

Satellite Transmission of Oceanographic Data

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Oceanographic data collected on a research vessel has been transmitted to a shore laboratory using the INMARSAT maritime satellite. The system configuration used, consisted of Satellite Communication Terminals interfaced to desk top computers. The system permits the transfer to error-free data files to a shore facility for subsequent processing and analysis. Besides the capability of near real time oceanographic data processing, the facility could be used for adaptive cruise planning especially in oceanography survey work.

INMARSAT—The International Maritime Satellite Organisation operates a system of geostationary communication satellites over the Atlantic, Pacific and Indian Oceans for maritime ship-to-shore, and ship-to-ship two-way communication. The link from satellites-to-shore facilities is serviced by the INMARSAT Coast Earth Stations which are connected to telephone and telex networks in various countries [1]. The communication services currently available by the coast earth stations of the INMARSAT system include, besides

other services—telephone, telex, facsimile, medium and high speed data, and slow scan television. In the system described here the INMARSAT satellite positioned at 63 deg E over the Indian Ocean was used in routing oceanographic data from the research vessel "Sagar Kanya" to a shore laboratory near the National Institute of Oceanography, Goa.

At the present stage of its development, the system is able to handle relatively small volumes of data transfers. It however offers a flexible approach for transmitting selected data files or observational reports by writing communications software in BASIC on an HP 9845 desk top computer. In contrast to this approach, there are professional companies that offer data transmission services which are capable of transferring large volumes (Megabytes) of seismic and other geophysical data on dedicated hardware and software systems. This is useful in oil well and drilling surveys where cost considerations play a secondary role.

The description of the system given in the next section is followed by a brief account of the communications software and an appraisal of the present system. Future modifications to be implemented on the system are given in the concluding section.

SYSTEM DESCRIPTION

The overall block schematic of the system is shown in Fig 1. The complete system consists of the ship's system linked via satellite to the shore system. The ship's system transmits selected data files, which are received, stored and processed off-line on the shore computer. A description of each system follows:

Manuscript received 1985 September 28, revised 1986 May 27.

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Ship's System

The system presently on board the research vessel 'Sagar Kanya' comprises :

- Integrated Navigation System (INS)
- HP 2117F General Purpose Computer (GPC)
- HP 9845B desk computer serially interfaced to a 2400 baud data modem.
- Satellite communication Terminal (SATCOM) from Magnavox, USA.

The INS is essentially a computer which accepts navigation inputs namely satellite navigation data, gyro compass, and ship's speed log, and computes a corrected estimate of the ship's position to a high degree of accuracy (-35 metres RMS). Besides this, the INS logs data from echosounders, a gravimeter, an air gun system for seismic surveys, and a magnetometer.

Data tapes from the INS computer are then processed, and stored in a reduced format on the GPC for geophysical analysis. Selected data tapes are then downloaded from the GPC to the smaller HP 9845B for subsequent transmission through the SATCOM terminal.

The HP 9845B computer with upto 1.6 Mbytes of user memory, has direct interfaces to a Conductivity-Temperature-Depth (CTD) profiler, and to a Shipborne Wave Recorder (SWR). The CTD and SWR data can be processed directly on this computer, or uploaded to the HP-2117F GPC for a more elaborate processing tasks. All reduced data files are ultimately stored on the HP 9845B prior to transmission.

The Data Modem was switch-configured for 4-wire full duplex operation with the SATCOM terminal, and was serially connected through its RS-232 interface to the HP 98036

serial I/O card on the HP 9845B computer. The function of the modem - a data communications equipment (DCE) is to convert the serial data from the HP 9845B, a data terminal equipment (DTE) to analog format. The analog signal is filtered and routed through an audio interface for coupling to the telephone circuits of the SATCOM terminal. The data rate used in this communications link is 2400 bits per second (bps).

Shore System

The basic system configuration at the receiving station (see Fig 1) is similar in all respects to the basic configuration on the ship, consisting of the SATCOM-DATA MODEM-HP 9845B combination. The dotted blocks in Fig 1 relate to the future enhancements to the present set-up. The function of the data modem here is to perform an analog-to-digital conversion of the signals from the audio interface. Before doing this, the signal is filtered for the removal of noise and other extraneous signals. The digitised signal is demodulated after which it is fed to the HP 9845B in RS-232 format. Processed data files received on the HP 9845B are directly stored in memory and later written on to micro cassette drive of this computer.

Satellite Communications Terminal (SATCOM)

The communication modes possible on the SATCOM terminals used in this system include telex, voice, medium speed data, and slow scan television. The high speed data facility at 56 kbps is not yet available in the Coast Earth Stations of the Indian Ocean Region.

The terminal (from Magnavox, USA) conforms to INMARSAT requirements [2] and is made up of :

- Antenna Unit
- Below deck Electronic Unit

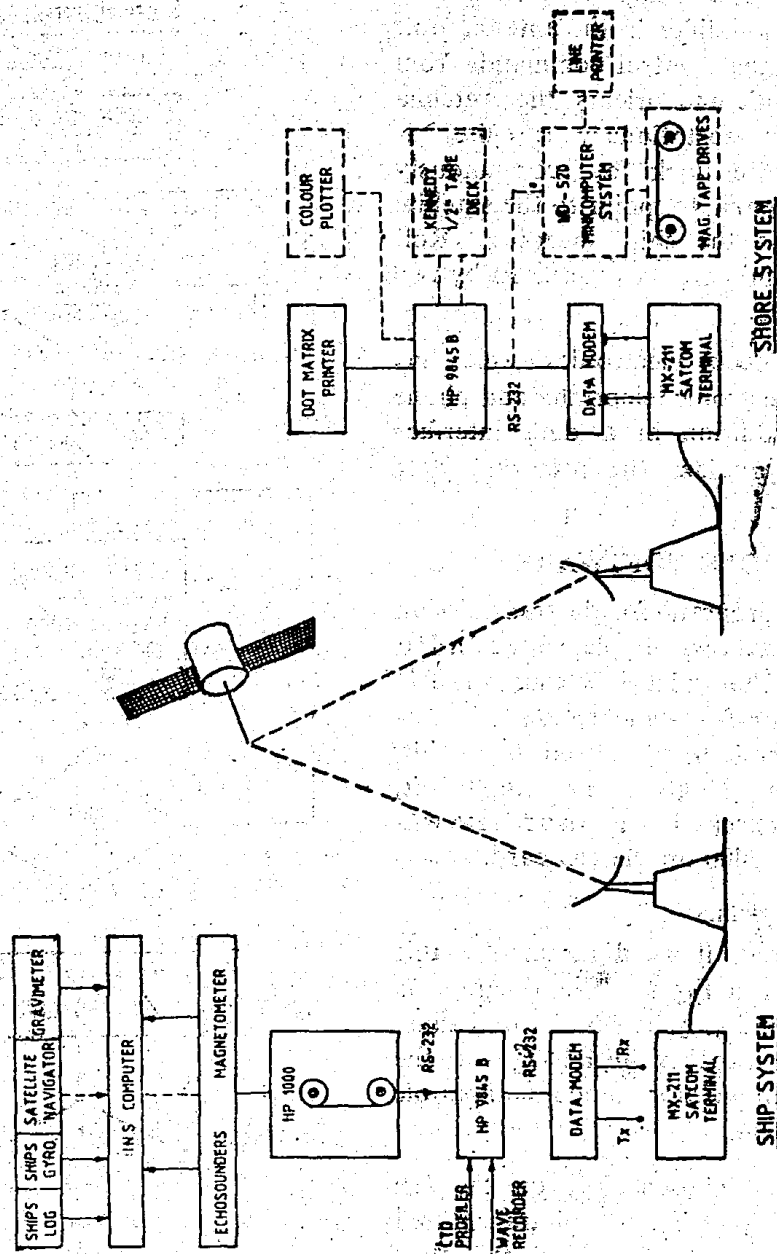


Fig 1 Block diagram of the complete system

The antenna electronics houses an integrated L-band amplifier which generates the 1.6 GHz transmit signal, and receives satellite signals in the 1.5 GHz range. A microprocessor-based servo amplifier in the antenna unit responds to antenna control commands from the below deck unit and orients the antenna to the selected geostationary satellite. It maintains 'satellite lock' by continuously adjusting the antenna to point to the satellite despite changes in the ship's heading. Roll and pitch of the ship are counteracted by two spinning flywheels.

The below deck electronics unit has interfaces to an electronic teleprinter and phone handset. The addition of a data interface card in the unit provides the necessary data mode option.

COMMUNICATIONS SOFTWARE

The software programs for the transmission and reception of data was implemented in HP 9845B BASIC. The serial I/O card on this machine was set up for asynchronous communication with a mode word defined by 7 bit, ASCII character length, 1 stop bit, and no parity checks. The baud rate was switch selected to 2400 on the I/O card.

Transmission Programs

The condensed flow diagram for this program is shown in Fig 2. The diagram is self-explanatory and may be summarized thus:

- (i) The interface card is initialised for the desired communication mode compatible with the modem.
- (ii) On pressing a chosen key on the HP 9845B, a prompt string is first transmitted to the shore computer to signal the start of transmission.
- (iii) The desired data file is opened, and each record of the file is sent as a stream of ASCII characters terminated by a CR, LF (carriage return, line feed) sequence.

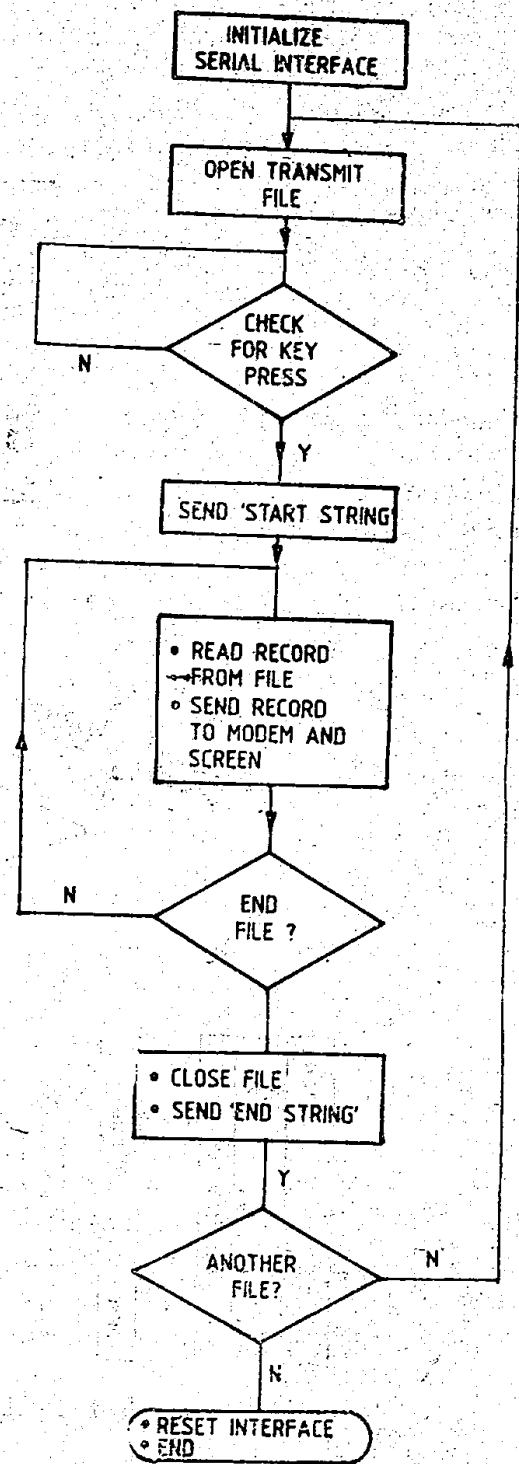


Fig 2 Flow diagram for transmission program

(iv) On checking for "end-of file" status, the computer transmits an "end string of characters" signifying no further transmission.

(v) The user is given the option of sending further files.

Receive Program

The flow diagram for this program is shown in Fig. 3. The program uses the interrupt structure of the I/O interface on the HP 9845B [3] so that when a character is received, an interrupt is sent to the CPU to fetch the character into a 320 byte circular buffer. Strings of characters terminated by CR, LF sequence are then directly stored in memory, and written to the CRT console as they are received from the data modem.

The program checks for the start and end strings (namely 'SAT TRANSMISSION START' and 'SAT TRANSMISSION END') in a background loop of the program. When the reception of the data file is over, the file is stored on micro cassette tape. The user has the option of printing data later or receiving another satellite transmission.

APPRAISAL OF THE PRESENT SYSTEM

The present set-up achieves the objective of transferring error-free scientific data to the shore laboratory. The positive attributes of the system are :

The use of a front-end processor such as the HP 9845B provides the user on the ship's system with a flexible tool for the design of *time critical* programs.

Programs written in BASIC can be tailored to transmit only essential data in the form of observational reports or selected data files.

Adaptive cruise planning can be implemented based on the nature of information or data received from the ship. Decisions can

then be made by directing the ship to sites where more pertinent data can be gathered especially in exploratory survey type expeditions.

The principal disadvantage applicable to this system and to most other satellite data transmitting systems relates to the cost of transmission data. In our set-up, the transmission of 3000 records could cost approximately 70 U.S. dollars at the rate of \$ 10 a minute. Cost is directly proportional to time, and it is therefore essential that communication software be designed to achieve optimum speed of data transfer.

CONCLUSION AND MODIFICATIONS

This paper has described a system for transmitting scientific data from a research vessel to a shore laboratory using the INMARSAT satellite system. The communications software was written in HP BASIC on a powerful desktop computer - the HP 9845B interfaced serially to a data modem and SATCOM terminal. Apart from the cost factor of transmitting data, the system provides a useful tool for sending and receiving error free data collected on a research cruise. In our experiment, several data files from the CTD profiler were received without errors on the shore computer.

The limitations of the present system are :

Low volume data can be transmitted presently because the communications information rate is limited to 2400 baud. By using the 56K bit option when it is available, large data files from seismic surveys can be received and stored on computer compatible tapes.

Handshaking mechanisms have been deliberately excluded so as to minimise data transfer time. A more comprehensive

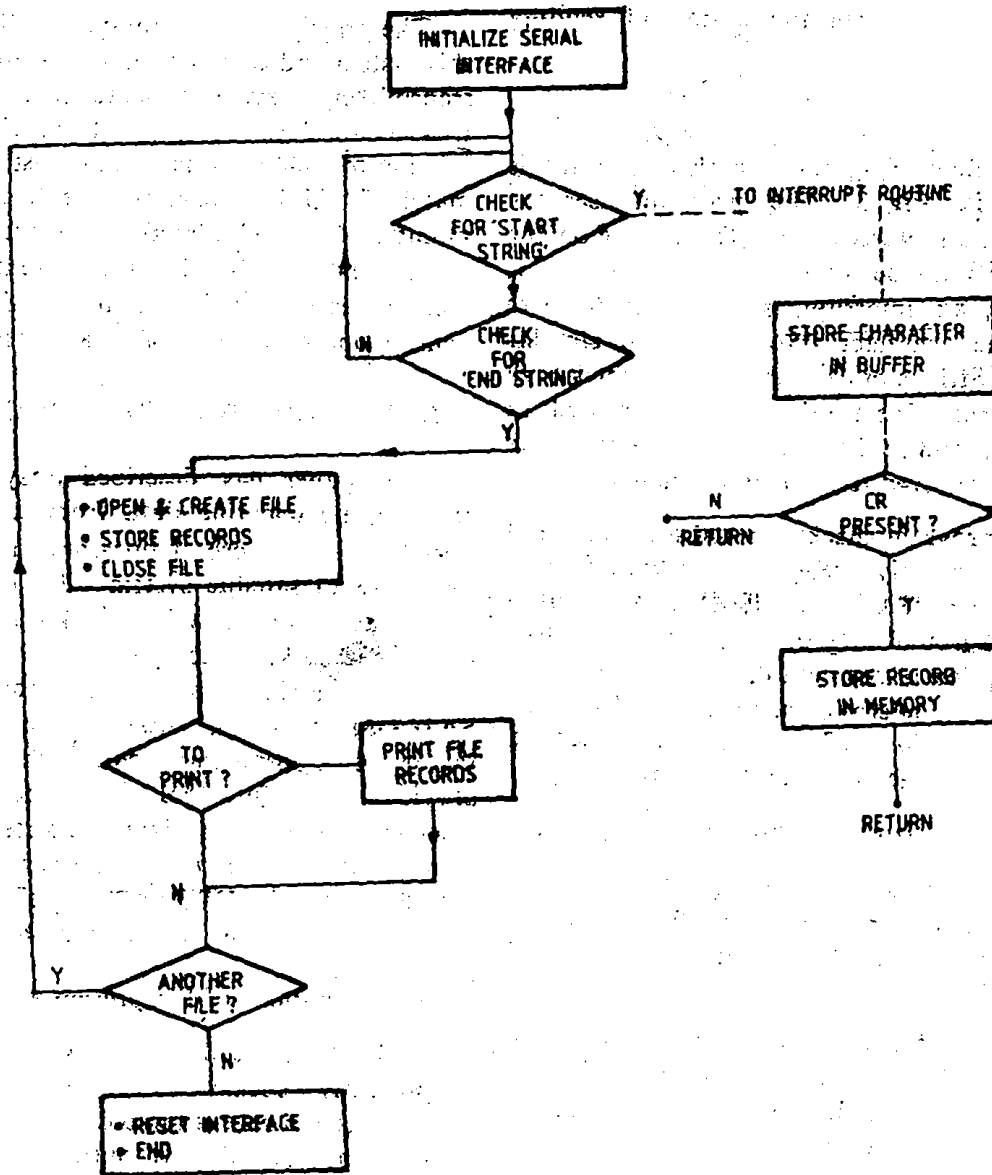


Fig 3 Flow diagram for receive program

handshake procedure would require the transmitting system to send a record only after receiving an acknowledge string from the shore system. If no acknowledgement is present then the data string is re-transmitted. Failing this, further transmissions are aborted by the ship's system.

Further work on the communications software will include the capability of transmitting binary data files, non-formatted ASCII files, and sophisticated handshaking protocols that will log errors, if any.

REFERENCES

1. INMARSAT Maritime Users Manual 1984.
2. MX-211 Satellite Communications System Manual
3. Basic Language Interfacing concept for the HP 9845 B, 1979, Manual No. 09835, 90600,

It is also planned to upgrade the shore system, so that data can be received optionally on a NORSK DATA 520 minicomputer system for the storage of larger data files on computer compatible 1/2" magnetic tapes.

ACKNOWLEDGEMENT

The authors would like to thank the Department of Ocean Development, for permission to install the SATCOM on their research vessel "Sagar Kanya". Considerable help in installing the system was given by Dr. Ehrlich Desa and Mr. O. D'Souza. The Director, National Institute of Oceanography has freely provided the use of all laboratory facilities.