Information and Communication Technology (ICT)

Common Terms in ICT

ISP	Short for "Internet Service Provider" - any company that provides internet to a user or agency.
Propagation	The method by which a radio signal is transmitted and interacts with the physical environment.
Frequency	The common measurement used in radio communications - measured by how close wavelengths of a radio wave are.
LEO	Short for "Low Earth Orbit" - when a satellite orbits close to the earth's surface.
Geostationary	An object in orbit of the earth that stays in a singular fixed location.
NOC	Short for "Network Operation Centre" - a central hub through which internet communication passes through, usually for linking remote connections with the rest of the global internet.
Carrier	A company that provides mobile voice communication.
Omnidirectional	An antenna does not have to be specifically pointed, and can send/receive signals from any orientation.
Unidirectional	An antenna that can only send and receive signals in one direction, and has to be pointed directly at the satellite.
Radio	Any analogue communications device that uses radio waves to transmit and receive signals.
Repeater	A device that amplifies and extends the range of a radio signal.
GPS	Short for "Global Positioning System" - a protocol for determining precise locations on the earth's surface using a network of satellites
Latency	Delay in time between a transmitted and received signal.
VSAT	Short for "Very Small Aperture Terminal" - a ground based satellite internet protocol.

Tampere Convention

The Tampere Convention – short for The "Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations" – is a binding international convention that governs the use of radio and satellite communications in response to disasters. Among the provisions, the Tampere Convention requires states who are signatory to ensure "the installation and operation of reliable, flexible telecommunication resources to be used by humanitarian relief and assistance organisations." In real terms, if an emergency has been declared in the country that has ratified the convention, and the country has accepted the assistance of the United Nations, then said nation cannot impede the use of telecommunications equipment in support of humanitarian assistance.

It should be noted legal obligations to provide free access to telecommunications only apply to member state who have fully ratified the convention. At the time of writing this guide, only 49 member states have fully ratified the Tampere Convention, with another 31 agreeing to ratify in the future. Many of the countries in which humanitarian organisations currently operate have not expressed any commitment to sign onto the convention, and even states who have ratified the convention may find specific reasons to impede or deny access to telecommunications services to humanitarian actors. Prior to importing communications equipment into a country, humanitarian agencies should consult with local authorities, customs brokers, and other humanitarians on the ground to understand what restrictions may be in place.

The full text of the Tampere convention can be found in[Spanish, French, English](#) and [Arabic](#).

Computer Networking

The computer networking needs of an office or compound are very specific to the budgets, the size, the capacity, and the overall operational needs of the agency. Agencies should investigate hiring dedicated IT and networking staff to support setting up office and sub office networks.

Office/Compound Set Up

In most field locations, there will be a mix of several very coming office network equipment. These items might include:

Connection to External ISP – Connection to an external Internet Service Provider (ISP) may come in the form of satellite internet, telephone line, or some other form of dedicated connection to a grid proved by the ISP.

Modem – Modems receive signals coming from ISPs and translate them into usable signals by home or office networks. Modems also contain user specific information which is used to identify, trace and monitor traffic for security and billing purposes. Without a modem, any home or office based networking equipment would be incapable of actually speaking to outside networks.
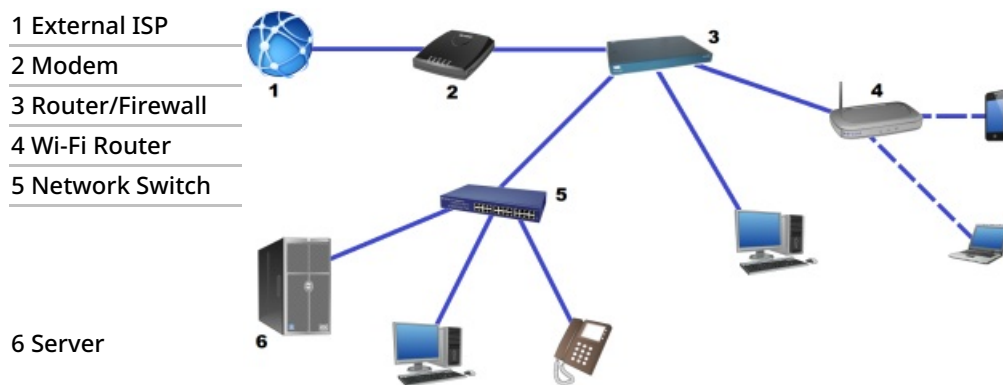
Router – A Router is a device that splits and manages internet traffic, enabling multiple computing devices to have their own unique IP and MAC addresses, and communicate with the internet and each other at the same time over a network. Routers have a variety of configurations and functions. Some can monitor and control traffic on the local network, and others have wifi capability. The type of router used will depend on the operational needs.

Firewall – A firewall is any device that specifically monitors and filters internet content coming

from outside networks. Firewalls are useful for preventing malicious software, casual unauthorised intrusion into networks, or even block content not allowed by the IT policy of individual organisations. In simplified networks, firewalls are often merged with modems or routers, but advanced networks can have standalone firewalls that have different protocols for different users of the service.

Switch – A network switch is like an advanced form of a router – it controls and distributes the internet between multiple networked devices, however switches are capable of detailed monitoring and control down to the individual device level. Switches are also used to filter, block and secure internal networks similar to firewalls securing external threats.

Server – Servers are defined a computers that are fully dedicated to storing and sharing files within a network. Servers can be as simple as regular desktop computers, or as complex as large specialised computing devices that have special installation requirements. In recent years, many agencies have started using "offsite" servers, which host and manage files and data from locations outside of offices, sometimes from a different country. Offsite servers perfectly acceptable solutions, however if the users of the server have inconsistent connection to the internet, a localised server may be preferable.

1 External ISP

2 Modem

3 Router/Firewall

4 Wi-Fi Router

5 Network Switch

6 Server

Operational Security

The operational security requirements of each of local networks should follow basic rules.

Access Control – Only authorised persons should have access to networks and computing devices. All computers should be password protected, and wifi routers should also require a login credentials. Some networks allow for temporary guest access, however the needs for special settings vary depending on the operational environment.

Malicious Software – All computing devices on networks should have some form of anti-virus software, and operating systems should always be up to date. Agencies should consider installing firewalls and/or switches with managed settings to also cut back on the intrusion attempts or the transmission of malicious software.

IT Policy – Agencies should develop and share internal IT policies for all employees and users of the network. IT policies should include rules and regulations for what is considered acceptable behaviour, what he rules for using different types of hardware is, and establish guidelines for failure to comply.

Terrestrial Connections

In a world with ever increasing technology, locally available and locally provided telephony and internet service is becoming more and more accessible. Locally provided service is referred to here as service provided by and to parties within countries of response, usually by local companies who may or may not operate in other countries.

Surveillance and Intervention

Locally provided telephony and internet may end up being cheaper and faster than any other solution, and the use of local services is encouraged where safe and available. Humanitarian agencies operating in multiple contexts should always keep in mind that local voice and data providers always operate under the authorisation and limits of national authorities and regulations.

Many phone carriers and internet service providers are required to provide surveillance to governments about some or all users of their services. In some cases, telecommunications companies are partially or wholly owned by governments, and may be extensions of state intelligence or security apparatuses. In extreme cases, telephone and internet service may be shut off or denied to key persons, organisations, or all users of the service at once due to concerns over conflict, political unrest, or other security related matters.

Humanitarian agencies utilising locally provided voice or data services should always operate under the assumption that their activities may be surveyed or monitored at any time, and seek out redundant communications systems in case of internet or voice being shut off for whatever reason. Some governments heavily restrict the usage of outside or independent communications, such as radio or satellite communications, limiting options for redundant communications may vary from mission to mission.

Mobile Phones / Data

Mobile phones and mobile provided data are quickly becoming ubiquitous throughout the world. While most people are becoming familiar with the regular use of mobile phones and data, there are a few things to keep aware of.

Wireless Carriers/Providers

Wireless carries and wireless providers are companies that interface directly with clients to provide wireless mobile service. The wireless carrier is often the same company the pays for the installation of a wireless network, however frequently providers rent or lease bandwidth from other company's cell phone towers to enhance their coverage.

A wireless carrier established in any given country will have close ties to regulators, working within the national laws and restrictions for provision of wireless communications. Due to the fact each country may have subtle differences in wireless regulation or usage based historical or financial reasons, the specifics of the service provided in each country may be slightly different. Each wireless carrier in a country will broadcast on slightly different frequencies to ensure their individual signals have the least interference. Specific "instructions" telling the phone exactly which frequency to speak on come from the SIM card provided by the carrier.

Mobile Virtual Network Operator (MVNO)

In recent years, there has been an increase in what are called Mobile Virtual Network Operators (MVNOs). MVNOs are mobile providers who don't actually own or manage any of their own network infrastructure, and instead are essentially companies who's service rests

upon other service providers.

The MVNO model may seem counter intuitive – paying for a company who then pays another company seems like it should always be more expensive. The MVNO model has distinct advantages, however; MVNOs can buy service on multiple networks, including international networks, yet continue to provide one singular seamless service to users. MVNOs can also buy bandwidth and airtime in bulk from other larger carriers, and sell smaller portions to multiple parties who may not be willing or able to pay for traditional large service packages.

Wireless Protocols

Global System for Mobile Communications (GSM)	The most widely adopted wireless communication protocol for mobile phones. GSM was developed by European Telecommunications Standards Institute as a method of dealing with standards across multiple countries in Europe, and has since become the default for most countries globally. GSM is easiest to identify by the use of SIM cards.
Code-division multiple access (CDMA)	An older and less widely adopted wireless communications protocol, first established prior to the invention of the modern mobile phone. CDMA makes up less than 10% of global mobile communications. CDMA phones don't utilise SIM cards as a mode of linking the phone to the carrier, however many CDMA phones have SIM card slots for GSM usage as well. CDMA phones must be directly programmed to speak to the mobile carrier network, and often CDMA phones can only ever be used for one provider.

GSM has become the dominant standard globally. In the early days of commercial cell phone service, carriers would sell phones that would only work on their specific frequency, which helped drive costs down because phones only had to have one set of antenna. This would however lock phone usage to single networks and discouraged competition. Consumer advocacy groups and a rise in phones used in international markets prompted the sale of phones that work on all available frequencies available at the time of manufacturing. Modern cell phones can accommodate operating on a wide variety of carrier networks, and with the rise of large singular brands and globally popular phones also helps keep manufacturing standardised.

Even with phone capable of supporting multiple frequencies, carriers will still sometimes sell locked phones – meaning the phone is programmed to only operate within that specific carrier network. This is usually justified by the fact the carrier might have subsidised the cost of the phone to the consumer, and is recovering the cost through monthly service fees. The practice of locking phones is becoming widely discouraged, however it still occurs in many places.

In some contexts, using a single mobile carrier is not sufficient, and users may wish to use two or more. Many mobile phones come with slots for two SIM cards, or may even have the ability to connect to both CDMA and GSM networks.

When acquiring mobile phones, humanitarian agencies should consider:

- Does this phone need to operate in a different country?
- Does this phone need to connect to more than one carrier?
- Will the phone need to be unlocked, or will it work natively with any network?

- Does this phone have the capacity to operate in the areas where it is needed?

Mobile Phone Generations

The technology surrounding how mobile communications work are segregated into "generations" or referred to a "G" for short. This is frequently shortened even more to a number to help reduce confusion, such as 3G, 4G, 5G, etc…

There is no one specific technology that composes a "generation," rather a generation is defined by a series of minimum standards, including voice communication encryption, data speeds and certain specifications for phone design. Each new generation of mobile communication is accompanied by new processors and new antenna technology which may not be compatible with previous generations. As such, as new mobile phone generations are introduced, older mobile devices will probably not work with new services.

Mobile Data

Internet service from mobile carriers has become ubiquitous and almost more important than regular voice communication. The same limitations on hardware, wireless protocol, generations, carrier lock ins and general coverage still apply to data specific mobile applications. If humanitarian agencies are planning on acquiring mobile hot spots or dongles, they should consider all areas of operation equally as they would a mobile phone.

Landline

Traditional landline communication is one of the oldest methods of electronic communication still in usage in humanitarian contexts. Landline voice communications are facilitated through physical infrastructure, usually telephone lines transmitting signals through large copper wires. Individual homes and offices are connected to the telephone network through a physical connection, usually requiring some form of professional installation from the telephone provider. Phones with dedicated phone numbers are called "dedicated lines."

Wireless communications are quickly eclipsing the use of physical landlines, especially in humanitarian contexts where physical landline telephony might not have been available in the first place. Landlines are also susceptible to physical damage and may be harder to repair. Many agencies may wish to use landlines because they are probably cheaper, and offer specialised business support. The choice to go with a landline dedicated phone is up to each agency, however it is recommended to always have redundant systems of communication to avoid problems should one system be cut off.

Internet Service

An Internet Service Provider (ISP) is any provider of internet in any format, however the term ISP is usually closely associated with internet provided by in-country terrestrial based companies. Traditionally, ISPs provided internet over telephone lines, however there is currently a wide spectrum of different methods of providing internet to a fixed location, including phone, cable, fibre optic, and even point to point wireless. As mobile communications have become increasingly popular, the methods and nature of ISP provided internet service has started to blur with other forms of mobile communication.

The global internet infrastructure is extremely complicated and ever evolving. In the broadest terms possible, local ISPs serve as the bridge to services and content largely hosted outside of the country of operation. General concepts for internet service provision are:

IP Address - Every computing device connected to the internet has what is called an IP address, short for Internet Protocol Address.

Web Servers - Web services – such as websites and apps – are hosted on large "servers", computers that store data and respond to incoming queries. Servers have IP addresses just like personal computers. Web hosting servers may or may not be in the same country as the person using the service hosted on the server. Many large companies have started hosting large numbers of services in one or a few locations globally.

URLs - The name of a website (example:www.logcluster.org) are defined as Uniform Resource Locators (URLs). URLs are what most people commonly understand as web site addresses.

DNS - Specialised servers called Domain Name Servers (DNS) are what hold the key to translating what we know as URLs into the unique IP addresses of remote servers. DNS servers may or may not be controlled by ISPs in a specific country.

Local ISPs have incentives or disincentives to prioritise or block certain traffic. Many local laws prohibit certain types of content for cultural or political reasons. Additionally, weak local regulation may result in privately owned ISPs favouring some companies or services over others, purely out of collusion or anti-competitive practices. ISPs have the ability to filter or block websites fairly easily, especially if they manage their own DNS servers.
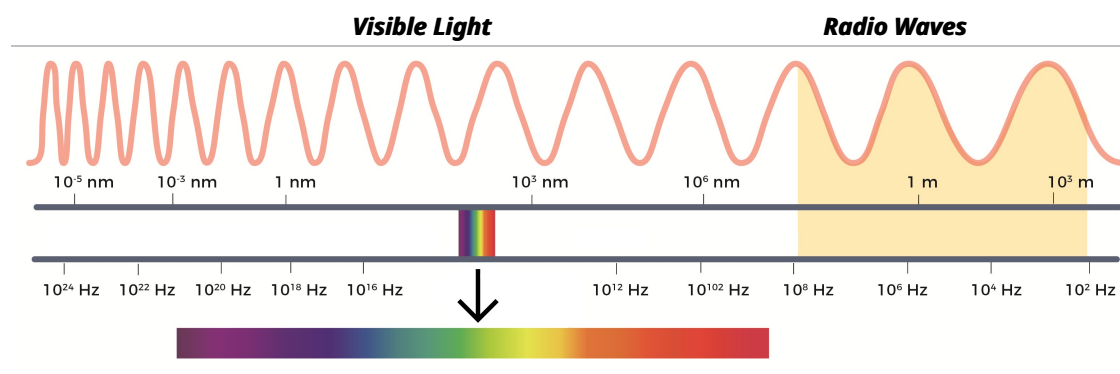
Wireless Communications

A large and increasing portion of communications technology is becoming wireless. As more and more processes become wireless, the more complex the infrastructure surrounding them becomes. Understanding the basics of wireless communication is becoming important for the average user.

Electromagnetic Radiation

All forms of wireless communication rely on what is knows as "electromagnetic radiation." Electromagnetic radiation refers to waves of energy in the electromagnetic field, which carry – sometimes referred to as "propagate" – electromagnetic radiant energy across three dimensional space. Though the term "radiation" has negative connotations in common usage, used here it simply implies that a single point source is giving off – or "radiating" – energy. Electromagnetic radiation isn't necessarily harmful to humans, however certain frequencies and in sufficient quantities it can be.
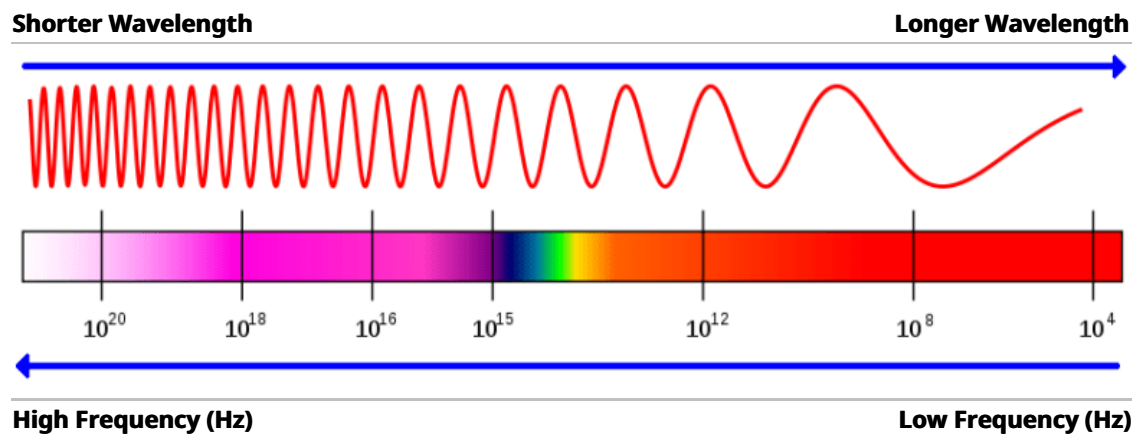
Observers perceive electromagnetic radiation in a variety of formats; both radio waves and light waves are forms of electromagnetic radiation, they just happen to have different wavelengths and fall on different parts of the spectrum.

In a vacuum, all electromagnetic radiation travels at the same speed – the speed of light. As electromagnetic waves travel through different substances, their speed and/or ability to transmit begins to change based on the properties of the physical matter and the wavelength of the electromagnetic radiation itself. For example, both light and radio waves are able to pass through the earth's atmosphere, while only radio waves can pass through the walls of a building as light bounces off the solid structure. In any situation when electromagnetic radiation interacts with any form of matter, the radiation will always lose at least some of its strength as electromagnetic waves interact with molecules of the physical matter itself.

Wavelength and Frequency

In electromagnetic radiation, there is a direct relationship between energy, wavelength and frequency. The shorter the wavelength, the shorter the period between the peaks of two waves. Because all electromagnetic radiation travels at the same speed, as the wavelength becomes shorter, the relative frequency of the of the wave increases, as the period between the peaks of two waves becomes shorter. As the frequency increases, more energy is conveyed over the same period of time, meaning shorter wavelengths with higher frequencies appear to be more energetic when received from a relative vantage point.

Shorter Wavelength   **Longer Wavelength**

10^{20} 10^{18} 10^{16} 10^{15} 10^{12} 10^{8} 10^{4}

High Frequency (Hz)   **Low Frequency (Hz)**

Antenna Size/Structure

As there is a direct relationship between wavelength, wave frequency, and wave energy, there is also a direct correlation between wavelength and the size of the required antenna to transmit/receive a signal. Practically this means that the higher the frequency of a signal, the smaller the receiving antenna needs to be, the implications being that radio waves on the lower end of the frequency of transmission will require significantly larger antennas. For humanitarian agencies, there are real world trade-offs between the usefulness of a certain band of transmission, and how large their radio reception equipment can actually be.

Radio Propagation

Propagation speed is defined as the length of time it takes for one thing to move to another. The speed of radio propagation in a vacuum is the speed of light, and this speed can be impacted by passing through a variety of transparent or semi-transparent mediums.

Additionally, as different wavelengths of electromagnetic radiation move through any transparent medium, there are subtle and very specific ways in which they are altered or interact with that medium which are governed by a variety of factors. When it comes to using radio or microwave signals within the earth's atmosphere, there are modes of propagation that impact communication.

Line of Sight Propagation – Line of sight propagation means radio signals can only successfully be received and transmitted if there is no large object blocking the path between the two. Line of sight propagation does not mean that both the transmitter and receiver need to be able to physically see each other – such as a satellite in orbit of the earth – nor does it mean that there has to be completely open space between two objects – such as a VHF radio working inside a structure with radio-transparent walls. Line of sight propagation is important because, hills, large structures, and even the curvature of the earth will limit how far a line of sight signal can go. Most VHF/UHF and microwave radio communications devices are limited by this method of propagation.

Groundwave Propagation – Radio waves can be propagated using what is called groundwave or "surface waves". Groundwave propagation involves radio waves moving along the surface of the earth and bouncing off solid structures such as hills or buildings. VHF and UHF communications might benefit from groundwave propagation a little, but generally only higher frequency signals benefit from groundwave propagation.

Skywave Propagation – HF radio waves in the earth's atmosphere propagate using skywave or "skip" propagation. Skywave propagation enables signals transmitted along portions of the HF frequency to bounce off the earth's ionosphere and oscillate within the earth's atmosphere well beyond the horizon. Skywaves are able to reach around the curvature of the earth's surface, sometimes to great distances, however distances are impacted by a complex series of environmental factors.

In practice, all spectrum of radio waves interact with their environment in many different ways, meaning multiple forms of propagation may be possible.

- **Absorbed** – Radio waves are absorbed and neutralised by large stationary objects like buildings.
- **Refracted** – As radio waves pass through any medium of varying density, their course may be altered.
- **Reflection** – Radio waves bounce off stationary or solid objects, sending signals in a new direction.
- **Diffraction** – The tendency for radio waves to bend towards large objects as they pass over/around them objects.

The combined effects of these different effects creates what is known as multi-path propagation. Multi-path propagation practically results in signals being received in seemingly random or inconsistent ways. It is why signal strength can be increased or decreased by moving one or a few meters in one direction or another, and what may create dead-zones for radio communication.

Satellite Communications

The availability and access to satellite communications has been steadily growing for the past few decades, and while the number of providers and wide scale availability of land based or localised internet and voice providers has dramatically increased in the past decades, humanitarian agencies are still heavily reliant on satellite communications in a variety of contexts.

Technical Considerations with Satellite Communications

National Regulations

Even though satellite signals can theoretically be received in any location under the satellite's coverage area, there are still national rules and regulations governing the use satellite communications in different countries. Some countries may require special licenses and registrations for the use of satellite equipment, while other countries may ban them outright. Many governments have close ties with local telecommunications providers which enables them to monitor and control voice and internet traffic – satellite communications devices can and do circumvent many of these controls. Some states allow for the use of some satellite communications equipment, but require additional hardware be installed at a user's location to properly monitor activities.

Prior to buying, importing, using or selling any satellite communications equipment, humanitarian agencies should research and understand what the local regulations are. Failure to comply with regulations may result in severe penalties.

Latency

The delay in time between when a signal or packet of information is sent and when it is received is known as "latency" in ICT terms. Latency is something that impacts all forms of electronic communication, however users of satellite communications are especially impacted by this. The inherent distances involved with satellite communication and the types of communications infrastructure in place to support satellite communications can lead to fairly high levels of latency between users. This is especially noticeable when communicating by voice over a satellite phone or VIOP connection – users will likely encounter some form of delayed feedback and must moderate their communication styles accordingly.

Antenna Focus

Satellite communications devices can use both what are called "omnidirectional" and "unidirectional" antennas.

- **Omnidirectional** – Antenna does not have to be specifically pointed, and can send/receive signals from any orientation.
- **Unidirectional** – Antenna can only send and receive signals in one direction, and has to be pointed directly at the satellite. Unidirectional antennas tend to be used for stronger signals.
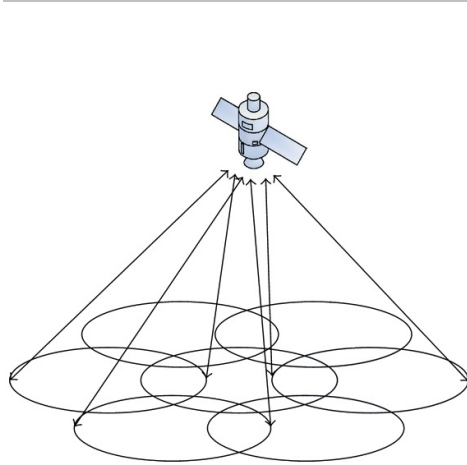
The antenna used by each device depends on the nature of the device, and it's relationship to the satellite.
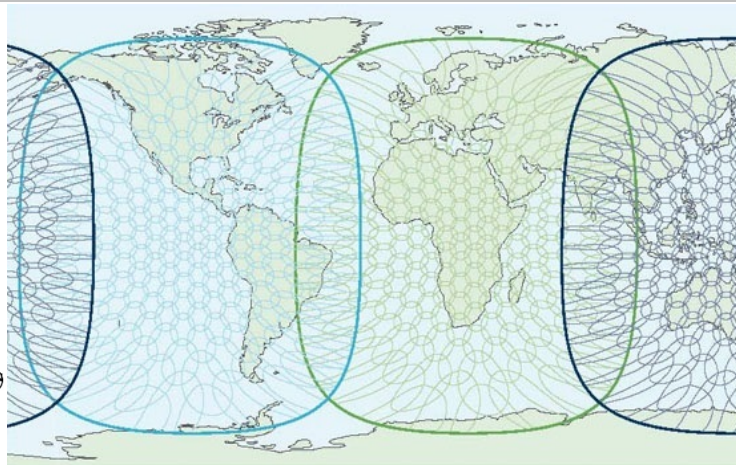
Spot Beams

In the process of delivering communications to the ground, satellites use a variety of antennas to transmit and receive frequencies. In order to better control specific areas served by the satellites, or to compensate for potential equipment failures, many communications satellites utilise what are called "spot beams".

When a spot beam set up is used, the satellite will break the signal up into many smaller geographic coverage areas. Often times, these spot beams directly correspond to physical hardware components, such as processors, individual antenna components or other stand alone features. In most cases, while special spot beams enable satellite communications providers to turn up or turn down the bandwidth available in specific spot beams, they also limit the maximum throughput per spot beam. In other words, the maximum data output capable of the entire satellite cannot necessarily be used in just one location.

Example: Spot Beams   **Real World Spotbeam Coverage - Inmarsat**

Understanding spotbeam coverage is important for humanitarian organisations utilising satellite communications. Often times, in post disasters or in complex emergency settings, many humanitarian agencies are co-located in the same clusters of towns and compounds. In situations where most or all actors are trying to access the same satellite communications service at the same time, they can overload the capacity of that specific spot beam. This is why even if only one or a few persons are using voice or data within your compound the system may still run slow – all of your neighbours may be doing the same thing at the same time.
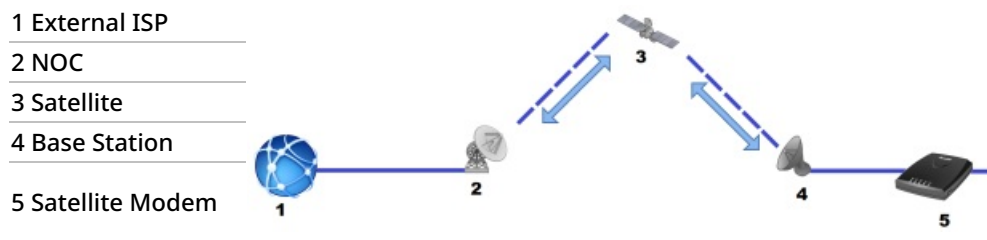
Contention Ratio

Contention ratio in normal networking terms refers to the ratio of the potential bandwidth capacity of a network compared to its actual network usage. In the world of satellite communications, contention ratio takes an entirely new context however. The contention ratio of a refers to the number of individual base stations that are using the same connection and the same channel at the same time. A ratio of 8:1 would indicate that eight total base stations are connecting to the satellite at once, and any organisation using a contract with a built on 8:1 ratio must be prepared to share bandwidth with seven other organisations at any given time.

In humanitarian response settings, the contention ratio of users can cause problems quickly. As many organisations pour into a disaster setting, often without any other functioning communications infrastructure, the number of concurrent organisations utilising a satellite communications network can add up quickly, especially for internet services. Many satellite communications providers can offer tailor made packages that guarantee lower contention ratios, however such packages tend to be more expensive. When planning to use a satellite communications device, plan ahead and know what it's intended use will be. Will this device be used for casual usage in areas where regular phone or internet coverage is spotty? Or will this device be used as the primary access point for multiple business essential users? If a data device is meant to be heavily used in emergency settings, perhaps a lower contention ratio package should be considered.

Network Operation Centre (NOC)

In satellite communications, the term "Network Operation Centre" (NOC) is colloquially used to refer to any location where a satellite routes terrestrial traffic through. When using a satellite phone or satellite internet, though the handset or base station may be speaking to the satellite

directly, the satellite itself must still eventually route its traffic through another form of connectivity to complete the communication. Very few satellites offer direct communication point-to-point, while the vast majority of the time the other receiving end, either a computer, mobile phone hosted service is on a different network entirely.

| 1 External ISP |
| 2 NOC |
| 3 Satellite |
| 4 Base Station |
| 5 Satellite Modem |

NOCs are the gateway rest of the world, and can route communications appropriately. NOCs are specially operated, and may be owned or sub-contracted by the satellite provider. In large satellite communications networks, a complex series of NOCs can be utilised to cover different geographic regions and special purposes. NOCs are also one many pieces of infrastructure required to enable satellite communications, but can also be another point along the communications chain that can slow down connections, and unfortunately service users have virtually no control over issues caused by NOCs.

Bands of Transmission

Communications satellites operate using various form of radio and microwave transmission, both of which found on the spectrum of electromagnetic wavelengths. Communicating with satellites from the earth and vice versa requires wavelengths that can penetrate the atmosphere and deal with a wide range ambient interference. Additionally, satellite communications providers have settled on certain standards that comply with state and international regulations. When speaking about satellite communications, the most common bands of transmission are:

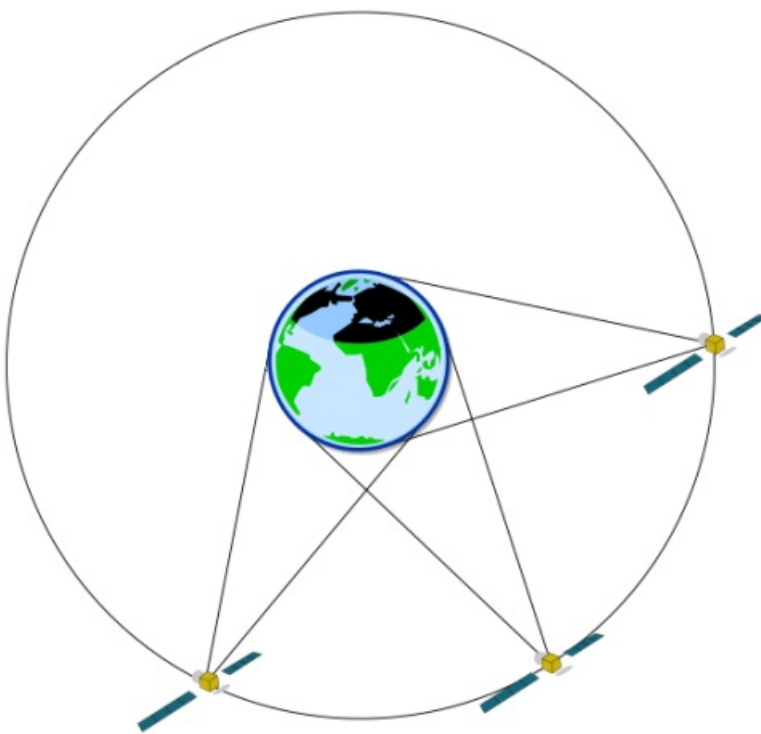| L | 1.0 - 2.0 gigahertz (GHz), radio range |
C	4.0 - 8.0 gigahertz (GHz), microwave range
Ku	12.0 - 18.0 gigahertz (GHz), microwave range
Ka	26.5 - 40.0 gigahertz (GHz), microwave range

Understanding Orbits

Satellites by definition are above and outside the earth's atmosphere, and move along curved paths that circle the globe called orbits. Two objects in the vacuum of space will interact with each other, relative to their respective masses, their velocities, and the distances between them. In order to maintain a consistent orbit around the earth, satellites will need move along their orbital paths at different speeds depending on their orbital distance from the earth – moving too slow would result in the satellite crashing back into the earth's atmosphere, while moving too fast would result in the satellite breaking orbit and flying freely into space. In addition to variable speeds based on their distance from the earth, the further a satellite is from the earth, the longer it's circular orbital path.

The differences in speeds and the length a satellite has to travel in orbit, combined with the fact the earth spins on its axis, result in extremely different experiences when satellites are viewed from a relative location on the earth's surface. If a single satellite is orbiting close to the

earth, it may only be "viewable" for a short period of time from any given point on the earth's surface. If a single satellite is orbiting close to the earth along a predefined path that does not change – along the earth's equator for example – it may never be "viewable" from certain angles, such as from areas near the earth's poles.

Inversely, the further away from the earth a single satellite orbits, the wider the viewing angle it may have, meaning it may be more consistently reachable from any given point on the earth. However, the speed at which a satellite may orbit the earth at a further distance might dictate that the satellite may be unreachable for longer periods of time, or unreachable at all depending on the viewers location.

Understanding how satellites work is essential for humanitarian organisations that plan to use satellite communications as an integral part of their own operations.

Geosynchronous/Geostationary Orbit

When the time it takes for a satellite to complete one full orbit matches the time it takes for the earth to complete one full revolution on its axis, and when the satellite is orbiting directly above the equator and in the same direction as the earth's revolution, it is in what is known as a "geosynchronous" orbit. The practical result of a geosynchronous orbit is that when viewed from the earth's surface, the satellite appears to stay in the exact location above the earth's surface at all times, and can be called a "geostationary" satellite.

A geosynchronous satellite will always be at a fixed altitude of 35,786 km, and will be able to reach approximately 40% of the earth's surface in the area immediately under the satellite. At the closest distance there will always be a delay of at least 240 milliseconds, or 0.25 seconds between the time data/a message is sent, and when it is received on the other side. However, depending on the network arrangement, the speed of the physical hardware, and where the transmitter/receiver are within that 40% coverage area, latency can be greater.

Satellites in geosynchronous orbit are useful for when there are only one or a few satellites required or used to provide a continuous service to a wide area. Due to the fact the satellites don't move relative to the viewer, communications devices accessing a geostationary satellite will need to be permanently installed and oriented, and cannot be moved or reoriented easily. This means that though the satellite receivers are not mobile, they also don't need to be compact, and can scale to be as large as required for the job.

Unfortunately, single satellites covering a large area means that singular geostationary satellites can and do service a high number of fixed base stations, and all users within the geographic area of coverage are reliant on a single source to transmit and manage their communications. This often leads to limited bandwidth availability, and can cause security problems – a single satellite poses a single point of failure. Additionally, geostationary satellites are easy for governments or militaries with the appropriate technology to block or jam, as the overall wavelength will remain constant and can be balanced out.

Low Earth Orbit

Low Earth Orbit (LEO) satellite is a catch-all term used to describe any satellite that operates below an altitude of 2,000 km, while the term Very Low Earth Orbit (VLEO) is reserved for any satellite that orbits below an altitude of 450 km. There is no one defined path or distance of communications satellites that may inhabit the LEO range, and there are a wide variety of different providers and satellite configurations who make use of this system.

LEO satellites orbit relatively rapidly compared to the earth's rotation, and will make at minimum at least 11.25 orbits of the earth in a single day, with more being possible for lower LEO satellites with shorter orbital distances. Due to the fact LEO satellites are much closer to the earth, their field of "view" is much lower, and each LEO satellite can only cover a small percent of the earth's surface at one time. LEO satellites are also not constrained by the direction of their orbit; LEOs may orbit north to south along the poles, along the earth's equator, or in diagonal patterns that constantly shift their relative coverage areas.

If a communications device on the earth's surface were to only communicate with one LEO satellite, the satellite would be out of communication for large portions of the day. To remedy this problem, satellite communications providers will establish multiple satellites and have them communicate with each other in a satellite constellation or array. LEO satellites in an array will communicate with either directly, or through multiple NOCs on the ground. The number and approximate coverage area of LEO satellites in an array is extremely variable, and can range from a small number for specific applications to potential arrays of hundreds of satellites serving a single purpose.

LEO satellites offer advantages, in that the increased number of functional communications satellites can dramatically increase the availability of useable bandwidth. LEO satellite arrays also offer some security benefits – if a single satellite has technical problems it likely won't impact the other satellites in the constellation. LEO satellites are also much harder to radar jam, as their movement makes signal interference more technically challenging.

Unfortunately, LEO satellites also lead to significantly higher start-up and usage costs because sending multiple satellites into orbit and maintaining them adds more cost to the process. Also, due to the fact LEO satellites have narrower fields of view, a consistent signal may be harder to maintain in some operational environments.

There has been a recent increase in the number of LEO and VLEO providers as commercial space cargo becomes more financially viable, and the hardware to make communications satellites becomes smaller and cheaper.

Very Small Aperture Terminal (VSAT)

VSAT satellite internet is probably one of the most established and widely used forms of satellite communication by humanitarian agencies. VSAT – short for "Very Small Aperture Terminal" – technology was developed in the 1960s, and became widely commercially available starting in the 1980s. Though prohibitively expensive in the beginning, today VSAT providers can be easily found in most countries where VSAT communications are allowed by local laws. VSATs are distinctive by their large, unidirectional satellite dishes.

VSATs work exclusively off of geostationary satellites. A variety of companies have launched multiple VSAT specific geostationary satellites in the past few decades, usually positioned above regions of the world where they believe most customers are or will be located. Though there are some universal parts to VSAT equipment, it should be noted that VSAT installations cannot switch between different satellites without obtaining new hardware, repositioning the dish, and likely entering into a commercial contract with a different service providing company. VSATs largely use the C, Ku and Ka band spectrum, and communications providers will even use specific frequencies within those bands. For this reason, specific components for VSAT provider likely cannot be used for a different provider.

VSAT connections are usually billed on a monthly basis just like a regular terrestrial based internet provider, however special arrangements can be made for usage only certain times of the day/week, or to only be used during emergency settings. The monthly cost for VSAT provided internet varies dramatically, depends on the data plan, usage, the number of VSATs governed under one contract, and the general geographic location, but can easily cost upwards of 1,000 dollars a month for a basic connection. Download speeds also vary, and depend on the hardware and the terms of the contract.

The internet service provided by VSATs, while expensive, is still largely one of the cheaper satellite internet connections available. Additionally, VSAT internet is usually capable of and suitable for supporting multiple connected computers and IP enabled devices concurrently. While upload and download speeds will never be equal to most terrestrial based connections, VSATs are still largely considered the preferred satellite option for business settings, or guesthouses where multiple persons will live and work.

Though the term "very small" would imply VSATs are little, they are actually currently one of the largest satellite communications terminals commercially used. The satellite dishes used in VSAT installations can be very heavy and measure up to 1.5 meters in length, or even more, and require a firm anchor.

Fixed VSAT Installations

In fixed installations, the dishes themselves are usually firmly attached to a standalone metal pole, which is sunk into the ground with concrete or anchored to a building. Fixed installation dishes installed at a specific location are specifically designed to match both the GHz transition frequency of the connecting satellite and the geographic location of the base station, and need to be carefully aligned and calibrated to work with the selected ISP. Installation of VSATs should only be conducted by professionals, usually working on behalf of the ISP.

Mobile VSATs

Recently, many emergency responders have moved towards more advanced mobile VSAT technology. While other mobile ground terminal technology exists, what is important about mobile VSATs is that their underlying technology is the same as regular VSATs: relatively large, specially made dishes that work off geostationary satellites. Mobile VSAT equipment must be purpose made with the mobile application in mind, including:

- Dishes that can be collapsed or taken part.
- Possibly multiple BUCs or Modems.
- Adjustable dish mount.

Some mobile VSATs are capable of automatically detecting the appropriate satellite and aligning themselves, and are referred to as "self-acquiring" VSATs. Other mobile VSATs require manual configuration every time. Mobile VSATs tend to be very expensive, and require

specialised training to handle and set up. Before attempting to buy a mobile VSAT, an organisation should understand it's intended end use. A mobile VSAT should never be used in place of a permanent VSAT wherever possible.

VSAT Components

Unlike other self-contained mobile ground terminals, VSATs are made of multiple pieces of specialised equipment that must be specified for the application.

1. Satellite Dish (also called a "reflector") – a parabolic dish of non-radio transparent material that reflects information going to and from the satellite to the focus of dish.
2. Block up Converter (BUC) – BUC units convert low energy signals to high energy signals, and are used to "send" the signal from the VSAT
3. Low Noise Block Converters (LNB) – LNBs convert high energy signals to low energy signals, and are used to convert data received rom the satellite into a usable signal for the modem.
4. Modem – proprietary hardware that translates the signal from the satellite into usable data for a computer or computer network.

BUC, LNB and modems all require some form of external power, though usually relatively low. If a base or office will be without power for multiple times of the day or week, it will have to consider a battery back up for the VSAT if satellite provided internet is required at all times. Additionally, BUC and LNB units are outside and easily accessible. Though they are relatively low powered, users should avoid touching them or coming into contact with them while power is supplied. If necessary, the dish can be marked with a warning sign, or even be fenced off in a secure location.

Common Problems with VSATs

Though VSATs are fairly well established and well used, they are not without their problems and users can and do make common mistakes.

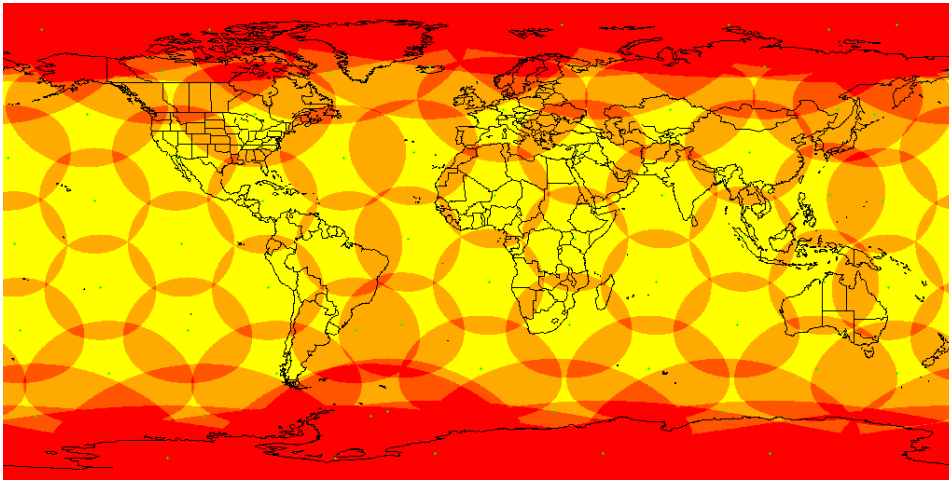|	
Bad Weather	The bands used by VSATs – C and Ku – can be adversely impacted by bad weather, including heavy rain, thunderstorms, sandstorms and even thick fog. Any tiny particles suspended in the atmosphere can and will impact the radio signals coming to and from a satellite.
Blocked Signals	Satellite dishes used for VSATs should have a direct line of sight to sky to properly function. Buildings and structures, trees, hills, vehicles and even people can block signals if placed in front of satellite dishes. When installing a satellite dish, users should plan for activities that might occur around the dish, or future changes that might impact the installation. Trees may eventually grow to block a signal, and the tree will either need to be pruned or the dish moved. Sometimes parked vehicles or stored materials can block dishes un-intentionally. Also, do to the mostly permanent nature of the dishes, users may simply forget how they work – building a new structure or raising a compound wall may block the signal. If users are experiencing problems with VSAT signals in good weather, they should investigate if something is blocking the signal first.
Low Power	VSATs equipment still requires power to receive, transmit and interpret signals from space. Sometimes, under-powered equipment may still appear to be working but not actually able to perform well. Low powered or under-powered equipment may come from a poorly maintained generator or power grid.

Mobile Voice and Data Satellite Systems

There has been an increase in the number of and availability of mobile voice and data devices that work off communications satellites. These devices usually run off proprietary satellite arrays that have their own configurations, shortcomings and special considerations. Many companies that started offering only one type of voice or data solutions have begun offering a spectrum of products for both voice and internet utilising their own satellite networks. For this reason, it makes sense to speak about them by provider instead of by service type.

Iridium

The Iridium satellite constellation is one of the earliest entrants into the mobile satellite communications services market, going online in 1998 and providing continuous service since. Today, Iridium is widely used by military, commercial companies, and humanitarians alike.

The Iridium network is comprised of 66 LEO satellites that orbit the earth from pole to pole, and utilise the L Band for uplink and downlink.

Iridium Coverage Map

Originally, Iridium provided voice only service, using large handsets that communicated with the overhead satellites, however Iridium now offers limited data service for internet connection. The basic idea behind the network isn't dissimilar to modern cell phone towers; there is a signal "hand-off" between satellites, meaning users on the ground may not notice when one satellite moves past the horizon and phone connects to another satellite.

The benefits of the Iridium network are that its coverage is global, and will realistically work on any place on the earth's surface. Iridium is beneficial for agencies that may send users to any or multiple locations on the planet, especially in unplanned emergencies. Its global coverage has made it very attractive to some industries, such as aviation and maritime. In practice, Iridium phones face the same challenges that any LEO satellites face – the fact the satellites are in constant motion means that they will inevitably move towards positions of less coverage. If a user is in an urban environment, a forest, or surrounded by mountains or canyon walls, signal strength may be intermittent.

Iridium devices connect via unidirectional antennas, and come in a variety of form factors. Though Iridium devices do provide data services, it is usually limited to below one megabyte per second download. The majority of the commercial Iridium devices used in the humanitarian sector are self-contained, meaning they only need a battery charge or connection to a power source to work, however there are a variety of accessories to augment usage.

Example Iridium Handset Phone

Thuraya

The Thuraya network, like Iridium, started offering consumer grade satellite voice services and has become a widely used and trusted network. Thuraya first began services in 2003, and currently uses two geostationary satellites to provide voice and data services to ground users.

Due to the geosynchronous nature of the satellites, the Thuraya network only serves a fixed number of geographic locations on the earth, predominantly in Europe, Africa, the middle est, South and Central Asia, and Oceania.

Coverage Map. Source: Thuraya

Thuraya voice devices work off the L band spectrum, and use omni-directional antennas to connect. The use of only two geosynchronous satellites drives down operating costs, however limitations include increased latency, increased interference, and the potential for more environmental interference. Additionally, Thuraya unfortunately cannot service anywhere in the Americas, or any location too far north or too far south in any of the hemispheres.

Thuraya also offers internet service through a proprietary terminals. The Thuraya internet terminals are unidirectional, and require physical orientation to connect to one of the two satellites, however there are self-pointing models available at higher costs, and depending on the needs of the user. Thuraya ground terminals can easily reach speeds of to 400 kilobytes per second.
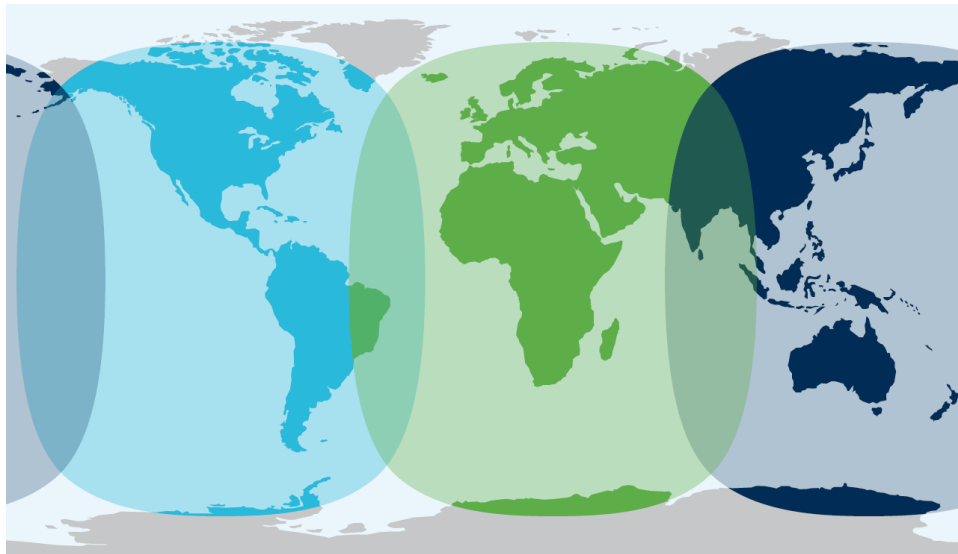
Thuraya IP Mobile Internet Terminal   **Thuraya Handset Phone**

Inmarsat/BGAN

Inmarsat began its life as a non-profit organisation in support of maritime vessels, but was privatised in 1998. Inmarsat began offering global satellite internet data starting in 2008 through what is called the Broad Global Area Network (BGAN). The BGAN network runs off on

three geosynchronous satellites strategically positioned to cover most areas of sea and landmass used by human settlements and activity.

Coverage Map. Source: Inmarsat

Inmarsat offers a wide range of BGAN terminals that are designed for different levels of throughput and usage. All BGAN terminals are unidirectional, run on the L band, and require orientation by the user, however various models include self-pointing models for use on moving vehicles. Depending on the type of terminal, BGAN speeds can reach 800kbps, and some BGAN terminals can even be linked together to produce speeds of over one megabyte per second. Because all Inmarsat satellites are geostationary, the same usual limitations apply.

Beginning in the early 2010s, Inmarsat also began offering standalone voice service as well. Dedicated voice plans run off standalone handset phones that use omnidirectional antennas, and work in all places BGAN service is provided.

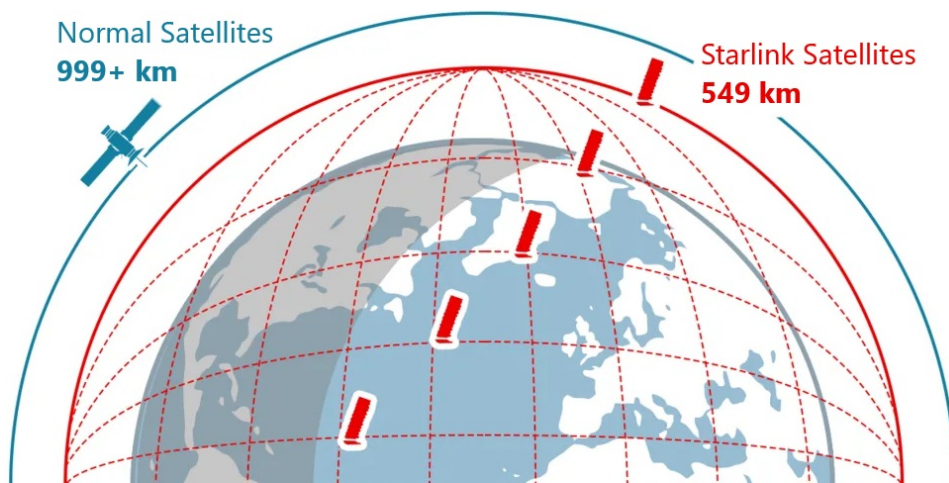**BGAN Terminals**   **Roof Mounted Self Acquiring BG**

Starlink

One of the newer companies to offer high bandwidth satellite internet is Starlink. Starlink began launching satellites in in 2018, and now has over 6,000 satellites in orbit, with more planned in the near future. Starlink satellites provide coverage for the entire planet, however

local regulations may limit this.

The Starlink satellite constellation takes a different approach than previous satellite internet providers – Starlink has launched satellites in various orbital paths in LEO and VLEO orbital planes. The LEO/VLEO satellites have very short orbital periods, circling the earth multiple times a day. The satellites all actively transmit data between each other, forming a virtual "net" around the world. This means Starlink satellites both actively transmit data to ground stations (NOCs) but also between each other, speeding up data transmitted around the globe.

Individual Starlink satellites are not designed to have long service lives, and their orbits are designed to decay after several years. The act of replacing the satellites allows the company to replace older models with upgraded hardware, and increase it's network offerings.

Starlink ground antennas are designed to be omni-directional, and don't require special orientation, however they will still require clear, unimpeded access to the sky. Nearby obstructions such as buildings or tall trees will still disrupt service. As the satellites rapidly orbit the earth, the antenna will automatically register and connect to satellites rising on the horizon. New antenna models are continually being produced.

Example Starlink antenna:

Other advantages of Starlink as a service include:

- The high number of satellites create critical redundancy, reducing the strain on any one orbital satellite, as well as compensate for any one satellite that may be experiencing problems.
- The network has extremely high bandwidth compared to most other satellite providers.
- The network will slowly evolve, enabling enhancements to internet speeds and newer hardware to be used.

Some disadvantages of Starlink as a service might include:

- The ground antennas and modems require comparably larger amounts of energy to maintain a constant connection.
- Many governments heavily restrict or block access to Starlink.
- As the satellite network slowly upgrades, older antennas and equipment may no longer function.

Consult with a professional supplier on hardware and ground installation needs before making a purchase of Starlink internet services.

Additional Providers

There are a number of additional providers of satellite communications that have either entered the market in the past few years, or will be entering the market in the very near future. Advances in technology and new investments will substantially increase not only coverage, but overall data speeds, while keeping costs at a manageable rate. It is very likely that in the next decade there will be a substantial increase in the number of commercial providers that humanitarian agencies will be able to use.

General Guidance on Mobile Satellite Device Management

Operating Costs

The operating costs associated with current mobile satellite devices can be extremely prohibitive for many agencies. The physical devices themselves can range from hundreds to

thousands of dollars, while the voice and data rates can cost vastly more than regular terrestrial based providers, especially for mobile satellite internet. Any individual or agency who plans to own and operate a mobile satellite communications device should investigate plans up front, and know what costs are going to be incurred.

Any personnel using satellite devices should be educated on their proper use and what costs are associated with each one. As our working environment becomes more and more dependent on connectivity, casual users may not be aware of all of the background data a single connected computer may use, including downloading system updates, emails, or corporate file sharing programs. Unless users are on some form of unlimited plan, all unnecessary data usage should be restricted, and no unauthorised access to the satellite terminals should be allowed! A single mobile satellite data terminal may end up costing tens of thousands of dollars in a single month if used like a regular connection, a problem that is compounded if more than one terminal is in use by an agency.

Hazards

Some satellite communications equipment, especially unidirectional satellite data terminals, can emit harmful amounts of radio and microwaves when in use. Users should clearly read the instruction manuals and pay attention to any hazard or warning stickers or labels. Users should never stand within 1 meter of the front of a unidirectional ground terminal, and ideally terminals should be placed at higher elevation to avoid risk of mismanagement.

Radio Transparency

A common mistake many users make is trying to use the satellite connected device indoors, under structures or generally obscured by physical objects. Many casual users are used to mobile devices such as phones that will work in most areas, and may not instinctively understand the need to have a clear line of sight to the sky, especially for users of sat phones. Generally, satellite connected devices will not work under roofed buildings, or any other solid structure that is not sufficiently "radio transparent" – meaning radio waves cannot easily pass through them. Material such as concrete, sandbags, metal rebar, and other common building components can interfere with and block radio waves all together. Satellite connected devices might be able to work under some materials, such as tent material or plastic tarpaulin, however users will need to be aware that this still may not work in all cases.

Extensions/Masts

Mobile satellite communications providers offer a wide range of accessories that assist and enable the usage of the phones and data terminals. These might include:

- **Extension cables** – to mount some devices on roofs or above tree lines.
- **External antennas** – to increase signal and broadcast strength.
- **Docking stations** – to permanently power or mount some devices like sat phones.
- **Self-orienting options** – devices that can auto detect and point data terminals while in motion.

Depending on the needs of a humanitarian operation, users should consider all options where required, and speak with providers to better understand what may be available or feasible.

Calling Codes

Due to the fact satellites provide telephony is never actually tied to a specific country, satellite communications providers have been provided their own "country code." Calling a satellite phone from an outside network required dialling the full country code prior to the satellite

phone number. The calling codes for each provider are:

Satellite Country Calling Codes	**Iridium/Thuraya: +882 16**
	Inmarsat: +8708

Additionally, calling from a satellite phone to a terrestrial based network requires dialling the full country code to reach the intended number, even if users are in the same country as the number being called.

SIM Cards and Devices

The vast majority of mobile satellite solutions work off the use of SIM cards, just like GSM mobile phones, while communications hardware have serial numbers and other identifying codes. When obtaining new satellite communications devices and plans, users should record SIM numbers and International Mobile Equipment Identity (IMEI) numbers of hardware devices. Both SIM cards and IMEI numbers should be tracked, and ideally audited periodically.

In emergencies, devices can be lost, stolen, or simply forgotten about. Users should take care not to misplace SIM cards, as the liability and costs associated with the service are tied to the card and not the device itself. If a SIM card is lost, it can be misused by other knowledgeable persons, possibly for criminal or violent activities. Users should be instructed to report loss or theft of satellite communications equipment as soon as they are able, and if a device is lost or cannot be accounted for, the service connected to the SIM card should be deactivated immediately to prevent misuse.

Resellers/Providers

The majority of satellite communications devices and plans are sold through resellers – other companies specialised in local laws and local markets. Different resellers can negotiate with the primary networks to offer a variety of different plans to end users. These plans may include:

- **Pay as you go** – plans that only bill as they are used – especially useful for emergency responders.
- **Monthly** – payment for all devices made monthly, with either fixed rates or flat fees.
- **Pre-paid** – plans with predefined limits that will only work up until the dollar value paid in advance.

There are also a variety of custom payments and plans that can be available to requesting agencies. As an example, humanitarian agencies that have a high number of active devices may choose to enter global plans that cover all active devices in a single bundle. Additionally, speed or bandwidth can be throttled in some parts of the world during periods of low usage (night time) to allocate to other areas of high usage (daytime) at the same moment. Any humanitarian agency seeking satellite communications devices should speak with multiple suppliers and obtain multiple quotes.

Common Problems with Mobile Satellite Devices

Signal is Weak or Broken	• Is the device being used indoors, or obscured from a direct line of sight to the sky? • Is there some other transmitting device or frequency that may be interfering with the device signal?
Device Won't Connect to Satellite	• Does the device have a SIM card in it? • Is the device SIM card Active? • Is the device being used indoors or around tall structures, hills or trees? • For unidirectional satellite antennas, are they pointed in the correct direction?
The Device Is Connected But no Service is Provided	• Has the service connected to the SIM card been activated? • Has the service connected to the SIM card been paid for, or is the SIM connected to a post-paid account? • Has the service connected to the SIM card been suspended or terminated for any reason?

Radio Communications

The use of mobile radio communications has a long standing history within the humanitarian response community, and is still widely used today. There are currently a wide variety of mobile communications devices available to humanitarian responders, however not too long ago radio communication was basically the only way to maintain continuous communication with a distributed network of humanitarian actors.

As radio networks are essentially completely self-maintained by humanitarian agencies, they are still in real terms the fail-safe within a communications network; state or military actors may shut of off or disable commercial communications networks, but radios will work as long the humanitarian agency keeps their radio networks active and well maintained.

Technical Concerns with Radio Communications

National Regulations

The use of radio communications to support humanitarian operations is generally considered an acceptable and legal practice in most countries of operation, however there are a few countries where radio communication may be banned or heavily constrained. Even if the use of radio communications is considered legal, there will almost certainly be a national registration process where owners and operators of radio networks will need to apply for and obtain licenses for lawful use.

The predominant reason that national authorities may wish to track and regulate radio communications is to protect the usefulness and functionality of already used radio frequencies, while deconflicting future use of frequencies. In most countries where humanitarians operate, some form of radio communications is already in use by national and state actors, including police, military, and emergency first responders.

To manage this process, national authorities usually have a pre-allocated frequency range that

non state actors such as humanitarian organisations can communicate using. As part of a registration and licensing process, national or local authorities may also allocate specific frequencies to each requesting organisation, so any activities associated with that frequency can be linked directly to the licensed body. Any humanitarian agency granted a specific license will be expected and obligated to utilise the frequencies provided, and will either need to program their own radios or find a means to have those radios programmed.

Constraints of Radio Communications

Distances – Depending on the type of radio, the size of the antenna and the energy source behind the radio, radios may only be able to communicate up to a few kilometres. In urban environments or places with dense vegetation, hills or canyons, this distance may be even less. Agencies or personnel utilising radio communications should have an understanding of the capabilities of the devices they are utilising, and ideally the IT, security and logistics personnel of a humanitarian organisation should have a sense of what geographic areas might be supported by the type of equipment in use.

Dead Spots – Even in areas of overlapping radio coverage, there may still be dead spots, brought on by structures, hills, vehicles, or other materials that might block radio signals. When conducting operations, personnel should be aware of that dead spots may occur, and may need to periodically conduct a radio check to determine if radio is still usable in a specific stationary location.

Interference – Radio signals can and will interact with other electronic equipment. Household appliances such as microwave ovens or other equipment using radio waves such as traditional broadcast TV might impact or impair radio operation. Objects with large electrical charges also produce electromagnetic fields that might impact radios as well – telephone power lines, large transformer boxes, and even large generators may affect a signal. Avoid installing or using radio equipment under or near power lines or radio towers used by other companies or agencies.

Components

Mobile Radio Unit

Mobile Radio/handset units "transceivers" – radio equipment that can both send and receive a signal. Some radio units are completely self-contained and come with batteries to power the device for several hours or a full day, while others require external power sources, like those mounted to vehicles. Additionally radios can be defined as mobile – radios that travel around with persons or vehicles, or as stationary – radios that are permanently connected to a ground station.

Handheld Radio   **Vehicle Mounted Radio**

Point to Point – when a radio units communicate with each other directly without a base station or a repeater between them, they are conducting point to point communication. Depending on the type of radio and the frequency used, point to point communication may be very limited. Most handheld radios that run off of batteries don't have the energy output or large enough antennas to push signals very far, and will be limited to hundreds of meters of point to point communication.

Networked/Relayed Communication – When two radio units communicate using at least one intermediary device, such as a base station, that communication is not point to point, and can be called a networked or relayed connection.

Antenna

Antennas are what physically enables the radio to capture radio waves and conduct the signal into the unit. The shape, size and overall construction of the antenna is determined by the type

of radio, including the width, length, orientation and composition materials. Antennas are essential for the communication process, and users should be wary of damage or obstruction to antennas to avoid communication lapses.

Common Antenna Terms:

- **Antenna Gain** - The factor by which input power to the antenna will be multiplied to provide higher output power. Higher output power results in greater broadcast distance and signal strength.
- **Antenna Bandwidth** - The range of frequencies over which antenna operates satisfactorily. The difference between highest and lowest frequency points is referred as antenna bandwidth.
- **Antenna Efficiency** - The ratio of power radiated or power dissipated in the antenna structure to the power input to the antenna. Higher antenna efficiency means more power is radiated into three dimensional space and less is lost within antenna.
- **Antenna Wavelength** - If wavelength is the distance a radio frequency wave travels during one cycle period, the antenna wavelength is the size of the antenna based on the wavelength. The longer the wavelength, the longer the antenna.
- **Antenna Directivity** - It is the ability of the antenna to focus EM waves in particular direction for transmission and reception.

Base Station

Radio base stations are also transceivers, usually installed in a fixed location in an office or living compound. The fundamental programming and etiquette of a radio base station isn't different than mobile radio units, however base stations can have significantly larger antenna arrays, and can supply greater power from the grid or generator to boost the signal to much further distances than mobile radios. The antenna arrays of base stations usually are more complex than mobile or hand held radios, often with two separate antenna structures separated by up to a meter or more – one antenna to receive incoming signals and another to broadcast outgoing signals, segregated so multiple communications do not interfere with each other.

Base station radios can also be configured to function as repeaters – taking a signal coming from one mobile radio unit, and amplifying it/rebroadcasting it so that it can reach a much further distance. Occasionally, specialised radio base stations are designed to accommodate multiple types of radio configurations at once, HF/VHF/UHF and others. These types of multi modal communications base units are highly specialised and typically used by agencies with professional radio and communications experts.

Example of a Base Station

Repeaters/Repeater Networks

Radio Repeaters are devices that can receive a radio signal, and rebroadcast it while at the same time amplifying its signal. In terms of voice communication, this means that a mobile handheld radio working off a radio repeater will be able to stay in continuous communication over longer distances. If two or more mobile radios are working off the same radio repeater, and are programmed to the same channel and frequency, they will be able to maintain direct communication while being far outside of point to point communication range. The requirements for a repeater are similar to a base station, in that a large external antenna array with multiple antennas and an external power source will be required to provide continued communications.

In some instances, governments or agencies may install what is called repeater network – more than one repeater arranged a pre-determined network that can continually share voice and data signals between them. A well-established repeater network can cover a wide area of terrain, however it will also require maintenance. If a repeater is installed in an insecure location, or in a location with intermittent access to power it will no longer serve its core

function and may not be worth the effort or cost.

Simplex vs Duplex

The concepts of simplex and duplex apply to any form of communication, however they are especially important for radio communications.

Simplex

Simplex communication is best described as "one way" radio – a configuration in which voice or data can only be broadcast in one direction. The basic example of a simplex network is a traditional TV or music radio broadcast signal; a primary source broadcasts a signal and a receiver with the appropriate hardware can pick up the reception.

Duplex

Duplex communication is best described as "two way" radio – both ends of the radio transmission can send and receive a signal. Radios used by humanitarian agencies for coordination and security would only really make sense utilising duplex communication, and the vast majority of radio communications equipment available on the market is built around duplex communication.

The concept of duplex communication is an oversimplification of how most mobile radios work, however. A true duplex configuration requires two more independent antennas, each broadcasting on a slightly different frequency so that signals can be broadcast and received simultaneously. Simultaneous broadcasts would in effect allow users to both talk and hear voice commands at the same time, not too dissimilar to modern phones.

Most mobile radios however frequently do not possess the ability to both send and receive a signal at the same time. There are multiple reasons for this, but fundamentally duplex mobile radios would be bulky and expensive and the trade-off includes using what is sometimes referred to as **half duplex**. In half duplex, a single antenna to is used to both send and receive a signal, and users utilise "push to talk" communication. When the user of a mobile radio unit is depressing the talk button, they cannot hear incoming signal, and vice versa. Though a base station may be able to manage and interpret multiple signals, users in the field on a mobile unit will not. It is important that users understand this – if they depress the button continuously they may miss important messages.

Operating Security

There are a variety of security constraints pertaining directly to radio usage in humanitarian contexts. Radios are widely available and used throughout the world, and humanitarian actors may be utilising radios alongside police, military and non-state armed actors.

Unencrypted Signals

The majority of radio communications used by humanitarian actors operate on open frequencies, and are not encrypted. An unencrypted signal means that anyone on the same frequency can listen and hear all communications. Many governments may require agencies to not use encrypted signals simply because they too wish to monitor activities of humanitarian agencies. National legislation may also limit the types of data that can be transmitted over radio, such as data. Even if an organisation is using a fully encrypted radio signal, if a radio is lost or stolen by a bad-faith actor they may still be able to eaves drop on radio communications.

Some radio networks are highly advanced, and allow users to call each other directly through a numerical dialling system, similar to a telephone. In instances where users may reach each other directly, it is advised to carry out as much communication directly as possible. The majority of radio networks operate on a "broadcast all" system however, meaning anything said into one radio unit can be heard across all units within reception and listening range.

Agencies using mobile radio for voice communication should always operate as if someone else is listening in on communications.

- Users should communicate only using calls signs – referring to themselves or each other by each persons assigned call sign. The list of call signs can be generated based on organisational structure or the local security personnel.
- Users should avoid talking about money, high value shipments, sensitive personnel issues, or anything else that might attract violence or theft. If certain key issues must be discussed over the radio, users should utilise pre-defined and mutually agreed upon code words or phrases.
- Users should establish common codes for identifying vehicles, geographic locations or buildings. Use of these codes will help speed up communication or remove ambiguity, but also make it harder for listeners to know exactly who is where.
- If at any time a radio is lost or unaccounted for, it should be reported immediately to the respective security focal point.

Radio Checks

The act of intentionally calling from one radio to another to ensure proper connectivity is known as a "radio check." The need and frequency of radio checks depend on the security constraints of the organisation and the operating contexts. In any context, it is advisable to conduct regular checks to ensure operational continuity. Unlike modern mobile phones, many radios generally cannot identify signal strength, and users may not know if they are within communication range or not.

- **Routine checks** – organisations may wish to conduct routine radio checks, including daily, weekly or monthly, depending on the security needs of the site. The routine checks might include a base station calling every single radio user separately by call sign, and asking the radio user to respond. Radio users should be advised of the radio check schedule, and their adherence to the schedule should be recorded. Any radio user that does not check in may be a sign of a faulty radio, or lack of understanding of the system.
- **Movement Checks** – Agencies may also wish to establish routine checks dedicated to the movement of vehicles. Depending on the security context, vehicles may be required to check in at pre-set intervals – usually every 1-2 hours – to provide status and location. This ensures that the base knows where the vehicle is, and that the vehicle is still within radio range to avoid possible gaps in coverage in case of incident.

Dedicated Radio Operators

As part of routine security measures, many humanitarian agencies choose to hire and train full time radio operators. The profile of a radio operator might vary, but the general function is to physically sit near a base station, route messages and conduct radio checks as needed. A dedicated radio operator is usually cross trained in variety of radios and communications devices, and may be expected to operate multiple communications base stations at once.

Radio operators are usually used in larger operations with multiple parties moving between different locations at once. Radio operators also work closely with IT, vehicle fleet and security personnel in the process of tracking movement, flagging emergencies and ensuring proper

communications are functioning at all time.

The duties of a radio operator might include:

- Updating a manual tracking system indicating where vehicles are.
- Conducting daily radio checks.
- Sending out updates or emergency signals.

When conducting daily radio checks, radio operators should have a list of all personnel and call signs, and should keep a running daily tally of who may be in the area and who is responding to radio checks. While conducting routine checks on vehicles in movement, radio operators may be expected to update movement boards or even record movements on a map. The rules and requirements for both routine checks and movement monitoring will depend on the needs of the agency and the security context.

Usage Requirements

Depending on the contexts, users may be required to keep a radio near them and on at all times. To facilitate this, all users should have access to:

- Spare batteries.
- Charging equipment.
- Carrying equipment (cases, clips).
- Maintenance instructions.

Programming of Radio Equipment

The act of programming a radio might include pre-defining:

- Frequencies of operation.
- Communications channels.
- Radio specific IDs for direct calling.
- Password protection.
- Encryption or other special functions.

Not all radios have the same functions, and even different models of radio coming from the same manufacturer might have a different set of functions. As an example, not all radios units will have the ability to establish direct calling links or offer higher levels of security such as encryption – these are usually specified at the time of procurement.

At a bare minimum, radios used by humanitarian agencies should have programmable frequencies and multiple communications channels:

- The **specific frequency** of use is usually defined by state or national authorities, and use of unauthorised frequencies may result in punishment. Different types of radio equipment have a defined spectrum in which they can operate, but within this band there are numerous specific frequencies that multiple parties may use at the same time without interfering with each other.
- The **communications channels** used are usually defined by the humanitarian agency. It is very common to define channels numerically (1, 2, 3...) however some agencies may wish to use specific names such as "calling channel" and "emergency channel" for clarity sake. A properly programmed radio will display the pre-defined channel name on the readout screen, if available. In instances where multiple agencies are using the same network, the channel names/numbers are usually defined by the lead agency controlling the network.

Programming radio equipment can be a very complicated task. Different manufacturers of radio equipment have different proprietary hardware and software packages to enable programming, and there is no one single method of programming all radios.

When agencies are planning a radio communication network they should consider the following:

- Who will be responsible for programming the devices? Does the humanitarian organisation in question have the capacity to program the radios themselves, or will the process need to be outsourced?
- What types of features are required for radios in their radio network?
- What is the plan for servicing equipment or making changes in the future?

Many accredited radio equipment sellers will have the capacity to program radios to the client's specifications for a fee, however the client will need to know all the required information up front. Prior to purchasing radios, humanitarian organisations should investigate what state and local laws are to avoid any restrictions, and should investigate the process for applying for any licenses or waivers utilising open airwaves.

Agencies may also investigate hiring a dedicated radio technician who can install, program and troubleshoot radio networks as needed. Another possibility is speaking with other NGOs or UN agencies to determine who may have spare capacity to support programming, or who may offer services for a small fee.

Very High Frequency (VHF)/Ultra High Frequency (UHF)

Very High Frequency (VHF) and Ultra High Frequency (UHF) radios are by far the mostly commonly used radio type by governments, military, police, maritime organisations, emergency responders and other entities that operate in environments when regular communications networks may be inconsistent or not properly functioning.

VHF radio waves occupy band between 30 to 300 megahertz (MHz), while UHF radio waves occupy the range between 300 MHz and 3 gigahertz (GHz). VHF/UHF radio waves are propagated by a line of sight path; they will not reach around the curvature of the earth and they can be blocked by hills, mountains and other large dense objects. The maximum broadcast distance of a VHF radio is around 160 km while the maximum broadcast distance of UFH radio is around 60 km – these distances are greatly variable however and depend on a number of operating and environmental factors. In almost all contexts, VHF and UHF signals will not reach their maximum potential distances.

Approximate distances for VHF communication:

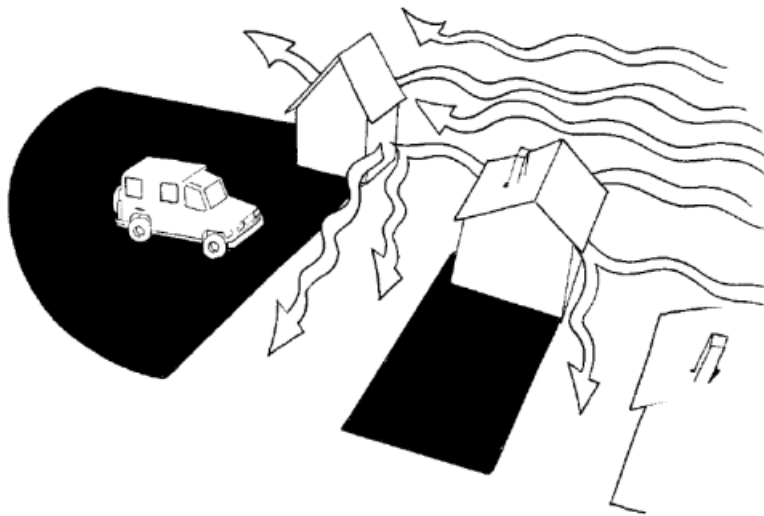| Communication Devices	Approximate Communication Range
Handheld to handheld	about **5 km** depending on terrain
Vehicle to vehicle	about **20 km** depending on terrain
Vehicle to base	about **30 km** depending on terrain
Base to base	about **50 km** depending on terrain

Adapted from RedR

There are a wide variety of applications and devices for VHF/UHF radio transmission, including traditional FM radio and broadcast television, GPS devices and mobile phones. VHF/UHF waves

can penetrate buildings and other radio transparent structures, but any object will cause some form of interference; though a VHF/UHF radio may work in a building, the signal will be weaker, and the more buildings in the surrounding area the more impacted the signal will be. Use of VHF/UHF communications in dense urban settings, thick forests, or deep valleys will significantly limit ranges even further.

Common Problems with VHF/UHF Communications

Some common problems encountered by users of VHF/UHF might include:

Dead spots - areas where signal is impossible to find and communication cannot occur. Dead spots are caused by an object of sufficient size/density blocking the incoming/outbound signal. If radio users are in a dead spot, they may need to relocate to obtain a proper connection, if if that means moving only a few meters in one direction or another.

Adapted from [ICRC "Staying Alive"](#)

Electromagnetic Interference - Objects that produce sufficient electric currents, such as overhead power lines or electrical plants can also block or interfere with signals, even if the source of the electromagnetic radiation isn't directly between the two radios experiencing interference. If experiencing issues, radio users should try moving away from overhead powerlines or other possible causes to get a better signal.

Adapted from [ICRC "Staying Alive"](#)

Antenna Direction - VHF/UHF radios transmit signals using line of sight propagation, meaning that their signals work best when perpendicular to the earth's surface. For the best experience and best signal, the long edge of the antenna should be pointing at the horizon, while the tip of the antenna should be facing the sky.

VHF/UHF Walkie Talkies

Despite the relative limitations of using VHF/UFH for two way communication, the vast majority of response organisations prefer VHF/UHF radios due to their portability. The size of the VHF/UHF wavelengths don't require massive or specialised antennas, while the relatively low energy requirements enable long lasting battery powered portable "walkie-talkies." Handheld walkie-talkie radios can be relatively expensive, but they are still cheap enough to buy in bulk and distribute to key personnel on the move.

Example Mobile Handheld Walkie Talkies

There are a variety of manufacturers of VHF/UHF handheld radio equipment available to humanitarian agencies. Though different devices from different manufacturers call be programmed to operate on the same frequencies and interoperate with each other, buying two different models of radio is strongly discouraged. Handheld radios have a variety of removable and replaceable parts, and having a standard fleet of handheld radios will greatly simply for maintenance and repair.

Replacement Antenna	**Removeable Battery**

Users of VHF/UHF radios should know how to properly turn on their radios, adjust the volume, and cycle through different channels. Each radio manufacturer may have slightly different standards and modes of operation, so users should familiarise themselves with operation.

Depending on the security environment, users may also be required to keep their radios on at all times, and continually charged. Users should be supplied with charging base stations and spare batteries so radios can be operated even in power outages. Users should also familiarise themselves with how to charge and replace batteries, and if a radio only holds a charge for less than 2-3 hours should ask for a replacement battery.

VHF/UFH Base Stations

Roof mounted antenna installations for VHF/UHF base stations are noticeably larger than antennas on the mobile handheld radios, however they are still relatively small compared to other types of wireless communication. A roof mounted VHF/UHF antenna will need to be able to broadcast/receive on the same frequencies as the intended mobile radios, and be compatible with base station in use.

A roof mounted VHF/UHF antenna will also need to support duplex two-way communication. Some VHF/UHF antennas are pre-made to handle both incoming/outgoing channels at the

same time, while other configurations will require installing two separate antennas relatively close to each other. Roof mounted antennas will connect to radio base stations through proprietary cables, and unless otherwise configured, the antenna will draw its power from the base station unit.

Roof mounted antennas should be installed at the highest point of the building roof, with no obstructions on any side. The antenna must be installed vertically, so the long edge of the antenna is pointing at the horizon while the narrow point is facing directly upwards. To facilitate this usually, the antenna is attached to a sturdy metal pole which is attached to the side of the building. The metal pole can also be used to increase the height of the antenna as needed. Some agencies may attach antenna to stand alone radio towers to reach sufficient height. Irrespective of what the VHF/UHF roof mounted antennas may be attached to, the proprietary cable should still be able to reach the base station, and the antenna should always be grounded in case of lightening strike.

Example Roof Mounted Antennas

Vehicle VHF/UHF Radios

VHF/UHF vehicle transceiver installations are also extremely common. A variety of manufacturers produce vehicle installation kits and vehicle specific radios, which are permanently mounted on, in or under the dash of the vehicles. A vehicle installed VHF/UFH radio will not noticeably increase its communications range or functionality, and the same limitations that apply to all VHF/UHF communications apply to mobile vehicle installed VHF/UHF radios.

The advantage of a vehicle installed radio however is that it draws its power from the car's battery meaning significantly longer periods of operation as long as the vehicle's battery is functioning and/or the vehicle is in motion. A VHF/UHF vehicle transceiver will be permanently wired to the vehicles electrical system, and requires special installations as holes may have to be drilled in the dash and conductive cabling pulled into the engine of the vehicle where it will be connected to the battery. Wires will also have to permanently connect to the antenna, and may require special installation as well. VHF/UHF vehicle antennas are also less obtrusive than other radio antennas and can be mounted with simple magnets.
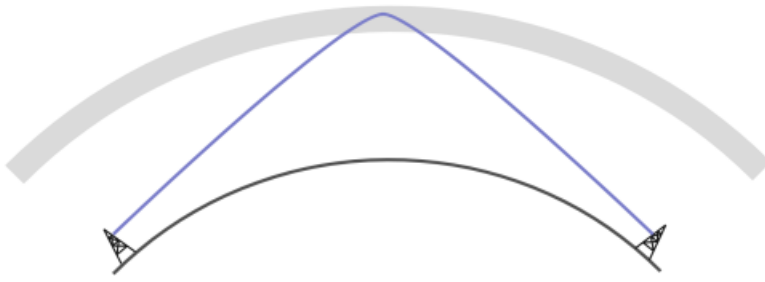
Example Car Mounted UHF Radio   **Example UHF Car Antenna**

High Frequency (HF) Radio

Another widely used radio band used by humanitarian actors is the High Frequency (HF) range. HF is used less frequently by commercial or governmental organisations, but due to the extremely long range communication provided by HF, it has become popular for use in aviation and remote exploration.

HF radio waves occupy the band between 3 and 30 megahertz (MHz), and are part of what is known as the shortwave band. HF transmit using "skywave" or "skip" propagation, giving HF the ability to send and receive over long distances. HF radio waves occupy a spectrum that interacts with the earth's atmosphere in a very specific way – when broadcast at an angle towards the they will refract off the ionosphere and back towards the earth's surface where it will bounce back multiple times. HF radio wave are capable of broadcasting signals beyond the horizon and around the curvature of the earth's surface. In optimal conditions and using the appropriate set up, HF waves can even be transmitted between continents, however this should never be relied on as a primary mode of intercontinental communication. HF radio waves refracting off the ionosphere greatly reduce dead spots and radio "shadows" cast by hills our mountains, however dense surrounding buildings may still effect HF usage.

While HF may offer an advantage in the distance of its communication, it also comes with limitations. Notably, the equipment required to transmit and receive HF signals is bulky and large, and requires a significantly larger antenna and a larger energy source. Generally speaking, there are no good solutions for handheld mobile HF radios used by humanitarian agencies – HF is almost always limited to vehicles and stationary buildings.

Vehicle HF Radios

HF communication has become the default for vehicle communication for many large humanitarian agencies. Due to the fact HF signals can reach far beyond VHF/UHF, and given the size of the equipment, HF is an excellent compliment to other forms of communication and a vital for vehicle security.

The vehicle mounted HF transceivers are very similar to other vehicle mounted radio units – HF radios are installed on, in or below dashboards, and must be permanently wired to the vehicle's battery or electrical system. Additionally, given the placement of the HF antenna, additional wires will have to be run through the chassis or body of the vehicle to properly reach the transceiver.

A distinguishing factor of an HF antenna is its sheer size. The length of an HF antenna installed in a car – sometimes called a "whip" - may be several times the height of the vehicle. Also, while the antenna may not be especially heavy, it's length will apply pressure to the base of the antenna as it encounter breeze or as the vehicle starts and stops. The HF whip will need to be securely bolted to the body of the vehicle, usually on the front or rear bumper.

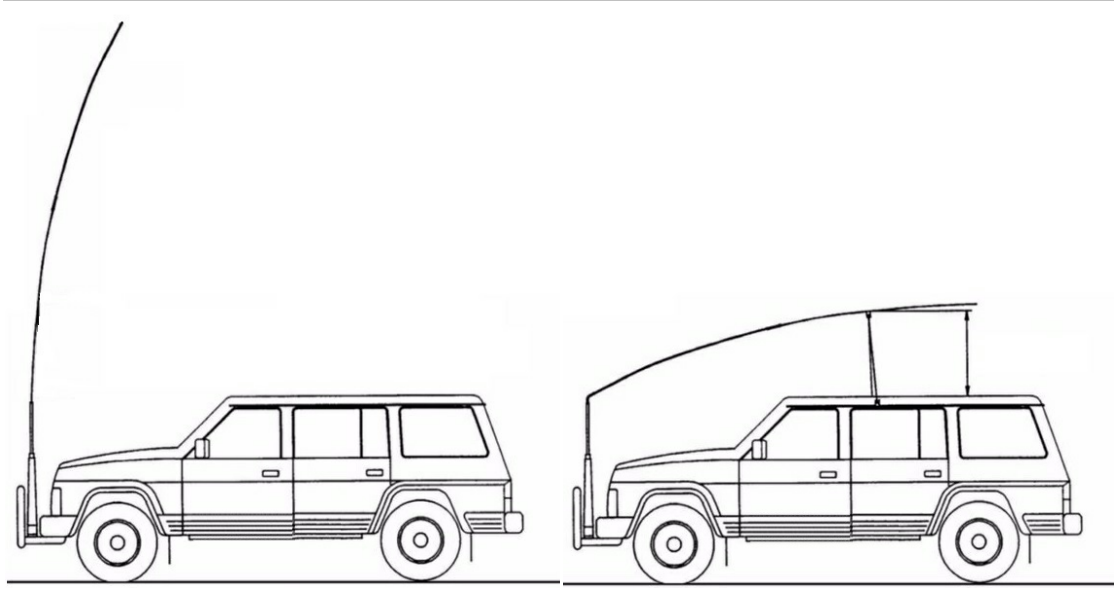**Example HF (Codan) Vehicle Antennas**

The antenna itself may cause security concerns. While the radio is in use, there is a significant amount of electricity flowing to the antenna if only for a short period of times. Persons or animals in contact with the antenna while in use may suffer heat or electrical injuries. Additionally, the height of the whip can easily become caught on trees, bridges, or any low hanging materials or structures, damaging the structure, the whip or both.

To remedy the height issues, users may want to tie back or anchor their HF antenna to a roof rack or other anchor point on the roof of the vehicle. While this is a perfectly acceptable solution and does not impact the functionality of the radio, users should be aware:

- Anchored whips are under high tension, and may injure people or animals if it breaks free.
- Whips can only be anchored using special built tie downs, available from the manufacturer.
- The whip should never be closer than one meter to the body of the car.

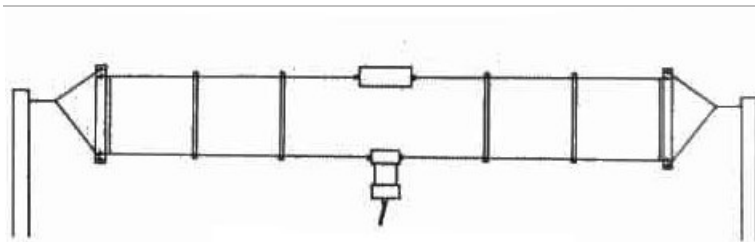**HF Vehicle Antenna Configurations**

HF Base Stations

The size and usage of an HF base station isn't dissimilar to other radio base stations, however specific usage requirements will depend on the specific unit and the programming needs of the agency.
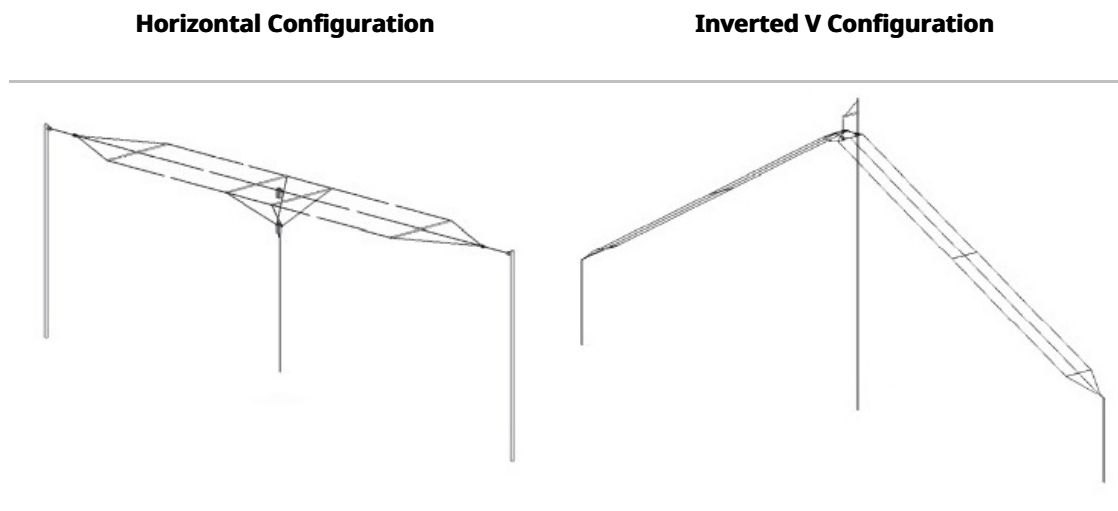
A significant difference with using permanent HF building installations however is the size and orientation of the HF antennas. Due to the relative size of the HF radio wave, HF base antennas need to be extremely large. To accommodate this, HF antennas tend to be made of flexible materials that can shaped to match the contours or needs of the grounds. The most common HF antennas come as di-polar – two separate conductive cables interrupted in the middle. the two separate cables are loose hanging, but separated by rigid bodies that prevent the two from making contact with each other.

Di-Polar HF Antenna

The HF di-polar antenna can take up quite a bit of space in a compound area. The antenna can be up to 40-50 meters longs insulator to insulator, and actually be longer accounting for the tie downs and the anchors. HF Antennas also must be mounted fairly high above the ground. The general rule of thumb is radio antennas should be mounted at least half the height of their corresponding wavelengths. For HF radio installations, it is recommended to install the antennas at least 12-15 meters above the ground.

Considering the ground space required to accommodate this, there are several configurations that users can adopt:

| **Horizontal Configuration** | **Inverted V Configuration** |

Horizontal Configuration – The di-polar antenna is tautly suspended from both ends at equal heights. The cable connection to the base station is free hanging, though ideally it will still be secured to something near the ground level or anchored to a sturdy pole to prevent movement in the wind, and to take weight off the installation. The horizontal configuration is considered the best case, and will carry a signal the furthers.

Inverted V Configuration – To save ground space, agencies may opt for the inverted V configuration, where the sides of the di-polar antenna are sloped like a tent. Important components to an inverted V configuration:

- The angle formed by the inside of the V should never be less than 90 degrees. The closer to flat the better.
- The middle will need to be suspended from a strong, non-conductive material using the proper anchor.
- The anchors at the low points of the slope should still be raised above the ground, connected to "stub masts". Ideally, the main mast would be raised higher than the minimum height to accommodate the height of the lower points.

Any form of antenna and mast configuration will need to be safely secured. Each antenna type comes with a certain wind rating, and users should understand what annual weather might impact antenna selection.

Additionally, HF antennas can consume and output large amounts of electricity. HF di-pole antennas while in use consume 250-350 watts of power on average, and can have peak consumption of up to 1,000 watts. Di-polar antennas are largely just exposed metal, and any thing bridging the connection between those two wires will pose a serious risk. Tree branches or trash might catch fire, while wires can seriously injure or kill humans or animals. At no point should humans or animals be able to grasp or bump into the wires of an HF radio, and if a

radio wire is knocked down, persons in the vicinity should be instructed to stand back until the power is cut.

Using Radios For Voice Communication

The overall privileges and limits of the use of radio communication may vary from organisation to organisation, however it is strongly advised that each organisation establish and develop its own policies for the proper used of radio, and disciplinary plans for misuse of radio equipment.

Channels

When using any network sometimes there are separate calling channels used to establish communication with other radio users, who then specify another dedicated channel. As soon as such communication is established both radio stations should move to determined talking channel to leave calling channel for other stations to establish contact. The use of calling channels is used especially in networks with high volumes of shared traffic, or in networks hosted by third parties such as UN repeater networks which multiple humanitarian agencies might use.

Etiquette

In general, there are rules that should be followed when communicating via voice using two-way radio. These might include:

Use of Pro-Words

Procedural Words (Pro-Words) are a pre-defined set of short phrases with precise meanings that have been developed to help network users and operators keep their transmissions brief and prevent confusion and misunderstanding. It is important that one understands these words and their meaning, to be able to understand what is said on the radio network and to be able to send short and precise messages. The following are commonly used pro-words and their meanings:

Pro-Word Phrase	Meaning
Affirmative	Yes/Correct
Break, Break, Break	Interrupt ongoing transmission for an urgent message
Correct	You are correct, or what you have transmitted is correct
Negative	No/Incorrect

Pro-Word Phrase	Meaning
Negative Copy	Your last message was not understood
Wrong	Your last transmission was incorrect
Over	This is the end of my transmission to you and a response is expected. Go ahead and transmit.
Out	This is the end of my transmission to you and no answer is required **Do not use OVER and OUT together!**
Relay To	Transmit the following message to the identified addressees/recipients
Roger	I have received your last transmission satisfactorily
Say again	Repeat the last message. **Do not say "repeat" on the radio! Repeat is commonly used by militaries to request soldiers to continue firing a weapon.**
Stand-by	Do not transmit until contacted. I need extra time.

Use the NATO Phonetic Alphabet:

The NATO phonetic alphabet is frequently used to remove ambiguity from radio communications. Voice commands over radio can be difficult to understand or signal strength than be weak. To work around this, radio users will frequently use the NATO phonetic alphabet when spelling out words or discussing single letter codes. As an example, a mobile ambulance vehicle might have the call sign "Mobile Ambulance 1" or MA1 for short. When pronounced using the phonetic alphabet, it would be spoken as "Mike Alpha 1".

Letter	Phonetic	Letter	Phonetic
A	Alfa	**N**	November
B	Bravo	**O**	Oscar
C	Charlie	**P**	Papa
D	Delta	**Q**	Quebec
E	Echo	**R**	Romeo

Letter	Phonetic	Letter	Phonetic
F	Foxtrot	S	Sierra
G	Golf	T	Tango
H	Hotel	U	Uniform
I	India	V	Victor
J	Juliet	W	Whiskey
K	Kilo	X	X-Ray
L	Lima	W	Yankee
M	Mike	Z	Zulu

Keep messages short - Messages sent over the radio must be brief and to the point. If

longer conversations cannot be avoided, they should be broken into segments. Long conversations may block other users from accessing the network as well.

Use Radios for Official Business Only – Communication should be kept to official business. No personal business should be conducted over radio waves, including personal conversations.

Making Calls - Before making a call, always verify that the intended radio channel is not in use by listening in for a few moments. If needed, increase the audio output.

The general procedure for making a call is as follows, with a radio user with the call-sign BF3 calling another user:

Example:

(BF3 Calling) - "BF31, BF31 (from) BF3"

(BF31 Responding) - "BF3 go ahead."

(BF3 Responding) - "Please give me the status of shipment 12345, over."

(BF31 Responding) - "12345 is packed and shipped already, over."

(BF3 Responding) - "Thanks, nothing further, BF3 out."

(BF31 Responding) - "BF31 out."

Adapted from International Medical Corps

If for some urgent reason an ongoing conversation needs to be terminated, the procedure is

as follows:

Example:

(Ongoing conversation) - (Talk)... over

(BF1 Breaking in) - Break, Break. BF3, BF3 (from) BF1

(BF3 Responding) - BF1 Move channel 3, over

(BF1 Responding) - Moving channel 3, BF1 out

(Ongoing conversation) - (Talk)... Over

Call Quality - To determine the quality of the audio connection, or if the transmission is already difficult, users should ask "How do you read?" To clarify radio strength and clarity, users may state "I read you loud and clear" however users may also state "I read you "X" by 5" where "X" is a number between one and five. Five corresponds to a loud and clear transmission and zero means complete lack of communications/signal.

Common Problems with Radio Communication

Radio Won't Turn on.	- Is the battery charged? - Is the radio connected to a power source? - Is the power source under powered or weak?
Transmissions are not being received, or no one is responding.	- Is the transmission being sent on the intended frequency? - Is the radio in a dead spot? - Is the radio within the expected transmission range? - Is the antenna connected properly? - Are the other radios possibly off?
Signal is weak or broken	- Are there atmospheric or environmental factors that may be interfering with the signal? - Is the radio being used indoors or around tall buildings or trees? - Is the radio being operated around power lines or other radio equipment.

GPS Systems and Devices

Global Positioning System (GPS) enabled devices and services are quite common for modern day technology such as computers and cell phones, and many current users interact with systems benefiting from GPS daily. The underlying concept behind GPS was once considered relatively exotic, and was used primarily by governments.

GPS enabled devices work by speaking to a loose network of navigational satellites called the Global Navigation Satellite System (GNSS) that continually orbit the earth at a variety of orbital altitudes and speeds. GNSS satellites continually transmit a weak radio signal that devices on the ground can detect. A GPS enabled device requires concurrent line of sight to at least three GNSS satellites to triangulate is position on the earth. Navigational satellites were first launched in the 1970s by the United States government for military use only, however by the mid-1990s GPS had become widely available for commercial use. Today, the GNSS constellation is made up from dozens of satellites from a variety of countries.

Using GPS Coordinates

GPS enabled devices communicate in a coordinate system, which are generally known as "GPS
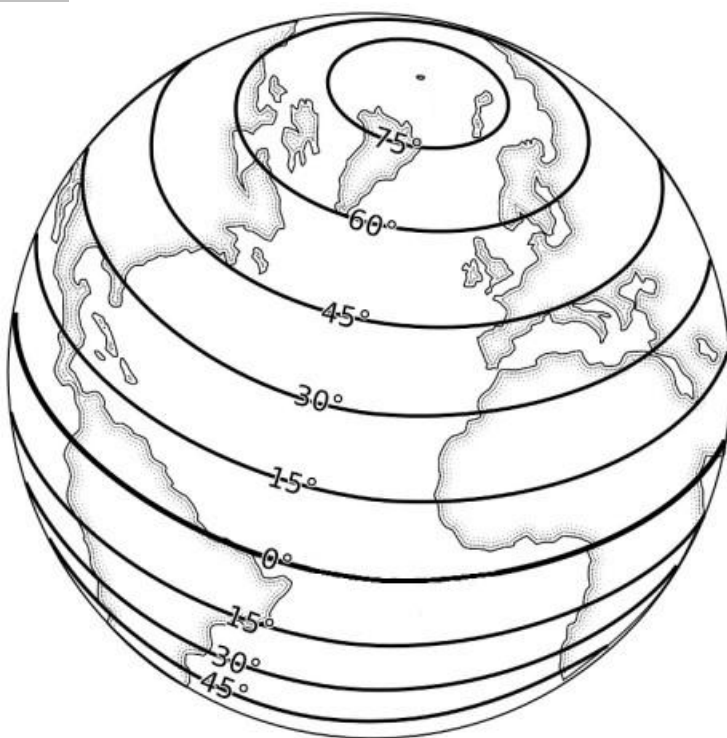
Coordinates". GPS coordinates define an exact location the surface of the earth within a pre-defined grid system. There is more than one grid system used, however the vast majority of communications systems are built on latitude and longitude:

Lines of Latitude – Lines of latitude are horizontal lines that stretch from east to west across the globe. The longest and main line of latitude is called the Equator.

The Equator is represented as 0° latitude, while the north and south poles are both represented as 90°. The space between the equator and the poles are evenly distributed between 0 and 90.

Latitude lines are expressed as 0-90° North (N) and 0-90° South (S), written as (example):
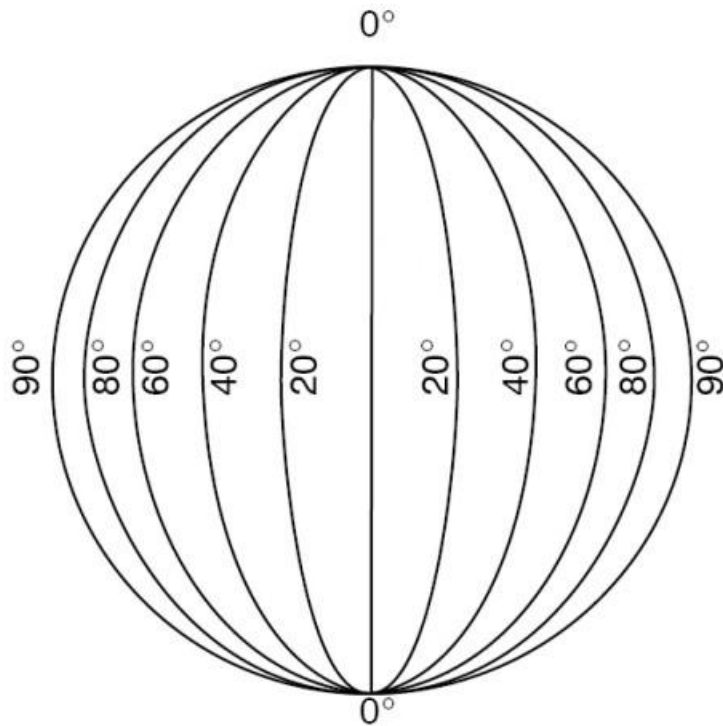
32° N

Lines of Longitude - Lines of longitude are vertical lines that stretch from the North Pole to the South Pole. The main line of longitude is called the Prime Meridian.
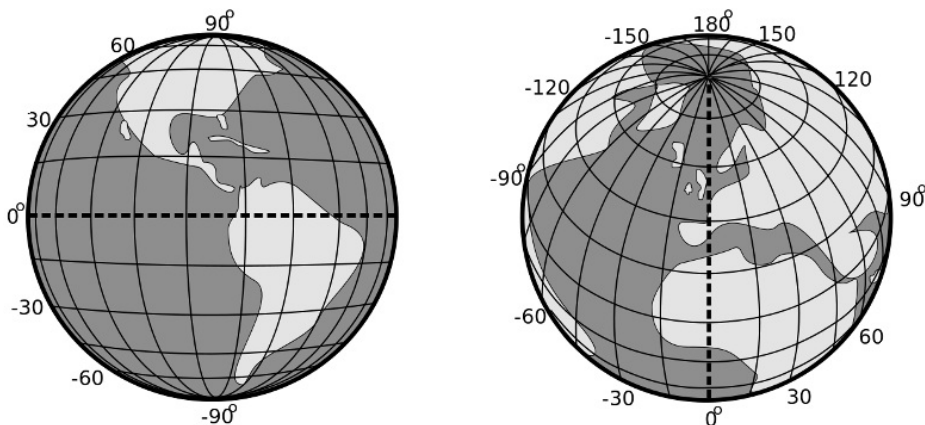
The Prime Meridian is represented as 0° longitude, while vertical lines east and west increase incrementally until 180°, making 360° in total.

Longitude lines are expressed as 0-180° East (E) and 0-180° West (W), written as (example):

163° W

Combined together, the grid structure generated from combining longitude and latitude would look like:

To more accurately describe GPS coordinates, the lines of longitude and latitude are broken down into smaller and smaller increments. Detailed incremental GPS coordinates can provide accurate locations anywhere on the earth's surface to down to less than a square meter.

In all GPS coordinates, the North/South orientation is always expressed first, followed by the East/West orientation. Unfortunately, there are multiple methods of expressing these coordinates, and they are not interchangeable. The different GPS coordinate formats are:

GPS Coordinate Grid Type	Explanation	Example GPS Coordinate Layout
Degrees, Minutes, and Seconds (DMS)	The most common historical method of expressing GPS coordinates was in degrees, arc minutes and arc seconds. While the degree number matches the line of latitude and longitude, minutes and seconds are expressed in units of 1-60, with sixty arc minutes in a degree. Traditional coordinates also require a N, E, W, or S to indicate their relation to the equator or prime meridian, as the numbers alone can represent different locations.	**41° 49' 17.3" N,** **12° 24' 27.0" E**
Decimal Degrees (DD)	Decimal degrees are quickly becoming the most common method for expressing GPS coordinates, as they are the easiest to read and understand for computer systems. A decimal degree is expressed as a whole degree (latitude or longitude number) followed by a decimal point and up to six numbers past the decimal point. The numbers past the decimal point are essentially fractions of a whole degree, and based on units of 1-10. Decimal degrees west of the prime meridian or south of the equator are expressed as negatives. As an example, a point off the cost of Peru (both in the southern hemisphere and western hemisphere) would be expressed as: **-9.791500, -81.199971**	**41.821468,** **12.407512**
Degrees and Decimal Minutes (DMM)	A hybrid between regular arc minutes/seconds and decimal degrees, where the regular arc minutes and seconds are expressed in decimal format.	**41 49.2881 N,** **12 24.4507 E**

When generating and using GPS coordinates, it is important to understand the differences between the different formats! Because arc minutes and seconds use a base 60 system while decimal degrees use a base 10, the same location will have two different numbers. If someone is recording GPS coordinates from a device that reports in arc minutes/seconds, users must remember to convert the coordinates to decimal degrees if they plan on using tools that require decimal degrees, and vice a versa.

GPS Devices

There are number of GPS devices available on the market for humanitarian organisations, all of which will have their own user requirements and instructions. It is important that users

understand what the intended use of the GPS device is when making a selection.

Offline/Standalone – Many GPS devices are designed for the sole purpose of taking GPS readings. Usually these devices have a simple interface, and a powered by disposable or rechargeable batteries. Offline GPS units are frequently used for maritime, aviation and military, but are also use for wilderness orientation, extractive industries, or any application that requires being far away from a mobile or internet connection. Offline GPS devices are generally just passive receivers of GPS signals from GNSS satellites, and will provide a flat set of coordinates when in use. Some GPS devices have mapping functions or the ability to leave waypoints. The need for these additional features will depend on the use and the agency.

Online/Phone Based – Most modern smart phones come with GPS capability, as well mapping and tracking applications. While most users are familiar with phone based GPS apps, there are a few important things to consider:

- Many phones also triangulate position based on mobile phone towers, and may not necessarily be getting a solid GPS reading from a GNSS satellite.
- Phones may be delicate, be less water/dust resistant, and have shorter batter lives than dedicated GPS devices.
- Without persistent connection to the internet, some GPS apps will not work.

Before relying on a smart phone as a primary GPS device, users should consider:

- How long will the device be required to operate for?
- Will the device withstand the environmental conditions required for the operation?
- Will this smart phone actually work without cellular connection?

GPS Coordinate Converter Tool