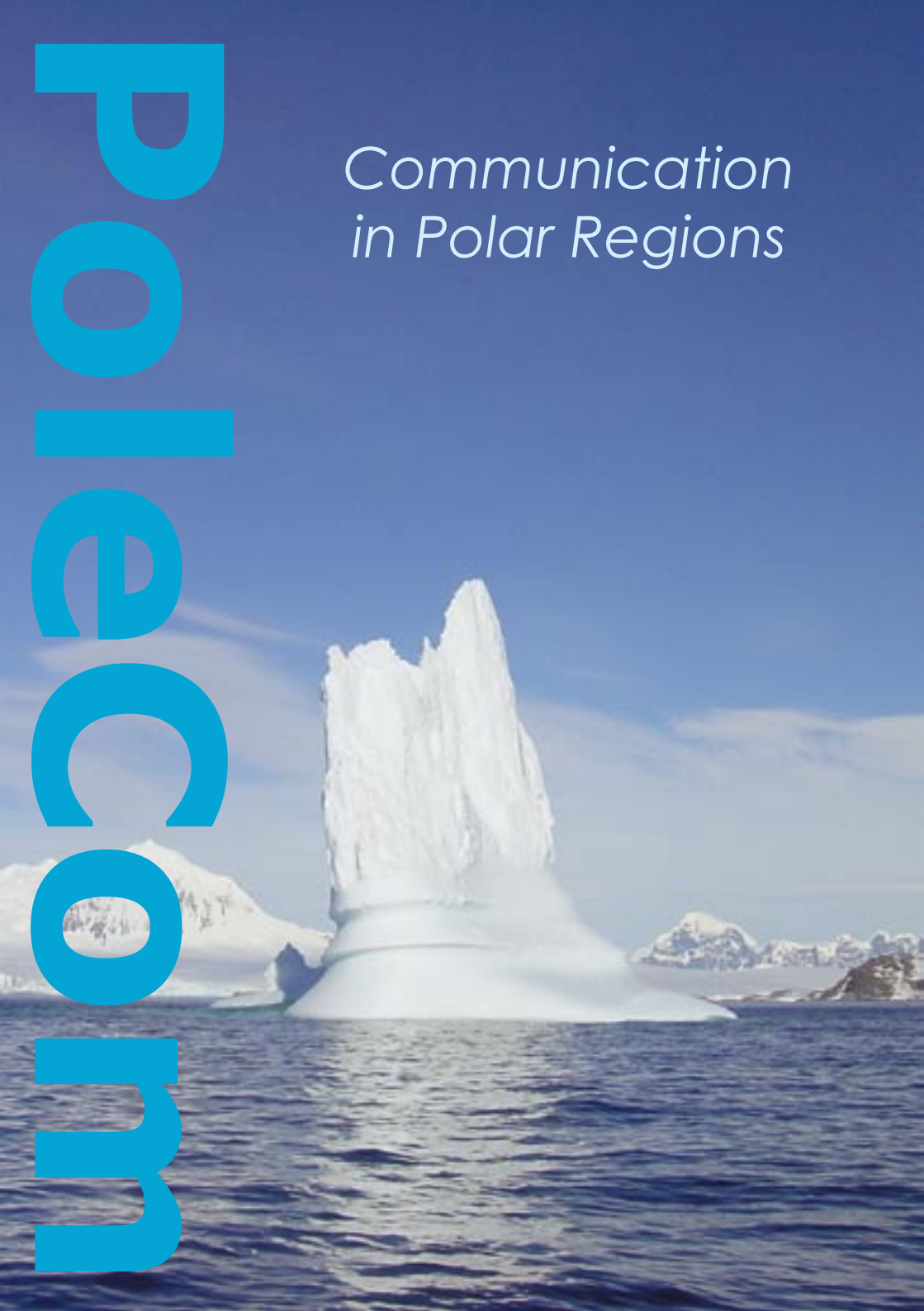
Polecom

Communication in Polar Regions



This handbook is made as a guide to communication technologies suitable for use under the special conditions of expeditions to Polar Regions.

It is the main deliverable of the PoleCom project, which was executed during the spring of 2005 by the following students:

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The project was a part of the Communication System Design course given 2005 at the Royal Institute of Technology (KTH) in Stockholm, Sweden.

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For more information, see the project web page at
http://csd.ssvl.kth.se/~csd2005-team10

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Content

Cross-reference

Satellite

Data

Voice

Positioning

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Everybody participating in our survey

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Photograph by: Sean Loutitt - National Science Foundation

Iridium

Company

The Iridium system was developed by Motorola, launching the first satellite on 5 May 1997. After 15 launches a constellation of 66 satellites was up and running in the orbit and ready for the start of service in January 1999.

In the first months of operation, Iridium didn't get enough customers because of the high phone price (up to $3 000) and traffic cost (up to $7 per minute). Instead, customers chose much cheaper terrestrial networks such as GSM.

Despite a dramatic price cut in summer of 1999 it was already too late to save the company. Iridium filed for bankruptcy in August 1999 and the satellites were planned to burn up in the Earth's atmosphere.

The satellite constellation was saved by a group of U.S.-based investors who purchased the system for 0.5% of its original value. Iridium LLC became Iridium Satellite LLC and the company underwent reorganization.

According to experts, the satellite constellation will be viable until 2014 without any additional satellite launches.

Iridium

IRIDIUM

Telephony

Voice bit rate: 2.4 kbit/s
Services: **Point to point calling**
Call forwarding
Voice mail
SMS
Paging

Network

Coverage: Truly global
Nr of satellites: 66
Orbit height: 780 km - Low Earth Orbit
Orbit time: 100 minutes
Inclination: 86.4°
Frequency: 1.6 GHz (L-band)

Data

Transmission bit rate: 2.4 kbit/s
Connection type: Circuit switched
Delay (up and down): 10 ms
Download of 1 MByte: 58 min.

Suitable for: **E-mail**
Transfer of small files
Remote controlling

Short Burst Data

(for transmission of small messages)
Max data amount: 1960 bytes (send)
1890 bytes (receive)
Transmission time: < 20 s

Suitable for: **Remote controlling**
Automatic tracking
Telemetry reporting

Economics

To land line: 0.85 - 2 USD/min
To Iridium: Down to half of land price
To other sat: 10 USD/min or more
SMS: 0.50 USD

For Internet Direct Data it usually costs 50 % more than the rate to land lines.

The prices vary with different monthly and pre paid plans provided by different VARs (Value Added Resellers). Lower pricing may be possible for Africa, USA and Canada. Prices are subject to change.

Survey of Users

Satisfaction: High
Desire: High

"Useful, handy", "Reliable"
"Some time periods of no coverage"

Direct Internet Data

This service provides Internet connectivity without the need for an ISP. With its transparent compression of data, speeds of up to 10 kbit/s can be reached.

A technique called "spoofing" quickly and automatically connects for data transmission and disconnects when idle. This reduces connection time costs, while the connection appears online all the time.

Coming services

A packet based data service based on Short Burst Data will be available in late 2005. The service will offer a transmission bit rate of 9.6 kbit/s.

Push-to-Talk Group Calling (PTT) is a service for multiple user communication. It is similar to function of VHF radios. Commercial availability is planned for 2006.

Iridium Continued

Multiple devices

For higher transmission speeds, up to 16 Iridium devices can be interconnected at 16 times the cost. Due to synchronization traffic, 4 or 8 devices are more cost efficient than 16. This solution is called RUDICS.

Products

Phone

With Iridium 9505A portable satellite phone, you can keep connected all over the World with one telephone number, by using a mini personal subscriber identity module (SIM) card.

It is the only satellite phone system that has truly global coverage.

A data kit is necessary for using the phone's built-in modem.

Specifications

Iridium 9505A (approx. USD 1400)

Weight:	Under 375 g
Dimensions H x W x D:	158 x 62 x 59 mm
Ambient temperature:	-10°C / +55 °C
Relative humidity:	93% RH at 40 °C
Battery standby:	30 hours
Battery talk time:	3.2 hours
Power consumption:	avg. 0.57W
Port interface(s):	1xRS232 data adapter
Card interface(s):	1xSIM
Wireless interface(s):	External antenna

Modem

with GPS and Phone

The NAL A3LA-DGP is a combination of Iridium 9505A satellite phone and NAL satellite data modem with build-in GPS system.

The modem can be controlled by a PC/PDA/ micro controller via a serial port.

See www.nalresearch.com for more info.

Specifications

NAL A3LA-DGP (approx. USD 1700)

Modem

Weight:	689 g
Dimensions:	196 mm x 83 mm x 40 mm

Phone

Weight:	200g
Dimensions:	161 mm x 55 mm x 26 mm
Input Voltage Range:	4.0VDC to 4.8VDC
Avg. Standby Current:	680mA @ 4.4VDC
Avg. Transmit Current:	1.5A @ 4.4VDC
Avg. Call Current:	1.0A @ 4.4VDC
Peak Power-Up Current:	~2.7A @ 4.4VDC

Iridium references

BBC, http://news.bbc.co.uk/1/hi/business/681646.stm
Iridium, http://www.iridium.com/
NAL, http://www.nalresearch.com/StandardModems.html

Inmarsat BGAN

Telephony

High quality 3G supported telephony
Services: **Point to point calling**
Conference calling
Caller ID
Call forwarding
Call waiting
Voice mail

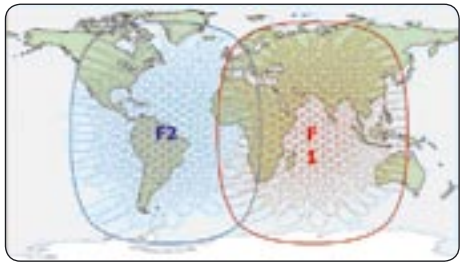
Network (future service)

Coverage:	85 % of world's land mass
Nr of satellites:	2 (Inmarsat I-4)
Orbit height:	36 000 km Geostationary Earth Orbit
Orbit time:	24 hours
Inclination:	0°
Frequency:	L-band (1-2 GHz)

Data

Transmission bit rate:	up to 432 kbit/s
Connection type:	Packet switched
Delay (up and down):	500 ms
Download of 1 MByte:	20 s

Suitable for: **E-mail**
Web browsing
Transfer of large files
Video conferencing
Video broadcast
Video store-and-forward



Economics

Prices have not been made official at time of writing. They may speculatively be similar to R-BGAN prices.

On 11 March 2005, the first satellite of the next generation I-4 satellites was launched successfully. This is the first step into the global mobile satellite broadband communication era.

Later this year, another I-4 satellite is planned to launch to form a global constellation of the new generation satellites. Those two satellites will provide the new Broadband Global Area Network service, which is planned to be commercially launched in early 2006.

The first new service to be launched on the Inmarsat-4 satellites will be BGAN – a broadband-speed mobile satellite service delivering data and voice, simultaneously through one device.

Europe, Africa, Asia and Western Australia will be covered by the first satellite (F1), followed by coverage in North and South America after launch of the second (F2).

The service will be available in Europe, the Middle East, Africa and Asia in late 2005. In Q2 2006, the service will expand to North and South America.

As for coverage in Polar Regions Inmarsat, as most other providers, are conservative in guaranteeing service. However, experiments have shown that there has been GAN coverage a bit outside guaranteed areas, although not around the poles.

Subscribers of Inmarsat's Global Area Network (GAN) and mini-M services will get higher levels of network reliability and availability through the increase in network capacity due to launch of the new satellites.

Regional BGAN satellite IP modems will continue functioning with increased coverage in new regions by a software update, but the bit rate remains the same (144kbit/s). Regional BGAN users will be offered to upgrade to new terminals.

Inmarsat GAN

Telephony

Voice bit rate: 4.8 kbit/s or 64 kbit/s
Services: **Point to point calling**
Conference calling
Call forwarding
Voice mail
SMS

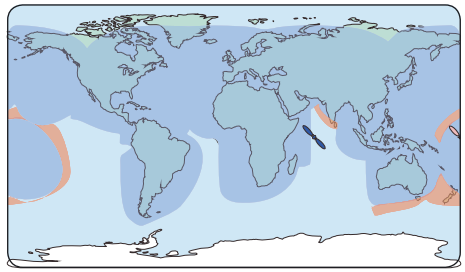
Network

Coverage: 98 % of world's land mass
Spot beam area
Nr of satellites: 4 (Inmarsat I-3)
Orbit height: 36 000 km
Geostationary Earth Orbit
Orbit time: 24 hours
Inclination: 0°
Frequency: 1.6 GHz (L-band)

Data ISDN

Transmission bit rate: 64 kbit/s
Connection type: Circuit switched
Delay (up and down): 500 ms
Download of 1 MByte: 2.2 min.

Suitable for: **Transfer of large files**
Video conferencing
Video broadcast
Video store-and-forward



Data MPDS

Transmission bit rate: up to 64 kbit/s
Connection type: Packet switched
Delay (up and down): 500 ms
Download of 1 MByte: 2.2 min.

Suitable for: **E-mail**
Chat
Web browsing

Economics

Voice: 2.5 USD/min
ISDN: 7.8 USD/min
MPDS: 35 USD/MByte

Prices are approximate and subject to change.

The Inmarsat Global Area Network (GAN) combines the IT network with a global mobile communication network. It satisfies the need for high-bandwidth communication that enterprises demand.

Global Area Network offers two services - Mobile ISDN and newly launched Mobile Packet Data Service, depending on which kind of communication one prefers.

Inmarsat's Mobile Packet Data Service (MPDS) is a packet-switched service that provides packet-based charge rather than airtime-based charge. It supports many popular IP-based applications.

As for coverage in Polar Regions Inmarsat, as most other providers, are conservative in guaranteeing service. However, experiments have shown that there has been GAN coverage a bit outside guaranteed areas, although not at the poles.

Nera WorldCommunicator

The WorldCommunicator from Nera is made by polycarbonate, so the advanced electronics are protected from extreme climatic conditions.

One can double throughput to 128 kbit/s by linking two terminals together, delivering large data transfer and video transmission at high speed.

Specifications

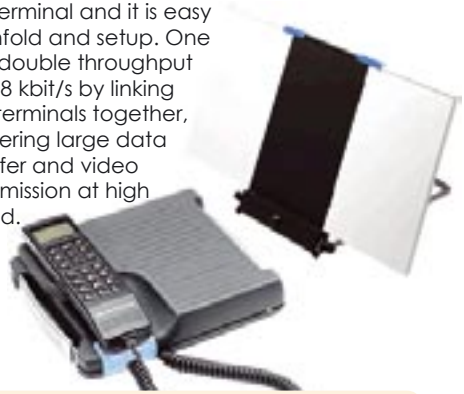
Nera WorldCommunicator
(approx. USD 10 600 excluding VAT)

Weight:	3.9 kg
Dimensions H x W x D:	68 x 260 x 355 mm
Ambient temperature:	-25°C / +55°C
Relative humidity:	95% RH at 40°C
Battery standby:	70 hours
Battery talk time:	4.8kbit/s: 9 hours 64kbit/s: 6 hours
Battery data time:	3 hours
Power consumption:	0.7 W (idle) 32 W (active)
Power supply:	10-32V DC
Port interface(s):	1xRJ45, 1xUSB, 1xRS232
Card interface(s):	1xSIM
Wireless interface(s):	Panel antenna, DECT

Thrane & Thrane TT-3080A

The TT-3080A from Thrane & Thrane is packed in a magnesium case, suitable for rugged outdoor use.

The antenna can be put 70 meters away from the terminal and it is easy to unfold and setup. One can double throughput to 128 kbit/s by linking two terminals together, delivering large data transfer and video transmission at high speed.



Specifications

Thrane & Thrane TT-3080A
(approx. USD 11 600 excluding VAT)

Weight:	1.7kg (terminal) 3.5kg (antenna)
Dimensions H x W x D:	43 x 205 x 200 mm (excluding antenna)
Ambient temperature:	-25°C / +55°C
Relative humidity:	95% RH at 40°C
Battery standby:	100 hours
Battery talk time:	4.8kbit/s: 4 hours 64kbit/s: 2 hours
Battery data time:	4.8kbit/s: 2 hours 64kbit/s: 35 min.
Power consumption:	0.1 W (idle) 40 W (active)
Power supply:	9.5-20V DC
Port interface(s):	1xRJ45, 2xRJ11, 1xUSB, 1xRS232, 1xaudio in, 1xaudio out
Card interface(s):	1xSIM, 1xPCMCIA
Wireless interface(s):	Panel antenna

Telephony

Voice bit rate: 16 kbit/s
Services: **Point to point calling**
Voice mail
SMS

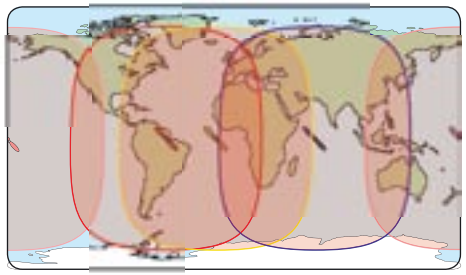
Network

Coverage: Global except poles
Global beam area
Nr of satellites: 4 (Inmarsat I-3)
Orbit height: 36 000 km
Geostationary Earth Orbit
Orbit time: 24 hours
Inclination: 0°
Frequency: 1.6 GHz (L-band)

Data

Transmission bit rate:	64 kbit/s (HSD) (and 9.6 kbit/s)
Connection type:	Circuit switched
Delay (up and down):	500 ms
Download of 1 MByte:	2.2 min.

Suitable for: **Transfer of large files**
Video conferencing
Video broadcast
Video store-and-forward



Survey of Users

Satisfaction: OK
Desire: High

"Clear communication compared to Iridium on same ship "

Economics

Voice:	2.8 - 3.8 USD/min
Data 9,6 kbit/s:	2.8 - 3.8 USD/min
Data 64 kbit/s:	9.5 - 10 USD/min

Prices are subject to change and vary with zones and time of day.

Inmarsat B is designed to replace the analogous Inmarsat A. It offers better quality, more cost-effective and greater capacity. The Inmarsat B system has channels for voice, telex, fax and data separately.

It offers an additional feature called High speed data (HSD), which is suitable for high volume data communication, such as transfer of compressed and slow-scan video.

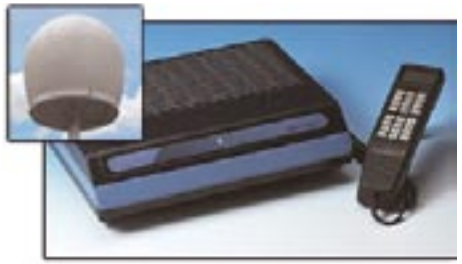
Two terminals can be connected to get a transmission rate of 128kbit/s. This is called Duplex HSD.

The coverage of Inmarsat B in Polar Regions is better than the GAN service. Depending on elevation and other factors, Inmarsat B may be available on the outer parts of Antarctica.

Inmarsat B Products

Nera Saturn Bm

The Saturn Bm offers Inmarsat B service such as telephone, telex, fax and data communications. It provides digital b-directional communication services.



Specifications

Nera Saturn Bm
(approx. USD 22 000)

Power consumption:	Recv: 100W Send: 200W
Power supply:	22-31V DC
Port interface(s):	5xRJ11 2xRS232(9pin) 1xRS232(25pin) 1xNMEA0183
Wireless interface(s):	Separate antenna unit

Terminal

Weight:	4kg
Dimensions H x W x D:	70 x 310 x 236mm
Ambient temperature:	-25°C / +55°C
Relative humidity:	95% RH at 40°C

Antenna unit

Weight:	90kg
Dimensions H x W x D:	145 x 142(d)cm
Ambient temperature:	-35°C / +55°C
Relative humidity:	95% RH at 40°C

Inmarsat D+

Data

For short messages

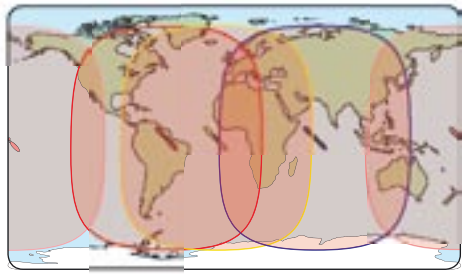
Connection type: Packet switched
Suitable for: **Remote tracking**
Remote control

Network

Coverage: Global except poles
Global beam area
Nr of satellites: 4 (Inmarsat I-3)
Orbit height: 36 000 km
Geostationary Earth Orbit
Orbit time: 24 hours
Inclination: 0°
Frequency: 1.6 GHz (L-band)

Economics

Other pricing plans than time and data based plans apply for Inmarsat D+. Check with resellers.



Inmarsat D+ is a data service for short messaging and reporting using a built-in GPS receiver. It is a low-cost, two-way store-and-forward solution offered by Inmarsat.

The terminal can be used with web-based tracking applications, remote monitoring and asset tracking. It transfers GPS coordinates and other environmental data.

Product

Skywave DMR-200 L

The DMR-200 L is an integrated Inmarsat-D+ transceiver, GPS receiver and omni-directional antenna.

It is suited in locations where the Inmarsat satellites are at a low elevation angle to the terminal, for example Polar Regions.

Specifications

Skywave DMR-200 L

Power consumption idle:	0.25W
Power consumption active:	Recv: 0.9W Send: 10W
Weight:	640 g
Dimensions L x Diameter:	100x160 mm
Ambient temperature:	-40°C / +70°C
Relative humidity:	95% RH at 30°C
Power supply:	9-30V DC
Port interface(s):	1xConxall mini-con-x
Wireless interface(s):	Build-in antenna

Inmarsat

Company background

Inmarsat was originally formed as an intergovernmental organization over 20 years ago. It focused on maritime-based communication for voice, fax and data. In 1999, Inmarsat became a privatized limited company.

Until today, Inmarsat have launched no less than three generations of geostationary satellites into the orbit, making it a worldwide leading company in global mobile satellite communication.

The first generation, called Inmarsat I-2 satellites were launched during 1990-92, they provide lease capacity as well as backup for the second generation I-3 satellites.

The second-generation I-3 satellites were launched during 1996-98, which adds functionality that generates both global beams and seven spot beams. The spot beams provide extra bandwidth for areas with higher demand of service. The current services (except Regional BGAN) which Inmarsat offers today are using the I-3 satellites.

On 11 March 2005, the first satellite of the next generation I-4 satellites was launched successfully. See the Inmarsat BGAN section for more information.

Inmarsat references

Clasatcom, http://www.clasatcom.com/inmarsat/inmarsathistory.htm
Inmarsat, http://www.inmarsat.com/
Marlink, http://www.marlink.com/
Crystal communications, http://www.crystalcommunications.net/
Skywave, http://www.skywave.com/
Nera, http://www.nera.no/
Trans European Technology, http://www.tet.co.uk/

Globalstar

Telephony

Services: **Point to point calling**
Call forwarding
Voice mail
SMS

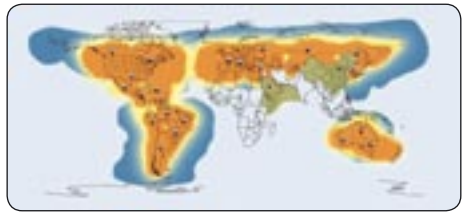
Network

Coverage: Regional
Nr of satellites: 48
Orbit height: 1 500km
Low Earth Orbit
Orbit time: 114 min.
Inclination: 52°
Frequency: 1.6, 2.5 GHz (L, S-band)

Data

Transmission bit rate: 9.6 kbit/s
Connection type: Circuit switched
Delay (up and down): 16 ms
Download of 1 MByte: 15 min.

Suitable for: **E-mail**
Transfer of small files
Simple web browsing
Remote controlling



Economics

Outgoing: 1 - 3 USD/min
Incoming: 0 - 2.8 USD/min
SMS: 0.50 USD

Prices are subject to change and vary with zones.

Globalstar was established in 1991 from a division of Ford Aerospace. The 48 satellites were launched during 1997-2000 and the commercial service began in late 1999.

Only after 2 year of operation, the company went into Chapter 11 reorganization. In April 2004, Thermo Capital Partners took over the control of Globalstar.

In 2004, Globalstar announced to launch new data compression service to increase the data rate; it also announced that a new faxing service would be available.

Ericsson R290

You can use Ericsson R290 for both GSM and Globalstar network. When the cellular coverage is not available, the phone can switch to satellite mode and connect to the Globalstar network.

It requires only one SIM card, one phone and one phone number for both GSM and Globalstar network. You can get one bill to cover both satellite and cellular calls if the service provider allows it.

Specifications

Ericsson R290

Weight:	350g
Dimensions H x W x D:	162 x 62 x 39mm
Battery (standby):	6 hours
Battery (talk time):	1.5 hours
Port interface(s):	1xAccesory port
Card interface(s):	1xSIM
Wireless interface(s):	External antenna

Qualcomm GSP 1620 modem

The QUALCOMM GSP-1620 provides two major features: two-way business-to-business Internet communication with field equipment and monitor, track, operate, manage and control their remote assets.

Specifications

Qualcomm GSP 1620

Power consumption idle:	2.4W
Power consumption active:	Send: 4.8W Recv: 0.5W
Weight:	180 g (excluding antenna)
Dimensions H x W x D:	17 x 75 x 190mm (exclude antenna)
Ambient temperature:	-30°C / +60°C
Power supply:	5-16V DC
Port interface(s):	1xDB25, 1xRS232
Wireless interface(s):	External antenna

Globalstar references

GMPCS, http://www.gmpcs-us.com/products/globalstar/globalstar.htm
Globalcom, http://www.globalcomsatphone.com/globalstar/history.html
Cellular, http://www.cellular.co.za/phones/ericsson/archive/ericsson_r290.htm
Qualcomm, http://www.qualcomm.com/qws/solutions/gsp1620.html

Data

Downlink bit rate:	4.8 kbit/s
Uplink bitrate:	2.4 kbit/s
Connection type:	Packet switched
Delay (up and down):	approx. 10 ms
Download of 1 MByte:	30 min.

Suitable for:
Email
Transfer of small files
Remote controlling

Network

Coverage:	Global (Only store-and-forward)
Nr of satellites:	30
Orbit height:	800 km Low Earth Orbit
Orbit time:	101 min.
Inclination:	45° (two: 78° and 108°)
Frequency:	137 - 150 MHz

Economics

Subscription fee 45 USD/month
Traffic fee approx. 5 USD/kbyte

Prices are subject to change.

Orbcomm was the first service provider of global LEO satellite data and messaging communication service.

It provides narrowband two-way digital messaging, short data communication and GPS service globally.

Orbcomm has true global coverage, but there are only two satellites that orbit over Polar Regions, therefore the data transmission delay could be significantly higher than transmitting from lower altitude, regions.

Orbcomm announced that they would launch a new satellite in Q1 2006. The satellite will be put into a Polar orbit as Orbcomm's third polar orbiting satellite. It will still provide the existing services plus support for United States Coast Guard's Automatic Identification System (AIS) capability.

Stellar-sat ST2500

The Stellar-sat ST2500 modem has many serial and I/O interfaces for the connection of many sensors.

The power management features and GPS accuracy are one of the best in the market.

Specifications

Stellar-sat ST2500

Power consumption idle:	0.72W
Power consumption active:	Send: 30W Recv: 1.08W
Dimensions H x W x D:	35 x 110 x 222mm
Ambient temperature:	-40°C / +85°C
Power supply:	9-36V DC
Port interface(s):	3xRS232 6xdigital in 6xdigital out 5xanalog in
Wireless interface(s):	External antenna

Quake Global Q2000

Quake Global Q2000 module has full RF/EMI protection and shielding to ensure enhanced RF performance and system sensitivity.

Reliable operation in remote and severe environments is ensured by an extended operating temperature range and a vibration-resistant design ensures

Specifications

Power consumption:	1.44 W (idle)
Power consumption:	30 W (active)
Weight:	425g
Dimensions H x W x D:	25 x 124 x 213 mm
Ambient temperature:	-40°C / +85°C
Power supply:	9-36V DC
Port interface(s):	2xRS232 1xRS485, 4xdigital out switches, 8xdigital in 4xanalog in
Wireless interface(s):	External antenna

Orbcomm references

Mobilecomms-technology, http://www.mobilecomms-technology.com/projects/orbcomm/
Orbcomm, http://www.orbcomm.com/
Stellar Satellite Communications, http://www.stellar-sat.com/html/products/st2500.html
Quake Glocbal, http://www.quakeglobal.com/prod_data_sheets/q2000.pdf

Data

Transmission bit rate: 64 kbit/s - 45 Mbit/s
Connection type: Circuit switched
Delay (up and down): 500 ms
Suitable for: **All services types including broadband services**

Network

Coverage: Global except poles
Nr of satellites: 27
Orbit height: Geostationary Earth Orbit
Orbit time: 24 hours
Inclination: 0° (usually)
Frequency: Several possibilities

VSAT stands for Very Simple Aperture Terminal. It is a solution for fixed mounted two-way satellite communication.

Intelsat provides VSAT Internet Connection services to a Tier-1 Internet backbone network through its Internet Trunking Service (ITS). It bundles the space segment, teleport, and Internet services into a complete solution for customers with a single monthly tariff.

The satellites are GEOs with coverage to approx. 75 degrees north and south.

Data rates from 128 kbit/s to 45 Mbit/s downlink can be provided depending on protocol, equipment and monthly cost. The recommended frequency for Polar Regions is C-Band with an antenna of 2.4 meters in diameter.

Other teleports could be used, such as the Stockholm Teleport. Intelsat is the VSAT provider with the biggest global coverage. There are many other, such as Eutelsat, with various coverage.

Economics

Example one

Downlink bit rate: 128 kbit/s
Uplink bit rate: 64 kbit/s
Monthly fee: 4 700 USD
Initial setup cost: 1 500 USD

Example two

Downlink bit rate: 256 kbit/s
Uplink bit rate: 128 kbit/s
Monthly fee: 6 900 USD
Initial setup cost: 1 500 USD

The monthly fee enables unlimited usage. Prices are subject to change.

VSAT references

Stockholm Teleport, http://www.ssc.se/default.asp?groupid=20049101584724
Intelsat, http://www.intelsat.com

DVB-RCS

Digital Video Broadcasting
Return Channel via Satellite

Data

Downlink DVB-S bit rate: 35 - 40 Mbit/s
Uplink RCS bit rate: 144 kbit/s - 2 Mbit/s
Connection type: Packet switched
Delay (up and down): 500 ms

Suitable for: **All types of services including broadband services**

Network

Frequency downlink: 14 GHz (Ku-band)
Frequency uplink: 30 GHz (Ka-band)

There are at this moment no known satellites with coverage in Polar regions that offer DVB-RCS services.

Economics

DVB-RCS services cost less than VSAT services since the capacity is shared with others. Prices differ between service providers.

Equipment costs from 1 300 USD to 64 000 USD depending on transmit capability of the terminal.

Expertise is needed for the network sustainability and network maintenance.

Dish size

The transmission speed depends on the size of the satellite dish.

Dish size	Sending speed
65-75 cm	144kbps
75-90 cm	384kbps
95-130cm	2048kbps

Digital Video Broadband Return Channel via Satellite is a two way DVB satellite system where the end user has the transmit capability via the same antenna. In conventional digital video satellite broadcasting, the user terminal equipment only receives.

The satellite user terminal receives the DVB-S transmission in the standard way generated by a satellite hub station. Packet data is sent over the forward link in the common way for e.g. MPEG, data streaming. A common satellite channel has 36 MHz bandwidth and data rates up to 35-40 Mbps.

The satellite user terminal transmits by using a Multi Frequency Time Division Multiple Access (MF- TDMA) access scheme to share the capacity available for transmission by the terminal. The band used to transmit from terminal to hub stations is Ka band(29.5-30 GHz).

DVB-RCS references

Dr Gorry Fairhurst, http://erg.abdn.ac.uk/research/future-net/digital-video/
DD Electronics, http://www.ddelec.com/internet/two_way.htm
Gilat Satellite Networks, http://www.gilat.com/SkyEdge_DVB-RCS_TechnicalSpecs.asp?Sbj=635

Argos

Data

No downlink
Uplink bit rate: max 2560 bit/s
Connection type: Packet switched

Suitable for: **Remote tracking**

Network

Coverage: True global
Nr of satellites: 6 (NOAA)
Orbit height: 833 km
Low Earth Orbit
Orbit time: 101 min.
Inclination: 98.8°
Frequency: 400 MHz

Economics

There are two types of prices:

1) The World Meteorological Organization and Intergovernmental Oceanographic Commission organizes the Joint Tariff Agreement. The JTA negotiates a tariff structure each year and that is available for all government-financed or non-profit programs.

2) Additional services
(not connected to JTA and will be billed directly from Argos, 2004 prices)

Automatic Distribution Service (ADS) using email or FTP through the Internet	0.10USD/kbyte
Accessing data on-line using Telnet/SSH through the Internet	0.25USD/min
Databank for data archived monthly, posted as mail	180USD/CD-ROM (600Mb) 180USD/3.5 diskette (1.4Mb)

The Argos system has been operational since 1978. It was founded under an agreement (Memorandum of Understanding) between the National Oceanic and Atmospheric Administration (NOAA, USA), the National Aeronautics and Space Administration (NASA, USA) and the French Space Agency (CNES).

Argos' service includes locating platform equipped with a transmitter anywhere in the world, collecting data from sensors connected to the transmitter. Over 10 thousand Argos transmitters are now operating around the world.

The satellites get the data sending from the transmitter and retransmit it to the Argos center for processing. One can retrieve the data through public data networks, often within 20 minutes of transmission.

Argos system uses small transmitters with low power consumption, it means that Argos can be used to track small animals.

PTT-100 30g Solar Argos/GPS

PTT-100 30g Solar Argos/GPS provide accurate location information and perfect data collection for researchers and it only weight for 30g. It means it can be carried on polar bears, fish and birds easily. Another advantage of PTT-100 Solar Argos/GPS is the efficient power management.

It gains the power from a tiny solar panel, with the latest battery management technology, the solar power can support it for a quite long time. It can be programmed to record GPS locations at intervals during the day and relay them to the user via Argos every third day.

Specifications

PTT-100 30g Solar Argos/GPS

Dimensions: 62 x 22 x 21 mm
Weight: 30 g
Power output: 200mW
Output impedance: 50 ohms
Transmission interval: 45 to 120 s
Supply voltage: 3.6 - 4 V
Temperature range: -15 to 45 °C

Argos references

Argos, http://www.argosinc.com/
Microwave Telemetry, Inc., http://www.microwavetelemetry.com/Bird_PTTs/12g.php

Teledesic

From the beginning, Teledesic planned 840 active satellites in 1994, the number drops to 288 active satellites in 1997 after a Boeing-led redesign and before the merge with Motorola's Celestri.

Teledesic later overtook ICO. In February 2002, Teledesic announced that thirty MEO satellites are planned. On 1 October 2002, Teledesic was officially suspending its satellite construction work.

Ellipso

Elliptical is unique for its design of elliptical Medium Earth Orbits (MEOs) where the altitude varies depending on the coordinates of the satellites.

It utilizes the property that the World's population is concentrated on the North half of the Earth, thus it has more coverage in the North than the South, makes bandwidth sharing more effective.

Skybridge

SkyBridge was proposed by Alcatel and it was a 64-satellite LEO constellation concept. Now they are plans to change to a geostationary satellite system, while in January 2002 it was reported that SkyBridge was on hold.

ICO

ICO (for Intermediate Circular Orbit) was originally designed by Inmarsat, known as Inmarsat P. It later formed a separate company and then filed for bankruptcy [4]. Craig McCaw led a group of international investors to provide $1.2 billion to acquire the ICO business in May 2000.

The concept of ICO is to make personal mobile communications possible all over the World by planning a family of quality voice, wireless Internet and other packet-data services. The goal of ICO is for data capabilities and voice quality It will be comparable or superior to those of current terrestrial mobile networks.

Data Planned transmission bitrates

System	Teledesic	Ellipso	Skybridge	ICO
Downlink	64 Mbit/s	28.8 kbit/s	5/60 Mbit/s	144 kbit/s
Uplink	2 Mbit/s	28.8 kbit/s	0.5/6 Mbit/s	144 kbit/s

References

Lloyd's satellte constellations, http://www.ee.surrey.ac.uk/Personal/L.Wood/constellations/
Ellipso, http://www.ellipso.com/
ICO, http://www.ico.com/

G P S Global Positioning System

The Global Positioning System, usually called GPS (the US military refers to it as NAVSTAR GPS), is a satellite navigation system used for positioning one's precise location and providing a highly accurate time reference almost anywhere on Earth or in Earth orbit.

It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites. The GPS system was designed by and is controlled by the United States Department of Defense and can be used by anyone, free of charge.

The GPS satellites continuously transmit digital radio signals that contain data on the satellites location and the exact time to the earth-bound receivers. The satellites are equipped with atomic clocks that are precise to within a billionth of a second.

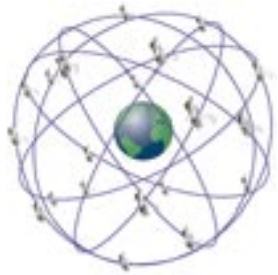
The GPS system was developed for military services at beginning and it has been popular to civilians now. The GPS's Standard Positioning Service worldwide is free of charge. Only a low cost GPS receiver (price $100 to $200) is needed, which could be combined in a bundle with a PDA or cell phone.

In Europe, companies' concern about the level of control over the GPS network and commercial issues has resulted in the planned GALILEO positioning system. Galileo will be a political statement of European technological independence from the United States.

A strong motivator for seeking technological independence is the policy of the United States government to employ only American companies for the building of components for the GPS.

Network

Coverage: Truly global
Nr of satellites: 24 (plus spares)
Orbit height: 20 200 km
Medium Earth Orbit
Orbit time: 12 hours
Inclination: 55°
Frequency: 1.58 GHz (L-band)



Economics

The standard GPS service is free of direct user fees.

GPS is also used widely in navigation. It helps people know how to get another place during expedition and traveling.
If expedition is the process of researching something from one location to another, then tracking is the process of monitoring it as it moves along. GPS tracking service is also suitable to the animal investigation.

There are some other commercial uses of GPS, including land measurement, mapping and road construction.

References

Galileo, http://www.galileoju.com/indexf.htm
GPSWorld, http://www.gpsworld.com/gpsworld/

H F Radio High Frequency

Voice

Half duplex - Walkie talkie type communication with varying quality

Link

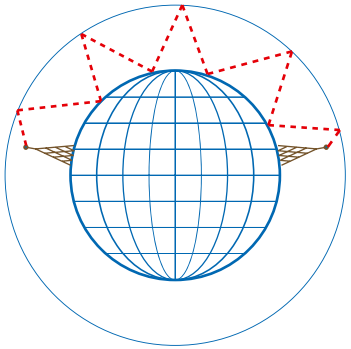
Range: Intercontinental
Frequency: 2 - 15 MHz

Data

Downlink bit rate: 0 ~ 2 kbit/s*
Uplink bit rate: 0 ~ 2 kbit/s*
Delay (up and down): varying*
Download of 1 MByte: ~70 min. or more*

Suitable for: **E-mail**
Telex
Transfer of small files

* Depending on distance, time of day, and several other factors



Survey of Users

Satisfaction: OK
Desire: Medium

"Slow but OK"

Economics

Yearly frequency licensing fees should be paid to the involved countries. Such fees are very **cheap** compared to all satellite services.

HF radio links is useful for half-duplex voice communication, but unreliable. The reliability depends on the weather conditions, antenna, frequency, right angle of take off, output power, etc. While we are using for voice communication we can either transmit (push to talk) or receive, but not the both at the same time.

It does not support for voice conference and it should be online always. However, it is economically feasible when compared with satellite phones, microwave and wireless links. It does not require any expensive hardware. It does not require much technical knowledge. It is easy to handle and use.

When compared with wireless technology like 802.11x, which can cover at the max of 10 miles. This help for long distance coverage. The HF radio signals, by reflecting to ionosphere follow the curvature of the earth. Therefore, we can reach quite long distance by using the HF signals.

E-mail through HF links is also possible, but not browsing. Once radio link connect to the remote HF link it downloads mail and send the mails to any mail. It allows sending the attachment of 110Kbytes of plain text. It also allows sending fax through E-mail. There is software available for sending mail through HF-links like Bush-mail, Wave-mail and Air-mail etc.

HF Radio Products

Bush mail

Bush-mail is an E-mail system. It is providing services in Africa to connect the remote villages where is no telephone system.

Services provided by Bush-mail:
- Once the Bushlink is connected we can automatically upload and download the incoming mails. It allows 5 pages of plain text (110kbytes) or attachments of word of 110kbytes or excel sheet of 110 Kbytes at the maximum per mail for commercial usage.
- It also provides the service of sending fax through e-mail.
- It doesn't allow spam and junk mails.
- It requires minimum power of 12V.
- Time delay of sending and receiving the mail from the bush link to anywhere in the world is approximately 30 minutes. However, this can also be improved by using proper frequency to 5mintues for forwarding.

Wave mail

Wave mail is e-mail system used in radio links. All the e-mails sent through this are compressed automatically while sending and decompression is done after receiving. It can be also used to send e-mails through satellite phones (Iridium, Inmarsat, and Thuraya) attached to this modems.

Services:
- We can send and receive E-mails with text, graphics.
- Compression and decompression is done automatically
- Transceiver control
- Message deliver and failure notification is also sent, it's optional
- One wave mail station can handle 7 modems
- Wave mail allows online discussion between two stations

In the future

The Kielradio company is planning to expand there HF data network services in Antarctica.

There future plans to set station in Patagonia and South Africa, so from there they can cover the Antarctica region. There services in this region may be available by October 2005.

HF modem

Schuemperlin Pactor-III is software upgrade of Pactor-II modem. It improves 3 to 5 times faster then Pactor -II. When compared with Pactor-II, Pactor-III uses most robust modulation. Under good conditions, the propagation is equivalent to satellite phones.

The maximum speed of uncompressed is 2722 bit/s and the online compression can be up to 5.2kbps. The Pactor-III is multi-tone waveform uses up to 18 carriers, but Pactor –II uses two carriers. A HF modem is approximately 680 USD.

HF Radio References

Bushlink, http://www.bushlink.co.tz/index.htm
Kielradio GmbH, http://kielradio.com/
Schuemperlin, http://www.schuemperlin.com/

VHF Radio Very High Frequency

Voice

Half-duplex - Walkie-talkie type communication with varying quality

Survey of Users

Satisfaction: OK
Desire: High

"Good short range"
"Dependability too variable"

Link

Range: Less than or equal to **line-of-sight** depending on transmitting power among other things

Frequency: 30 - 300 MHz

Economics

There are license free frequency spectrums of the VHF band in many countries.

Transceiver: 100-300 USD
Repeater: 700-1500 USD
Antenna: 30-300 USD

Very high frequency (VHF) is the radio frequency range from 30 MHz (wavelength 10 m) to 300 MHz (wavelength 1 m). Frequencies immediately below VHF is HF, and the next higher frequencies are known as Ultra high frequency (UHF).

Common uses for VHF are FM radio broadcast at 88-108 MHz and television broadcast (together with UHF). VHF is also commonly used for terrestrial navigation systems and aircraft communications.

VHF frequencies' propagation characteristics are ideal for short-distance terrestrial communication, with a range generally somewhat farther than line-of-sight from the transmitter. Unlike high frequencies (HF), the ionosphere does not usually reflect VHF radio and thus transmissions are restricted to the local area.

VHF is also less affected by atmospheric noise and interference from electrical equipment than low frequencies. Whilst it is more easily blocked by land features than HF and lower frequencies, it is less bothered by buildings and other less substantial objects than higher frequencies.

An approximation to calculate the line-of-sight horizon distance is: Distance in miles = square root of (1.5 * height of antenna in feet)

VHF Radio References

Tackletogo.com, http://store.tackletogo.com/sthohxhavhf1.html
Multec Communications,
http://www.rfwiz.com/Maxon/Repeaters/Maxon_SR-6151_SR-6451_Repeater.htm

Transceiver

A transceiver is a device which combines both transmission and reception capabilities within a single housing.

VHF radio transceiver mostly uses half-duplex transmission, where communication can only take place in one direction at a time. A transmit button on the set or microphone determines whether it is operating as a transmitter or a receiver.

The HX260S has all U.S., International and Canadian Channels plus one button access to weather channels including NOAA weather alerts as well as channels 9 and 16. User programmable scanning allows the user to scan any number or combination of channels. In addition, the HX260S features Dual Watch allowing the user to prioritize 16 while monitoring an additional channel.

Specifications

Standard Horizon HX260S Handheld VHF

Weight:	0.45 kg
Dimensions:	135 x 61 x 41 mm
Temperature Range:	-20° C to +60° C
Battery Voltage:	7.2 VDC
Standby:	30mA
Receive:	180mA
Transmit:	1.5A High, 0.7A Low
Battery Life:	8 hours 5W, 12 hours 1W (5% TX, 5% RX, 90% Standby)
Frequency:	TX: 156.025-157.425 MHz RX: 156.050-163.275 MHz

Repeater

A repeater is an electronic device that receives a weak or low-level signal and retransmits it at a higher level or higher power, so that the signal can cover longer distances without degradation.

"Low-level" repeaters are used for local communications, and are placed at low altitude to reduce interference with other users of the same radio frequencies. Low-level systems are used for areas as large as an entire city, or as small as a single building.

"High-level" repeaters are placed on tall towers or mountaintops to maximize their area of coverage. With these systems, users with low-powered radios (such as hand-held walkie-talkies) can communicate with each other over many miles.

Maxon's SR-6000 Series VHF and UHF repeaters provide an extended range of communications from your portable and mobile radios. It provides you with dependable operation in/between Polar research camps, construction sites, or other large, multi-building environments.

Specifications

Maxon SR-6100 series
Repeater & Base Station

Weight:	7.2kg
Dimensions:	184 x 216 x 298 mm
Temperature Range:	-30° C to 50° C
Frequency Range:	VHF 148-174 MHz UHF 450-480 MHz
Input Voltage:	13.8 VDC ± 20%
Standby:	<150 mA
Receive:	<500 mA
Transmit:	<10 A
RF Output Power:	40 W

Data

Standard	Throughput	Download of 1 MByte
802.11a	Up to 54 Mbit/s	0.2 s
802.11b	Up to 11 Mbit/s	0.8 s
802.11g	Up to 54 Mbit/s	0.2 s

Suitable for: **E-mail**
Web browsing
VoIP
Video conference
Transfer of large files

Link

Standard	Range Indoor	Range Outdoor	Frequency
802.11a	90 m	360 m	5 GHz
802.11b	150 m	500 m	2.4 GHz
802.11g	150 m	500 m	2.4 GHz

Economics

No license is needed since these standards operate in the Industrial Scientific and Medical (ISM) band.

Survey of Users

Satisfaction: High
Desire: High

"Wireless links between ships"

Short for wireless fidelity, Wi-Fi technologies include the approved IEEE 802.11a, b and g specifications, as well as the yet-to-be-ratified 802.11n specification. Wi-Fi is the first high-speed wireless technology to enjoy broad deployment, most notably in hotspots around the world – including homes and offices, and increasingly cafes, hotels, and airports.

The advantage of 802.11a over 802.11b is the throughput of 802.11a is 54Mbps and 11Mbps respectively. Due to high frequency, the coverage of 802.11a is limited. When we compare with cost, the 802.11a is more costly. The IEEE 802.11g WLAN standard can be thought of as an intersection between the 802.11b and 802.11a standards. Like 802.11a, 802.11g uses Orthogonal Frequency Division Multiplexing (OFDM) for transmitting data.

OFDM is a more efficient means of transmission than Direct Sequence Spread Spectrum (DSSS) transmission, which is used by 802.11b. When coupled with various modulation types, 802.11g is capable of supporting much higher data rates than 802.11b.

W-LAN References

Cisco, http://www.cisco.com/en/US/products/hw/wireless/ps5279/
Mikrotik, http://www.mikrotik.com/3index.php#ptm

W - M A N IEEE 802.16 WiMAX

data

Data (theoretical)

Standard	Throughput	Download of 1 MByte
802.16 2004	Up to 75 Mbit/s	0.1 s
802.16 e	Up to 30 Mbit/s	0.3 s

Suitable for: **Interconnecting WLANs**

Link (theoretical)

Standard	Range	Frequency
802.16 2004	Up to 45 km	2 - 11 GHz
802.16 e	5 Km	2 - 6 GHz

WiMAX is an acronym that stands for Worldwide Interoperability for Microwave Access, is a certification mark for products that pass conformity and interoperability tests for the IEEE 802.16 standards. IEEE 802.16 is working group number 16 of IEEE 802, specializing in point-to-multipoint broadband wireless access.

WiMAX is an evolution technology used to improve the last mile broadband connectivity in the metropolitan area. It can provide long distance and flexible coverage and much higher data rate services than the traditional last mile solutions, like DSL/LAN.

The current 802.16 standard is IEEE Std 802.16-2004, approved in June 2004. It renders the previous (and 1st) version 802.16-2001 obsolete, along with its amendments 802.16a and 802.16c. IEEE Std 802.16-2004 addresses only fixed systems. This standard may be referred to as "fixed wireless" because it uses a mounted antenna at the subscriber's site.

The antenna is mounted to the user site in the balcony or a roof, which communicate to the base station without cables. This technology can provide various data rate solution based on the customer's requirement and the coverage of the central base station. In another word, it's an ideal solution for both remote area and crowded urban area. See figure-1

Intel began shipping its first-ever processor that taps into the wireless standard 802.16-2004 in April 2005. In addition, some equipment vendors announced products using the chip, formally called the Intel Pro/Wireless 5116.

An amendment 802.16e is in the works which adds mobility components to the standard. 802.16e standard focus on full portability solution. The mobile clients could move anywhere with the connectivity with the WiMAX base station without fixed antenna as long as under its coverage. See figure-2. The 802.16e is still in draft state. This amendment is expected to be completed in 2006.

Intel, the world leading Microprocessor Company, is the maker of WiMAX and has rolled out the silicon for WiMAX. The WiMAX Forum is an industry-led, non-profit corporation formed to promote and certify compatibility and interoperability of broadband wireless products. Member companies support the industry-wide acceptance of the IEEE 802.16 and wireless MAN standards, including Alcatel, AT&A, Cisco System, Ericsson, Nokia, Siemens Mobile, etc.

W - M A N References

IEEE 802.16 Working Group on Broadband Wireless Access Standards, http://grouper.ieee.org/groups/802/16/
WiMAX Forum , http://www.wimaxforum.org/home
Intel, http://www.intel.com/netcomms/technologies/wimax/

G S M Global System for Mobile Communication

data

Voice

Voice bit rate: 13 kbit/s
Services: **Point to point calling**
Conference calling
Call forwarding
Call hold
Caller ID
Voice mail
Short Message Service (SMS)

Link

Coverage: Up to 35 km (one macro cell)

Frequency: 900 MHz
1800 MHz
1900 MHz

Survey of Users

Satisfaction: High
Desire: High

Economics

GSM is a complex and expensive system, which costs approximately 3 million USD for the system (without installation) and around 0.5 million USD a year for operations and maintenance.

Data

Data service	Bitrate	Download of 1 MByte	Switching
Standard	9.6 kbit/s	15 min	Circuit switched
HSCSD	Up to 60 kbit/s	2.5 min	Circuit switched
GPRS	Up to 40-50 kbit/s	3 min	Packet switched

Suitable for: **E-mail**
Transfer of small to medium files
Web browsing
Remote controlling

Generally, the coverage is based on the number of subscribers. We could set up a macro cell in the remote area; if number of subscribers increases, micro cell could be set up in the macro cell hierarchically as long as following the frequency reuse concept.

Typically, one cell could provide a maximum of 1000 channels for calling simultaneously. It means 1000 subscribers could call at the same time.

Ericsson is the largest supplier of mobile systems in the world and supports all major standards for wireless communication. Ericsson can provide mobile communication equipments of all mainstream 2G and 3G standards around the world.

For the polar expeditions, Ericsson plays an important role of GSM system sponsor. A whole GSM system was set up on one of the vessels and a volunteer from Ericsson joined the expedition to maintain and operate the GSM system.

With one base station set on one of the vessels, the whole expedition teams were covered and people on different ships could easily maintain contact with very good voice quality instead of VHF radio or satellite phones.

GSM Continued

The GSM network on vessels is an internal and local network, which could not communicate with other operator's network in other countries unless there are agreements between the Polar GSM network and other operators.

GSM References

Ericsson, http://www.ericsson.com/about/ericssonresponse/actions/acex_2004.shtml
3GPP, http://www.3gpp.org/
GSM switching, services and protocols Second Edition.
Authors: J Örg Ebersp Ächer Hans-J Örg V Ögel and Christian Bettstetter

Microwave link

data

Data

Transmission bitrate: Up to 45 Mbit/s
Delay (up and down): < 1 ms
Download of 1 MByte: 0.2 s

Suitable for: **Linking two local sites**

Link

Range: Up to 80 km
Frequency: 1 to 59 GHz

Economics

The cost of design, implementation and maintenance is high. While designs care must be taken to see free from obstacles. To handle and setup this needs high technically skilled person.

The Microwave link uses RF technology and for long distance communication. It requires maintenance .The atmosphere will also effect the communication particularly in rain and terrain characteristics. The sites should be line of sight for communication between two-microwave links.

In an E1 microwave link, there are 32X64Kpbs channels. These products can be broadly divided into three categories point-to-point, point to multipoint and spread spectrum. The point-to-point links are high speed of date rate can be reached then wireless networks. It is cost efficient.

This type is useful where connection between two fixed stations is required. Microwave links with only licensed frequencies can transmit 50 or 100 Mbps full duplex at ranges of a maximum 80 km (45 Mbps). Even though if we increase the range of the microwave, but the problem because of the earths natural bending (spherical shape) and may have to use really high masts.

While deploying microwave links the following practical factors need to be considered

1. Line of sight: The clear line of sight between the transmitter and receiver must be need. If there is obstacle like mountain in between the sites then to solve the line of sight, we need to place the repeater.
2. Frequency: The authorized frequency is need that does not disturb the other radio links.
3. Range: This factor depends on several other factors

i) Power of transmitter
ii) Frequency
iii) Gain of the transmitter
iv) Gain of receiver
v) Sensitivity of receiver
vi) Signal loss in cables and equipment
vii) Atmospheric attenuation and loss of path

4. Power: The power depends on the range of transmission. Greater the range more power is required for transmitter.

Microwave link references

Swiss Wireless, http://www.swisswireless.org/wlan_calc_en.html
Airlinx, http://www.airlinx.com/products.cfm/product/1-20-64.htm
Mikrotik, http://www.mikrotik.com/3index.php

Traffic cost

The satellite technology services that may be relevant for polar expeditions differ in some aspects such as transmission speed, delay, reliability and pricing.

Since expeditions differ a lot in length, destination and number of participants, they have very different needs for communication.

No service with time-based pricing is efficient for sporadic usage such as web browsing. For such uses, the packet-based services such as Inmarsat GAN MPDS and the new BGAN would be suitable, but also fixed priced VSAT could be suitable if the monthly traffic is more than 300 MByte per month.

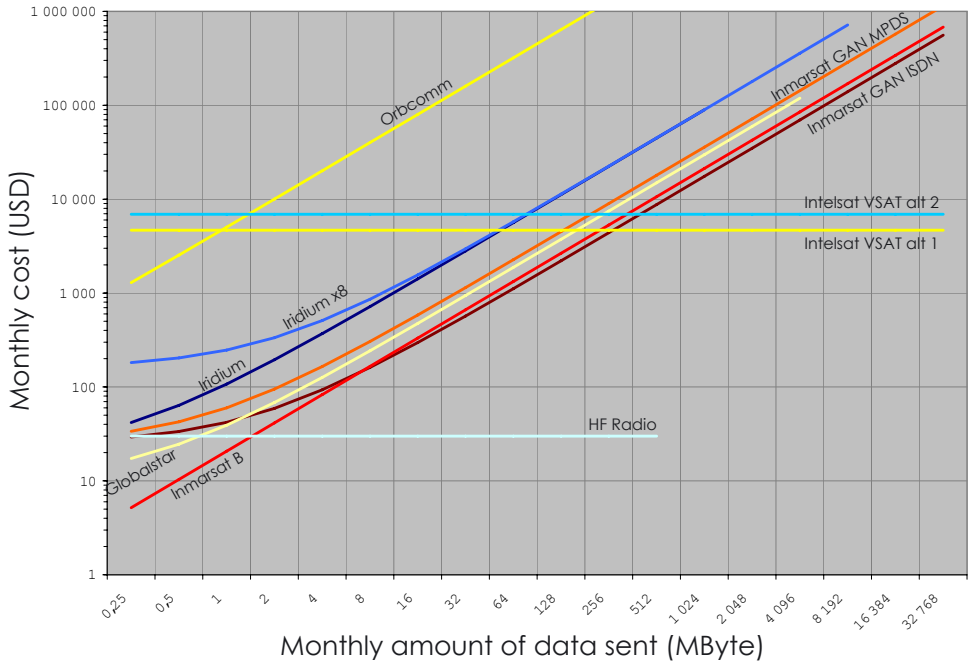
The graph below shows, for each of the intercontinental communications technologies, the monthly cost of data traffic as a function of the amount of data sent each month.

It is assumed in the calculations that transmissions over services with time-based pricing are done as efficiently as possible; that there is almost no idle time. That implies for example sending of files and batches of emails, not web browsing.

For such transmission of files and emails of an amount of no more than ten MByte per month, HF Radio and Inmarsat B are the cheapest.

Sending or receiving from 10 to 300 MByte per month makes Inmarsat GAN ISDN and HF Radio the cheapest. HF Radio, being far the cheapest, however has poor reliability and very low speed. If time is a factor, it's not an option.

For any type of usage with amounts of over approximately 300 MByte, Intel's VSAT alternative 1 is the cheapest. If higher speed is desired, there are substantially faster alternatives at correspondingly higher costs.



Transmission speed

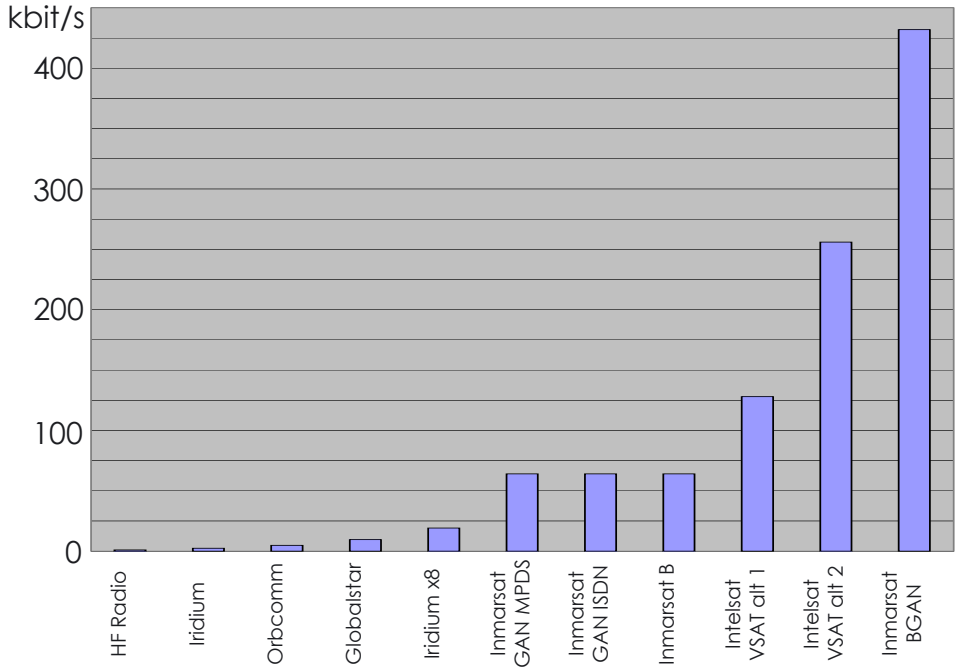
In the graph below, the differences of transmission speed between intercontinental communication technologies is shown.

The fastest one is VSAT, which can provide up to 45 MBit/s. Inmarsat's coming service Broadband Global Area Network will be the fastest available with a mobile terminal. For handheld equipment Globalstar is currently the fastest with its 9.6 kbit/s.

HF Radio, which is the slowest and most unreliable, is often also the cheapest. It can serve as a backup as it can be independent of service providers.

In some parts of Polar Regions, choosing is not really possible due to the coverage situation. At those places, such as the poles, Iridium is the only choice for reliable real time communication.

HF radio could work, but is interfered with by northern lights. Orbcomm could be used for store-and-forward of small messages.



Speed and range

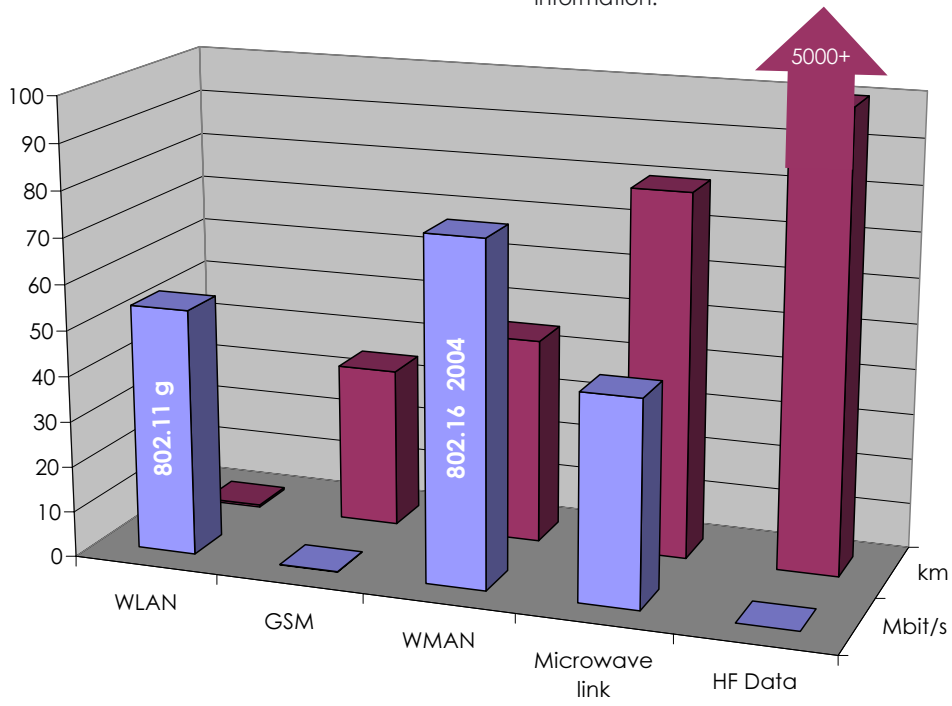
Showing in the graph below is the maximum transfer rates and distances for regional and local connectivity technologies that could be used within an area on Polar expeditions.

Sorted by distance, W-LAN on the left is the one with the shortest distance offered. HF Radio is superior with its intercontinental range. The bars in the back indicate these distances.

The bars in the front illustrate data speed. As can be seen, 802.16 2004 WiMax is superior for distances up to 45 km.

It should not be forgotten that all these technologies use different types of equipment, everything from a GSM phone to large antenna masts.

Cost is another issue that differs a lot between them. See the technology section for more information.



Local voice communication

For voice communication a few alternatives are suitable. Handheld VHF is a classic, not needing any infrastructure. Problems are that line-of-sights is need and that the sound quality often is poor. It is a half duplex technology which means that only one can speak at the same time. This can be frustrating for people no used to that.

GSM is a alternative. It provides a more reliable and more usable way of communicating. It could be hooked up to the international phone network over satellite, enabling global connectivity. Cost is however very high. See technology section.

Another reliable and good alternative is satellite phone such as Iridium or Globalstar. While they offer great communication and security, they ore often a bit to expensive for small talk.

Let us take a possible scenario with two research stations situated 40 km apart relatively close to the fringe of Antarctica. One of them is the main station with room for 20 persons. The other is a small station were five persons can spend a couple of nights. There are also mobile units, i.e. snowmobiles around and between the stations.

These parties need communication between each other and to the civilization back home. Most important is voice for safety purposes but also data may be needed for sending research data, coordinates and photos.

Intercontinental

For global connectivity, several technologies could be suitable. VSAT might be a bit to pricey for this scenario. Assuming that there is coverage on the Inmarsat I-3 global beam, Inmarsat B will be the cheapest available satellite service for transmission of files and emails.

HF radio could be a very good complement for transmission of not so urgent emails. Since there are no traffic costs, one could try to send a batch of emails with HF first. If unsuccessful, due to southern lights (aurora) or other interference, one could just switch on the Inmarsat B.

Iridium is a good backup, providing a reliable way to send emails and make important phone calls. There should be at least one phone per location and mobile unit.

For web browsing, a packet-based service is optimal. The closest to that currently in Antarctica would be the Iridium Internet Direct Data service, which simulates packet switching. However, at a speed of 2.4 kbit/s web browsing is hardly a pleasant experience, even without loading of pictures.

In the near future however, Iridium say they will provide a real packet-based service of 9.6 kbit/s. This would enable a more cost efficient way for simple browsing. Text chatting could be the absolutely cheapest

A research station in Antarctica
Photograph by: Jenny Baeseman/Univ. of Colorado - National Science Foundation

Research stations Continued

way of communication with the civilization back home.

Although Inmarsat doesn't guarantee anything, their new BGAN service may have coverage also. This would most likely be more cost efficient and pleasant than any Iridium service.

With all that bandwidth, one needs to restrain oneselves and other's usage. The cost can quickly escalate to repulsive levels if you are not careful. Chatting on MSN, ICQ or IRC is very cheap, but if your Windows starts downloading updates in the background, you could be spending 100 USD per minute without knowing it.

For voice, Iridium would be the cheapest. Inmarsat B could be used for backup or when there is need for higher sound quality. Voice over IP (VoIP) over BGAN would be possible but not economically feasible.

Regional

By having a WLAN access point at the main station, flexible transmission of files and email is possible between researchers' laptops. A local email server could be set up providing an easy and familiar way to share results, photos, thoughts and files within the station.

To make it more valuable, WLANs could be set up on the other station and on mobile units. These could be interconnected with as a WMAN (Wireless Metropolitan Area Network) such as WiMax, when it's available.

In this case, VoIP would be an excellent way for voice communication, replacing VHF radios. PDAs with built-in WLAN capabilities could be used.

For safety purposes, automatic tracking of mobile units could be done with a combination of GPS and an Iridium modem that sends coordinates regularly with the Short Burst Data service. The information can then be accessed at the main station through an internet connection.

One good way to easily put text, photo, audio and even video on a personal home page is to connect a PDA or laptop to an Iridium phone. CONTACT is a product including software and server space that makes it very easy and cost efficient to update a home page from anywhere in the world.

A mobile unit in Antarctica
Photograph by: Kris Kuenning - National Science Foundation

Icebreaker

This scenario is on an icebreaker, housing more than a hundred people for a couple of months. Continuing on the solutions for the research stations, here would be natural to have several WLAN access points, linking all the passengers with local email and file sharing. If there are several ships, they could be linked with WLAN and WMAN.

VoIP could be a way for local voice communication. An even more appealing solution is to have a GSM system onboard, enabling everybody to use their own cellular phones to call each other without traffic costs. Such a system is however costly and requires a person to maintain it.

The Ericsson Response program did precisely that on the ACEX expedition 2004. With the results were successful, they decided to do it again on Beringia 2005. They are also going to connect the GSM system to the icebreaker's internal telephone system.

For intercontinental communication, a VSAT or DVB-RCS solution could be feasible. For that, a stabilized antenna is needed. Such an antenna is a dish that automatically rotates to always point to the satellite for any bearing of the ship.

An icebreaker
Photograph by: Al Hickey - National Science Foundation

Comparison & Solutions references

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