horn). The sound of a whistle travels over longer distances than the sound of a human voice, and whistling is less energy consuming than shouting, e.g. when you are cold, tired, or injured. Use a whistle preferably outside, they are less effective inside a tent or snow cave. A whistle should be among the basic items that are always in your backpack.

If you bring a rifle or a signal pistol, you can also use a shot to attract attention. Point it in an upward and direction away from the position of potential rescuers before you pull the trigger.

Advantages of visual and sound signals

- Low-tech way to mark positions precisely. Useful in emergencies.
- Most tools do not require battery power but are sturdy, light and portable.
- Some signals can help air rescuers to know the wind direction on ground.

Disadvantages of visual and sound signals

- Can only be used for short-range communication and in relatively good visibility.
- Some signals can be diverted by wind.

Considerations

- Use short-range communication tools when you know rescue teams are very close, e.g. when you can hear an approaching helicopter or aircraft or can see its lights.

Types of devices

Mobile phones

Mobile phones have become everyone's companion and can also be used for fieldwork, for example (i) for communication with text messages and calls, if the field site is within phone coverage, (ii) for obtaining weather forecasts from online services, if there is WiFi coverage or mobile data access, and (iii) for taking notes and photos. We do not describe how to use a mobile phone as we consider this being device-dependent and common knowledge. Mobile phones rely on ground-based network towers to receive and transmit information. It is therefore important to check coverage in the area you will be working in to ensure that you can rely on this type of device.

Advantages

- Mobile phones are multifunctional with camera, GPS, notepad, phone, email and a wealth of apps that can be useful for fieldwork. If mobile phones can be used in your fieldwork area, it may reduce the number of different devices needed to be carried into the field.
- Because mobile phones make use of A-GPS (assisted or augmented GPS), they can be used inside structures, if the mobile coverage is good enough. This is because A-GPS enhances the GPS signal received by satellites by using cell tower data to enhance quality and precision.
- Mobile phones are easy to use and intuitive.
- Mobile phones allow two-way communication.
- Most people have a mobile phone and have experience in using it.
- You can easily communicate with others, e.g. other field teams, research stations (if they have a phone or a satellite phone), SAR operators, police, home institution, family and friends.

Disadvantages

- Remote and mountainous areas often lack cell phone networks and WiFi coverage.
- Smartphones are fragile and consume considerable energy, and their batteries run down quickly in cold weather.
- Touchscreens do not cooperate well with cold and wet weather or gloves. A great option is to use touchscreen gloves, glove liners or pens.

Considerations

- Before leaving home, make sure that the phone can be used in the country you are going to visit (that the SIM card is working) and that you have adequate data available.
- Roaming might be very pricy, so check in advance and buy a local SIM card if needed.
- Prior to going into the field, make sure that emergency contact phone numbers are stored on the phone.

- Make sure that the phone is fully charged every day. Remember to bring a spare battery, charger and/or a power bank, charging cable and socket adapter for the specific country.

In which situations is it best to choose this device?

- Only rely on your mobile phone when you are 100% sure that you will have access to a regular mobile phone network and good charging options.

Box 3.3 The line-of-sight principle

With some means of communication you can only communicate with someone that you are actually able to see. For communication devices, it means an uninterrupted line between any two points of wave propagation between the source (the person calling) and the receiver(s) (the person(s) being called). Line-of-sight can specifically be obstructed by e.g. topography. Further, a person being more than c. 20 km away can simply disappear below the horizon due to the geoid shape of the Earth.

Satellite phones

Satellite phones rely on line-of-sight connections with satellites in the Earth's orbit to receive and transmit information. In general, these phones enable communication anywhere around the globe, regardless of the location. Due to the cost and for other reasons, such as government regulations on usage, satellite phones are used primarily where mobile phone coverage is limited or absent.

Figure 3.5 Iridium phone.

Photo: Morten Rasch.

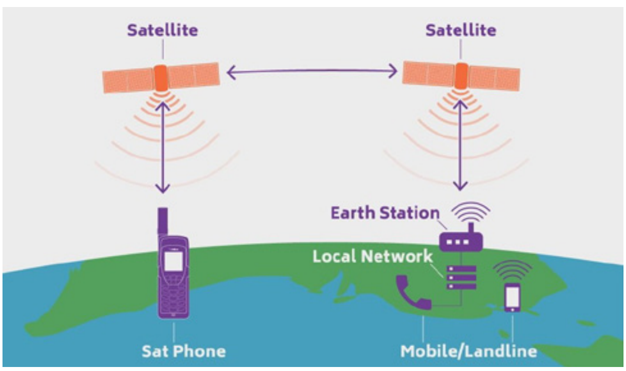


Figure 3.4 Satellite networks have ground stations and subscriber units (satellite phones). The satellites act as cellular towers in the sky. Voice and data messages can be routed to anywhere in the World. The ground network is used for making communication possible between satellite phones and any other telephone or computers anywhere in the World.

Image source: https://blog.campermate.com.au/advice/satellite-phone-buyers-guide/

Types of satellites

Satellite phones use Low Earth Orbit (LEO) or geostationary satellites. They do not have any intermediate towers such as mobile phone networks, so communication rarely gets interrupted as long as a line-of sight connection with a satellite is maintained.

The geostationary satellites rotate at the same speed as the earth and are located at an altitude of c. 36,000 km, thereby staying in the same location relative to the Earth. You are therefore less likely to lose the signal to a geostationary satellite than to a moving satellite. Unfortunately, geostationary satellites do not work well at high latitudes because they are positioned around the Equator and therefore disappear below the horizon at high latitudes.

The LEO satellites are not locked to a specific location but orbit around the Earth at an altitude of less than 1,000 km. This movement allows LEO satellites to orbit the Earth and pass by northern latitudes, and when the phone loses contact with one satellite that is disappearing below the horizon it automatically switches to another satellite. As such, LEO satellites are generally considered more efficient than geostationary satellites in remote high-latitude areas such as the Arctic.

Choosing a satellite network operator

The satellite networks are operated by different companies. Therefore, when choosing what satellite phone and network to use, it is a good idea to look into (i) the geographical coverage of the different service providers at high latitudes and (ii) recommended device technologies.

The main satellite networks for civil terrestrial and marine communication purposes are Iridium, Globalstar and Inmarsat. The Iridium satellite network provides good coverage in the polar areas and mountainous terrain (see Box 3.4 for details and a coverage map). Globalstar has insufficient or no coverage in the polar areas. INMARSAT is based on geostationary satellites, so it does not cover high latitudes, and is mainly used for maritime communication. Note that there are new initiatives that have launched LEO satellites or plan to do so, so it may be worth exploring recent developments before choosing a service provider.

Box 3.4 The Global Iridium Satellite Network

'All Garmin InReach devices use the Global Iridium Satellite Network, which is run by a US communications company. It operates the world's largest commercial satellite constellation with 66 cross-linked LEO satellites that provide high-quality voice and data connections all over the planet, including the poles. In early 2019, Iridium upgraded its network by completely replacing its first-generation satellites and adding more satellites and ground stations to ensure optimal coverage (Iridium NEXT).

The Iridium network employs the major advantages of LEO satellites located at approximately 480 miles (780 km) above the Earth's surface, in six rings with 11 satellites on each, making a complete orbit around the Earth every 100 minutes. Iridium satellites are travelling in a polar orbit, which means that they move around the Earth from one pole to the other. This provides coverage in the polar regions and mountainous terrain. Image source: https://www.groundcontrol.com/Iridium_Coverage_Map.htm

Your Iridium device connects with these LEO satellites for communication. Free visibility to the satellites is required to ensure an optimal connection. This means that connectivity in gorges, deep valleys and dense forest might be limited. Hence, it is recommended to seek out an elevated place for communication, if possible.

How to use a satellite phone

Before leaving for the field, make sure that the satellite phone is fully charged and bring spare batteries/power banks. To connect to the satellite network, make sure that you are outside and in an area with few obstructions (not inside a dense forest, between tall buildings, in canyons, etc.). Extend the antenna and point it upward towards the sky to automatically connect with satellites. Wait a few minutes for the phone to make contact with the satellites.

Now you dial the phone number of the person you want to reach (both ordinary phone numbers and satellite phone numbers work). Remember to dial the country code even if you are calling a number within the country you are visiting. Make sure to pre-programme important emergency contacts into the phone or have them handy nearby.

Figure 3.6 Scientist making an Iridium phone call from somewhere in Northeast Greenland.
Photo: Morten Rasch.

Advantages

- Satellite phones generally work in areas where there is limited or no mobile phone coverage.
- Satellite phones enable two-way communication.
- Satellite phones are often built sturdy and dust-/waterproof.
- Satellite phones often have a built-in GPS-function.
- Some satellite phones can be connected with a computer to allow for e.g. exchange of emails.
- Some satellite phones offer an SOS button for emergencies.

Disadvantages

- The price of a satellite phone often exceeds 1,000 EUR, so it is more expensive than a mobile phone. In addition, satellite phones require pricey voice and data subscriptions. Often your home institution or the research station can borrow/rent you satellite phones and arrange subscriptions.
- Satellite phones are heavier (c. 500 g) and bulkier than mobile phones.

Considerations

- Make sure that your satellite phone has a subscription for the fieldwork period and country.
- Even though satellite phone batteries last longer than mobile phone batteries, it is always a good idea to carry a spare battery, a charger and a socket adapter (if needed).
- Some countries may regulate or prohibit the use of satellite communication devices. It is your responsibility to know and comply with the regulations on satellite phone use in the area you will be working in. Regulations for all Arctic countries are available at: http://www.cospas-sarsat.int/en/documents-pro/beacon-regulations-handbook.

In which situations is it best to choose this device?

- Satellite phones allow two-way communication in places where a mobile phone has no coverage/connectivity.
- For local communication between field team members and between field team and camp, a set of VHF radios (see below) would be a good and less expensive choice.

HF Radio

High Frequency (HF) radios are quite large and cover a frequency range of 3 to 30 megahertz (MHz). They are ideal for long distance communication (thousands of kilometers) and mountainous terrain. However, they generally require that the transmitter/receiver is permanently fixed to a location, because the antenna system is quite extensive and normally needs to be mounted on a mast or pole (unless you are lucky to find one of the very old RACAL radios, originally produced for military purposes).

In recent years, Iridium phones have more or less replaced HF radios due to their higher operational reliability and due to the fact that they allow for private two-way communication. However, HF radios are much cheaper in use than Iridium phones, and, accordingly, they are still in use in the Arctic, mainly for routine communication between field teams and their base camps.

Because the HF radio waves travel through the atmosphere, ionospheric disturbances affect the quality of the signal. This means that the time of day or season affects the suitability of HF radio communication. Expect poor HF radio communication during periods of elevated sunspot activity.

If you use HF radios, you may share channels with other field parties. It is not an exclusive conversation – everyone being on the same frequency can listen in and interrupt. Therefore, it is important to follow a proper fieldwork radio communication protocol not to interrupt or offend others unintentionally (see Appendix 1).

Remember that the frequency 2182 kilohertz (kHz) is the international emergency frequency. Do not use this frequency for your field-based communication. Leave it mainly for use during an emergency – you will be heard far away and may interfere with other emergency situations. You may, however, also use the channel for a short call to contact whoever you want to talk with and let them know that you would like to communicate with them on a new frequency. In that case, you should listen for a few minutes on the channel, to make sure that you are not interrupting another conversation, before you make your call.

Ensure that you are familiar with the set-up procedure before you depart for the field. Further make sure that the device is fully charged, and that you bring a manual, extra batteries, charger and socket adapter if needed. A HF radio is rather heavy (up to ten kilos) and normally needs to be fixed to a specific location. It is therefore not ideal for local communication between field team members. However, it has its relevance for communication between field camps and base camps.

How to use it

- Set up the antenna. There are different types. Follow the specific instruction for your device.
- A dipole antenna, which is basically two cables connected to a small central box, should ideally be raised above ground by a pole or a mast and ideally set up at approximately right angles to the direction to your recipient.
- Connect the antenna coax to the dipole socket and turn the radio on.
- Once the self-pass test has run, turn the channel knob until you have selected your preferred frequency. On some devices, you need to select the frequency manually by turning the 'Frequency' knob while watching the frequency on the display.
- Select a frequency by turning the power knob to TUNE.
- To talk, press and hold the handset button.
- To receive, release the handset button.

Advantages

- The advantage of this communication device is that it works over long distances, in low temperatures, and that it is inexpensive to use.
- Allows for two-way communication, however without privacy.

Disadvantages

- It takes some experience and time to set up the radio correctly (no plug-and-play).
- HF radios are heavy and bulky, hence they are not easily moved around. At every new location, it has to be fixed or frequencies reset.
- Your conversation is not private since others may be using the same frequency. Therefore, it is important to follow a proper fieldwork radio communication protocol (see Appendix 1).

Considerations

- HF radios are used for long distance communication, whereas VHF (Very High Frequency, see next section) radios are useful for communication between people being relatively close to each other. This is because HF radios have a greater range (of thousands of kilometers) as compared to VHF radios.
- If you need to regularly move between different field sites, you need to remember that the system needs to be set-up from scratch at every new location.
- Make sure you have the relevant permits and licenses needed to operate the HF radio where you will be working.

In which situations is it best to choose this device?

Generally, HF radios have lost much of their relevance in communication to satellite telephones. You might use them for relatively cheap communication between two points being far away from each other, as long as you do not have to move frequently.

VHF Radio

Very High Frequency (VHF) radios, which have frequencies ranging from 30 to 300 megahertz (MHz), work by line-of-sight (Box 3.3) over a radius of less (often much less) than 100 kilometers if the view between transmitting and receiving device is unobstructed. For communication between VHF-antennas mounted on high masts, the range of c. 100 km can be accomplished. For small hand-held devices a range of between 8 and 20 km is more realistic.

A VHF radio has 55 international channels (1-28, 60-88). Researchers should familiarise themselves with the appropriate frequencies to use in the field (between field teams, with station and emergency operators). In order to communicate with other VHF devices or field parties, both devices must be on the same channel or frequency.

Figure 3.7 Small handheld VHF radios are ideal for short distance communication between field teams. Photo: Morten Rasch.

Remember that others may be using the same channel for communication, so others can also listen in. Do not use emergency channels to communicate in the field. You may use an emergency channel (normally Channel 16) to notify others that you want to talk with them on another frequency (but first listen whether the channel is being used, then keep the message short – who you are, who you contact, what frequency/channel to switch to and at what time)(see Appendix 1).

Figure 3.8 The VHF-radio is ideal for communication over relatively short distances.
Photo: Katrine Raundrup.

How to use it

This radio looks like an early mobile phone – it has a keypad and a 'push-to-talk button (PTT)'. To use it:

- Turn the device on.
- Ensure that the antenna is mounted and extended. Select the appropriate working frequency or channel number (have one for field team communication; know the channel of the research station and the emergency channels).
- Press the PTT button and speak while holding the button down. Always start a conversation by calling on whoever you want to talk to, to let people know if they need to listen or not.
- Talk short, clear and not too fast (for a proper fieldwork radio communication protocol, see Appendix 1).
- Release the PTT button to allow others to communicate to you (you cannot hear others while you push the talk button).

If you find yourself in an emergency situation, press the distress button (if the device has one). Otherwise, follow the procedure below:

1) Select Channel 16 (international distress frequency).
2) Push the PTT button.
3) Say 'Mayday-Mayday-Mayday', three times with a short break between each time.
4) Say your name and your position
5) Explain your situation.
6) Release the PTT button.

7) Answer questions and follow instructions from the emergency operator.
8) If you do not receive a reply, wait a little and then repeat point 1 – 4.
9) If you still do not receive an answer, say: 'Nothing heard. Out' and your name (it might be that the recipient (emergency operator) can hear you, but you cannot hear them), and use another communication device for your emergency call.

Advantages

- An VHF radio is easy to use once you have read the user guide.
- VHF-radio communication is free of charge.
- Due to its small size, similar to an early mobile phone or smaller, it is easy to carry in your backpack.
- The device allows two-way communication.
- Good for communication with SAR personel when they are approaching in the case of an emergency/evacuation.

Disadvantages

- A VHF radio only works over short distance.
- You will have to use a proper communication protocol in order to use it efficiently.
- The batteries will last less in cold conditions.
- You must ensure that you are on the same channel as the receiving device, otherwise you will not be able to communicate.

Considerations

- Suitable only for short distance communication (max. 100 km, and often much less, e.g. 8-20 km) as it depends on the line-of-sight principle (Box 3.3) and is affected by atmospheric conditions.
- Remember that Channel 16 is the international emergency channel. Do not use this channel for your normal field-based communication. Only use it in an emergency. You may also use the channel for a short call to contact the person you want to talk to. In that case, you wait for a few minutes to make sure that no one else is using the channel. Then you make the following call: '[Name of the person you call], [Name of the person you call], [Name of the person you call] this is [Your name], switch to [The channel you want to switch to]'.
- As with HF radios, the signal quality depends on atmospheric and geographic conditions. Because the device works on line-of-sight, an unobstructed view between you (in the field) and the one you communicate with or your host station is necessary. Mountains or buildings can interfere with communication.
- Make sure you have the relevant permits and licenses needed to operate the VHF radio where you will be working.

In which situations is it best to choose this device?

Consider using a VHF radio when you are doing remote fieldwork in areas where there is no mobile phone coverage. VHF radios are extremely good for conversation between two persons working together at a short distance (e.g., when surveying). It is a good idea to carry a satellite phone as a backup, especially with increasing distances and line-of-sight obstructions (e.g. mountains).

Figure 3.9 Station VHF radios at Toolik Field Station. Photo: Morten Rasch.

Garmin InReach Devices

Garmin offers different devices for two-way text messaging, GPS tracking, weather forecast, social media postings and SOS functions with global coverage via the Iridium satellite network, including polar and mountainous areas. The main differences between the devices are size/weight, display properties, keypad, battery life, internal memory, preloaded maps/ability to add maps, navigation capabilities and the price.

Figure 3.10 Garmin InReach Explorer+. Photo: Morten Rasch.

For all devices, a subscription is required to access the satellite network for tracking and messaging functions, including SOS capabilities and weather forecasts. Garmin offers flexible subscription possibilities, so you can pay only for the services you find relevant for your work. Subscription costs are independent from device type. Find out more details here: https://www.garmin.com/en-US/inreach/personal/#subscriptions.

You can use the InReach to have two-way communication with other InReach devices, with mobile phones, and with one or several e-mail addresses. Pretyped messages can be send free-of-charge within the subscription fee, while for more special messages, you may have to pay a fee per message depending on subscription plan. When you send a message to contacts outside the field, they will be able to see both the message and a map with your position when you send the message. As such you can easily tell your contacts where you are and whether you are OK or not.

When you purchase an InReach subscription, it also includes a subscription to the GEOS International Emergency Response Coordination Center, a professional 24/7 global monitoring and response center, see Box 3.6.

Outgoing and incoming text messages are charged the same. When logging in to your active Garmin subscription online (via computer/mobile phone/tablet), you can see how many messages were sent and received, social media posts, waypoints and routes you have travelled.

The SOS function of all Garmin InReach devices is a button under a protective cap. Lifting the cap and pushing the SOS button connects your device to the GEOS International Emergency Response Coordination Center and automatically sends a distress message with your coordinates. You should only use the SOS function in life threatening situations. When activated, you still have a few seconds to cancel the SOS.

What happens if you push the SOS button

- If you do not cancel the SOS within a few seconds, you will receive a message saying that your SOS was received.
- Shortly thereafter, GEOS will send a text message to your InReach, asking about the nature of your emergency and other details that will help them initiate the required assistance.
- GEOS notifies the appropriate rescue services nearest to you and stays in touch with you (via text messages) until the rescue team arrives and takes over the operation. Remember to give short and clear messages, and respond to the instructions given by GEOS and local rescue services.

Box 3.5 Distress calls

Be aware that your distress message will get out rather quickly, often in a matter of minutes. SAR responses rarely reach you within an hour. Depending on weather, terrain, remoteness, socio-political issues and economic factors, it could be days away. Remember – when you trigger a rescue call – that rescue operations can be challenging, expensive and pose significant risks for professional rescue personnel. Consider carefully whether the situation is severe enough for a SAR operation or whether self-evacuation is a possibility – without being too proud to call for help, if at any doubt. If possible, use your communication devices to get in contact with emergency professionals. They can help you solve the situation or decide to initiate a rescue operation.

An optional weather forecast service provides detailed updates for your current location or a specific waypoint directly to your InReach or paired device (e.g. a smartphone, tablet or computer). There are basic and premium weather packages available. Find out more details here: https://inreach.roadpost.ca/inreach-weather-forecasts

HANDY TIP
Before you leave home, put aside an hour or two to set up your device, enter relevant information into your online dashboard and synchronise your smartphone, tablet or computer. Use it on a hike or a walk close to your home first to familiarise yourself with the device and learn the functionalities. Follow the instructions to test your device before leaving home. Send some messages, get a weather forecast and navigate.


Photo: Morten Rasch

Box 3.6 GEOS

The GEOS International Emergency Response Coordination Center (IERCC) is the only global Search and Rescue Coordination Center for all satellite emergency notification devices. It is a private company that maintains a professional 24/7 monitoring and response center and coordinates SAR missions around the globe. GEOS offers a list of supported devices (https://www.geosresponse.com/geos-supported-devices.html) and welcomes free testing of your device. Find information and instructions here: https://www.geosresponse.com/device-and-testing-info.html

Advantages

- Good coverage in polar and mountainous areas.
- Small (palm-sized) and lightweight (100-230 g).
- Two-way communication with text messages (160 characters, preset with predefined recipients or individually typed) with any phone contact, e-mail address or other inReach device.
- SOS function notifying rescue services.
- Weather forecast option.
- Relatively cheap to use.

Disadvantages

- Two-way communication is possible but limited to text messages.
- It is time consuming to type an individual text message on an InReach device, when not paired with another device that has a keyboard. Prewritten messages with predefined recipients are easiest to send.
- Devices are expensive and additional subscription for use of services is required.

Considerations

- If you are in a remote area with limited access to weather information and challenging communication with local rescue operators and you would like to be able to text others, then InReach is a good solution.
- Some InReach devices offer sophisticated GPS navigation capabilities.
- Some InReach devices come with the free Earthmate app that enables pairing your smartphone, tablet or other compatible devices. Using this option is easier for composing messages than on the devices themselves. The app also provides access to downloadable maps, colour aerial imagery and more.
- Note that some countries may regulate or prohibit the use of satellite communication devices, and hence also the use of InReach. It is your responsibility to know and comply with the law, where the device is intended to be used: http://www.cospas-sarsat.int/en/documents-pro/beacon-regulations-handbook

In which situations is it best to choose this device?

Choose an InReach device, when you primarily need (i) the SOS function, (ii) simple two-way communication via text messages, (iii) weather forecasts and (iv) tracking.

Photo: Morten Rasch

SPOT devices

SPOT offers GPS tracking devices that use the Globalstar satellite network to provide text messaging and GPS tracking. Similar to other satellite-based devices, a subscription is required. The Globalstar satellite network has a coverage area that includes a large portion of the planet, with the exception of high northern and southern latitudes and parts of the Pacific Ocean.

SPOT Gen3 Satellite GPS Messenger

The SPOT Gen3 Satellite Messenger offers sending rudimentary pre-programmed one-way text messages ('I am OK' and 'I am right here'), which can be sent to a list of telephone and e-mail addresses. It also includes an SOS function that operates similar to the one on Garmin InReach devices (see above).

The Gen3 has a clear and easy-to-use SOS button. Activating this functionality sends your location and an alert to the GEOS International Emergency Response Coordination Center (same as for the Garmin InReach)(Box 3.6). From there, a team of SAR dispatch experts works to secure the help of resources local to your position – see details about how and how fast in the section about Garmin InReach devices above.

SPOT offers another similar model that is not covered here (SPOT Gen4).

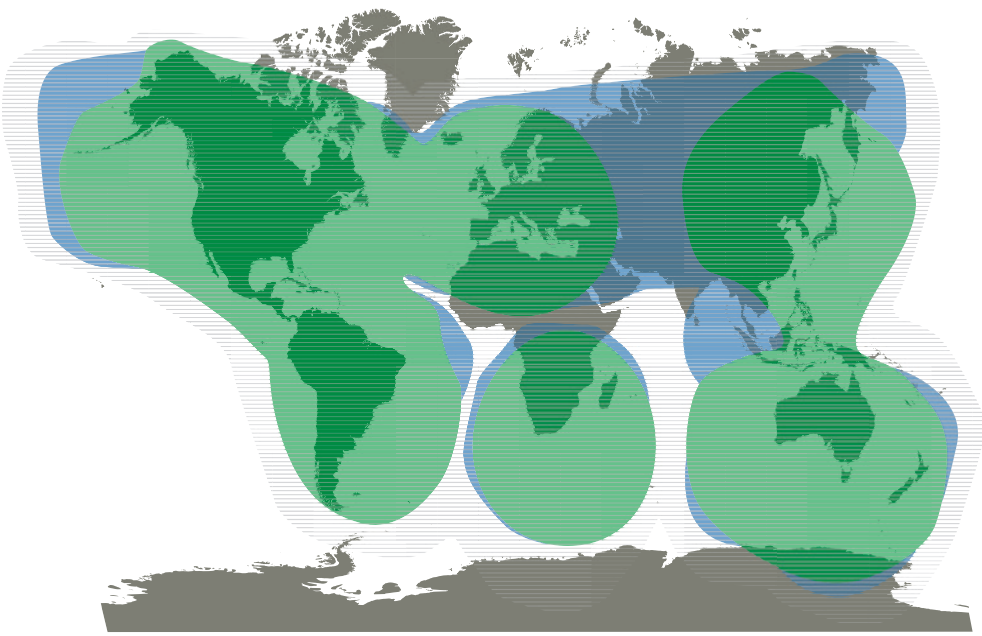


Figure 3.11 SPOT X coverage map.

Image source: https://www.globalstar.com/en-us/products/coverage-maps.

SPOT X

In 2018, SPOT launched the SPOT X, a 2-way satellite messaging device with GPS location tracking, navigational capabilities, social media linking and direct communication options to emergency services, i.e. the SPOT equivalent to Garmin InReach. The Spot X has a keyboard to send and receive text messages and short emails. This makes it fundamentally different from the SPOT Gen3, which can only send messages. Messages can be predefined, custom or posted to social media (Facebook, Twitter or both). SPOT X also has an SOS message function.

Advantages

- All SPOT devices have an SOS function.
- Both the device and subscriptions are less expensive than InReach.
- Compact and lightweight ergonomic design.
- Customised tracking feature.
- Only SPOT X devices have:
  - Two-way text messaging.
  - Twice the battery life of the InReach SE and Explorer (in ten-minute tracking mode).
  - A dedicated U.S. mobile phone number, so it is easier to send messages to it from telephones or other two-way satellite messengers.
  - Social media links are possible.

Disadvantages

- Globalstar satellite network used by SPOT devices has less coverage at high latitudes (Arctic and Antarctic) than Iridium or COSPAS/SARSAT.
- Minimal navigation features, no weather reporting function.
- No smartphone interfaces.

Considerations

- Make sure that the area you work in is covered by the Globalstar satellite network.
- Choose a model with one or two-way communication and a subscription that suits your needs.
- If you only need the services offered by SPOT, it is a relatively cheap option.

In which situations is it best to choose this device?

Choose a SPOT device when you primarily need the safety net of the SOS function for emergencies, you are outside the high latitude areas, and good communication is secondary.

Emergency location devices based on the Cospas-Sarsat programme

The International Cospas-Sarsat Programme, a cooperative effort of 43 countries and agencies, maintains a network of satellites and ground facilities to receive distress signals from emergency beacons and forward the alerts to the SAR authorities in more than 200 countries and territories. Cospas-Sarsat was initiated by Canada, France, the United States and the former Soviet Union in 1979. The programme is dedicated to detect and locate radio beacons activated by persons, aircrafts or vessels in distress, and to forward such alert information to the national-government SAR point of contact.

406 MHz is the radio-frequency band in which the beacons transmit, and is the band monitored around the Earth by Cospas-Sarsat. Most beacon devices have a GPS system built in. This greatly improves the location accuracy and the time required for rescuers to locate the device. To help owners ensure that the batteries are operational, manufacturers provide a battery expiry date on the device.

The system operates at no cost to beacon device owners and the receiving government agencies. However, some countries may impose licensing and/or registration charges for beacon ownership, and some jurisdictions may estimate costs for rescue operations that must be covered by the device owner, if a distress call is made. Some countries also demand a SAR insurance before giving license to bring the beacon into specific areas. The insurance coverage takes into consideration prior experiences with costs of SAR operations in the specific area.

As Cospas-Sarsat is a global network, registered beacons can be used anywhere in the world.

A beacon does not transmit until it is activated. During an emergency, you should first try to communicate with others by using radios, phones and other signaling devices. Different beacons have different features for activation in an emergency. They are normally printed on the device. Distress alerts will be sent to a Rescue Coordination Centre responsible for the region, in which the distress incident is occurring. A second notification is sent to where the beacon's registration details are kept.

Cospas-Sarsat encourages free of charge testing of beacons and provides a detailed guide for a test at its website: (https://cospas-sarsat.int/en/testing-your-beacon).

Types of beacons

For satellite reception of alerts by Cospas-Sarsat, the beacon must transmit at a frequency of 406 MHz (406.0 to 406.1 MHz). Devices based on the Cospas-Sarsat programme are classified in three main types of radio beacon devices:

- Emergency Locator Transmitter (ELT), for use in aircrafts.
- Emergency Position-Indicating Radio Beacon (EPIRB), for use aboard marine vessels.
- Personal Locator Beacon (PLB), to be carried by an individual.

Figure 3.12 Different emergency beacons for individuals, ships and aircrafts.
Image source: https://www.marsat.ru/en/cospas-system-organization.

Many beacon models do not only transmit a distress message on 406 MHz for satellite reception but they also transmit a lower powered signal on 121.5 MHz or 243 MHz to be received by nearby aircraft(s) or local rescue personnel. This is called "homing capability". The homing capability helps to detect the location of the person in distress more precisely, especially in challenging terrain, when the rescue team arrives near the location. In some countries, such a 'homing transmitter' is a mandatory beacon feature.

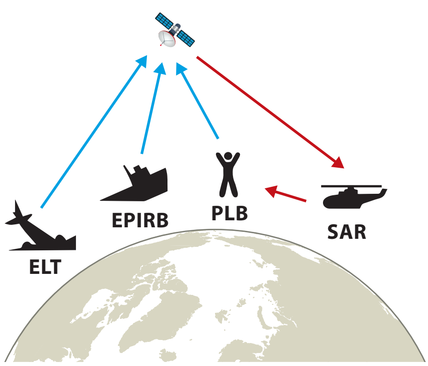


Figure 3.13 Emergency beacons for respectively aircrafts (ELT), ships (EPIRB) and individuals (PLB). Emergency signal is transmitted to Search and Rescue centres (SAR) via satellite.
Image source: https://cospas-sarsat.int/en/system-overview/cospas-sarsat-system.

The system consists of a beacon, satellites and ground facilities. Satellites transfer the signals of activated distress beacons to a signal processing ground station (Local User Terminal, LUT). They relay the signal to local/national Mission Control Centers (MCCs) that distribute distress alert data and location to local/national Rescue Coordination Centers (RCCs), which facilitate coordination of the SAR response.

Personal Locator Beacon (PLB)
A Personal Locator Beacon (PLB) is a radio transmitter designed to be carried by a person and used for sending out a distress signal, which initiates a SAR operation. This device should only be activated in case of a life-threatening emergency. It is not a day-to-day communication device.

Figure 3.14 Personal Locator Beacon (PLB).
Photo: Morten Rasch.

Correct registration is essential
Each PLB needs to be registered with the relevant national authority in the country you are going to use it in. Its unique hexadecimal identification code (Hex ID, 15 digits) is written on a label affixed to the device and can be found in the documentation provided by the manufacturer. Note that if you buy a PLB from a vendor based outside the country of fieldwork, you may need to ask an authorized dealer to change the country code so that it corresponds to your fieldwork country (comes at an additional cost).

If the country indicated by the Hex ID does not provide a registration facility and does allow direct registration in the International 406 MHz Beacon Registration Database (IBRD), maintained by the Cospas-Sarsat, then you can register your PLB online through the Cospas-Sarsat website: (https://www.406registration.com/).

The beacon registration needs to be updated every two years. The purpose of the registration is to give relevant information about the beacon owner and additional contact information that help distinguish true and false alarms. An unregistered beacon can cause a delay in the response. Note that in some countries you may be obliged by law to register your beacon and in some cases insure all team members in relation to a potential SAR operation. For example, for beacons that are coded for the U.S., registration is required by law.

How to use it
These are the main stages of communication when using a PLB in a life-threatening emergency:

1) For most beacons, you have to remove a cover and raise its antenna, before you can press the SOS button to activate your PLB and transmit a distress radio signal. The signal sent by your PLB includes its Hex ID and if the device is equipped with a navigation device also your location. Once the beacon has been activated, leave it switched on.
2) The Cospas-Sarsat satellite system will detect your PLB signal and then relay it to a ground station. If the location is not provided by the signal, then the ground station will compute it (by triangulation using several receiving stations).
3) The ground station will transfer the beacon message and location information to the associated MCC, which will send it to the relevant SAR authority as well as to the national authorities of the country indicated by the Hex ID.
4) The concerned rescue authorities will proceed to rescue operations.

A 406 MHz beacon will send a complete digital code to the contact authorities, even if it is only on for less than a minute. These authorities include the appropriate RCC, Coast Guard Station, Air Traffic Control, Flight Service Station, park rangers or police force in that jurisdiction.

If any accidental activation occurs, it is important that you turn the beacon off and contact authorities immediately. Inform them that the false alert was transmitted and should be cancelled. Have your beacon's 15-digit identification (ID) code available (if possible) when you contact them. If it is not possible to turn the beacon off, you should hide it from the view of satellites by putting it in a metal container (e.g. a Zarges box).

Technical characteristics
All PLBs have global coverage but need to be registered in the country where it is being used. They transmit at 406 MHz, which is the international rescue signal, and many of them also have a 121.5 MHz homing capability, used by rescue teams to find you when they are close to you. RLS-enabled beacons include the Return Link Service feature, which consists of the reception of a confirmation that the distress signal has been received by the relevant authorities.

Some PLBs have built-in buoyancy, others include a buoyancy pouch.

Depending on their minimum operating temperature, PLBs are classified in two types:

- Class 1 operates down to –40°C.
- Class 2 operates down to –20°C.

PLBs should be properly maintained. The main maintenance procedures are:

- Periodic inspections for physical damage.
- Periodic self-tests.
- The battery must be replaced either by the expiry date indicated on the device or after activating the beacon in an emergency, or after repeated testing.
- Periodic technical inspection and service by an approved service centre.

Advantages

- Worldwide coverage.
- Relatively small and lightweight.
- No service fees.
- The battery lasts several years, if the device is not activated.
- Easy to operate.

Disadvantages

- One-way communication device (only distress call, some have an RLS confirmation function).
- No text message or voice communication function.
- Some countries do not permit their use.

Considerations

- Before using a PLB, you should inquire:
  - If the use of PLBs is permitted in the country.
  - If carrying a PLB is compulsory when doing fieldwork in a certain area.
- When used, the beacon should have an unobstructed view of the sky, so that it is within line-of-sight of the satellites.
- A PLB usually has a shorter battery life than an EPIRB (the version for ships – see below) and will only emit the distress signal for approximately 24 hours (enough for alerting SAR entities).

In which situations it is best to choose this device?

PLBs are useful when working in remote areas with challenging voice communication with rescue services (e.g. by telephone). They work all over the globe and provide rescue services with precise location information. They do, however, not allow communication as to what type of emergency situation has occurred, so it would be ideal to use additional communication devices that allow text or voice communication.

A PLB should only be activated when there is a threat of grave and imminent danger as it triggers governmental (or voluntary rescue) services and may put the lives of rescue teams in danger while trying to help you.

Emergency Position Indicating Radio Beacon (EPIRB)

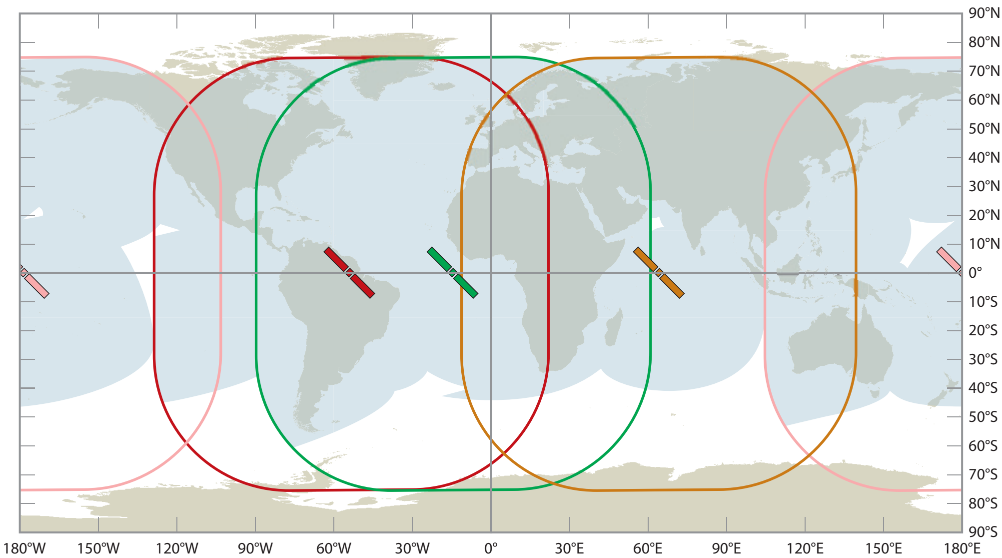
EPIRBs are mandatory aboard boats and vessels. Like PLBs, each registered EPIRB has unique information about the vessel and its owner. EPIRBs are waterproof and also work on the 406 MHz /121.5 MHz frequency. An EPIRB designed for marine use will float and keep the antenna above the water. Some EPIRBs also have a light signal that is activated in contact with water. When activated, an EPIRB emits a continuous distinctive radio distress signal for at least 48 hours.

Emergency Locator Transmitters (ELT)

ELT are used primarily in aviation. ELT devices are designed to automatically activate after a physical shock, such as in a crash, and initiate SAR.

Box 3.7 INMARSAT

INMARSAT (International Maritime Satellite Organization) is a British satellite company that deals primarily with maritime communication, based on geostationary satellites. The global coverage is better than that of SPOT, but less good than Iridium. It also excludes high latitude polar areas.



Coverage of the different INMARSAT satellites.

Image source: https://www.inmarsat.com/about-us/our-technology/our-satellites/.

Comparison of devices

	Visual signals	Mobile Phones	Satellite Phones	HF Radio	VHF Radio
Portability	Good	Good	Intermediate	Intermediate	Good
Cost	Affordable – Intermediate	Affordable	Expensive	Expensive	Intermediate
Range	Short	Very short, requires line-of-sight to a network tower	Long: Satellite network, for example Iridium®	Large (> 1000s of km)	Short (< 100 km, for hand-held devices 8-20 km)
Communication type	1-way, distress signal + location	2-way	2-way	2-way	2-way
Ease of use	Easy	Easy	Easy, learn before first time use	Medium (training required)	Easy, but learn before first time use
Suitability	Most useful in good visibility	Useful in areas with network coverage; only use for short trips due to battery considerations; fragile touchscreens	Can be used in any situation	Best for long-range (>100 km)	Best for short-range (<20 km)
Effectiveness	Depends on visibility	Signal quality depends on atmospheric and geographic conditions	Signal quality depends on atmospheric and geographic conditions	Signal quality depends on conditions of the ionosphere, time of day, and the seasons	Signal quality depends on atmospheric and geographic conditions
Special features		Multifunctional with camera, notepad, emails, and a wealth of other useful apps	Works globally and in any situation	Somewhat complicated set-up	

	Garmin inReach	SPOT Gen3	SPOT X	PLB
	Good	Good	Good	Good
	Affordable	Affordable (cheaper than InReach)	Affordable (cheaper than InReach)	Expensive
	Long: Iridium® satellite network	Long: Globalstar satellite network	Long: Globalstar satellite network	Long: COSPAS-SARSAT satellite system
	2-way, distress signal + location	1-way, distress signal + location	2-way, distress signal + location	1-way, distress signal + location (RLS equipped devices provide confirmation message)
	Easy	Easy	Easy	Easy
	Use only in emergency situations	Use only in emergency situations; not usable in the high polar regions	Use only in emergency situations; not usable in the high polar regions	Use only in emergency situations
	Signal quality depends on atmospheric and geographic conditions	Signal quality depends on atmospheric and geographic conditions	Signal quality depends on atmospheric and geographic conditions	Transmits emergency signal unique to its owner globally for at least 24 hours
	Can also be used for navigation and receiving weather reports			Needs to be registered

4 Navigation devices

Photo: Lars Holst Hansen

Navigation basics

Identifying your needs

In the planning phase of the fieldwork, it is very important that you select one or more navigation devices that match your needs. It is also important that you practice how to use your devices well in advance of your fieldwork.

The main characteristics of navigation devices that you need to consider are:

- Portability
- Durability
- Reliability
- Resolution
- Information provided
- Accuracy
- Ease of use
- Sources of interference
- Power supply
- Price

The technical specifications of the device must be adequate for your fieldwork, so you need to consider the following external factors:

- The environment, where you will conduct your fieldwork:
  - Climate, mainly temperature and risk for rain
  - Topography
  - Presence of landmarks
  - Geographic location
- The applicable law in the area, where you will conduct your fieldwork: Is the use of a particular device allowed in the area?
- The applicable rules at your potential research station: Is the device included in the list of compulsory or recommended equipment for going into the field?
- Before you spend considerable amounts of money, it is always a good idea to check whether the navigation devices are provided by the research station.

Common navigation devices include topographic maps, compasses and GPS devices. GPS devices are easy to use and provide you with your position with high accuracy. Topographic maps and magnetic compasses are valuable navigational backups, so you should always carry them in addition to any other navigation devices. They are compact, relatively cheap and lightweight, and unlike electronic navigational devices, they do not depend on battery power.

Figure 4.1 Different helpful equipment for field navigation. Photo: Morten Rasch.

HANDY TIP
Read more to train your specific fieldwork competences and find examples of good field-work practices in the *INTERACT Management Planning* handbook, Chapter 10.

Types of devices

Topographic maps

A topographic map is a 2-dimensional representation of the 3-dimensional physical features of an area. It normally includes information about the topography, hydrography, vegetation and infrastructure. It is an important source of local information and can be used to identify potential fieldwork areas and safe travel routes.

Map projection

When using topographic maps during fieldwork, it is important to be aware of what map projection the map is in. This ensures that location coordinates are recorded precisely and that field sites can be found again in following years by yourself and/or another person or field team.

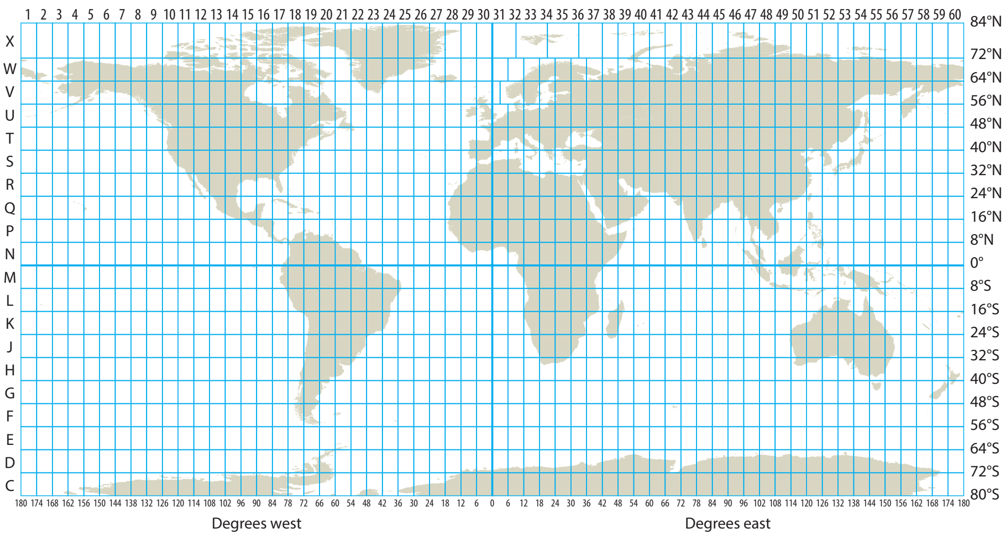
Box 4.1 Map datums

The shape of the Earth's surface is approximated by a geometric surface called an ellipsoid (e.g. World Geodetic System 1984, WGS 84). Based on a specific ellipsoid, we can define a horizontal datum, which is a coordinate system for specifying positions on the Earth's surface (e.g. North American Datum of 1983, NAD 83) and a vertical datum (e.g. Australian Height Datum of 1971, AHD), which is used as reference for specifying elevation.

Box 4.2 UTM and UPS grids

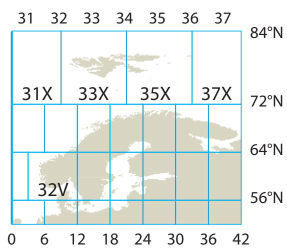
The UTM grid divides the Earth's surface into:

- 60 vertical bands, known as "zones", of 6° of longitude in width, numbered from 1 (180°W – 174°W) to 60 (174°E – 180°E).
- 20 horizontal bands of 8° of latitude in height (except for band X, which is 12°): from Band C (80°S – 72°S) to Band X (72°N – 84°N).



UTM grid

Note that there are special UTM zones around Svalbard, Norway.

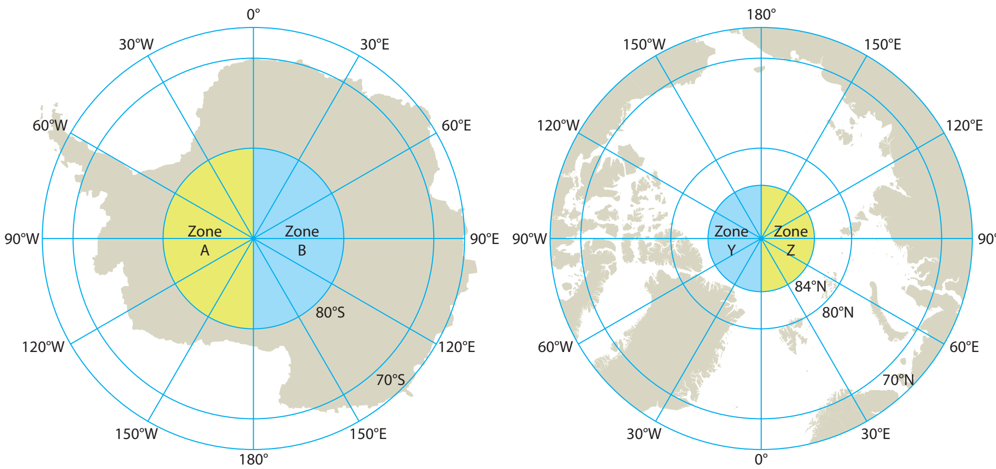


A map projection is needed to represent the 3-dimensional Earth's surface on a 2-dimensional map. The map projection establishes the correspondence between geodetic coordinates (latitude and longitude, showing the earth's surface on a curved surface in 3D) and plane coordinates (showing the earth's surface on a flat surface in 2D).

The Universal Transverse Mercator (UTM) Projection is normally used for newer large and medium-scale topographic maps (i.e. small to medium areal cover), except for maps of polar regions. For the latter, the Universal Polar Stereographic (UPS) projection is used. The UTM grid covers the Earth's surface between latitudes 80°S and 84°N, whereas the UPS grid covers the surface south of 80°S and north of 84°N. Other map projections might be used locally/nationally, so always check the projection and include the projection used when sharing your coordinates.

The UPS grid divides each polar region into two half-moon shaped zones:

- Zones A and B cover the western and eastern hemisphere south of 80°S, respectively.
- Zones Y and Z cover the western and eastern hemisphere north of 84°N, respectively.



UPS grid

Reference: Touche, F. & Price, A. 2004. Chapter 1: Maps. Wilderness Navigation Handbook.

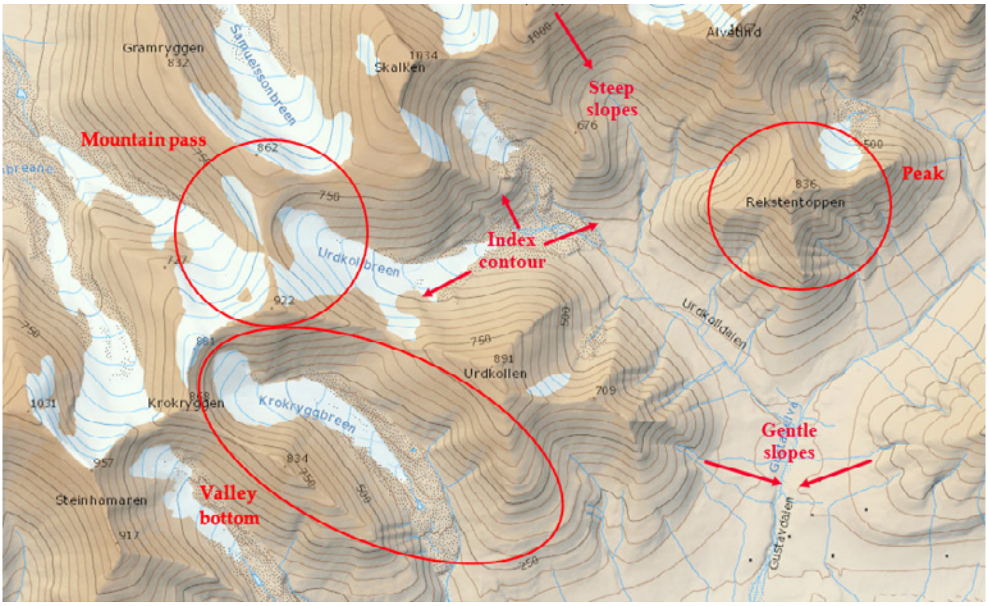


Figure 4.2 Examples of contour lines from a glaciated terrain on Svalbard.
Map source: Adapted from https://toposvalbard.npolar.no/.

How to read a map

Maps include basic cartographic data such as the scale, distance between contour curves, map projection and the datum (see box above).

The scale of a map is the ratio between a distance on the map and the real distance in the terrain. It helps you to estimate distances on the ground based on map information. For example, a map with a scale of 1:100,000 means that 1 cm measured on the map represents 100,000 cm, i.e. 1 km, on the ground. Most maps used for fieldwork need to be more detailed with scales of 1:50,000, i.e. 1 cm on the map equals 500 m on the ground, or 1:25,000, i.e. 1 cm on the map equals 250 m on the ground.

For navigation, make sure to orient your map with north pointing northwards/upwards. The margins of the map and the helplines within the map refer to the coordinate system that is used on the map. They can help you to find the coordinates of a specific place, e.g. the location you want to go to.

When you use your map for navigation, pay close attention to the magnetic declination. All maps include a declination diagram that shows the relationship between the Grid North, the Magnetic North and the True (Geographic) North valid at the area covered by the map (for more information, see section about magnetic compass). The declination diagram often also includes an indication of how much the declination has changed over the last years, and/or how much it is expected to change in the future.

Contour lines represent locations with the same elevation. Index contour lines are thick contour lines with elevation values written along the lines. The closer the contour lines are, the steeper the terrain is. Conversely, widely spaced contour lines indicate gentle slopes or flat terrain. Blue contour lines are used for glaciated terrain. The map in Figure 4.2 shows examples of terrain features indicated by contour lines.

You can calculate the slope gradient in % as follows:

$$\frac{\text{elevation difference}}{\text{horizontal distance}} \times 100$$

The table below shows the correspondence between slope gradient and angle.

Table 4.1 Conversion between slope in percentage and degrees.

Gradient	Angle
9%	5°
27%	15°
47%	25°
70%	35°
100%	45°
143%	55°

Many topographic maps also include information about general habitat types (e.g. tundra, forest, marsh, glacier, river, lake, etc.), infrastructure (e.g. buildings, power lines, sites of historic interest, etc.) and protected areas. The colours and patterns used to indicate the different features are all presented in the legend of the map.

Advantages

- Unlike electronic devices, printed maps and compasses do not need a battery and do not get technical failures. Provided that your map is waterproof and tear-resistant and that your compass is sturdy, it will not let you down during your fieldwork. Therefore, it can be a life-saving navigation instrument when all the other devices fail.
- Maps provide an overview of the terrain which is helpful to identify important features such as mountain passes, steep slopes and water sources.
- Maps can be easily used to find your way in places with landmarks, even without a compass.
- You can write notes on a map to help you keep track of your past and future tracks, as well as highlight points of interest, e.g. where to find a good camping spot, a place to cross a river easily or where to find drinking water sources.
- Some countries (e.g. all Scandinavian countries) offer digital maps online for free, partly with an option to see satellite or aerial images of the area. These portals allow you to mark and measure routes, add notes, and to download and print customized maps for offline use.

Disadvantages

- You need to spend time on getting to know the basics about cartography and how to read a map. GPS-based navigation is generally easier – in some cases you simply watch your current position on your mobile phone, without having to think about geographic coordinates, etc.
- If the terrain is not rich in landmarks or the weather is bad, you will need a compass to know your current position and to find your way.
- It is somewhat cumbersome to use maps, as you need to unfold and fold them every time you use them, which can be especially difficult in the extreme arctic conditions. To avoid this, you can use a plastic folder or a map pocket and store your map folded – so it only shows the area that you need. This also makes your maps last longer. You can find map pockets in any outdoor shop.
- Some features and points of interest may change with time (e.g. glacier extent, camping facilities, bridges/river crossings, etc.), so you need to use a relatively recent map.

Considerations

- Look for topographic maps made of waterproof and/or tear-resistant material (e.g. Tyvek) or laminate them yourself.
- When selecting a map, there is a compromise to make between scale and area covered: A large-scale map shows more details than a small-scale map, but covers a smaller area. You may therefore need to bring multiple maps in different scales.
- You can combine a topographic map with printed high-resolution satellite images that ideally have a scale and are georeferenced. Be considerate in areas close to national borders and in the entire Russia, where use of satellite images can be restricted.

In which situations is it best to choose this device?

Topographic maps are basic components of almost all fieldwork. They are particularly useful in areas with many landmarks and mountainous terrain, and minimum one map per group should be brought as a backup if other more technical devices fail.

Magnetic compass

A compass is a simple and handy navigation device that relies on the magnetic field of the Earth. Among the different types of magnetic compasses that exist, the baseplate compass is the one most often used for navigation on land in combination with a map. A baseplate compass is a small device with a weight between 30 and 80 g. The resolution of a baseplate compass is 1° or 2°, but it has lower accuracy near the magnetic poles. The operating temperature range normally goes down to –30°C (–22°F). Some baseplate compasses are equipped with a mirror for taking more accurate bearings.

A compass is balanced for the northern hemisphere, the southern hemisphere or both. The difference between a compass balanced for the northern hemisphere and one balanced for the southern hemisphere is the location of the counterbalance that compensates for the dip of the needle due to the magnetic field.

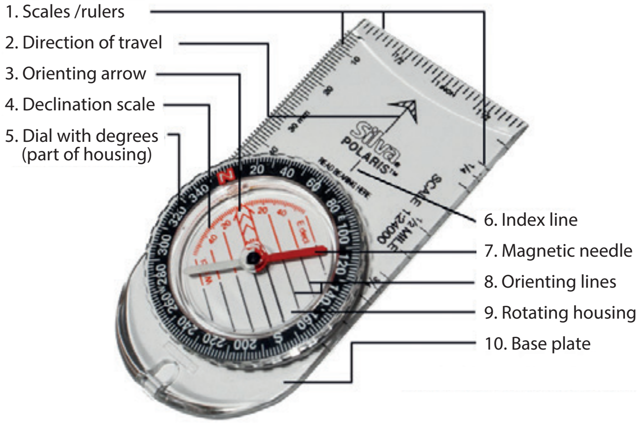


Figure 4.3 The basic components of a baseplate compass. Compasses have a mechanism to adjust declination, which is normally a screw. Note that a mirror compass does not have a direction-of-travel arrow but a mirror line or a sighting notch. In addition, many compasses have a magnifying lens, luminescent markings, an inclinometer to measure slope angles and a thin strap to attach it to a bag or clothing.

Image source: https://www.wildernesscamping.com/images/articles1-100/compass01-800.jpg.

Magnetic declination

The compass needle aligns itself with the Earth's local magnetic field in a direction called Magnetic North. The True (Geographic) North is the direction from a specific location to the Geographic North Pole. Note that the Magnetic North does not correspond to the True North. Topographic maps show True North (or Grid North) and will indicate the magnetic declination of the map (the declination diagram), so you can work out Magnetic North for that particular map (see the section Topographic maps). The angle between the True North and the Magnetic North is called the magnetic declination, and it differs across the polar areas:

- Declination is West, if the compass needle points left of the True North.
- Declination is East, if the compass needle points right of the True North.

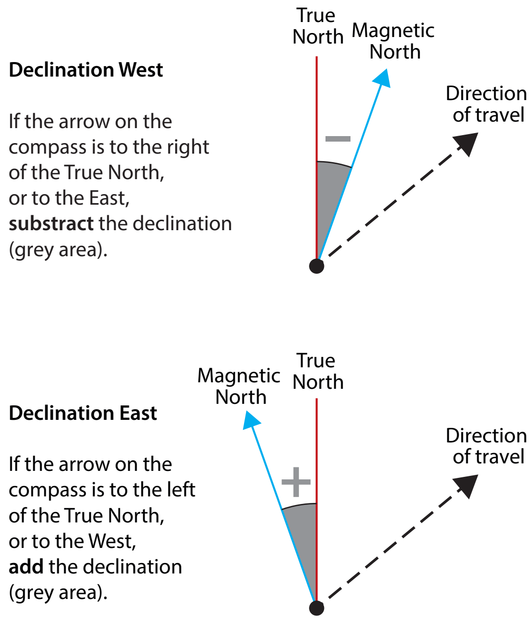


Figure 4.4 How to calculate your true bearing based on knowledge of your magnetic bearing and the local declination.

Image source: https://geomag.nrcan.gc.ca/mag_fld/compass-en.php.

The magnetic declination changes with time as a result of the geomagnetic secular variation, which refers to the slow changes of the Earth's magnetic field on timescales from years to millennia. There are three ways to determine the magnetic declination at your location:

1) Use the declination diagram of your topographic map together with the information about the annual change of declination (normally indicated on the map).
2) Use a magnetic declination calculator available online, for example those provided by Natural Resources Canada (https://www.geomag.nrcan.gc.ca/calc/mdcal-en.php) or NOAA (https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination).
3) Directly measure the magnetic declination: The declination is the difference between the map bearing and the field bearing from your position to a selected landmark. If the declination obtained is larger than 180°, subtract it from 360°.

How to use a compass

Compass bearings (directions) are measured as degrees clockwise from True North, Magnetic North or Grid North. Before taking a bearing, make sure that electronic equipment (e.g. mobile phones, large watches, VHF radios, GPS devices) and ferromagnetic objects (e.g. tent poles, power lines) are far from your compass in order to avoid magnetic interference that gives you inaccurate bearings.

To take a bearing:

If you want to determine the direction to a certain landmark in the real world, you need to:

1) Point the direction-of-travel arrow at the landmark.
2) Turn the graduated dial until the orienting arrow aligns with the north-seeking end of the needle.
3) Read off the bearing.

The bearing relates to the Magnetic North and is the one you need to follow, if you want to move towards the specific landmark.

How to navigate with a map and a compass:

When taking a bearing with a map and a compass, you need to adjust it for the magnetic declination. If your compass does not have an adjustable declination mechanism, you will have to add or subtract the declination given on the map (or calculated) every time you take a bearing.

To find your position on a map:

1) Look for at least two physical features that you can identify in the terrain. Locate them on your map. Then, take bearings to these features and draw the bearing lines on the map from each feature. Your position is the point where these lines intersect.
2) If you have a GPS device, it will provide you with the coordinates of your location. The GPS datum needs to be the same as the map datum.

To take a bearing off a map:
If you want to determine the direction to a certain landmark by using your map, you need to:

1) Locate your position in the map.
2) Align the direction-of-travel arrow of your compass with an imaginary straight line connecting your location and the location of your target.
3) Turn the graduated dial (Item 5, in Figure 4.3) of your compass, until its orienting lines become parallel to the north-south grid lines of the map.
4) Read off the bearing.
5) If your compass lacks an adjustable declination mechanism, you need to convert the grid bearing to a magnetic bearing by adding or subtracting the declination to the grid bearing, depending on whether the declination is West or East.
6) To follow a compass bearing, turn around until the north-seeking end of the needle lines up with the orienting arrow. The direction-of-travel arrow indicates the direction you need to follow. Note that you may drift away from the straight line to your destination, so if distances are long and the target is difficult to see, you may need to regularly take new bearings.

The compass accuracy is lower near the magnetic poles. We can divide the regions affected by this into two main zones:

- Blackout Zones are regions, where compass accuracy is highly degraded.
- Caution Zones are regions, where compass accuracy may be degraded.

NOAA's National Centers for Environmental Information has maps, which show where the Blackout and Caution Zones are: https://www.ngdc.noaa.gov/geomag/WMM/image.shtml.

Advantages

- Unlike electronic devices, a compass does not need a battery to function. Therefore, it can, in combination with a map, be a life-saving navigation instrument when all other devices fail.
- A compass is useful for identifying your location, taking bearings to visible features and for navigating using a topographic map.

Disadvantages

- The compass accuracy can be affected by magnetic interference due to external magnetic fields from electronic equipment and objects made from ferromagnetic materials.

Considerations

- Your compass should be designed to work in the hemisphere where you will use it.

In which situations is it best to choose this device?
Compasses are basic navigation tools that should be used with a topographical map at least as a backup. They are particularly valuable in places with few landmarks and used together with a map to navigate. You should not rely on a compass near the magnetic poles.

Global Positioning System (GPS) devices

The Global Positioning System (GPS) is a satellite-based navigation and positioning system, which provides users with real-time data about their position. There are many different types and brands of satellite navigation devices with varying degrees of complexity, some of them include communication functions (the most commonly used brand is Garmin).

Typical GPS-enabled devices are accurate to within a 5 m (16 feet) radius under open sky.

Figure 4.5 Small handheld GPS for personal navigation. Photo: Morten Rasch.

Figure 4.6 With a GPS you can easily find your position. Photo: Guido Grosse.

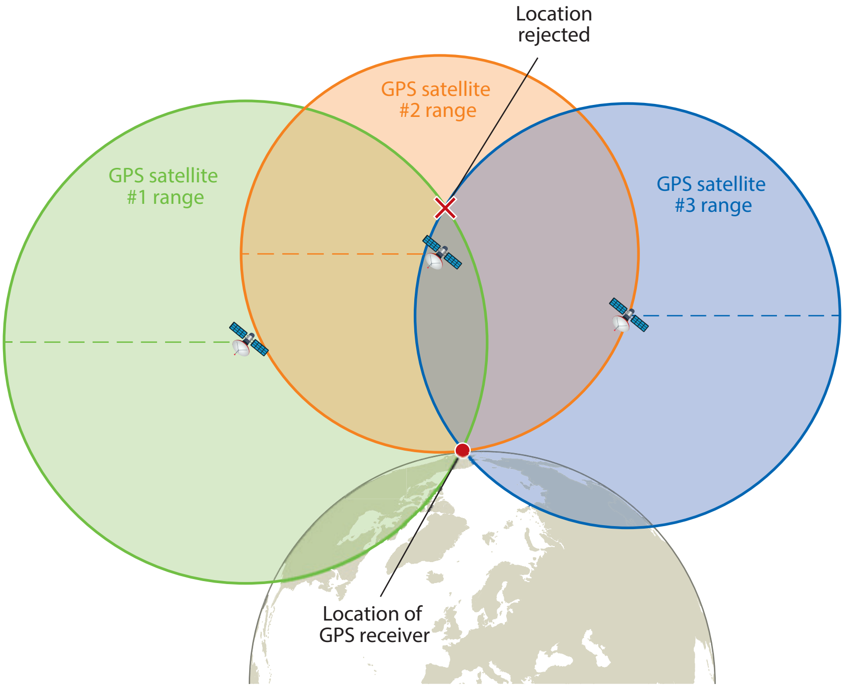


Figure 4.7 GPS uses the mathematical concept of trilateration to identify the user's location. Trilateration works by the radio wave signals of at least three satellites, emitted spherically around the satellite, intersecting twice – once on the Earth surface, and once in space. The point where the spheres intersect in space is rejected, because the user is located on the Earth. Using the atomic clocks on the satellite and the speed of the signal (which is a constant), the distance between the satellite and the user is calculated, identifying the precise location of the GPS receiver. Image source: https://medium.com/@aryamansharda/how-gps-actually-works-e6e0d126d2d5.

How to use your GPS device

- Go outside and switch the device on. It will automatically begin searching for satellite signals.
- Once connected to an adequate number of satellites, your latitude and longitude coordinates should appear on the screen.
- An indicator on the screen will inform you of how accurate your signal is. Depending on the product model, the display will show elevation, speed of movement, a map and a compass.
- Many models let you record your path or field locations as "waypoints" to show where important places are. This enables you to save their exact coordinates and makes it easier to find these places again.

Advantages

- GPS navigation devices are easy to use and relatively affordable. There are no subscription fees to use a satellite network for navigation purposes.
- GPS devices offer precise real time location information that is independent on local weather conditions.
- GPS devices perform user-assisted calibration by themselves.

Disadvantages

- GPS location accuracy is worse at the poles as compared to other areas on Earth. This is due to the ionospheric effect on the satellite signal needed by the device to triangulate your position. The angle of visible geostationary satellites needed for triangulation is also acute, reducing positional accuracy.
- Signals can be obstructed by high mountains, steep cliffs, dense forest or tall buildings. A GPS does not work underground or within structures.
- Geomagnetic storms, extreme weather events and radio interference/jamming can reduce accuracy.
- Most devices are battery powered and hence have limited operational time in cold climates.

Considerations

- Download the latest maps onto your device before departure into the field.
- Do not rely on GPS receivers built into cars or mobile phones – they may be less accurate than a dedicated device.
- The devices require occasional software updates to avoid navigational errors.
- Remember that a GPS does not compensate for lack of local knowledge. Therefore, it is always a good idea to ask locals about local conditions, recent landscape changes, etc. when you move into areas new to you.
- Consider the type of batteries to carry with you. With rechargeable batteries, you will need to be able to charge them. Enough replaceable batteries will be extra weight to carry.

In which situations is it best to choose this device?

GPS devices are always good to bring along, but do not rely on them as your only piece of navigation equipment. It is best to combine one with a map and compass.

Comparison of devices

Parameters	Topographic map	Magnetic compass	GPS navigation devices
Information provided	Overview of the terrain	Direction to the Magnetic North/South	Real-time location data
Portability	High	High	High
Durability	High, if it is waterproof and tear-resistant	High	Depends: Dedicated GPS devices are rugged, waterproof and reliable. Others, such as the GPS in your smartphone are only as durable as your phone.
Reliability	High	High, with operating temperature down to –30°C	Batteries discharge faster when it is cold
Resolution	Depends on the scale of the map	1° or 2°	Depends on the device and the map loaded onto it
Accuracy	Depends on the temporal coverage of the map	Low accuracy near the magnetic poles	GPS-enabled smartphones (depends on the type of phone): 4.9 m GPS devices used for navigation: Depends on the device. As a rule of thumb, a Garmin device has a resolution of 3 m in the horizontal and 10 m in the vertical Accuracy near the poles: Affected. The more satellites within line-of-sight of the device, the higher the accuracy
Sources of interference	Mist, darkness, snowy weather, or other reduction of visibility	Mist or other reduction of visibility, external magnetic fields, objects made from ferromagnetic materials	Geomagnetic storms, extreme weather, radio signals, ionospheric interference, signal obstruction, i.e. deep valleys, dense forest, tall buildings, any impermeable structure/layer (does not work underground)
Ease of use	Knowledge of cartography basics and how to read a map in general is required	Knowledge of compass basics and how to take a bearing is required	Easy, being digital in nature
Cost	Cheap and sometimes free	Ranges from cheap to intermediate	Affordable but can range up to expensive
Suitability	Must-have device, particularly in mountainous and feature-rich areas	Must-have device, useful for taking bearings	Useful to find one's location and the direction to the destination
Other considerations	A topographic map and a compass must be used together to find one's location and the direction to the desired destination		GPS should not be your only navigation device

5 Recommendations for safe and effective fieldwork

Photo: Andrea Schneider

Before going into the field

Good to know

- Know how your devices work. If you are new to using the device, compile a short step-by-step guide on its use and take that with you into the field. Many devices come with such a guide. Make a copy and have it in your pocket, inside a zip-lock bag or laminated.
- Know how to do minor repairs and/or fix common issues.
- Know the magnetic declination, map projection and datum used in maps of your fieldwork area – and set your GPS for the same.
- For radio communication, learn proper radio etiquette before you head to the field.

Good to check

- Check that your devices work.
- Check the charge, or measure the voltage of batteries with a multimeter. This will allow you to remove batteries that are no longer serviceable and/or cannot be charged anymore.
- Do a beacon check before you leave (if you have a PLB). This is free to do but needs to be planned and announced. Cospas-Sarsat provides a detailed guide for a test at its website: (https://cospas-sarsat.int/en/testing-your-beacon).
- If you carry a satellite phone with you, ensure that your home base has its number and vice versa.

Good to bring

- Always have two independent means of navigation and communication.
- Ensure each team member (or members if working in pairs) has at least one communication and one navigation device for redundancy. Never work in the field or leave the town/hotel/station without either.
- If your device has a touch screen, ensure that you bring a touchscreen pen or gloves that are designed to be used with touch screens. Otherwise, buy convertible gloves (where the fingertips can be removed and put back, while your hand stays inside the glove to keep warm).
- Bring fully charged spare batteries and keep them warm.
- Obtain a copy of the call-in schedule, numbers and frequencies to your home base.
- For many devices, you can order fitted shock- and waterproof cases, with attachment points for carabiners, wrist loops or floatation lanyards. Use this opportunity to minimise the risk of dropping, damaging or losing your device.
- It is worth investing in an emergency bivouac bag: This is a wind- and waterproof shelter for one to several people that packs light and small and keeps you warm and dry. Sometimes the weather might turn bad, and you will still need to operate sensitive equipment in rain/snow. A large enough bag will allow you to crawl into it and operate any machinery/electronics/equipment in relative comfort and safety. Always have it easily accessible, e.g. in your backpack.
- Bring some handy tools, e.g. different types of tape (duct tape, electro tape, etc.) and a multi-tool knife.

Tips for ensuring that devices work adequately

- Cold temperatures drain batteries faster. Protect batteries from cold by storing them in your pocket or sleeping bag. Charge batteries at a warm place: If a battery is charged at a very high current at low temperatures, it might result in the formation of dendrites. Dendrites are small particles formed inside lithium batteries by the copper plate inside the batteries peeling off and getting deposited on the non-conductive separator. This will result in a short circuit that discharges the battery.
- Pack your devices waterproof. There can always be rain, or your drinking bottle might spill. Zip-lock bags work well and are cheap but tend to leak or break easily. You can also buy relatively inexpensive waterproof bags made of durable materials from any outdoor store.

In the field

Common problems and how to solve them

- Finding places in the field (your field site, your camp or your snowmobile) in bad weather or in different field seasons can be a challenge. An easy way around this is to mark the locations, for example as waypoints in your GPS. In addition, write the coordinates in your field book, and download the coordinates and store them in a safe place.
- Important locations: Store the coordinates of the point with your device multiple times. This allows you to take an average location.


Photo: Katrine Raundrup

- Map and compass: Remember to take magnetic declination into account for precise navigation.
- GPS: Remember to use the correct/agreed coordinate system and datum.
- Radios: Use the agreed frequency, remember to let go of the "speak" button, so that you can hear replies, and use radio communication etiquette.
- Avoid touch screens if you can as they do not cooperate well with cold weather and gloves.
- Keep your communication devices, navigation devices and PLB (if you bring one) at a place with a zipper that is fast and easy to access; for example in the top lid or a side pocket of your backpack. Avoid jacket pockets, as it is easy to lose items if/when you forget closing the zipper.

Future developments

There are promising technologies under development that may soon become available to support fieldwork activities. Some of them are collected here as examples.

New Low Earth Orbiting (LEO) Satellites to improve internet coverage and satellite-based communication in the Arctic. For example, the Norwegian company Kongsberg Satellites AS is developing two projects for improved internet connection globally (Oneweb) and across the Arctic (Arctic Satellite Broadband Mission). In addition, new developments in Iridium and InReach technology aim to improve internet connection in the Arctic (Inmarsat GX10).

Inmarsat GX10 is an initiative that aims to enable broadband connectivity at latitudes beyond where geostationary satellites can reach. Two satellites with a highly elliptical orbit will cover the Arctic Circle and above. The GX10 Arctic expansion is being developed in a partnership with Space Norway as part of the Arctic Satellite Broadband Mission. The satellites are scheduled for launch in 2022.

The upper layer of the atmosphere, the Ionosphere, has special properties in the Arctic: It is characterized by an enhanced electron precipitation causing an increased ionospheric variability. Northern Lights is the visible result of the increased ionospheric variability at high latitudes. However, this can impair GPS navigation and make it inaccurate and difficult. Research that aims to improve our understanding of ionospheric activity and variability can also help to improve GPS navigation in the Arctic.

Seasonal or temporary mobile technology may assist fieldwork activities in the Arctic in the near future. For example, long distance UAVs (drones) could be used for scouting, communication and navigation purposes and as mobile relay stations for VHF. Major issues are the costs, and an elevated risk of loss in mountainous terrain, in poor weather conditions and during icing events.

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Appendix 1: Radio protocol and etiquette

General etiquette

- Prepare your message before you transmit it.
- Do not send a message if someone else is already using your channel.
- Remember to speak concisely.
- Keep your message short and to the point.
- Speak slowly, clearly, in plain language at medium speed.
- Keep to a natural rhythm as if you are having a normal conversation.
- Use a higher pitch than normal (this improves reception of your message) but keep the pitch at the same level and do not drop it toward the end of words. This makes words unintelligible.
- Do not use ambiguous words.
- Do not use 'uhm' or 'er'.
- Ensure you have pauses between important parts of your message.
- Pay attention to volume – do not speak too loudly nor too quietly.
- Try to keep your volume the same throughout your call.
- Do not raise or drop the volume and tone of your voice toward the end of a sentence.
- Hold the microphone about 5 cm from your mouth to ensure you are heard clearly.
- If you are in an emergency situation have all important information ready (see Emergency Calls, p. 20).
- Use the phonetic alphabet if necessary (see The Phonetic Alphabet, p. 21).

Never

- Share sensitive information, like personal information, since your channel might be shared by others.
- Use swear words, or obscene language.
- Waste airtime.
- Shout.
- Use 'MAYDAY' or 'EMERGENCY' unless you are truly in an emergency situation.

Sending a message

- Press the transmit or Push-to-Talk button.
- Say '[NAME OF RECIPIENT, NAME OF RECIPIENT, NAME OF RECIPIENT] this is [YOUR NAME/YOUR FIELDWORK PARTY CALL SIGN], OVER'.
- Release the transmit or Push-to-Talk button.
- Wait for the person you were contacting to acknowledge they have received the message.
- Then press the transmit or Push-to-Talk button again and relay your message.
- If the person you call does not reply, wait for a minute, and start the call up procedure again.

- If you do not receive an answer after three calls, end the call procedure by saying ' Nothing heard. Out [YOUR NAME/YOUR FIELDWORK PARTY CALL SIGN]'. It might be that the recipient can hear you but you cannot hear the recipient. The recipient then knows that you want to get in contact and can try to move to a better spot, e.g. higher in the terrain or away from obstacles).
- If you made a mistake use the word 'CORRECTION' to indicate that you made a mistake and continue with the correct information.
- Use 'I SAY AGAIN' if you want to emphasise something.
- If you are going to use the phonetic alphabet, then first say 'I SPELL'.
- Use 'AFFIRMATIVE' to indicate 'Yes'.
- Use "NEGATIVE' to indicate 'No'.
- Use 'ROGER" to indicate 'OK'.
- If anything was not clear you can use 'SAY AGAIN' to have the person you are speaking with repeat what they had just said.
- When you are done complete the transmission by saying 'OUT [YOUR NAME/ YOUR FIELDWORK PARTY CALL SIGN]'.

Receiving a message

You follow the same procedure as for sending a message. However, here wait for the operator on the other end to initiate the transmission.

MAYDAY

When you are in a life-threatening situation and need immediate assistance or extraction use:

> 'MAYDAY-MAYDAY-MAYDAY
> [YOUR NAME/YOUR FIELDWORK PARTY CALL SIGN]
> MAYDAY-MAYDAY-MAYDAY'
>
> or
>
> 'EMERGENCY-EMERGENCY-EMERGENCY
> [YOUR NAME/YOUR FIELDWORK PARTY CALL SIGN]
> EMERGENCY-EMERGENCY-EMERGENCY'

Never use these call words unless you are truly in an emergency situation.

Additional information

Sometimes a station will have to transmit or receive a message that has a greater priority than yours. They will then interrupt your message by using 'BREAK'. If you hear this word, cease with your transmission immediately.

Author’s short biographies

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Christel is a lecturer at the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria, South Africa. She is a geomorphologist and GIS specialist, focusing on periglacial environments in the Antarctic and sub-Antarctic, as well as the high-altitude areas of mainland South Africa. Through her involvement in APECS, Christel has also helped organising numerous workshops, meetings and webinars.

Marta Moreno Ibáñez – University of Quebec in Montreal (Canada)

Marta is a PhD candidate in Earth and atmospheric sciences, and she is affiliated to the Centre for the Study and Simulation of Regional-Scale Climate (ESCER). The aim of her research is to analyse the development mechanisms of polar lows. Marta has been actively involved in APECS as an Individual Council Member since 2019. She has coordinated two group reviews of the IPCC 6th Assessment report, organized by APECS, MRI, PAGES ECN, PYRN and YESS. She was a member of the Editorial Board of the State of Environmental Science in Svalbard report 2020 (Svalbard Integrated Arctic Earth Observing System 2021).

Rebecca Duncan – University Technology Sydney (Australia) and University Centre in Svalbard, Longyearbyen (Norway)

Rebecca is a PhD candidate at University Technology Sydney and UNIS Svalbard. Her research interest is the biological implications of sea-ice decline and climate change in the polar regions, in both terrestrial and marine environments. She is also interested in science communication, and through her roles in APECS, she has assisted in organising numerous workshops and conferences.

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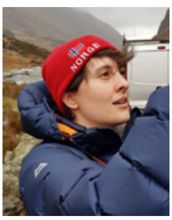
Priyanka is an environmentalist specialized in Hydro-Glaciology. Currently, she is working as a Consultant for Glacial Risks and Hazard Management at National Disaster Management Authority under the Government of India. Through APECS, Priyanka has worked on various projects. She has been a co-convener for organizing the SCAR 2020 workshop for APECS, and she is currently acting as a Council Co-chair for 2020-21 in APECS.



Charlie Hewitt – University of Leicester (United Kingdom)

Charlie is a PhD student in the Department of Geography, Geology and the Environment at the University of Leicester, UK. His PhD is about how machine learning can be used to improve path-network data and the OS footpath dataset. Charlie has been an individual council member within APECS since 2018, and has most recently been leading the APECS UArctic Congress Workshop project group.

Andrea Schneider – UiT The Arctic University of Norway, Tromsø (Norway)

Andrea is a paleo-geologist with a strong interest in permafrost research. She has terrestrial and marine fieldwork experience in the Arctic in summer and winter. Through APECS and INTERACT, Andrea has shared experiences and tips in three INTERACT fieldwork planning-related publications.

About INTERACT

INTERACT is a circum-arctic network with over 85 terrestrial field stations in the Arctic and adjacent boreal and alpine areas. INTERACT specifically seeks to build capacity for research and monitoring in the Arctic and beyond. INTERACT offers access to numerous research stations through its Transnational Access Programme.

One of the main objectives of INTERACT, being funded by the European Union through the Horizon 2020 Programme, is to build capacity for identifying, understanding, predicting and responding to diverse environmental changes throughout the Arctic. This is fundamental, since the Arctic is so vast and sparsely populated that the environmental observing capacity is limited compared to most other regions.

INTERACT offers a multi-disciplinary research platform, and together the INTERACT stations host thousands of scientists from around the world, working on projects within the fields of e.g. glaciology, permafrost, climate, ecology, biodiversity and biogeochemical cycling. The INTERACT stations also facilitate many international single-discipline networks and support educational activities by hosting courses and training schools.

It is a priority for INTERACT to support the education of future polar scientists, and INTERACT therefore cooperates closely with the Association of Polar Early Career Scientists (APECS). One of the results of this cooperation is this guidebook developed to provide insight and guidance on communication and navigation tools to improve fieldwork planning for young and experienced scientists alike.

The guidebook is one in a series of publications by INTERACT to improve the services offered by research stations to the scientific community and to facilitate efficient and safe fieldwork by the scientists themselves.

About APECS

The Association of Polar Early Career Scientists (APECS) is an international and inter-disciplinary organisation for undergraduate and graduate students, postdoctoral researchers, early faculty members, early career professionals, educators and others with interests in the polar and alpine regions and the wider cryosphere. APECS strives to create opportunities for early career researchers to enhance innovative and inter-disciplinary collaborations across the globe, helping to retain and promote the next generation of polar enthusiasts. APECS serves as an institutional partner supporting the involvement of early career researchers in a wide range of activities and organisations, including international research and infrastructure projects such as INTERACT.

Working together with the INTERACT Station Managers' Forum, a group of APECS members has helped put together this guidebook, with the aim of providing a resource for anyone performing fieldwork at arctic research stations and elsewhere in the polar and alpine regions of the world.

The INTERACT Fieldwork Communication and Navigation guidebook is published to help you choose relevant means of communication and navigation for your fieldwork in the Cold North and in mountain regions. It gives advice on how to communicate during face-to-face fieldwork preparation meetings, while in the field and in emergency situations. Finally, it looks to the future to foresee what improvements in relation to means of communication and navigation we can expect for tomorrow's fieldwork.

The book has been made in cooperation between INTERACT, APECS and the managers of arctic and northern alpine research stations, with funding provided by the European Union through the Horizon 2020 Research and Innovation Programme.

If you are planning fieldwork, we also strongly encourage you to take a look at the comprehensive INTERACT Fieldwork Planning Handbook, which is meant as a planning tool for studies in the Cold North, and the shorter INTERACT Practical Field Guide, which is meant as a handy tool to be brought with you into the field.

Let's INTERACT !

www.eu-interact.org

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