

# **The Wireless Toolbox**

**A Guide To Using Low-Cost Radio Communication Systems for  
Telecommunication in Developing Countries - An African Perspective**

**International Research Development Centre (IDRC)**

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## PREFACE/SUMMARY

With 6 billion people on the planet and only about 800 million telephone lines, access to modern communications services is still a dream for most people. It is now an accepted fact that the telecom infrastructure is one of the key factors that affect economic, social and cultural development in both developing and industrialised countries but as we move into the next millennium, over half the world has yet to make a phone call, let alone surf the web. The growth of the Internet, as well as widespread moves to increased use of electronic information in society, has put even more pressure on the existing telecommunications infrastructure. Even the advanced networks in developed countries are straining to cope with the growth in data communications, which now exceeds voice traffic.

In developing countries the use of the Internet is beginning to take off, but much of the public telephone grid is simply not up to the task, even where it is available. This is a specially severe problem in the rural areas where telecom networks are even more scarce, but are now faced with yet greater challenges to meet renewed demands for fulfilling Universal Access objectives, such as the many rural 'telecentre' projects which aim to provide for advanced communication services and access to the new media.

When traditional cable-based public networks are unavailable, or simply not up to requirements for reliability and bandwidth, wireless systems have recently become a cost-effective and easy to use solution for providing communications services. The technology has advanced tremendously from the days of the rural radio telephone networks and wireless systems are now a serious alternative for the full range of telecommunication services. Aside from use in the public network, new developments make possible for even a novice to set up a high-speed 2Mbps data link. These can cost less than \$2 000 for a simple point-to-point connection over a few kilometres, and there are even cheaper options if less bandwidth is required.

Wireless networks are of particular importance in developing countries where most people live in a distribution which is fundamentally different to the developed world, but ideally suited to radio technologies. In the industrialised and more wealthy countries by far the majority of people live very close together in towns and cities, while the rural areas are thinly populated. In this environment using cable makes more sense - it is much more cost effective to wire for dense concentrations of use in a particular location. But in the developing world the situation is largely reversed - over 70% of the people are located in rural areas where most people are spread sparsely over landscape in districts that can cover thousands of square kilometres. This makes cabling very expensive, especially when the low usage of the lines in these economically under developed areas is taken into account.

As a result, wireless local loops (WLL) have become an ideal alternative for rolling out new networks, even in developed countries where bandwidth limitations of cable systems continue to restrict efficient access to the Internet. For telecom operators, infrastructure investments in the local loop represent a very large percentage of their costs, typically around 50%, due to the extensive and labour-intensive civil-engineering work involved. By contrast wireless capacity can quickly be distributed over many hundred square kilometres by erecting one base station in a strategic location and this can be shared efficiently by the users as they need it. It is not necessary to know in advance the location and numbers of all the potential subscribers and as demand grows it is very easy to add more capacity to the base stations and add more base stations where needed. With the use of these systems the average cost of installing a new fixed line is being reduced from about \$2 000 for the traditional copper cable system, to less than \$500 for basic wireless telephony services.

Although public networks are beginning to spread faster into rural areas through the use of wireless technologies, there are still many government offices, companies, schools and development NGOs located in remote areas which have little prospect of gaining access to the public network for some time. In these situations, private wireless systems offer one of the only means of establishing immediate links with the outside world.

Even in towns and other economic centres, which are likely to have better local infrastructure, increasing numbers of private wireless solutions are being used. This is because bandwidth and reliability requirements are often higher than can be provided by the public cable-based networks, which have usually been slow to respond to the quickly growing demands for digital broadband infrastructure. Private links are also increasingly being set up for broadband circuits because wireless is often a lower cost alternative to the public network operator.

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As further deregulation of the telecom sectors occurs it is expected that increasing numbers of telecom operators will emerge to provide low-cost, broadband, fixed wireless connectivity services. In fact, wireless systems have already gained much of their popularity precisely because of the increasing number of deregulated and open markets. With wireless systems' rapid roll-out times they are able to enter new markets far more quickly than traditional systems which must lay cable and can require the establishment of time-consuming 'right-of-way' agreements.

Finally, wireless networks offer the added advantage of mobility. While this may not be as important a requirement in developing countries as it is in the developed, with their larger transport infrastructures, it is nevertheless a further benefit, and one that is already being exploited by the growing numbers of cellular telephony operators which have been given licenses in most developing countries. Mobility can be a useful feature in developing countries because it allows increased sharing of scarce resources, such as phone lines and Internet connections. A cellular phone can be handed around, or even moved around a village to meet the needs of the old and infirm. A PC or laptop with a wireless Internet connection can be taken around to different classes in a school, or different offices in an organisation. It should also be noted that much of the innovation taking place in mobile systems has had positive spin-offs for fixed network development and in many respects there is now a strong convergence between mobile and fixed public wireless networks.

It not surprising therefore that market group Cahners In-Stat estimates a 17% compound annual growth over the next five years in wireless communications spending. It has also been forecast that over 10% of the world's population will be connected by wireless local loops in the next 3 years.

But wireless connections will not be a complete replacement for all wired networks. Private wireless systems are usually considerably more expensive to set up than simply tapping into the public network (where it is available) and so should be seen as an interim solution which will ultimately be superseded by the growth of the public networks with their much larger economies of scale and lower costs.

Aside from the additional equipment which makes wireless systems more costly, they often require more skilled technicians to install, and network planning for efficient spectrum use in a public network is a complex and costly exercise. In situations where usage is dense (large numbers of users in one location, or where Gigabit bandwidths are needed) fibre-optic cable is superior in capacity and cost, especially for long trunk routes such as international circuits and inter-city links. Where there are already dense copper cable networks (mostly in cities in rich countries) new digital subscriber loop (DSL) encoding techniques can bring connections of more than 2MBps to most subscribers far more cheaply than setting up an entirely new broadband wireless network.

Also, in data communications, the dominant protocol - TCP/IP - was designed for a relatively error-free environment and many wireless networks are inherently prone to errors. Some wavebands are particularly susceptible to weather conditions (rain, temperature, solar interference etc.) and they also generally require a much greater level of co-ordination to avoid interfering with the activities of other radio spectrum users.

For most purposes, wireless data communications options can be broadly divided into three functional categories:

- Terrestrial systems that can only be used over short distances, up to line of sight. This can be pushed to about 70 kilometres maximum when terrain is flat or the transmitter is at a very high location, however this can be extended with the use of repeater stations
- Terrestrial systems that provide long distance communications - in some cases almost completely independent of distance or location
- Satellite based systems, which actually use line-of-sight technology, but because of the satellite's height above the earth, has a much larger coverage area than terrestrial line of sight ranges.

There are also a number of very-short distance wireless systems that are beyond the scope of this report, which focuses on systems which address deficiencies with the public networks, more common in developing countries. These are mainly used to transfer data between devices in the same office, usually based on the infrared spectrum. Also excluded from the report for similar reasons is the growing field of radio telemetry and paging systems.

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Some of the systems are specifically designed for data communications, others are standard voice telephony applications which can also be used for data. In the same way that there is convergence between mobile cellular technologies and fixed cellular technologies for wireless local loops, there is also convergence between voice oriented and data oriented systems. As the world moves away from running data over voice-networks to running voice over data-networks, wireless systems manufacturers are already at the forefront of moves to make their products compatible with voice-over-IP technology, as evidenced by Nokia's recent purchase of IP telephony vendor Vienna Systems.

However there are still a number of wireless systems being deployed by telecom operators, especially in developing countries, which do not provide adequate capacity for data. The current GSM cellular systems only provide 9.6Kbps and even the South African operator, Telkom, is still installing new wireless subscriber lines in 1999 which cannot provide dialup connections at faster rates than 7.2Kbps. This is about 8 times slower than the current 56Kbps achieved by dialup modems on most public cable-based networks and 16 times slower than an ISDN line.

As demands for higher bandwidth increases more rapidly in the developed countries, subscribers and operators in developing countries will need to increase their vigilance against manufacturers and distributors off-loading their older, lower capacity systems. While these may be considerably cheaper than some of the new technologies, especially if they are heavily discounted end-of-line items, the commonly perceived need in developing countries that low capacity voice-only systems will suffice should be re-evaluated in light of the increasingly common perception that access to advanced services such as the internet is part of the basic human right to communicate.

For both long and short distances there are solutions that can provide either narrow-band or broadband links (2MBps or more). Cost is clearly the most important factor in choice of technology. Higher bandwidth solutions are significantly more expensive and for this reason it is important to have a clear idea about the quantity of data traffic that is likely to flow over the link when making choices about systems.

The major features of the various wireless technologies are:

- The range and capacity of the link (data transfer rate). This is directly related to the radio frequencies used. Lower frequencies (HF, UHF, VHF etc) travel further but can carry less data than the higher frequencies (Microwave, ISM bands, Ku Band etc). At one end of the scale, HF systems operating at 1.2Kbps - 2.4Kbps are increasingly popular for limited long-distance voice conversations and data transfers over 100s or even 1 000s of kilometres, such as email and environmental monitoring from very remote areas. In the mid-range, data and voice links providing up to 2Mbps over line-of-sight links are becoming very common and this area is probably the most active area of wireless development. At the other end of the scale 155Mbps is being provided by satellites operating in the multi-GigaHertz microwave bands and by terrestrial infrared laser systems over 2-3 kilometres.
  - The latency of the link - the delay between sending and receiving a signal, which can have a negative effect on interactive communications such as voice calls and real-time simulations. This can be a problem in complex multi-hop cellular networks, but is more usually caused by the use of geostationary satellites which are so far from the earth that the signal is appreciably delayed in transit - about half a second.
  - The amount of radio spectrum used, this reflects how efficiently the strictly limited resource of the spectrum is used. Some technologies are able to squeeze more bandwidth out of a smaller portion of the spectrum, making them more desirable, especially in high density situations.
  - Design for mobile or fixed links, which in turn affects cost, with differing needs for switching, power, trunking and radio spectrum.
  - Adherence to open standards. Proprietary protocols are still very common in wireless networks which usually makes them more expensive and less flexible for the user and operator. However open standards are being adopted in some of the more mature technologies. For example the IEEE recently passed the 802.11 standard, which allows interoperability between spread-spectrum wireless LAN/MAN products from different manufacturers.
  - Multi-user access and expandability. Some systems are purely designed for point-to-point links and cannot be expanded to include other connections. Others are designed for operation in a multi-user hub arrangement (commonly called a base-station) which can service a number of users. In these systems the available bandwidth is usually shared among the active users, so as the subscriber base grows, at some point depending on the bandwidth needs of the users and the overall network design, the base-station's capacity may have to be increased to ensure sufficient quality of service.
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- Operational and design complexity. Planning a large network and achieving a reliable and efficient wireless connection over distances greater than a few kilometres can require an experienced radio technician to design and install the system. While a growing number of systems are becoming 'plug & play', especially over short distances, squeezing additional bandwidth and distance from connections can require extensive experience

As mentioned above, probably the most popular systems in private use are the spread spectrum wireless LAN/MAN data links in the 900MHz, 2.4GHz or 5.7GHz frequency range which provide connections over 'line of sight' links. Line of sight is dependent on the terrain, but up to 75kms has been reached in some cases. The capacity of these links is usually about 2Mbps but newer systems are now providing 10Mbps. A connection of this type can often cost less than \$1500 for all the equipment if properly planned and distances are below 4-5kms (which results in less expensive antenna costs). The most popular manufacturers of these products in Africa are BreezeCom, Cylink, Lucent (WaveLAN) and Wi-LAN. Longer distances usually require some amplification, as well as more complex and expensive antennae, which can add another \$500 - \$2 500 to the cost of each end of the link for connections over 20 kilometres.

Lower bandwidth and lower-cost VHF solutions are also in use for line-of-sight connections running at speeds from 1.2Kbps to 56Kbps and costing between \$500 and \$1 000. However most of these are operated by amateur radio enthusiasts and there is little available on the market in packaged format.

Some of the most interesting developments are now happening in the higher frequency microwave bands above 5GHz where companies such as Spike Technologies have developed systems capable of delivering 10Mbps over line-of-sight links to a large number of sites, providing an aggregate bandwidth of 400Mbps while still making efficient use of the spectrum. C-Spec's new version of its OverLAN wireless LAN offers 10Mb/s and a growing number of vendors now support the higher frequency bands, which are likely to be best utilised for people in crowded urban areas. Telecom operators such as Teligent and Winstar are already offering voice, data and video services over their new broadband fixed wireless networks operating in the 24GHz and 38GHz bands in the US.

For distances a little longer than 70kms, or in situations where there is an obstruction to line-of-sight, it is possible to use a repeater or central hub for one or two hops. For greater distances short-wave (HF) is normally used, but here the bandwidth is much more limited. About 2.4Kbps is the maximum currently available with HF, and the cost of the equipment is much greater than for a line-of-sight link – usually about US\$7 000 - 8 500 per site. These systems are also more difficult to install and usually require an experienced technician. CODAN is the dominant supplier of equipment in this area.

For higher bandwidths over long distances, satellite systems are really the only answer for rural areas, although their installation and operating costs are much higher and therefore usually require a larger group of potential users to share the expense. Satellite terminals for just 128Kbps or 64Kbps will cost upwards of \$30 000 currently, although it is possible to bring this down to about \$10 000 - 15 000 in some regions where higher powered (Ku-band) signals are being delivered, such as in Southern and Northern Africa. Bandwidth costs are similarly much higher than terrestrial links, with a 128Kbps Internet connection costing between \$3 000 and \$5 000 per month depending on quality of service.

There is however a lot of innovation taking place in satellite systems and with new entrants to the market such as Tachyon and SkyBridge, it is expected that costs for terminals will shortly drop to less than \$5 000 and bandwidth to less than \$500/month. At the same time there are large numbers of global mobile voice-oriented satellite services that are coming on stream, with the first, Iridium, already providing services to anywhere on the planet. While substantially reduced costs and increased capacities are expected early next century, these systems are currently relatively costly to use and only provide limited data services. Iridium, for example, only provides for a 2.4Kbps data connection.

Hybrid systems which make use of two different technologies are also increasingly being seen. A common example is the hybrid HF&UHF/VHF long/short distance system where an HF link operating over many hundreds of kilometres carries data for a number of users who are linked to the remote hub by short distance VHF/UHF transmitters. Another example is the use of a VSAT satellite link to bring in the long distance connection which is then redistributed locally over line-of-sight wireless links. Also worth mentioning in the hybrid category are the Direct to Home (DTH) satellite broadcast systems which deliver incoming traffic while outgoing traffic travels over a normal terrestrial telephone line.

For larger public fixed line wireless local loop systems there are four different flavours:

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- Cellular-based systems consisting of a network of base stations. The older systems are usually based on analogue technology which is well proven and low-cost, but provides reduced speech quality, limited data capacity and low security. Examples include NMT 450/900, AMPS, TACS, N-AMPS. The newer digital systems offer better spectrum usage and are cost-effective for voice but are less standardised and still provide only limited fax/data throughput. Examples include GSM, DCS1800/PCS1900, IS-136/D-AMPS, IS-95 800/1900.
- Cordless-based systems. These provide efficient spectrum usage in high densities but with limited range, making high infrastructure costs for smaller cell sizes. Examples include DECT, CT2, PHS.
- Proprietary systems. These are usually custom-designed for the application and provide high quality voice and data services, and other enhanced services. While many of these systems provide superior service to the cordless and digital cellular standards, they must overcome the inertia created by the high installed base of the older technologies. These include FDMA, TDMA, CDMA systems, such as the products made by Qualcomm and Granger.
- Satellite-based systems, as described above, are also proprietary and are mainly focussed on the mobile market, but fixed line access is also envisaged in a few years. These provide global coverage in virtually all environments, but currently have very high usage costs and there are still unresolved domestic control issues. Examples include Iridium and Globalstar.

As can be seen, choosing the right wireless system is not a simple task. The variety of factors involved is large and the topic can be highly technical. However it is hoped that this guide will provide the necessary information to make more informed decisions about the options available.

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## 1. INTRODUCTION

The use of radio frequencies for wireless communications has advanced extremely rapidly over the past few years and this has combined with the liberalisation of the telecommunication sectors in many countries, resulting in an explosion of possibilities for improving communications infrastructures worldwide. The huge growth of cellular telephones is just one example of the pace of these new developments, and these may soon be eclipsed by new technologies such as personal satellite communications and Personal Handyphone Systems. Many believe wireless local loops will replace copper as the chosen way to expand basic subscriber services which are facing much heavier demand due to the growth of the Internet. In developing countries in particular, wireless technologies are seen as one of the most important ways of addressing their needs. Existing network penetration is so low that new infrastructure-building initiatives can take full advantage of the latest technologies without having to recoup the costs of massive investments in the older systems that Europe and North America are burdened with.

While large scale wireless systems are being rolled out for national public networks, many remote areas are not part of near-term coverage plans and this still leaves those with pressing needs for access to communications out of the loop. In addition, even where the public network does penetrate, it may be unreliable and unable to provide sufficient bandwidth to meet requirements, or may simply be overpriced. In these cases 'private' wireless data networks have become a viable option in a great many situations.

Wireless solutions usually rely on proprietary hardware and software platforms developed by different commercial companies. The development of industry-wide standards for many applications is still at an early stage and while open protocols are increasingly coming into operation, in many cases it is mandatory to use the same company's products at each end of a link. With this sort of limitation, in a competitive environment with a great variety in types of connections, equipment and protocols, choosing a system can be difficult, especially as there are few ongoing forums to improve information exchange for those with non-technical backgrounds.

The purpose of this 'Toolbox' is to provide a guide in simple language to the various technology options that can be used to establish cost-effective communications facilities where traditional cable based telephony systems are not available or cost effective. As a "layman's" handbook and catalogue for selecting a technology appropriate to the communication needs of a particular project, this guide is not aimed at the public telecom operator planning a national WLL network, although these technologies are mentioned due to their utility in more integrated development projects where, for example a village co-operative might be assisted in establishing its own telecentre or even a full local telecom operation. And with the continuing convergence of telephony, data and broadcasting it is expected that many of these solutions can also be applied in providing a wider range of services and connectivity strategies.

This publication originates in the International Development Research Centre's early interest in the use of low-cost computer-based communications in developing countries, such as in its work to support academic and NGO networking in Africa in the late 80s and early 90s. The limitations of the existing telecommunication infrastructure were clear in these projects, and in 1996 IDRC commissioned a report on wireless communication technologies for Africa (<http://www.idrc.ca/acacia/studies/ir-jens.htm>) which identified a broad range of wireless systems that could be used.

Subsequently IDRC began work to support connectivity in an integrated natural resource management project in two very remote areas in Mozambique as part of its Acacia programme to study the use of ICTs in meeting the development needs of local communities in Africa. Specific solutions were needed in this case, but the range of possible technologies that could be used appeared broad - there was line of sight access to the PSTN in one case and potential options for connecting to the GSM cellular network in another, as well as the possibility to use HF radio or satellite communications. As a result it was decided to commission a broad study that would build on the earlier study of wireless technologies and identify specific products and costs for the various categories of systems that could be used in this project, or similar situations elsewhere.

Thus it is hoped that the guide will have wide relevance, assisting the project manager in remote areas to more easily decide on a connectivity solution, put together a budget and contact suppliers. The full range of wireless communication technologies in the market today is covered in this guide, including some systems still in development because they may have an impact on technology choices we make today. There are some areas that have been excluded from the report because they are less important for meeting the needs of basic communications infrastructures in developing countries. These include radio telemetry and paging systems as well as local area infrared systems which were excluded from the report because their range is restricted to only a few metres and are largely used for data transfers between devices in the same office.

With such a large and rapidly advancing area as wireless communications, no guide can hope to be completely comprehensive or up to date. It is hoped that this effort will serve as a starting point which can be further refined and enlarged with input from the growing number of wireless projects taking place.

Chapter 2 serves as a brief knowledge building exercise in radio transmission for the novice and also creates an environment in which to discuss technology options outlined in Chapter 3 with equipment and service details covered in Chapter 4. Chapter 2 could be skipped by those already familiar with the basics. The report ends by highlighting relevant implementation issues and is followed by a directory of sources for further information, training courses and contact details for all the equipment suppliers and service providers covered. This includes the web site URLs for most of the products and services discussed in the handbook.

## 2. A RADIO COMMUNICATIONS PRIMER

### 2.1 Signal Frequency

The frequencies of the electromagnetic impulses we call radio waves have been divided into bands along a scale starting at 0 Hertz (oscillations per second), which is relatively close to where audible sounds are (10Hertz), up through the conventional radio and television bands, into infrared, visible, ultraviolet, X-rays, Gamma rays and finally Cosmic rays. The section of the radio spectrum that can be used for wireless communications varies from about 3KHz, which is still in the audible range, up to the visible light range at about  $10^{15}$  Hertz where some laser-based systems operate. However most communications actually take place between 30MHz and 30GHz.

These frequencies all vary in their propagation characteristics and susceptibility to interference, which determines their value for a particular purpose. A general rule is that as the frequency increases, its range and ability to travel through or around barriers decreases. For most applications the usable spectrum stops about 300GHz -at the beginning of the infrared band where the usable distance of the link is down to a few metres.

The most well known wavelengths are those used for audio broadcasting - the Medium, High and Very High Frequencies - MF(AM), HF and VHF(FM). However these are also used for point-to-point and multi-point data and voice communications. The major distinction between different parts of the spectrum is in a particular waveband's utility for fixed or mobile communications, the distance the signal travels and the volume of data it can carry. The higher the frequency of the signal, the greater the potential data rate, but also the greater the impact of the environment (distance, rain, dust, terrain, etc.) on the transmission, reducing the effective range at which the signal still remains usable. At frequencies below the VHF bands (30MHz), signals can bounce off the ionosphere to travel across continents and around the curvature of the earth.

Above the VHF frequencies, line of sight is required to communicate in what is generally termed the 'microwave bands'. Even within the microwave bands however, the lower frequencies are better able to overcome the effects of obstacles such as rain, trees and rough terrain. Generally, however, there are advantages to going higher in frequency, due to the higher antenna gains which can be achieved. Higher frequencies also have smaller Fresnel zones (see below), and thus require less clearance over obstacles to avoid diffraction losses which means greater flexibility in choice of sites and lower cost antenna towers, which don't have to be so high. Lower frequencies usually require larger and more complex antennae.

At VHF and UHF frequencies (30-1000 MHz), narrow-band fixed voice services are used over short ranges (up to 75 km), often sharing frequencies in mobile bands by using directional antennas. Currently the most common fixed services use microwave frequencies (above 1 GHz) for point-to-point wide-band communications over line-of-sight paths. This includes transmissions from communications satellites. Most public telecom operators still rely heavily on microwave links for their trunk routes and the towers can be seen in any city and often along major highways. As bandwidth requirements increase though, telecom operators are steadily replacing these links with fibre-cable.

Tropospheric scatter systems can also provide point-to-point service over paths up to 200 km, using highly directional antennas and high-power transmitters but are not in common use these days.

Higher up the spectrum, Infra Red wavebands (300GHz-1014 GHz) are used for very short distance communications, usually between computer devices in an office for cordless printing, file transfer etc, especially with PDAs and other handheld devices (including cell phones).

Beginning at about 10 GHz, absorption, scattering and refraction by atmospheric gases and hydrometers (the name for the various forms of precipitated water vapour such as rain, fog, sleet and snow) become important limiting factors in transmission distance. This has its biggest impact in the tropics where the use of satellite transmission systems in the Ka-band (26.5-40GHz) and even Ku-band (12.5-18GHz) can be problematic during periods of heavy rain. This is most likely to be a problem with the new generation of consumer DTH television systems which also provide PCDirec type high bandwidth connections to the internet (400Kbps).

**Table 1: Frequency Band Characteristics**

Band Name	Range	Comments
VLF (Very Low Frequency)	3 – 30 kHz	The earth and the ionosphere acts as a wave-guide. Used in submarine communications.
LF (Low Frequency)	30 – 300 kHz	Waves can travel through the surface of large objects like the earth as the earth acts as a conductor. Ionospheric effects can cause interference.
MF (Medium Frequency)	0.3 – 3 MHz	
HF (High Frequency)	3 – 30 MHz	Ionospheric propagation is available, so very long distance communication is possible. Much interference and fading is experienced through the shifting of the ionospheric layers and solar activity.
VHF (Very High Frequency)	30 – 300 MHz	Ionospheric waves can be neglected (except for interference). Lower VHF frequencies can adapt somewhat to the terrain, so communication over distances of 100 km is possible. At the higher VHF and all UHF frequencies, communication is possible mainly in strictly line of sight conditions. Rain is generally not a problem
UHF (Ultra High Frequency)	0.3 – 3 GHz	
SHF (Super High Frequency)	3 – 30 GHz	Over longer distances than 10kms rain, obstacles, and atmospheric attenuation become serious problems here.
EHF (Extremely High Frequency)	30 – 300 GHz	
Infrared	0.1– 1000 GHz	Not capable of penetrating walls and other opaque objects or media such as dense fog or rain. This communication is weakened by strong light on the transmitter.

Microwave frequencies, requiring line of sight, are among the most heavily used for satellite communications and are further divided into bands that are commonly designated by letters. Some characteristics and comments about these bands are provided in Table 2.

**Table 2: Microwave Frequency Band Characteristics**

Band	Freq. Range [GHz]	Comments
L	1 – 2	Effectively no rain attenuation but the ionosphere can introduce a rapid fading called ionospheric scintillation. This band represents a regulatory challenge and not a technical one. There are more uses and users for this spectrum than there is spectrum available. Additional spectrum for satellite communications will be opened up as terrestrial users are migrated out to other frequencies.
S	2 – 4	Inherently low background noise level and suffers less from ionospheric effects than L band.
C	4 – 8	This is the most heavily developed and used piece of the satellite spectrum. Service characteristics are excellent because of modest amount of fading from rain and ionospheric scintillation. The large size earth station antenna is a drawback.
X	8 – 12.5	Military usage dominates. X band can provide service quality on par with C band, but commercial users will find the equipment costs to be higher due to the thinner market.
Ku	12.5 – 18	Spectrum allocations here are more plentiful than in C band. Digital Direct To Home (DTH) services such as DirecTV use this band. VSATs and DTH receivers must anticipate more rain attenuation, but this can be countered by increasing satellite radiated transmission power.
K	18 – 26.5	
Ka	26.5 – 40	From a technical standpoint, Ka band has many challenges. The biggest is the heavy attenuation due to rainfall. Spectrum is abundant in this band and new services opt for this band for this reason and the high data bandwidths that it promises.

These tables are not meant to be an exhaustive radio spectrum band allocation reference. More comprehensive band allocations may be obtained from the US Office of Spectrum Management and the SA Gazette (for details see the list of further resources in the Appendix).

## 2.2 Link Capacity

The capacity of a communications link determines the amount of information it can carry (bandwidth) and the direction it can carry it in. The amount of information is often specified in bits per second (bps) for digital systems, or the number of circuits used, for analogue systems. In the past, analogue transmission systems were the only type available, and the recent availability of digital systems has been one of the reasons for the growth in use of wireless technologies. Digitisation expands the amount of space available in the spectrum in two ways - a) it allows more layers of information to be transmitted simultaneously - and more efficiently - in the same frequencies that were used before, and b) digital systems have opened up parts of the spectrum that were once considered useless because analogue systems are not amenable to their use.

Wireless systems also vary in the nature of the flow of the communications between each end of the link. The direction may be in one direction only (simplex), common in mobile 'walkie-talkie' systems, or bi-directional, known as duplex or full-duplex. The flow of data can be symmetric (i.e. the same speed in both directions) or asymmetric, where the speed is greater in one direction. Usually asymmetric links are configured so that the reception of data is faster than sending data.

The maximum theoretical capacity of a wireless link is largely determined by the encoding or modulation technique used and the amount of the spectrum that is occupied, measured in Hertz. In the 4-11GHz range, 1Mhz of spectrum corresponds to about 1.2Mbps when using a digital system. Higher frequency signals are capable of transmitting more data, resulting in a general tendency to use the lower frequencies for lower bandwidth or last mile applications, leaving the higher frequencies for broadband systems and trunk routes.

There are a number of factors which can act to reduce the capacity of a wireless link below its theoretical maximum. The distance separating transmitter and receiver is clearly the most important factor, with the impact of distance being affected by a number of factors - levels of interference, obstructions, signal strength of the transmitter, sensitivity of the receiver and the latency of the link. Radio engineers usually prepare a 'link budget' to determine the impact of all these factors.

The strength or energy of the radio signal, more precisely the Effective Radiated Power (ERP), is measured in watts. Increasing the signal strength tends to dramatically improve the effective range of the received signal and power amplifiers now commonly being used to increase the range of equipment originally designed for indoor or short range use. However this increases the likelihood of interference with other transmissions sharing the same frequencies from other locations. As a result licensing regulations usually restrict the power to below prescribed limits.

In situations where loss of signal strength makes it impossible to use equipment designed for broadband communications (2Mbps or more), it may still be possible to use systems designed for lower bandwidth links.

The other side of the coin is the sensitivity of the receiver to the incoming signal, or the receive power requirement, which is usually measured in dBm. Devices with lower receive power requirements will be able to operate where others cannot, but the throughput may be less. For example, FreeWave modems operate at 115Kbps, only requiring -108dBm signal strength for reliable operation (low Bit Error Rate), while the WaveLAN 2Mbps product needs at least -78dBm which may make it unusable in places where there is too much signal loss caused by distance or obstructions. This principle also applies to the higher bandwidth products which may have a fall-back rate to lower throughput when used over longer distances or where there the levels of signal loss and interference are higher.

Latency is another factor which affects capacity and responsiveness of the link, describing the amount of time that elapses between the sending of data on one side and the reception of the data on the other side of the link. As radio signals travel at the speed of light, this is only really a problem with geostationary satellite communications, where the signal has to travel over 70 000kms round trip (still less than a second). Interactive real-time activities such as telnet and IRC are most affected by high latency levels, while email and other applications such as ftp and the web are not strongly affected. Telephone conversations tend to be degraded by a latency greater than about 300 ms.

There is a further impact of latency on geostationary satellite Internet connections imposed by the "lossless" design of the TCP/IP protocol. Since a data packet may be lost in transmission, a copy is kept in a buffer on the sending computer until receipt of an acknowledgement from the computer at the other end that the packet has arrived successfully. As the data packet's trip over a geostationary connection takes at least 250 milliseconds, and the acknowledgement packet takes another 250 milliseconds to return, the copy of the data packet cannot be removed from the buffer for at least 500 milliseconds. Since the buffer can only hold a limited number of packets, no new packets can be transmitted until old ones are removed when their acknowledgements are received. The default buffer size in the standard implementation of TCP/IP is 32Kb and this means that at any given moment, only 32Kb can be in transit and awaiting acknowledgement. As a result, irrespective of the channel capacity, it still takes at least a half a second for any 32Kb to be acknowledged. So, the maximum data rate is 32Kb per half second, or 64Kbps, unless modifications to the defaults of the TCP/IP protocol are made.

This problem rarely affects users on low capacity satellite links, but it may require ISPs using satellite circuits to modify the configurations of their hub equipment. Also, a number of VSAT equipment manufacturers have developed equipment specially to deal with the impact of latency. The issue is also behind discussions to develop protocols for the extension of the Internet for space travel, known as InterPlanet.

### 2.3 Antennae and cabling

A very important factor in determining the coverage and range of wireless links is the antenna design and cabling used to ensure sufficient sensitivity to incoming signals and to shape their transmissions. Range can be substantially increased for the same power and frequency if a directional dish antenna is carefully aimed at the receiving antenna. This strategy is especially important for satellite communications, where the transmitter may be orbiting many thousand kilometres away, requiring very large antennae (up to 30 metres across) which are very accurately pointed at the satellite. Using omni-directional antennas provides a wider area of coverage allowing point-to-multipoint communications, but a penalty is paid in terms of reduced range caused by the loss of signal clarity as distance increases from the transmitter.

In terrestrial line of sight links, the height, design and orientation of the antenna is a very important factor when distances exceed a few kilometres. Clearly the type of intervening terrain will have the major impact, but as distances increase, the curvature of the earth begins to have an effect, and antenna must be sited on the tallest buildings or be erected on the top of large towers to achieve a line-of-site connection. Purchase, transport and installation of these towers is not trivial and can be a major part of the cost where line-of-sight links are pushed to the limit.

When the link is less than a few kilometres long it is usually not necessary to purchase an expensive antenna system and a simple outdoor antenna is usually sufficient. As bandwidth and distances increase, it becomes increasingly important to use highly directional antennae and even power-amplifiers to boost the signal. It should be noted that it is still possible to have a LOS path even though the other end of the link cannot be seen visually. This is because the radio horizon extends beyond the optical horizon. Radio waves follow slightly curved paths in the atmosphere, so if there is a direct path between the antennas which doesn't pass through any obstacles, then we still have radio LOS resulting in the need for higher towers or higher powered signals.

To calculate the possible line of sight for longer distances (more than 10km) it is relatively easy to calculate the effect of the curvature of the earth. If  $h_1$  and  $h_2$  are heights of the antennas (in meters), the maximum distance (in kilometres) for line of sight between the antennas in unobstructed terrain can be calculated according to the simple square root formula:  $3.55 * (\sqrt{h_1} + \sqrt{h_2})$ . For example, an elevation of two antennas, one at 5m and the other at 40m gives a line of sight distance of 30.30km -  $3.55 * (\text{SQRT}(5\text{m}) + \text{SQRT}(40\text{m}))$ .

This doesn't give the entire picture however, because it does not take into account the 'Fresnel Zone' caused by obstacles such as trees and other buildings. These may not be directly in the line of site path of the signal, but they can still cause disruptive interference. So a certain minimum vertical distance between the top of the antennae and the nearest obstruction is necessary, known as the Fresnel zone. The zone is an ellipsoid, widening to its maximum at a point midway between the two antennae. At 2 km the Fresnel zone must be at least 13m at the midpoint, at 10 km it must be at least 28m. Clearly, wireless hubs that plan to maximise coverage range should be situated on the highest buildings or nearby hills. Due to the great variability of propagation in cluttered urban environments, accurate path loss predictions can be difficult but the height of the antenna can often spell the difference between success and failure.



It is also necessary to avoid losses caused by reflections from the ground and other surfaces, which can be a problem in rural areas. Trees can be a major source of loss of signal strength, and this can vary with factors such as the specific type of tree, whether it is wet or dry, and in the case of deciduous trees, whether the leaves are present or not. Isolated trees are not usually a major problem, but a dense forest can cause substantial loss of signal strength. The attenuation depends on the distance the signal must penetrate through the forest, and it increases with frequency. Fortunately, there is also significant propagation by diffraction over the treetops, especially if antennas are up at near treetop level or a good distance from the edge of the forest. An interesting new approach to obstruction is to use very high frequency systems in the 5-25GHz bands. Because systems using these frequencies have very high data capacities, interference can be accommodated while still providing significant bandwidth.

In long distance communications using HF radio, antenna design is a real art, and very large, complex antennas are often erected to improve reception.

Finally, the cables linking the radio transceiver to the antenna can also have a very big impact on the range and effective bandwidth of a link. The cable introduces signal loss and can also be a conduit for interference. Therefore when signal loss is a factor, it may be necessary to minimise cable length where possible, or to use high quality low-loss cabling and to avoid routing the cabling around potential sources of interference such as induction motors in elevators, and

## 2.4 Mobility factors

Some wireless systems such as cellular telephones are designed specifically for mobility. This means two things - being able to continue communications while moving, such as in an automobile, and being able to continue communications with the same equipment from a variety of different locations.

With the relatively high frequencies used in many systems such as GSM phones ((900MHz), rapid movement is possible - up to 180km/hr for voice and 70km/hr for data. However as these frequencies require line of sight, mobility requires a network of antennae (cells) which can hand over transmission to each other as the user moves from one location to the next.

Although mobility is perhaps not as important a requirement in developing countries as it is in the developed, which have much larger transport infrastructures and more clogged cities, it is nevertheless a further benefit, and one that is already being exploited with the growing numbers of cellular telephony operators which have been given licenses in most developing countries. Mobility is also a useful feature in developing countries because it allows increased sharing of scarce resources (a common practice already in most developing countries for many different services) such as phone lines and Internet connections. A small entrepreneur with a cellular phone can easily hand it around and move it through the village to meet the needs of the old and infirm. A PC or laptop with a wireless Internet connection can be taken around to different classes in a school, or different offices in an organisation.

## 2.5 Shared Access Hubs

A single 'point-to-point' link is usually the first step for a prospective private wireless user, but as the use of the system grows, it is quite common to find that the need for a star network topology will emerge and additional links will have to be installed. If only a small number of links are required, the easiest way may be to purchase a whole new set of equipment for each the links. However this does not scale well for larger networks as there is equipment duplication at the hub, and sometimes inefficient use of the spectrum because a dedicated frequency must be allocated to each link.

The alternative is to plan for any growth in advance and use a differently designed network. Since many communications are sporadic, it is inefficient to dedicate portions of the radio spectrum to each user for 100% of the time. As a result a number of methods have been developed to share a frequency among many users. Most commonly, a special transceiver and omni-directional antenna is located at the hub which can handle multiple links to the users. This is known as a point-to-multipoint system. In this system many users share the same frequency and some procedure must be used to separate the traffic from different users. These are known as 'multiplexing techniques' as they govern the sharing of the medium between multiple users. Examples of wireless multiplexing techniques are TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access) and CDMA (Code Division Multiple Access), each of which have their own advantages and disadvantages, For example GSM cellular telephony uses TDMA while many of the newer cellular systems use CDMA, which is claimed to be a more efficient user of the radio spectrum but is not yet as well accepted by the industry.

## 2.6 Bandwidth Requirements

The capacity or bandwidth required in a communications project is an important determinant of the type of wireless technology to use. However bandwidth requirements are not easy to predict - the only safe prediction is that more bandwidth will be needed than is available. That said, there are some guidelines that can be usefully applied to network design. Text messages transmitted by email probably have the lowest bandwidth requirements - even a 2400 baud connection will transmit about 240 characters a second which translates into about 3 pages of text a minute. If the text is compressed before transmission this will increase to about 10 pages a minute due to the 3:1 compression rates commonly achieved with text files. Word processing files are usually even more compressible, often reducing in size by 90%, so using compression becomes even more important with these transmissions, especially on low-bandwidth or high-cost links.

For the end-user, web browsing through dialup links on wired networks is rapidly moving to the 56Kbps V.90 standard. However many people still use 33.3Kbps or 28.8Kbps connections and the speed is deemed quite acceptable, especially as many of the bottlenecks are further up the network and increases in the speed of the local link have little effect on the speed of downloading from remote sites. As a result web access at 14.4Kbps or even 9.6Kbps is still useful, and it is even possible to access specific web pages at 2.4Kbps (2400 baud) when necessary, especially if there are no time-based usage charges associated with using the wireless link.

If the link to the Internet is shared by a number of users, such as in a LAN or ISP, then the 'statistical multiplexing effect' takes place because not all users are likely to be downloading files at exactly the same time. As a result, five or more users can usefully share a 33Kbps link and as the bandwidth available goes up, the number of users that can share the link increases at an even greater rate. In Africa it is not uncommon to find ISPs with 60 or more dialup lines using a 256Kbps link.

For voice transmissions, telecom operators on wired networks have standardised on 64Kbps as the necessary bandwidth required for acceptable quality, however new compression techniques have reduced this to as low as 4.8Kbps in some VSAT-based systems. Current GSM cellular systems are designed to provide a 9.6Kbps channel for each call, with the next generation systems expected to provide 32Kbps.

For audio and video applications on the Internet, a monaural AM quality sound or a small screen slow-scan video broadcast (about 20% of the computer screen at 3-4 frames a second) can be received at 14.4Kbps. Connections at 28.8Kbps allow stereo sound or faster slow-scan video images, while 64Kbps provides near to CD quality sound and reasonable quality video reception. About 128Kbps in each direction is the minimum needed for television quality video conferencing

## 2.7 Regulations on the Use of Radio Frequencies

One of the reasons wireless solutions have taken so long to become popular has been the disincentive created by the need to obtain a radio license. The process is often not well understood, or has in the past been restricted by state bodies wishing to ensure control over the content of transmissions. As a result many have found it simpler just to avoid the technology. Fortunately, regulatory authorities are becoming more transparent and the process of obtaining a license has become much simpler in many cases.

Although radio spectrum is not strictly a consumable resource it is a finite one - the use of a frequency at a particular location can exclude that part of the spectrum from being used by others in the same area. This need for exclusive geographic use has resulted in regulations to ensure optimal benefits to society by clearly defining rights of use, through granting licenses and allocating areas of the spectrum for particular applications. In some cases the regulator will provide part of an already allocated waveband for a 'secondary' purpose as long as it doesn't interfere with the primary use.

Regulations usually prescribe the frequencies at which certain services can operate, the maximum power at which they may transmit, the maximum interference they are allowed to cause to other users, and the maximum amount of interference they are obliged to endure.

One of the major issues facing regulators at present is to rationalise the current allocations in the light of new technological developments which can make more efficient use of the spectrum already allocated to some other use. This is not an easy task given the pace of technological change and the inertia resulting from the vested interests of those already occupying the spectrum. In Southern Africa, a project known as SABRE, co-ordinated by the Southern African Transport and Communications Commission (SATCC), is currently attempting this process of rationalisation for the sub-region.

The nature of the regulatory authority varies from country to country but there is a world-wide tendency toward the establishment of independent and autonomous government departments which answer to Cabinet. In Africa a minority of countries have so far established independent regulators and it is most often the state operated PTOs who are delegated this responsibility by the Ministry concerned.

For frequencies that can travel across national borders, the International Telecommunication Union (ITU) is responsible for assisting with negotiations between countries through its World Radio-communications Conferences (WRC) which take place every two years and result in modifications to the treaty known as the 'Radio Regulations'. The conferences are comprised of delegations from roughly 180 countries around the world and adoption of allocations and regulations is done by majority vote, with each country getting one vote. The needs for international co-ordination were identified in the last century, shortly after the invention of radio communications, resulting in the ITU being the world's oldest international body (and a member of the United Nations since the UN's inception).

The ITU's activities in the area of radio regulation have steadily increased over the years - the rapid development of long distance radio-based technologies and the internationalisation of telecommunications development has substantially increased the need for an international decision-making process. The increased use of satellite systems has also focused attention on the role of the ITU which is responsible for the process of negotiation for orbital positions above the earth - there are only 120 positions available around the equator for geostationary satellites, and the ITU has received over 400 applications for their use, mostly from developed nations.

In developing the regulations for international frequencies, the world has been divided into three Regions. Region 1 includes Europe, the Former Soviet Union, Africa and parts of the Middle East. Region 2 includes the entire Western Hemisphere. Region 3 includes Asia and Oceania. As a result regulations in Africa are generally more aligned with those in Europe than in with regulations in north America or Asia. This can cause significant problems if equipment is sourced across regions as the equipment is usually developed for local markets and it may not have frequencies required. This is a particular problem in the 'free' ISM bands where much of the wireless LAN/MAN equipment operates. (see below).

The use of the 30-960 MHz band (VHF/UHF) is essentially up to the country, as long as activities don't interfere with neighbouring nations. Most national telecommunication networks use these particular bands. In some cases, such as in North America, Europe and Southern Africa, countries have established a voluntary mechanism for co-ordination with neighbouring countries on cross-border use of frequencies. The ITU has a Master Frequency Register of frequencies allocated for different usage, mostly in the bands that require co-ordination because registering is voluntary in other bands.

Although a significant part of the spectrum is not subject to international agreement, spectrum allocations are relatively uniform world-wide, largely because of the dominance of the US in wireless technologies which means that it often sets de-facto national standards for other countries, most of which depend on wireless products which originate from US companies. This isn't always the case however, especially in Africa where spectrum allocations may be made with less awareness of developments in the US, especially since the demand for the latest systems is likely to be much smaller. Also, the US allocated the 900MHz band before the advent of European developed standard for GSM cellular telephones which use these bands. As a result, GSM's wide use in developing countries means that many US developed wireless technologies in the 900MHz band may not be allowed, although experience has shown that they cause little interference.

In the US, telecommunication liberalisation has resulted in rapidly increasing numbers of companies providing private wireless communications services. Initially there were only administrative fees attached to obtaining a license but recently the US regulator (the FCC) has chosen to try to use market mechanisms to allocate spectrum resources. This involves holding public auctions for parts of the spectrum and this has generated billions of dollars on the basis of the huge revenues that some wireless telecom operators are expected to generate (the PCS spectrum auctions raised \$20billion alone).

In Africa and other developing countries, access to the airwaves is often a highly political issue and much more restricted for a number of reasons. Security concerns may still prevail over the use of public information channels (the state often owns the monopoly public broadcasters), many of the markets are serviced by legally constituted monopolies, and the state often does not have the skills or the resources to monitor spectrum use, making it easier to simply not allow any form of radio transmission.

While cellular telephone services have been opened to the public in most developing countries, much of the rest of the spectrum, aside from radio and television broadcast frequencies, is usually allocated to the

military. Security is the major concern in many countries and if there is civil strife, wireless communications are likely to be severely restricted. On the other hand, demand for many of the wireless services is so small in many of these countries that governments have not yet had the incentive to open the airwaves by being offered large sums from companies willing to pay big license fees for access to the market.

Some exceptions have been made for state agencies such as the post office and the police, as well as for the parastatal corporations which often have special access to government. The UN organisations are able to make extensive use of wireless links having been recognised by the ITU member states as an independent telecommunications operator, which means it is allowed to build its own telecommunications infrastructure in any member country. There are also amateur radio bands which are set aside for experimentation, emergency preparedness and private use of a 'non-pecuniary nature'. The latter implies that unless there is an emergency, no third party traffic can be carried and systems using these frequencies cannot be automatically connected to the public network.

Of special interest are the less controlled special 'free' microwave bands set aside for industrial, scientific, and medical (ISM) applications. These bands have been opened for general purpose data communications, without requirement for a license, if restrictions on the power and transmission characteristics of equipment used are adhered to. In order to avoid interference with others sharing the same frequencies in different locations, use of these bands is only unregulated if they do not exceed a certain power level and a maximum antenna gain which usually limits the range to a few hundred metres.

In the US, there are many radio bands set aside for unlicensed ISM use, the most used are 902 - 928 MHz, 2.400 - 2.483.5 GHz and 5.725 - 5.850 GHz. In region 1 the range of ISM bands does not include the 902-928MHz frequencies and there is only a small overlap in the 2.4GHz range, so much of the equipment designed for US markets has limited use. In theory, licenses could be obtained to use the frequencies required by equipment designed for using US free ISM bands, but in practice it is often found that these bands have already been licensed to other users who got there first. Also, limited resources for spectrum allocation planning in many developing countries means that some regulations may not yet be clearly defined because many wireless technologies are so new. So national policy is often only set when the technology is introduced by a company, creating ad-hoc decisions which can cause problems later.

Due to the lack of radio spectrum monitoring facilities and skills in many developing countries, quite a few organisations and individuals have simply gone ahead and installed wireless technologies in licensed frequencies without seeking permission. In some cases the regulatory agencies may exist only on paper, with virtually no resources to identify non-compliance and to enforce a country's decisions about spectrum use. But regulators and telecom operators are becoming more aware of the growth in use of private wireless systems and are committing resources to developing monitoring capacities, or enlisting the help of amateur operators in the country to identify unregulated use.

If the telecom sector has not been deregulated, the transport of voice or even data on private networks that 'cross' public property is in most cases prohibited, especially if this is viewed as a bypass of existing public telecommunications infrastructure. However in a number of countries some users have gone ahead and installed technically illegal links after taking legal advice which they believe will hold up in court if the monopoly telecom operator presses charges. In other countries, such as in Mozambique, the regulator has separated data from voice services and the PTO only has a monopoly over voice services, thus making data communications across public roads possible for anyone.

Nevertheless, if there is a PTO monopoly it is almost essential to involve them in some way if a radio license application is to be successful. The PTO may need to be convinced that it cannot reliably provide the service required through its existing infrastructure, that it will not be used by third parties or cause interference.

A common procedure where the PTO has a monopoly is to apply to the PTO to provide the service even if it appears unlikely that they will be able to provide it. If the PTO 'declines service' then an application for a radio license is more likely to be accepted. In some cases the PTO will offer to provide the service, but at a higher installation cost than the user believes is necessary. There have been some precedents where a license has still been granted despite the PTO's willingness to provide the service, but at a higher cost than is deemed reasonable. Also, if a social improvement dimension is present in a project involving wireless technologies, it may be easier to obtain approval

The user can offer to pay for the additional equipment costs needed to establish the link and it may also be necessary to give the PTO ownership over equipment and to pay a rental fee for access to the

service. In South Africa this has happened recently with a number of independent satellite links, where the equipment was bought and installed on the customer premises (by the customer), but was 'sold' to the PTO and leased back. In some countries this is made easier because the PTOs can provide financing arrangements to spread the user's equipment costs over a period of 3-7 years.

## 2.8 Wireless Technology Standardisation

Because of the rapid pace of development in a competitive environment, many wireless technologies are still "owned" by the companies that invented them (or increasingly by the companies they have been bought) by. As a result many wireless links must use the same proprietary equipment on each side of the connection. The exception to this is in the various 2<sup>nd</sup> generation public cellular telephony systems such as AMPS and GSM which have become an open standard and in VSAT technologies where there are also a wide variety of manufacturers to choose from. There are a number of standards being considered for so-called 3<sup>rd</sup> generation mobile cellular systems such as IMT-2000, UMTS, W-CDMA and Wideband IS-95

Recently, the Spread Spectrum Wireless LAN/MAN systems commonly used for short-haul line-of-sight data links have been standardised by the IEEE as 802.11, however most manufacturers are only starting to adopt the standard widely. Bluetooth is a similar industry driven standard for wireless communications between office devices such as hand-helds, laptops and printers.

Another wireless standard is on the horizon called the Wireless Application Protocol. This is not a transport protocol however but a content oriented one. Most of the technologies developed for the Internet have been designed for desktop and larger computers supporting medium to high-bandwidth over reliable networks. But many wireless devices must work in a more constrained environment such as lower bandwidth, more latency, smaller displays, less memory and restricted power consumption. To address these issues a number of the major ICT companies such as AT&T and Intel have come together as the WAPForum to develop the Wireless Application Protocol (WAP) for improved mobile access to the internet via wireless technologies.

The WAPForum is developing specifications for tightly linking mobile wireless protocols such as GSM and CDMA to Internet protocols such as HTTP, XML, URLs etc. By adapting the Web architecture to the wireless environment the WAPForum believes more sophisticated applications will be made available to wireless users. This will consist of a Wireless Markup Language (WML) which is a tag-based display language providing navigational support, data input, hyperlinks, text and image presentation, and forms.

## 2.9 Wireless data network design and Data Terminal Equipment (DTE) Interfaces

The overall design of the wireless network and the nature of the existing devices that must be linked up will normally determine the type of wireless device interfaces used. In a small peer-to-peer wireless LAN network, ethernet cards with built in RF units can be used throughout, using PCMCIA and ISA bus cards. Where the network is large or where there are some obstructions which stop each of the peers from 'seeing' each other, it may be necessary to use a star topology or repeater arrangement and install a centrally placed hub which can more easily 'see' each of the remote wireless points.

To connect to the outside world this arrangement would normally require a wireless-ethernet to wired-ethernet bridge. In some cases this can be a PC or embedded PC device, housing two or more ethernet cards with at least one having wireless RF unit and another with a standard ethernet 10BaseT or 10Base2 socket. In some cases the RF unit is separable.

A simpler solution used by some manufacturers is to provide a standalone RF/ethernet unit with a 10BaseT interface. This makes it much simpler to connect PCs and laptops which already have ethernet cards using standard LAN cable (CAT 5 etc). This design also has the advantage of a separable RF unit in that the standalone unit can be connected to the PC with a long ethernet LAN cable, allowing the RF unit to be placed closer to the antenna, resulting in lower signal loss and reduced RF cable costs.

When an entire wired LAN must be connected to a remote network using a single wireless link then a connection to another type of device such as a router is needed, normally using a serial link. For low data rates (usually up to 38.4Kbps) this is usually either a standard asynchronous RS232 interface used by analogue leased line and dialup modems. For higher bandwidth links, synchronous serial interfaces with devices requiring a common clock signal are normally used. These include RS422(EIA-530), V.35, G.703/E1, DSX-1/T1, X.11 and X.21. DSX-1 is a more commonly used interface in the Americas while G.703 is more commonly used in Europe and Africa. There are also a variety of other interfaces in use for connecting to PABXs and other voice switching exchanges.

The most common physical interfaces, or connectors in use are the DB50, DB25 and DB9 sockets, ISA bus, PCMCIA/PC-Card, RJ-11 and RJ-45.

## 2.10 Costs

The cost of a wireless system consists of three components: the capital costs, recurring costs and usage costs. Capital costs refer to the purchase price of the equipment, importation duties, installation costs, transportation costs, labour costs, etc. to set up the facility. Recurring charges often appear as service charges (\$/month) and occur only if an independent service provider is involved in the provision of telecommunication services. Usage costs depend on how much the system is used and are often specified in terms of time connected (\$/ minute or hour) or a traffic charge (\$/kilobyte or megabyte, but sometimes 'per message').

In private wireless networks, usage costs and recurring charges are usually non-existent except perhaps for an annual license fee for radio spectrum use, and of course depreciation of the equipment. If the wireless network is to be connected to the Internet there will be additional charges. In public networks which use wireless systems, there is usually a time-based usage charge and/or a flat-rate monthly service rental. For data, sometimes the service provider will substitute or add a traffic charge for the amount of data carried. This can either be for data transferred in either direction, or in one direction only, or for the committed bandwidth allocated to the circuit.

The time of day can affect communication costs in some public networks where service providers may reduce charges in off-peak periods to encourage use when traffic levels are normally low, such as outside office hours.

The period of the contract with the service provider can also have a big impact on charges, especially in the provision of satellite space segment. Many satellite operators drop their rates dramatically as the length of the contract increases, with commitments of up to 15 years often available.

### 3. WIRELESS COMMUNICATION SYSTEMS

#### 3.1 Mobile Voice Radios/Walkie talkies

The walkie-talkie includes Citizens Band (CB) radios and other two-way radio systems which are useful for teams of people who need to keep in voice contact while moving around. These systems operate in the UHF and VHF frequency bands, either as single or dual frequency systems. Single frequency systems are simplex in operation (cannot send and receive simultaneously). Sometimes "parrot repeaters" are also used to provide some form of store and forward type of messaging.

Dual frequency systems always involves repeaters. Mobiles and hand-helds transmit on one frequency and receive on another frequency. For wide ranging use of these systems, three types of stations are necessary: the hand-held portable radios for the users, base stations and repeaters. The number of repeaters needed depends on the topology of the area.

As the power supply in the case of a portable radio is not high (10 to 15W) and omni-directional antennas are used, the transmission range from such a radio is not more than about 3 km to 5 km. Within this distance users can communicate directly from each other.

A repeater is an automatic radio station that receives on a frequency and re-transmits the same signal on a different frequency. Repeaters are usually located on mountain tops, towers, skyscrapers, etc. because their main purpose is to provide a wide area coverage to the mobile stations. Repeaters mostly have a range of about 20 to 30 km, depending on location. The power supplied is much higher than for portable equipment and solar panels or generators are usually needed.

These radios usually operate in the VHF/UHF frequency range and as usage is independent of any third party, there are no operating costs except for the annual license fee from the regulator. In Mozambique the licensing costs are as follows:

- Portable (Handset): USD \$85.00/year
- Base, Mobile or Repeater: USD \$210.00/year
- Link: USD \$500.00/year

#### 3.2 HF Radio

HF frequencies bounce off the ionosphere, allowing them to travel around the globe, making it possible to communicate with virtually any part of the planet. Within the HF band, a particular radio frequency is chosen to obtain the range required. A general rule of thumb is that low frequencies from 4 -10 MHz are good for short range between 10 and 450 km. Medium frequencies between 8 and 12 MHz are better for medium range from 450-1200 km. Frequencies above 12 MHz are more suited for longer range links from 1200-3000 km during daylight hours.

The bandwidth of these systems is very low, partly because of problems with interference in these wavebands. Determination of the propagation characteristics of HF signals is complex and can be extremely difficult to predict. Time-of-day and sunspot activity are particularly important factors in the ability of the HF bands to support long distance communications and a good selection of frequencies, spread throughout the HF bands is critical to maintaining reliable communications.

The data transmission rates available on HF frequencies are only really useful for relatively small messages - equipment capable of 75-300 baud using the SITOR protocol has been available for many years but is now being overtaken by systems able to transmit up to 2 400 baud. However with these systems, the average achievable throughput observed is about 10Kb/minute. Transfer rates can also vary considerably, depending on the atmospheric conditions, and are also affected by distance and antenna design.

HF based systems are far more expensive than line of site systems, costing at least \$3000 for a basic 300 baud system and over \$6000 for a 2400 baud system. Very long distance (>1 000km) transmissions with the higher speed 2 400 baud systems are not yet very reliable. As a result many companies are still selling 300 baud systems and even these have a high cost. No costs are incurred while communicating data, but some service providers which provide an HF-radio to Internet gateway charge monthly and/or traffic charges. There will also be annual HF radio license fees.

Most of the HF systems have fax capability as well as data and voice facilities.





If the system will be used to provide email connectivity to the Internet it is necessary to use the same equipment that is used by the HF-to-Internet gateway providers. Much of the developments in this area for data networking have come from amateurs and the relief organisations. The International Federation of the Red Cross (IFRC), World Food Programme (WFP), UN Department of Humanitarian Affairs (DHA), VITA, HealthNet, Mission Aviation Fellowship (MAF) and Worldcom (a Dutch NGO) have all developed a variety of HF data networks to support their projects in Africa.

The most popular system in use is the Australian developed Codan 9002 which has been adopted by a number of agencies needing to communicate throughout the central African region. The Codan 9002 provides a close-to-standard Hayes-compatible modem command set to connect to remote units, which allows mainstream email software such as Pegasus Mail and cc:Mail to be used at each end of the link.

The system uses the Windows (3.1/NT/95) operating systems and is completely automatic, handling binary files as well as text, and also allows routing of messages and files through multiple Codan links. In addition it is able to conduct route failure recovery and re-route messages through an alternative working link when the primary one fails.

If the data usage per station is going to be quite low per day and 300baud is sufficient it may be feasible to use the Kenwood TRC-80 which would cut the price to about \$2 500. This could be used in conjunction with the more sophisticated Codan 9002 in a hub configuration.

IFRC has been focusing on longer distance communications from its field offices to its head office in Geneva and have found the Codan deficient for these purposes. In an evaluation of the Codan, IFRC's Field Support & Telecom Unit found it to work well on shorter paths where interference is lower, but that on longer distances where the signal is weaker, the Pactor system supplied by Schuemperlin AG provides superior throughput and is able to negotiate down to low speeds when link quality is poor.

Worldcom, has adopted a rather different approach and believes the solution it has identified offers some advantages over both the IFRC and BushNet/WFP/MAF systems. Worldcom says cc:Mail and other such products are not designed for the minimal bandwidth of HF radio communications where overheads must be reduced as much as possible. So purpose built software is required to optimise the use of the frequency. In addition, the Codan solution is based on a single hardware product, using its own proprietary protocol to communicate and Worldcom believes that a system which can operate with most standard HF radios and communicate with more than one protocol is necessary to ensure flexibility and maximise the use of existing radio equipment. As a result Worldcom has decided to use specially designed software that has been optimised for HF communications, rather than using traditional email software 'bolted' on to the radio. Called DTS (Digital Transmission System) it has been developed by EURAF which is based in Cotonou, Benin.

DTS can be used within a wide range of HF frequencies between 3 and 30 MHz and multiple frequencies can be assigned for use during day and night to ensure automatic link establishment. Distances depend on propagation and frequency, but Worldcom has established links from Bukavu in Zaire to DTS' email server in Benin, a distance of more than 4000 kilometres and there is also a UHF version of the product to provide short distance communications.

DTS uses standard POP and SMTP protocols to receive and send mail from the radio link to the Internet. The result of all this functionality is a high price - about \$4000 for the software package (recently negotiated down from \$8000 by UNHCR). Worldcom believes that if enough organisations adopt DTS it will be possible for it to obtain an OEM license which would reduce the price to about \$900 a copy.

In Africa there are four publicly accessible Internet gateways:

1. Euraf: <http://www.dtsdata.intnet.bj>
2. MAF: <http://www.maf.org>
3. BushNet: <http://www.bushnet.net>
4. Twiga: <http://www.twiga.com>.

BushNet is the most well known service in central, southern and east Africa. BushNet charges \$0.30/Kb of data transferred (in either direction) and \$100/month for 4 incoming connections per day and \$200/month for 8 connections/day. BushNet normally initiate the connection to optimise the use of their equipment, so for 'emergency' outgoing connections from the user, the data traffic charge is US\$0.60/kb. CyberTwiga is the most recent entrant on the market, charging a \$US600 set-up fee and a flat rate (irrespective of data traffic or time) of \$160/month. Antenna and mast costs can be quite high for HF systems. The price of a standard antenna is about \$400 and a 12 m telescopic mast will add another \$400.

When HF connections are being considered as a solution three factors need to be taken into consideration:

1. HF links are not 100% reliable, especially over distances longer than a few hundred kilometres, due to the variations in propagation characteristics caused by solar conditions, and can usually only be used during the day.
2. The volume of data that can be transferred is very restricted and scalability is limited.
3. HF gateways that charge for traffic means that costs are difficult to control, especially as the user often has no control over the reception of incoming email.

As a result HF solutions are best for special situations and it is likely that they will be superseded in the future by low-cost satellite based solutions (see below).

### 3.3 VHF and UHF Narrowband Packet Radio

Originally developed by amateur radio enthusiasts, packet radio has steadily grown in sophistication, bandwidth and popularity, and now offers a wide range of data services. VHF is the same frequency used for FM radio broadcasts, UHF is also one of the television broadcast bands. Line of sight or 35-50kms is the generally usable range but this can go higher if sufficient power amplification is used. In addition, a packet radio set-up can be used as a relay station, sometimes called a digipeater, which allows for greater range by stringing several packet stations together.

The frequencies in use start at 27MHz and extend upward to 300MHz. VHF is generally preferred over UHF because of the high absorption of UHF signals in high foliage areas. UHF will work in an acceptable manner in desert conditions. The most common frequencies in use are between 140-170MHz. As most of the radios are manufactured for the US 2-metre amateur radio band (144-148Mhz), performance is usually best in this waveband. So frequencies should be obtained in this range if possible, ideally just outside the local amateur band to avoid interference. In most parts of the world 144-146Mhz is the amateur band, so 146-148MHz is the most popular frequency range used for other purposes.

While most VHF/UHF transceivers are designed for voice communications, many can be used for data as well. The choice of transceiver model is very important if maximal speeds are to be obtained as it has been found that there are quite large variations in their capacity to maintain maximum bandwidth. The Kenwood 251-A (VHF) and 451-A (UHF) have been found to provide a consistently higher throughput than other models and manufacturers. For low speed data, most other VHF radios will work quite well, such as the Icom IC-2000.

To provide the interface between the transceiver and the computer, a 'radio-modem' is used, commonly called a TNC (Terminal Node Controller). The TNC automatically divides the message into packets, keys the transmitter, and then sends the packets. While receiving packets, the TNC decodes, checks for errors, and displays the received messages. A popular TNC for 9600 baud are Kantronics KPC-9612+ with 32k of RAM. For 1200 baud, the KPC-9612+ or KPC-3 (32k) would be acceptable. The connection to the TNC can be made either via the microphone connector or via the data connector on the rear panel. Prefabricated cables are available for many radios for the microphone connector approach.

While most amateurs currently use 1200 bps for local VHF and UHF packet, and 300 bps for longer distance with HF communication, higher speeds up to 56Kbps have been in use for some years.

Many packet stations use the AX.25 (Amateur X.25) protocol which was developed in the 1970's and based on the wired network protocol X.25. Because of the difference in the transport medium (radios vs. wires) and because of different addressing schemes, X.25 was modified to suit amateur radio's needs. AX.25 includes a digipeater field to allow other stations to automatically repeat packets to extend the range of transmitters.

AX.25 is considered the de-facto standard protocol for amateur radio use and is even recognised by many countries as a legal operation mode. Other formats including TCP/IP are also used in some cases. Often special packet radio protocols are encapsulated within AX.25 packet frames. This is done to insure

compliance with regulations requiring packet radio transmissions to be in the form of AX.25. However, details of AX.25 encapsulation rules vary from country to country.

The KA9Q NOS program (also called NET) is the most commonly used version of TCP/IP in packet radio. NOS was originally written for the PC compatible. However, NOS has been ported to many different computers such as the Amiga, Macintosh, Unix, and others.

A TNC unit costs only about \$300, and an entire station, including the computer, costs between \$4,000 and \$10,000 plus installation and training.

The Centre for Policy Research on Science and Technology and the Telematics Lab, Simon Fraser University, the Canadian Communications Research Centre with the Ottawa amateur radio group have been engaged in a number of projects focusing on packet radio. They have both developed prototypes which incorporate a modem operating at 56 Kbps with a capability to upgrade to a point-to-point system running at 1.5 Mbps and upwardly compatible systems as higher speed capabilities are reached. The equipment uses the TCP/IP protocols and can provide a link between stations over 100 Km apart and support point-to-point as well as point-multi-point paths, and can be used while mobile.

Designed for low cost and flexibility, the costs per station (including Linux server for routing) is about \$1400. A newer version is expected to lower costs even more and the 1.5Mbps versions will be in the same price range. Aside from design considerations, all of the main electronics are off-the-shelf components which could be assembled virtually anywhere.

Nevertheless, there are a number of barriers to extend the use of UHF/VHF narrow-band packet radio beyond the amateur field. The frequencies are notoriously subject to interference and propagation variations, making them less practical for unsophisticated users. There are also regulatory difficulties - to operate at 56Kbps and above, a broad section of radio spectrum is required (85KHz is common) and it can be very difficult to convince the regulator that such a broad slot is required, especially as the VHF & UHF bands are normally broken into 12.5KHz wide channels. Also, the commercial VHF & UHF bands are highly populated with paging, cellular phones and other applications. Amateurs don't have this problem because large segments of the VHF & UHF bands are reserved for their use.

Finally, a large barrier to using packet radio systems is the knowledge and effort required to establish the initial infrastructure. With no packaged solutions available, experience is needed to assemble the equipment, properly site antennas, test radio link performance, install networking software etc. It may also be necessary to disassemble and modify the radio for data transmission. However operating a packet station is usually transparent to the end user, to whom the network will simply appear as a slow LAN connection.

### 3.4 Satellite Services

Satellites orbiting at about 36 000 kilometres above the earth can remain stationary with respect to its surface and have provided the backbone for international telecommunications for decades, using large satellite antennas and high frequency focused spot beams. Because of the high costs and delays in transmission which are noticeable in telephone conversations as the signal travels the 72 000 km round trip, the use of satellites for voice communications has decreased where international and transcontinental fibre optic links have become available. While many countries have established international fibre-optic links, virtually every PTO still operates a large satellite ground-station for international voice communications.

Some countries, such as Mozambique and Gabon, which have a limited domestic terrestrial telecommunication infrastructure also use geostationary satellites to provide links for their secondary cities. As costs of equipment and satellite bandwidth has decreased with the use of advanced techniques such as Demand Assigned Multiple Access (DAMA) and Time Division Multiple Access (TDMA), it is now possible to service much smaller towns and villages with largely the same technology.

World-wide, the most popular application of domestic and international satellites is video communications, mainly involving programming for television broadcasters, but also for distance learning and teleconferencing. Until recently this traffic was all routed via large terrestrial transceivers located in urban centres, beyond the reach of all except those who could afford large TVROs, which still left the bulk of the rural population out of reach. But the advent of Direct to Home (DTH) satellite TV broadcasting is now taking place on a wide scale following the launch of

satellites capable of transmitting a more powerful signal and the development of ever more sensitive reception equipment. A world-wide DTH satellite audio broadcasting service for a new digital hand-held radio will be launched this year by WorldSpace.

For two-way traffic, the cost of equipment capable of transmission to the satellite has in the past put this technology beyond the reach of all but the national PTOs and other large organisations with sufficient volumes of traffic to justify the cost. More recently, new innovations in antenna design and digital coding techniques have resulted, hub-based systems using high powered satellites and shared 'mother ground stations' have reduced the size and cost of the equipment required at one end of the link, resulting in the growing popularity of these Very Small Aperture Terminal (VSAT) based systems, even for low traffic applications such as connecting an individual branch of a bank in a small town to its head office. These star topology systems contrast with the alternative mesh topology where larger antennae are used at every station, increasing the cost, but allowing direct peer-to-peer communication without the necessity to go through the hub.

A telecommunications satellite is equipped with a number of radio transceivers usually known as 'transponders'. The greater the number of transponders the greater the bandwidth available on the satellite, which is usually between 36 MHz and 54 MHz. The orientation of different transponders on the satellite determines 'footprint' pattern on the earth in which the satellite can provide a usable service. Some transponder beams can be focused more tightly, which decreases the area of the footprint but results in reducing the power and antenna size requirements on the ground. There are four types of transponder 'beams' responsible for the size of the footprint - the 'global beam' which covers 40% of the earth's surface, the 'hemispheric' beam covering 20%, the 'zone' beam which covers about 10% and the 'spot' beam which covers less than 10%.

Footprints do not have precise borders but exhibit a gradual loss in signal strength from the centre to the periphery of the footprint where larger antennae and higher powered equipment are required. It is not necessary for the hub and remote terminals to be in the same footprint - traffic can be switched through from one transponder aimed at one region, to another aimed at a different region.

Spot and zone beams usually transmit in the KU band (11-14 GHz) which allow antennae to be as small 90cm in diameter. Receive-only KU band systems can cost less than \$500, even for digital (DSTV) services. Commonly used private units which are capable of transmission as well currently cost about \$10 000 - \$15 000, but prices are rapidly coming down. The wider global and hemispheric beams usually transmit in the C-Band (4-7 GHz) and require antennae between 1.8m and 10m in size. A 2.7m C-Band send/receive unit usually starts at about \$10 000. Hughes Network Systems (HNS) dominates the market for C-band equipment with about 70% of the installed base.

The wavebands between 20 and 30GHz are now being proposed for a number of 'broadband' satellite transmission systems. Seven systems proposing global coverage and seven systems proposing regional coverage were submitted to the regulatory bodies last year. These systems will have bandwidth and channel capacities far in excess of any systems currently in orbit. For instance, the capacity of the AT&T and Hughes systems are 100,000 simultaneous 384 Kbps circuits which can support roughly 2.4 million phone calls. Such capacity will permit interactive multi-channel video, video phone service, broadband computer connectivity and other services.

#### Broadband Satellite proposals:

Applicant	# of Sats.	Cost	System Capacity
AT&T (VoiceSpan)	12	confidential	100,000 386 Kbps channels
Lockheed Martin Astrolink	9	\$3.75 billion	90,000 386 Kbps channels
GE American (GE*Star)	9	confidential	not provided
Motorola (Millennium)	4	\$2.3 billion	1 million 16 Kbps channels
Hughes Spaceway/Galaxy	17	\$6.2 billion	100,000 384 Kbps channels/2.4 million phone calls
Morningstar	4	\$847 million	600 compressed video channels
Teledesic	840	\$9 billion	2 million phone calls
SS/Loral (Cyberstar)	3	\$1.05 billion	6.75 GHz of effective bandwidth
Echostar	2	\$340 million	not provided
KaStar	2	\$645 million	12 GHz of effective bandwidth
NetSat 28	1	\$250 million	500,000 1.544 Mbps channels
Orion F-7, 8, 9	3	\$757 million	not provided
PanAmSat 10, 11	2	\$409 million	not provided
VisionStar	1	\$207.5 million	100 video channels

End users will access these systems over small ground terminals similar to the inexpensive 33 to 100cm dishes currently used to receive DTH signals.

VSATs are subject to interference from hydro-meteors, especially in the KU band where rain-water droplets are similar in size to the wavelength, resulting in regular disruptions of service during storms. As a result C-Band is the preferred band for most data communications requiring reliability in tropical conditions. The C-Band is very close to the frequencies used by some terrestrial microwave systems which can cause problems when such equipment is sited in close proximity.

Transponders can be leased in full or in part from the owner of a satellite system, or from a reseller who has leased a large number of transponders at wholesale rates. Because of the long lead times required in planning for capacity, satellite operators usually offer considerable discounts for long term contracts. Also, the power requirements for the satellite to deliver a signal to larger more sensitive earth-stations can be much lower, so tariffs for circuits can vary by up to 500% depending on the type of antenna used and the bandwidth required. For example, a 256Kbps Internet circuit on PanAmSat's PAS-3 using a 2.4m dish will cost about \$15 000/month for the end user, while using a 3.7m dish will drop the price to \$9 000 a month.

There are two channels to be leased: the out-route - a channel from a ground-station hub to the satellite - and the in-route - a channel from a satellite terminal (VSAT) to a satellite. The bandwidth of these two channels does not need to be the same, which is a particularly valuable facility for Internet traffic which is usually asymmetric - there is usually substantially more traffic coming in from the rest of the Internet than going out.

In VSAT systems, the hub ground-station is usually responsible for management of the network, monitoring terminals, assigning channels and routing. It would normally have a very large antenna (up to 20m although 10m is more common) and the entire set-up usually costs about \$1 million to build, but can cost as much as \$10 million for high capacity systems with redundancy capacity and intelligent switching.

In the past, the protocols used in communication between the hub and the VSATs were proprietary, resulting in the need to purchase equipment for both ends of the link from the same supplier. As a result the VSAT equipment supplier has been known to donate the ground-station hub in the expectation of increased sales of terminals that would be able to connect to it. This has happened in Egypt where both NEC and Hughes have built ground-station hubs for the Government. However many different hubs and VSATs are now being developed which use the International Business Systems (IBS) standard which allows equipment from different suppliers to inter-operate.

In most cases it is not necessary to build a hub to establish a VSAT network - existing hubs in foreign countries can be used. Aside from various hubs in North America and most European countries and in South Africa, Egypt, Gabon, Gambia and Ghana already have such facilities. However, to provide a viable solution for connecting to the Internet, the hub must have access to a local low-latency high-bandwidth Internet service which currently eliminates most of the African hubs, except for those in South Africa and Egypt. Many hubs usually have a maximum up-link capacity of 512K while some equipment, such as those manufactured by STM Wireless, can allocate channels of up to 8Mbps and Intelsat has recently launched a 155Mbps service.

The three main components of a satellite ground-station are the parabolic antenna (or dish), the outdoor unit and the indoor unit. The dish and the outdoor unit perform the transmission and reception of the signal, and the indoor unit provides the interface with the users' equipment and does the digital conversion to a suitable radio signal.

VSAT terminals are versatile units, such as the Hughes Network Systems' Personal Earth Station (PES) which can be configured with most common data interfaces including RS232, X.21, V.35 and G 703 as well as 10-Base-T Ethernet sockets. Additional cards can usually be added to provide more channels when needed and most VSATs can carry multiple voice and data channels at the same time.

VSAT units are typically installed by trained technicians (in less than a day, barring unforeseen problems) but the skills are not hard to acquire and simply require a compass and GPS unit to orient the antennae and a db voltmeter to fine-tune the system.

The two most common protocols in use between the ground-station and the satellite are Time Division Multiple Access (TDMA) and Single Channel Per Carrier (SCPC). TDMA based networks are very cost effective but not particularly suited to Internet traffic - it is a statistical multiplexing demand contention based system where the assigned bandwidth of the hub is shared between all of the VSATs resulting in reduced throughput when all of the ground-stations are creating traffic. In addition, added to the double satellite hop delay when communicating between VSATs (traffic must go via the hub) there are further delays caused by the connection set-up time required and in the overheads in conversing with the network management system (NMS). This can result in minimum delays of 2 seconds and often as much as 4 seconds.

SCPC based networks offer guaranteed bandwidth and are similar to a terrestrial leased line arrangement. Circuits of up to 8Mps and even more can be provided, but 2Mbps is the most common upper limit of standard VSAT equipment. SCPC Demand Assigned Multiple Access (DAMA) is a relatively new service which allows the user to specify the bandwidth required as it is needed.

Shared/TDMA systems do however allow the satellite space segment to be efficiently shared amongst a number of users. So in situations where a number of different locations must be connected and bandwidth requirements are relatively low, at least initially, this architecture is an attractive alternative to HF radio for remote areas, especially with the cost of equipment dropping so rapidly.

If the application is for an Internet service then there can be some limitations on bandwidth imposed by the "lossless" design of the TCP/IP protocol if satellite connectivity is not taken into account. Since a data packet may be lost in transmission, a copy is kept in a buffer on the sending computer until receipt of an acknowledgement from the computer at the other end that the packet has arrived successfully. As the data packet's trip over a geostationary connection takes at least 250 milliseconds, and the acknowledgement packet takes another 250 milliseconds to return, the copy of the data packet cannot be removed from the buffer for at least 500 milliseconds. Since the buffer can only hold a limited number of packets, no new packets can be transmitted until old ones are removed when their acknowledgements are received. The default buffer size in the standard implementation of TCP/IP is 32Kb and this means that at any given moment, only 32Kb can be in transit and awaiting acknowledgement. As a result, irrespective of the channel capacity it still takes at least a half a second for any 32Kb to be acknowledged. So, the maximum data throughput rate is 32Kb per half second - 64Kbps - unless modifications to the defaults of the TCP/IP protocol implemented in the equipment used are made.

Another aspect related to the provision of Internet services in developing countries is the lack of shared facilities, which means that each user is required to lease the whole path to the Internet backbone. Ideally there should be an Internet router on the satellite itself, which would allow the lease of a single high capacity up-link which could then be shared amongst all the ISPs on the down-link. This is not currently available, but the same principle can be applied to the ground-station hub. If a high bandwidth Internet link to a hub is made available, then costs can be substantially reduced because each customer no longer has to lease independent circuits from the hub to the nearest ISP. A number of service providers covered in the following chapter provide this service. There are also some more advanced facilities coming onto the market such as Tachyon which are designed specifically for Internet connectivity and are expected to drop the cost of Internet bandwidth very dramatically.

In remote areas the concept of a shared facility could be extended further. Because a VSAT can carry a number of different data or voice channels, it is possible to spread the capital and operating costs over voice telephone, television and radio services, as well as the Internet service. The television and radio services would require some additional re-broadcasting equipment at the VSAT end, and the ground-station hub would need to have access to the required television and radio services.

Because of the inherent advantages of VSAT for broadcasting data, many satellite service providers are now promoting the use of broadcasting protocols such as DVB and MPEG for delivering service to many sites at the same time. The cost of video conferencing is expected to substantially reduce by the increased use of these systems.

Intelsat and PanAmSat are the dominant satellite operators in Africa, but Russian satellites with African coverage are now also available from Intersputnik with very low prices for large quantities of

bandwidth. However many are ageing and have developed wobble and inclined orbits, requiring larger antennae and more sophisticated tracking equipment to operate. Eutelsat has provided coverage in North Africa for some years and it now has plans to direct one of its steerable transponders over the rest of Africa. Gulsat, has some coverage over Africa, in the Horn and as far south as Tanzania.

There are an increasing number of telecommunication and broadcasting satellites being launched by developing countries, such as Brazil, China, India and Indonesia. The first African satellite was launched by the Egyptian Radio and Television Union of the Ministry of Information, with coverage in North Africa, Southern Europe and the Gulf states. Finally, RASCOM, the intergovernmental agency set up by the African PTOs to establish Africa-wide satellite coverage, is still planning to launch a satellite shortly.

Aside from these fixed ground-station services, mobile services, or at least 'transportable' services have been available for many years through Inmarsat's family of geostationary satellites. The voice, data and fax services require specially designed terminals, and there is a range of service levels, ranging from 64Kbps to simple voice and /or 2.4Kbps data, or even less, where the application is remote sensing, such as in vehicle monitoring. If dialup data connections are planned with Inmarsat, it is important to try to avoid a double satellite hop to the remote server, as this causes much impaired throughput and unreliable modem handshaking. Depending on location, it is possible to choose different down-link destinations and so the one with an ISP closest to the remote ground-station should be chosen. It may even be necessary to establish a new Internet service account with that provider for the purpose of the Inmarsat link.

Small satellites which rapidly circle the earth in polar or inclined orbits at lower altitudes than geostationary satellites are rapidly gaining popularity in providing wireless access solutions world-wide. In Africa, radio connections to low earth orbiting satellites (LEOs) have been in use for a number of years by organisations such as VITA and Satellite. The low altitude of the orbit - 780 km - of the micro-satellites (which are essentially solar powered PCs with a transceiver) makes it possible to use a small transmitter and lightweight tracking aerial to connect with the satellite when overhead. Also, the propagation delay to these satellites is much smaller than to a geostationary satellite - about 12 msec vs. 0.25 sec.

Many countries, even small ones such as Portugal, as well as associations of amateurs have launched LEOs, for a variety of remote sensing, research and experimental purposes. Many of them can be used by third parties, once the appropriate agreements have been made.

Acting as a store-and-forward host, messages are held on the satellite for download when the satellite passes over the recipient's location, or where there is a gateway on the ground-station to the Internet. The storage capacity and bandwidth of these systems is not high (9.6K for a maximum of 20-40 minutes a day when the satellite is in view) but the increased cost of the radio equipment can be justified where there is no telephonic link to the outside world.

Because the satellites are relatively low altitude and employ relatively sophisticated modulation and coding techniques, the connections to ground stations are strong and virtually error-free, despite the comparatively low effective radiated power.

Recently, constellations of satellites have been proposed to provide voice and data communications to fixed and mobile users world-wide. These systems are divided into "Little LEOs" and "Big LEOs and MEOs" (medium earth orbit). These will offer real time mobile voice communication systems from hand held telephones which will probably be useful for travellers in isolated areas, but the cost of these services is likely to be high - \$3 /min and the density will be fairly low - a few million subscribers. The "little LEOs," such as OrbComm, are the satellite equivalent of paging. Operating below 1 GHz, they will provide simple store-and-forward messaging similar to the VITA and HealthNet systems.

Iridium aims at the high purchase capacity travellers market, and has designed a system which will provide links between satellites to forward traffic to the appropriate satellite for down-linking to the customer. Globalstar's target is the complementary market near the big cities. It foresees that 90% of the whole market will be in the vicinity of such big centres. A Brazilian project - ECO-8, aims to place various satellites in the same equatorial orbit, to guarantee that there is always one satellite visible by a user in the equatorial belt covered. The initial configuration foresees eight satellites plus two for backup placed at an altitude of 2000 km of altitude. The coverage encompasses most of the

Brazilian territory and parts of Australia, Africa and India, among others. The orbit altitude is sufficiently low to permit the use of portable communications terminals.

Inmarsat's recently formed subsidiary, ICO, is the most advanced MEO project with its plans to launch 12 satellites orbiting at 10 335km above the earth. Being a subsidiary of Inmarsat, ICOs indirect investors include all of the national Signatory investors of Inmarsat and then a number of direct investors, which in Africa include Telkom SA (the South African PTT), ARENTO (the Egyptian PTT), Nigerian Telecommunications Limited, Sonatel (the Senegalese PTT), and the Liberian Bureau of Maritime Affairs. Full service is expected to be operational by the year 2000.

While still under debate, Teledesic's LEO proposal referred to earlier, is the first "broadband LEO" and may offer the most potential for increasing connectivity in Africa. Teledesic argues that in the absence of high levels of economic development, many developing countries such as those in Africa are unlikely to attract the investment required for an advanced information infrastructure, but that systems like Teledesic could help developing countries overcome this "chicken and egg" problem in telecommunications development.

In a recent presentation, Teledesic's Daniel Kohn states: "Once you come out of a geostationary orbit, then by definition, satellites move in relation to Earth. With an NGSO system, continuous coverage of any point requires, in effect, global coverage. In order to provide service to the advanced markets, the same quality and quantity of capacity has to be provided to the developing markets, including those areas to which no one would provide that kind of capacity for its own sake. In this sense, NGSO satellite systems represent an inherently egalitarian technology that promises to radically transform the economics of telecommunications infrastructure. It is a form of cross-subsidy from the advanced markets to the developing world, but one that does not have to be enforced by regulation but rather is inherent in the technology."

Teledesic plans to launch hundreds of satellites starting in 1998 which will be capable of carrying high bandwidth services directly to the end user. To date, Teledesic has received most of its funding from Bill Gates--the founder of Microsoft and Craig McCaw--who founded McCaw Cellular, the world's largest cellular communications service provider before its sale to AT&T in 1994.

The concept of a network consisting of hundreds of satellites appears a radical concept when compared to traditional geostationary satellites but it is less radical when compared with the evolution of networks on the ground. Computer networks have evolved from centralised systems built around a single mainframe computer to distributed networks of interconnected PCs. Similarly, satellite networks (for switched network connections) are evolving from centralised systems built around a single geostationary satellite to distributed networks of interconnected LEO satellites. The evolution in both cases is being driven by some of the same forces.

Also, because a LEO satellite has a smaller footprint within which frequencies can be re-used, it is inherently more efficient in its use of spectrum resources. Geostationary satellites will continue to have an important role to play, particularly for broadcast applications where their large footprint is advantageous. But increasingly, geostationary satellites are expected to co-exist with NGSO satellite networks.

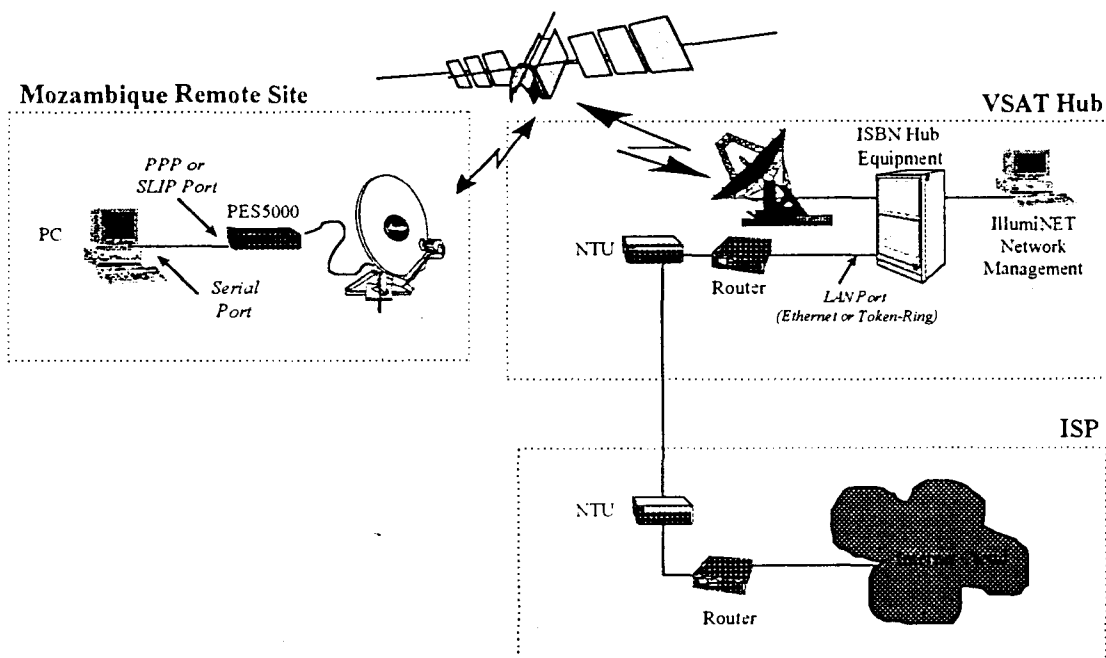
The real concern is how developing nations will license and regulate LEO satellite operations and wireless technologies in general. Liberalising the regulatory apparatus will probably require willingness to consider the advantages addressed by these new technologies.



Summary Table of LEO/MEO Satellite Projects

<u>Name</u>	<u>Type of system</u>	<u>No. of satellites</u>	<u>Type of service</u>	<u>Launch date for services</u>
OrbComm	Little LEO	28	Data	mid 97
E-Sat	Little LEO	6	Data	1997
FAISAT Final Analysis	Little LEO	26	Data, voice paging	1997
VitaSat	Little LEO	2	Data	1997
Koskon (Polyot)	Big LEO	32	Voice, data, paging	1997
Globalstar	Big LEO	48	Voice, data, paging	1998
Iridium	Big LEO	66	Voice, data, paging	1998
GE Starsys	Little LEO	24	Data, messaging	1998
GEMnet	Little LEO	38	Data	1999
LEO One USA	Little LEO	48	Data	1999
ECCO	Big LEO	46	Voice, data, fax	2000
ICO Global	MEO	10	voice, data, fax	2000
Ellipso	LEO/MEO	17	Voice, data, paging, email	2000
Odyssey	Big LEO	12	Data, voice, fax, short message	2000
Teledesic	Broadband LEO	288	Voice, data, video, broadband services	2001

Example of a proposed VSAT network.



### 3.5 Stratospheric Telecommunication Services

Stratospheric telecommunication services are a new wireless communications innovation where lighter-than-air structures are stationed 20-25kms above large cities. Housing a specially tailored set of wireless services for the particular market, these platforms will have a 1000-20 000 square km footprints and will be able to provide 2-10Mbps connections. The altitude is expected to provide better line-of-site conditions than terrestrial services, better latency than satellite services and will minimise the impact of weather on equipment maintenance requirements. The major contenders in this area are SkyStation and Halo, but services have yet to be launched.

### 3.6 Wideband, Spread Spectrum and Wireless LAN/MANs

There are probably over 100 different manufacturers of products in this category. Most of them use spread spectrum technology in the 900Mhz, 2.4Ghz and 5.7GHz bands but others use narrow-band techniques, especially in the 5.7Ghz bands. Most of the products are geared toward providing connectivity between PCs within a large office or "wireless LAN" (WLAN) and have a range of only a few hundred metres. With suitable antennae and in some cases the use of external power amplifiers, they are also able to provide line-of-site links at distances varying from 2-3 kilometres to over 70kms. There are a wide range of data rates available, from 19.2Kbps to over 10Mbps.

Spread spectrum techniques are popular because they minimise the effect of interference by transmitting a signal successively on dozens (or even hundreds) of different frequencies, overcoming distortion by virtue of their wide bandwidth, which provides "frequency diversity". Spread spectrum technology was originally developed for use by U.S. military to overcome problems of intentional interference from hostile jamming and to reduce the possibility for unauthorised monitoring. The US de-classified spread spectrum technology in the mid-1980s and today it is used in wireless ethernet links, cordless telephones, digital cellular telephony (CDMA) and global positioning services (GPS).

The term "spread spectrum" arose from the characteristic broad spectral shape of the transmitted signal. The spreading techniques normally used can be divided into two families: Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS). DSSS is commonly accepted as a superior protocol in in high-bandwidth applications.

The frequency band used is actually much wider than the minimum bandwidth needed to transmit the data. In this respect these systems are not particularly efficient in their use of spectrum, but they excel under 'noisy' conditions, and when there are other users that occupy the same frequency. With the signal being "spread" over a large bandwidth, they can coexist with narrow-band signals, only adding a small increase to the interference endured by the narrow-band receivers. However a number of common appliances such as microwave ovens cause interference in these bands which can result in the need for higher cost equipment where this is a problem. Ironically the high density of electronic equipment in cities in developed countries makes this problem much more severe than in the developing world.

One of the reasons for the popularity of many of the WLAN products is that in most countries they can be used without the need for a radio license as long as they do not cross public roads, in which case a license must usually be sought. In order to qualify for license exemption, however, they must meet various requirements with regard to power output, antenna gain which results in greater potential for interference from other users of the same radio spectrum than is the case with the licensed narrow-band systems, since the license carries with it some degree of exclusivity in the frequency allocation.

The present situation in most of Europe and Africa is that ISM bands need no license with ETSI (European Telecommunications Standards Institute) certified equipment. According to the ETSI standard, the effective radiated power from the antenna must not exceed 100mW which effectively limits the distance to a few hundred metres without amplification. The 902-928MHz band generally is not permitted, because 890-915MHz band in Europe and Africa has been allocated for GSM mobile telephony.

However in some cases it is possible to obtain a secondary license for use of the desired frequency with a stipulation that it will not interfere with the primary license holder's transmissions. An example of this situation is in Latvia, where LATNET has a secondary license for 902-928MHz band, while primary license for 890-915MHz band belongs to the GSM operator. Practice shows that low power spread spectrum wireless LAN adapters at 902-928MHz band do not interfere with GSM.

Nevertheless, spread spectrum systems have a number of issues attached to them that should be borne in mind before using them. They are not particularly efficient in use of the available spectrum, contributing to

the general level of radio frequency 'noise' in the area that may cause interference to other devices. High densities of the same devices in any one area may reduce their performance significantly. Also, governments in some countries may not be keen on these technologies because of the designed-in difficulty of monitoring the contents of the transmissions.

The short-distance WLAN products have not yet seen much use in developing countries because of the overarching requirements for improved telecommunication infrastructure and the small number of LANs, but these products are still of special interest in developing countries. In particular the mobility allowed by these systems means that LAN or WAN connected computers are much easier to share. In schools or other large organisations with few computers, they can be wheeled to different classes or offices where needed. Also, LANs can be scaled up more simply and cheaply because it is not necessary to wire for a big network ahead of time, or to continually re-cable as the network expands. This is an especially important factor in a campus environment where a number of buildings may need to be linked together. In addition, wireless LANs can be rolled out very quickly, which means that the costs of installation are much lower, especially if an expensive team of technicians would normally be hired to install the LAN and cabling.

In a manufacturing, warehousing and wholesaling environment, spread spectrum techniques are also being increasingly used to provide connectivity to handheld and embedded devices such as cash registers and bar-code clients for inputting and accessing operational data in real-time. These devices are linked to a central server to carry out inventory collection, order fulfilment and shipment applications. This can increase efficiency and reduce errors substantially because purchase orders can be directly linked with inventory records, cutting out the need to transfer information through paper forms. Laying cable in this environment is usually not feasible because of the need for mobility and the cost of cabling such large areas.

As with the narrow-band packet radio systems described above, a wireless LAN (WLAN) unit consists of a PC interface, modem, radio hardware, antenna and possibly amplifier. However, these functions tend to be more tightly integrated, and in some cases, the entire unit, including antenna, is on a PCMCIA card. These provide very short range and are intended for use within buildings, but can still be attached to more elaborate antennae and amplifiers. The Lucent WaveLAN product is an example, and is probably one of the cheapest options for linking two PCs - a couple of cards and antennae can be put together for less than \$1000. There are other WLAN products which are designed to be used over longer distances with directional antennas to span distances of a few kilometres or more if good line-of-sight paths exist.

Prices span a wide range, from about \$1000 for a PC card solution (not counting the cost of the PCs housing them) to at least \$5000 for a standalone system intended for long-range wireless bridge applications. However, there are a variety of interesting products in the \$2000-\$4000 range which offer 1-2 Mbps data rates over a few kilometres and the investment of another \$2000 - \$3000 can stretch the stretch the distance to the maximum line of site available. Often a more expensive hub unit is purchased to provide access to many users in a point-to-multipoint arrangement.

Lucent Technologies' WaveLAN product is one of the most popular products and has seen use in a number of African countries such as Mozambique, Tanzania, Uganda and South Africa. A large number of companies are integrate the WaveLAN products in 'packaged' wireless bridges and shared access points with appropriate antennae. The companies providing these solutions include Camalex (Asia), Cabletron, CIDS, C-SPEC, Digital Equipment's RoamAbout, KariNet, SolecTek (Americas), ASK Communications, and Rupex (Europe).

If there is a limited budget and only a point-to-point link required, it is quite possible to just purchase the WLAN cards and use a couple of old 386 or 486 machines running Linux or BSD Unix as bridges or access points. However a technician will likely be needed to install and configure the networking software on the PCs.

It is also fairly easy for the end user to install the packaged products if the distance is only going to be a few kilometres, and the antenna can be sited next to the RF unit. However if the links are to be over longer distances, then it may be necessary to engage the services of an experienced radio technician to design, install and troubleshoot the link and antenna system.

The IEEE recently passed the 802.11 standard, which theoretically allows interoperability between different spread-spectrum wireless products. Although most manufacturers are still ironing out the bugs in the implementation of the standard in their products, most new equipment from the major vendors such as Lucent and BreezeCom conform to 802.11 and systems that do not conform should be avoided. However, the standard does not guarantee compatibility or even interoperability between different products and many wireless systems may produce higher throughput or have more management features when using the company's own proprietary protocols, instead of the standard.

One particularly interesting example of this is Rooftop's Spirit Radio product which allows a community of users to establish a web of interconnected access points. The system allows users to treat each other as repeaters to find the best route to the Internet or to another local user, encouraging the network to grow, in almost the same organic fashion that the Internet itself has grown.

### 3.7 Optic Systems

In situations where there are very high levels of radio interference, or very high bandwidth requirements, optic systems in the Infrared band using LED and LASER technology can provide 155Mbps links over limited distance - usually up to about 2kms maximum. A particular advantage of these systems is that their use is usually license-free because the optical frequencies are generally unregulated world-wide, although there may be the usual PTO monopoly restrictions. These systems are virtually immune to radio interference but humidity, especially mist or fog, as well as other solid obstructions can limit the use of these systems.

Two of the companies supplying this market are Israel-based Jolt, and Cablefree.

### 3.8 Electric Power grid transmission

While not strictly a wireless technology, systems that use the electric power network infrastructure to transmit data are briefly mentioned here for the sake of completeness because they can now provide another alternative to traditional cable telecom networks.

Baby monitors which use the wiring in a home to link a microphone in an infant's room to a remote loud-speaker at some other location in the house have been in existence for decades. Some people even found that they would work in the neighbour's house too. It is this principle that has been used to provide new data transmission facilities via the electric power network. The technology has been demonstrated for some years now, especially in eastern Europe for linking PCs for office local area networks. A small adapter is plugged into the nearest power socket and this is in turn plugged into the PC via standard LAN networking cable (10-BaseT). Now Nortel has developed what it calls Digital Powerline as a system that can be implemented more broadly by electric power infrastructure operators wishing to sell data services.

Within a substation it is actually possible to act independently of the power company and provide connectivity to everyone connected to the substation. For full Internet connectivity this would require bringing in one broadband connection via a more traditional means such as a leased line from the PTO, or a wireless connection. If the power operator wishes to supply the upstream connectivity to the Internet then it needs to link the substations to a hub via the special bridges.

### 3.9 Data Broadcasting

In many Internet applications large quantities of data are received by the user but little data is sent. In addition, many different users receive exactly the same data through newsgroups, mailing lists and file mirrors. This opens up the possibility for using traditional broadcasting infrastructures for broadcasting of data, commonly called datacasting. Existing radio and television broadcasts can carry substantial amounts of data encoded in their transmissions and in the excess capacity on many broadcast satellite transponders. Users require additional equipment to receive these broadcasts and they use the normal connection via telephone to send their data.

Services providing datacasting of the Internet are already available in the US, Europe and Asia. These include CleverCast, DirecPC, InfoSat, Kingston Satellite Systems, PageSat, CleverCast and WebTV).

While establishing a dedicated datacasting channel will provide the most bandwidth, the possibility also exists to encode data inside existing satellite and terrestrial television and radio broadcasts. The most well known application of this technique is to use the vertical blanking interval (VBI) in existing television broadcasts to carry the data. Teletext services are an unsophisticated application of this technology which

has since advanced substantially. Philips and Olivetti have both developed systems which are capable of 30-60Kbps transmissions over the VBI which can be security encoded for the individual user.

To establish a VBI datacast, the information provider installs the data broadcast software on the server which schedules when which files should be broadcast and translates the content into a format suitable for insertion in the TV signal. A teletext-inserter combines the content with the TV signal and the new signal is broadcast as normal. The user requires a decoder to separate the information packets from the TV signal. The Philips data broadcast decoder is a set-top box or a PC add-on board.

Intel has also released a similar system it calls Intericast. Based on the growing popularity of TV tuner cards for the PC, the software allows television programmers to include web pages in the VBI with their broadcasts, which are then browseable with the user's standard web browser.

In radio broadcasts, the same principles apply except that the side-band on the carrier signal is used instead of the VBI. An example is USA Digital Radio's In-Band On-Channel (IBOC) which uses current AM and FM spectrum and station assignments to transmit analogue and digital signals. It also has a hybrid mode providing simulcast digital/analogue on same channel. The peak data rates are 48 Kbps for FM and 1.2 Kbps for AM.

Shortly, when terrestrial and satellite-based Digital Audio Broadcasting (DAB) becomes widespread, such as through WorldSpace's plans to launch a satellite this year to broadcast 18 digital radio channels to Africa, further opportunities for datacasting will become available.

### 3.10 Gateways and Hybrid Systems

Gateways and hybrid systems make use of two or more different communications technologies to bridge between different types of communication networks.

#### 3.10.1.1 HF<->UHF/VHF long/short distance links

An HF link operating over many hundreds of kilometres carries data for users who are linked over line-of-sight to the remote hub by short distance VHF/UHF transmitters. These systems are in use in central Africa by MAF and BushNet using Codan equipment.

#### 3.10.1.2 VSAT satellite<->Line-of-sight wireless links

These offer similar functionality to the above but with higher bandwidth (and higher cost). A VSAT link is used to bring in the long distance connection which is then redistributed locally over line-of-sight wireless links which may be VHF/UHF systems but with the higher bandwidth available, could be spread-spectrum broadband links.

#### 3.10.1.3 HF<->PSTN links

Codan and other HF radio equipment can be equipped with a connection to the public telephone network for making voice calls to anyone with a normal telephone.

#### 3.10.1.4 Direct to Home (DTH) satellite broadcast <-> Terrestrial Internet link

Satellite broadcast services such as DirecPC deliver incoming traffic over the standard TVRO satellite dish (costing about \$1 000) while outgoing traffic travels over a normal terrestrial line (either a dialup telephone connection for personal use, or over a leased line for ISPs and corporate users). Service providers in Africa include Interpacket and InfoSat.

### 3.11 WLL and Cellular Telephony Systems

Wireless Local Loop (WLL) systems replace the copper wire between a local exchange and the subscriber premises. They are becoming extremely popular for rolling out new public telecommunication infrastructure in developing countries, and are even being considered in developed regions. For telecom operators, infrastructure investments in the local loop represent a very large percentage of their costs (typically around 50%), due to the labour-intensive civil-engineering work involved and frequent time consuming requirements to obtain rights-of-way. Wireless systems are easily distributed over large areas using a network of strategically located base-stations whose capacity is shared by the users as they need it. It is unnecessary identify in advance the location and numbers of all the potential subscribers and as demand grows it is very easy to add more capacity to the base stations and add more stations where needed. With the use of these systems the average cost of installing a new fixed line is being reduced

handsets have a built in RS-232 serial port and do not require a PCMCIA card, simply plugging directly into the serial port of the computer. Costs vary, but usually between \$200 and \$500.

- A cellular phone handset with data capability.
- Applications software (which often is packaged with the data card). Most of the PC cards emulate a standard serial port, and so on most operating systems (UNIX included), the insertion of the card is detected as a standard serial device with modem control (RS-232 protocol). Modem dialling scripts may have to be altered as some of the cards are not 100% Hayes command set protocol compliant. In particular, as there is no concept of pulse or tone dialling on a cellular phone, the 'P' and 'T' commands for pulse and tone are often not accepted, so for example, a script which would normally say "ATDT123-4567" will return an error until it is replaced with "ATD123-4567".

## 4. IMPLEMENTATION ISSUES

### 4.1 Sourcing and training

In most developing countries, sourcing of equipment can be difficult. Even if equipment suppliers do exist for a particular product, they are often not well advertised and often inexperienced with the use of these new systems. In countries with high import duties or limited local suppliers there is a tendency to bypass the local market and source directly from suppliers in the more developed economies. When a product is purchased from external sources, the supplier may be able to identify authorised service agents in the country. When purchasing equipment externally, bear in mind:

- Customs duty and clearance procedures
- Sales Tax
- Transportation costs
- Power supply voltage and frequency compatibility with the destination country - 60Hz equipment can have problems with 50Hz power supplies, and 120V equipment designed for the US market will require purchase of transformers if the equipment does not have a 240V option.
- Obtaining installation support and training for the use of equipment

Purchasing the support equipment necessary to keep communications equipment should take into account 'hidden costs', such as the need for solar power systems where the electricity grid is unavailable or unreliable. Quotes for solar power systems may also not take into account all of the costs, for example, the solar panel may require a steel superstructure to point sun-ward at the correct angle. Also, various protection mechanisms are necessary to prevent a damaged inverter from damaging other components through 'back voltage'. Lightning protection and cabling costs as well can push up the total costs substantially.

### 4.2 Power supply

Many rural areas in developing countries don't have access to reliable power supply and in many cases it will be necessary to make alternative arrangements for electricity supply. If grid power is available on an irregular basis, a simple battery charging system is the preferable solution. This uses banks of deep-cycle batteries which are topped up when power is available, and an inverter can be used to provide 240/120V for equipment that requires it, such as PCs (many wireless systems operate on 12V). Equipment with low power consumption and with optional integrated standby power subsystems will be an advantage.

Solar power is generally cheaper to operate than a motorised generator but the capital costs are usually higher and can increase the overall costs of the project by more than 100%. Some wireless equipment has a 'sleep' mode when not in use, which means less power is consumed and cheaper solar generators can be used.

The costs of a solar power supply for equipment with substantial power requirements, such as a VSAT, can be very costly. For example, a VSAT with a 260 VA continuous power supply rating (i.e. no sleep mode), will require a the solar generator costing about \$15 000 and the overall installation costs of the project will also increase dramatically. For HF radio systems, nested battery power packs and 3 solar panels of 60 watts connected to 2 gessel batteries of 120 Ah would be needed.

Most solar power and other battery charging systems need to be purpose designed for the specific equipment and an expert in this area will likely be required. A number of solar power suppliers are listed in the Appendix.

### 4.3 Operating Temperatures, Humidity and Other Environmental Factors

Wireless and other electronic equipment is susceptible to the effects of temperature and humidity. Many developing country environments are hotter and more humid than those found in North America and Europe where most of the equipment is designed. Therefore close attention should be paid to the operating temperature and humidity specifications of the equipment planned for use. By the same token, measurements of these environmental factors in the location where the equipment is to be deployed need to be made where these are likely to be close to the maximal values for the equipment. Measurements may need to be made over an extended period of time if there are large seasonal variations.

If the conditions are close to or above the extremes for the equipment, it may be necessary to install air conditioning (for indoor equipment) or choose alternative equipment with a higher capacity to withstand the impact of high temperature or humidity.





For outdoor equipment, the impact of wind speed, lightning and rain, hail or snow may also have to be assessed. A checklist of all the environmental factors to be taken into account should include:

- average monthly temperature highs, lows, and extremes;
- highest relative humidity and temperature combination;
- highest wind speed (steady and gusts) and prevailing direction;
- frequency of electrical storms (lightning);
- precipitation rates (rain, hail, snow);
- presence of dust, insects, fungus;
- corrosive atmospheres or pollutants;
- insolation data (for solar power);
- seismic activity;
- soil characteristics (for civil works and for earthing).

Yearly distribution statistics should be collected for each location, if available. Minimum and maximum values should be those normally encountered rather than unusual incidents, since it is generally impractical to design to extreme, but rarely encountered, conditions.

Adequate grounding is a key factor because the antenna and cable provides an electrical pathway from the roof to the machine room which can attract a lightning strike. The extent of grounding provided by the electrical system should be measured during the dry season, as the lowering of the water table during this period can render useless some earthing systems with inadequate penetration.

#### 4.4 Installations and Site surveys

Adequate budget for installation costs are often overlooked. In many cases it will be necessary to contract the equipment supplier or hire experienced technicians. For example this can cost up to \$800/day, plus travel and subsistence costs, for an experience US based VSAT technician. Luckily installation times are usually quite short for most equipment, rarely exceeding 1 or 2 days.

With any project, the number of different equipment types in use should be kept as low as possible in order to maximise economies of scale and minimise operational costs such as spares and training.

Modular equipment or systems which have *maximum flexibility for expansion and ease of redeployment* will be preferred and field-proven equipment with reliability data, based on in-service statistics, should be selected for any large-scale deployments.

In all cases, warranties should be specified, including Y2K compliance guarantees. In remote situations, sufficient spares of all kinds - from the basic radio, through cabling, connectors, antennas need on hand, since obtaining them after an equipment failure may be very time consuming.

Short of using modern spectrum analysers which can measure true signal strength and interference sources, with sample radios, it is often not possible to predict radio performance and link margin remotely. As a result, a good deal of pragmatic experimentation is likely to be necessary on site to identify the best location, the RF cabling lengths, antenna placement and orientation. Allowances need to be made for the time it takes to do this.

#### 4.5 Health Issues

Recent discoveries of the potential health problems caused by excessive use of cellular phones has drawn attention to the possible dangers of wireless systems. While there is as yet no conclusive evidence that radiation from wireless equipment is a definite problem, it is wise to be cautious and minimise the proximity of users to powerful transmitters. Dense metal shielding can also be used where this is not possible.

#### 4.6 General Checklist

Questions that need to be answered to ensure the success of a project involving wireless include:

- How much traffic needs to be transported?
- How reliable does the link have to be?
- Are there any other potential users of the system in the area that can help defray the set-up or operating costs?
- What are the characteristics of the terrain where the equipment is to be used?
- What is the required distance of the link?
- What are the precise frequencies that the proposed equipment uses?

- Can channels at different frequencies be used, or can the supplier modify the equipment to use different frequencies?
- Is the transmission frequency in a band permitted by the regulator?
- Is a license required?
- What is the license fee?
- Has some other agency already obtained an exclusive license for the frequency?
- Is secondary use allowed for that frequency?
- If a repeater or tower is to be erected, who owns the land where it is to be located? Is 24X7 hour access available?
- Is lightning common? If so, how will the risks of a strike be addressed?
- Have the other environmental factors (temperature, wind, humidity etc) been adequately assessed and matched with the equipment specifications?
- How will security be addressed? - Cellular phones and other portable equipment such as laptops are easily stolen, have a high resale demand and are not easily traced. Repeater equipment in isolated areas is also vulnerable.
- How will heavy equipment (such as VSAT dishes, solar panels, etc.) be transported to the sites where they are to be installed?
- Is there a local supplier for the equipment?
- What is the import duty on the equipment if it is to be sourced from outside the country?
- Where will technical support for the installation of the equipment be obtained?
- Where will technical support for the maintenance and troubleshooting of the equipment be obtained?
- If the wireless solution is being implemented because there is no existing local telecom infrastructure, is the PTO planning to extend the PSTN/POTs network to the area in the near future?
- Have all the other wireless options which may provide more functionality or lower operating costs been considered? Especially those on the horizon?
- Can increased spending on initial equipment result in lower operating costs or better scalability for expansion.
- What are the electric power requirements of the equipment?
- Is the electric power grid available in the area, and how reliable is it?

## 5. PRODUCT & SERVICE DETAILS

This chapter provides further relevant details on the major products and services covered in the previous section. Pricing information is included where available (in USD). Some of the prices were obtained from quotes provided by local distributors. Further information on the products is available from the vendors, for which URLs and other contact information is provided in the Directory of Sources in the Appendix.

### 5.1 Mobile Voice Radios / Walkie talkies

#### 5.1.1 Motorola P110 handheld portable radio (2 channel, 5 W)

Coverage: 3 – 5 km

Cost: Radio plus antenna, radio charger, carry holder and belt clip \$350

#### 5.1.2 Kenwood TK 260 mobile portable radio

Coverage: 3 – 5 km

Cost: \$360

#### 5.1.3 Kenwood TKR 720NM fixed repeater 150-174 MHz. 30/20W.

Mobility: Stationary.

Coverage: 20 – 30 km

Cost: \$5 121 (repeater plus power supply and duplexer)

#### 5.1.4 Motorola GR300 fixed repeater station.

Mobility: Stationary

Coverage: 20 to 30 km

Cost: \$2 401 including power supply and duplexer.

#### 5.1.5 Motorola GM350 VHF base station radio (25 watts/4 channels)

Mobility: Stationary

Coverage: 20 to 30 km

Cost: \$382.70 for radio plus base station antenna including 3 m mast, cable and all extra accessories.

### 5.2 HF Radio

#### 5.2.1 Codan

##### 5.2.1.1 9360 fixed voice station

Provides voice communication facilities, and is the base to which can be added the data modem (see below). Not to be confused with the 9480 which is a voice-only unit which cannot be upgraded to data. Includes ALE (automatic link establishment), a three-module clamp for 9002, 9360 and interface cables. With additional equipment the unit can interconnect to a standard PSTN voice network or to an additional radio network, for example VHF/UHF.

Cost: \$3 193 plus \$392 Codan 411 terminated folded dipole antenna 5 – 15 MHz

For mobile operation (in a vehicle) it is necessary to purchase battery cable, vehicle mounting cradle, fan, solar panel and co-axial cable for an additional \$1523. The solar panel might not be needed if a power supply is used which will charge the battery but if power is erratic, solar is necessary. Nested power packs and 3 solar panels of 60 watts connected to 2 gelsel batteries of 120 Ah each are needed as the Codan equipment has heavy power requirements.



### 5.2.1.2 Codan 9002 data modem

Adds data capability to the 9360 above and provides data compression, binary and text file transfer, "chat" mode operation and data encryption. The modem is separate box about the same size as the 9360 transceiver with outside cables interconnecting both units. The unit comes with application software for point to point messaging and file transfer but when used to connect to the Internet it is usually necessary to use software provided by the HF/Internet gateway ISP.

**Capacity:** 1475 bps (uncompressed) is the data-transfer rate average claimed. This can vary tremendously depending on atmospheric conditions, distance and type an antenna. A general average observed by BushNet is about 10Kb per minute.

**Cost:** \$2 139

### 5.2.2 Motorola Micom-2B HF SSB Transceiver

Voice and data capability. Package includes:

- Selective call (selcall) option
- modem and interface
- Wideband antenna 4 - 30MHz
- 30 m coaxial cable and connectors
- 12 m telescopic mast.

**Capacity:** 3 000 bps claimed.

**Cost:** \$6 342. 105Amp back-up battery \$91. The price of the Motorola Micom-2B HF transceiver with ALE (Automatic Link Establishment) is an additional \$2 267.

### 5.2.3 Kenwood TRC-80 HF transceiver

Includes antenna, power supply, modem and cable.

**Capacity:** 300 bps

**Cost:** \$2 434

**Comment:** A terminal node controller (TNC) radio modem could be linked to this transceiver and be used in a hub arrangement with the more sophisticated Codan 9002. The price of the TNC modem is about \$400.

### 5.2.4 Javelin RC9125 HF transceiver

Data, fax and voice capabilities, 2 – 30 MHz in 10 Hz steps. Package comprises:

- Automatic selection of optimum frequency and ALE facilities
- Connection for a PST or private PBX
- Local telephone interface
- Telephone line interface
- Fax machine interface
- Operating software for PC
- Telephone set

**Capacity:** Up to 3 600bps in data mode.

**Cost:** US \$ 10 500.00. Additional \$1 390.00 for power supply unit (115/230 V AC 50-60 Hz input, 13.8 V DC 35 Amp output). Additional \$1,315.00 for antenna system (fan dipole cut to four spot frequencies within 2-30 MHz range).

**Comment:** System only does half-duplex data transmissions and requires proprietary software for data transmission - not easily interfaced with the Internet.

## 5.3 VHF and UHF Radio

### 5.3.1 Kenwood

To connect the two transceivers below to a PC, a TNC is required. The 9600 baud Kantronics KPC-9612+ with 32k of RAM is recommended by MAF. For 1200 baud, a KPC-9612+ or KPC-3 (32k) is acceptable.

Prefabricated cables to go between the radio and the TNC are usually not available. The easiest method is to buy a partially assembled cable from the radio manufacturer and attach the extra connector. The Kenwood PG-5A cable has the 6 pin mini-DIN connector and about 5 feet of cable. The KPC-9612+ includes a male DB-15 connector to be attached to the cable. Only the send and receive audio, press to talk, and ground need to be wired. For the KPC-9612 connect the following connector pins:

TM-251A <->KPC-9612+ Function PG-5A colour

1-3 Transmit Brown  
2-11 Ground Red  
3-1 PTT Orange  
4-2 9600 Receive Yellow

#### 5.3.1.1 TM-251A Transceiver

A VHF transceiver that has been well proven for speed over LOS links. Recommended by MAF. The Kenwood TM-251A is delivered with receive capability from 118-174 MHz and a transmit range of 144-148 MHz. The transmit coverage needs to be increased to 136-174 MHz. This is accomplished by removing a single diode. Modification data is available from MAF.

Capacity: 9600 baud

#### 5.3.1.2 Kenwood TM-451A Transceiver

A similar UHF transceiver that has been well proven for speed over LOS links. Recommended by MAF  
Capacity: 9600 baud

#### 5.3.2 Paccom

RF Modems include a short range antenna. Desktop units include a 120 VAC power supply (USA Only). All Data Transceivers operate between 450-470MHz. Most models are available equipped for VHF frequencies, and many models for 900MHz operation.

- ❑ PackeTen NOS-AX.25-NET/ROM Network Switch. Supports up to 5 ports. RS-232 or RS-422 Modulation \$ 595.00
- ❑ PackeTen PT-24M 1200/2400bps MSK Modem \$125.00
- ❑ PackeTen PT-56K 57600bps DFM Modem \$170.00
- ❑ I-SPIRIT High Performance 9.6-56kbps DFM Modem. \$ 495.00
- ❑ RF-24M 2 Watt UHF Desktop RF Modem 1200/2400bps MSK Modulation \$ 795.00
- ❑ RF-19200 2 Watt UHF Desktop RF Modem 19200bps DFM Modulation \$ 895.00
- ❑ WM-MSK Wireless Modem 1200/2400bps MSK Modem \$ 395.00
- ❑ WM-GMSK 4000/19200bps GMSK Modem \$ 495.00
- ❑ IPC-320 PC Internal Wireless Dual Modems 1200/300-1200bps AFSK Output \$ 275.00
- ❑ IPC-396 PC Internal Wireless Modem Single Modem 4800/9600/19200bps DFM Output \$ 375.00

#### 5.4 Satellite Operators

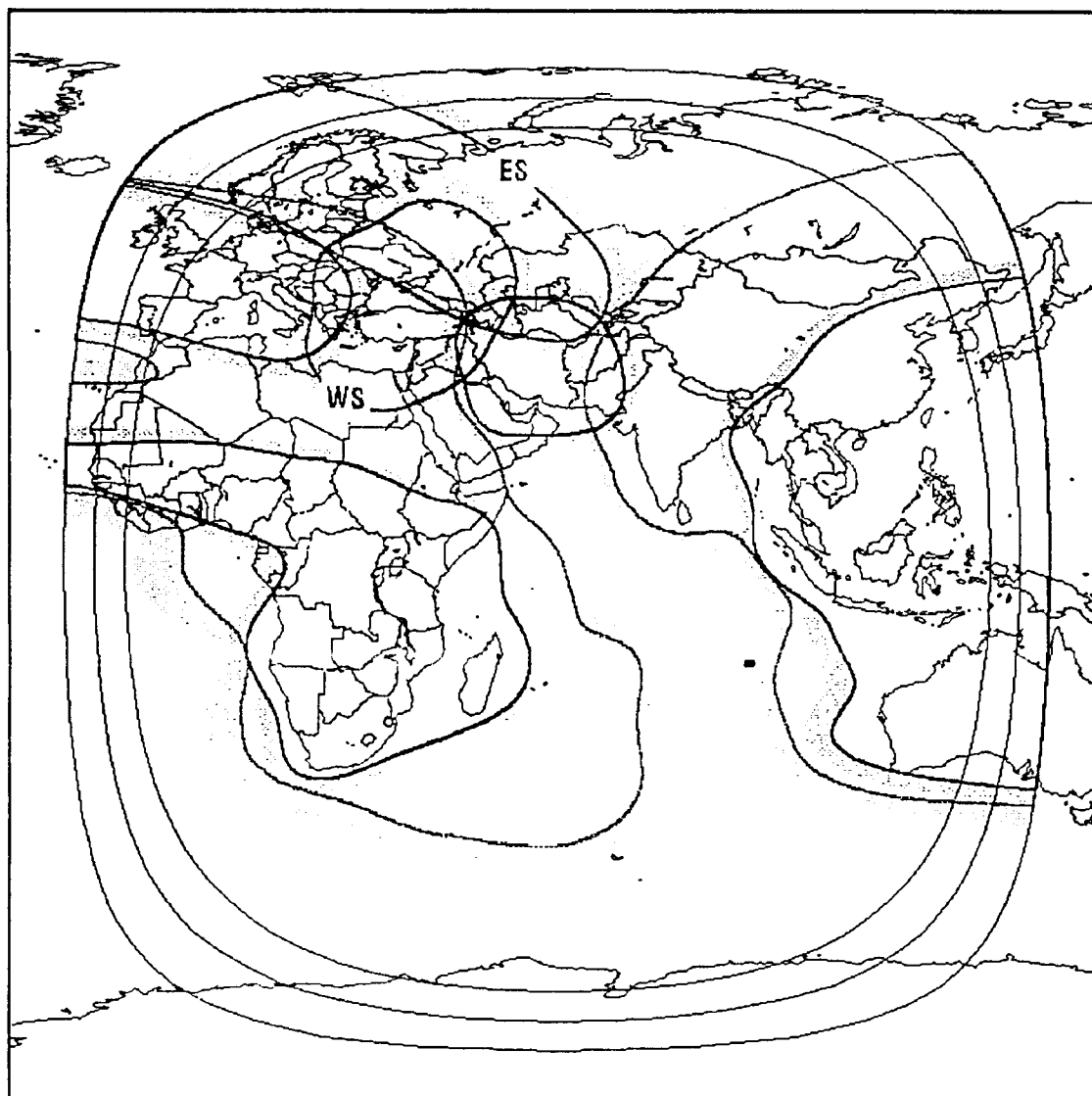
##### 5.4.1 Intelsat

Intelsat (International Telecommunications Satellite Organisation ) is the largest satellite network, created in 1964 by treaty when most countries had monopoly providers. It currently has 139 member countries which are still largely the national PTOs. Intelsat's constellation of satellites cover almost every land-mass on the planet with C-band signal and a growing number of higher powered Ku and Ka band beams. It provides international voice, data, and video services as well as domestic services for many countries. It has recently announced a range of high bandwidth Internet and multimedia services bundled into the cost of a satellite circuit.

**Cost:** Intelsat circuits range in size from 64Kbps all the way up to the recently announced 155Mbps service. As an indication of prices, a one year contract for a 64Kbps half-circuit costs \$370/month for an 11m antenna and \$2470/month for a 3.5m antenna. A 2Mbps half-circuit would cost \$9975/month for an 11m antenna and \$66500 a month for a 3.5m dish. There are also substantial discounts for long-term contracts which can be up to 15 years. The discounts offered for long-term contracts and large antennae (which cost a few hundred thousand dollars) makes it far cheaper for the national PTOs to provide service, but this is usually restricted to medium sized towns. If another agency obtains permission to operate an Intelsat link, then the PTO or regulator usually adds a mark-up on the cost of the bandwidth - in the case of South Africa it is about 30%, in DRC the PTO charges about 5%.

The graphic below shows an Intelsat coverage map for satellite 604 located at 60 degrees east.

### IS-604 at 60°E



	Beam Peak	Extended 2 dB Contour
— Heml	36.7	31.0 - 29.0 dBW
— Zone	36.9	31.0 - 29.0 dBW
— Ku-Spot: West	48.8	41.7 - 37.7 dBW
— East	48.9	41.7 - 39.7 dBW

#### 5.4.2 PanAmSat

The first large private sector satellite system to be established was in 1988 when Pan American Satellite (PanAmSat) launched its PAS-1 satellite into geostationary orbit over the Atlantic Ocean. Since then it has launched a number of additional satellites to complete its network which now provides global coverage reaching about 98 percent of the world's population. Although television and radio broadcasting accounts for most of PanAmSat's revenues, it also provides data and voice services to businesses in areas where the regulatory climate allows it.

PAS-4 was launched over Africa last year, providing C-Band coverage to most of Europe and Africa except for the extreme west of the continent (Gambia, Senegal, Mauritania, Guinea Bissau, Guinea and

Sierra Leone are excluded). The satellite also provides a Ku-Band spot beam aimed at South Africa but also covering the southern parts of Namibia, Botswana, Lesotho, Mozambique, Swaziland, Zambia and Zimbabwe).

**Cost:** PanAmSat usually has resellers in each region but can sell direct to the customer such as in its SpotBytes service. Prices charged by the African agent are described further below.

### 5.4.3 Inmarsat

Inmarsat (The International Mobile Satellite Organisation) is an international co-operative set up in 1979 to provide mobile satellite communications world-wide for the maritime community. It now has 79 member countries and its systems are also used by a growing number of subscribers on land, at sea and in the air which use it primarily for voice services but also for fax and low to medium bandwidth (2.4Kbps-64Kbps) data services.

Specially designed terminals are required to access Inmarsat's satellite network, known as A, B, M and C terminals, costing between \$45 000 for the A series and \$4 000 for the C series. The C series only transmits data in a store-and-forward arrangement for small messages. Charges depend on the terminal and on the package purchased from the reseller which may include a certain minimum number of minutes per month. Usage costs range from \$1.4 to \$9 a minute - often competitive with the IDD rates in many developing countries. This, combined with the poor infrastructure has meant that developing countries have been a major market for Inmarsat although other satellite service providers such as PanAmSat and ArabSat will also be providing these facilities shortly. Fleet management and vehicle tracking have been the other major uses for these facilities and this is now spinning off into other areas such as environmental and weather monitoring. Service providers include Radiospoor, Station Africa and Global Telephone & Telecommunications.

#### 5.4.3.1 Inmarsat B

Terminals come in two varieties: transportable and fixed. Comes with RS 232. RS449, X21, V35 modules can be obtained for about \$200 to \$300 each.

**Cost:** Terminals cost from \$20 000 to \$100 000 depending on capability and weigh about 20 kg

Usage costs about \$4.00/min for terminal to PSTN calls at 9.6Kbps and \$10.59/min at 64Kbps. Terminal to terminal call rates are 80% more.

There are no monthly recurring charges and no installation charges for the transportable unit.

**Latency:** Medium for terminal to PSTN calls and high for terminal to terminal calls.

**Capacity:** 16kbps voice and 9.6kbps data and G3 fax. Duplex and symmetrical. Optional high speed data at 64kbps. The fixed version can have up to four channels, which can be operated simultaneously in any combination of voice and data.

**Mobility:** Transportable in a vehicle.

**Coverage:** Global

**Comment:** Best for infrequent usage of high quality and capacity. Some countries such as Mozambique charge high license fees.

#### 5.4.3.2 Inmarsat Mini-M

The Inmarsat Mini-M terminals are smaller and more portable than the Inmarsat-M phones, weighing about 2kg.

**Latency:** Medium for terminal to PSTN calls and high for terminal to terminal calls.

**Capacity:** voice and duplex, symmetrical data and fax at 2.4Kbps

**Coverage:** Global

**Cost:** Various packages are available. The options from Station Africa are:

Equipment: \$3850

Recurring: \$100/month subscription

Usage: \$2.40/min mobile to any fixed destination in the PSTN world-wide.

Or

Equipment: \$4250 (for fixed site and high gain antenna)

Recurring: \$100/month

Usage: \$1.40/min mobile to any fixed destination in the PSTN world-wide

In both cases corporate customers who purchase more than five terminals do not have to pay a monthly subscription.



Another South African supplier, Grintek, has four packages:

Equipment cost: \$3550 (including connection charge)  
Traveller package (0-80mins/month): \$25/month at \$3/min  
Voyager package (80-200mins/month): \$40/month at \$2.70/min  
Office package (200mins/month): \$60/month at \$2.40/min  
Season package (includes 30 free minutes a year): \$220/year at \$3.20/min

## 5.5 VSAT Satellite Connectivity Service Providers

Most of the companies mentioned in this section have made a deal with one or more satellite operators and have a particular connectivity service to sell. The service is often based around a particular equipment configuration, and so the company will usually supply and install both the equipment and the connectivity service. In this section, the emphasis is on the service, with the following section focussing on the equipment.

### 5.5.1 Telkom South Africa

The South African PTO, Telkom, provides a range of VSAT equipment and satellite service options for Intelsat-based VSAT services in Africa, including ISBN and both SCPC and TDMA shared synchronous stream point-to-point links for one host site and between one and ten remote sites for data speeds ranging from 64Kbps to 2 048Kbps.

**Cost:** For a 64Kbps SCPC circuit the monthly service charges per terminal are about \$2 700 while the 2Mbps link costs about \$19 500 per month. This charge is only for space segment and port charges, and does not include Internet access fees.

### 5.5.2 Transtel (SA)

The South African para-statal Transnet's subsidiary, Transtel, is the agent for PanAmSat in Africa and also operates a ground-station hub in Johannesburg.

Transtel is currently excluded from bringing public traffic into its hub in South Africa due to the monopoly of the national PTO, Telkom SA. It can, however, bring the traffic down in Europe or the US. Transtel provides both SCPC and shared TDMA bandwidth which can have a CIR.

**Cost:**

512/128Kbps shared - \$1 000 set-up fee, \$2000/month rental  
512(CIR 64)/128 shared - \$2 000 set-up fee, \$4400/month  
512(CIR 128)/128 shared - \$3000 set-up fee, \$8300/month

### 5.5.3 Lyman Brothers

Lyman brothers are resellers for both Intelsat and Intersputnik space segment, operating their own teleport hub in Whitsinville MA.

1) Shared 512Kbps up-link with 128Kbps maximum on the down-link (i.e. the maximum 128Kbps will be achieved if there are 4 or less sites drawing maximum bandwidth). Includes all charges - space segment, port charges and Internet access.

**Cost:** \$3 000/month

2) Dedicated 512Kbps SCPC circuit. Includes all charges - space segment, port charges and Internet access.

**Cost:** \$16 400/month.

### 5.5.4 Interpacket (USA)

California based Interpacket has been aggressively signing up ISPs in Africa with its Espresso service which is available on both PanAmSat and Intelsat satellites and can provide both simplex (half-duplex) and duplex solutions from 256Kbps upwards.

**Cost:** The Espresso shared E-1 downstream (2 048Mbps) with a CIR of 512Kbps and dedicated 128Kbps upstream costs about \$15 000 per month. The Espresso shared 256Kbps downstream with a CIR of 128Kbps and dedicated 64Kbps upstream incurs a total monthly charge of \$8 500 per site. A flat activation fee of \$5 000 is charged and the minimum contract period is three years.

### 5.5.5 InfoSat (SA)

InfoSat provide a similar service to Interpacket's simplex facility using standard Ku-band DSTV satellite dishes in southern Africa or C-band antennae in the rest of Africa with the outgoing data carried via standard dialup or leased lines. Two services are available - the Solo service for personal use, and the Station service for corporate users. Solo uses a PCI expansion card for the PC (with drivers available for Windows 98 and NT) connected, via cable, directly to a satellite dish. The cable from the dish can be split so that the card and television decoder work concurrently. The Station service is a custom router that is connected to the satellite receiver, and then to a LAN. The custom router is a Linux-based system which will connect seamlessly to most networks.

**Cost:** R200/month for a Solo service at 64Kbps and R4500/month for a 64Kbps Station link to a LAN.

### 5.5.6 Tachyon

Tachyon is a new VSAT services company that has developed proprietary technology allowing for high throughput with short response times across the satellite link. Forward channel speeds (from the Internet to the user) will range up to 45 Mbps, and traffic from the user will usually operate at 256 Kbps. The system is based on packet technology and maintains continuous "live" connections which reduces response times by eliminating connection set-up and tear-down times.

There are two principal elements to the Tachyon system: Customer premise equipment, which is called the Tachyon Access Point (TAP), and a Tachyon Satellite Gateway (TSG) located at or near a bandwidth-rich point of access to the Internet. The TAP connects to the Internet via a small satellite dish (approximately 0.95 meters in diameter). Outdoor transmit/receive RF electronics are integrated into the dish, which is connected by cable to a personal computer-like chassis that houses a Pentium II class CPU, memory, and a large disk drive. The system is designed to be easy to install and maintain.

The TSG consists of a satellite antenna about 5.0 meters in diameter, associated transmit/receive electronics, a rack of modem and processing electronics, and a set of work-station class computers. The TSG connects to the Internet via a high-speed connection using standard hardware and protocols.

**Cost:** Not yet finalised, but expected to be less than \$5000 for the TAP, and less than \$400/month for a 64Kbps link.

## 5.6 VSAT (Very Small Aperture Terminal) Equipment

### 5.6.1 Hughes Personal Earth Station (PES) Series

The Hughes PES range is the most common VSAT in use today. Features of the PES include:

- Support for multiple user ports on each remote port
- Expansion capabilities depending on the type of chassis utilised (maximum of a 15-slot chassis);
- Support for direct interfaces to Ethernet and Token-ring LANs
- Capability to add other technologies such as read-only VSAT or SCPC/DAMA VSAT;
- Port speeds ranging from 1.2 Kbps to 512Kbps
- Remote configuration of operating parameters via software downloadable from the central site;
- Remote diagnostics.

Protocols supported by the Huges PES: SNA/SDLC (PU4-to-PU2), Ethernet, Group Poll, SNA/SDLC (PU4-to-PU2), 3780 ICL, SNA/SDLC, PU4-to-PU4, 3270 BSC, SNA/SDLC PUT2.1 (LU6.2), 3270 Telnet, HDLC frame passthrough, HASP, Token-ring, X.780, Synchronous bit transparent, Modified Burroughs poll select, Asynchronous byte transparent, General poll select Async - X.25, TINET, X.25, PPP, Data Broadcast and IP.

**Cost:** Depends on model and configuration. Hughes have recently released the PES 3000 which costs a little less than \$10 000 for an Internet access configuration providing a 128Kbps shared TDMA link.

### 5.6.2 Lyman Brothers

1) 3.7m dish plus radio equipment, for shared 512/128Kbps system consisting of:

Prodelin 3.7m Antenna, Baird mount, Hughes PES8000 5 Watt C-Band transceiver, EF Data receiver, Cisco 2500 router and cables.

**Cost:** \$33 720.

2) For a SCPC capability up to 2Mbps it is necessary to substitute in the above configuration a 20 Watt EF Data transceiver for the Hughes PES8000.

Cost: \$48 000

### 5.6.3 Transtel

Transtel supply a Scientific Atlanta system comprising a 1.8M dish including all radio equipment capable of delivering 128Kbps.

Cost: \$11 460

### 5.6.4 Gilat/ Spacenet

Spacenet is now a Gilat subsidiary, having recently been sold by GE in return for shares in Gilat. It offers VSAT and hub equipment which provide variety of voice and data connectivity services.

Gilat's Skystar Advantage is a TDMA based modular hub and VSAT product which provides two-way voice, fax and data communication. The voice service uses a proprietary voice compression algorithm with a MOS (Mean Opinion Score) of 3.9 at 6.4 Kbps, which is slightly higher than the MOS rating of the 32 Kbps ADPCM (Adaptive Differential Pulse Code Modulation) compression algorithm (CCITT G.726) used by many other systems.

The system supports up to 64 HSPs (Hub Satellite Processors). Each HSP consists of a chassis with slots for 20 data cards. HSP cards have serial ports (19.2 Kbps to 512 Kbps) and ethernet ports (10 Mbps, with 100 Mbps planned). One or more HPPs (Hub Protocol Processors) are used with each having one or two receiver chassis with 6 to 18 receivers. Each HPP supports outbound channel speeds of 64 to 1024 Kbps and inbound speeds of 19.2 to 76.8 Kbps.

At the VSAT end of the network, each indoor unit can accommodate up to three plug-in cards. IDUs can be customised for additional functionality including: dial backup, voice, fax, audio, and video. The voice service includes echo cancellation and is compatible with PBX and conventional telephone systems. The hub supports up to 50 simultaneous calls per HSP as well as simultaneous data traffic. The fax service accepts transmissions at 14,400 bps (maximum). The Skystar Advantage IP Router facility uses protocol spoofing techniques to help reduce the inherent 'chattiness' of TCP/IP to deliver greater throughput. Gilat claim that this puts less load on the available bandwidth making their 76.8Kbps connections equivalent to a 128 Kbps link.

Protocols Supported: X.25, Async (X.3/X.28/X.29), SDLC, Bisync, TCP/IP

Rx Frequency Range:

Ku-Band: 10.95–11.70 GHz, 11.70–12.20 GHz, 12.25–12.75 GHz, C-Band: 3.70-4.26 GHz,

Extended C-Band: 4.50-4.80 GHz

Antenna Size (typical): Ku-band: 0.55 m to 1.20 m, C-band: 1.80 m

Operating Voltage: 110 V, 220 V, 24 VDC, 48 VDC

Power Consumption: Less than 40 W

## 5.7 Global Mobile Personal Communications Services (GMPCS)

### 5.7.1 Iridium

Iridium, a Motorola subsidiary, is the first and currently the only entrant in the market in Global Mobile Personal Communications (GMPCS) market, having completed the launch of 66 LEO satellites in 1998.

Iridium handsets are almost indistinguishable from a cell phone and there are dual-mode handsets which will also be able to connect to the conventional terrestrial network, for which Iridium is selling its satellite system as a backup network for cellular providers. Iridium subscribers will have their calls routed over the traditional cellular network when possible, but over the Iridium network if they are out of the range of cellular stations.

Users will be largely drawn from business travellers, wealthy tourists and international relief agencies, but there is also expected to be some use by lower income rural populations. Governments may provide isolated villages and remote public works projects with phones for use in emergencies. Iridium also has a social responsibility programme called NOMAD which aims to provide free phones and call time to governments and agencies involved in relief work and crisis management.

Iridium is working intensively with the public telecom operators in Africa to finalise tariffs and interconnection agreements, so that calls made to destinations within country are cheaper than 'international' calls, which may justify their use to a wider segment of the local business community.

The issue is a complex one because only 12 satellite earth-station gateways are required to link the satellites back to the terrestrial network, so not each country will have their own local link. So for example, someone in Mozambique making a call from an Iridium phone to the terrestrial network in the same country, will also have to cover the costs of bringing the call from the gateway to Mozambique.

The Iridium system does provide for data connections, albeit limited to a maximum of 2400baud, useful for email and short file transfers. Terminals in multi-storey concrete buildings will probably have poor communications unless the user is close to a window with the right aspect, but forests (and foliage) and rain is not expected to be a problem. Iridium handsets can be used from within moving vehicles. Antennas are available for installation on cars to improve performance. Special car phones will also be available, as will be desk chassis for the terminals. Itemised billing will provide details about the duration of each call. Additionally, some of the phones may have counters on them to determine minutes of usage.

Handset manufacturers give a one-year warranty against defects with 72-hour replacement.

**Cost:** Connection fee: approximately \$100.

**Equipment:** Handset costs \$2 300 for the Kyocera Iridium-only terminal or \$3 000 for the Motorola dual mode terminal with terrestrial cellular phone capability.

**Usage Cost:** Iridium to Iridium calls within a country will be charged at about \$1.5-2.5 per minute.

Iridium to PSTN international calls will be charged at about \$6.20/min.

**Recurring costs:** \$100/month rental fee.

Stand-alone solar charger panels which can fold into a briefcase are available for about \$700.

### 5.7.2 Ellipso

Ellipso is a \$910 million project led by Mobile Communications Holdings Inc. It plans 17 satellites in a patented MEO orbital architecture using wide-band CDMA to provide voice, data, fax, paging, messaging and geo-positioning (GPS) services. Ellipso will use the GSM network model for its ground network and support SS7. It is expected to be in operation in the year 2000. Ellipso is still in development and the pricing may change but the planned prices are comparable to today's cellular calls and much lower than those of its anticipated competitors.

**Latency:** Low to Medium.

**Cost:** Terminals are expected to cost \$1 000 (mid 2001) and eventually \$500

**Usage Costs:** \$0.12/min for fixed services. \$0.50/min for mobile service

**Recurring costs:** nothing for fixed services, \$35/month for mobile service.

**Capacity:** data up to 9 600 bps duplex

### 5.7.3 GlobalStar

GlobalStar was founded by Loral and Qualcomm to provide high quality telephony, data & fax transmission, paging and position location. GlobalStar will not offer service directly to the end user but instead to regional and local GSM service providers. In South Africa, Vodacom will be the GlobalStar service provider. GlobalStar handsets and vehicle-mounted units are anticipated to be priced comparably and will be similar in size and function to current state of the art digital cellular phones.

GlobalStar satellites will act as a "bent pipe" so there is no on-board processing. GlobalStar planned 48 satellites orbiting at 1414km and was expected to commence initial services in early 1999 but in September 1998 12 GlobalStar satellites (costing \$180 million in total) were destroyed when the rocket carrying them malfunctioned and crashed shortly after launch from Kazakhstan. GlobalStar still plans to be operational by the end of 1999, perhaps using just 32 satellites.

The voice capability of the GlobalStar system has been tested since May 1998.

**Latency:** Low

**Capacity:** In phase 2 the data rate is planned at 9600 bps duplex, though the actual throughput may only be about 7600 bps.

**Coverage:** All parts of the world except the Polar Regions and the middle of the oceans. Initially, Central Africa will not be well covered. Southern Africa will however be well catered for.

**Cost:** Equipment costs are expected to be about \$1000 per handset.

**Usage:** Outside GSM coverage charges will be \$1.70/min for national calls. Payment is made for making and receiving calls outside normal GSM coverage. International charges are planned at \$1.70/min plus normal international rates.

**Recurring:** GSM monthly subscription plus \$12.50/month for GlobalStar capability.

Installation: There is a connection fee of approximately \$17.00.

#### 5.7.4 ICO

Inmarsat's subsidiary, ICO, is the most advanced MEO project with its plans to launch 12 satellites orbiting at 10 335km above the earth. Being a subsidiary of Inmarsat, ICO's indirect investors include all of the national Signatory investors of Inmarsat as well as a number of direct investors, which in Africa include Telkom SA (the South African PTO), ARENTO (the Egyptian PTO), Nigerian Telecommunications Limited, Sonatel (the Senegalese PTO), and the Liberian Bureau of Maritime Affairs. Full service is expected to be operational by the year 2000.

The basic terminal will be a handheld similar in size, weight and design to current pocket-sized cellular units. It will be multi-mode, capable of working with satellite, cellular and PCS systems based on GSM as well as US, Japanese and other cellular standards such as CDMA, D-AMPS and PDC. Other terminal types are expected to include dedicated data, car, commercial vehicle, maritime, aeronautical, semi-fixed and supervisory control and data acquisition (SCADA) units. The terminals will be developed and supplied by leading mobile communications manufacturers.

Latency: Low.

Capacity: ICO will offer digital voice, data, fax and a suite of messaging services, beginning in the year 2000.

Mobility: high mobility and very portable terminals.

Cost: Expected to be similar to GlobalStar or lower.

### 5.8 Other Satellite Systems

#### 5.8.1 VitaSat (US)

VITA is a US-based NGO focussing on technical assistance for developing countries. VitaSat is a 'Little LEO' satellite system, mainly used for store and forward data and messaging systems using the amateur frequency bands.

For some years VITA has been operating an experimental LEO satellite network using a satellite to carry daily e-mail between several stations and VITA's offices in the US (where there is an Internet gateway in operation). The most regular user is located in a remote part of Tanzania and has used the system for several years.

VITA is also working on a separate project to co-ordinate a "virtual constellation" of low orbiting satellites already in orbit and to permit much greater utility through the development of a multi-satellite earth terminal which is expected to cost a fraction of the current technology with a much higher degree of user "friendliness." Several organisations around the world own single LEO satellites or, like VITA, satellite capacity, that are used to advance their specific missions. The capacity of these satellites usually exceeds the needs of the organisations that own them. VITA has proposed a coalition of satellite service providers to offer email services at no cost to organisations engaged in humanitarian and development activities in the developing countries.

Formal agreements are being structured with SatelLife, a health service NGO of Cambridge, Massachusetts and POSAT, a Lisbon, Portugal group. In addition, WorldSpace, a for-profit digital broadcasting company that will use GEO satellites, has agreed to join with VITA to create a separate wide-band capacity using their satellites to send data which can be downloaded into VITA's ground station and using the VITA system to make the WorldSpace system interactive.

A stationary or steerable antennas may be used. The latter is more reliable, but more complicated to use.

Latency: Because the system is based on LEO satellites which can only be used when the satellite is overhead there is a relatively high level of latency. A satellite is expected to be available from any one point in Africa 6 times a day.

Capacity: 9600 b/s

Coverage: Orbiting satellites, which circle the earth, provide coverage to the whole earth but not at the same time.

Cost: At the moment a system is available at a discounted \$5 000 instead of \$10 000.

### 5.8.2 HealthNet/SatelLife

HealthNet is a service provided by SatelLife, an international not-for-profit organisation which uses internetworking technology to serve the health communication and information needs of countries in the developing world. SatelLife's mission is to improve communications and exchanges of information in the fields of public health, medicine and the environment. A special emphasis is placed on areas of the world where access is limited by poor communications, economic conditions, or disasters. SatelLife has put much of its efforts into providing and improving access to "store-and-forward" email-based message communications using:

- Conventional Internet technology including routers, permanent leased circuits, and UNIX computer systems;
- Low-cost amateur PC networks using high-speed modems and conventional dialled telecommunications, via UNIX gateway hubs;
- Low-earth-orbit (LEO) store-and-forward amateur packet-radio satellite service for remote areas, via UNIX gateway hubs;
- Surface amateur packet-radio network for regional access via UNIX gateways and routers;

HealthNet operates the HealthSat-2 LEO, and provides a "fixed" station and a portable station. The fixed stations are based on a PC, steerable antenna system, radio transceiver and TNC. The software used is WiSP, a windows based package for a full featured end-user terminal. HealthNet have also developed a gateway package for this to Linux which is in use in Mwanza, Tanzania.

The portable stations also use a PC (generally lap-top), but with a cigar-box sized package containing both radio and TNC. With the addition of simple omni-directional antennas, this becomes a portable email solution. However, the bandwidth is seriously reduced, so attaching a gateway would not really be worthwhile.

HealthNet also support TCP/IP over VHF using standard ham radio equipment and a Linux-based PC.

### 5.9 Data broadcasting

See also Interpacket and InfoSat, above. Further details of the other recently announced services from CleverCast/PickSat, Kingston Satellite Services and USA Digital Radio (AM/FM band data broadcasting) should be available from the URLs listed in the Appendix for these organisations.

#### 5.9.1 WebTV Network Plus

WebTV Networks and EchoStar Communications recently announced an Internet TV service for satellite using the EchoStar Model 7100 satellite receiver to integrate Dish Network's digital satellite television programming with WebTV Networks' Internet interface. The service also includes digital video recording (DVR), an electronic program guide (EPG), broadband data delivery and video games.

The EchoStar Model 7100 satellite receiver is claimed to be the world's first satellite receiver with a built-in multi-gigabyte hard drive, capable of simultaneously recording and playing back full-quality digital video. The disk drive makes possible a number of enhanced digital TV features, including TV Pause ("freezing" a TV show for up to 30 minutes, and resuming when the subscriber is ready to watch again), DVR (automatic recording of several hours of high-quality digital video) and downloadable video games. The DVR feature is planned to be available at the end of the year as a WebTV Plus and EchoStar service upgrade.

**Cost:** Equipment is expected to cost about \$500, service charges will depend on the provider.

### 5.10 Wireless LAN/MAN data links

With so many products in this category it is almost impossible to list full details for them all. Fortunately Mr Barry McLarnon of the Ottawa Amateur Radio Group in Canada maintains a comprehensive summary of these products which he has kindly given permission to use in this guidebook. The table below is based on Barry's data with some additional products added to the list. Not included in the list are very short range office oriented products and 900Mhz systems as they are not normally licensed outside of North America. Note that the ranges the products are capable of is open to interpretation. Some manufacturers quote the maximal range the product is capable of when using optional high-gain antennae, while others quote the range for the standard antennae included with their product and this could be substantially increased with the use of amplifiers and high gain antennae. Where figures are available, additional data is included in the Comments column.

The latest version of Barry McLarnon's summary, including data for 900MHz products, is available at <http://hydra.carleton.ca/info/wlan.html>

Wireless LAN/MAN Products Summary									
Vendor	Product	Freq. (GHz)	Type	Capacity	Power	Range	Configuration	Price (\$US)	Comments
ACT Networks	SkyWave Wireless Modem	2.4	FH	64K-2.048M*	50mW	32km	SA S422/530/V.35	-	*Half-duplex. Full-duplex up to 1.024 Mbps. Adaptive Equalisation.
ADTRAN	Tracer	2.4	DS	2xT1 or 1xE1	100mW	48km	SA DS1/DSX-1/T1 G.703/E1	-	Separate RF deck, mast mountable
Aerotron	NLR-2.4T	2.4	DS	19.2K	500mW	2.4km	SA (RS232)	1695	
Aironet	PC3500	2.4	FH	Up to 2M	100mW	600 m	PCMCIA	-	IEEE 802.11 compliant
Aironet	BR2000	2.4	DS	1 or 2M	100mW	40km	SA (ethernet)		
Aironet	BR2040	2.4	DS	1,2 or 4M	100mW	40km	SA (ethernet)	-	
Altwater	WIMANline	2.4	FH	625K*	100mW US:1W	5km	SA (RS232, X.21/V.11)	-	*Data rate up to 115.2 K async, 128K sync.
Apex Wireless	SS-300	2.4	FH	166K* (Channel bit rate).	50mW, 1W	16km	Serial (RS-232)	-	Serial link 115.2K simplex or 57.6K simulated full-duplex. Repeater
BreezeCom	AP-10 PRO Access Point	2.4	FH	1-3M*	10/100 mW	1km	SA (10BaseT)	1495	Up to 30% higher throughput than standard version. Fallback to 1 or 2M, 12km with high gain antenna
BreezeCom	SA10 PRO Station Adapt	2.4	FH	1-3M	10/100 mW	1km	SA (10BaseT)	695	Up to 30% higher throughput than standard version.
BreezeCom	SA40 PRO Station Adapt	2.4	FH	1-3M	10/100 mW	1km	SA (4X 10BaseT)	1195	Up to 30% higher throughput than standard version.
BreezeCom	WB-10 Bridge	2.4	FH	1-3M	0.1-4W ERP	1-10km	SA (10BaseT)	1995	Full Duplex. Many antenna options.
BreezeCom	BreezelINK-121 E1/T1	2.4	FH	56K-2.048M	50mW	1-32km	SA T1/E1/V.35 /RS-530/X.21	-	Range depends on data rate, model.
Clarion	M10	2.4	DS	10M	-	8km*	SA ethernet AUI	-	*With optional high gain antennae.
CRL	DS16-24/ISA	2.4	DS	1M	60mW	1km	ISA card*	-	*Radio/modem unit is external (RS485 interface).
C-SPEC	OverLAN RF-2 B/Router	2.4	DS	2M	88mW	32km	SA (ethernet)	3995	WaveLAN. IP routing, roaming. 8km normal range w/ included high gain antenna
C-SPEC	OverLAN RF-10 B/Router	2.4	DS	10M	-	24km*	SA (ethernet)	9495	*With optional amplifiers. Standard range 5 km.
Cylink	AirLink 64SMP	2.4	DS	64K	650mW	48km	SA RS232 /RS422 V.35)	3395	BPSK, 8 PN codes. 5.1 MHz bandwidth.
Cylink	AirLink 128S	2.4	DS	128K	650mW	48km	SARS232/422 / V.35	3595	BPSK, 8 PN codes. 10.2 MHz bandwidth.
Cylink	AirLink 256S	2.4	DS	256K	650mW	48km	SA RS232/422 V.35	3995	BPSK, 8 PN codes. 20.5 MHz bandwidth.
Cylink	AirLink 384S	2.4	DS	384K	650mW	48km	SA RS232/422 V.35	4495	BPSK, 8 PN codes. 30.7 MHz bandwidth.
Cylink	AirLink 512S	2.4	DS	512K	650mW	48km	SA RS232/422 V.35	4995	BPSK, 8 PN codes. 41 MHz bandwidth.
Cylink	AirPro T1	5.7	DS	1.544M	-	35 km	SA (DSX-1)	-	E1 version also available
DATA-LINC	SRM6000H	2.4	FH	Up to 115.2K	-	30-50km	SA RS232/422 /485	1975	Several antenna options repeater available
DCT	VL128	2.4	DS	128K*	18dBm	48km	SA RS232/422 /V.35	-	*115.2 Kbps async. AT-command set. Full duplex..
DCT	VL256	2.4	DS	256K*	18dBm	48km	SA RS232/422 V.35	-	*115.2 Kbps async. AT-command set. Full duplex..
DCT	VirtualNet PCMCIA	2.4	DS	1-4M	18dBm	1.1km	PCMCIA Type II	-	IEEE 802.11. Harris PRISM chip set..
DCT	VirtualNet	2.4	DS	1-4M	18dBm	1.1km	ISA card	-	IEEE 802.11. Harris

	ISA Adapter								PRISM chip set.
DCT	VirtualNet Access Point	2.4	DS	1-4M	18dBm	1.1km	SA (ethernet)	-	IEEE 802.11. Harris PRISM chip set.
Digital Wireless	WIT2400M OEM Module	2.4	FH	115.2K	-	1km	RS232	~400	Ranges are with unity gain dipole antenna.
DTS	Skyplex I	2.4	DS	1.2-512K*	-	100km*	SA S232/422 /EIA530/V.35	-	*Depends on model. Appears based on Cylink
DTS	Skyplex II	2.4	DS	1.544M*	8 or 28dBm	-	SA (DSX-1)*	-	*E1 w/G.703 and fractional T1 w/V.35 also available.
FreeWave	DGMR-115R DGMR-115W	2.4	-	115K	400mW - 500mW	32km	RS232	1300 1750	Needs 5 dB omni. - 108dbm / 230kHz. 115W is ruggedised/waterproof
Glenayre	Lynx cp2	2.4	DS	1.544M	Upto1 W	48km	SA (DSX-1)	9950	Full duplex, 43 MHz separation. DSU/CSU optn
Glenayre	Lynx.sc 31000	5.7	DS	1.544M	23dBm	80 km	SA (DSX-1)	-	E1 version also available
Glenayre	Lynx.sc 31600	5.7	DS	2 x 1.544M	23dBm	80 km	SA (DSX-1)	-	E1 version also available
GRE	GINA 7000N GINA 7000NV	2.4	NB	38.4K	500mW	20km	SA RS232	2100 2300	Half duplex. 56K option BPSK, incl 2 omnis
GRE	GINA 8000NVK	2.4	DS	64K	725mW	19km	SA RS232/449 V.35	1979	Other versions available.
IBM	2480 ISA Wireless LAN	2.4	DS	2M	-	-	ISA / PCMCIA	-	Access points, bridges, etc,
InTalk	ST500	2.4	DS	2M	-	915 m	PCMCIA	-	IEEE 802.11 Based on Harris PRISM™ chipset.
InTalk	WR1000 Access Point	2.4	DS	2M	-	915 m	SA (ethernet)	-	IEEE 802.11 compliant. Based on Harris PRISM™
KarlNet	Wireless KarlBridge	2.4	DS	2M	88mW	8km	SA (ethernet)	2895	WaveLAN compatible multipoint, roaming. Incl high gain antenna.
KarlNet	KarlBridge Bridge /Router	2.4	DS	2M	88mW	8km	SA (ethernet)	3195	WaveLAN compat., IP routing, multipoint roaming. Incl high gain antenna.
Lucent	WaveLAN	2.4	DS	2M	88mW	20km	PCMCIA / ISA	545 495	IEEE 802.11 compliant
Lucent	WavePoint	2.4	DS	2M	88mW	20km	SA	2000	Multipoint hub
MikroTik	MikroTik Router	2.4	-	2M	100mW	-	SA (ethernet)	1499	PC-based, includes parabolic antenna & cable
Multicap	Serial-Wave	2.4	FH	1.6M*	100mW	18km	SA (RS232) Incl TCP/IP	1200	RangeLAN2 compatible. *Data rate up to 115 Kbps.
Multipoint Networks	RAN64ss	2.4	DS	64K	18dBm	-	SA RS232 EIA530/V.35)	-	Remote RFhead eliminates 2.4 feed-line losses
Multipoint Networks	RAN128ss	2.4	DS	128K	18dBm	-	SA RS232/ EIA530/V.35	-	Remote RFhead eliminates 2.4 feed-line losses
Multipoint Networks	RAN2048ss	2.4	FH	2.048M	18dBm	Up to 30km	SA (G.703)*	-	T1 (DSX-1), multi-rate 64-2048 K (RS530/V.35/X.21) versions available.
No Wires Needed	Swallow 550	2.4	DS	1,2,5.5M	18dBm	-	PCMCIA	-	Complies with IEEE 802.11 air interface.
No Wires Needed	Parrot 550 Access Point	2.4	DS	1,2,5.5M	18dBm	-	SA (ethernet)	-	Dual diversity antenna. Complies with IEEE 802.11
P-COM	Model 100-2	2.4	DS	56K-2.048M	6mw or 500mW	75km	SA (V.35, DSX-1, G.703)	~600 0	Separable Modem / RF deck.
P-COM	Model 100-5	5.7	DS	56K - 2.048M	100mW	50 km	SA (V.35, DSX-1, G.703)	-	Modem and RF deck are separable.
Proxim	RangeLink	2.4	FH	1.6M	100mW	4.8km	SA (ethernet)	5950 7450	6 models, range/data rate depends on model.
Radio Connect	Remote Office Link	2.4	DS	256K (or More)	-	32km	SA (10BaseT ethernet*)	-	Also has 6 telephone ports for voice/fax.
Raytheon	Raylink PC Card	2.4	FH	2M	100mW	-	PCMCIA Type II	-	IEEE 802.11 compliant.
RDC	PortLAN	2.4	FH	1M	-	830 m	PCMCIA II	695	-



Solectek	AIRLAN/Bridge 200E	2.4	DS	2M	4WERP	40km	SA (ethernet)	3495	3 channels. High gain and sectoral/omni antenna opts
Solectek	AIRLAN/Router 200E	2.4	DS	2M	4WERP	40km	SA (ethernet)	5995	Includes Cisco router. Token ring ver also avail
Solectek	AIRLAN/Bridge 400E	2.4	DS	4M	4WERP	32km	SA (ethernet)	4495	
Solectek	AIRLAN bridge 1000E	2.4	DS	10M	4WERP	40km*	SA (ethernet)	8895	*With optional high-gain antennas
Solectek	MP200-E	2.4	DS	2M	-	40km	SA (ethernet)	-	Multipoint capability.
Solectek	MP550-E	2.4	DS	5.5M	-	32km	SA (ethernet)	-	Multipoint capability.
Solectek	MP1100-E	2.4	DS	11M	-	40km	SA (ethernet)	-	Multipoint capability.
Symbol	Spectrum24 LA 2400	2.4	FH	1M	100-500mW	-	PCMCIA Type II	-	66 sequences, 10 hops/s
Teletronics	WINC 2400A	2.4	FH	38.4K		500m	SA	1200	Async, 30km with Yagi
Teletronics	WINC 2400C	2.4	FH	128K		500m	SA	1500	Sync, 30km with Yagi
Teletronics	WFL-MTB	2.4	FH				SA	1200	Master Transceiver
Teletronics	WFL-RTB	2.4	FH				SA	1000	Remote Transceiver
Teletronics	WINC 2400C	2.4	FH	128K		30km	SA	1500	Sync
TTI Wireless	InterBuilding Link 200TSE	2.4	DS	2M	15dBm	48km	SA (ethernet)	-	Repeater configurations available
TTI Wireless	InterBuilding Link 500TSE	2.4	DS	5M	15dBm	48km	SA (ethernet)	-	Repeater configurations available
TTI Wireless	InterBuilding Link 1100TSE	2.4	DS	11M	15dBm	48km	SA (ethernet)	-	Repeater configurations available
Utilicom	LongRanger 2020/ISM2.4-4TS256	2.4	DS	Up to 256K	0.25-4WERP	50km*	SA (RS232/422/EIA530/V.35)	2550*	*Depends on version. Directional antennas extra. Full-duplex.
Wave Wireless	SPEEDLAN 3	2.4	FH	3M	4WERP	8km	SA (ethernet)	3000	Indoor LAN + outdoor bridge configurations available
Wave Wireless	SPEEDLAN 5	2.4	DS	3-8M	4WERP	16km	SA (ethernet)	5500	
Wave Wireless	SPEEDLAN 10 BRouter	2.4	DS	8M	4WERP	16km	SA (ethernet)	9500	Multipoint capability
WaveAccess	Jaguar DS132	2.4	FH	3.2M*	50mW	1.5km	SA (10BaseT ethernet)	1395	*Max. throughput 2.5M QPSK, 16QAM modulation
WaveAccess	WaveLyNX BR132 Bridge	2.4	FH	3.2M	50mW	32km*	SA (ethernet)	2495	*With highest-gain antenna option. Range is greater at 1.6 Mbps fallback rate.
WaveAccess	Jaguar AP132	2.4	FH	3.2M*	50mW	1.5km	SA (ethernet)	1495	*Max throughput 2.5 Mbps. Access point.
WaveSpan	Model 5800 EthernetBridge	5.7	FH	10M		8km	SA		Up to 32km with lower throughput
Wi-LAN	Hopper Plus EthernetBridge	2.4	DS	1.9M	100mW	9km	SA (ethernet)	3295	
Wi-LAN	Hopper Plus 30-24	2.4	DS	3.0M	22dBm	-	SA (ethernet)	-	
Wi-LAN	Hopper Plus 45-24	2.4	DS	4.5M	-	-	SA (ethernet)	3900	
Wi-LAN	Hopper FD Modem	2.4	DS/FH	19.2K*	16mW	-	SA (RS232)	-	*Full duplex (38.4 Kbps max in half duplex)
Windata	FreePort	2.4	DS	5.7M	1WERP	-	SA (ethernet)	9000	Also uses 5.8GHz . Trellis-coded 16PSK
Windata	AirPort II	2.4	DS	5.7M	1WERP	2.9km	SA (ethernet)	1100	Also uses 5.8 . Trellis-coded 16PSK
Windata	FreePort	5.7	DS	5.7M	1WERP	80 m	SA (ethernet)	9000	Also uses 2.4 . Trellis-coded 16PSK
Windata	AirPort II	5.7	DS	5.7M	1WERP	2.9 km	SA (ethernet)	1100	Also uses 2.4 . Trellis-coded 16PSK
YDI	Model 2400	2.4	FH	115.2K	100mW	16km*	SA (RS232 sync / async)	1175	*80 km + with amp. 250 Kbps over-the-air data rate
YDI	WL2400-PCM-J	2.4	DS	2M	50mW	8km*	PCMCIA	645	*32 km with amp. Used in the AP2400 and laptops. IEEE 802.11 compliant.

YDI	WL2400-ISA	2.4	DS	2M	50mW	8km*	ISA card	535	*32 km with amp. IEEE 802.11 compliant.
YDI	AP2400 Access Point	2.4	DS	2M	50mW	8km*	SA (Ethernet)	945	*32 km with amp. Requires a WL2400 WLAN card.
Z-COM	WL2420 LANEscape	2.4	DS	2M	50mW	8km	ISA card	420	IEEE 802.11.
Z-COM	WL2430 LANEscape	2.4	DS	2M	50mW	8km	PCMCIA	450	IEEE 802.11.
Z-COM	WL2410 LANEscape	2.4	DS	2M	50mW	8km	SA (ethernet)	800	IEEE 802.11. Hub/ Access Point

DS=Direct Sequence Spread Spectrum  
FS=Frequency Hopping Spread Spectrum  
NB=Narrow Band (non-spread spectrum FSK, MSK, PSK, etc.)  
SA=standalone system (not a PC card)  
M=Megabites per second  
K=Kilobits per second

Other features of some of the more popular products listed in the table are described in more detail below. Note that many suppliers do not provide all of the relevant information, which may require further contact with the vendor to obtain further specifications.

### 5.10.1 Lucent WaveLAN

This is the most commonly used product on the market, used for point to point links and wireless multipoint hubs. Lucent provides the WaveLAN in an OEM model which is used in a variety of other companies' wireless LAN/MAN systems, usually integrated with a bridge or router. Resellers include Camalex (Asia), Cabletron, C-SPEC, CiDS, Digital Equipment's RoamAbout, KarlNet, SolecTek (Americas), ASK Communications, and Rupex (Europe).

Recently Lucent released its IEEE 802.11 compliant product, the WaveLAN/IEEE, which will inter-operate with 802.11 compliant cards from other manufacturers. The new cards are only available in the PCMCIA format and for desktop PCs, a PCMCIA/ISA bus adapter card is supplied. The cards can communicate peer-to-peer, or through an ethernet bridge to a wired network. The bridge product supplied by Lucent is called the WavePoint which can take two PCMCIA cards to sub-divide large networks and increase coverage.

### 5.10.2 Rooftop Communications

The 'Rooftop Community Network' uses different approach to wireless systems, aiming to create fast, robust networks with an interlocking web topology that is constructed entirely by the end-user. The Rooftop system allows many users to share an Internet link by joining a local Rooftop network. To join, users purchase an Spirit 2000 Internet radio and antenna consisting of a high-speed (256Kbps to 10 Mbps) digital radio that uses ISM bands and an embedded microprocessor to run Internet Radio Operating System (IROS) software.

A Rooftop network is a self-managing web of peers in which each radio serves not only as a user's connection to the network, but also as an automatic repeater to forward other users' traffic, as needed. This makes the system unique in that traffic is automatically routed via the nearest repeater to its final destination, and the data can take multiple routes where necessary. If a potential user is not within range of the Internet gateway, then a closer user must install a system to provide the route to the gateway.

IROS software in the radios automatically control the routing of packets across multiple links between their sources and destinations. This software requires no configuration or intervention by users, beyond that required for connecting a computer to the Internet over a typical, dial-up line (it uses a standard RS232 serial port for the interface to the PC). A gateway hub unit to interface to the wired network is also necessary.

Latency: low to large (depends on the size of the network).

Capacity: duplex, asymmetrical, data rates depend on the actual implementation of the radio links and the model being used (115Kbps to 10 Mbps).

Range: 8km in multipoint-to-multipoint mode, 18km in point-to-multipoint and 45-50kms in point-to-point mode.

Coverage: a new user can join if the site is in radio line-of-sight of at least one existing user

Cost: \$500 per Internet radio and antenna.

### 5.10.3 FreeWave Technologies

The DGR series of spread spectrum transceivers is available in a ruggedised enclosures, at both 900 MHz and 2.4 GHz. The transceivers use standard N type RF connectors, and are available in waterproof (115W) and non-waterproof versions.

The DGMR-115R and the DGMR-115W (waterproof) are the 2.4Ghz models.

Frequency: 2.400 to 2.4835 GHz

Output Power: 1 W (+30 dBm) at 9.5 to 14.0 V  
400 mw (+26 dBm) at 7.5 to 9.5 V  
500 mw (+27 dBm) at 9.5 to 14.0 V

Range: 32km with 5 dB omni antenna.

Modulation: GFSK, 120 Kbs - 170 Kbs

Occupied Bandwidth: 230 kHz

Sensitivity: -108 dBm at 10-6 raw BER

Link Throughput: 115 Kbaud

Interface: RS-232 Standard DB9 connector (DGR-115R)

11-pin waterproof connector with 6 foot pigtail (DGR-115W)

Transmit current: 600 ma at 8.5V for 400mW 650 ma at 12V for 500mW

Receive current: 100 ma at 12V

Idle current: 65ma at 12 V

Sleep mode current: 5 ma at 12V

Operating Modes: Point-to-Multipoint/ Peer-to-Peer / Store and Forward Repeater

Operating Environment: -40°C - +65°C

Dimensions: 56.5mmH x 74.3mmW x 165.1mmL (DGMR-115R)

60.3mmH x 78.1 mm (W) x 165.1mmL (DGMR-115W)

Weight: 441g (DGMR-115R), 496g (DGMR-115W)

Cost: DGMR-115R - \$1300 / DGMR-115W - \$1750

1 Watt Active Amplifier - \$575

5 Watt Active Amplifier - \$675

### 5.10.4 Breeze Communications

Breeze is an Israeli company which supplies point-to-multipoint spread-spectrum wireless equipment, in use in many parts of Africa and elsewhere, by networking companies, ISPs and PTOs. The new Pro series conforms to the IEEE 802.11 interoperability standard.

Breeze systems are designed to be used in a hub arrangement. The Access Point (AP) is needed to communicate either with an end-user's Station Adapter or with a Wireless Bridge unit. BreezeCom manufactures three kinds of station adapters. The SA-10 series connects a single Ethernet device to the Access Point. The SA-40 has four 10Base-T ethernet ports and a built-in four-port 10BaseT hub. BreezeCom also manufactures a PCMCIA adapter called the SA-PC that plugs into a laptop. The Wireless Bridge connects up to 256 ethernet cards across the wireless network to the Access Point and supports a maximum of 64 stations per cell.

With the exception of the SA-PC, all of the BreezeCom units can operate with one or two antennas. Although it is possible to use one antenna, it is better to use two, which exploits the system's "antenna diversity" feature, helping to solve the problem of momentary physical obstructions in the radio path by creating more routes for the radio signals to travel.

BreezeCom only supports its own custom Management Information facility and does not support SNMP.

### 5.10.5 WI-LAN

Wi-Lan manufacture the Hopper-Plus range which are similar to the Breezecom range of point-to-multipoint standalone ISM products. Extensively used in Africa, the systems use a polling protocol to eliminate the inefficient data collisions common in most CSMA based systems.

### 5.10.6 Teletronics

Teletronics designs and develops wireless voice and data communication products. The company will customise systems according to the needs of the project.

#### 5.10.6.1 WINC 2400C Synchronous Wireless Instant Network Connector

Frequency: 2.400-2.483Ghz

Range: 500 m outdoor; Indoor 50 m. Omni-directional included (optional high gain Yagi antenna increases range to 30 km LOS).

Capacity: 128 Kbps (Synchronous/full duplex)

Interface: RS-232, RS-422(EIA-530), DB-25, V.35

Power output: 50mW with 20 channels.

Modulation: DQPSK Direct-Sequence Spread Spectrum

Bandwidth (per channel): 4 MHz in async. and sync. modes

Receiver Sensitivity: -80dbm (not including spreading gain)

Power supply: 28W 120-250V AC

Operating Temperature: 0-70C

Cost: \$1500

#### 5.10.6.2 WINC 2400A Asynchronous Wireless Instant Network Connector

Similar to the above product, with 26 3Mhz channels and a -85dbm sensitivity, range is up to 1km without high-gain antenna.

Cost: \$1200

#### 5.10.6.3 Amp2400

A 500mW amplifier for the above products to increase range.

Cost: \$750

#### 5.10.6.4 WFL -10X Wireless Final Loop

The WFL-10X is an interesting approach to local loop systems which provides standard telephony functions using ordinary telephones which plug into the unit using standard RJ-45 cabling. Based on TDD/TDMA, a Master Transceiver Box, or MTB, which is basically an RF unit with PBX wired to the PSTN, will provide links of up to 30 kilometres to end-user Remote Transceiver Boxes (RTBs) which are wired to ordinary telephones or modems. Although the system uses the 900 MHz, it is covered here because it may be possible to use it elsewhere.

Features: Automatic Queuing for Remote Dial-Out, Multiple Individual Intercom Pairs, PC Ready Monitoring and Billing functions.

Frequency: 902-928 MHz, ISM Band

Power: Up to 1 Watt

Number of Channels: 8, 3 MHz each

Tone: DTMF (touch tone dialling phones)

Dimensions: 9 x 6 x 1.25 in.

Power: 110/220 AC V

Operating Temperature: 0 to 70C

Operating Humidity: 0 to 90% Non-condensing

Cost: MTB - \$1200, RTB - \$1000

#### 5.10.7 DTS

DTS manufacturer the Skyplex range of Direct Sequence SS microwave radio devices. These operate between 2.400 and 2.4835 GHz and in the 5.7GHz range.

##### 5.10.7.1 Skyplex 1

Claimed to be capable of up to 100kms, the Skyplex 1 supports synchronous data rates from 1.2 to 512 Kbps and asynchronous rates up to 38.4 Kbps. Available with V.35 V.11, RS232, X.21, RS-422 and EIA-530. Has 2 overlapping channels and 1 non-overlapping.

Output Power: 650 mW (28 dBm), adjustable

Channel Bandwidth: 41 MHz (4 channels)

Cost: \$4995.00

##### 5.10.7.2 Skyplex II Wireless SS T1 2.4Ghz and 5.7GHz models

Skyplex II is the higher capacity product operating at 1.544Mbps with two versions, one for 2.4GHz operation and one for 5.7GHz. Available as an E1 2.048 Mbps unit with a G.703 interface or a N x 56/64 Kbps unit with a V.35 interface. Uses a split architecture consisting of a modem unit and an RF unit. The RF unit can be mounted indoor or outdoor to achieve the desired performance levels.

Output Power 650 mW (28 dBm), adjustable

Channel Bandwidth: 20 MHz (4 channels / 6 channels for the 5.7GHz ver)

Receive Sensitivity -91 dBm / -89dbm (5.7GHz ver)

Frequency: 2.400-2.4835Ghz / 5.725 - 5.850 GHz

Cost: \$9040.00. \$9995.0 for 5.7Ghz version.

#### **5.10.8 C-SPEC**

Similar to the CIDS product and a number of others that repackage the Lucent WaveLAN PC-cards, C-SPEC has the OverLAN product series, integrating bridges and routers into some of their models. One centrally located bridge is designated as the base station. With additional options, satellite stations can then be located within 15km of the base station creating a "Cell" up to 30km in diameter.

Where the 900Mhz band is not used for GSM, C-Spec has a product which uses both the 900MHz and 2.45 frequencies at the same time to almost double bandwidth available. The product is called the OverLAN® Roaming Bridge II.

The radio is built from a low-profile industrial PC chassis equipped with 486 CPU, ethernet card, Lucent WaveLAN card, proprietary card with flash RAM and an interface for the front panel lights. The OverLAN unit can operate as either a hub or a spoke, with two modes of operation - as an ethernet bridge, connecting many ethernet segments together, or as true routers, linking multiple TCP/IP, Novell or AppleTalk networks. C-Spec supports multiple layers of security and the SNMP community can be changed. The system also allows access control lists, so that SNMP commands can only be accepted from particular IP addresses. The over-the-air traffic is encrypted with the Data Encryption Standard (DES). And, unlike some other products, C-Spec supports remote software upgrade, even over the air.

C-Spec have also recently released the OverLAN RF-10 which has a 10Mbps capacity.

##### **5.10.8.1 OverLAN RF-2**

OverLAN RF-2 provides a 2Mbps link between two or more remote LANs up to 5-8 km apart, extendable to 16 km with optional amplifiers and antennas.

Configurable as either point-to-point or as a cell application with a base station and satellite stations with a cell diameter up to 32 km with a throughput rate of 2 Mbps shared bandwidth.

Frequency: 902-928 MHz and 2.4

Cost: \$3995

##### **5.10.8.2 OverLAN RF-10**

OverLAN RF-10 provides a high speed (10Mbps) wireless 2.4Ghz SS link between two or more remote LANs up to 5km (extendable to 16 km with optional amplifiers and antennas)

Configurable as either a point-to-point or as a cell application with a base station and satellite stations with a cell diameter up to 32 km.

Cost: \$9495

#### **5.10.9 Bay Networks**

Bay Networks market two wireless products - the Baystack 650 and the Baystack 660. These were originally developed by Xircom, which was taken over by Netwave-Wireless, which in turn is now part of the Bay Networks group, itself bought by Northern Telecom (Nortel) last year. These products are similar to the WaveLAN system with the Baystack 660 providing greater range than the 650.

#### **5.10.10 Data Communications Technologies (DCT) VirtualNet**

VirtualNet can operate in a variety of different modes - infrastructure mode, ad-hoc mode, roaming mode and bridge mode - to connect users and/or wired LAN segments. Infrastructure mode enables clients to communicate to other clients and a wired LAN via the access point. Ad-hoc mode enables clients to communicate without making use of the access point. Roaming mode enables clients to 'roam' around from one access point to another. Bridge mode routes traffic between two wired LANs up to 16km.

Data rates: 1 Mbps(DBPSK), 2-4 Mbps(DQPSK)

Frequency: 2.412 - 2.484GHz

Modulation: Direct Sequence Spread Spectrum (DSSS).

#### **5.10.11 KARLNET**

KarlNet repackages the Lucent WaveLAN PC-cards as the KarlBridge and KarlBridge/Router product series, integrating bridges and routers into their models. The products compress and provide multiple links within a single cell.

Range: Point-to-point range up to 16 km, cell diameter up to 24 km. Optional RF amplifier extends range up to 40 km.

#### **5.10.12 OTC Telecom**

##### **5.10.12.1 AirEZY 2411**

A 2.4Ghz DSSS product that claims to be capable of connecting buildings 12 km apart with point-to-point and point-to-multipoint networking capabilities.

Capacity: 11Mbps throughput – an aggregate rate of 33 Mbps if using three simultaneous RF channels.

#### **5.10.13 P-COM**

A vendor of 2.4/5.7Ghz SS products aimed at metropolitan also able to provide PCS/Cellular site interconnection. A novel feature is the separable RF unit which provides greater flexibility in placement of equipment.

Capacity: 56Kbps - 2MB

#### **5.10.14 PICOCOM**

Directional point-to-point and point-to-multipoint wireless connectivity solution provider using Low power Narrow Band Microwave Transmission (NBMT) with ASK modulation in the 5.7Ghz band.

Range: up to 13 km.

#### **5.10.15 Community Information Delivery Services (CiDS)**

Based on the Lucent WaveLAN product and developed by the South African Council for Scientific and Industrial Research (CSIR), the CiDS system is configurable as either point-to-point or as a cell application with a base station and satellite stations with a cell diameter up to 20 km (50 km with external amplification). Housed in a PC running the BSD Unix operating system, CiDS is compatible with various industry standard interfaces such as X.21, V.11, etc.

#### **5.10.16 GLB Synthesised Netlink Radio Data System (SNRDS)**

SNRDS is designed for point to point or multipoint networks to handle reliable high speed data up to 19200 baud available in all frequencies between 100-512 MHz and 800-1000 MHz.

The two RS-232 serial ports can operate at 300 - 38,400 baud, while the network data rate may be 1200, 2400, 4800, 9600 or 19,200 bps with standard 25 kHz channels, or up to 9600 baud with 12.5 kHz channels. An optional second DB-25 can be added for data or other requirements. The system can operate as a simple point to point data link between two computers or data terminals or in a multipoint network. In a multipoint configuration, a host computer can communicate with several remote computers for data acquisition or control of remote devices.

### **5.11 Telephone line extenders**

#### **5.11.1 GLB Line Extender Multiplexer (LEM)**

Provides up to 16 simultaneous voice or data channels on point-to-point links or point-to-multi-point with up to 16 remote locations. LEM uses licensed frequencies between 106-512MHz and 806-960Mhz and is also available in the 2.46 and 900Mhz using DSSS.

Capacity: Total bandwidth of up to 2Mbps, each channel has 9600baud for data/fax.

#### **5.11.2 Global Telephone and Telecommunication (GT&T) Telink Series**

The Telink Series provide a range of telephone line extenders operating in a variety of frequencies - 169-174MHz, 404-408MHz and 928-952MHz. On special request the units can be provided to use 66-68MHz, 403-512MHz, 140-174MHz and 1.2-1.3GHz.

A suite of products are available, each designed to operate over a different range, providing high quality voice, G3 fax at 14.4Kbps and data transfer rates of up to 28.8Kbps.

#### **5.11.2.1 Telink5000M**

Power output: 2W

Range: up to 40km

Cost: \$5 800 (two required, one for each end)

#### **5.11.2.2 Telink6000**

The Telink6000 is only available in VHF/UHF frequency models.

Power output: 50W. Total power including antenna gain and coaxial cable will be 1.6Kw.

Range: up to 350km

Cost: \$7 900

### **5.12 Optic Systems**

#### **5.12.1 Cablefree Solutions**

UK-based Cablefree manufacture infrared optical communication systems which may be used for data networking, telecommunications, or even television broadcast. They send data through the air up to 622Mbps over 1km in UK weather with reliability figures in excess of 99.7%. This distance will be considerably extended in countries with clearer atmospheres.

A Cablefree 1000 system that sends data 1km through the normal range of UK weather at 99.7% reliability would run 2km in Africa with at least 98% reliability. The main cause of interference in the UK is dense fog or heavy snow. In Africa, however, shimmer is likely to present the greatest problem.

Cost: \$7 425 for one Cablefree Lite operating at 10Mbps full-duplex with a range of at least 1km (two required for one link).

#### **5.12.2 Jolt**

JOLT offers the UWIN, OmniBeam and PhoneLink series of Infrared-based products. Using LED and laser technology, the links operate at data rates up to 155 Mbps, and can be installed either indoors or outdoors. The different products provide support for a wide range of protocols and interfaces including: ATM, FDDI, Ethernet, T3, Token Ring, PABXs (T1/E1), analogue video and multi-plexed data and voice. The range of the links vary from 250metres to 1200 metres, depending on the product.

### **5.13 Solar Power Systems**

#### **5.13.1 Solar Energy Industries Association**

SEIA is a national trade group (USA) for commercial enterprises involved in solar energy. It has close associations with the World Bank and other multi-national development banks. SEIA provides export-related support to its members as well as produces publications and puts on conferences.

#### **5.13.2 Canadian Solar Industries Association**

The CanSIA aims to develop a strong, efficient, ethical, and professional Canadian solar industry and to service and expanding domestic and international energy market.

#### **5.13.3 SunLight Power International**

SunLight Power International aims is to provide affordable, high-quality and profitable solar electric services to rural un-electrified populations around the world. Founded in 1997, SunLight Power offers fee-for-service, cash and credit payments for packaged solar systems and follow-up services--including delivery, installation, customer education, and follow-up maintenance. Their systems are typically in the 25-75 watt range.

#### **5.13.4 Energy PhotoVoltaics, Inc.**

EPV is engaged in the manufacture of PhotoVoltaic (PV) modules that are cost competitive with utility-generated electricity. Their mission includes conducting research and development on thin film PV devices, manufacturing turn-key PV systems, and building integrated PV modules for power stations. In the 1980s, EPV built eight large PV factories around the world.

#### **5.13.5 Siemens Solar**

Siemens Solar is a leading manufacturer of solar modules. In 1996 they had supplied a cumulative peak output of 100 Megawatts, an amount equal to approximately 20% of the PV power installed around the world

#### **5.13.6 Solarex**

Solarex is the largest US manufacturer of polycrystalline silicon PhotoVoltaic modules and cells (second largest in the world), and a leader in the developing field of thin-film silicon technology, with offices world-wide. In addition to their own capabilities, Solarex is allied with a number of other firms providing complementary products and services.

#### **5.13.7 AstroPower**

AstroPower provides solar electrical power products aimed at meeting the unserved needs for on-site production of electricity. AstroPower manufactures 5 and 6 inch single crystal solar cells--the largest and most powerful on the market today (each rated between 1.5 and 3.3 watts each. Their PV modules are available in rated powers up to 120 W peak, but also available up to 480 W in a single unit.

#### **5.13.8 BP Solar**

BP Solar, a subsidiary of British Petroleum Company, one of the largest companies involved in the design, manufacture, and installation of PhotoVoltaic systems, selling their products in over 60 countries around the world. In addition, they are a leader in the development of thin-film technology. They have been actively engaged in powering telecommunications systems in rural/remote areas.

#### **5.13.9 Kyocera Corporation**

Kyocera, is a large Japanese-based company with many product lines; one being the manufacturer, distribution and servicing of solar-based energy and heating systems. These systems include those that are connected to public utility systems as well as those that operate in a stand-alone, "satellite" operation.

#### **5.13.10 Spire Corporation**

Spire offers a range of solar products and support, including solar cell and module materials supply, engineering, marketing, and systems design. They are especially active in developing countries--providing turn-key production lines for module, cell, and wafer manufacturing in capacities up to 25 Megawatts/year.



## 6. DIRECTORY OF SOURCES, EQUIPMENT & SERVICE SUPPLIERS

### 6.1 Support Organisations and Web Sites:

Advanced Communications Technology Satellite (ACTS) <http://kronos.lerc.nasa.gov/acts/acts.html> The Advanced Communications Technology Satellite (ACTS) undertakes development of high-risk, advanced communications satellite technology.

AMT Home Page <http://haagar.jpl.nasa.gov/sec339/3392/amt.html>. The ACTS Mobile Terminal (AMT) is a proof of concept designed to incorporate solutions devised to overcome the challenges of Ka-band land mobile.

Berkeley Wireless Research Centre <http://infopad.eecs.berkeley.edu/BWRC> University of California at Berkeley. Designs low-power integrated circuits (both analogue and digital) small size wireless radio systems for a wide variety of applications. Has a 100Mbps/sec wireless project.

Bluetooth <http://www.bluetooth.com> A new short distance wireless data communication standard for mobile office devices

Canadian Centre for Marine Communications (CCMC) <http://www.ifmt.nf.ca/~ccmc>

Canadian Radio and Telecommunication Commission <http://www.crtc.gc.ca>

CDMA Development Group <http://www.cdg.org> Association of CDMA manufacturers.

DECT Forum <http://www.dect.ch>

European Telecommunications Standards Institute <http://www.etsi.org>

Federal Communications Commission <http://www.fcc.gov>

File Mobility Group <http://ficus-www.cs.ucla.edu>

GSM MoU Association <http://www.gsmworld.com/gsminfo/gsminfo.htm>

HealthNet <http://www.healthnet.org>

Internet Engineering Task Force (IETF) <http://www.ietf.cnri.reston.va.us/home.html> The primary standards making body of the Internet. The IETF's Mobile-IP Working Group is in the process of defining an official Mobile-IP standard.

International Development Research Centre Acacia Programme <http://www.idrc.ca/acacia> Multimillion dollar programme to support the use of ICTs in community development in Africa

Institute for Telecom Research (ITR) <http://www.itr.unisa.edu.au/home1.html>. ITR does research and postgraduate studies of the applications of coding, signal processing and systems engineering.

International Telecommunication Union (ITU) <http://www.itu.int>. The ITU, headquartered in Geneva, Switzerland is an international organisation within which governments and the private sector co-ordinate global Telecom networks and services.

Linux Mobile-IP <http://anchor.cs.binghamton.edu/~mobileip>

Linux IEEE WaveLAN development <http://www.fasta.fh-dortmund.de/users/andy/wvlan> WaveLAN/IEEE drivers for Linux

Mobile Computing Lab <http://www.mcl.cs.columbia.edu>

Mobile and Wireless Computing Index - University of Washington  
<http://snapple.cs.washington.edu/mobile>

National Science Foundation Wireless Field Trials <http://wireless.oldcolo.com> Systems tested: Xircom Wireless LAN, Metricom, Ricochet Wireless Modems, FreeWave 115kbs Radios, Solectek Airlan 200E systems, AT&T/Lucent Wireless LAN Cards, BreezeCom Wireless Bridge and Wireless Access Points and Wi-LAN 1.54Mbps 'Hopper' Wireless LANs  
2502 West Colorado Ave., Suite 203; Colorado Springs, CO 80904; Voice +1-719.636.2040; Fax +1-719.528.5869

Ottawa Packet Radio Group <http://hydra.carleton.ca>

Office of Frequency Management - US frequency allocations  
<http://www.ntia.doc.gov/osmhome/allochrt.pdf>

Network Engineering and Wireless Telecommunications research group (NEWTON).  
Electrical Engineering dept, Arizona State University. [rho@asu.edu](mailto:rho@asu.edu)

New Space Network <http://www.newspace.com>. The New Space Network is an information clearinghouse for anyone interested in small and low cost space programs.

NASA <http://www.nasa.gov>

NASA New Products Development Group <http://newproducts.jpl.nasa.gov/npd/projdesc.html>

National Oceanic and Atmospheric Administration (NOAA, USA) <http://www.noaa.gov>

National Telecommunications and Information Agency <http://www.ntia.doc.gov>

Nomadic Research Labs <http://microship.ucsd.edu>

PANSAT <http://www.sp.nps.navy.mil/pansat/pansat.html>.

RF Globalnet <http://www.rfglobalnet.com> Online community for RF/Microwave and Wireless engineers, supported in-part by MTT, a society of IEEE.

Satellite Communications Research Centre <http://audrey.levels.unisa.edu.au/dcg/scrc/scrc.html>. The

charter of the SCRC is to provide highly specialised support in the field of communications technology to Australian industry

Satellite Communications Systems and Technology Group.

[http://144.126.176.213/AnnRprt93\\_94/SCST.htm](http://144.126.176.213/AnnRprt93_94/SCST.htm). The National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) commissioned a panel of U.S. experts to study the international status of satellite communications systems and technology.

SatelLife <http://www.healthnet.org> HealthNet LEO service and support provider

Satellite Systems and Technologies <http://rosa.vpcs.doc.ca>

SpectrumWare <http://www.tns.lcs.mit.edu/SpectrumWare/home.html>

Telecommunication Laboratory

<http://ee.oulu.fi/EE/Telecommunication.Laboratory/Telecommunication.Laboratory.html>

Telecommunications Research Center (TRC) Communications Group <http://emelc1.eas.asu.edu>

Transmitter Documentation Project <http://www.transmitter.org> A web site that deals with short-wave radio broadcast transmitters of all types.

Tucson Amateur Packet Radio group (TAPR) <http://www.tapr.org>

UMASS Wireless <http://www.ecs.umass.edu/ece/wireless>

Wireless Application Protocol (WAP) Forum <http://www.wapforum.org> Industry Group focussing on the links between wireless access and the Internet.

Wireless Computing Lab <http://www.pitt.edu/~ppd/wclpp>

Wireless Information Network Laboratory <http://winwww.rutgers.edu/pub/Index.html>

Webproforum <http://www.webproforum.com/amd> Wireless local loop 'tutorials' sponsored by the International Engineering Consortium

Wireless LAN Alliance <http://www.wlana.com> Industry trade association of wireless LAN vendors established to help educate the marketplace. rich@papr.com

Wireless LAN Group <http://www.ecs.umass.edu/ece/wireless>

Wireless LAN/MAN Modem Product Directory <http://hydra.carleton.ca/info/wlan.html> Barry McLarnon  
bm@hydra.carleton.ca

Wireless Libraries Homepage <http://www.duc.auburn.edu/~fostecd/docs/wireless.html>

Wireless Modems <http://pasture.ecn.purdue.edu/~laird/Electronics/wireless-modems>

## 6.2 Periodicals and News:

Canadian Space News <http://www.conveyor.com/space/news.html>

IEEE Communications Magazine <http://www.ieee.org/comsoc/commag.html>

Mobile Communications Newsletter <http://www.ibmpcug.co.uk/~scrfin/screen/others/mobile/mobbie.htm>

PCS Data Today <http://www.pcsdata.com>

Satellite Journal International - SJI <http://www.nmia.com/~roberts/sji/sj.html>

Spread Spectrum Scene Online <http://www.sss-mag.com>

TELE-Satellite Journal <http://xan.esrin.esa.it:2602/TELE-Satellite.html>

Wireless International Magazine <http://www.wireless.com.tw>

Wireless Local Loop World <http://www.telecomresearch.com>

Wireless Now news service <http://www.commnw.com/wirelessnow.html>

Wireless Web Pointers -- University of Waterloo, Shoshin Lab <http://ccnga.uwaterloo.ca/mobile/sites.html>

Wireless Week <http://www.wirelessweek.com>

World of Wireless Communications <http://www.wow-com.com>

## 6.3 Mailing Lists:

Gateway - An electronic discussion area for those interested in wireless-to-wireline connections. To subscribe send email to [listproc@vita.org](mailto:listproc@vita.org) and in the text of the message put: 'sub gateway yourname'  
WirelessNOW <http://www.wirelessnow.com> Variety of industry mailing lists (daily/digests), news briefs and analysis. Commercial, free trial.

## 6.4 UseNet News Groups:

Wireless Standards Newsgroup news:comp.std.wireless

Electronics Repair news:sci.electronics.repair

## 6.5 Training Courses:

Besser Associates <http://bessercourse.com> 3-4 day courses offered in a wide range of wireless and radio topics. Cost US\$720-1050

201 San Antonio Circle, Building E, Suite 280, Mountain View CA 94040, Tel: 1-650-949-3300 Fax: 1-650-949-4400 [info@bessercourse.com](mailto:info@bessercourse.com)

RF GlobalNet <http://www.rfglobalnet.com/educ/schedule.asp> - A large number of online Internet based courses by recognised experts. Courses cost \$500-\$1200USD.

TRA Telecommunications Training <http://www.tra.com/cgi-bin/ft-new/ID=0/uss7ain.htm> Understanding SS7, AIN and Wireless

Zsigo Wireless Data Consultants <http://www.zsigo.com>

East Lansing, Michigan, USA. Operates a wireless training lab, provides self-study courses, on-site training, seminars and consulting

## 6.6 Reports and Reference Works:

Wireless Village: A First-Mile-First Model. Nov 30 1998. Darrell E. Owen. [darrell\\_owen@email.msn.com](mailto:darrell_owen@email.msn.com)  
An excellent introduction to rural wireless local loop systems, looking at both the policy issues and the technologies.

ITU Handbook on "New Developments in Rural Telecommunications". Claude Garnier, Jan 1999. For Public Telecom Operators this is an indispensable resource published by ITU Telecommunications Development Bureau Study Group 2 - Handbooks for Developing Countries. Johan Ernberg [johan.ernberg@itu.int](mailto:johan.ernberg@itu.int) Aiming to provide information to assist in decision-making, emphasis has been placed on methodologies rather than specific recommendations.

ITU Handbook on Land Mobile (including Wireless Access) Vol. I: Wireless Access Local Loop.

[http://www.itu.int/itudoc/gs/subscirc/itu-r/209e\\_35981.html](http://www.itu.int/itudoc/gs/subscirc/itu-r/209e_35981.html)

ITU (203-8) Frequency Assignment Plans on CD-ROM - Edition - September 1998 (9)

[http://www.itu.int/itudoc/gs/subscirc/itu-r/203-8\\_50570.html](http://www.itu.int/itudoc/gs/subscirc/itu-r/203-8_50570.html)

ITU (219-8) The International Frequency List (IFL) on CD-ROM (9)

[http://www.itu.int/itudoc/gs/subscirc/itu-r/219-8\\_46631.html](http://www.itu.int/itudoc/gs/subscirc/itu-r/219-8_46631.html)

ITU (170) BR: ITU-R Handbook on "National Spectrum Management" 1995 (6)

[http://www.itu.int/itudoc/gs/subscirc/itu-r/170e\\_28602.html](http://www.itu.int/itudoc/gs/subscirc/itu-r/170e_28602.html)

BMI Techknowledge "Communications Technologies Handbook for Africa 1998" - <http://www.bmi-t.co.za>  
Haydon Saulez [haydon@bmi-t.co.za](mailto:haydon@bmi-t.co.za) Expensive (\$300), but includes country profiles of the infrastructure, users and regulations.

Principles of Spread Spectrum Communication <http://olt.et.tudelft.nl/~glas/ssc/techn/techniques.html>

## 6.7 Local suppliers - Antennae, Services, Systems Integrators and Installation

Note: many US and European suppliers will service other regions too.

### 6.7.1 Global:

All of the companies below have provided services in Africa and they also cover the rest of the world.

Global Telephone and Telecommunication (GT&T) Telink telephone extender and other wireless equipment supplier Tel: +32-10-45-79-75, Fax: +32-10-45-79-75 [gtt@mail.interpac.be](mailto:gtt@mail.interpac.be)

Lyman Bros <http://www.lymanbros.com> provides satellite telecommunications contracting and consulting. Specialises in emergency response, disaster recovery and transportable satellite systems.

International Centre for Theoretical Physics <http://www.ictp.trieste.it> Has assisted with WaveLAN and

BreezeCom at a number of Universities in Africa and elsewhere. Aeronomy and Radiopropagation Laboratory, Strada Costiera 11, 34014 Trieste, Italy. Tel: +39 40 2240331 Fax: +39 40 224604 Director:

Prof. Sandro M. Radicella, [rsandro@ictp.trieste.it](mailto:rsandro@ictp.trieste.it) Technical: Fulvio Postogna, [postogna@ictp.trieste.it](mailto:postogna@ictp.trieste.it)

Mission Aviation Fellowship <http://www.maf.org> HF/VHF Internet gateway service provider.

NSN Network Services <http://www.nsn.net> - Gilat and other VSAT equipment and satellite link reseller

VITA: Volunteers In Technical Assistance <http://www.vita.org> VitaSat operator

### 6.7.2 Africa:

BushNet <http://www.bushnet.net> African HF Internet gateway and broadband data/Internet link provider in Kampala

Citec <http://www.citec.co.za> Wireless LAN/MAN Internet service provider.

CyberTwig <http://www.twig.com> African HF radio Internet gateway and ISP in Dar es Salaam and Arusha.

Dimension Data <http://www.didata.co.za> BreezeCom, satellite equipment

Eduardo Mondlane University <http://www.ci.uem.mz> Mozambique ISP and wireless service provider. Can train and do remote installs on WaveLAN products.

EURAF <http://dtsdata.intnet.bj> Benin

Globalstar South Africa. Ben Higson, Project Director. Tel. +27 12 4212502. Fax. +27 12 4212507.

Grintek Communications Tel. +2712 810 1000 - Mr Jelliman

Infosat <http://www.infosat.co.za> DTH data broadcaster (like DirecPC) for Africa.  
Interpacket <http://www.interpacket.net> provides the 'Espresso' VSAT service with a large number of users in Africa. Julie Spira [jspira@interpacket.net](mailto:jspira@interpacket.net)  
Iridium Africa. Xoliswa Kakana, Regional Mgr Southern Africa, 884-9320, fax: 884-9046.  
[jgrege@mweb.co.za](mailto:jgrege@mweb.co.za)

Liebermann Communications / Alcom <http://www.alcom.co.za> Motorola and other radio equipment supplier

Johannesburg, South Africa. Mr. Jorge Ferreira, tel: +27 11 444 0444

MTDS <http://www.mtds.com> Karl Stanzick [karl@mtds.com](mailto:karl@mtds.com) VSAT and Spread Spectrum (Rooftop) installations, assessments and systems integration.

Olympic Communications Kenwood and other radio equipment suppliers/installers.

Johannesburg South Africa. CC Mr. Bosman, tel: +2712 331 0123

Plessey Solutions, <http://www.plessey.co.za> Satellite Communications Division. Hughes Network Systems VSATs service

provider. Bayan Monadjem, Tel. +27 83 677 1172. Fax. +27 11 266 0482. Johannesburg SA Email: [bm.plessey@pixie.co.za](mailto:bm.plessey@pixie.co.za)

QKon <http://www.qkon.com> wireless systems integrator and equipment supplier. ArLan/Aironet products

Radiospoor. <http://www.radiospoor.co.za> Lionel Naude, International Business Executive. Tel. +27 82 655 0890. Fax. +27 11 650 2252.

Siemens South Africa <http://www.siemens.co.za>

DECT cordless telephony systems. Stefan Skarabis, Tel. +27 12 352 5746 or +27 82 787 6859.

Telkom Satellite Solutions SA. <http://www.telkom.co.za> A space segment provider, Renette van Aswegen,

Tel. +27 82 573 9061. Fax. +27 12 311 4236. Email: [vaswegmm@telkom.co.za](mailto:vaswegmm@telkom.co.za) / Jason van Aardt, +27 12 311 2869. Fax +27 12 311 1776. Pretoria, South Africa.

Transtel <http://www.tnet.co.za> Satellite Communications Division, Kevin Finlay [kevinfi@tnet.co.za](mailto:kevinfi@tnet.co.za) Tel +27 11 774 8219.

Fax +27 11 774 8243. Johannesburg South Africa.

University of Dar es Salaam <http://www.udsm.ac.tz> Tanzanian SS LOS provider using WaveLAN products. Has developed its own antenna.

### 6.7.3 Americas:

KarlNet, Inc. <http://www.karlnet.com/wireless.html>

5030 Postlewaite Rd., Columbus, OH 43235-3450, Tel: 614-457-5275, Fax: 614-442-7599, Email: [sales@karlnet.com](mailto:sales@karlnet.com)

C-SPEC Corp. <http://www.c-spec.com> Spread Spectrum WAN/MAN products

20 Marco Lane, Dayton, OH 45458, Tel: 800-GOCSPEC or 937-439-2882, Fax: 937-439-2358 Email: [sales@c-spec.com](mailto:sales@c-spec.com)

Rock House International <http://www.rock2000.com> New York based supplier, GRE/GINA distributor

Winncom <http://www.winncom.com>

### 6.7.4 Asia:

Camalex Pty.

245 Hamersley Rd, Subiaco WA 6008, Australia. Tel: 61-2-449-8133 Fax: 61-9-381-5163

Clover Solutions Pty.

16 Suakin St, Pymble, NSW 2073, Australia. Tel: 61-2-449-8133 Fax: 61-2-488-9450

### 6.7.5 Europe:

ASK Communications

3 Milbanke Court Way, Bracknell, Berks. RG12 1BR, UK. Tel: +44-1344-483-999 Fax: +44-1344-485060

## 6.8 Equipment Manufacturers and Service Providers

3Com Corporation <http://www.3com.com>

Advanced Charger Technology <http://www.actcharge.com>

80 Engineering Dr. Suite 180, Norcross, GA 30092. Phone: 770-582-0001, Fax: 770-582-0003. E-mail: [sales@actcharge.com](mailto:sales@actcharge.com)

ACT manufactures the ACTivator line of two-way radio battery chargers.

Advanced Research Projects Agency <http://www.arpa.mil>

Advanced Satellite Consulting <http://dSPACE.dial.pipex.com/adsc>. The home page of Alex da Silva Curiel, independent consultant on mobile satellite communication, and until recently Director of Operations at Inmarsat, the International Mobile Satellite Organisation in London.

Aegis <http://www.demon.co.uk/aegis>. Aegis Systems Ltd offers expertise in radio frequency spectrum engineering, including interference analysis, propagation modelling, etc.

Air Communications <http://www.aircomm.com>

Aerospace Consulting <http://www.aeroconsult.com>

Aerotron-Repco Sales, Inc. <http://aerotron-repco.com/nlr.html>  
2400 Sand Lake Road, Orlando, FL 32809-7666 USA. Tel: 800-950-5633/407-856-1953 Fax: 407-856-1960

Aironet Wireless Communications, Inc. <http://www.aironet.com>  
367 Ghent Road, Suite 300, Akron, OH 44334-0292, Tel: 800-394-7353 or 330-665-7900, Fax: 330-665-7922, Email: sales@aironet.com

AIRplex Cordless Modems <http://www.kme.com>

AirTouch Cellular's Data Hut <http://datahut.airtouch.net>

Alcatel <http://www.alcatel.com>

Alice WorldView <http://www.alice.com>

Altwater Gruppe <http://www.altwater.com/index.en.html>  
Riemenstrasse 30 - D-74906, Bad Rappenau, Germany, Tel: +49-7264/804-0, Fax: +49-7264/804-210, Email: info@altwater.com

Allied Access, Inc. <http://www.intrnet.net>

Andrew Satellite Communication Systems <http://www.andrew.com/esag0001.htm>. A leading satellite ground segment equipment manufacturing.

Antenex, Inc. <http://www.antenex.com> Antennae  
2000-205 Bloomingdale Road, Glendale Heights, IL 60139 USA, Tel: 800-323-3757 or 630-351-9007, Fax: 630-351-9009, Email: sales@antenex.com

Apple <http://www.apple.com/documents/fcc.html>

Applied Wave Research - <http://users.deltanet.com/~pekarek> Microwave and Electromagnetic Software and Consulting

ARDIS <http://www.ardis.com>

Arrick Robotics <http://www.robotics.com/oci.html> Robotics equipment supplier with the Lawn wireless link.

AstroComPage <http://infoweb.magi.com/~bcblevis/astrocom.html>

Astron Antenna Co. <http://www.astronantennas.com>  
22560 Glenn Drive, Suite 114, Sterling, VA 20164-4440, Tel: 703-450-5517, Fax: :703-450-9753, Email: astronco@monumental.com

AstroPower <http://www.astropower.com> Solar Power manufacturer

Atec, Inc. <http://www.sccsi.com/Atec/rflink.html>

Atlantic Communications Enterprises <http://www.newcomm.net/webpage/ace>. ATLANTIC COMMUNICATIONS Ltd. offers unlimited flexibility in the design of comprehensive turnkey communications projects.

AT&T Wireless Services <http://www.attws.com>

Aurastar Satellite Communications Analysis Software <http://www.aurastar.com/satcom.html>. Software Tools & Services for Telecommunications Regulators, Voice and Data Carriers, Broadcasters and Satellite System Operators.

Aviator <http://www.mmicro.com/momentum>

Bay Networks <http://www.netwave-wireless.com>

Belcom <http://www.belcom.net>

BellSouth Cellular Corp <http://www.com/bssc>

BellSouth Mobile Data <http://www.data-mobile.com>

BP Solar <http://www.pb.com/bpsolar>

Breeze Wireless Communications <http://www.breezecom.com>  
Breeze was previously called Lannair. 2195 Faraday Ave, Suite A, Carlsbad, CA 92008, Tel: 619-431-9880, Fax: 619-431-2595

British National Space Centre <http://www.open.gov.uk/bnsc/bnschome.htm>. Involved in some mobile satellite communications research.

Cable and Wireless <http://cwix.com/cwplc>. Company that owns mobile satellite service providers.

Cablefree Solutions <http://www.cablefree.co.uk> Infrared short distance high-speed data transmission using infrared

Cabletron Systems <http://www.cabletron.com> Lucent WaveLAN technology integrator.  
35 Industrial Way, Rochester, NH 03867-5005, Tel: 603-332-9400, Fax: 603-337-2211

Cal Corporation <http://www.calcorp.com/aboutcal.htm>. Manufacturer of mobile satellite communications terminals .

California Amplifier <http://www2.calamp.com/calamp/mmds/parabolic.html>  
460 Calle San Pablo, Camarillo, CA 93102, Tel: 805-987-9000, Fax: 805-987-8359, Email: sales@calamp.com

Canadian Solar Power Industries Association <http://www.ctn.nrc.ca/on/content/type15/org1282/parent.htm>

Cancom <http://www.cancom.net>. Canadian Satellite Service Provider.

Cellular Telecommunications Industry Association (CTIA) <http://www.cityscape.co.uk/cgi-bin/dat2html?file=8616>. The membership of the association has been expanded to cover all Commercial Mobile Radio Service providers, including cellular, personal communications services, enhanced specialised mobile radio, and mobile satellite services.

Cincinnati Microwave <http://www.cnmw.com>

CIT Research <http://www.citresearch.com/about.htm>. CIT is a market research company specialising in the international communications industry, principally covers Europe and the Asia-Pacific region.

Clarion

2-22-3, Sibuya, Shibuya-ku, Tokyo 150, Japan, Tel: (03)3400-1121 USA: 201-818-1166, Fax: (03)3400-8505 USA: 201-818-1317

Communications Standards <http://www.csrstds.com>

Community Information Delivery Services (CiDS) <http://www.cids.org.za>

Comsat <http://www.comsat.com>. Providers of mobile satcom services and systems.

ComSym [http://www.wp.com/comsym\\_uk/home.html](http://www.wp.com/comsym_uk/home.html). ComSym Limited is a UK registered Consultancy, offering a wide range of satellite communications services to the world's communications and space industries.

Conifer Corp. <http://www.conifercorp.com/intro.html>

1400 N. Roosevelt Avenue, Burlington, Iowa 52601 USA, Tel: 800-843-5419 or 319-752-3607, Fax: 319-753-5508, Email: [conifer@conifercorp.com](mailto:conifer@conifercorp.com) Supplier of Antennae.

CRL (Central Research Laboratories) Ltd. <http://www.crl.co.uk>

Dawley Road, Hayes, Middlesex, UK UB3 1HH, Tel: +44 (0)181 848 6661, Email: [jbates@crl.co.uk](mailto:jbates@crl.co.uk)

C-SPEC Corp. <http://www.c-spec.com> Spread Spectrum WAN/MAN products

20 Marco Lane, Dayton, OH 45458, Tel: 800-GOCSPEC or 937-439-2882, Fax: 937-439-2358 Email: [sales@c-spec.com](mailto:sales@c-spec.com)

CTA Space Systems <http://lois.space.cta.com/index.html>. GEMStar (non-profit email satellite) via GEMnet, CTA's little LEO system.

Cushcraft Corp. <http://www.cushcraft.com>

48 Perimeter Road, Manchester, NH 03103 USA, Tel: 800-258-3860 or 603-627-7877, Fax: 800-258-3868 or 603-627-1764, Email: [sales@cushcraft.com](mailto:sales@cushcraft.com)

CWI Online <http://techweb.cmp.com/techweb/cwi/current>. Communications Week International

Cylink AirLink <http://www.cylink.com> One of the leading SS hardware manufacturers

910 Hermosa Court, Sunnyvale, CA 94086 USA, Tel: 408-735-5800, Fax: 408-735-6643, Email: [info@cylink.com](mailto:info@cylink.com)

Data Communications Technologies

2200 Gateway Centre Blvd, Suite 201, Morrisville, NC 27560-9122 USA, Tel: 1-800-344-1395, Fax: 919-462-0300, Email: [sales@dctcorp.com](mailto:sales@dctcorp.com)

DATA-LINC Group <http://www.wolfenet.com/~datalinc>

2635 151st Place N.E., Redmond, WA 98052-5562, Tel: 206-882-2206 or 425-882-2206, Fax: 206-867-0865 or 425-867-0865, Email: [info@data-linc.com](mailto:info@data-linc.com)

Data TeleMark <http://www.mnsinc.com/datatele/mark/dtm.html>

Data Communications Technologies (DCT) <http://www.dctcorp.com>

Deutsche Telecom <http://www.dtag.de/dtag>. Mobile satellite service provider

Digital Equipment Corp. <http://www.networks.digital.com>

Maynard, MA, Tel: 508-493-5111

Digital Transmission Systems, Inc (DTS). <http://www.dtsx.com>

3000 Northwoods Parkway (Bldg. 330), Norcross, GA 30071, Tel: 770-798-1300, Fax: 770-798-1325, Email: [info@dtsx.com](mailto:info@dtsx.com)

Dish Network <http://www.dishnetwork.com> DBS service provider

Diva Communications <http://www.diva.com> Wireless access equipment

32930 Alvarado-Niles Rd, Union City, CA 94587, US +1-510-476-5500, fax: +1-510-476-5501  
[info@diva.com](mailto:info@diva.com)

DLI Datalink International <http://www.axionet.com/dli>

EchoStar <http://www.echostar.com> Data broadcasting service provider

Electromagnetic Sciences Inc. (ELMG) <http://www.elmg.com>. Electromagnetic Sciences Inc. now includes three subsidiaries that work in wireless data and mobile satcoms systems.

Ellipso Mobile Communications Satellite System <http://www.ellipso.com>

ELIRIS Inc. <http://www.soonet.ca/eliris/eliris.htm>. Involved in the fields of GPS, GIS, and vehicle tracking. Currently using UHF/VHF packet radio modems - soon to be satellite based

Energy PhotoVoltaics <http://www.epv.net> Solar power systems

Ericsson <http://www.ericsson.se>. Cellular and wireless local loop equipment manufacturer

ESA <http://www.esrin.esa.it>

etiGATE <http://starbase.NeoSoft.com/~eti>. Provides consulting and systems integration for distance-

insensitive and seamless connections between remote sites and home offices. European Telecommunications Satellite Organisation <http://www.eutelsat.org>  
Freespace InterBuilding Links <http://www.silcomtech.com>  
FreeWave Technologies <http://www.freewave.com> Makers of the SpeedLAN  
1898 Flatiron Court - Suite 2B, Boulder CO 80301, 303-444-3862, 303-786-9948  
French Space Agency (CNES) <http://www.cnes.fr>  
Frost & Sullivan Home Page <http://www.frost.com>. Help clients become more market-focused by providing the critical market measurements and information they need to be proactive in the marketplace.  
Gabriel Electronics Inc. <http://www.gabrielnet.com>  
P.O. Box 70, Scarborough, ME 04070 USA, Tel: 207-883-5161, Fax: 207-883-4469, Email: [info@gabrielnet.com](mailto:info@gabrielnet.com)  
GE SpaceNet <http://www.spacenet.com> VSAT internet service now a Gilat subsidiary. GLB Wireless Data Systems <http://www.glb.com> telephone line extenders and WLL systems Tel: 1-905-878-7794, Fax: 1-905-878-2544 [sales@glb.com](mailto:sales@glb.com)  
Gilat Satellite Networks <http://www.gilat.com> VSAT manufacturer see also <http://www.spacenet.com>  
Glenayre Western Multiplex Corp. <http://www.glenayre.com> / <http://www.wirelessinterconnect.com>  
1196 Borregas Avenue, Sunnyvale, CA 94089-1302, Tel: 408-542-5200, Fax: 408-542-5300  
Globalstar <http://www.globalstar.com> GMPCS  
GlobeSat Inc. Home Page <http://www.globesat.com>. Manufacturer of Inmarsat satellite terminals.  
Granite <http://home.navisoft.com/granite/index.htm>  
Granger Telecom <http://www.granger-tele.com> Wireless local loop (WLL) vendor Roy Walker [roy.walker@granger-tele.com](mailto:roy.walker@granger-tele.com)  
GRE America <http://www.greamerica.com/~gre>  
425 Harbor Blvd., Belmont, CA 94002, Tel: 800-233-5973 or 415-591-1400, Fax: 415-591-2001, Email: [gre@greamerica.com](mailto:gre@greamerica.com)  
GTE Mobilenet <http://www.wireless-gte.com>  
GTE Wireless Data Services <http://www.datalife.gtem.com>  
Halo <http://www.angelcorp.com>  
Harris Semiconductor [http://www.semi.harris.com/feature\\_product](http://www.semi.harris.com/feature_product)  
Harris Allied Broadcast Equipment <http://www.broadcast.harris.com>  
HHCA, Inc. <http://bertha.chattanooga.net/HHCA>  
HIPERLAN <http://www.atg.apple.com/areas/wireless/default.html>  
Hiperlan/Netplan <http://www.netplan.dk/netplan>  
Hughes Electronics Corporation <http://www.hughes.com>. General link to a number of Hughes sites .  
Hughes Network Systems <http://www.hns.com>  
Hummingbird <http://www.xetron.com/900xcvr.htm>  
Hybrid <http://www.hybrid.com>  
IBM Wireless/Mobile <http://www.raleigh.ibm.com/wir/wireprod.html>  
700 Park Office Road, Highway 54, Building 662, Research Triangle Park, NC 27709, Tel: 919-543-7708, Fax: 919-543-5568  
ICO Global Communications <http://www.i-co.co.uk>  
IETF <http://www.ietf.cnri.reston.va.us/home.html>  
Industry Canada - Emergency Telecommunications <http://hoshi.cic.sfu.ca/ic>  
Inet, Inc <http://www.inetinc.com>  
Inficom, Inc. <http://www.inficom.com>  
645 Southcenter, Suite 343, Seattle, WA, USA 98188-2836, Tel: 206-865-9753, Fax: 206-562-6066, Email: [inficom@inficom.com](mailto:inficom@inficom.com)  
InfoSat Telecommunications <http://www.nav.ca>. Canada's wireless communications experts. Infosat provides remote voice, fax, data, and video services using SkyCom, MSAT, DirecPC, VSAT, INMARSAT, and digital radio.  
InfoWave <http://www.gdt.com>  
INMARSAT <http://www.inmarsat.int/inmarsat>  
InTalk Inc. <http://www.intalk.com>  
P.O. Box 2181, Melbourne, FL, USA 32901, Tel: 800-510-1516 or 407-724-7972, Fax: 407-724-7886, Email: [sales@intalk.com](mailto:sales@intalk.com)  
Intelsat <http://www.intelsat.int>  
Intermec Technologies <http://www.intermec.com>  
International Datacasting Corporation <http://www.intldata.ca> Canadian satellite broadcasting manufacturer  
Interpacket <http://www.interpacket.net> Espresso VSAT service. Julie Spira [jspira@interpacket.net](mailto:jspira@interpacket.net)  
International Satellite Integration Services, Inc <http://www.intr.net> Telecommunication Consultants specialising in satellite solutions to organisational communications problems world-wide, including mobile applications.  
iPost Services <http://www.ipost.net>

Iridium <http://www.iridium.com/english/prodserv/products/index.html>  
ITC Home Page <http://www.telematrix.com>. ITC - International Telecommunications Center - devoted exclusively to telecommunications, data communications and networking. Has some mobile satellite communications info.  
Jolt <http://www.jolt.co.il> Optic systems  
8 Hamarpeh Street, Building 12, Har Hahotzvim, Jerusalem 97774, ISRAEL, Phone : + 972 2 586 9005, Fax : + 972 2 586 9006, Email : sales@jolt.co.il  
Kavicom International <http://www.kavicom.qc.ca>  
217-3860 Cote Vertu, St Laurent, QU Canada H4R 1V4, Phone: 1-514-337-5757. Fax: 1-514-337-5858  
Trunking systems, repeaters, GPS, AVL and radios.  
KDD Labs <http://w3.lab.kdd.co.jp>. KDD owns various mobile satellite stations and systems.  
Kenwood <http://www.kenwoodcorp.com>  
Kingston Satellite (KSS) <http://www.kingston-satellite.com> satellite services  
Kyler Laird <http://pasture.ecn.purdue.edu/~laird/Kyler/info.html>  
Kyocera <http://www.kyocera.co.jp/index-e.html> Solar Power manufacturer  
Larsen Electronics, Inc. <http://www.larsenet.com>  
3611 N.E. 112th Avenue, Vancouver, WA 98682, Tel: 360-944-7551 or 800-426-1656, Fax: 360-944-7556, Email: larsen@larsenet.com  
LATNET <http://www.latnet.lv/LATNET>  
Leslie Taylor Associates, Inc <http://www.lta.com>. A telecommunications legal and consulting firm which specialises in satellite communications, spectrum management, U.S. and international regulation and ITU matters.  
LinCom Corporation <http://www.lincom.com>  
Logica Aldiscon <http://www.aldiscon.com>  
Lucent Technologies Inc. <http://www.wavelan.com> WaveLAN Commercial Sales  
Room 1H62, 5 Wood Hollow Road, Parsippany, NJ 07054, Tel: 201-581-4296/4297 or 1-800 WAVELAN, Fax: 201-581-4282, Email: support@wavelan.com  
Magic WAND (Wireless ATM Network Demonstrator) <http://www.tik.ee.ethz.ch/~wand>  
Maxrad, Inc. <http://www.maxrad.com>  
4350 Chandler Drive, Hanover Park, IL 60103, Tel: 800-323-9122, Fax: 630-372-8077, Email: sales@maxrad.com  
McCaw Cellular <http://www.cellular.com>  
MCS Group, Inc <http://www.themcsgroup.com>  
Memorial University of Newfoundland <http://alta.uccs.mun.ca>  
Metricom <http://www.metricom.com>  
980 University Ave., Los Gatos, CA 95030, Tel: 800-556-6123 or 408-399-8200, Email: info@metricom.com  
Microhard Systems Inc. <http://www.microhardcorp.com>  
#209, 12 Manning Close N.E., Calgary, AB, Canada T2E 7N6, Tel: 403-248-0028, Fax: 403-248-2762, Email: info@microhardcorp.com  
MICROTIK <http://www.mt.lv>  
Millennium Antenna Corp. <http://www.millenniumantenna.com>  
1001 Broad Street, Suite 401, Utica, NY 13501, Tel: 315-798-9374, Fax: 315-798-9431, Email: ask@millenniumantenna.com  
MIVS <http://www.igd.fhg.de/www/zqdv-mmivs/index.html>  
Mobile Mark, Inc. <http://www.mobilemark.com>  
3900-B River Road, Schiller Park, IL 60176 USA, Tel: 800-648-2800 or 847-671-6690, Fax: 847-671-6715, Email: sales@mobilemark.com  
SIA "Mikrotiks" <http://www.mt.lv>  
Aizkraukles iela 23, Riga, LV-1006, Latvia, Tel: +371 2 528 982, or +371 2 520 286, Fax: +371 7 542 530, Email: mt@mt.lv  
Mobile Communication Research <http://www.tde.lth.se/pcnh/ancor1.html>. Research being done at the department of applied electronics. - Lund University, Lund Institute of Technology.  
Mobile Communications <http://www.ibmcpug.co.uk/~scrfin/screen/others/mobile/mobbie.htm>. Mobile Communications is produced twice monthly by the X25 Partnership and published by Financial Times Business Information - the same team that puts together Screen Finance.  
Mobile Computing Lab <http://www.mcl.cs.columbia.edu>  
Mobile Datacom Corporation <http://www.rdss.com>. Mobile Datacom Corporation provides satellite-based data communication services and systems to mobile platforms, remote, and fixed site assets..  
Mobile Planet Online Catalog <http://www.mplanet.com>  
Mobile Telesystems, Inc <http://mti-usa.com>. A provider of Satellite Telephones designed to operate under the INMARSAT Satellite system.  
Mobile Solutions, Inc. <http://www.mobisol.com/index.html> Wireless software development and consulting.



Motorola <http://www.mot.com>

Motorola WLL <http://www.mot.com/CNSS/CIG/Products/WiLL>

Multicap

Antwerpsesteenweg 124/19, B-2630 Aartselaar, Belgium, Tel: +32 (0)3 877.44.80, Fax: +32 (0)3 887.10.16 [multicap@eunet.be](mailto:multicap@eunet.be)

Multipoint Networks Inc. <http://www.multipoint.com>

19 Davis Drive, Belmont, CA 94002, Tel: 650-595-3300, Fax: 650-595-2417, Email: [sales@multipoint.com](mailto:sales@multipoint.com),

Navisoft <http://home.navisoft.com>

Nera <http://www.nera.no> Inmarsat supplier / wireless trunking systems

Netwave <http://www.netwave-wireless.com>

NOCOM <http://www.nocom.se>

Nokia <http://www.nokia.com>

Nomadic Technologies <http://www.robots.com>

2133 Leghorn Street, Mountain View, CA 94043, Tel: 415-988-7200, Fax: 415-988-7201, Email: [nomad@robots.com](mailto:nomad@robots.com)

Nomadic'96 <http://www.tticom.com/nomadic>

Nomadic Technologies <http://www.robots.com>

2133 Leghorn Street, Mountain View, CA 94043, Tel: 415-988-7200, Fax: 415-988-7201, Email: [nomad@robots.com](mailto:nomad@robots.com)

Norand Corporation <http://www.norand.com>

550 2nd Street SE, Cedar Rapids, IA 52401, Tel: 319-369-3100 or 800-553-5971, Fax: 319-369-3453, Email: [info@norand.com](mailto:info@norand.com)

Nortel <http://www.nortel.com/wireless> (Northern Telecom) WLL and digital powerline manufacturer

Novacom Home Page <http://www.clark.net/pub/novacom/homepage.htm>. Satellite communications systems consultant

Nu-Metrics <http://www.nu-metrics.com>

Box 518, University Drive, Uniontown, PA 15401, Tel: 412-438-8750 or 800-346-2025, Fax: 412-438-8769, Email: [sales@nu-metrics.com](mailto:sales@nu-metrics.com)

Nusantara Communications <http://www.nci-arts.com> Indian WLL manufacturer

Omnes <http://www.omnes.net>. A joint venture between Schlumberger and Cable & Wireless, was created to provide global communications solutions to the energy business sector - including some mobile comms.

On The Move <http://www.sics.se/~onthemove>

O'Neill Connectivities, Inc. <http://www.ocilawn.com>

607 Horsham Road, Horsham, PA 19044, Tel: 800-624-5296 or 215-957-5408, Fax: 215-957-6633

OPTUS Communications <http://cwix.com/cwplc/fedoz.htm>. Mobile satcoms service provider in Australia.

Optaphone Systems <http://www.asis.com/optaphone> US WLL manufacturer

ORA Electronics <http://www.oraus.com>

ORBCOMM <http://www.orbcomm.net>

OTC Telecom <http://www.ezylink.com>

2036 Bering Drive, San Jose, CA 95131, Tel: 800-770-6698 or 408-245-6888, Fax: 408-245-8886, Email: [otcsales@ezylink.com](mailto:otcsales@ezylink.com)

P-COM Inc. <http://www.p-com.com/products/spreadspec.html>

3175 S. Winchester Blvd., Campbell, CA 95008, Tel: 408-866-3666 or 1-800-646-PCOM (7266), Fax: 408-866-3655

Paccomm <http://www.paccomm.com> Low cost packet radio and VHF supplier.

Pacific Communication <http://www.pcsi.com>

PageSat <http://www.pagesat.com> satellite broadcasting services

PanamSat <http://www.panamsat.com> the first private sector Satellite operator, now with global coverage.

Pepper & Corazzini L.L.P. <http://www.commlaw.com/p-and-c>. The law firm specializes in communications, telecommunications, Internet and on-line services law.

Persoft, Inc. <http://www.persoft.com>

465 Science Dr, PO Box 44953, Madison, WI 53744-4953, Tel: 800-368-5283 or 608-273-4357

Phil Karn's, KA9Q <http://www.qualcomm.com/people/pkarn>

Philips homepage <http://www.philips.com>

PickSat <http://www.picksat.com> Specializes in the delivery of Internet and high-speed broadcast and interactive services via satellite [kuijcki@am.umc.ce.philips.nl](mailto:kuijcki@am.umc.ce.philips.nl)

PICOCOM <http://www.chi.de>

Pinpoint Communications Inc <http://www.avl.com>

Portable Products <http://www.portableproducts.com>

Proxim, Inc. <http://www.proxim.com>

295 North Bernardo Ave., Mountain View, CA 94043 Tel: 800-229-1630 or 415-960-1630, Fax: 415-960-

1984, Email: sales@proxim.com  
Qualcomm <http://www.qualcomm.com>  
Quest Telecom International <http://www.hypernet.com/quest.html>. n Inmarsat Partnership Company providing consultation on mobile satcom equipment and services by assisting prospective users and operators planning to purchase Inmarsat satellite telephone systems.  
Racal <http://www.racalcanada.com> Javelin radio. Berge Tuysuzian Tuysuzi@racalcanada.com  
RadioConnect Corporation <http://www.radioconnect.com>  
6041 Bristol Parkway, Culver City, California 90230, Tel: 310-338-3388, Fax: 310-338-3399, Email: info@radioconnect.com  
RadioLAN <http://www.radiolan.com>  
455 DeGuigne Drive, Suite D, Sunnyvale, CA, Tel: 408-524-2600 or 888-2RadioLAN, Fax: 408-524-0600, Email: sales@radiolan.com  
RadioMail Corporation <http://www.radiomail.net>  
Radiometrix <http://www.radiometrix.co.uk>  
Radiosat <http://www.radiosat.com>  
Radioware <http://www.radio-ware.com>  
PO Box 1478, Westford MA 01863, USA, Tel: 800-950-9273 or 603-899-6959, Fax: 800-903-2987 or 508-251-0515, Email: radware@radio-ware.com  
Radio Waves, Inc. <http://www.radiowavesinc.com>  
267 Boston Road Corporate Place, Billerica, MA 01862 USA, Tel: 508-663-5777, Fax: 508-663-6226, Email: info@radiowavesinc.com  
RAM Mobile Data <http://www.ram.co.uk>  
Raytheon Wireless Solutions <http://www.raylink.com>  
RDC Communications Ltd. <http://www.rdccom.com>  
1 Hamelacha Street, Lod 71293, Israel, Tel: +972-8-977-7000, Fax: +977-8-977-7050, Email: support@rdccom.com  
Remote Satellite Systems International <http://www.remotesatellite.com>. Specializing in Remote Connectivity, systems integration, sales, and engineering support.  
Raytheon Electronics <http://www.raytheon.com>  
362 Lowell Street, Andover, MA 01810, Tel: 508-470-9011, Fax: 508-470-9452, Email: raylink@raytheon.com  
Ricochet <http://www.metricom.com> (See Metricom)  
RoamAbout Wireless-to-Wired Access Point <http://www.digital.com/info/infosheet/EC-F2666-42.txt.html>  
Lucent WaveLan product.  
Rooftop <http://www.rooftop.com>  
SatCorp Communications Inc <http://www.satcorp.com>. Through satellite and radio links, SatCorp equipment connects groups of mobile, or isolated rural, or fixed location users to the information superhighway.  
Satellite Telephone <http://www.satellitetelephone.com>  
Scientific-Atlanta Home Page <http://www.sciatl.com>  
Seanet <http://vislab-www.nps.navy.mil/~seanet>  
Seavey Engineering Associates, Inc. <http://www.seaveyantenna.com>  
135 King Street, Cohasset, MA 02025 USA Tel: 617-383-9722, Fax: 617-383-2089, Email: info@seaveyantenna.com  
Siemens <http://www.siemens.com>  
Siemens Solar <http://www.solarpv.com>  
Sierra Wireless <http://www.sierrawireless.com>  
Signal Processors Ltd <http://www.cityscape.co.uk/cgi-bin/dat2html?file=10716>. Manufacturers of satellite modems and other related equipment.  
Skybridge <http://www.skybridgesatellite.com>  
Sky Station <http://www.skystation.com> Stratospheric Platforms providing broadband comms for metropolitan areas.  
SkyStream <http://www.skystream.com> Data broadcasting service  
Socket Communications, Inc <http://www.socketcom.com>  
Solar Energy Industries Association <http://www.seia.org>  
Solarex <http://www.solarex.com>  
Solectek Corporation <http://www.solectek.com>  
Spacelink International <http://www.sat2net.com> VSAT-based ISP-in-a-box solution  
Spacenet <http://www.spacenet.com> Gilat VSAT services company, recently merged with GE Spacenet  
6370 Nancy Ridge Drive, Suite 109, San Diego, CA 92121-3212, Tel: 800-437-1518 or 619-450-1220, Fax: 619/457-2681  
Spectrum - Shuken <http://www.iwe.com/spectrum>. A global network of satcom system and equipment engineers and marketing professionals.

Spectrum Guide <http://home.navisoft.com/nspi>  
Speedcom <http://www.the-wave-wireless.com> SpeedLan manufacturer - see below.  
Speedlan <http://www.speedlan.com>  
Speedycom International <http://www.iinet.com.au/~speedy>  
Spire <http://www.spirecorp.com> Solar Power supplier  
Spread Spectrum Research <http://ee.oulu.fi/~tipe/ann.rep/res.list.html>  
SRC - Subscriber Radio Communications - Joint venture between SR Telecoms and Plessey in South Africa.  
SR Telecom <http://www.srtelecom.com>  
Sunlight Power International <http://www.ttcorp.com/sunlight> Solar Power Systems  
Symbol Technologies, Inc. <http://www.symbol.com>  
116 Wilbur Place, Bohemia, NY 11716, Tel: 800-SCAN 234 or 516-563-2400, Fax: 516-563-2831  
Tachyon <http://www.tachyon.net> New high-speed low cost VSAT Internet service provider  
TDK Systems <http://www.tdksystems.com>  
Techlock Distributing <http://www.erinet.com/kenny>. Microwave and RF component supplier.  
Tecom Industries, Inc. <http://www.tecom-ind.com/wireles.htm>  
9324 Topanga Canyon Blvd, Chatsworth, CA 91311, Tel: 818-341-4010, Fax: 818-718-1402, Email: [webmaster@tecom-ind.com](mailto:webmaster@tecom-ind.com)  
TekNow, Inc <http://www.teknow.com>  
Teledesic <http://www.teledesic.com>  
Teleglobe Canada <http://www.Teleglobe.ca> Providers of fixed and mobile satcom services.  
Telenor <http://www.telenor.no>. Norwegian Mobile Satellite Service Provider.  
Teletronics <http://www.teletronics.com>  
1803 Research Blvd., Suite 404, Rockville, MD 20850 USA, Phone: 1-301-309-8500, Fax: 1-301-309-8851, [sales@teletronics.com](mailto:sales@teletronics.com) Nusrat Jamal  
Telewave, Inc. <http://www.telewaveinc.com/index.shtml>  
1155 Terra Bella Ave, Mountain View, CA 94043 USA, Tel: 800-331-3396 or 1-650-968-4400, Fax: 1-650-968-1741, Email: [sales@telewaveinc.com](mailto:sales@telewaveinc.com)  
Telex Communications Inc. Wireless Products Group <http://www.telexwireless.com>  
8601 E. Cornhusker Hwy., Lincoln, NE 68505 USA, Tel: 1-800-898-6723 or 1-402-467-5321, Fax: 1-402-467-3279, Email: [sales@telexwireless.com](mailto:sales@telexwireless.com)  
Teligent <http://www.teligent.com> Wireless broadband network operator.  
Telstra Corporation: {Tele}Communications Information Sources  
<http://www.telstra.com.au/info/communications.html>. A very good list of communications resources, including some mobile satellite stuff.  
Telular Corporation <http://www.telular.com>  
Tetherless Access Ltd. (TAL). This company has ceased operation  
Telxon Corp. <http://www.telxon.com>  
3330 West Market Street, Akron, OH 44334-0582, Tel: 800-800-8008 [sales@telxon.com](mailto:sales@telxon.com)  
The Mobile Office Outfitter <http://www.themoo.com>  
Til-Tek Antennas Inc. <http://www.tiltek.com>  
500 Van Buren St, P.O. Box 550, Kemptville, ON K0G 1J0 Canada, Tel: 1-613-258-5928, Fax: 1-613-258-7418 [info@tiltek.com](mailto:info@tiltek.com)  
Transferable European Space Technology <http://esapub.esrin.esa.it/pointtostest/test0.html>. The European Space Agency is offering a range of technologies that have been developed by European and Canadian firms while taking part in the European space programmes. Some mobile satcoms technologies.  
Traveling Software <http://www.travsoft.com>  
TRL Technologies <http://www.trltech.com> Design, development and manufacturing of RF products  
Tucson Amateur Packet Radio <http://www.tapr.org/tapr>  
UK fishing vessel tracking systems <http://www.smithsys.co.uk/smithsys/techp/maff/maff.html>  
UNICOM Inc. <http://www.unicompl.com>  
MATIX-MEDIA UNICOM America, P.O. Box 3486, Winter Springs, FL, USA 32708, Tel: 888-696-5517 or 407-696-5517, Fax: 407-696-5526, Email: [unicom-usa@unicompl.com](mailto:unicom-usa@unicompl.com)  
Uo-Sat <http://www.ee.surrey.ac.uk/EE/CSER/csertext.html>  
USA Digital Radio <http://www.usadr.com> FM/AM data broadcasting.  
Utilicom Inc. <http://www.utilicom.com>  
323 Love Place, Goleta, CA 93117, Tel: 805-964-5848, Fax: 805-964-5706  
VEGA Group PLC <http://www.vega.co.uk> Consulting services related to space and satellite comms.  
Veritas Electronics Ltd. UK <http://dSPACE.dial.pipex.com/town/plaza/jm73>. UK Suppliers of the Inmarsat-M Satellite Telephone (manufactured by Thorne and Thorne in Denmark).  
Vodafone <http://www.vodafone.co.uk>  
W.L. Pritchard & Company Inc <http://www.wlpc.com>. Provides technical, economic, and market analysis for new and established telecommunications ventures.

WaveAccess Wireless Communications <http://www.waveaccess.com>  
 One Apple Hill, Ste. 203, Natick, MA 01760, Tel: 508-653-3646 or 508-653-3306, Email: [ascott@waveaccess.com](mailto:ascott@waveaccess.com)

WaveLAN <http://www.wavelan.com> Lucent product.

Wavelets/Subbands: Fundamentals and Applications <http://www.ecse.rpi.edu> Courses available.

Wave Wireless Networking <http://www.the-wave-wireless.com> SpeedLan manufacturer  
 1748 Independence Boulevard, C-5, Sarasota, FL 34234, Tel: 800-721-9283, Fax: 941-355-0219, Email: [sales@the-wave-wireless.com](mailto:sales@the-wave-wireless.com)

Westinghouse Wireless Solutions <http://www.wireless.westinghouse.com>

Wi-LAN Inc. <http://www.wi-lan.com>  
 #300-801 Manning Rd. N.E., Calgary, AB, Canada T2E 8J5, Tel: 800-258-6876 or 403-273-9133, Fax: 403-273-5200, Email: [wi-lan@wi-lan.com](mailto:wi-lan@wi-lan.com)

Windata Corp. <http://www.windata.com>  
 543 Great Rd., Littleton, MA 01460, Tel: 508-952-0170 or 800-553-8008, Fax: 508-952-0168 or -0169, Email: [patc@wireless.windata.com](mailto:patc@wireless.windata.com)

WINLAB <http://winwww.rutgers.edu>

Winstar <http://www.winstar.com> Broadband fixed wireless network operator

Wireless Scientific <http://titan-solutions.com/WSI/wsi.html>  
 1890 South 14th Street, Building 100, Suite 105, Amelia Island, FL 32034, Tel: 904-261-6977, Fax: 904-261-2129, Email: [rschweit@titan-solutions.com](mailto:rschweit@titan-solutions.com)

Wireless and Satellite ISDN <http://www.NeoSoft.com/~eti>

Wireless Books <http://members.tripod.com/~wirelessbooks>

Wireless Dealers <http://wirelessdealers.com>

Wireless RF & Satellite ISDN <http://www.neosoft.com/~eti>

Wireless Inc <http://www.wire-less-inc.com>

Worldcomm Systems <http://www.worldcomm.com> Company Products.

WorldSpace <http://www.worldspace.com> Digital satellite radio

World-Wide Web Virtual Library: on Communications & Telecommunications  
<http://www.analysys.co.uk/commslib.htm>

Wynd Communications <http://www.callamer.com>

Xetron Corporation <http://www.xetron.com/900xcvr.htm>  
 460 West Crescentville Rd., Cincinnati, OH 45246, Tel: 513-881-3500, Fax: 513-881-3379, Email: [sarab@xetron.com](mailto:sarab@xetron.com)

Xircom Road Warrior Central <http://www.xircom.com>

Xtend Micro Products-Notebook <http://www.xmpi.com>

Xybernaut Corporation <http://www.xybernaut.com>

Young Design, Inc <http://www.ydi.com>  
 103 Rowell Court, Falls Church, VA 22046, Tel: 703-237-9090, Fax: 703-237-9092, Email: [MFYoung@ydi.com](mailto:MFYoung@ydi.com)  
 Email: [center@zcommwireless.com](mailto:center@zcommwireless.com)

Z-Communications Inc. <http://www.zcomm.com>  
 9939 Via Pasar, San Diego, CA 92126, Tel: 619-621-2700, Fax: 619-621-2722, Email: [sales@zcomm.com](mailto:sales@zcomm.com)

Zenith Data Systems <http://www.zds.com/htdocs/zds/htm/products/crlan.htm>  
 2150 East Lake Cook Road, Buffalo Grove, IL 60089, Tel: 800-416-7591 or 708-808-5000, Fax: 708-808-4434, Email: [ask.sales@zds.com](mailto:ask.sales@zds.com)

Further listings can be found at: <http://www.wirelessweek.com/guide/index.htm>

## 6.9 Other Information Resources.

### Further ITU Publications.

- [\(138-8\) Rules of Procedure \(1998 Edition\) \(9\)](#)
- [\(119-8\) Radio Regulations - Edition 1998 \(9\)](#)
- [\(210-8\) ITU-R Recommendations Online - Subscription Service \(9\)](#)
- [\(257-8\) ITU-R Recommendations - Supplement No. 1 to Volume 1997 - SA Series and TF Series 1998 Edition \(9\)](#)
- [\(215-8\) ITU-R Recommendations on CD-ROM \(August 1998 edition\) \(9\)](#)
- [\(254-8\) ITU-R Recommendations - Supplement No. 1 to Volume 1997 - 1998 Edition \(9\)](#)
- [\(244-8\) The Local Frequency List Management System \(LFL\) and the Weekly Circular on Diskette \(WIC-on-Diskette\) \(9\)](#)

- (190-8) Final Acts of the World Radiocommunication Conference Geneva, 1997 (9)
- (220-8) Space Radiocommunications Stations on CD-ROM (SRS on CD-ROM) 1998-1 Edition: March 1998 1998-2 Edition: September 1998 (9)
- (240-8) List of Volumes of ITU-R Series of Recommendations 1998 Edition (9)
- (239-8) Book of Resolutions and Opinions of the 1997 Radiocommunication Assembly 1998 Edition (9)
- (235-7) ITU-R Handbook on the ionosphere and its effects on radiowave propagation (9)
- (202-7) Preface to the International Frequency List (IFL), the Space Radiocommunication Stations on CD-ROM and the Weekly Circular (WIC) (November Edition, 1997 - Update May 1998) (9)
- (231-7) Propagation at frequencies above the basic MUF Report ITU-R P.2011 (9)
- (233-7) Report ITU-R SM.2012 / Economic aspects of spectrum management / Edition 1997 (9)
- (229-7) Handbook on Principles and Approaches on Evolution to IMT-2000/FPLMTS - Volume 2 - Handbook on Land Mobile (including Wireless Access) (9)
- (224) BR - Space Network Systems Online (6)
- (223) BR - Summary of Monitoring Information on diskette 1997 edition (6)
- (222) BR - Handbook on Selection & Use of Precise Frequency & Time Systems (1997 Edition) (6)
- (213) BR - ITU-R Recommendations. M Series Fascicle - Parts 1, 2, 3, 4 & 5 - Mobile services (SG 8) (1997 Edition) (6)
- (206) BR - Radiowave propagation information for predictors for Earth-to-space path communications (6)
- (196) BR - Handbook on Digital Radio-relay Systems 1996 (6)
- (194) BR - 1996 Updating of the Radio Regulations (Volume 4) (6)
- (189) BR - ITU-R Handbook on "Radiometeorology" (6)
- (181) BR: New and revised Recommendations on radiocommunications ITU-R Series (1995) (6)
- (180) BR: Excerpts of ITU radiocommunication texts concerning the amateur service and amateur-satellite service (6)
- (173) ITU Radiocommunication Reports (ITU-R) Radiocom. Study Group 8, M Series, Part 3 (6)
- (172) ITU Radiocommunications Reports (ITU-R) Radiocom. Study Group 8, M Series, Part 1 (6)
- (163) List of International Monitoring Stations (List VIII) (8th Edition, 1995) (6)
- (156) Handbook on Spectrum Monitoring (6)
- (144) VSAT Systems and Earth Stations: Supplement 3 to ITU Handbook on Satellite Communications (Fixed Satellite Service) (Geneva, 1988) (6)
- (132) ITU Radiocommunication Recommendations (ITU-R) (R Series) (6)
- (116) ITU Radiocommunication Books (6)
- (114) ITU Radiocommunication Recommendations (IS Series) (6)

#### 6.10 Books:

Many of these are available from Amazon.com in partnership with the Wireless Books web site <http://members.tripod.com/~wirelessbooks>

This means that if you go to the Wireless Books web site, you can just click on the titles to get them from Amazon.

#### Recent Books:

Mobile Computing for Dummies (For Dummies) by Dummies Technology Press; Idg Books Worldwide; Paperback; \$15.99

Universal Wireless Personal Communications by Ramjee Prasad & Ramjee Prasad; Artech House; Hardcover; \$89.00

Mobile Systems by Ian Stanley Groves; Chapman & Hall; Hardcover; \$119.95

Low-Power CMOS Wireless Communications : A Wideband CDMA System Design by Samuel Sheng, Robert Brodersen; Kluwer Academic Pub; Hardcover; \$98.00

GSM and Personal Communications Handbook (Artech House Telecommunications Library) by Siegmund Redl, Matthias Weber, Malcolm W. Oliphant; Artech House; Hardcover; \$89.00

Understanding Cellular Radio (Artech House Telecommunications Library) by William Webb; Artech House; Hardcover; \$59.00

CDMA RF System Engineering (Artech House Mobile Communications Library) by Samuel C. Yang; Artech House; Hardcover; \$73.00

Wireless CMOS Frequency Synthesizer Design (Kluwer International Series in Engineering and Computer Science, Secs 439.) by J. Craninckx, Michiel Steyaert;

Multiaccess, Mobility and Teletraffic Advances in Wireless Networks by David Everitt, Michael

Rumsewicz; Kluwer Academic Pub; Hardcover; ?  
 Introduction to Wireless Local Loop (Artech House Telecommunications Library.) by William E. Webb; Artech House; Hardcover; \$69.00  
 Surface Acoustic Wave Devices for Mobile and Wireless Communications (Applications of Modern Acoustics) by Colin Campbell; Academic Press; Hardcover;?  
 Residential Broadband Networks : Xdsl, Hfc, and Fixed Wireless Access by Uyles D. Black; P T R Prentice Hall; Binding: Hardcover; \$54.00  
 Wireless Multimedia Communications : Networking Video, Voice and Data (Addison-Wesley Wireless Communications Series) by Ellen Kayata Wesel; Addison-Wesley Pub Co (Short Disc); Hardcover; \$62.35  
 Advanced High-Frequency Radio Communications by Eric E. Johnson, (Artech House); Hardcover; \$85.00; Subjects: Wireless communication systems, Shortwave radio;  
 Cellular Communications : Worldwide Market Development (Artech House Telecommunications Library.) by Garry A. Garrard, Garry Gerrard; Artech House; Hardcover; \$85.00  
 Digital Cellular Systems (Wiley Series in Telecommunications and Signal Processing) by William C.Y. Lee; Wiley-Interscience; Hardcover; \$49.95  
 Cellular Mobile Radio Systems : Designing Systems for Capacity Optimization by H. Hammuda; John Wiley & Sons;

#### **Older Books:**

Wireless Local Area Networks : Technology, Issues, and Strategies (McGraw-Hill Computer Communications); Craig R. McGuffin, Peter T. Davis; Hardcover; \$40.00  
 Wireless Networked Communications : Concepts, Technology, and Implementation (McGraw-Hill Series on Computer Communications); Regis J. Bates, Bud Bates; Hardcover; \$50.00  
 Wireless Networking Handbook; Jim Geier; Paperback; \$35.99  
 Wireless Personal Communication Services (Computer Communication); Mahi Dontamsetti, et al; Hardcover; \$55.00  
 Wireless Personal Communications : The Evolution of Personal Communications Systems (Kluwer International Series in Engineering and Computer Science.); Theodore S. Rappaport, et al; Hardcover; \$88.50  
 Wireless Personal Communications : The Future of Talk; Ron Schneiderman; Hardcover; \$34.95  
 1995 IEEE 6th International Symposium on Personal, Indoor & Mobile Radio Communication (Pimrc) (2 Volume Set; Paperback; \$198.00 (*Special Order*)  
 1995 IEEE Mtt-S Symposium on Technologies for Wireless Applications Digest 20-22 February 1995 Vancouver, Bc, Canada : 20-22, February, 1995, Vancouver; IEEE Mtt-S Symposium on Technologies for Wireless Applications; Paperback; \$92.00 (*Special Order*)  
 1996 IEEE International Conference on Personal Wireless Communications : Proceedings & Exhibition-Future Access, 19-21 February, 1996, New Delhi, India; V. K. Bhargava, et al; Paperback; \$108.00 (*Special Order*)  
 2nd International Conference on Universal Personal Communications : Personal Communications: Gateway to the 21st Century; Paperback; \$132.00 (*Special Order*)  
 Digital Beamforming in Wireless Communications (Artech House Mobile Communications Series); John Litva, Titus Kwok-Yeung Lo; Hardcover; \$69.00 (*Special Order*)  
 Drums & Wireless: Bbc Sessions; Xtc Cdpham 67992; Audio CD; \$19.98 (*Special Order*)  
 Europe's Wireless Revolution; Arthur H. Hill; Paperback; \$30.00 (*Special Order*)  
 High Power Wireless Equipment; Morgan; Hardcover; \$15.95 (*Special Order*)  
 History of Broadcasting in the United Kingdom : The Golden Age of Wireless Vol 2; Asa Briggs; Hardcover; \$79.00 (*Special Order*)  
 IEEE Conference on Wireless Lan Implementation : Proceedings : Dayton, Ohio, September 17-18, 1992; Paperback; \$20.00 (*Special Order*)  
 Intelligent Broadband Multimedia Networks : Generic Aspects and Architectures : Wireless, ISDN, Current and Future Intelligent Networks; Syed V. Ahamed, Victor B. Lawrence; Hardcover (*Not Yet Published -- On Order*)  
 Marconi Wireless on Cape Cod : South Wellfleet, Massachusetts, 1901-1917; Michael Whatley; Paperback; \$6.35 (*Special Order*)  
 Materials and Processes for Wireless Communications (Ceramic Transactions, Vol 53) Vol 53; T. Negas, Hung Ling; Hardcover; \$83.00 (*Special Order*)  
 Microwave and Wireless Synthesizers : Theory and Design; Ulrich Rohde; Hardcover; \$94.00 (*Not Yet Published -- On Order*)  
 Mobile and Personal Communications : Proceedings of the 2nd Joint Cost 227/231 Workshop on Mobile and Personal Communications Florence, Italy, 20-21 a; Enrico Del Re; Hardcover; \$187.50 (*Special Order*)  
 Modern Quadrature Amplitude Modulation : Principles and Applications for Fixed and Wireless

Communications; William Webb, Lajos Hanzo; Hardcover; \$89.95 (*Special Order*)

Networks for Personal Communications Conference Proceedings, 1994 : Conference Proceedings, March 16-18, 1994, Ocean Place Hilton, Long Branch, New Jersey; Paperback; \$74.00 (*Special Order*)

Nikola Tesla on His Work With Alternating Currents and Their Application to Wireless Telegraphy, Telephony and Transmission of Power; Nikola Tesla; Paperback; \$40.00 (*Special Order*)

The Performer Fm Wireless Microphone; James Barbarello; Hardcover; \$10.95 (*Special Order*)

Personal and Wireless Communications : Digital Technology and Standards (Kluwer International Series in Engineering and Computer Science, Secs 361.); Kun Il Park; Hardcover; \$95.00 (*Special Order*)

Pre Modernist Wireless; Gong Cdpham 226042; Audio CD; \$22.98 (*Special Order*)

Principles and Practice of Multi-Frequency Telegraphy (Iee Telecommunications Series, 11); J.D Ralphs; Hardcover; \$109.00 (*Special Order*)

Radios : Wireless Sound (Encyclopaedia of Discovery and Invention); Roger Barr; Hardcover; \$22.44 (*Special Order*)

Rf Circuits : Practical Design and Layout for Wireless Communication; James S. Ussailis; Hardcover; \$50.00 (*Not Yet Published -- On Order*)

Speech and Audio Coding for Wireless and Network Applications (The Kluwer International Series in Engineering and Computer Science : Communications A); Bishnu S. Atal, et al; Hardcover; \$95.00 (*Special Order*)

Technologies for Wireless Computing; Anantha P. Chandrakasan, Robert W. Brodersen; Hardcover; \$110.00 (*Not Yet Published*)

Tesla's Fuelless Generator & Wireless Method; Oliver Nichelson; Paperback; \$9.85 (*Special Order*)

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## 7. DEFINITION OF TERMS AND ACRONYMS

ALE	Automatic Link Establishment
AMPS	Advanced mobile phone system - an old analogue technology
ANSI	American National Standard Institute
ASK	Amplitude Shift Key - modulation technique for wireless comms
ATM	Asynchronous Transfer Mode - a new high-speed telecom protocol
Asymmetric	A link where the send and receive data rates are different.
Band	This is a contiguous range of frequencies that are grouped together for convenience or because of some technical characteristic.
Baud	The number of line signal variations per second. If a single signal level represents each bit of data, then the baud rate will be the same as the data bit rate. Typically, 2400 Baud will be 2400 bits per second, which translates into about 240 characters per second, assuming 10 bits per byte (character), or 2.4Kbps
BDT	The ITU's Telecommunications Development Bureau
BER	Bit Error Rate
BOT	Build, Operate, Transfer - a financing arrangement for public infrastructure
BPSK	Binary Phase Shift Keying
CDMA	Code Division Multiple Access
CIR	Committed Information Rate
CPE	Customer Premises Equipment
CSMA/CA	Carrier Sense Multiple Access/Collision Avoidance
CSMA/CD	Carrier Sense Multiple Access/Collision Detect
CT2	Second generation Cordless Telecommunications - a WLL technology
CTM	Cordless Telephone Mobility
dBi	Decibel power measurement of receive or transmit antenna gain
dBm	Decibel power measurement of transmitter power output or signal level required by receiver
DAMA	Demand Assigned Multiple Access
DBS	Direct Broadcast System - Satellite broadcasting direct to the user
DECT	Digital Enhanced Cordless Telecommunications
DBPSK	Differential Binary Phase Shift Keying - a radio comms protocol
DQPSK	Differential Quadrature Phase Shift Keying - a radio comms protocol
DSL	Digital Subscriber Loop - a telephone cable transmission system that can provide broadband connections over limited distances.
DSSS	Direct Sequence Spread Spectrum - a radio communications protocol providing superior throughput to FHSS (see below)
DTH	Direct to Home (satellite television broadcasting)
Duplex	Information exchange protocol between two communicating devices where information (data) is passed in both directions simultaneously. This is also known as Full-duplex and two-way simultaneous communications.
ERP	Effective Radiated Power - a measurement of signal output
ETSI	European Telecommunications Standards Institute

FDMA	Frequency Division Multiple Access - a radio communications protocol
FEC	Forward Error Correction
FHSS	Frequency Hopping Spread Spectrum - a radio communications protocol providing inferior throughput to DSSS
Footprint	Coverage area on the earth for a satellite
GEO	Geosynchronous Earth Orbit satellite
GMPCS	Global Mobile Personal Communications by Satellite
GSM	Global System for Mobile communication (A European developed digital cellular telephony standard)
Half-duplex	Half-duplex communication does not allow send and receive to occur concurrently. This is also known as two-way alternate.
HF	High Frequency - a radio spectrum waveband
IAPP	Inter Access Point Protocol - a new IEEE standard
ICTs	Information and Communication Technologies
IDR	International Digital Route - a satellite communications channel
IDRC	International Development Research Centre
IMT-2000	The global ITU standard being developed for 3 <sup>rd</sup> generation cellular wireless standard
Inroute	Information flow from the subscriber to the hub equipment in a satellite network
ISDN	Integrated Service Digital Network
ISM band	Industrial Scientific and Medical band allocated for unlicensed communications
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunication Union
ITU-R	ITU Radio communication sector
ITU-T	ITU Telecommunication Standardisation Sector
LAN	Local Area Network
LEO	Low Earth Orbit Satellite
LMR	Land Mobile Radio
LOS	Line of Sight
MCPC	Multi-Channel-Per-Carrier
MEO	Medium Earth Orbit - satellite
Modulation	The method used to encode data in the analogue radio signal.
MMDS	Multi-channel Multi-point Distribution Service. Used in the 2.5-2.7GHz band.
NBMT	Narrow Band Microwave Transmission
NGO	Non-governmental Organisation
NOS	Network Operating Systems
Outroute	Information flow from hub to subscriber equipment in a satellite network
PBX	Private Branch Exchange
PC	Personal Computer
PCS	Personal Communications Services

PES	Personal Earth Station
PHS	Personal Handyphone System
PMP	Point-to-Multipoint - a star configuration for wireless telecom links where each subscriber connects to the same central hub.
PMR	Private Mobile Radio
POTS	Plain Old Telephone System
PSDN	Public Switched Data Network - used to be X.25, now Internet
PSTN	Public Switched Telephone Network
PTO	Public Telecommunication Operator
RF	Radio Frequency
RS232	A serial data interface commonly found on PCs.
RX	Receive channel
SCPC	Single Channel-Per-Carrier
SDH	Synchronous Digital Hierarchy. A telecommunications technology often used to efficiently transport information on a Network Operators backbone.
Simplex	A type of communication strategy whereby information (data) is only passed in one direction.
SMS	Short Message Service - available on GSM cell phones
SNR	Signal-to-Noise Ratio - effects the capacity of a link
SNMP	Simple Network Management Protocol
SS	Spread Spectrum - a radio communication protocol
Symmetrical	Send and receive data rates are the same.
TCP/IP	Transmission Control Protocol / Internet Protocol
TDMA	Time Division Multiple Access
TX	Transmit channel
UNDP	United Nations Development Program
UHF	Ultra High Frequency - radio spectrum waveband
USB	Universal Serial Bus - the new standard interface for peripherals on a PC
VHF	Very High Frequency - Radio spectrum waveband
VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal - a satellite terminal used by a subscribers to a satellite telecom service.
WAN	Wide Area Network
WAP	Wireless Access Protocol content oriented wireless/Internet protocol development
WIN	Wireless Intelligent Network
WLAN	Wireless Local Area Network (or Wide Area Network - WAN)
WLL	Wireless Local Loop: an application of radio technology to extend the Public Switched Telecommunications Network (PSTN). A local loop contains the facilities that connect a customer's premises to the local telephone exchange. Traditionally, the local loop consists of pairs of copper wire to provide the connections. WLL is a wireless alternative for the local loop.