TELECOMMUNICATIONS SYSTEMS EVOLUTIONARY DEVELOPMENTS

Real time long distance communications -- telecommunications -- have only been possible since the development of electricity. The telegraph appeared in 1844 and the telephone in 1876. The first successful use of wireless radio transmissions occurred in 1895; by 1901 radio was being tested over a transatlantic path. The next major innovative transmission concepts was not introduced until 1962, when the world's first communication satellite, TELSTAR 1, was placed in service. The latest major innovation surfaced in 1970, when optical fibers began to replace copper wire. Optical fibers are now competing successfully with large segments of the radio relay and communication satellite market.

In parallel with these transmission technology breakthroughs, the electronic industry was moving ahead at the component level, especially during and immediately following World War II, as a result of the remarkable efforts of the MIT Radiation Laboratory, which researched and developed higher frequencies, wider bandwidths, greater powers, and increased reliability. It was invention of the transistor in 195__ however which heralded the beginnings of the information age, in much the same way that the steam engine ushered in the industrial age about 200 years ago. Transistors, and their evolutionary descendents integrated circuits microprocessors, minicomputers, personal computers, etc.

-- constitute the core technology of the new, digitally based information and communication systems.

INTERNATIONAL COMMUNICATIONS

International commercial communications have been and continue to be developed according to "international standards," that is, according to recommendations that are agreed to by the 160 member nations of the International Telecommunications Union (ITU), which regulates, standardizes, coordinates, and plans all international telecommunications. The ITU hosts dozens of conferences, attended by thousands, to discuss technical, economic, legal, and policy issues relating to all aspects of the industry, HR satellite broadcasting, regional networks (Africa constitutes a "region" for this purpose), maritime services, international civil aviation, and space communications. The ITU manages frequency assignments and spectrum usage, assigns satellite locations, recommends interference protection, and standardizes radio-navigation systems. One of the ITU's committees, the CCITT, works closely with the world's communications industry leaders, in order to develop, by consensus, international standards that will ensure total system compatibility, regardless of country of origin or destination. Many national systems now specify only international standards, to ease the cost and difficult of connecting with the international network. This, in effect, creates a world standard for all the new systems.

No country is now going it alone. The PRC is modernizing at a rapid pace--and following the international standards, as developed by Japan and West. The Soviet Union is also modernizing, but at a slower pace. Both countries are active in the ITU and the CCITT.

FOUR BASIC TRANSMISSION MODES

1. Wire, cable. and optical fibers

The use of wire and cable predates the invention of radio, but is still used as a major media for the transmission of information. Obviously, it is limited to point-to-point applications. It also is subject to environmental problems, such as corrosion and breakage, as well as electrical problems (signal attenuation, distortion, electrical interference). But in general, it has been very reliable and relatively inexpensive. The recent introduction of fiber optics is an exciting improvement for cable transmissions, because it solves most the problems of copper wire: It does not corrode, it is lightweight, have very low signal attenuation and distortion, is immune to noise pickup, has extremely wide handwidth capabilities, and is relatively inexpensive. It has made major inroads into the markets traditionally held by the wire industry, and is also impacting some of the microwave radio relay markets, as well as intercontinental satellite traffic thru the use of fiber undersea cables.

2. Short-wave Radio

The term short-wave refers to the High Frequency band and those bands just below it on the spectrum chart. High Frequency (HF) = 3-30 Mhz; Medium Frequency (MF) = .3-3 Mhz; Low Frequency (LF) - .03-.3 Mhz. Radio transmissions in these bands are characterized by an important operational feature -- they travel over extremely long distances, well beyond the horizon, and until the invention of satellite communications, they were the only method of radio communications over the ocean or other hostile environments. These frequencies propagate by means of reflection from the ionosphere in the upper atmosphere and subsequent reflections from the earth's surface. Such a process has many uncertainties and variations, therefore the unpredictable nature of the signal path causes a variety of distortions, any of which can be minimized, but seldom eliminated. The major shortcoming is that only narrow bandwidth signals -- just a few channels -- can be sent. The other major problem is the susceptibility of these frequencies to static, noise, fading, and other interference problems. In spite of the difficulties, the medium is still heavily used throughout the world, because it is fairly reliable and inexpensive, and the equipment is simple and portable. In recent years, computers and microprocessors have been incorporated into these systems, in order to model in real time the signal path, based on technical measurements and

continous analysis of the received signal quality. Immediate, automatic adjustments to the transmission are then made, including changing the frequency, if necessary. Such "adaptive" signalling is allowing the short-wave bands to continue to be competitive with the newer transmission modes. Military and diplomatic applications is this band are now increasing, and greater reliance is being placed on it.

Most of the world's communications travel over line-of-sight systems, which offer high capacity, excellent quality and reliability, and reasonable costs.

3. Line-of-Sight

All signals at frequencies generally above 30 Mhz travel in straight paths, line-of-sight, and are not reflected by the ionosphere. Radio transmissions of this type include most portable two-way radios (portable military, CB, cellular) microwave radio relay systems, commercial television, and satellite communications. The upper ranges of this category are the millimeter wave band (30-300 Ghz), which is beginning to be used for some special applications, and the optical (laser and infra-red) band, used for very short range, high capacity applications.

4. Satellite

Although satellite signals are in the line-of-sight frequency bands, they are so unique they require a separate category to adequately describe their operational aspects. The new generation of digital signal satellites have tremendous capacity, typically 10,000 voice channels plus TV. These line-of-sight, high capacity signals can span great distances, providing communications to remote, inaccessible areas that wire or radio relay cannot reach. Most satellites are linked to one or more earth terminals for two-way communications, but a new generation of Direct Broadcast Satellites are going into service for one-way transmission for wide area coverage.

MILITARY AND COMMERCIAL COMMUNICATIONS

Technical differences between military and commercial communications systems of a country are generally not severe. Equipment manufacturers and vendors usually handle both product lines, therefore the basic technology is similar or identical. Differences arise in parametric choices (frequency, bit rates, modulation states, coding schemes, etc.), all of which are within the limits of the electronic technology that is available.

Military systems can be aggregated into two groupings:

1) strategic, national level, command and control, and
2) tactical, mobile, or portable radios.

Strategic systems tend to be quite sophisticated, and may push the state of the art. These systems are generally large fixed installations having excellent maintenance and operation. Technical risk is thereby minimized and the equipment tends to reflect this consideration. Tactical systems, however, are operated and maintained by less skilled persons, and the equipment is often subject to a much harsher environment. These equipments tend to use proven technology and less sophisticated designs.

National priorities have a major influence on the relationship of military communication systems and those of the commercial sector.

Western Europe -- Although military communications are very advanced technically, the commercial systems are in the forefront. European vendors are very competitive and sell commercial equipment world wide, including the Soviet Union and the PRC.

Japan -- Because of the Japanese reluctance to maintain offensive military forces, as well as their aggressive marketing of superior electronic equipment, they have one of the best lines of commercial equipment in the world, but are not recognized as vendors of military communications systems.

USSR - The Soviet Union does not produce quality commercial radio equipment for export. Their indigenous equipment, although adequate, requires modernization and expansion. The Soviet semiconductor industry does not have the capacity to support an expansion program, nor the technical base to improve its manufacturing processes at the required pace. They are attempting to import the necessary technology from abroad, but in spite of some successes, they continue to lag behind the West, with no indications that they will close the gap significantly.

Soviet military communications dominate their electronics industry, and their strategic military communications are quite good. Their communications satellite technology is excellent, utilizing digital signaling, zonal beams, multiple access, spread spectrum, secure encryption, and packet switching. Tactical radios, on the other hand, are based on older technology, although some of them are being replaced by newer models which have the capability for digital control by microprocessors.

PRC -- Rapid modernization, through high technology importation, is the announced goal of the Chinese leadership. All major communications industries are affected by this decision -- HF, microwave, satellites, fiber optics, computers, digital switches, etc. Both the military and the non-military (civil and commercial) systems are being upgraded. Foreign factories, as well as foreign equipment, are being imported. The results of

these improvements are not yet much in evidence, but in several years time the signals should represent the newly acquired technology.

Lesser Developed Countries -- The LDCs, when they do decide to improve their communications systems, have generally opted for a European or Japanese firm to provide a total system, including long-term maintenance. In the case of African countries, the company selected is frequently from the former colonial power (England, France, Italy, Netherlands). Satellite systems are often selected over radio relay or cable systems, because the cost of communications to remote areas can best be borne by a time-shared satellite system, such as ARABSAT or INTELSAT.

Newly Industrialized Countries -- The NICs are moving into high technology areas very rapidly, but are becoming manufacturers of equipment, rather than designers and inventors of new systems and communications networks.

DIPLOMATIC COMMUNICATIONS

The Ministries for Foreign Affairs of foreign governments transmit their diplomatic communications over various governmental and international commercial circuits including international or regional satellite systems, international submarine cables, HF systems, regional terrestrial microwave systems and various nationally-owned networks. A variety of

communications media is employed including Morse, voice, teleprinter, data, facsimile, text, graphics, and video which are passed by methods ranging from conventional analog to the most modern digital systems. Ciphere systems range from relatively simple to complex machine-operated systems. The trends for these diplomatic communications are toward more use of encipherment devices and complex transmission modes (e.g., packet switching and use of high-speed computer-relay systems), increased use of enciphered facsimile, and upgrading of existing, or establishing new, HF radio networks.

FIBER OPTICS

There is much discussion and debate over the future of fiber optics and its possible mergence as the principal communications, media, possibly replacing satellite and radio relay networks. Such concerns seem to be exaggerated, however, as each media has specific market areas wherein each performs best, both technically and economically. The current evidence indicates that fiber excels in three major market areas. First is the local exchange; local loop, intro city market, which is characterized by high volume and short distances. It is cheaper to buy, cheaper to install, and provides better service. Second is the medium distance market, where the cost of satellite or radio relay systems is too expensive. At distances greater than 1000 miles, it is more economical to switch from fiber to

satellite. Third is the intercontinental market, or other areas involving long ocean distances. High-capacity undersea cables have competed successfully against satellite, but the newer generation satellites will be offering better and cheaper service. Because fiber optic undersea cables offer so many advantages over copper cable, all future undersea cables world wide will be optical. These cables, due to their high capacity, low cost, and low maintenance will begin to replace satellite service on the long-haul, high-volume routes, such as US-Europe, US-Hawaii-Japan, etc. Also, for telephone traffic, fiber is preferred over satellite because it eliminates the time delay associated with satellite. For thin route traffic, especially to remote areas, satellite will remain the choice.

Radio relay systems may have difficulty competing with optical fiber or satellite systems. Their strength lies in the short and medium market, especially over rough terrain where cable would be impracticable, and for low density traffic areas that are not too remote. Military operations will rely heavily on mobile radio relay rather than cable or satellite for many situations.

Fiber optics offer a unique feature not available from other modes of communications. Fiber is immune to unauthorized intercept by conventional means, therefore, it affords the user a high degree of privacy and communication security. The PRC,

because of this feature, is very interested in fiber networks and is pursuing an aggressive program of manufacturing and installation.

ISDN

Integrated Services Digital Networks, ISDN, is a modern communication network concept whereby all types of information services -- voice, data, printer, video -- are digitized, merged, and transmitted to any subscriber, without the user having to perform any technical operations. The system is now under going test in Europe, Japan, and North America, and is in process of being internationally standardized by the IIU and the CCITT. Narrow bandwidth systems are being tested first, and the wideband systems will follow shortly. There are few technical impediments to the ISDN Program, as the technology is well in hand. What is not resolved yet is the economic base to support the huge up-front investment required to implement the program. All potential users must procure the necessary digital interface equipment prior to start-up of the system, and until volume discounts are readily available, most users find the cost too high at present.