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Satellite technology : reinforcement of computer data transmission technology : implications for the maritime world communications, data transfer and maritime education

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AWSL

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SATELLITE TECHNOLOGY: REINFORCEMENT OF COMPUTER DATA TRANSMISSION TECHNOLOGY-IMPLICATIONS FOR THE MARITIME WORLD IN COMMUNICATIONS, DATA TRANSFER AND MARITIME EDUCATION

By

U KYAW HTUT
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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

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DEDICATED TO MY BELOVED PARENTS

(U Ohn Thaw & Daw Khin Than Nwe)

5-10-98

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **Satellite technology: Reinforcement of Computer Data Transmission Technology-Implications for the Maritime World in Communications, Data Transfer and Maritime Education**

Degree: **MSc**

This dissertation is a study of the impact of data transmission via satellite on the maritime world of communication, data transfer and education. The aim of the study is to understand the technological reinforcement of the maritime industry and the changes taking place in it. With the avalanche of changes that are taking place in the field of information technology, they can be used to facilitate the shipping industry. This dissertation assists in understanding some of the technological evolution of satellite technology and data communication and in the needs of the maritime industry as well.

This dissertation describes satellite technology and data communication and analyses the data communication software (protocols), compression software, and other application software combinations with maritime communication system provided to improve ship operation and management for safety.

The conclusion and recommendations chapter examines the implications of the technology changes on developing countries, the need to be harmonised in training and education for the maritime industry, maritime communication systems and the equipment, policy of shipping companies and communication costs.

KEYWORDS: Satellite technology, Data transmission, Software, Technology changes, Policy of shipping company, Ship operations and management, Communication cost, Education and training, Information Technology.

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LIST OF ABBREVIATIONS

AM	Amplitude Modulation
ASCII	American Standard Code for
ATM	Asynchronous Transfer Mode
bps	bits per second
BPSK	Biphase Phase Shift Keying
CDMA	Code Division Multiple Access
CN114	Change Notice 114
CSMA	Carrier Sense Multiple Access
DBMS	Database Management System
DSC	Digital Selected Calling
ECDIS	Electronic Chart Display and Information System
ECG	Electro-Cardio-Graph
EDI	Electronic Data Interchange
EGC	Enhanced Group Calling
EPIRB	Emergency Position Indicating Radio Beacon
FDMA	Frequency Division Multiple Access
FM	Frequency Modulation
FSK	Frequency-Shift Keying
GEO	Geosynchronous Earth Orbit
GMDSS	Global Maritime Distress and Safety System
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite System
GHz	Gega Hertz
GOC	General Operator Certificate
GPS	Global Position fixing System
HSD	High Speed Data
ICO	Intermediate Circular Orbit

IMO	International Maritime Organisation
INMARSAT	International Mobile Satellite Organisation
INTELSAT	International Telecommunication Satellite
IOL	Inter-Orbit Link
IP	Internet Protocol
ISDN	Integrated Services Digital Networks
ISL	Inter Satellite Link
ISM	International Safety Management
ISO	International Standards Organization
ITU	International Telecommunication Union
LAN	Local Area Networks
LEO	Low Earth Orbit
LUT	Local User Terminal
MCC	Mission Control Centre
MEO	Medium Earth Orbit
MET	Maritime Education and Training
MHz	Mega Hertz
MIS	Management Information System
MODEM	Modulator Demodulator.
MRCC	Maritime Rescue Co-ordination Centre
NOAA	National Oceanic and Atmospheric Administration
OSI	Open Systems Interconnection
PLB	Personal Locator Beacon.
PM	Phase Modulation
PPS	Precise Positioning Service
PRN	Pseudo Random Noise
PSK	Phase Shift Keying
PSTN	Public Switching Telephone Network
QPSK	Quadraphase PSK

RAIM	Receiver Autonomous Integrity Monitoring
RCC	Rescue Co-ordination Centre
RF	Radio Frequency
RFI	Radio Frequency Interference
RO	Receive-only
SAR	Search and Rescue
SCPC	Single Channel Per Carrier
SDMA	Space Division Multiple Access
SHF	Super High Frequency
SOLAS	Safety Of Life At Sea
SPS	Standard Positioning Service
SQL	Structured Query Language
SS-TDMA	Satellite Switched Time Division Multiple Access
SSB	Single Side Band
STCW	Standard Training, Certification and Watchkeeping
TDMA	Time Division Multiple Access
TCP	Transmission Control Protocol
UHF	Ultra High Frequency
UN/EDIFACT	United Nations Electronic Data Interchange for Administration Commerce and Transoprt
VDU	Video Display Unit
VHF	Very High Frequency
VSAT	Very Small Aperture Terminals
WAN	Wide Area Network
WMU	World Maritime University
WWRNS	World-Wide Radionavigation System

Chapter 1

INTRODUCTION

1.1. Satellite technology

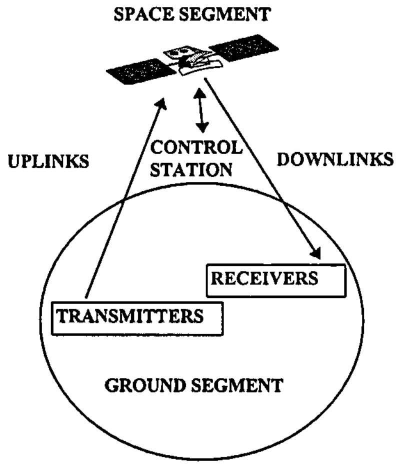


Figure 1.1 The architecture of a satellite communication system

Figure 1.1 shows the various components of a satellite system. It comprises a ground segment and a space segment. The space segment contains the satellite and all terrestrial facilities for the control and monitoring of the satellite. The satellite consists of a payload and a platform. The payload consists of the receiving and transmitting antennas and all the electronic equipment. The platform consists of all the subsystems which permit the payload to operate. The satellite has a dual role which is to amplify the received carriers for re-transmission on the downlink and to change the frequency of the carrier to avoid re-injection of a fraction of the transmitted power into the receiver. To fulfil its function the satellite can operate as a simple relay. The new generation of satellites are equipped with demodulators, and baseband signals are available on board.

1.2. Satellite technological progress

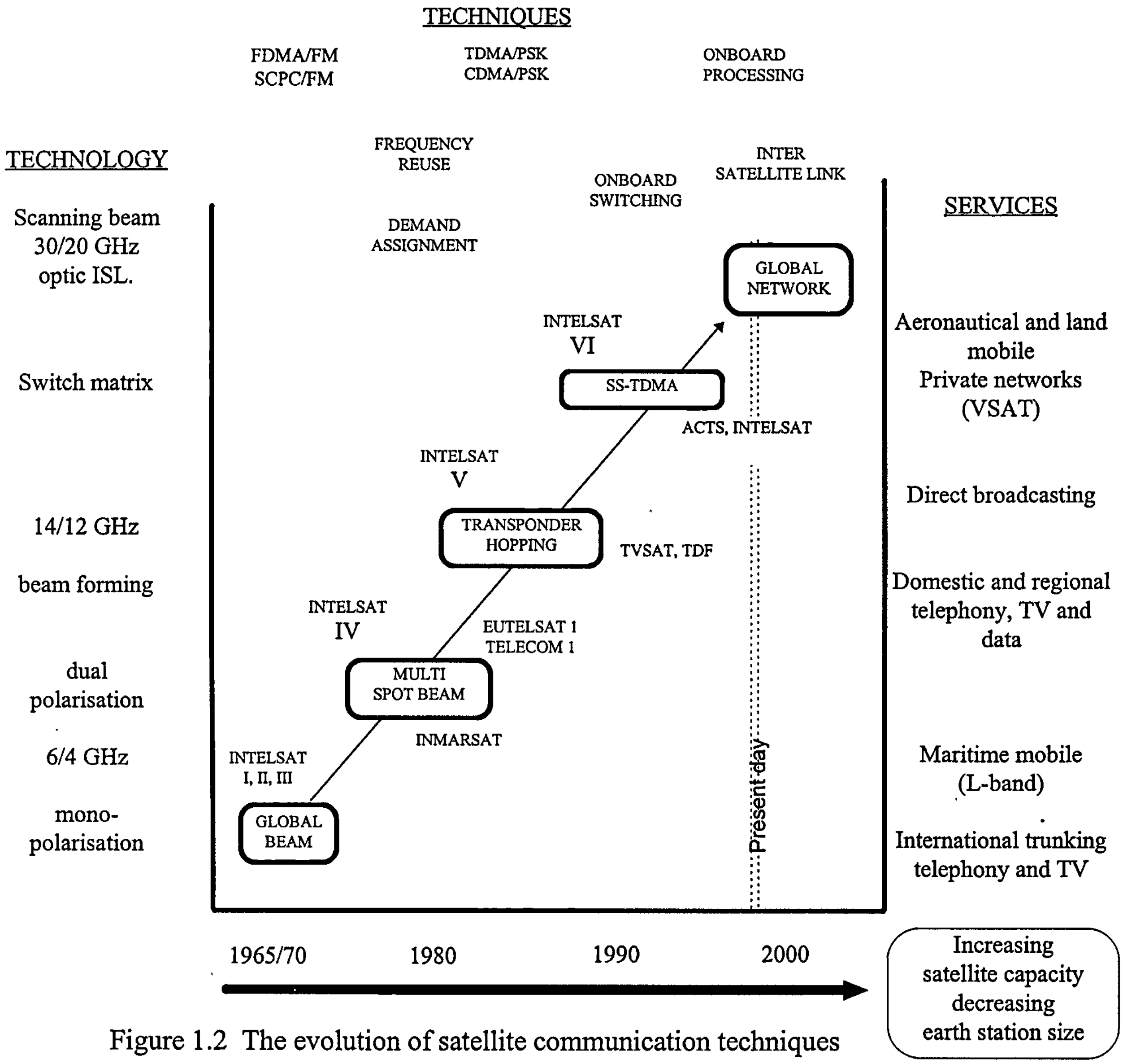


Figure 1.2 The evolution of satellite communication techniques

Sources: Maral, G and Bousquet, M (1993). Satellite Communication Systems, 2nd edition,. p. 9

Satellites opened new worlds in communication technology, because satellites are an excellent platform for large-scale, high-bandwidth, and wide coverage distribution of service products. Because of this, they have become an essential part of long range, wide area communications systems.

The space age began in the late 1950s. At that time satellites were small by present day standards. Global communications have been developing since the beginning of the satellite communication era. Commercial satellite telecommunications began with the commissioning of INTELSAT 1 (Early Bird) in 1965. Until the beginning of the 1970s, the services provided were telephone and television signal transmission between continents using the analog signal. The goal of increased capacity has led rapidly to the institution of multi-beam satellites and the re-use of frequencies first by orthogonal polarisation and subsequently by spatial separation.

In 1980, the introduction of demand assignment first used Frequency Division Multiple Access (FDMA) with Single Channel Per Carrier/Frequency Modulation (SCPC/FM) or Phase Shift Keying (PSK) and subsequently used Time Division Multiple Access/Phase Shift Keying (TDMA/PSK) in order to profit from the flexibility of digital techniques.

Today Satellite Switched Time Division Multiple Access (SS-TDMA) is used. Satellite communication has been at the heart of the information technology revolution in the maritime world, providing the mechanism for data to be exchanged between shore and ship.

In the near future satellites will play a pivotal role for Internet-related multi-casting applications by using onboard processing and inter satellite links. Figure 1.2 shows the technological developments. (Maral and Bousquet, 1993, 4)

1.3. Computer data communications and the maritime world

In the early 1970s computers were introduced into the communication system. First, computers communicated with each other by using modems. Modems make modulation and demodulation in an analogue transmission systems. This technology has continued to progress. (Capron, 1996, 126) Today digital technology provides a system with computers connected directly.

The combination of computer data transmission and satellite technology meets the varied needs of the maritime community because the required amount of data and facts can be sent and received in short air-time anywhere in the world. In maritime satellite communications, a large number of mobile stations need to be able to send and receive messages at irregular intervals. In the same manner ships sail or dock, so the network must be able to accommodate whenever a communication system is activated.

1.4. Information Technology on board ship

The progress of satellite technology has allowed efficient communication between ship and shore. Shore based information can be accessed onboard. It has led to improvement in vessel operation, management, onboard training and in many other areas. It is showing signs on having the greatest impact on shipping in the future. The improvements meet safety reporting requirement of SOLAS, implementation of the ISM Code and STCW 95. (Muirhead, 1998c, 2)

Chapter 2

THE PRINCIPLES OF SATELLITE TECHNOLOGY

2.1 Basic satellite theory

A satellite is carried into orbit aboard a rocket capable of reaching the velocity required to enable it to overcome the earth's gravitational field. An artificial orbiting satellite obeys the three laws of Kepler. The laws can be summarised as follows:

1. The orbit of an artificial satellite with respect to the earth forms an ellipse.
2. Vectors down from the satellite orbit to the earth describe equal areas in equal times.
3. The square of the period of the satellite's orbit is equal in ration to the cube of its mean altitude above the earth's surface.

Artificial earth satellites follow elliptical paths. The closest point of approach to the earth of an elliptical orbit is called perigee and the furthest distance away is termed the apogee. The direction vector of the satellite from the observer is called the azimuth and is quoted in degrees. The angle between the satellite, at any instant, and the earth's surface tangent is termed the elevation and again is quoted in degrees. The satellite orbital velocity can be calculated by using the formula:

$$V = \frac{K}{(r+a)^{\frac{1}{2}}} \text{kms}^{-1}$$

where V = orbital velocity in kms^{-1}

a = altitude of the orbit above the surface of the earth, in km

r = the mean radius of the earth (approximately 6371 km)

K = 630 (a constant derived from a number of parameters)

The orbital period of a satellite can be calculated using the formula:

$$P = K\left(\frac{r+a}{r}\right)^{3/2} \text{ minutes}$$

Where P = the period of one orbit in minutes,

a = the altitude of the orbit above the earth's surface, in km

r = the mean radius of the earth, in km

K = 84.49 (a constant derived from a number of parameters)

(Tetley and Calatt, 1991, 190)

2.1.1 Satellite orbital plane and orbit

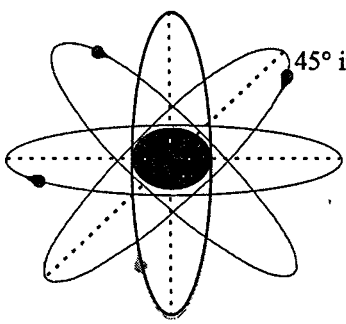


Figure 2.1 Orbital plane

The orbital plane is called the inclination and is the angle produced between the eastern end of equatorial plane and satellite orbit. Figure 2.1 illustrates orbital inclinations of zero for the equatorial orbit, 45 degrees, and 90 degrees for a polar orbit. (Tetley and Calatt, 1991, 191)

Circular Equatorial Orbit or Geosynchronous Earth Orbit (GEO) is exactly 36,000 km above the Equator taking exactly 24 hours to complete one orbit, thereby holding itself steady above a fixed spot. Three geostationary satellites are required for global coverage. The main disadvantage of the geostationary orbit is that its altitude is very high and a considerable amount of thrust is necessary to lift a payload into orbit. The 0.25 signal delay each way, plus further delay occurring in ground based switching, makes GEO use for mobile telecommunications awkward.

Medium Earth Orbit (MEO)/ Intermediate Circular orbit (ICO) is at 60,000 to 15,000 km. It reduces the signal delays but MEO's coverage is smaller than a GEO. MEOs are not geostationary. They require more complex tracking and co-ordination than a GEO. The time delay is eighty mili-seconds and the time in sight is two to four hours. Ten to twelve satellites have to be used for global coverage.

There are three generally accepted types of Low Earth Orbits (LEOs): little LEOs, big LEOs and broad band or super LEOs. They all operate some 200 to 3000 km above the earth. There are negligible transmission delays between end-users and satellites. The advantage of LEO technology is that only low transmission power is required. This means that small hand-held cellular-type units can transmit signals to and from LEOs. Time delay is 10 ms and time in sight is approximately 15 minutes. fifty to seventy satellites need for global coverage. (Spoo, 1998, 4)

2.2 Attitude Control System

Sun synchronous orbits have a nodal regression rate equal in magnitude and sense to the mean rate of revolution of the earth about the sun and the spacecraft maintains its initial orientation relative to the sun. Such an orbit is retrograde and lies between inclination angles of 95.7 degrees and 180 degrees at altitudes up to 5900 km.

The attitude control system depends on the type of orbit. If a satellite orbit is a low earth orbit (LEO), the satellite is launched directly into this orbit. The satellite will possess a low spin rate which is imparted by the launcher/rocket. When the satellite is already in its orbit (final attitude and inclination), its attitude (orientation) is changed to achieve its final attitude. A satellite whose final orbit is a geosynchronous orbit (GEO) can be launched into a low attitude elliptical orbit and circularised later using propulsion rockets or thrusters. When the satellite is put into a highly elliptical orbit with its apogee attitude equal to its final satellite orbit attitude, firing the apogee kick motor at apogee will circularise the satellite orbit. The satellite attitude is modified into its final desired attitude by the attitude control system.

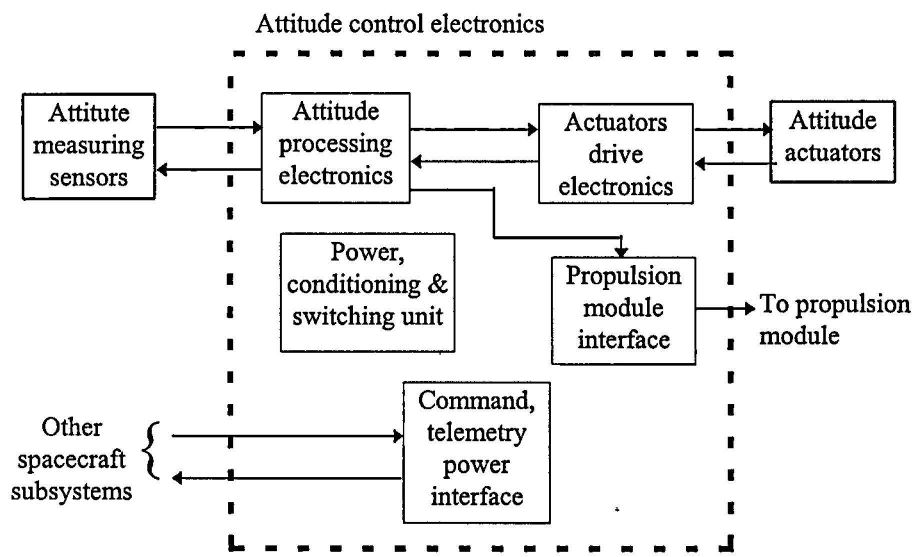


Figure 2.2 Block schematic of Attitude control system

Sources: Chetty P. R. K.(1988). Satellite Technology and Its Applications, p. 160, Figure 4.3.

Attitude control techniques can be classified into two types: active and passive. Active systems use torquing devices that require power, such as reaction jets or wheels. Passive systems derive the torque from the environment, such as the gravity gradient or the earth's magnetic field.

Every satellite has some kind of attitude control. Figure 2.2 shows a typical attitude control system. The attitude of the satellite is measured using various sensors on-board the satellite and attitude actuators are used to correct the attitude so that the satellite is brought back or reoriented into the desired attitude and maintained there. (Chetty, 1988, 162)

2.2.1 Satellite stabilisation control

The perturbation of the satellite's orbit is due to a variety of disturbing torques generated by atmospheric drag, solar wind and radiation pressure, magnetic field, gravitational field, micrometeorite impact and even movement of components within the satellite itself. Instead of following a perfectly circular path in the plane of the Earth's equator, the satellite is pulled and pushed into a gyrating ellipse. This affects the satellite's orbital position and produces the need for an orbital control system. (Chetty, 1988, 164)

2.2.2 Type of stabilisation

Some satellites must meet two opposite functional requirements simultaneously: pointing towards the Earth and orienting a solar cell array towards the sun. In such cases, it becomes necessary to stabilise them. There are three principal stabilisation techniques: gravity gradient stabilisation, three-axis stabilisation and spin stabilisation with a large despun antenna platform.

Gravity gradient stabilisation stabilises orientation with respect to the main central body of the satellite, requires long booms, and can decay or drift.

Three axis stabilisation which is an active control method, requires attitude actuators, enables more fine pointing control, uses consumable fuel, is too fast for some experiments, is expensive, and has a limited life.

Spin stabilisation is simple, it allows any orientation to be made and is used for some scientific satellites. This technology is currently state of the art. (Chetty, 1988, 172)

2.2.3 Type of missions

Generally, there are two types of missions. Type 1 is for communications satellites. The purpose of satellites is to handle communications with earth stations. The satellite's transmitting and receiving antennas point towards the coverage zones on the surface of the earth. The satellite may be a spin-stabilised cylindrically shaped spacecraft having its spin axis normal to the orbit plane. This stabilisation technique requires the least amount of energy to control the spacecraft. Three-axis stabilised spacecraft with deployable solar panels for generating power are another type used for Type 1 missions. Type 2 missions are for low earth orbiting spacecraft. Polar orbits provide the greatest earth coverage for mapping or navigational applications. (Chetty, 1988, 174)

2.3 Frequency bands

A particular range of frequencies is called a frequency band, while the full extent of all frequencies from zero to infinity is called the spectrum. The radio frequency (RF) part of the electromagnetic spectrum permits the efficient generation of signal power, its radiation into free space, and reception at a distant point. An RF signal on one frequency is called a carrier and the actual information that it carries (voice, video, or data) is called modulation. A carrier with modulation occupies a certain amount of RF bandwidth within the frequency band of interest. If two carriers are either on the same frequency or have overlapping bandwidths, then radio frequency interference (RFI) may occur. Frequency bands are allocated for various purposes by the

International Telecommunication Union (ITU). The spectrum of RF frequencies is depicted in Figure 2.3, which is set up on a logarithmic scale. The spectrum from 0.1 to 100 MHz has been applied to the various radio broadcasting services and the frequency bands of interest for satellites lie above 100 MHz. There are the VHF (very high frequency), UHF (ultra high frequency) and SHF (super high frequency) bands. The SHF range has been broken down further by common usage into sub-bands with letter designations.

The C band was the first part of the microwave spectrum to be used extensively for commercial satellite communication. It is identified as the nominal centre of the uplink frequency band (5.925 to 6.425 GHz) and downlink frequency band (3.700 to 4.200 GHz). One particular part of Ku band is referred to as 14/11 GHz, where the uplink range is 14.000 to 14.500 GHz and the down link range is 10.95 to 11.7 GHz. L band, which is below C band, is effective for providing rapid communication by way of mobile and transportable earth stations, like ship to shore. S band is nominally centred at 2 GHz. X band with an uplink range of 7.9 to 8.4 GHz and a downlink range of 7.25 to 7.75 GHz is used extensively for military purposes. Ka frequency band is 20 to 30 GHz. (Elbert, 1987, 12)

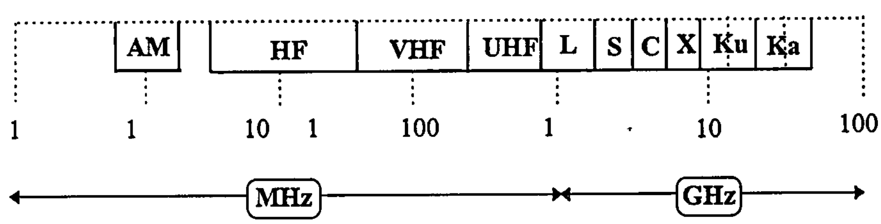


Figure 2.3 The radio frequency spectrum identifying commonly used frequencies.
Sources: Elbert R. B. (1987). Introduction to satellite communication. p. 12.

2.4 Multiple Access Methods

Multiple access is important to the efficient and effective use of communication satellites. The process of combining several channels is called multiplexing. Before transmission takes place a baseband is created for increasing the efficiency of transmission. The basic concept of multiple access is that earth stations transmit to the same satellite without interfering with one another. Radio Frequency(RF) carriers can be maintained separate in frequency, time or space.

The frequency Division Multiple Access (FDMA) technique is frequency separation between carriers. The constraint in FDMA is that the sum of the bandwidths of the individual carriers cannot exceed the satellite's available bandwidth.

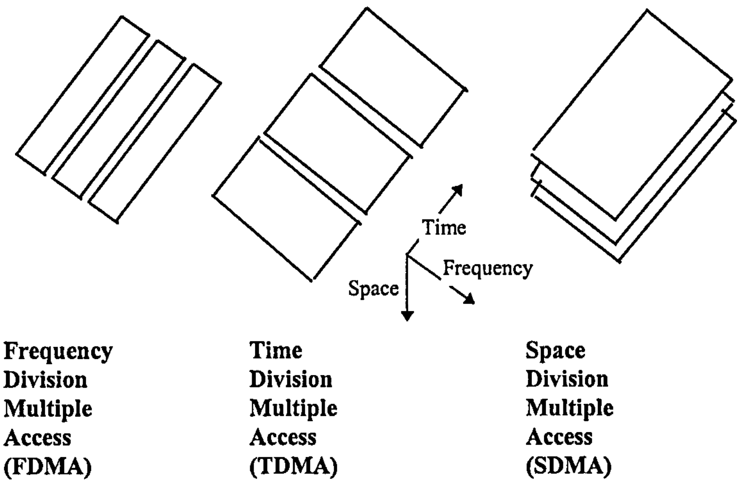


Figure 2.4 Generic Multiple Access Methods using the three dimensions of frequency, time and space

Sources: Elbert, R. B. (1987). Introduction to satellite communication. p. 120.

The time Division Multiple Access (TDMA) is all on the same frequency and each employs the full bandwidth of the RF channel. Jamming is prevented by sequencing the transmissions in time so that they do not overlap. A common system of timing or control must be employed by the earth stations sharing the channel. In TDMA, transmitted traffic is in the form of bursts of information, necessitating compression of the traffic in time at the transmitting end and the complementary expansion at the receiving end.

The Space Division Multiple Access (SDMA) method is makes physically separate paths available for each link. Transmission can be on the same frequency and at the same time. The frequency reused technique is effectively a form of SDMA which depends upon achieving adequate beam-to beam and polarisation isolation. (Elbert, 1987, 12)

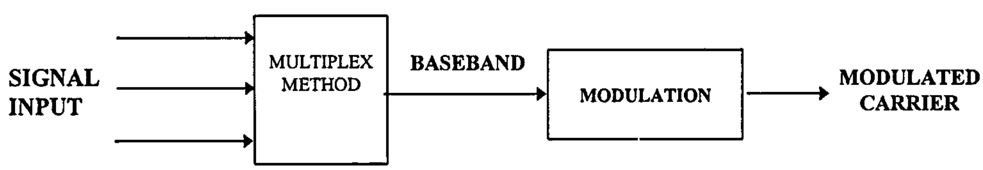
Carrier Sense Multiple Access (CSMA) allows multiple distributed devices to communicate with each other over a single radio channel using a satellite as a transponder. One station communicates with another by waiting until the radio channel is idle (determined by carrier sensing) and then sending a packet of data with a destination address, a source address, and redundant check bits to detect transmission errors. All idle stations continuously monitor incoming data and accept those packets with their address and valid checksums. Whenever a station receives a new packet, the receiving station returns an acknowledgement within a specified time interval. It retransmits the packet under the assumption that the previous packet was interfered with by noise or by a transmission from another station at the same time. Ethernet employs the same concept. (Taub and Schilling,1986, 704)

Code-division multiple access (CDMA) is A coding scheme, used as a modulation technique, in which multiple channels are independently coded for transmission over a single wide band channel. In some communication systems, CDMA is used as an access method that permits carriers from different stations to use the same transmission equipment by using a wider bandwidth than the individual carriers. On reception, each carrier can be distinguished from the others by means of a specific modulation code, thereby allowing the reception of signals that were originally overlapping in frequency and time. Thus, several transmissions can occur simultaneously within the same bandwidth, with the mutual interference reduced by the degree of orthogonality of the unique codes used in each transmission. CDMA permits a more uniform distribution of energy in the emitted bandwidth. (United

State National Communications System Technology & Standards Division, 1996, Internet)

2.5 Modulation Techniques

The relationship between multiplex and modulation for analog and digital information signals identifies in table 2.1. Thè reverse processes are called demuliplex and demodulation, respectively. An RF carrier at a specific frequency can be modulated by varying either its amplitude or phase. Frequency modulation is a special case of phase modulation.



Analog signals(voice and video) Frequency Division Multiplex (FDM)	Digital signals(coded information) Time Division Multiplex (TDM)
• Amplitude Modulation (AM) • Phase Modulation (PM) • Frequency Modulation (FM)	• Frequency Shift Keying • Phase Shift Keying • Hybrid Modulation

Table 2.1 Multiplex and Modulation Methods for use with analog and Digital Information channels

Sources: Bruce R. Elbert (1987). Introduction to satellite communication. p. 124.

2.5.1. Analog signals modulation

The basic form of AM is generated by varying the amplitude of the RF carrier in accordance with the level of the modulating signal. The unmodulated carrier is still present at the centre frequency and sidebands are visible above and below the carrier. The upper sideband is an exact replica of the modulating baseband spectrum while the lower sideband is its mirror image. This technique is called single sideband (SSB).

Phase and Frequency Modulation are used heavily in satellite communication systems. In both systems, the amplitude of the carrier is held constant so that there is no change in the power level. The unmodulated carrier is delayed in time (plus and minus) in proportion to the amplitude variations of the information being sent. Delaying of a carrier causes the angle of its phase to changes, which can be detected at the receiving end and converted back to the original form.

Frequency modulation is varying the frequency of the carrier in proportion to the amplitude of the information. The carrier effectively swings back and forth in frequency. Maximum range of swing establishes the bandwidth of the modulated carrier. (Elbert, 1987, 125)

2.5.2. Digital signals modulation

Digital modulation is discrete in nature. This requires that the carrier's amplitude, phase, or frequency be shifted at a fixed amount in response to the digital code. The process by which a continuos information signal is converted into a stream of digital data is called analog to digital conversion (A/D conversion) and the reverse process is called digital to analog conversion (D/A conversion). The digitised form in either case contains a stream of coded numeric values, each corresponding to a voltage level which was measured (sampled) at a particular instant. For each analog sample, the voltage range is divided into narrow bands called quantization levels.

The fidelity of channel transmission results from the number of samples taken per second (the sampling rate) and from the number of discrete levels into which the signal's voltage has been divided (the quntization). A basic theorem in communication engineering is that the sampling rate must be greater than or equal to twice the highest baseband frequency of the information signal.

Processing of a digital bit stream, using the spread spectrum technique can make the carrier more tolerant of radio frequency interference. The baseband bandwidth of the input data is expanded by mixing in a sequence of essentially random bits which are delivered at a much higher rate than the data. The random bits comprise what is called a Pseudo Random Noise (PRN) code that is generated electronically and can be independently replicated at the distant end with the same type of generator.

Frequency shift keying is switching between two discrete frequencies corresponding directly to the bit being sent. The carrier frequency jumps back and forth between two frequencies. Two different modulators are being used: one to transmit binary "1" and the other to transmit binary "0". This is shown in Fiugre 2.5.

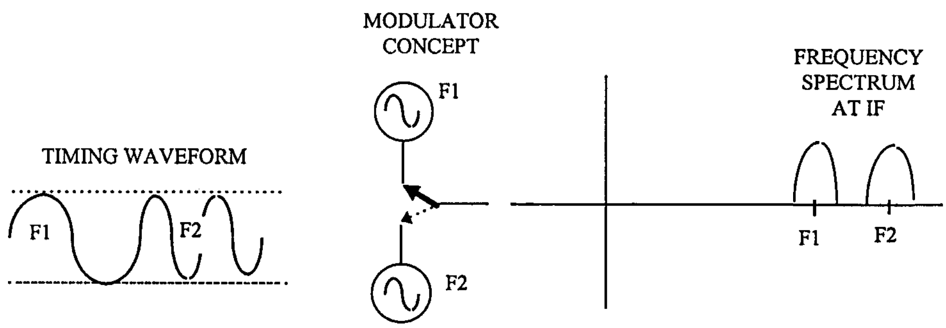


Figure 2.5. Frequency-Shift Keying (FSK); time and frequency can be generated from two oscillators on different frequency

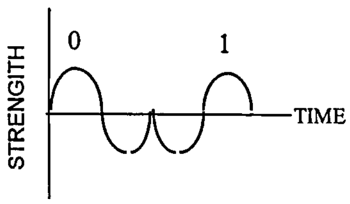


Figure 2.6. Phase-shift keying (PSK)

Sources: Bruce R. Elbert (1987). Introduction to satellite communication. p. 140.

Phase-shift keying (PSK) is the transition form binary "1" to "0" which occurs where the phase of the sine wave reverses. The shifting (Flopping) of the phase by 180 degrees the means by which information is transmitted. This is shown in Figure 2.6. Biphase PSK (BPSK) uses phase states from 0 and 180 degrees. Quadraphase PSK (QPSK) uses four states spilt into pairs: 0 degrees and 180 degrees (the in-phase or "I" component), and 90 degrees and 270 degrees (the quadrature or "A" component). Both are very efficient in the way bandwidth is used.

BPSK modulation is employed with spread spectrum in such a manner as to multiply the RF bandwidth. The density is reduced substantially by the inverse of the expansion of the bandwidth. (Elbert, 1987, 141)

2.6 Payload technology

2.6.1 Communications system

The communications satellite is an orbiting repeater, a device which receives and amplifies and retransmits a signal. The signal from the earth station is radiated to the satellite in a beam. The spread of the beam reduces the radiated power density by the ratio of the area of the beam at that height to the area of the earth station antenna, about 10^{10}:1, a phenomenal reduction, too much to be of any practical use to the weakened unlink leg. Although amplification is the primary function of the satellite communications payload, it must also filter out any unwanted signals and change the frequency of the wanted signal to a lower value stipulated for downlink transmissions. The precise arrangement of the components which perform these functions is governed by what the payload is required to do, for example transmit a number of broadcast TV channels.

The basic components of satellite transmission are earth stations, which send and receive signals, and a satellite component called a transponder. The transponder receives the transmission from an earth station, amplifies the signal, changes the frequency, and retransmits the data to a receiving earth station (In satellite transmission, a satellite acts as a relay station and can transmit data signals from one earth station to another. A signal is sent from an earth station to the relay satellite, which changes the signal frequency before transmitting it to the next earth station.). If a signal must travel thousands of miles, satellites are usually part of the link. From aground station it is beamed to a satellite, which sends it back to earth to another transmission station near the data destination. Communications satellites are launched into geosynchronous orbit e.g. Intelsat. Navigational satellites (Transit and Nova) are launched into LEOs. Today, communication satellites are also launched into the LEOs and MEOs e.g. Iridium and Global Star. (Spoo, 1998, 2)

2.6.2 Inter satellite link

With the development of inter satellite links communications technology has opened up faster, more efficient communication. The old satellite system has communications links only with the Earth, an uplink and a downlink. The data relay spacecraft system allows a link to be made between a spacecraft in low Earth orbit and the ground. Two satellites in geostationary orbit have yet to be interconnected . To be able to do this would be to increase the flexibility of a satellite system. At present, a satellite communications link between two parties on opposite sides of the world is made either using the double-hop technique, which uses two satellites, or using a single-hop and a terrestrial link to cut down the delay. With an ISL, a signal could be uplinked to the receiving earth station. Although for the largest cross-orbit paths this does little to reduce the signal delay, it allows a more efficient use of the available channels in a communications system: signals can be switched through whichever satellites have free channels, which varies with the time of day and at a satellite's longitude.

The most likely candidate technology for Inter Satellite Links (ISLs), is a communications link between orbiting spacecraft. When the link is between two spacecraft in different orbits, it may be termed an inter-orbit link (IOL). IOLs do not fall into radio-frequency bands but are laser based which is an optical link. They have several advantages. They avoid frequency allocation and congestion problems, offer high-rate data links and suffer virtually no interference with terrestrials systems. Using the laser beam eliminates all the restrictions in cross-linking between satellites. The very narrow beam-widths involved (typically < 0.1°) eliminate interference with neighbouring satellites. These narrow beams also provide high antenna gains curing the size, weight, and power problems of the communications terminals. The optical frequencies used with laser beams can provide essentially unlimited communication band widths of greater than 2000 Mbps capability. It would be suitable for GEO-to-GEO or LEO-to-GEO communications links as illustrated as a simplified functional block diagram of a satellite Lasercom system by Figure 2.7. (Katzan, 1987 , 2)

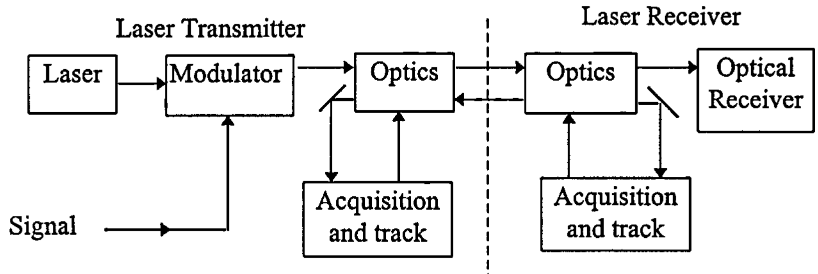


Figure 2.7 Lasercom system functional block diagram

Sources: Katzman, M. (1987).Laser Satellite Communications, p. 2,

2.7 Satellite networks

The purpose of operating a satellite in orbit is clearly to provide connection between earth stations which in turn deliver or originate various types of communication services. The application of such satellite networks are broken down into three broad categories: video, telephone, and data. There are three generic forms of connectivity: point to point, point to multipoint, multipoint to point.

2.7.1 Point-to-point

Point-to-Point is illustrated in Figure 2.8 with two earth stations both transmitting simultaneously to the satellite. A typical network of several earth stations and a satellite provides many duplex point-to-point links to interconnect the locations on the ground. There are many possible circuit routings between the locations. In a fully interconnected "mesh" network, the maximum number of possible links between N earth stations is equal to N(N-1)/2. (Elbert, 1987, 44)

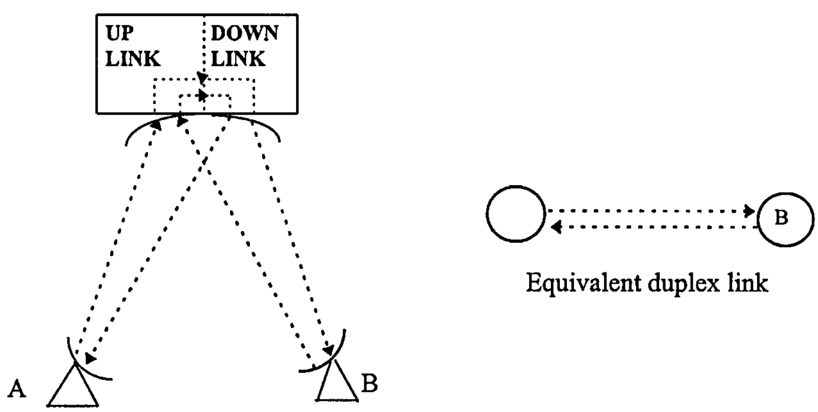


Figure 2.8 Point-to-Point connectivity using a full duplex satellite link

Sources: Elbert R. B. (1987).Introduction to satellite communication, p. 44, Fig. 2-1

2.7.2 Multipoint-to-point

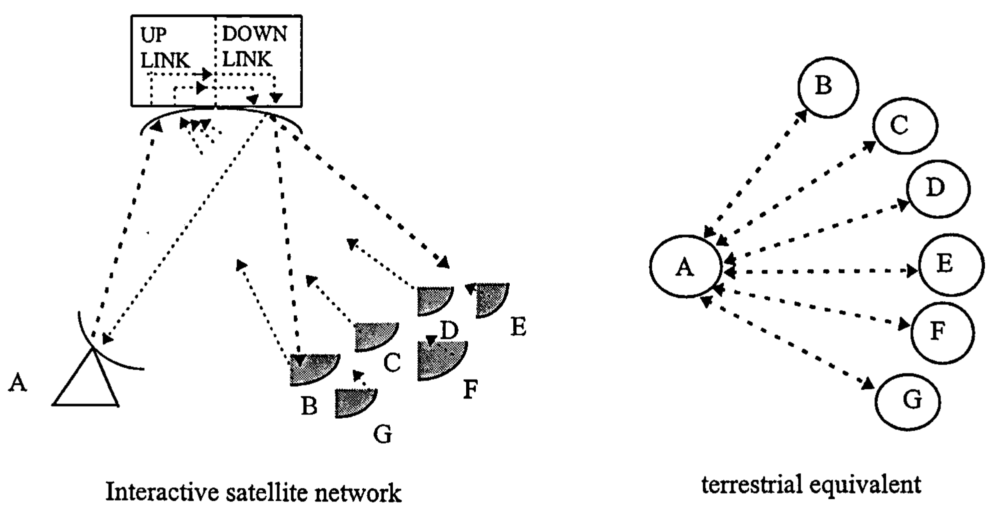


Figure 2.9 Interactive satellite network using multipoint-to-point connectivity

Sources: Elbert R. B. (1987).Introduction to satellite communication, p. 45, Figure 2.3

Multipoint-to-point connectivity provides two-way communication because the remotes receive the broadcast from the central station and can transmit back over the same satellite. The remote stations can not communicate directly with one another except through the central station, commonly referred to as the hub. In Figure 2.9, the remotes efficiently transmit packets of data toward the satellite on the same frequency but timed so that the packets do not overlap when they enter the satellite repeater. Multipoint-to-point networks are an important extension of point-to point because of the relatively small antenna size and simplicity of the remote stations. Modern digital technology has supplied the low-cost means of adding the necessary intelligence to the remote stations while keeping the overall network cost competitive with modern terrestrial networks. .(Elbert. 1987, 45)

2.7.3 Point-to-multipoint

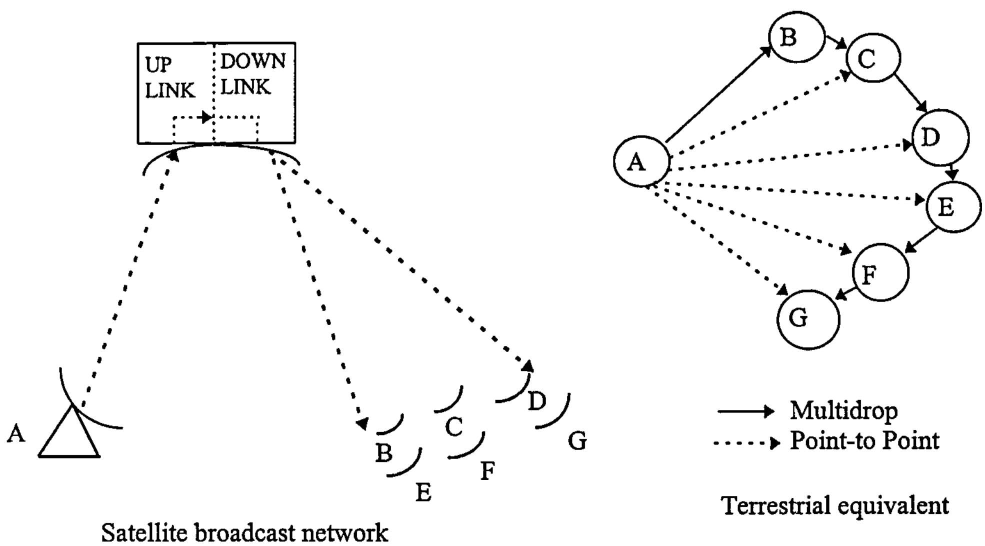


Figure 2.10 Ponint-to-Multipoint connectivity providing a One way broadcast capabiltity

Sources: Elbert, R. B. (1987).Introducation to satellite communication, page 45, Figure 2.2

Figure 2.10 indicates the Point-to-Multipoint. Satellite broadcasting is accomplished with one transmitting earth station and many Receive-only (RO) earth stations. The satellite repeater retransmits the single RF carrier containing the information to be distributed. A Very Small Aperture Terminal (VSAT) is used in a multipoint-to point network. The effectiveness of a VSAT is its interactive nature, allowing two-way communication. Two network architectures are effective for VSATs: the star and the mesh. The star networks are satisfactory for one-way and interactive data communications. VSAT allows permanent linkS between shore and vessel networks with capacities up to several Mbs.(Elbert. 1987, 46)

Chapter 3

COMPUTER DATA TRANSMISSION

A substantial number of computers are situated at different locations. These computers are able to communicate with one another. Such communication allows the sharing of data and computational output, and improves overall reliability of the entire computer system.

3.1 Data Transmission

A terminal or computer produces digital signals, which are simply the presence or absence of an electric pulse. The state of being on or off represents the binary number 1 or 0, respectively. Some communications lines accept digital transmission directly. Most communications lines accept analog transmission which are telephone lines, coaxial cables, and microwave circuits.

To be sent over analog lines, a signal must first be converted to an analog form. It is converted by altering an analog signal, called a carrier wave, which has alterable characteristics. This can be seen in Figure 3.1.a. One such characteristic is the amplitude, or height of the wave, which can be increased to represent the binary number 1. It is illustrated in Figure 3.1.b. Another characteristic that can be altered is the frequency, or number of times a wave repeats during a specific time interval, frequency can be increased to represent a 1. It illustrated in Figure 3.1.c. (Capron, 1996, 129)

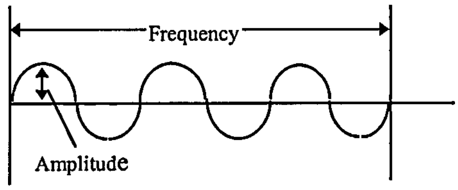


Figure 3.1 (a) Analog wave form

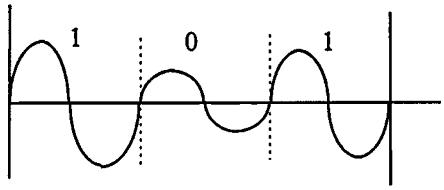


Figure 3.1 (b) Amplitude Modulation

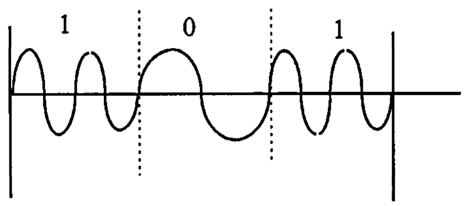


Figure 3.1 (c) Frequency Modulation

3.1.1 Modulator/demodulator (Modem)

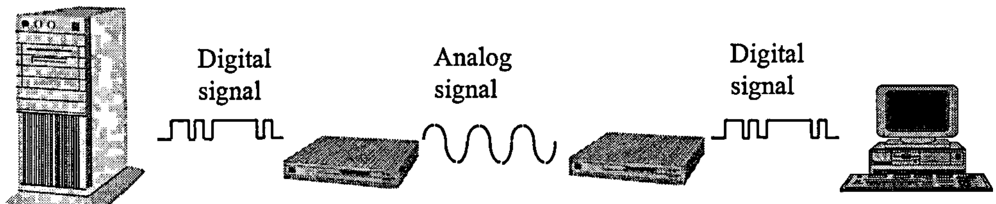


Figure 3.2 Modems. Modems convert and modulate digital data signals to analog signals for travelling over communications links, then reverse the process, demodulation, at the other end.

Sources: H. L. Capron (1996). Computers Tools for an Information Age,. p. 131.

Conversion from digital to analog signals is called modulation, and the reverse process is called demodulation. An extra device is needed to make the conversions. This device is called a modem which is short for modulator/demodulator.

A modem converts digital signals to an analog signals and vice versa as seen in Figure 3.2. The old standard modem speeds of 1200, 2400, and 9600 bits per second (bps) have now been superseded by modems that transmit an astonishing 14,400 bps or higher. (Capron, 1996, 131)

3.1.2 Asynchronous and Synchronous Transmission

In digital transmission, two techniques are commonly used, namely asynchronous and synchronous transmission. When asynchronous transmission (also called start/stop transmission) is used, a special start signal is transmitted at the beginning of each group of message bits. A group is usually just a single character. Likewise, a stop signal is sent at the end of the group of message bits. This is illustrated in Figure 3.3.a. When the receiving device gets the start signal, it sets up a timing mechanism to accept the group of message bits. Today, most of the communication networks are using Asynchronous Transfer Mode (ATM).

Figure 3.3 a Asynchronous transmission

Figure 3.3 b Synchronous transmission

Synchronous transmission is a little trickier because characters are transmitted together in a continuous stream. It can be seen in Figure 3.3.b. There are no call-to action signals for each character. Instead, the sending and receiving devices are synchronised by having their internal clocks put in time with each other by a bit pattern transmitted at the beginning of the message. This assures that all characters are received properly. Synchronous transmission equipment is more complex and more expensive but, without all the start/ stop bits, transmission is much faster. (Capron, 1996, 132)

3.1.3 Simplex, Half and Full-Duplex transmission

Data transmission can be characterised as simplex, half duplex, or full duplex, depending on permissible directions of traffic flow. Simplex transmission sends data in one direction only. See Figure 3.4 (a). Half duplex transmission allows transmission in either direction, but only one way at a time. See Figure 3.4(b). Full-duplex transmission allows transmission in both directions at the same time. See Figure 3.4(c).

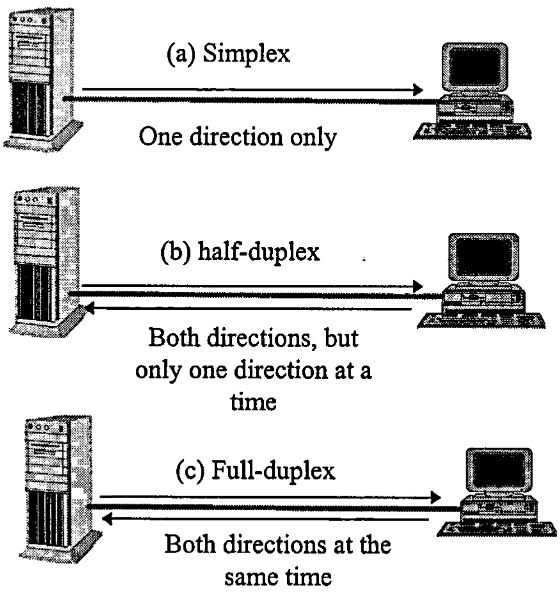


Figure 3.4 Transmission directions

3.2. The computer communications network

A computer communications network is represented in Figure 3.5. The square boxes are the computers. The small open circles are terminals, while the larger black circles are the switching centres which provide the switching facility needed to make the connection as required. The squares with C in the center are computers. Some computers serve a number of terminals and some of the lines connecting terminals to their local computer serve more than one terminal. Generally, lines joining terminals to a local computer are characterised as low speed lines. High speed lines are needed to interconnect switching centres. Orphan terminals have no associated local computer and are, instead, connected directly to a switching centre. Some computers are associated with the network only through their connection to a switching centre.

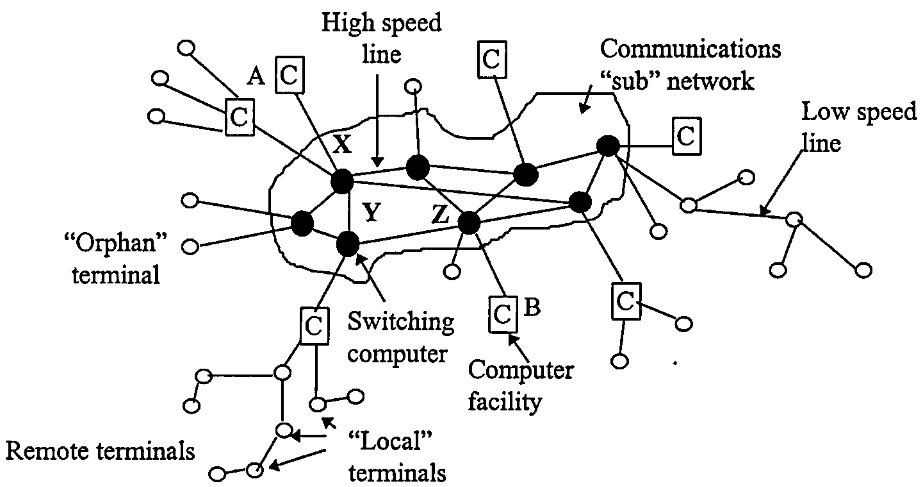


Figure 3.5 Computer communication network

Sources: Taub and Schilling (1986). Principles of Communication Systems, 2nd ed.,. p. 683.

3.2.1 Type of networks

There are three basic types of communication networks in service. These are circuit (line) switching, message switching and packet switching.

3.2.1.1 The circuit Switching network

In circuit switching the hosts which are to communicate are connected by a wire path which is dedicated to the communicating pair, without interruption, for the entire duration of the transmission. This type of system is entirely analogous to a telephone switching system. The entire wire path remains allocated to the single set of users until released and, during this time, no other potential user can use any part of the wire path, not even during intervals when the path happens to be idle. (Taub and schilling, 1986, 683)

3.2.1.2 The message switching network

In message switching, transmission generally occurs in relatively short bursts separated by long intervals of no transmission. Idle time is random. No complete connection is needed. Typically a line connecting two computers may be in use only 1 percent of the time allocated. The example is shown in Figure 3.5.

Computer A needs to transmit data to computer B. The communication will consist of relatively short messages separated by long intervals when there is no transmission. Suppose that the transmission path selected is A→X→Y→Z→B. The line from X to Y and from Y to Z can be used as part of a connection from many computers to may other computers. The computer A will transmit a message to switching centre X where it will be stored in a buffer. This stored message will be kept waiting in the buffer at X until the line from X to Y is not required for some other prior transmission. When that line becomes available the message at X will be transmitted to Y. Again, after storage and a possible delay to wait for available open time, the message will go from Y to Z and then to computer C. This system involves storing and subsequent forwarding of messages; a message-switched network is referred to as a store and forward network. (Taub and schilling, 1986, 684)

3.2.1.3 The packet switched network

A packet-switched network undertakes to circumvents the less desirable features of message switching by subdividing messages into packets. A typical packet may be 1024 bits long. Messages are then transmitted packet by packet. Like the messages in message switching, each packet must be stored in buffers at the nodes of the subsystem and then forwarded. Packet switching is a store and forward system illustrated in Figure 3.6. In some packet switched systems different packets of a single message may arrive at a destination by different routes and with different delays. It is also entirely possible that the packets of a message may arrive out of order. The packet in packet switching, must include not only the information bits but additional bits referred to as overhead information. These overhead bits must identify the destination of a unit (message or packet) so that each switching centre will know how further to route the unit, where the source of the unit is so that acknowledgement is possible, and the user identification so that the user can be charged for services. Further, synchronisation bits, also part of the overhead, must be included to identify the beginning and end of a unit. In packets must be numbered so that they may be reassembled in the proper sequence. (Taub and schilling, 1986, 685)

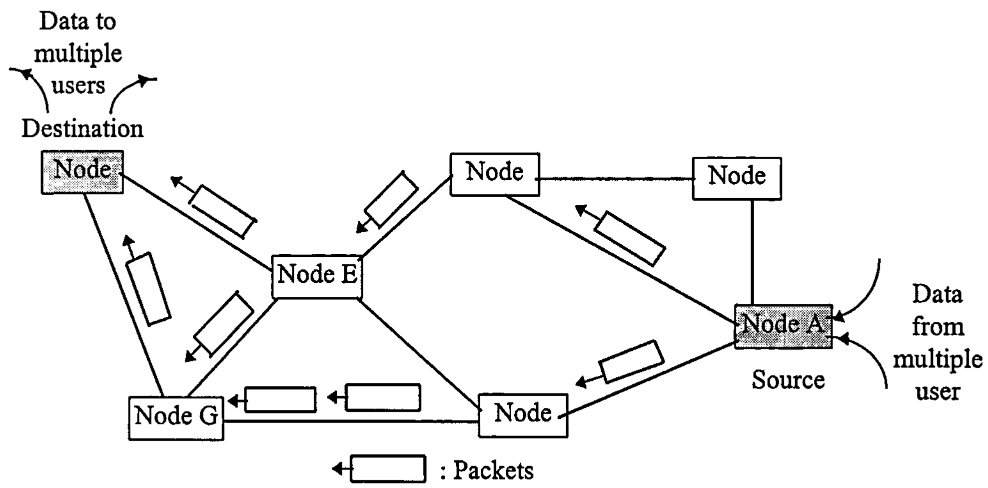


Figure 3.6 Packet-switching

Sources: Black, U. (1989). Data Networks Concepts, Theory, and Practice. p. 450.

3.2.2 Network connectivity

Network topology is a description of a computer network involving interconnection between computers, which computer functions are being used, and the geographic location of the computers. Each computer participating in passing data across the network is called a network node. The node may be a stand alone computer dedicated to moving data through the network or it may communicate to a larger local computer, a host, that supports user functions by storing or processing user data. Specific topologies depend on the constraints of the geography of the sites of the network.

3.2.2.1 Horizontal topologies

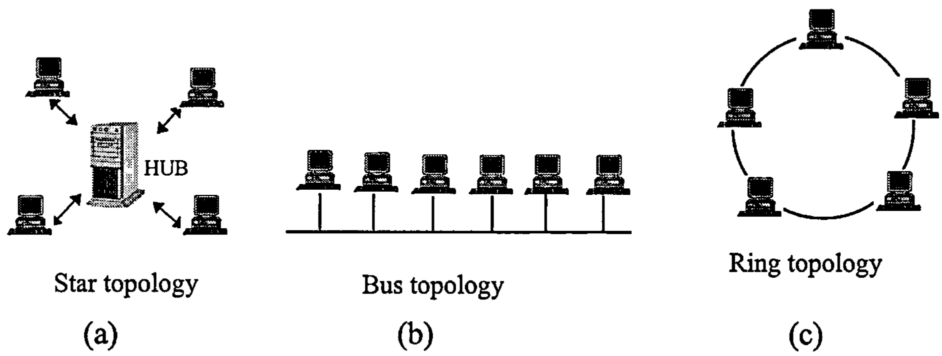


Figure 3.7 Horizontal topologies

Source: Markley, R. W. (1990). *Data Communications and interpretability.* p.3

Star topology is the simplest topology and describes a network with nodes that are linked to a central switching node (Hub). See Figure 3.7 (a). All traffic in the network must travel the central node. The central node is acting primarily as a communications controller, facilitating communication among the nodes on the outside of the star. Star topology is an efficient way to control a network. Like vertical topology the central node requires a powerful computer.

In bus topology all network nodes communicate through a common transmission medium, Figure 3.7 (b), and the data and control signals are simultaneously signalled or broadcast, to all the nodes. Each node has a unique address. Although each node senses every message on the bus, it only transfers data to its associated host when the message is addressed to itself. There are a variety of ways for the nodes to gain access to the medium for transmitting their messages. The computers may contend, take a turn when given permission by another computer on the network (token-passing), or be given a turn by a master node (polling). Bus topology is useful for data processing without a central control. It does not require as powerful a computer as the other topologies.

Ring topology Figure 3.7 (c) is characterised by a path between network nodes that forms a complete circle, with each node connected by two adjacent neighbour nodes. The data flow may be unidirectional or bi-directional. Sharing the ring can be done through token-passing or contending with the other computers. Ring topology is replacing bus topology. (Markly, 1990, 6)

3.2.2.2 Vertical topologies

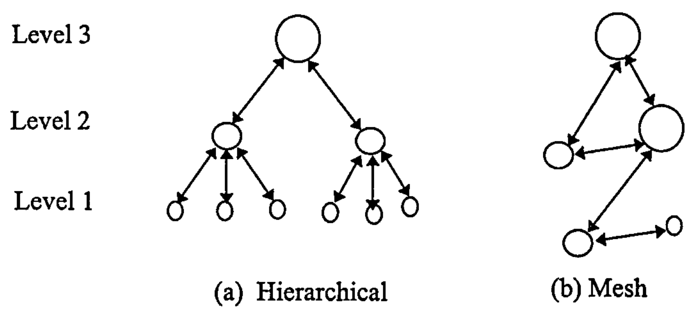


Figure 3.8 Vertical topology

Source: Markley, R. W. (1990). *Data Communications and interpretability.* p.7

Hierarchical topology Figure 3.8 (a) describes networks that interconnect hosts that have increasing data management responsibilities. A key characteristic of them is that the data-processing capability of the host computers increases at each level.

Mesh topology in Figure 3.8 (b) has no recognisable organization or geometric pattern to the network. Many wide area network WANs have a mesh topology. This type of network is used especially when the number of users with different size hosts from different manufacturers exchange data with each other in the Internet.

Local area networks (LAN), Wide Area Network(WAN), Integrated services digital network (ISDN) and Internet are shown as examples of computer communications networks in appendex 1. (Markly, 1990, 6)

3.3 Software and communications

Software consists of programs written by programmers that instruct computers to perform specific tasks. Operating systems and applications software are programs written for computers. There are several operating systems and numerous applications software packages available. The connection of the computers need some kind of communication software in order to interact. Software systems are developing to take advantage of ever faster computing power and cheaper hardware, particularly in the communications field. In the shipping industry, communication software needs to be flexible in the range of data bases that can be accessed and it must be able to integrate different packages together.(Fairplay, 1998, iv)

Most of the software applies icon driven interface (graphical user interface). It is easy for users beacuse many users have become familiar with the Windows environment.

Software increasingly is concerned with handling information and distributing it where it can be used most effectively to increase a company's efficiency, profitability and safety. Communication software establishes a protocol that is followed by the computer's hardware. The software can take a variety of forms. Users work exclusively on a local area network. All communication tasks are taken care of with a network operating system software, e.g. Novell's Netware. A network operating system shields the user from the hardware and software details of routine communication between computers. (Beekman, 1997, 207)

3.3.1. Protocol

Protocol is the formal set of rules governing formatting and relative timing of the information exchange between two or more computers. A protocol is embedded in the network software. It is a sort of pre-communication to make sure everything is in order before a message or data is sent. Protocols are handled by software related to the network.

Different vendors develop different protocols so standarization of rules is important. It provides a framework for the way data is transmitted. The International Standards Organization (ISO) has defined a set of communications protocols called the Open Systems Interconnection (OSI) model. It has been endorsed by the United Nations.

Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical

Figure 3.9 The Open System Interconnection model.

Source: Lane, E. and Summerhill, C. (1993). Internet Primer for Information Professionals, p.72.

A full OSI "stack" includes seven layers of operation. It is illustrated in Figure 3.11. OSI has fully developed protocol specifications for certain features such as security/access control and resource auditing / accounting which would have to be built as application layer protocols in a Transmission Control Protocol/Internet

Protocol (TCP/IP) stack(but are more generally ignored in the TCP/IP Internet). The TCP/IP are explained in Appendix 2. (Lane E. and Summerhill C., 1993, 72.)

3.3.2. Protocol and satellite time delay

The key to successful computer to computer communication over satellite is to employ the right protocols and coding schemes. Terrestrial links transmit data in relatively short bursts called words. Sending and receiving ends follow the protocol in assembling the words for transmission and determining if the received words are valid. If an error is detected at the distant end, re-transmission request is made automatically. Signals travel to and from the satellites in half a second for geostationary communication satellites. LEO satellites do not have this problem.

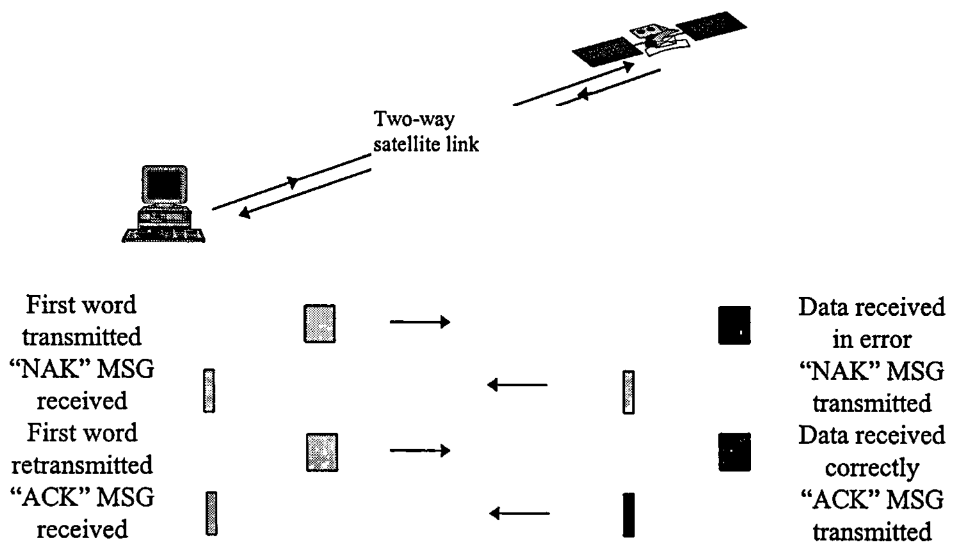


Figure 3.10 Data communication protocol and satellite link

Sources: Elbert R. B. (1987). Introduction to satellite communication. p. 53.

Figure 3.15 shows when the receiving end detects an error and requests re-transmission from the sending end (on the left). The sequence starts at the upper left and moves right to left and left to right, following the direction of the arrows. Introducing satellite delay would force the sending end to halt the transmission to new data for two seconds, at least, as the necessary requests and re-transmissions are executed. The sending end, using old protocols, waits for this acknowledgement each and every time. This slows down transmission over a satellite link. This problem was corrected in early satellite data links by giving the sending end the acknowledgement that it expects even before the distant end has received the group of words.

Newly developed protocols do not require acknowledgements that data packets have been received,. for example, IP Multicast protocols and silding window protocols. Basically, the protocol allows flinging data packets into the ether. The probability is good that the packets will be received correctly because of the quality of the satellite channels. The sliding window protocol is explained in Appendix 3. (Elbert, 1987, 53)

3.4. Computer data compression

Most computer generated data, including ordinary text files, contains redundant information, which can be compressed into a smaller number of bytes without any data loss. A smaller data file consumes less storage space and reduces the amount of transmission time and network resources it takes to transmit a file across a communications line. The most efficient way to send data is to compress it prior to transmission and decompress it to its original format upon receipt using readily available software. Some of the software can compress the original down by a factor of 8. (Smith, 1998, 40).

Compressed data needs a smaller bandwidth so the transmission can maintain high channel capacity on the limited frequency spectrum. When data compression is used to reduce storage requirements, overall program execution time may be reduced. The reduction of storage will result in a reduction of disc-access attempts, while the encoding and decoding required by the compression technique employed will result in additional program instructions being executed. (Held, 1987, 4)

With respect to the transmission of data, compression provides the network planner with several benefits: potential cost savings; reduction of the probability of transmission errors occurring since fewer characters are transmitted when data is compressed while the probability of an error occurring remains constant; increased efficiency which can reduce or even eliminate extra workshifts and a level of security against illicit monitoring by converting text that is represented by a conventional code such as standard ASCII into a different code. (Lane E. and Summerhill C., 1993, 72.)

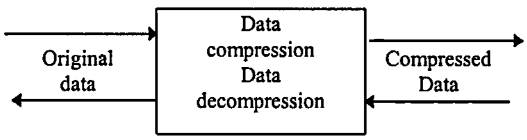


Figure 3.11 Basic data-compression block daigram

Source: Held, G. (1987). Data Compression Techniques and Application Hardware and Software Consideration, 2nd ed., p. 5.

Data compression can be implemented on most existing hardware by software or through the use of a special hardware device that incorporates one or more compression techniques. In Figure 3.16, a basic data-compression block diagram is illustrated.

3.5. Computer data base management system

A database is an organised collection of related data. A database management system (DBMS) is software that organises data as an efficient and elaborate file system. The DBMS is composed of three major parts: (1) a storage subsystem that stores and retrieves data in files; (2) a modelling and manipulation subsystem that provides the means with which to organize the data and to add, delete, maintain, and update the data and (3) an interface between the DBMS and its users.

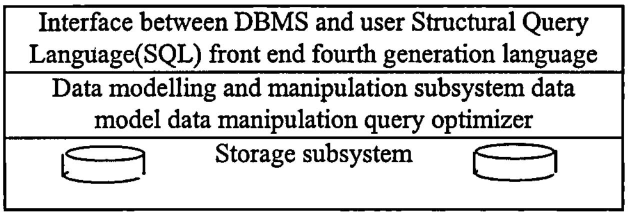


Figure 3.12 Database management system

Source: Blissmer H. R. (1994). *Introducing Computers, Concepts, Systems, and Application*. p. 191

The Figure 3.17 shows a database management system (DBMS). At the physical level, the storage subsystem manages disk storage. The data modelling and manipulation subsystem operates at the logical level, taking care of storing the data model and structures, and translating questions from the users into instructions for the storage subsystem. A query language provides the means to formulate commands that permits the user to perform such data manipulation.

3.5.1 Types of database

A data model describes a way to structure and manipulate the data in a data base. The structural part of the model specifies how data should be represented such as tree, tables and so on. The manipulative part of the model specifies the operations with which to add, delete, display, maintain, print, search, select, sort, and update the data.

There are four main data base types (models): hierarchical, network, relational, and object. Each type structures is differently organized and used. The hierarchical model is a tree structure. Some records are root records and all others have unique parent records. This model is commonly found in business applications (See section 4.6). Top management is at the highest level, middle management at intermediate levels and operational employees at the lowest levels.

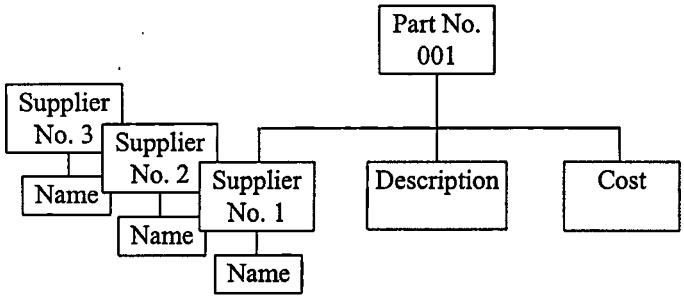


Figure 3.13. The hierarchical model

Source: Blissmer H. R. (1994). *Introducing Computers, Concepts, Systems, and Application.* 1993-1994 edition, Johno Wiley and Sons. Inc, USA. Page 191

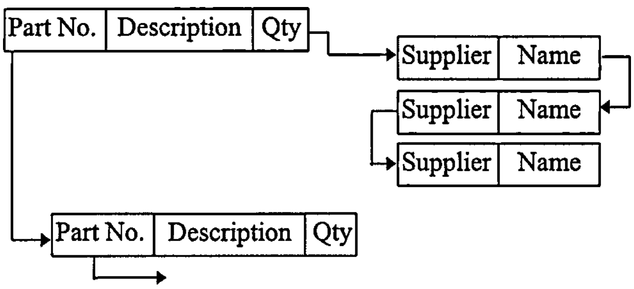


Figure. 3.14 Network model

In the hierarchical model the modem contains files designed like an inverted tree, with the root at the highest level. Figure 3.18 shows a simplified airline spare parts database.

The network model arranges records into a linked list called a directed graph. Each record in the network model can have more than one parent. The network model uses a navigational query language. See Figure 3.19.

The relational model uses a table as its data structure. A table, like a spreadsheet, consists of rows and columns. Each row identifies a record and each column corresponds to a field. (In relational language, a table is called a relation, a row is called a tuple, and a column is called an attribute). Structured query language (SQL), is a query language for manipulating data in a relational database.

The object model is a system in which records are represented by entities called objects that can both store data and provide methods or procedures to perform specific tasks. The inner workings of an object are hidden or encapsulated. Each object belongs to a family or class of similar objects. The class is a template that describes the common characteristics of a set of objects. The query language used for the object model is the same object-oriented programming language used to develop the database application. (Blissmer, 1994, 193)

Chapter 4

APPLICATIONS AND IMPLICATIONS IN THE MARITIME WORLD

4.1 Global Maritime Distress and Safety System (GMDSS)

One of the most significant advances in marine communications since the beginning of the GMDSS currently is being phased in. This process started in 1992 and this will be complete by 1999. The IMO initiated system is partly based upon satellite technology and advanced onboard electronic devices to automate and improve emergency communications for world shipping, as well as to co-ordinate rescue operations. GMDSS was developed by IMO and introduced as a series of amendments to the International Convention for the Safety of Life at Sea (1974) in October 1988. It was implemented, beginning in February, 1992 and applies to all ships of more than 300 gross tons and all passenger ships subject to the 1974 SOLAS Convention.

4.1.1 The System

The basic concept of GMDSS is illustrated in Figure 4.1.a. The diagram shows that a ship in distress is essentially inside a highly efficient radionet. If the casualty is correctly fitted with GMDSS equipment, it is able to alert and communicate with a wide range of radio stations and through them initiate a co-ordinated search and rescue (SAR) operation based on a rescue co-ordination centre (RCC). Two satellite systems are available, namely International Mobile Satellite Organisation Geostationary Satellites System (INMARSAT) and Polar-orbiting satellite system (COSPAS-SARSAT). The INMARSAT geostationary satellites operate in the 1.5 and 1.6 GHz band (L-band) and provide ships fitted with ship earth stations with a means of distress alerting and a capability for two-way communications using direct-printing telegraphy and radiotelephone. L-band satellite EPIRBs are also used for distress alerting. The INMARSAT Safety NET system is used as a main means to provide Maritime Safety Information(MSI).(Wortham, 1998,1-4)

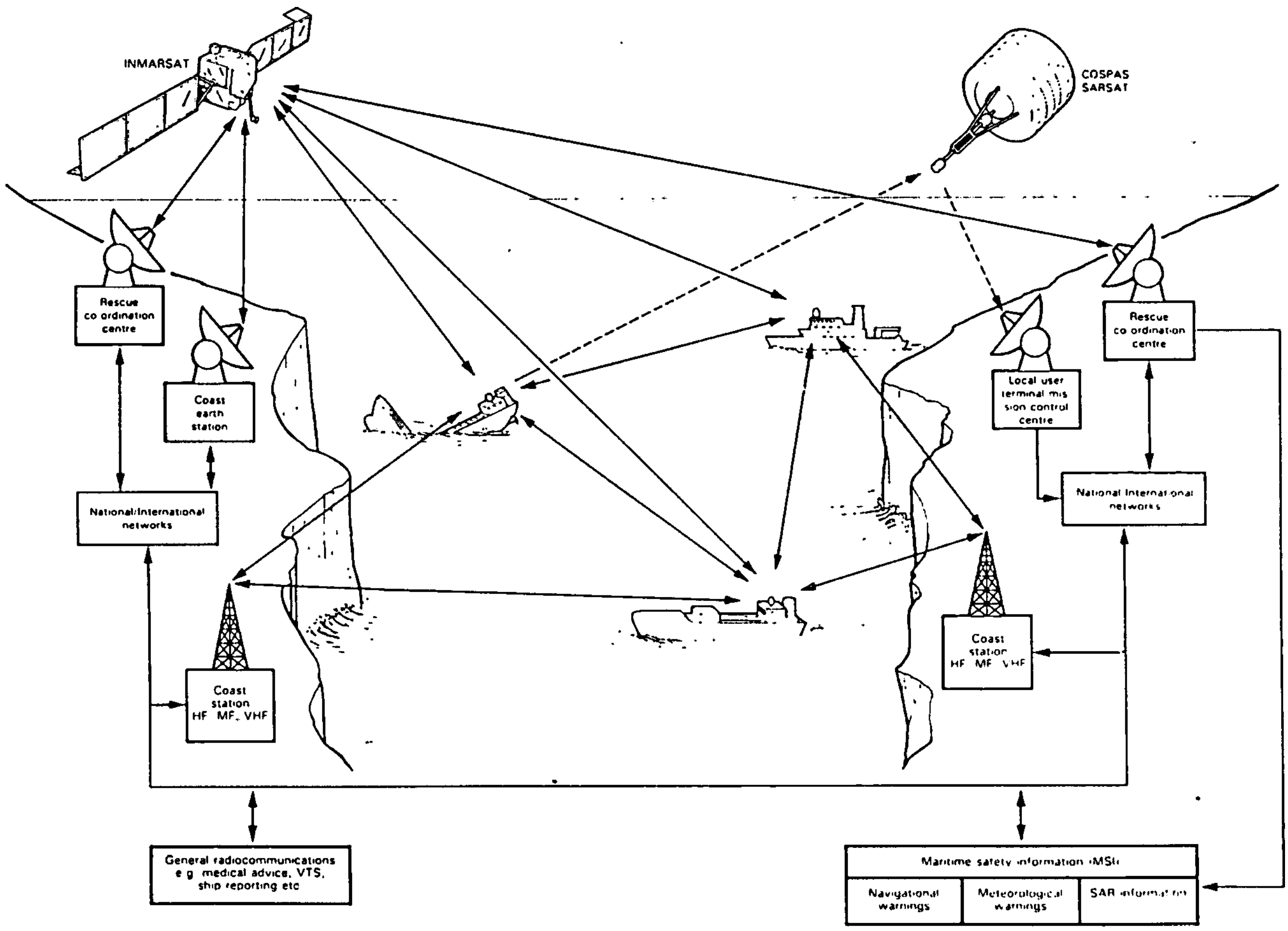


Figure 4.1.a General concept of the GMDSS

Source: IMO (1992). GMDSS handbook, p. 3

The INMARSAT provides the major global communications network. The GMDSS is based on new technologically advanced and automated systems. The GMDSS equipment also can be used in communication with ships trading in any area including established systems and new or modified techniques. Sending a distress message via the INMARSAT system involves only a special button or an abbreviated dialling code. This automatically sends a message giving the ship's name and position. GMDSS divides the seas into four different operating zones:

Sea Area A1: an area 20-30 miles from land, within the range of shore based VHF radio stations equipped with DSC (Digital Selective Calling)

Sea Area A2: an area, excluding area A1, within the range of shore-based MF radio (about 100 miles from shore depending on propagation conditions) with DSC.

Sea Area A3: an area, excluding areas A1 and A2, within the range of services provided by the INMARSAT geostationary satellite system. The INMARSAT covers the whole globe except small areas of navigable water in polar regions

Sea Area A4: all other areas outside areas, A1, A2 and A3. (Wortham, 1998, 11)

GMDSS calls for ships to be capable of:

1. Distress alerting, ship-to-shore
2. Distress alerting, shore-to-ship
3. Distress alerting, ship-to ship
4. Search and rescue co-ordination communications
5. On-scene communications
6. Locating signals
7. Transmitting and receiving Maritime Safety Information(MSI)
8. General radio communication
9. Bridge-to bridge communications (Wortham, 1998, 5)

4.1.2 COSPAS-SARSAT system

The COSPAS-SARSAT system is a satellite-aided SAR system designed to locate distress beacons. The system was established by organisations in Canada, France, the United States and the former USSR. The basic COSPAS-SARSAT system concept is illustrated in Figure 4.1.b. There are at present three types of beacons, namely ELTs (airborne), EPIRBs (maritime use) and personal locator beacons PLBs (land). These beacons transmit signals that are detected by COSPAS-SARSAT polar-orbiting spacecraft equipped with suitable receivers. The signals are then relayed to a ground receiving station termed a local user terminal (LUT), which processes the signals to determine the beacon location. An alert is then relayed, together with location data, via mission control centre (MCC) either to a national rescue co-ordination centre (RCC), another MCC or to the appropriate search and rescue authority to initiate search and rescue operations.

The Doppler shift (using the relative motion between the spacecraft and the beacon) is used to locate the beacons. The carrier frequencies in use are 121.5 MHz and 406 MHz. The 406 MHz beacons are more sophisticated because of the inclusion of identification codes in the messages but complexity is kept to a minimum. To optimise Doppler location and reduce the uplink power, a low-orbit is used.

The Doppler location concept provides two positions for each beacon: the true position and its mirror image relative to the satellite ground track. This ambiguity is resolved by calculations that take into account the earth's rotation, if the beacon stability is good enough, as with 406 MHz beacons which are designed for this purpose. Both 121 and 406 MHz systems operate in the real-time mode, while only the 406 MHz system operates in the global coverage mode as well.

Ships which do not operate in area A4 may be equipped with EPIRBs operating at 1.6 GHz(the L-band, INMARSAT frequency). The advantage of L-band satellite EPIRBs is that they provide an instantaneous alert. L-band EPIRB's are equipped with GPS receivers to include the correct position in distress alert messages. (IMO, 1992, 15)

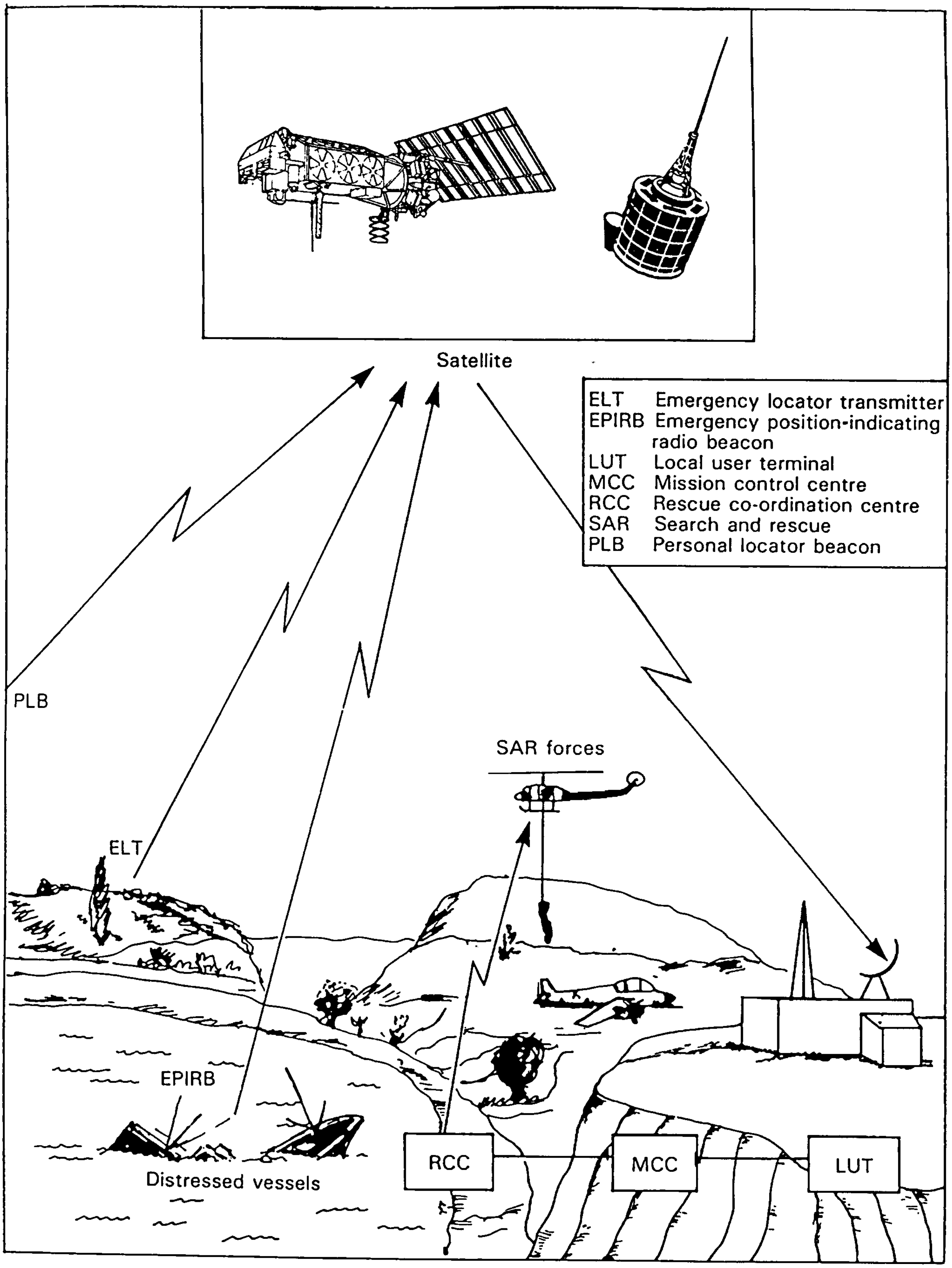


Figure 4.1.b Basic concept of COSPAS-SARSAT system

Source: IMO (1992). GMDSS handbook, p. 15

4.1.3 A vital role for INMARSAT

Satellite communications play a vital role in IMO's GMDSS. Since 1982 London-based INMARSAT has developed a global system of geostationary satellites to provide mobile communications for maritime, land and aeronautical applications. The original INMARSAT-A system allows world-wide telephone facsimile and data as well as safety and distress communications. The INMARSAT-A allows only analog systems so digital data have to convert to analog using a modem. INMARSAT-A has benefited from progressive developments. The increasing popularity of facsimile equipment, for example, has led to the heavy use of fax on Satcoms.

The INMARSAT-B, which services digital communication, makes more efficient use of satellite bandwidth than the analog system. The satellites can accommodate more traffic at any given moment, reducing congestion and permitting more calls to be completed faster during peak use times. INMARSAT-B supports full-duplex high speed data (HSD) at 64 kbps, with automatic connections to the international Integrated Services Digital Networks (ISDN), making it easier to bring ships at sea into shore side data systems. The high quality HSD channels can support data-hungry applications such as live video-conferencing through the use of video compression techniques. The biggest advantage of using INMARSAT-B is the usage cost. An average per-minute price for INMARSAT-B is about half of that of INMARSAT-A.

The INMARSAT-C system allows world-wide two-way low speed data messaging communications using very small portable terminals. INMARSAT-C is designed to make the speed and reliability of satellite communications available to the smallest vessel at an affordable price. It uses store and forward techniques (the packet-switched network) to enable messages to be sent via satellite but with comparatively small shipboard equipment. It can be operated using any PC computer.

The INMARSAT-M system provides an instant and reliable connection operating through the public telephone and data networks. INMARSAT-M is a digital system and uses minimal bandwidth and satellite power, thus reducing operating costs. INMARSAT-M maritime terminals are not currently accepted for used in the GMDSS because they do not provide a direct printing facility.

The INMARSAT mini-M (INMARSAT-phone) is a family of mobile satellite communications products and services providing good-quality phone and low-speed (2.4 kbps) fax and data links everywhere in the world, with the exception of the poles. Designed to exploit spot-beam power, the latest INMARSAT-phones are the smallest, lightest and cheapest mobile satellite units ever made.

The INMARSAT-E system provides global maritime distress alerting services via INMARSAT satellites. Distress alerts transmitted from Emergency Position Indicating Radio Beacons (EPIRBs) are relayed through INMARSAT-E L-band satellites to dedicated receiving equipment located at Coast Earth Stations. Following reception of the distress alert, it is immediately and automatically forwarded automatically to a Maritime Rescue Co-ordination Centre (MRCC).

Enhanced group calling (EGC) via INMARSAT-C enables messages to be sent to a group of ships, rather than to all ships within range. INMARSAT has developed two EGC services. The first, called FleetNET, is a commercial service and enables ship owners and others to send information to specific ships. This is done by preceding the message with a special calling code and for additional commercial security the message itself can be encoded. The second service is called SafetyNET. It enables ships in the high seas to receive NAVTEX-type information, which involves transmitting short range maritime safety information including navigational warnings, meteorological forecasts and warnings, ice reports, search and rescue information, pilot messages and details of changes to navigational aids. EGC receivers are compulsory on all SOLAS vessels sailing in areas without NAVTEX coverage. (Wortham, 1998, 37)

4.2 Global Navigation Satellite System (GNSS)

IMO recognises the need for a future civil internationally-controlled global navigation satellite system (GNSS) to provide ships with navigational position-fixing throughout the world for general navigation, including navigation in harbour entrances and approaches and other water in which navigation is restricted. They aim to develop a system which is outside the control of any one nation or any group of nations.

A GNSS is a satellite system which provides a world-wide position determination, time and velocity capability for multi-modal use. It includes user receivers, one or more satellite constellations, ground segments and a control organisation with facilities to monitor and control the world-wide conformity of the signals processed by the receivers to pre-determined operational performance standards. Resolution A.860 (20) adopted maritime policy for a future global navigation satellite system. The resolution notes the following general requirements for the future GNSS:

- It should primarily serve the operational user requirements for navigation including navigation. For maritime use this includes navigation in harbour entrances and approaches and other waters in which navigation is restricted.
- It should have the operational and institutional capability to meet additional area-specific requirements through local augmentation, if this capability is not otherwise provided. Argumentation provisions should be harmonised world-

wide to avoid the necessity of carrying more than one shipborne receiver or other device.

- It should have the operational and institutional capability to be used by an unlimited number of multi-modal users at sea, in the air and on land.
- It should be reliable and of low user cost. With regard to the allocation and recovery of costs, a distinction should be made between maritime users who rely on the system for reasons of safety and other users who primarily profit from the system in commercial or economic terms. Also, the interests of both shipping and the coastal states should be taken into consideration when dealing with allocation and recovery of costs.
- Three possible cost-recovery options are identified: funding by international organisations concerned (IMO, ICAO, etc.); cost-sharing between governments or commercial entities (e.g. satellite communication providers), or through providers), or private investment and direct user charges or licensing fees.

IMO itself is not in a position to provide and operate a GNSS. However, IMO has to maintain control over the following aspects of a GNSS: the continued provision of the service to the maritime users; the operation of the GNSS concerning of its ability to meet the maritime user requirements; the application of internationally established cost-sharing and cost-recovery principles; and the application of internationally established principles on liability issues.

Transitional requirements of the resolution note that the future GNSS should be developed in parallel to the present systems, or could evolve, in part or in whole, from them. At the same time, in advance of full system implementation, a regional system that is fully operational and which has the potential to be a component of a future GNSS should be developed.

The terrestrial infrastructure (surveillance stations and monitoring centre) should, as possible, be compatible with the infrastructure used in the present systems, and shipborne receivers or other devices required for a future GNSS should, where practicable, be compatible with those of the present systems.

IMO envisages continuing involvement in developing the future GNSS and the resolution notes that the maritime requirements set out should be continually reassessed and updated on the basis of new developments and specific proposals.

The performance standards are developed by the IMO. The operational requirements for ship board equipment are developed by the service provider but must meet IMO standards. The future system should enable shipborne equipment to provide the user with information on position, course and speed over the ground, have a data-link capability and meet the requirements of interoperability with the shipborne GMDSS equipment. The future GNSS should be controlled by an international civil organisation representing the contributing governments and users. The future system should be developed parallel to the present system.

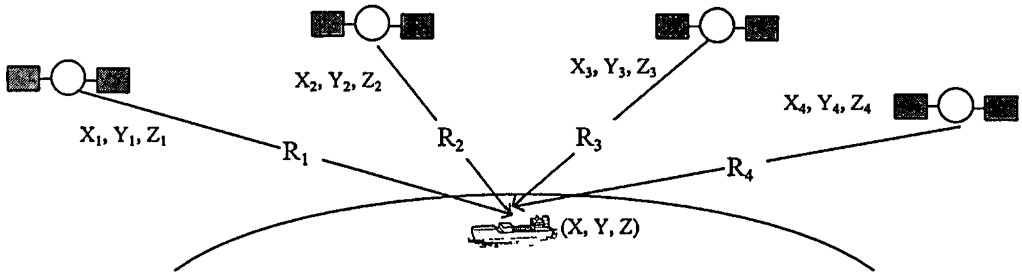
Presently two state-owned military-controlled positioning satellite systems are offered for civilian use. These systems are mainly used in shipping and in aviation, and land mobile transport survey. For maritime use the following aspects of each system are most relevant: The Global Position System (GPS) is a space-based three dimensional positioning, three dimensional velocity and time system which is operated for the Government of the United States by the United States Air Force. GPS meets the requirements for general navigation with a horizontal position accuracy of 100 metres (95%). The accuracy is not suitable for navigation in harbour entrances and approaches or restricted waters. GPS does not provide instantaneous warning of system malfunction. However, differential corrections using maritime radio beacons can enhance accuracy to 10 metres and also offer integrity monitoring.

GLONASS (Global Navigation Satellite System) is managed for the Government of the Russian Federation by the Russian Space Agency. The service meets the requirements for general navigation with a horizontal position accuracy of 45 metres (95%). This system does not provide instantaneous warning of system malfunction either. However, augmentation can greatly enhance both accuracy and integrity. Differential corrections can enhance accuracy to 10 metres (95%) and offer integrity monitoring.

Both systems have been offered and recognised as a component of the World-Wide Radionavigation System(WWRNS), and integrity provision may be possible by receiver autonomous integrity monitoring (RAIM). Wide area augmentation systems are also being developed using differential correction signals from geostationay satellites, in particular INMARSAT satellites. (IMO, 1997, 137-148)

4.2.1 The system

Some satellites transmits two L-band frequencies and a unique coded sequence allowing identification of them, the calculation of ranges to them and the ability to decode data from them. This is the simplex data transmission system. The modulations are in the forms of codes: a Precision (P) Code (alternatively called the Precise Positioning Service PPS) and a Clear Acquisition (C/A) code (alternatively called the Standard Positioning Service SPS) which degrades the signals through a process called selective availability. A satellite with this transmission system makes two fundamental observations, namely the pseudo-range and the phase. Pseudo-ranges allow position to be calculated under all dynamic and static conditions and phase observation has some limitations to its use. A pseudo-range is the radio travel time between the satellite and the receiver, expressed in metres. This is obtained by decoding the P or C/A code which , in essence, contains a snapshot of the satellite clock at the time of transmission. This is compared to a receiver clock at the time of reception, thereby giving a time/ distance measurement. With the ability to measure pseudo-range and knowledge of the satellites' position at all times, the receiver now has enough information to calculate a position. The solution to position is effectively a mathematical reduction and an exercise in three dimensional trigonometry. It is shown in Figure.



$$(X_1 - X)^2 + (Y_1 - Y)^2 + (Z_1 - Z)^2 = (R_1 - C\Delta t)^2$$
$$(X_2 - X)^2 + (Y_2 - Y)^2 + (Z_2 - Z)^2 = (R_2 - C\Delta t)^2$$
$$(X_3 - X)^2 + (Y_3 - Y)^2 + (Z_3 - Z)^2 = (R_3 - C\Delta t)^2$$
$$(X_4 - X)^2 + (Y_4 - Y)^2 + (Z_4 - Z)^2 = (R_4 - C\Delta t)^2$$

Figure 4.2 Ranging principle

Source: Ackroyd, N. and Lorimer, R. (1994). *A GPS users guide.*. p. 156.

For every computation of position there are four unknowns factors called X, Y, Z and t (for time). The position can be calculated using a series of four simultaneous equations. (Ackroyd and Lorimer, 1994, 156)

4.2.2. Geostationary overlay concept

Users of GPS and GLONASS benefit in three ways from the geostationary navigation satellites. They are shown in Figure 4.2.a. First, these satellites appear as additional signal sources. This is called the ranging function. This increase in the number of satellites in view greatly enhances the availability of the system.

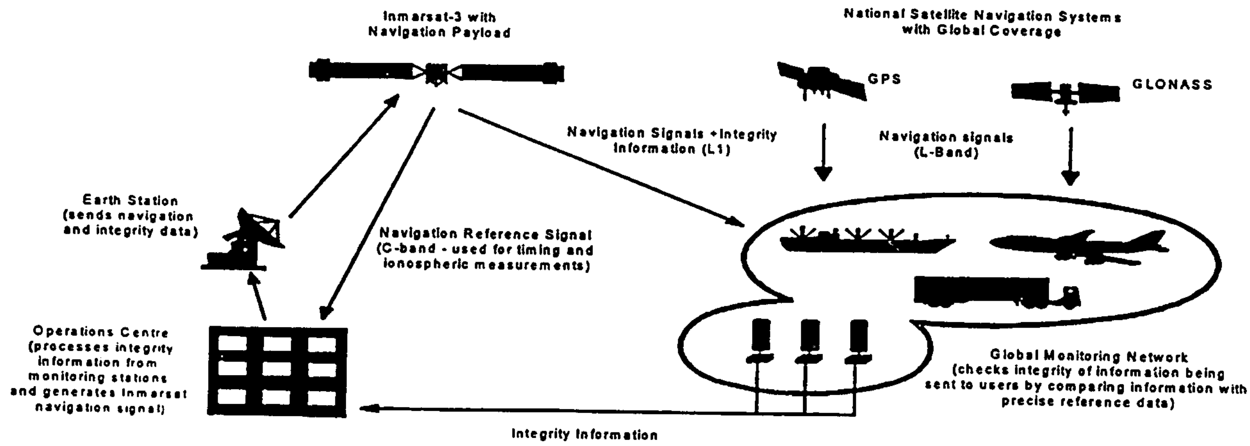


Figure 4.2.a. Geostationary overlay concept

Source: Wortham C. (1997). 'Maritime Satellite Communications Book I'. p.90.

Secondly, the data carried by the signal is planned to include integrity monitoring data derived from a ground monitoring network. This is termed the GPS (or GNSS) integrity channel (GIC). It turns out that for aviation applications, the GIC function itself provides a further increase in availability. Using Receiver Autonomous Integrity Monitoring (RAIM) techniques the user receiver must itself determine integrity when external integrity data is absent.

Thirdly, function also can be provided through the navigation payloads. The integrity channel carries real-time measurements of the errors in the navigation signals provided by GPS and GLONASS. Each user receiver is able to use this data to determine if each navigation satellite's signal is suitable. This further increases system availability, as the user may be able to use sets of satellites

4.3. Applications

4.3.1 Weather routeing

Bad weather means more fuel, more time at sea and more chance of cargo damage. Ships need to get away from areas of bad weather. Weather routeing both from shore based stations and onboard ships has come a long way since its inception. Expert meteorologists ashore analyse weather forecasts for days ahead to calculate the best route for a ship to take. Regular updates on the expected weather and detailed course adjustments are sent to the ship during the voyage. Sophisticated technology now allows the use of key data on an individual vessel, such as engine performance and speed reduction curves, and the vessel's particular characteristics, to be integrated with weather to optimise routes for any of a whole series of criteria that a shipping company might select.

Historically, the cost of communications was expensive and on-board systems could offer better route-optimisation than shore-based routing. The situation now is one of integration of ship and shore. Being on the spot, the master can feed real, rather than theoretical, data into the system. If the actual speed reduction or fuel consumption experienced in certain conditions differs from what's been calculated, the master can fine-tune his route and re-calculate accordingly. Integration with engine performance monitoring systems can offer further enhancement. However, all this requires a certain skill level that the master may or may not have. All meteorological data around the world is available free of charge to anyone who wants it, but only a few organisations and a small number of government meteorological offices have the computing power to store and process raw meteorological data through complex computer models to produce detailed forecasts. Today, some commercial companies are forecasting for particular routes and vessels. The forecasts are transmitted to the ships via INMARSAT. Onboard weather routing can bring direct savings in the form of reduced fuel bills and/or faster voyages using less money for communication cost. Indirect savings are in the form of reduced maintenance costs, fewer cargo insurance claims and increased safety. (Compuship, 1997f, 18)

4.3.2 Vessel reporting and administrative systems

Important operational data is entered into the system onboard ship, compressed and transmitted ashore to provide shore-side managers with the up-to-date status of each vessel and position, personnel and payroll management, cargo loading and so on. Computerised forms and data files ashore can be transmitted automatically either to selected ships or to all vessels. Information can be entered quickly and easily into the form with automatic transfer of data to a central shore-side data repository. Only the updated information, rather than the entire form, is transmitted, saving on communications costs. Every form update in the fleet creates a transaction that is traced by date and time, user ID and tells where the change was made. A detailed audit trail of the ship's safety management system can be established easily with the electronic support of computer systems.

The ISM Code requires that there should be good communication between those responsible on the ship and those responsible for the management of the ship. The reporting requirements for many companies result in an increased volume of reports and therefore, communication time increases and air time costs rise. Reports are written on word processors and spreadsheets, printed and sent by fax or data. (Marine Log, 1998, 44-46)

A half-page telex, a two-page fax and a 50 page document sent by data communications all cost about the same over satellite. Using data communications can be a vital part of ISM Code procedures, and saves money.

4.3.3 Planned maintenance and communication

Section 10.1 of the ISM Code guidelines states that there should be a system of planned maintenance, which requires that data transfer to shore be performed once a week. Ships will send lists of jobs done, components used and spare parts needed, to the superintendent ashore. The office will send the ships information on orders placed, deliveries, dry-docking schedules and major jobs that require preparation. The computer system must be able to transfer only the updated information - not the whole database.

The combination of planned maintenance software and communication software prevents breakdowns and reduces unplanned maintenance. The system: allows efficient allocation of labour and time to jobs; predicts spare part requirements which allows advance ordering; and permits accurate stock control. (Compuship, 1997a, 18)

4.3.4 Electronic Chart Display and Information System (ECDIS)

Traditionally, a ship received a list of chart corrections when it arrived at a port. Then, the navigator laboriously marked these corrections on the relevant charts by hand. The era of electronic charting allows the updating of charts automatically using satellite communications as a means of transferring the required update data regularly. This can reduce manning costs, increase navigational safety, reduce fuel costs, and reduce the scope of navigational error.

It also supplies complete charts when appropriate. The problem is the cost of the transmission for a whole chart. Typically an ECDIS chart may contain several megabytes of information making normal satellite transmission too expensive. However there are certain cases where the cost, at least of using satellite links, can be justified. For example, in the case of a vessel suddenly diverted in mid-voyage to a new port of call for which the vessel does not possess a chart. In this situation it probably is cost-effective to send a chart to the vessel by satellite rather than having the vessel divert to a third port to collect the information. Also, as with much in the area of computers and communications, costs may well come down in the future as more and more people make use of these systems and communication companies compete for customers. (Compuship, 1997d, 25-27).

4.3.5 Telemedicine

A PC based satellite telemedicine system can provide medical care for accidents and emergencies onboard ship providing a real time satellite link between an injured or sick person and a medical specialist anywhere in the world. One such system is supplied by ARIES Communication. This system compresses and sends at 64 kbps using the INMARSAT-B, increasing the flow of data and saving time and money. It carries, not only live video and audio links, but also a medical telemetry link which, when connected to a medical monitoring unit can provide a real-time display of the patient's vital signs, such as Electro-Cardio-Graph (ECG). pulse rate, oxymetry, blood pressure, respiration rate and temperature. This can greatly reduce the expense associated with airlifting patients to the nearest hospital or deviating the ship's course to the closest port.(Ocean Voice, 1996c, 27)

4.3.6 Fisheries

Using the satellite vessel monitoring system in the fishing industry, vessels can be contacted any where, the value of their product can be maximised level of safety to protect valuable resources can be increased and the cost of management operations can be minimised.

New satellite fishing maps are now available. The maps carry data on plankton distribution and water temperature. They are prepared from data downloaded from the satellites which are Orbimage and National Oceanic and Atmospheric Administration (NOAA) satellites. The satellites are equipped with a sea-viewing wide Field-of-view sensor instrument. The maps are e-mailed daily to vessels for display on a standard PC. This allows them to expand regarding the area of fishing control. (Fishing News, 1998, 1)

4.3.7 Electronic sea trading

Internet technology is transforming business. Internet-based marine trading systems transfer information and use local software because it is cheaper to access the Internet via a local phone call. Data can be viewed and prepared off-line using this approach and that also saves money. Off line entry is particularly cost-effective for transactions, such as requisitions, that are generated on board ship. The time-consuming data input is performed off-line and only a very short transmission burst over the satellite is needed to transfer the requisition on the trading system. (Compuship, 1997c, 8)

Electronic Data Interchange (EDI) system is a method in which business information is transferred from one computer to another computer via a computer network in an agreed upon format. It is one of the solutions to the transfer of business information between dealers. It was started in the 1970s. Today standard format is known as UN/EDIFACT (United Nations EDI for Administration Commerce and Transport).

In any electronic trading system, data security is a key issue, and storing data centrally protects it from unauthorised access with software. Security and reliability requires a range of technologies (encryption, digital signatures, access controls, firewalls, etc.) and effective, consistent use of those technologies, all supported by a trustworthy key and security management infrastructure.

Digital signatures allow users to identify their partners' reliably in communications; encryption protects the confidentiality of stored data and electronic communications by making them accessible only with a particular decryption key.(Samaranayake, 1997, 45)

4.4 Integrated Bridge Information Systems

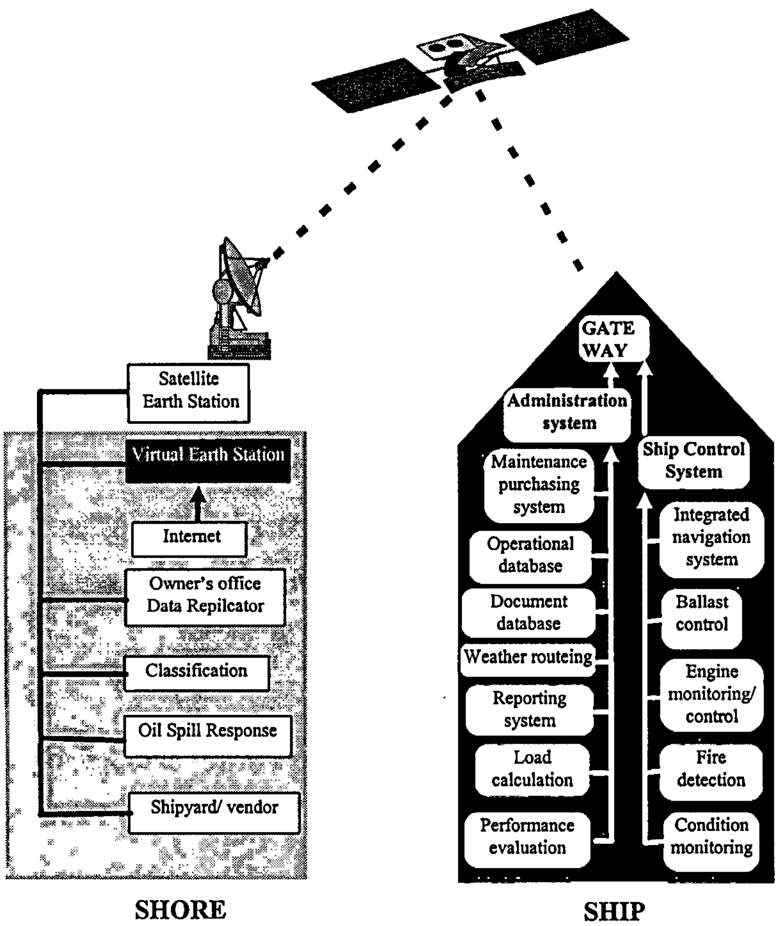


Figure 4.3 Ship and shore network and communication structure

Sources: Ocean Voice (1996b). The Office Afloat, p.20. and Compuship (1997b) The Office at Sea, p. 11.

The information technology in Ship operation programmes are the latest development in computer technology and satellite communications to improve vessel operation and maintenance.

4.4.1 Optimisation of the communications facilities: Optimisation of communications ability is the combination of software and hardware to exploit communications technology to the full, maximising the ship/shore data throughout automatically. PCs and communications hardware/software combinations can take advantage of high transmission speeds, data compression and traffic routeing to reduce traffic costs by 60% to 80%. Electronic mail can replace telex and fax. Fax transmission can be optimised to reduce time by using computer transmission. The concept of the optimisation of communications promotes the freedom to exchange high quality information. The managed ship-to-shore communication infrastructure is the foundation of the information explosion which can totally optimise costs, minimise on-board intervention and maximise flexibility.

4.4.2 Inter-connectivity of industry network: The effectiveness of communications networks relates to user population. The bigger the population is the better the system. The more businesses that participate, the less expensive it is for each user. A prime objective of Inter-connectivity of industry network is the integration of the ship/shore communications into the corporate environment and beyond, linking a variety of computer and communications systems into a functional network. The shore based hub system must provide a store-and-forward exchange link via gateways to other communications networks allowing fax and e-mail delivery to corporate and non-corporate destinations. It is the latent opportunities for non-corporate vessel/shore communications that will feature in the next major development in marine communications.

4.4.3 Management of the ship/shore communication: Ship/shore communications is a notable inclusion in communications network management. Layered over the features in the optimisation of the communications facilities and inter-connectivity of industry network is the virtual automatic operation of the onboard applications network and communications. They require little human interface or involvement. Essential monitoring, control administration and support is carried out by based central services offices. The present system maximising availability, reliability, flexibility and quality of communications whilst minimises onboard and shore end-user involvement. It is this layer that defines a true infrastructure approach.

Whether as the result of individual corporate planning, the unrelenting march of formal regulation, or the sheer momentum of informal PC proliferation, vessels are destined to become floating offices integrated with shore systems. A managed ship/shore communications infrastructure is a mandatory prerequisite for the 21st century. (Ocean voice, 1996b, 20)

4.5 Onboard training

Satellite and computer technology provide an important link for onboard education and training to improve standards of safety in the work place and to increase the number of well trained crews at an affordable cost. Computer data compression and high speed data transmission techniques make the cost of using the medium to undertake distance learning at sea affordable. Data transmission can send text, drawings, graphics and tabular information. Internet is a good example.

Most vessels today are equipped with computers. Computer aided learning is an effective method for acquiring knowledge, understanding and, in some cases, skills- depending upon the degree for sophistication and the interactive nature of the programming. Using satellite communication links, data transfer can be effected quickly and cheaply. Video pictures can be relayed. The handling of practical tasks and functions can be demonstrated onboard. Satellite communication provides a unique link between students at sea and tutors or company training officers ashore. Assignments can be transmitted, marked and returned within a very short period of time. Distance learning programmes must be planned carefully and be designed and edited by professionals so they are suitable for the market at sea.

4.6. Onboard data base system

Onboard ship the role of the computer is to be the information manager. Most of the modern ships are constructed with built-in LAN network. The collected information can be presented directly on a Video Display Unit (VDU). The available data bases onboard are the local monitoring sensors. The ship must be self-sufficient on all the data references. Crew members must be capable of responding effectively to all the information: handling of engine and bunkers' monitoring, maintaining schedules and onboard spare parts' management, loading cargo, calculating payroll and crew information

The ship earth station can be connected to any onboard equipment fully accessible from shore via satellite link. The network can monitor engine performance and condition, fuel consumption, ship speed and heading, cargo condition, the navigation system, weather forecasts and sea state conditions. It can hold database information such as maintenance records, equipment condition, engine logging supplies.

The vessel equipped with Satcoms and a computer has access to any computer-based technical information relating to equipment, including engineering drawings and equipment part numbers which can be kept current. Updating and transmitting plans and drawings is done with this system by electronically scanning and converting them to digital form. This system can rapidly convert large volumes of paper records into electronic filing systems and databases.

The ship operators are able to hasten ship turnaround considerably by means of exchanging loading data at sea. The loading computers can be linked to their ship earth station, thus enabling the offices to calculate all information pertinent to making routing decisions to maximise profit. Specifically they consider the laid and ballast situation of the ship in the trading. This information can be updated frequently allowing the calculations to be complete and available onboard before the ship enters the harbour.

On board data base systems allow cruise ships to dispatch restaurant seating plans and supply lists in advance of arrival and to receive newspapers and commercial information of passenger interests. Passenger vessels also receive a variety of data communications such as messaging, ship-shore reporting, port information, weather bulletins and chart corrections for passenger vessels. (Silva, 1991, 11)

4.7. E-mail/Internet and INMARSAT-C

Today, a standard form of business communication is the sending of e-mail the via Internet. It is beginning to make a significant mark in the maritime industry. E-mail messages can include plain text or file attachments and valuable features such as address books, multi-addressing and archiving are common to most e-mail packages. Internet e-mail is being used more by shippers for a variety of reasons. A number of INMARSAT land-earth stations are now offering quick and easy access to Internet e-mail services. The Internet has become the driving force in the development of communications technology. E-mail is replacing telex as the most common way to communicate between ship and shore.

INMARSAT C is being used most widely for the emergency transmissions covered by the GMDSS, and most ships are having the equipment installed specifically for this purpose. The big advantage to INMARSAT C is that the computers can be used for normal business while they are monitoring for emergencies. Should an emergency message be sent, it overrides any application in use. To protect against a high false alarm rate. IMO drew attention to the problems, which often included the use of commercial equipment that GMDSS equipment often incorporated into a general purpose computer running non-GMDSS applications.

IMO has called back for existing INMARSAT C terminals for modification to reduce the likelihood of false distress alerts. Any new INMARSAT-C terminal fitted to comply with GMDSS has had to conform to Change Note 114 (CN114), and an important set of changes to the INMARSAT-C system definition manual (SDM). CN114 requires a dedicated computer. It also allows the terminal to have a second port, to which an ordinary, non-GMDSS computer can be attached. In an emergency, the secondary computer is overridden and the dedicated, built-in software takes over. The manufacturers of CN114 terminals have built second computer ports into their hardware. INMARSAT-C can be used for e-mail messages between vessels and their head offices, and it also can be a cheaper way for crew members to keep in touch with their families. Cost savings can be achieved when sending multiple messages. Using INMARSAT-C for multiple e-mail is also cheaper because the space segment is used only once, and service providers generally do not charge for the terrestrial link for Internet users, only for the space segment. In effect, INMARSAT-C is likely to become another access route for the Internet. Once a ship is fitted with the system, whatever the equipment supplier, it automatically will have the ability to send ship-to-shore Internet messages. Registration is only required in order to receive Internet-mail because it is necessary to have an address and contact number.

Now, most major INMARSAT service providers are able to locate INMARSAT-C terminals wherever in the world they may be. The sender does not need to know which Ocean Region the ship is in when the message is sent. The ship-board user simply inserts the shore-side Internet address in the address field of the message before activating the send function. A key consideration in shipping, most offer confirmation of delivery and some even confirm that a message has actually been read. (Compuship, 1997e, 25)

Chapter 5

TRAINING PROGRAM FOR SHIP OFFICERS

5.1. Implementation of GMDSS

GMDSS goes into effect on 1 February, 1999. At that time all ships (it is depended on tannage) must have GMDSS installed. Chapter IV of SOLAS, as revised in 1988, requires every ship to carry personnel qualified to carry out distress and safety radio-communications to the satisfaction of the Administrations of the nations. In order to use GMDSS, at least one person on board an ocean going vessel must hold a General Operator Certificate (GOC). The deadline for implementation of the International Safety Management (ISM) Code for the majority of vessels was 1 July, 1998. Complying with the ISM Code requires having effective communications systems in place for the transmission of information and data. Satellite communications will play a vital role in the application of this code.

5.2. Training for GMDSS

GMDSS training has followed two different routes: one involves the use of real equipment in a training room, and the other provides the student with images of equipment displayed on the screen of a personal computer using simulation techniques. Both methods are effective and have been widely used.

Real equipment provides the student with the important tactile "feel" of the actual knobs, buttons and switches of working units. The student also will usually have at arms reach all the real world of bridge operations. Unfortunately, live transmissions on distress frequencies are prohibited, for obvious reasons, which immediately impacts the realism of the simulation. Secondly, because of the technical complexity of linking several separate suites of GMDSS equipment together, the number of participants in a training scenario is quite limited. Thirdly, students first must spend time learning the individual characteristics of each specific manufacturer's unit being used in the training even though they may never encounter these units again in their careers. Finally, the system cost is very high for buying and maintaining.

The PC system allows complete freedom to select and transmit on distress frequencies, since all communications are simulated. Similarly, many individual PCs can be linked together to allow a number of students to participate jointly in complex training scenarios. However, the PC approach lacks the tactile "feel" and look of a full suite of real equipment and its mode of operation prevents the development of important situational awareness skills. For example, should the student decide to transmit a message over VHF, the keyboard is used to "call up" a picture of a VHF control panel on the screen and the computer mouse and its screen pointer are then used to "click on" the various control functions. This system can build the student's confidence in working with any manufacturer's equipment although the student has not learned the individual idiosyncrasies of each product on the market. In other words, once the basic knowledge foundation is laid, any unique features can be quickly mastered. Furthermore students would not spend time learning unnecessary operating procedures. This system cost is not so expensive compared with the first one as most of the institutions in the developing world can buy this simulation program. (Ocean Voice, 1996a, 12)

5.2.1. GMDSS Training in Myanmar

In Myanmar, two GMDSS training centres were established in 1996 and 1997. One is under the control of the Marine Administration Department. It can train 20 students simultaneously. Another one is in the Institute of Marine Technology. It can train 10 students simultaneously. Both centres are using a PC based simulator system and are training Myanmar ship officers according to IMO model course 1.25. Both centres are running joint-ventures with crew management companies. To date nearly one thousand ship officers have been trained.

The length of the course is two weeks and it fulfils the requirements of SOLAS. The certificate is issued by the Department of Marine Administration co-operated with Telecommunication Department in accordance with Resolution 4, Chapter IV, STCW 95. (Department of Marine Administration, 1996)

5. 3 Training for Information Technology applications

5.3.1. What is Information Technology?

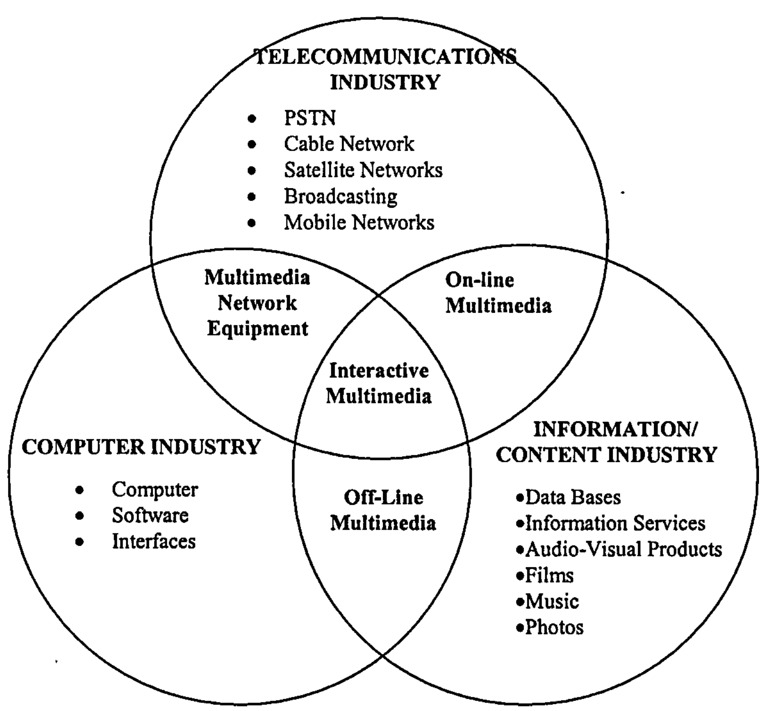


Figure 5.1 IT technology

Source: Department of trade and Industry (1996). Development of the Information Society, Report by Spectrum Strategy consultants, HMSO , London.

Information technology (IT) is a collection of data. Specifically, it involves acquisition, processing, storing, and disseminating of vocal, pictorial, textual and numerical information from industries involved in using a combination of computing and telecommunications. It is shown in Figure 5.1.

IT is not confined to hardware and software. It acknowledges the importance of man: the goals he sets for this technology and the values he uses in making these choices. Management techniques and the scientific technological and engineering disciplines are all used in this process. Computer technology is an integral part of it.

5.3.2. Needs training

Information technology is of added value in the business world of today. IT provides updated information, data re-use, supplies chain integration and business flexibility. It is of strategic and competitive importance and covers all aspects of business and management. IT helps make information more accurate and useful, and makes it available when and where it is needed.

Using IT, an organisation can set clear objectives, cut bureaucracy, paperwork and administration costs and constantly measure many variables using a metrics set. IT provides access to quantities of information about a particular need and, by allowing manipulation of data, contributes to informed decisions. It can help avoid problems, save time and personnel and therefore money. The employees should be familiar with IT, know how it works, know its affect on their organisation and know how to effectively and efficiently use it in order to be competitive. For all these reasons a number of people in the organisation should have IT training.

5.3.3. Information management system

A management information system (MIS) refers to a system that gathers, condenses, and filters data until it becomes information, and then makes it available on time and in a useful form for use in decision making at various levels of management within an organisation.

information is achieved via the use of electronic mail and Internet. ISM implementation and IT are related to each other. (. Katsoulakos, 1998, 6). Figure 5.2 below shows this.

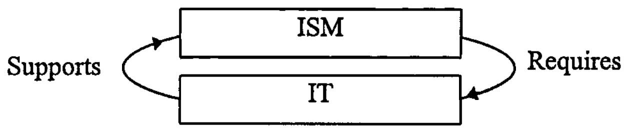


Figure 5.2 ISM and IT inter-relationship

Source: Katsoulakos, P. (1998). *A New Approach to ISM*, IT Strategies in Shipping Conference, Amsterdam, The Netherlands.

5.3.5. Training needs for ship personnel

If communication, computing and information management skills are to be used by ship operators, the latter will require training in their use. Today ship operations use full or partial computer control systems. Most of the ship operators are working with computers on a daily basis. Training in IT communication and software applications is especially important for ship operators. STCW 95 did not address IT or computing skills at all. Capt. Stephen Bligh, marine manager at P&O Nedlloyd pointed out that,

> In general shipboard staff receive no special IT training and therefore any systems installed on ships must be simple to use. More attention should therefore be given to training seafarers in the effective use of IT system.

In most developed countries, most companies and institutions use computer technology extensively and have at least the basics of IT in place. (Matthews, 1998,14)

In some developing nations neither of these technologies is used. The developed and the developing nations need to get together to set objectives of teaching and design new curricula to fully utilise modern technological changes for the many varying situations encompassed by developing and developed countries.

Developing nations are contributing more and more ratings to ships and constitute the major source of crews. Nationals of these countries are desirable in part because of the lower because of the lower economic scale in their countries. It is this lower economic scale, however, that keeps these nations isolated form IT:

In developing countries, lack of knowledge of how the IT works and how it affects the systems and costs, lack of good training software and lack of funds to purchase commercial onboard application packages are all obstacles to achieving full use of computer technology. Any curricula and training developed must take this into account.

Ship operators should know which type of product best suits their organisation, and be familiar with the value-added features that are now available.

5.4. IT and the developing world

As modern IT technology appears on the computer usually it is written in English. It can be accessed using other languages. However, to fully utilise the system one must use English. Most of the developing world uses their own languages and have few people who understand English. Many also have no access to computers. The real problems of IT for the developing world are computer familiarisation as well as English.

In an evaluation of computer training at the World Maritime University, Professor Muirhead (1998) made the following statement:

> It is interesting to note that some 40% of new students entering the World Maritime University have never touched a computer before.

The World Maritime University targets people from the developing world for its student body. The Figure of 40% reflects the rate of computer illiteracy in the maritime industry in the developing world. Before entering WMU 60% of the students have already known something about computers. However, many of them need training to achieve an efficient level of competence. In addition, many developing countries do not have data communication networks and can not access e-mail or the Internet. The primary reason for this is economics.

Another problem is proficiency in the English language. Approximately 50% of the students at WMU face language problems and thus are enrolled in the Intensive English Language Program. In order to be able to meet the University standards they have to attend an Intensive English language course, because in their countries they never or rarely used English. Today, IT, Internet and the maritime industry push seafarers to use the English language. Professor Muirhead (1998) also stated in the same paper that,

> While many western school leavers are now computer literate, most seafarers are now from Asia and may never have used a computer before they go onboard.

It is absolutely true. In the present day in the shipping industry, crews come from developing countries, especially Asian countries. Therefore, the maritime schools of Asian countries should have programs for computer familiarisation, intensive maritime English language and IT application.

Computer familiarisation courses should provide different levels for managers and operators, meeting the needs for different requirements for each group and providing appropriate application software and operating software for each job (needs of actual end-users). All should be taught keyboard familiarisation and basic knowledge of computers, how to select the hardware or software suitable for their job and how to use application software.

Language training should provide the operator with a functional level of English reading, listening, and speaking skills as well as writing skills for using e-mail or theInternet. Maritime and economic terminology needs to be emphasised.

Training in IT application must include instruction in accessing the information, and determining which informatin is valid or not. It also should cover techniques to manipulate the information. The use of Internet technology in particular has grown exponentially in the past decade, and the Internet is expected to have a profound impact on world trade, involving computer software entertainment products, information services (databases, on-line newspapers), and technical information.

5.4.1. Myanmar and IT technology

One of the developing countries, The Union of Myanmar, established a computer lab at the Institute of Marine Technology in 1992 and started computer technology. Now 14 computers, which are connected with a local area network (LAN), are available for 100 students who are cadets in the training course. Some refresher courses also are available. The cadets are trained in keyboard familiarisation, some software applications and other fundamental skills. The refresher courses train people in many software application programs which concern navigation, loading and so on.

All the cadets' training programs include a maritime English language course. Refresher English language training programs were established in 1995 for officer candidates. Myanmar has changed its education system and now the English language program is started in Kindergarten and computer education programs are started in high school.

These programs are recent developments. Data communication networks still need to be established in the maritime and other sectors. The need for information exchange and access is greatest in education and the management sectors.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

Present technological improvement is very fast. By the end of the century satellite global network systems (onboard processing techniques) will be accessible. Development of different multiplexing methods and digital modulation techniques have enabled the satellite channels to facilitate high speed and wide bandwidth digital transmission. Satellites' channels can presently be used as a link in computer networks. The old satellite system communication is primarily hardware based. However in combination with computerised technology the software programming allows greater flexibility for modern satellite communications

Satellite time delay problems have been solved by using new transmission protocols or using LEO satellites. Software developments, coupled with equally rapid communications improvements, are opening up new ways for ship operation and management. The development of onboard networking system (LAN) and combination of application software and communication software have led to integrated bridge systems and one man bridge operations.

6.1. Impact of technical evolution on GMDSS system

The GMDSS and the implementation of the Search and Rescue (SAR) Convention have both been made possible by advances in technology. These advances are continuing to evolve and have begun to challenge some of the basic assumptions of the system. Much of the work carried out by IMO to develop a global radio-communications system for shipping is based on a resolution adopted in 1979, which in turn took into account technology as it then existed. (IMO, 1998, 12).

The present distress system gives more than 90 % false alarms. Because of the expense and rapid changes in technology, colleges, maritime academies and training programs often have outdated equipment and manuals. Training, therefore, often is inadequate, does not reflect the range of equipment in use at sea and variations in operating procedures. Another problem contributing to the high proportion of false alarms is that an officer trained in one system may have difficulty transferring to another- where a similarly placed button may have a completely different function, or different keystrokes are used on each system to produce a distress call. (IMO, 1998, 10)

By the end of 1998 the hand held satellite phone will be able to access any place in the world. The satellite phone can be used for sending distress messages at sea. It can provide an emergency number for distress alerts like the ones on land. The satellite phone system could replace existing distress alert systems. It will take several years to reach this point. One of the main advantages of the GMDSS is the back-up facilities provided by the required systems.

INMARSAT-B and INMARSAT-C and INMARSAT-M will be popular for data communication in the next decade. Using Internet, E-mail, 64 kbps HSD with high compression technology, file/message size can be reduced by a factor of 8 or 80% of the original. The INMARSAT system will be emphasised in commercial communication rather than in distress communication.

6.2. The impact of technological changes on MET institutions

New information technologies and the Internet are forcing major changes on traditional campus-based institutions, open universities and distance learning. Using technology, institutes can improve access to education and training, the quality of learning, the cost-effectiveness of education and reduce the overall costs of education. Institutes can send their lessons anywhere in the world where there are learning centres or receiving terminals.

New technologies now allow a powerful combination of highly interactive stand-alone material with two-way asynchronous and synchronous communication between teachers and students. Seafarers especially could utilise this for educational and professional development while at sea. There is a relationship between the type of technology used and the type of learning outcomes intended.

To achieve the most cost-effective use of new technologies, major changes are required to the organisation of both traditional and dedicated open and distant learning institutions. As well as the need for institutional re-structuring, there is a need for open and distance educators to re-think and re-define their roles. (Bates, A.W.,1997, 93-109).

The competence and training requirements of STCW are an extension of those in ISM and ISO. The three sets of requirements are complimentary to each other and information exchange plays a vital role in the implementation of them.

The structure of modern MET institutions should be based on information systems to ensure the quality of the institution. The institution's information department (library) should contain the core of the structure. This is shown in Figure 6.1. The information department should link with other institutions' information departments from around the world. All information can then be up to date and can fulfil the quality management requirement (ISM code).

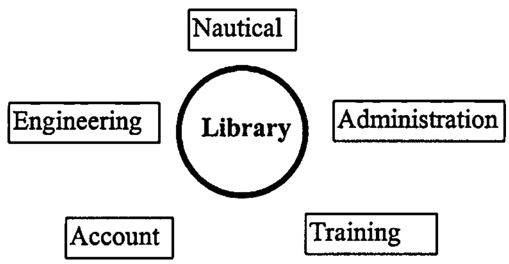


Figure 6.1 Information core institution management structure

Source: Muirhead, P (1998).. 'Management of Institution'. Lecturer Note (4-4-98). World Maritime Universitiy, Malmö, Sweden.

The information department personnel (library staff) should be trained for appropriate courses to meet modern shipping IT requirements at maritime institutes in developing nations. Developing countries' maritime institutes wil need to rely upon the resources of places like WMU because of economic constraints in their own institutions.

6.3. Equipment approval and standardisation

Equipment approval is an important part of ship board equipment. The approval is done by the administration according to the IMO Regulations. Standard interfaces between equipment and humans is essentially needed. Many companies produce a variety of equipment. Equipment to serve the same purpose is often very different from manufacturer to manufacturer. Variations in operating procedures, and poor operating manuals are the biggest problems on board ship.

This situation has led to the need for training for various models of equipment and a need for people to have time to familiarise themselves with new interface systems. Therefore, approval should control not only reliability and quality but also standardise interface systems. Specifically this means standard panel boards with the same functions and symbols. This will provide the seafarer ease in changing from one piece of equipment to another. (IMO, 1998, 10).

This decade has seen great growth in IT, the Internet, integrated ship board management and communication systems. There is a real need not only for hardware but also for application softwares, already complying with ISO 9002, to be standardised in their user interfaces. (Fairplay, 1998, vi)

6.4. Policy of shipping company and communication costs

The policy of shipping companies plays a very important role in modern communication developments and seafarers use of computers on board. There is an explosion of information technology services ashore, but many shipping companies are still using low-speed communications links which cannot cope with accessing Internet-based information. Even if simple e-mail is used it can result in relatively high costs.

Communication will become the back bone of business competitiveness in the shipping industry in the next century. Shipping companies can reduce manning costs, paper work onboard ship and in the office and communication costs. They can increase navigational safety, the efficiency and the quality of work to the maximun satisfication of their customers, meet national and international regulatory requirements, exploit new business opportunities, and make management more efficient. In the past shipping companies and cargo owners found it difficult to meet each other, so they needed a third party (broker or agent). Today with the benefit of the Internet it is easy to get the required information and to connect with each other. Both parties get the benefit from not needing a ship broker. (Samaranayake, 1997) Shipping companies should invest in appropriate modern communication equipment and software. High speed data transmission, data compression techniques, quality of satellite channels and growing competition among service providers provide a reduction in air time costs. This new system can reduce the communication cost approximately 80% by creating great savings over the old system. (Smith, 1998, 18). The capital cost of companies will be very high initially but within one year they will see a profit from their communication bills.

Some companies allow their crew to use computers to send and receive e-mail with their families and friends. Some companies do not allow this. The International Research Centre at the University of Wales, Cardiff conducted a study of " seafarers' use of e-mail". The study concluded that,

> many seafarers are being denied access to shipboard Internet and e-mail facilities as a result of 'widespread ignorance' of the costs and implications involved.

The reasons for denying seafarers access to e-mail facilities include security, costs and lack of capacity. (Telegraph, 1998, 14-15) Some of the communication software allows individual billing systems, so some systems can charge bills individually. The company then doesn't need to pay for their crews' bills. However, companies do have to install individual billing system software to do this.

Professor Peter Muirhead pointed out the importance of company policy in providing a better work environment for its crew, specifically in the areas of IT and education and professional development while at sea. (Muirhead,P.1998a) At sea, accessing e-mail and the Internet is an added value for the company and creates a more relaxed environment for seafarers. Ship companies need to be convinced of the importance of communication. The vessels become part of the virtual office network.

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APPENDIX 1

Examples of computer communications networks

1. Local area networks (LAN)

Networks limited to local facilities are called local area networks (LANs). Transmission bit rates are typically 1 to 20 Mbps and packet transmission is employed. The LAN is usually 1 to 25 km in length and supports up to several thousand users. The LANs are made up of a standard set of components such as network cable or wireless for interconnection, network-interface card (NIC) which connects each computer to the wiring of the network, the bridge which recognises the messages on a network and passes on those addressed to nodes in other networks, and the gateway which is a collection of hardware and software resources that lets a node communicate with a computer on another dissimilar network. Two ways to organise the resources of a LAN are client /server and peer to peer. The server is a computer that controls the network and has the hard disks holding shared files. It often has the highest-quality printer. The clients are all other computers on the network. Peer to peer arrangement has equal status. No one computer is in control. Users share each other's data and devices as needed.(Taub and Schilling,. 1986, 693).

2 Wide Area Network (WAN)

A wide area network is a network of geographically distant computers and terminals. A personal computer sending data any significant distance is probably sending it to a minicomputer or main frame computer. Using terminal emulation software on the personal computer, a personal computer can communicate with a minicomputer or mainframe. The personal computer emulates, or imitates, a terminal of the mainframe. The larger of the computers to which the terminal or personal computer is attached is called the host computer. The user can download data files from the host or upload data files to the host using file transfer software.

3. Integrated services digital network (ISDN)

The integrated services digital network is a generic term for any network which connects users. An ISDN is shown conceptually in figure A.1.

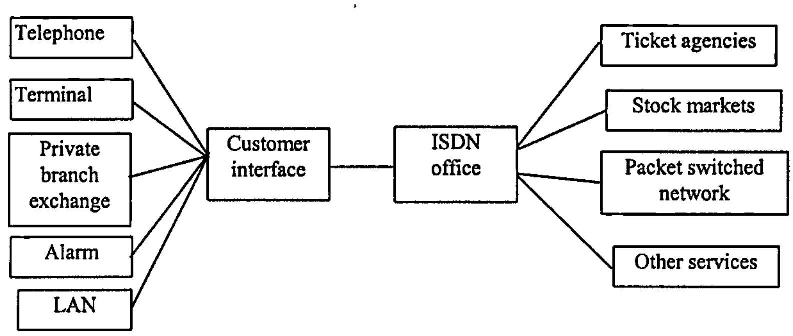

Figure A.1 An integrated services digital networks

Source: Taub and Schilling. (1986). Principles of Communication Systems, p.694

The "owner" of the network must be able to accommodate a wide variety of computers and terminals, thereby making it easy and inexpensive to access the network. This network needs to have the ability to connect a wide variety of services and users to the network.

4. The Internet

The Internet, sometime called the Net, is the largest and most far-flung network system of all. The Internet began in early 1969 under the name ARPAnet. The ARPA part of ARPAnet stood for the Advanced Research Projects Agency which was part of the U.S. Department of Defence. One of the goals of ARPAnet was research in distributed computer systems for military purposes. The government and the military sought ways to make networks tolerant to failures; ARPAnet was designed to allow messages travelling from one computer to another to be handled in a flexible and robust way.

The ARPAnet was designed to transmit data and voice. Data packets are approximately 1000 bits long and voice packets are of variable length, being less than approximately 2000 bits. The ARPAnet was designed to provide minimum cost and no more than 200 ms time delay independently of the packet size.

Each packet in the system can be forwarded from the source to destination using different nodes and therefore different paths. The packets can arrive at the host (destination) out of sequence and must, therefore, be stored and re-ordered before being processed by the host. Such a message is said to be transmitted as a datagram.

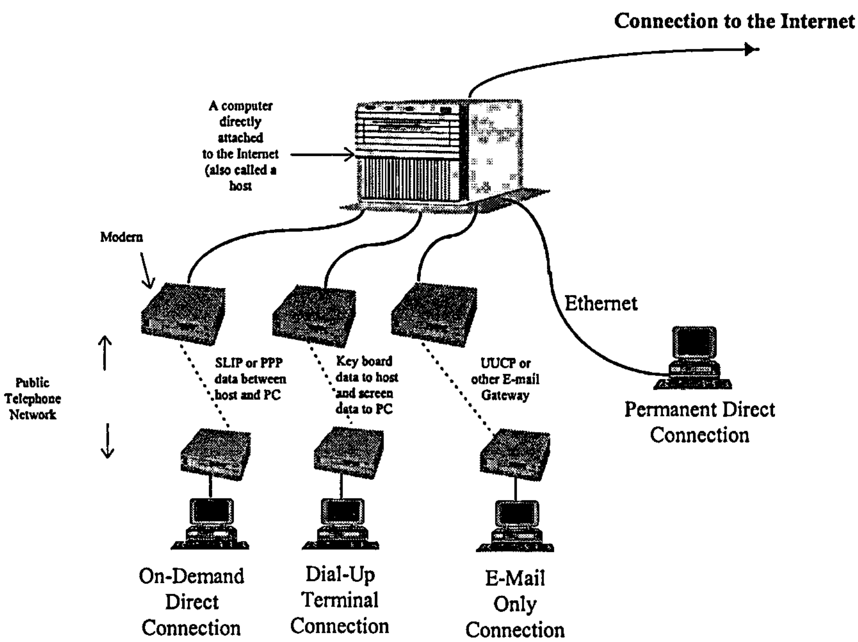

Figure A.2 How permanent direct, on-demand direct, dial-up terminal, and e-mail-only connections access the Internet.

Source: Smith, R. J., Gibbs, M. and Fedries, P. M. (1995). Navigating the Internet, 3rd ed.,. p.22.

As a consequence of the storage needed at the host prior to processing, the host must connect all of the source when it can accept the next message. To do this, the host sends to the source, after receipt of a complete message, a short packet which tells the source that the host is Ready-For-The-Next-Message. This is called the RFNM Such a control message, between source and destination, is called an end-to-end or host-to-host protocol. The Internet uses standard protocols to allow Internet work communication to occur.

There are four ways to connect to the Internet: namely permanent direct, on-demand direct, dial-up terminal, and mail-only. These ways provide different degrees of access to Internet services. This is shown in figure A.2. A direct connection provides the most complete and fastest service, but users can also access most Internet information through terminal connections.

Most Internet applications are based on client/server models. The user interface for these applications varies depending on the type of connection and the type of client software used by the user. A user might type UNIX commands to a host computer or use point-and-click tools on a personal computer.

The Internet offers two broad classes of services: communication with other people and information access. The most popular communication service, e-mail, uses a standard e-mail addressing scheme so users on different networks can communicate. Mailing lists and news groups provide for group discussions, debates, and information sharing on particular subjects. Other communication tools allow real-time interaction, voice communication and video teleconferencing.

The most popular information access tool today is the World Wide Web, the hypermedia part of the Internet. It is accessed using a Web browser like Netscape. Web pages are published by private companies, public institutions, and individuals. The Internet is evolving from a publicly funded research experiment into a commercial information super highway. (Smith, R. J., Gibbs, M. and Fedries, P. M., 1995, 23)

APPENDIX 2
Protocols

1. The Internet protocol (IP)

The Internet Protocol works just like an envelope (IP datagram). It is shown in figure 3.12. The IP takes care of addressing, or making sure that the gateways know what to do with the data when it arrives. It is stacked with Post Office analogy.

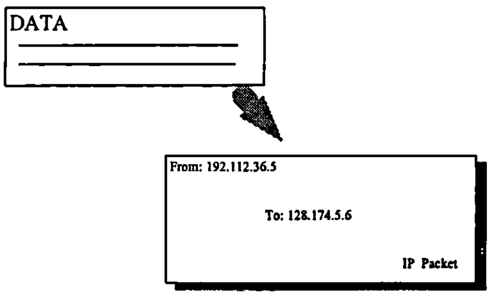

Figure 3.12 IP (datagram) envelop

Source: Krol, E. (1992). The Whole Internet User's Guide and Catalog, O'reilly and Associates, Inc. USA. Page 21.

The gateway uses the datagram header to determine where to route the traffic. IP protocol data unit is shown in figure A.3.

Version(44)	Header length (4)
Type of service (8)	
Total length (16)	
Identifier (16)	
Flags (3)	Fragment offset (13)
Time to live (8)	
Header checksum (16)	
Source address (32)	
Destination address (32)	
Options and Padding (variable)	
Data (variable)	

(n) = Number of bits

Figure A.3. Internet Protocol Data Unit (PDU)/IP Diagram

Sources: Uyless Black (1989). Data Networks Concepts, Theory, and Practice, Prentice-Hall,Inc, USA. Page 450.

User data is given a specific "lifetime" in the networks. This mechanism is useful for several reasons. First it prevents lost or misdirected data from accumulating and consuming network resources. Secondly, it gives the transmitting entity some control over the disposition of aged data units. Thirdly, it greatly simplifies congestion control, flow control and accountability logic in the networks.

If the lifetime value reaches 0 before the protocol data unit (PDU) reaches its destination it is discarded. An error report data unit is generated to inform the originator of the lost data.

2. The Transmission Control Protocol (TCP)

TPC takes the information to be transmitted and breaks it into pieces. It numbers each piece so receipt can be verified and the data can be put back in the proper order. In order to pass this sequence number across the network, it has an envelope of its own which has the information it requires " written on it". It is shown in figure A.4.

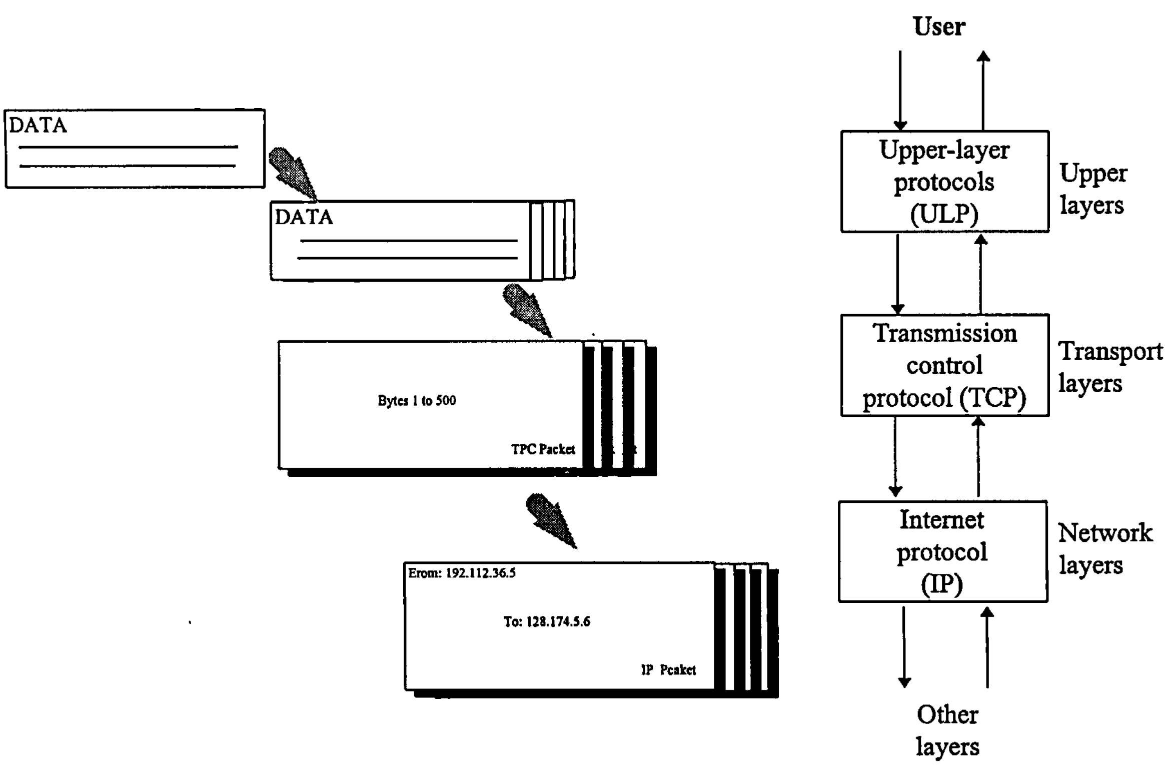

Figure A.4. Transmission Control Protocols (TCP)

Source: Krol, E. (1992). The Whole Internet User's Guide and Catalog, O'reilly and Associates, Inc. USA. Page 21.

3. Sliding window protocols

Sliding window protocols is a method of confirming data delivery that requires only occasional acknowledgement from the receiving software, allow full-duplex communication on a single channel. It is a must for data transfer via satellite. Sliding Window Protocol is called the continuous Automatic Repeat Request (ARQ) system: the transmitter continuously transmits frames without waiting for Acknowledgement (ACK). Frames and ACKs are numbered. This technique is called pipelining. If the frame in the middle of the stream is damaged, only lost or unacknowledged frames are retransmitted, and sequence numbers are used to detect duplicates. Receivers can use sliding windows to control flow. Window size W is the number of information frames that can be transmitted before ACK is required. The receiver slows down transmitter by withholding ACKs. (Maguire Jr.G.Q., 1995, Internet).

Appendix 3

File format

Suite of programs depends on the type of data being compressed, as shown in table A.1

Data Format	File Extension	FTP Type	Application
ASCII	.asc	ascii	Word processor
	.txt		Word processor
Binary/Hexadecimal	.hqx	ascii	BinHex
Binary	.bin	binary	Operating System dependent
Compressed (DOS)	.ARC	binary	ARCE.COM
	.ZIP	binary	PKUNZIP.EXE
Compressed (Mac)	.cpt	binary	UnStuffit
	.sea	binary	Compact Pro
Compressed (UNIX)	.tar	binary	tape archiver
	.Z	binary	un/compress
Graphics formats	.gif	binary	Operating System dependent
	.pict	binary	Operating System dependent
	.tif/tiff	binary	Operating System dependent
Object Code	.o	binary	C (?) compiler
postscript	.ps	ascii	Adobe PS device
Source Code (C)	.c	ascii	C compiler
Word Processing	.Word	binary	Microsoft Word
	.WP	binary	Word Perfect

Table A Commonly used file formats

Source: Elizabeth Lane and Craig Summerhill (1993). Internanet Primer for Information Professionals, London, Page 72.