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TRANSACTIONS(TM)

SOME TELEMETRY SYSTEMS FOR MARINE USE

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Some Telemetry Systems for Marine Use

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SYNOPSIS

This paper aims to describe some of the systems which are available to the marine industry to transmit data and to give some knowledge and confidence to engineers in the industry who may require telemetry systems. It will describe both radio and acoustic subsea systems and will outline the use of satellite telemetry systems, as used on databuoys which operate unmanned in one of the most turbulent seas in the world.

INTRODUCTION

Definition of telemetry

Telemetry has two meanings according to the dictionary, first it is the measurement of distance and secondly it is the transmission of data from one point to another. It is, therefore, a vast subject involving a large number of different methods using various media. Books are being written about the subject and this paper will confine itself to specific examples relating to the marine and offshore industry and problems that may be encountered.

Voice communication can be said to be a simple form of telemetry, but usually we mean the transmission of data such as information about position, weather conditions, speed etc. The time taken for transmission is not necessarily vital. For example, the transmission of instructions to a spacecraft may take several hours to arrive even by radio, and the information that is sent back takes an equally long time.

The rate of transmission of data may be very slow in, for example, underwater low-frequency acoustic transmission. Voice communication is by comparison quite fast. In other cases the transmission of data is rapid and efficient, as with modern satellite transmission, and enormous amounts of data can be transmitted in a second, far faster than by human voice communication.

Reasons for telemetry

We live in an information oriented society. Clearing a cheque through a bank, buying some shares or reporting the position of a ship can all involve telemetry systems. Facsimile machines are now commonplace, allowing complete reports to be transmitted over the telephone in a matter of minutes. Complete newspapers are transmitted to the printing works which may be many miles from the editor's office.

In some cases the information that is transmitted comes from a computer and may be fed directly into another computer, with no human involvement at any stage. Some of the information transmitted may never be used, but that begs another question I do not propose to answer here.

Components of a telemetry system

Possibly the most basic telemetry system is the telex. There is one telex machine, a telephone line and a second telex machine, and they can transmit either way. However, the majority of telemetry systems are much more complicated, and most employ some sort of computer which converts and stores the information ready for transmission.

Figure 1 shows the most basic form of telemetry system currently used, comprising a transmitter and a receiver. The transmitter takes the input, which may be an analogue or digital signal, and passes it through an interface unit, which is sometimes called the signal conditioning card and which prepares the signal and converts it into a suitable form to transmit to the computer.

J. K. Forsdyke started his career with Joseph Lucas Electrical and initially concentrated on the automobile industry. This was followed by a period with Associated Engineering as a Sales Executive, again primarily involved with the automobile industry. In 1975 he joined Eutectic as an Engineering Consultant and was involved in control systems for automatic welding machines. He now works for Thorn EMI Electronics as Marketing Manager to the Offshore Group who design, manufacture and operate remote control and monitoring systems for the offshore industry.

The computer formats the signal or encodes it and passes it to a modem, which then translates it into frequencies for the radio to accept. The radio receiver passes the signal through the modem, which turns it back into a signal suitable for the computer to accept. The computer then decodes it or reformats it and stores it ready for onward transmission either to a display or to a printer. In certain circumstances both computers can be eliminated and replaced by a simple encoder and decoder. In some cases there are a multitude of inputs which the computer has to sort out, store and then transmit at a given time. Some telemetry systems may consist of a combination of media using perhaps underwater acoustic, radio and hard-wire systems.

The advantage that data telemetry systems have over voice is supposed to be accuracy, but often unless checking systems are incorporated the claim of accuracy is misplaced. This makes the role of the computer in the telemetry system particularly important as it has to incorporate a form of checking. It is worth pointing out at this stage that the accuracy of a telemetry system relies heavily on the input being correct and the output being correctly interpreted. The old adage 'rubbish in = rubbish out' applies.

Over the years electronic systems have gained a poor reputation for reliability. The reason for this has often been the desire of engineers to oversophisticate their designs. It must be borne in mind that if there are a large number of electronic components working in series then the reliability factor decreases as the number of components increases.

The solution is to keep the system simple, and where it is

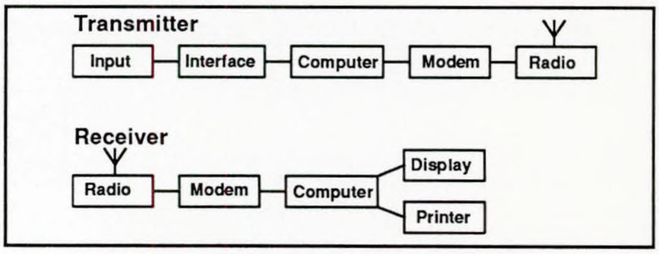


FIG. 1: Elements of a telemetry system

necessary to increase sophistication then duplication and triplication is required. By this method the electronics industry has succeeded in improving reliability significantly. Modern telemetry systems are extremely reliable and many industries would grind to a standstill without their new telemetry systems.

An early telemetry system

The first real example of a telemetry system I have been able to find in the records of EMI illustrates the old adage 'keep it simple'. The system, of which a number were supplied to the Indian Water Authority in the early 1930s, was designed to monitor the level of water in reservoirs. The system was operated by a float coupled to a number of levers which moved the arm of the old HMV wind up gramophone. This was fitted with a record of a voice giving the various depths in the reservoir. Thus if the gramophone was switched on it would automatically play the record and so give the depth.

The system was linked to a telephone, such that the ringing of the telephone dropped the arm on the appropriate part of the record and started the motor. In this way the person enquiring on the end of the telephone merely heard a voice which read out the reservoir depth. This simple system needed periodic maintenance and an engineer had to visit each site from time to time to replace the needle and to wind up the gramophone.

Proof that the system was reliable and effective is demonstrated by the fact that until recently orders were still being received for needles and gramophone motor springs. This is a good example of the old engineering principle that 'if it works do not change it'.

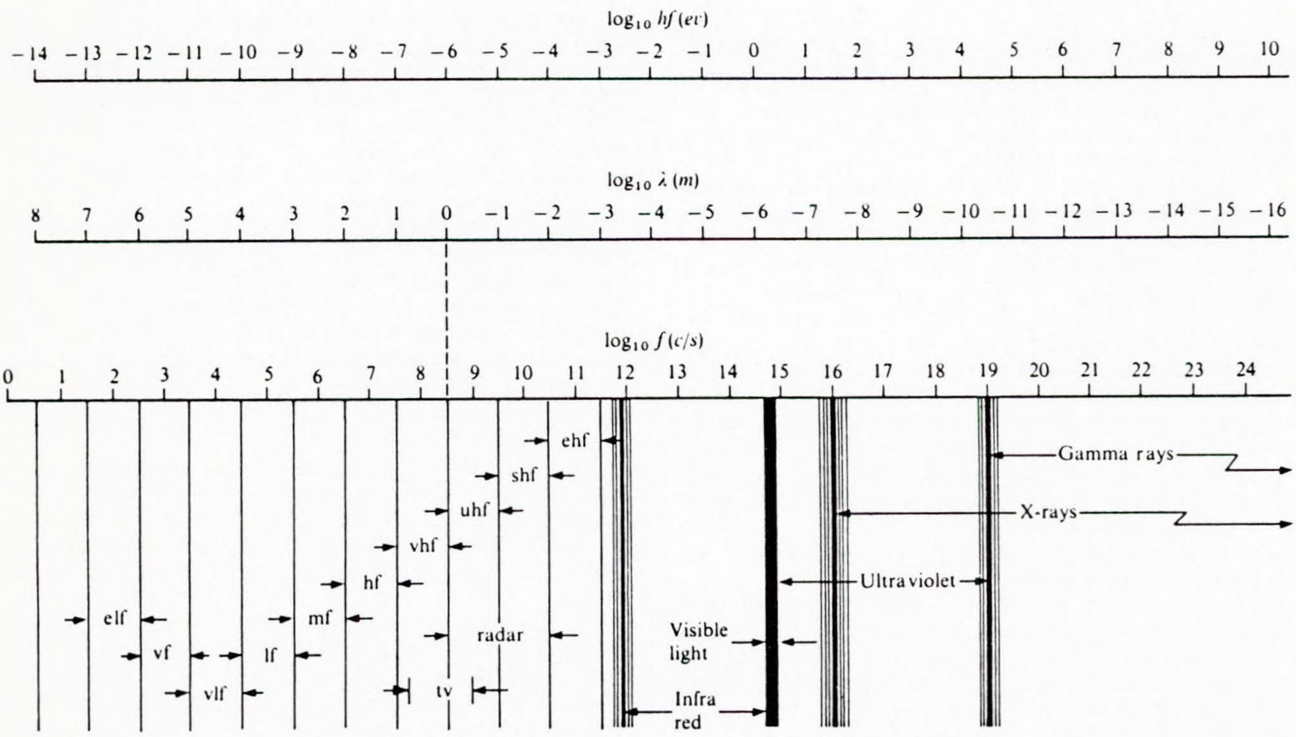
REQUIREMENTS OF THE MARINE AND OFFSHORE INDUSTRY

Anyone who has any experience of the marine industry knows the havoc that seawater produces in electrics. Overcoming this problem is no easy task, and cannot really claim to have been solved. Special precautions still have to be taken with anything electrical, even on surface installations, and the problem increases dramatically as you go subsea.

At the same time, electronic components and assemblies which are designed for marine and underwater applications tend to be very expensive. An electric plug which in the domestic environment may cost £1 will cost up to £100 for a marine version. Underwater plugs and sockets may cost even more. The reason for this is that they may have gold-plated pins and may be precision machined castings in brass or stainless steel.

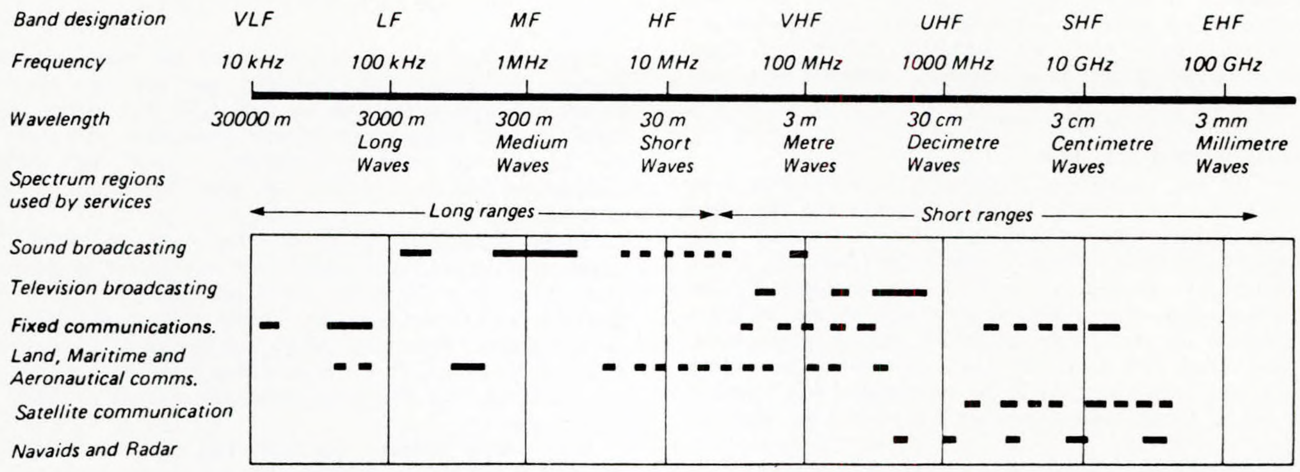
The marine industry generally has the requirement to transmit very modest amounts of data over comparatively long distances, from sometimes unstable platforms. This makes radio transmission the preferred method rather than cable, especially as the sea is relatively flat and cables are notoriously unreliable underwater. The reason for the unreliability of cables is in part that it seems difficult to produce long lengths of water-proof cables, and fishermen have an unhappy knack of damaging them. Even fairly short subsea cables are avoided for data transmission and acoustic telemetry is becoming increasingly used. Unfortunately radio cannot be used under the sea.

Both radio and acoustic telemetry can be used to indentify position accurately, which is one of the word's definitions.



The abbreviations elf, vf, vlf ... mean, respectively, extremely low frequency, voice frequency, very low frequency, low frequency, medium frequency, high frequency, very high frequency, ultra high frequency, super high frequency, and extremely high frequency. The limits indicated by the shaded regions are approximate. The energy *hf*, where *h* is Planck's constant (6.63 x 10^{-34} J s) and *f* is the frequency, is that of a photon or quantum of radiation.

FIG. 2: The spectrum of electromagnetic waves



Frequencies above 1000 MHz are generally known as microwaves. The long and short ranges apply to terrestial applications; space services use microwaves for very long ranges. Precise allocations of frequency bands can be found in Article N7 of the Radio Regulations

FIG. 3: The radio frequency spectrum, with an indication of its application

Claims are made that certain satellite systems can position an object to a few centimetres.

Let us first look at radio telemetry.

COMMUNICATION TECHNIQUES

Radio telemetry

Spectrum

The radio spectrum extends from a few Hertz to 500 GHz (500 x 10^9 Hz). However, this is not the limit of electromagnetic radiation and therefore a medium for telemetry. The full spectrum is shown in Fig. 2 and the radio spectrum is shown expanded in Fig. 3.

The normal range used in telemetry is, however, restricted to between 10 kHz very long wave to 30 GHz ultra high frequency. BBC long wave transmission is about 200 KHz and BBC medium wave about 1 MHz; it is thus a matter of horses for courses. The range of radio communications varies depending on the frequency, the power transmitted and the conditions. Two watts may travel to the moon and back but will not necessarily reach Wapping from central London.

In telemetry the amount of data which can be compacted on to a radio wave will depend on the frequency and thus the bandwidth. Baud rates, therefore, may vary with frequency. Modulation is now mainly frequency and phase, and amplitude modulation is unusual. However, there are a number of other variations and combinations of these three.

Before looking at specific methods of radio telemetry we must define some terms or at least clarify what we mean.

'Line of sight' is a phrase which is misused and misunderstood by many engineers. It theoretically means that a straight line can be drawn between the transmitting and receiving aerials without anything getting in the way. Thorn EMI use line of sight radio transmission from one sealed compartment to another on a submarine, hardly line of sight. Line of sight radio was also used over 170 miles from the DB1 databuoy in the Western Approaches to Land's End, again hardly line of sight with the curvature of the earth cutting off the sight at about 30 miles. Citizens Band radio is line of sight but clearly does go round corners. In practice line of sight means ground wave or when two points are in sight of one another.

Aerials come in various forms and are not the subject of this paper. There are, however, a number of ways of improving the performance of a radio by the use of directional aerials, such as dishes, dipoles and other configurations. The size and shape of the aerial is generally related to wavelength and, therefore, the higher the frequency the smaller the aerial.

Ground wave transmission

This term is becoming old fashioned but broadly refers to anything which uses the low, medium, high and very high frequency bands. The lower frequencies are not necessarily line of sight, and will bend with the earth, whilst HF and VHF tend to be more line of sight. Because of frequency shortages and the danger of data corruption caused by interference, VHF (and of course UHF) is now used mainly for data telemetry under normal conditions.

Owing to the earth's curvature, line of sight rules dictate that if the aerials of both receiver and transmitter are high, then the range will be more than if the aerials are at sea level. In practice, up to 25 miles is normally the maximum range for consistent transfer of data using VHF. However, if the transmitter is high power and high up, then this range is increased to perhaps 70 miles.

Tropo scatter

This method is used a great deal by the North Sea oil and gas industry. It usually uses the 1.6-2.7 GHz band and employs highly directional dishes to beam the transmission at the horizon. Usually there are two transmitter/receiver dishes to cover horizontal and vertical polarisation of the signals.

The beam bends in the troposphere by around 1.4°. This is called the scatter angle, and the dishes are angled at around 0.5° to the horizontal. The dish angle can be negative if it is mounted high enough, say on a mountain. Tropo scatter uses frequency modulation exclusively.

The part of the world where tropo is used has a bearing on the length of the link. In the marine environment the maximum distance is about 450 km, whereas in highly arid and unhospitable terrain of very low humidity, eg the Sahara Desert, the maximum distance reduces to 250 km. These figures are based on the Marconi Mobile Tropo System.

Typical power required for this system is 10 kW, so it

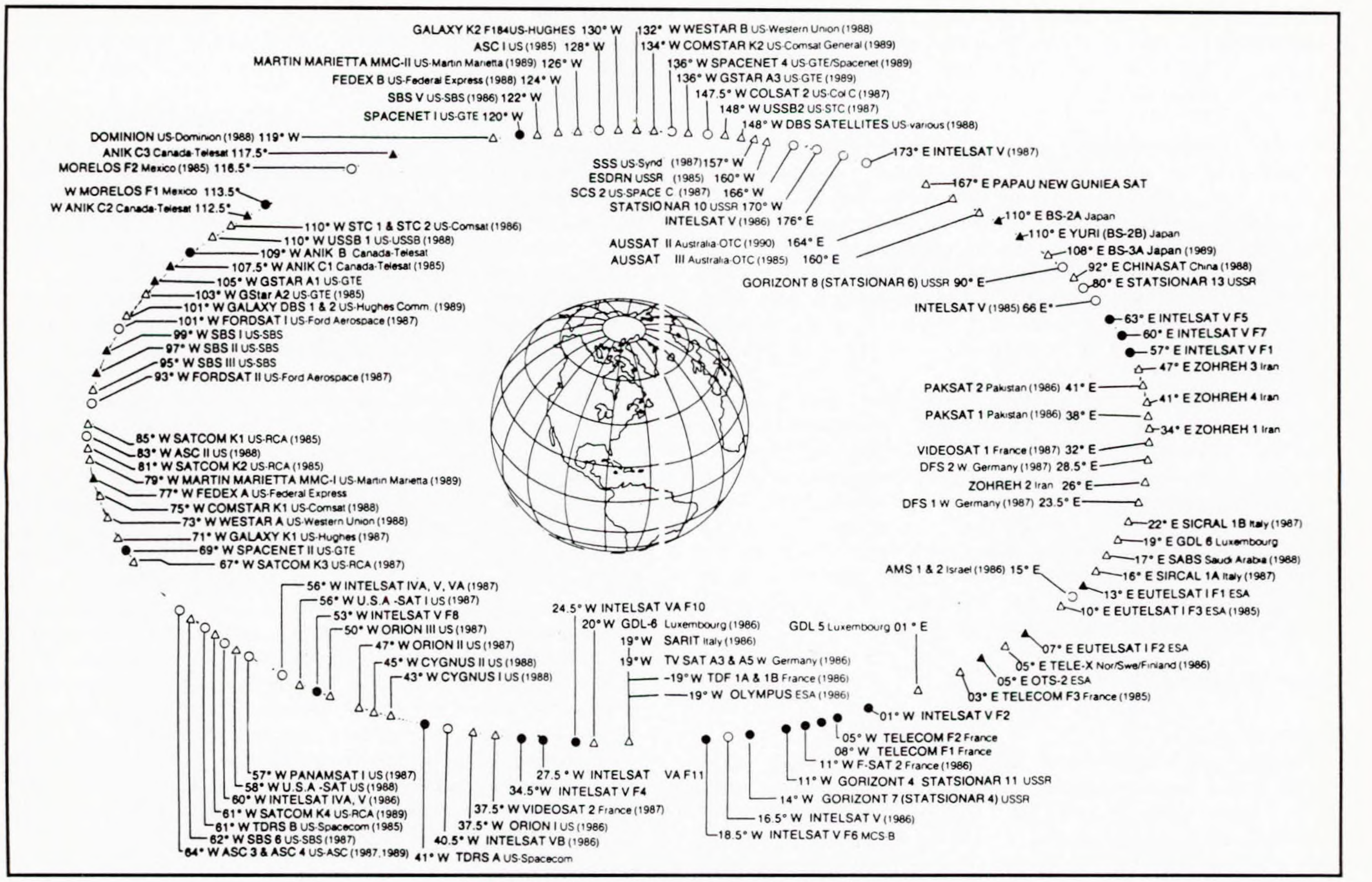


FIG. 4: Ku band geosynchronous satellites

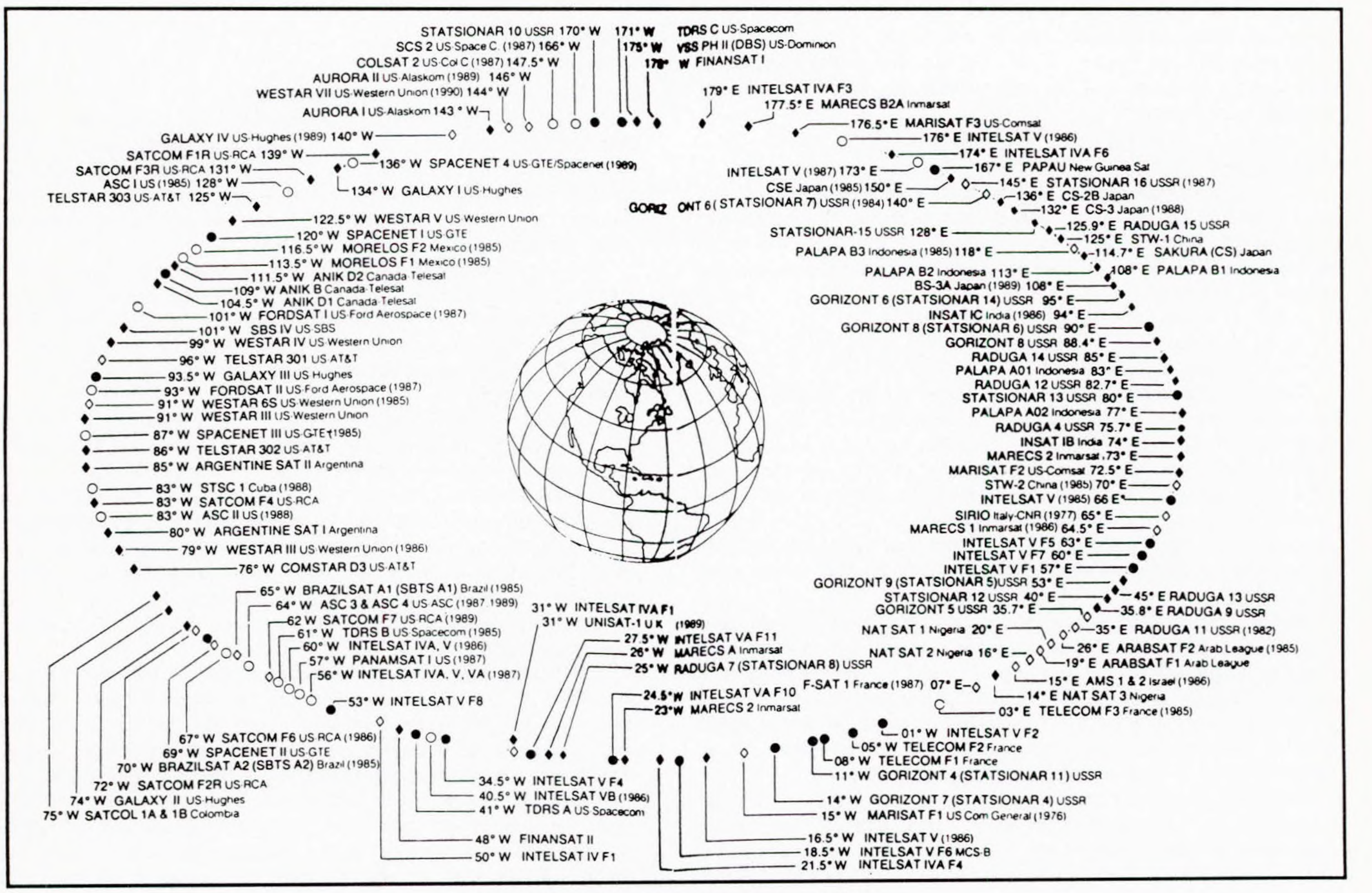


FIG. 5: C band geosynchronous satellites

does not lend itself to battery operation. One of the principal requirements is for a stable platform for the dish aerials. Bearing in mind the high frequencies used, very high data rates can be achieved.

Satellite communications

There is a wide variety of satellite communication systems, and there is a tendency to assume that at least two of the characteristics of such a system are high power and a large dish antenna. However this is quite untrue. Thorn EMI effectively transmits data to the American GOES East satellite positioned 22 000 miles above the equator using a very basic YAGI antenna and only 2 W. Thorn also uses the ARGOS satellite, and a mere 2 W is used with a simple modified 0.25 wave rod.

The first commercial satellite 'Early Bird' was put into orbit in 1965, by the International Telecommunications Satellite Organisation 'Intelsat'. Since then hundreds of satellites have been launched, of which approximately 115 are currently strung around the equator in a single orbit. These geostationary satellites have the advantage of being apparently stationary, because they orbit every 24 h in the same direction as the earth's rotation and appear to hover above one place. Like any satellite, the geostationary satellites are of course orbiting (see Figs 4 and 5).

Acoustic telemetry

Description

Whilst radio waves work well in air, this is not so in water. It has been found that sound waves do travel in water rather better than in air and slightly faster (1500 m/s). Provided sound energy can be transferred efficiently into water and a microphone can be used to listen, then communication can be achieved.

Unlike sound waves in air, the waves in sea conditions are hampered by echoes not only from the sea surface but also from the temperature interfaces in the water. To illustrate the range possible in water, it is known that whales transmit their mating call up to 4000 miles using the temperature layer near the sea bottom.

Frequency limitations

The range of acoustic transmission is governed (as in air) by frequency for a given energy. In commercial underwater acoustic telemetry various frequency bands are used based on an input of 750 W or an output of 190-195 dB. The following ranges are expected:

7.5 to 17 kHz	15 km
18 to 36 kHz	1.5 km
40 to 80 kHz	1 km

Only the first low-frequency band is in the audible range; the other two are ultrasonic. In the commercial field acoustic transmission is often effected by bleeping two frequencies, usually positioned 0.5 kHz apart, in a kind of morse code. This is called frequency switch keying. In water, sound takes time to build up and die away, and the operator either has to transmit the information quickly before the reverberation sets in, or very slowly allowing reverberation to die away each time.

Sound cannot be generated in water instantaneously and commonly there is a build-up lasting about 0.3 ms at high frequency and 1.5 to 2 ms at low frequency. The duration of a pulse is usually about 2 ms at high frequency but as long as 10 ms at lower frequencies. Using this technique transmission rates of 250 baud at high frequencies can be achieved, but at lower frequencies only about 50 baud.

There is of course no reason why a sound signal cannot be modulated in the same way as a radio signal. Amplitude, frequency or phase modulation is available on acoustic waves as well as radio waves. An alternative to frequency switch keying for transmission of data would be to modulate the waves in some way. However, in underwater telemetry modulation of the carrier is not normally done except for speech. In this case single side band modulation is used, which is quite effective.

Transducers

Injection of the acoustic signal into the water is effected by instruments known at transducers, which not only transmit but also receive the signals. They are either slightly lighter than water and are attached to the bottom using a heavy weight, or heavier than water and are suspended from buoys.

Transducers are also mounted on submarine surfaces, underwater vehicles or underneath surface ships. In addition they can be attached to underwater objects such as wellheads and are frequently battery driven. More sophisticated transducers will collect information from an installation and then transmit it on demand from a surface transducer.

Coding

Coding is very much up to the user and frequency shift keying of various kinds is used. Frequency shift keying is the use of two or more discrete frequencies to indicate numbers. For binary code only two frequencies would be needed.

In practice the information is packed in a serial stream like a set of coloured balls and sent and received in that form. In a stream of 200 digits, a great deal of information can be stored and as information is frequently confidential, a code is often used. Some method of checking the data is incorporated in the code so that an error is immediately obvious.

Decoding of a signal taken off the 'air' at random can produce some apparently very strange messages. For various reasons some operators of radio telemetry links keep them open by transmitting these messages.

TELEMETRY SYSTEMS

Inmarsat

The Inmarsat satellites were originally intended for use by the US Navy, and from 1982 they have been available through Inmarsat for commercial use. Inmarsat are geostationary satellites and are sited over each of the three major oceans of the world — Atlantic, Indian and Pacific. A simple transreceiver and aerial costing £5000 is all that is required to use this system. A fee is then payable to Inmarsat of $4 per minute.

The earth stations are linked to the telephone network and transmit and receive in the 4-6 GHz band (C band). The ship stations transmit on 1625-1645 MHz and receive on 1525-1544 MHz. Because the satellites can see more than a third of the earth at any one time, three satellites can cover the whole globe (see Fig. 6).

Inmarsat, therefore, provides a complete global communication network for ships and aircraft at a price affordable by most commercial organisations (see Fig. 7).

Satellites have a limited life depending on the amount of gas they can carry. The gas is used to keep them in position as they have a tendency to wander off station and gas jets are fired from time to time to bring them back into the correct position and orbit. Clearly, if the satellite drifts too far off station the ground station aerials will not be able to maintain communications.

Until recently the jets were fired at regular intervals to maintain a fairly precise position but recent developments have enabled the ground station to predict the satellite's drift and to follow it. This has reduced the number of jet firings needed to maintain contact and the satellite's anticipated life has therefore been much increased. Even so, every satellite will fail sooner or later and there are a number of spare satellites in orbit waiting to be brought into action. They are easily moved into a new position by a squirt of gas, and hours or days later they can be in the required position.

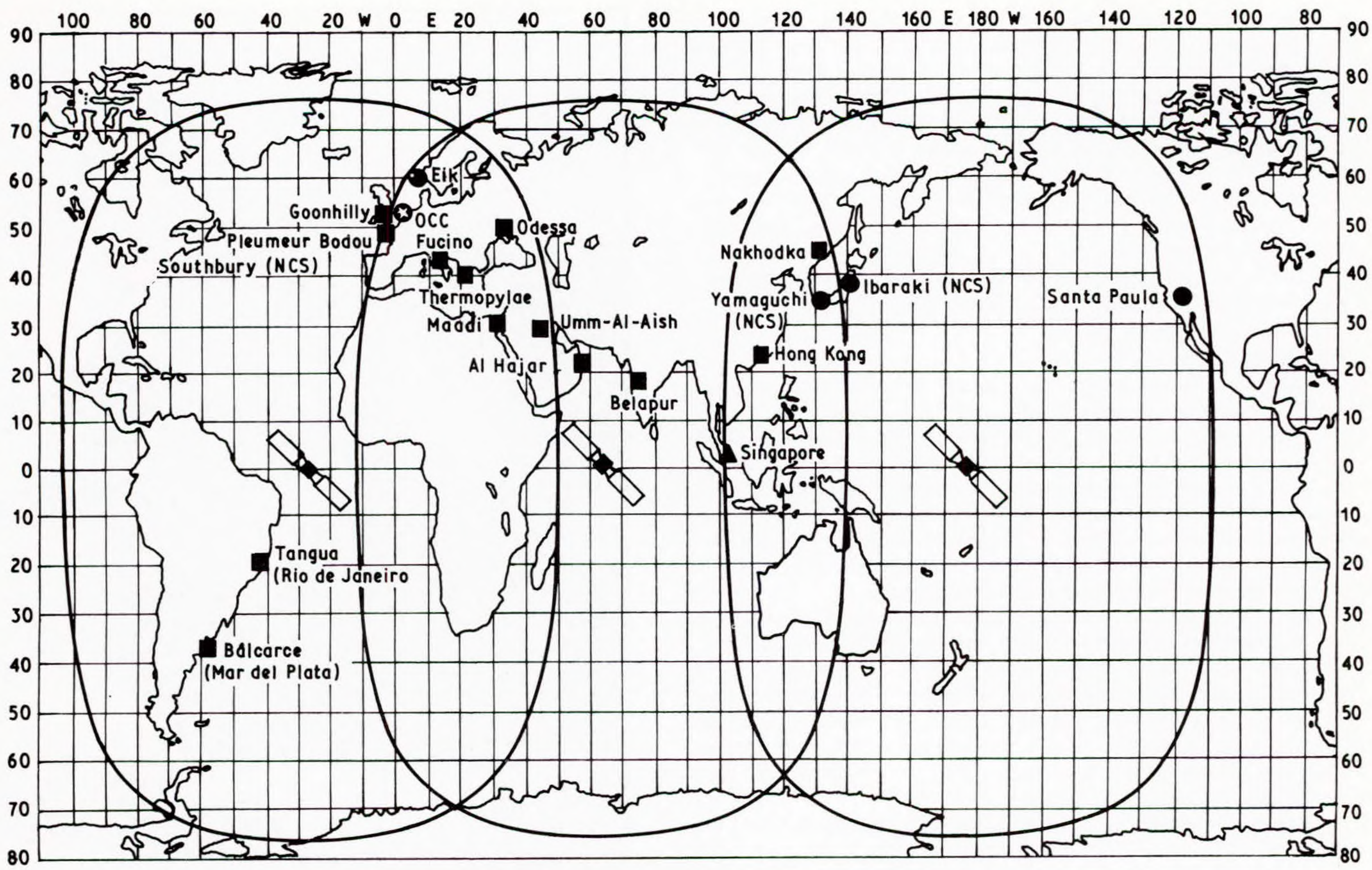


FIG. 6: The global coverage of the INMARSAT system

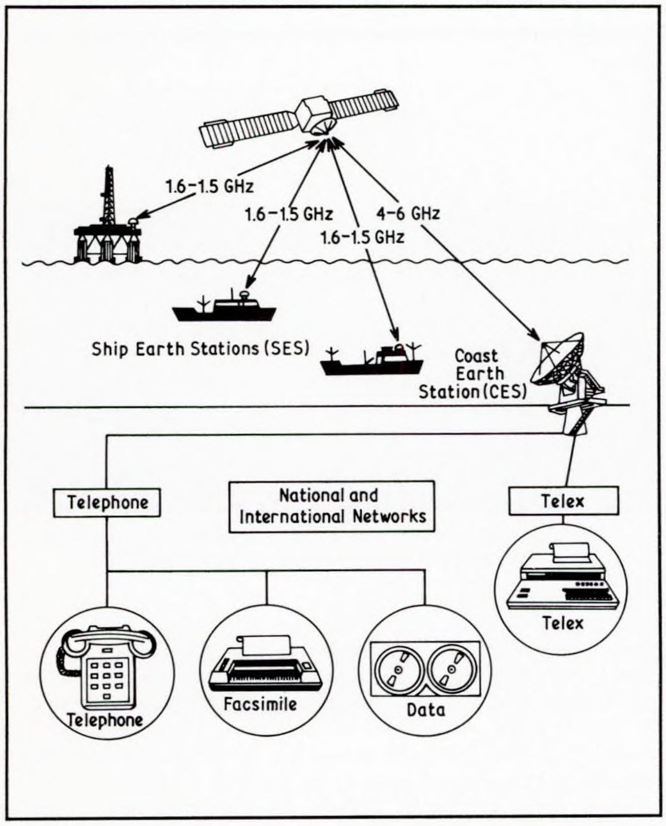


FIG. 7: Outline of maritime satellite communications

Meteosat

The Meteosat system was intended to emulate Inmarsat and is operated by the European Space Agency in Holland. There was one satellite which operated until recently over the Atlantic and our own databuoys used it. The American GOES East satellite has now been moved over and is being used by the Meteosat subscribers.

Argos

The Argos service is interesting and technically sophisticated. To do it full justice would requires a complete paper. Basically, it consists of two satellites, each orbiting the earth about 850 km high every 101 min. Each satellite passes over the North and South Poles and the two satellites' orbits are inclined at 75° to one another.

With two satellites orbiting 14 times each day, the two Poles receive 28 passes per day. As the latitude decreases so does the coverage and at 55° the UK receives 16 passes. At any single point on the equator they only pass seven times per day.

Data is transmitted to the satellite on 401.650 MHz, in 1 s bursts every 60 or 100 s. It is received on board so that each time the satellite passes over one of the three telemetry stations, the recorded data are read out and transmitted to ground. The three stations are at Toulouse in France, Walops Island on the East Coast of the USA and Gilmore Creek in Alaska.

All the platform transmitter terminals (PTTs) transmit either every 40-60 s or 100-120 s, depending on the type. Each message lasts less than 1 s. The satellite sorts out the messages, and the location of the PTT can be determined by the satellite by measuring the Doppler effect on the carrier frequency of the incoming message.

The location ability is very important to some users such as Thorn EMI because it enables them to check the position of moored buoys. There is the true story of the parting of the tow rope at night of one of Thorn's largest buoys. The Captain of the tug called up some hours later on the radio telephone to ask where he had left it. Its position was located within 200 yards. Drifting buoys use the Argos service almost exclusively, and the tracking of animals such as deer and dolphins is commonplace. Argos is also used for emergency beacons.

Data from the Argos service can be sent through the post, received on Telex or sent by telephone.

Databuoys

These are buoys which are moored or drifting at sea and which transmit environmental data to shore. They are normally used for research or weather forecasting. The UK, being surrounded by sea and with an ocean on the side of the prevailing wind, is particularly interested in the weather conditions in the Atlantic. The Americans, for the same reasons, are very interested in what is going on in the Pacific. Databuoys and satellites together can do this, but one without the other cannot give a complete picture.

The databuoy can provide ground pressure, wind, sea and air temperature, wave height and period and humidity. Satellites can show cloud cover, upper winds and other important data. The databuoy is becoming a necessary source of information for the weather forecaster. However, it has been the oil companies who have pioneered databuoys in the UK and Thorn EMI has been one of the designers and operators.

Figure 8 shows the first databuoy positioned in the Western Approaches in 1976. This weighed 40 tons and measured all the normal environmental parameters which it then transmitted back to Land's End using long wave. Transmission was intermittent in rough weather, as the buoy could be behind a large wave. However, despite using old fashioned equipment by today's standards, it worked for nearly four years and represented a major achievement. This successful first deployment, which was sponsored by the Department of Energy, was followed by two more giant databuoys sponsored by the oil companies and the Department of Energy.

This time the oil companies required reliability of data reception and duplication of everything. Each buoy effectively had three transmitters plus one booster and six tape recorders. All data were recorded on board at least twice and some of it three times, as well as being transmitted three times on different transmitters. A measure of the rate of electronic systems development can be gauged by the fact that the second generation buoys were half the size and weight of the original DBl with a battery life 3-4 times greater.

DB2 and 3 had the major advantage of having the use of satellites to relay their messages to shore for the first time. They each weighed about 22 tons and were deployed in 1984, one in the Western Approaches and one West of Shetlands (see Fig. 9). Reliability was high and they worked well.

The oil companies' reason for spending their money on databuoys was not entirely in the public interest for weather forecasting. Their main reason was to establish firm environmental data which could subsequently be used to specify the strength of oil production platforms in the area. At that time drilling had started in the Western Approaches and West of Shetlands. Since then interest in finding oil in the Western Approaches has dwindled, probably because they have not found any. West of Shetlands the story is different. Interest has moved into the sea areas off Sula Sgeir and DB2 has been moved to a point 30 miles West of these islands.

Following the successful deployment of DB2 and 3, Thorn EMI developed a new range of databuoys principally for use by Meteorological Offices. The first of these has been sold to the UK Meteorological Office, who plan to use it in

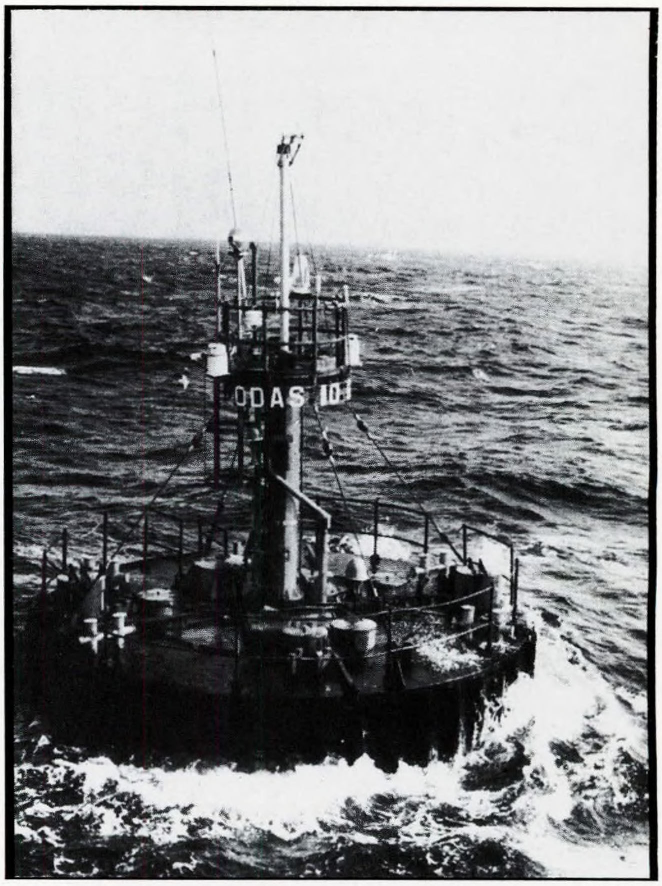


FIG. 8: Databuoy moored in Western Approaches from 1976-1980 which transmitted data using long-wave ground transmission

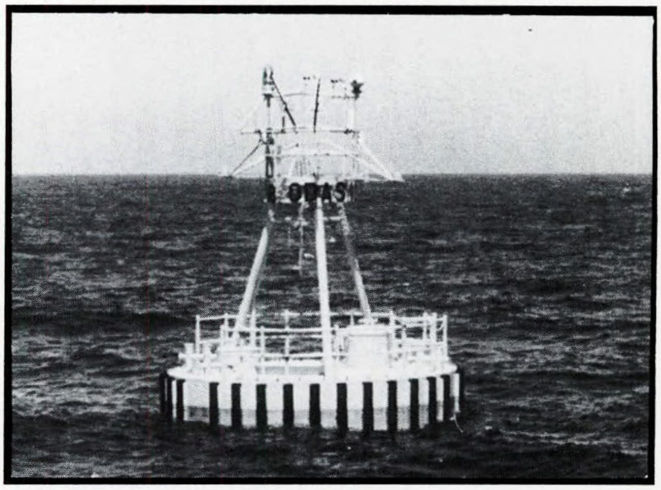


FIG. 9: Databuoy moored in North Western Approaches which transmits data via two different satellites

the South Western Approaches to replace DB2. This new range of databuoys is called Seawatch, and has been repackaged into a small fibreglass hull and now weighs only 3 tons (see Fig. 10). It could have been smaller but for two outside factors. First, environmental conditions dictate that a mooring of a certain strength is required to hold a buoy on station. Such a mooring cannot be supported by a smaller buoy. Secondly, smaller buoys are attractive to fishermen who have other uses for them and their accompanying moorings.

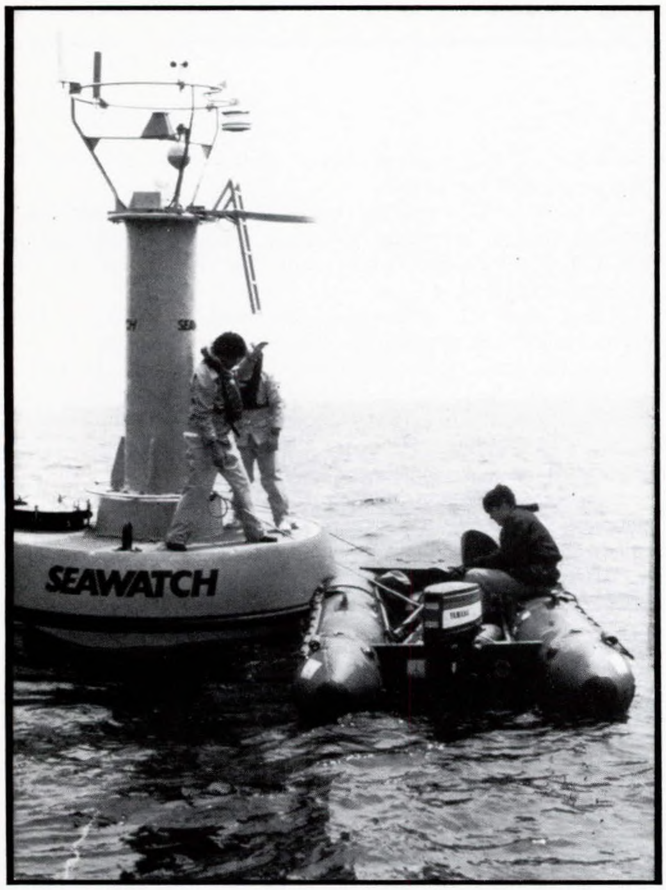


FIG. 10: The new low-cost, lightweight Seawatch databuoy which transmits data by either VHF or satellite

Since satellite communication became commonplace, drifting buoys have become popular: deploy a drifting buoy in the ocean and it will move with the current and transmit back its position, sea and air temperature and pressure. Average current can be calculated from the drift. Sometimes extremely large drogues are attached to them to ensure that wind does not appreciably influence their drift by currents. The buoys are not recovered and when the batteries run out they stop working and are no doubt either caught by fishermen or run down by ships. They are fortunately quite small and are unlikely to damage ocean-going vessels.

A Norwegian Institute was carrying out a drifting buoy programme off Africa, and by satellite telemetry plotted its course in the Gulf of Guinea. The buoy followed a roughly circular course for about six weeks, when suddenly it took off to a port on the Ivory Coast. The engineers flew out and found the buoy moored to the quay. Nobody knew anything about it or how it came to be there.

The engineers hired a local boat and repositioned it again out at sea. Three weeks later it took off again to a different part of the coast. This time the natives were clearly more involved and it cost the Institute 100 bottles of wine to obtain the release of their captured buoy. Next time they put it further out to sea. Sea piracy is one of the hazards to databuoys.

Subsea applications

One of the common applications of underwater acoustics is for positioning objects. This technology was originally developed for tracking experimental torpedoes fired from submarines. The system has been developed to incorporate three transducers attached to buoys or alternatively laid on the sea bottom, and will now not only track four weapons at once but also the target and the launch vessel. Hydrophones mounted on the submarine can also track missiles leaving their tubes and launch debris, which can be monitored to see how it is dispersed. They can also be used to measure the miss distance of practice torpedoes.

Acoustics have developed into the offshore industry, and similar systems are used to position platforms accurately on the sea bed. They are also used for the positioning of underwater installations on the sea bed, such as monifolds for the collection of oil from remote wells, and probably their most talked about use was in the installation of the templates and subsequent positioning of the Hutton TLP.

This special system was developed by Sonardyne of Fleet, Hampshire, and claims to position the templates to a relative position of plus or minus 50 mm. During the installation of the floating platform, a Micro Nav. system made by Sonardyne was used to monitor continuously the height and position of the first tension leg to be stabbed into each foundation plate.

The Micro Navs. with their associated external HF transponder remote transducers were deployed on the foundation templates by divers. A pair of miniature command transponders were attached in a special bracket to the lower section of the tension leg. Two transponders were used to ensure that no masking occurred, and were interrogated alternately from the selected Micro Nav. transponder remote transducer. The range measurements were telemetered acoustically to the floating platform where they were computed and displayed. The position so determined was updated every 2 s. It should be noted that the positioning by this method was for monitoring purposes, and not for actual installation.

It is probably fair to say that this particular operation used acoustics to the full, which provided a reliable means of telemetering high-accuracy data through the water. It certainly marked a major advance in acoustic positioning.

Sonardyne systems are now being used to telemeter data to the code interrogator and are measuring various data from the sea bed. The transducers now actually store the data and transmit on demand. The range of this sort of system is limited, and the whole technology is poised to make a quantum leap forward with the introduction of a new material from Thorn EMI called PVdF.

FUTURE DEVELOPMENTS

Radio telemetry will develop further as equipment and satellites become less expensive. It seems likely that all ships' telemetry will be by satellite quite soon. Underwater telemetry is being developed using acoustics and current developments include the transmission of drilling data through the mud used for lubrication.

Thorn EMI are working on a telemetry system which uses torsional acoustic signals in a subsea drill pipe. There is no doubt that, theoretically, downhole data in an oil well can be relayed via surface buoys from the well bottom to anywhere on earth in real time. It is not yet done but it is not far away.

ACKNOWLEDGEMENTS

The author wishes to thank all those at the following companies who have assisted in the preparation of this paper and who have loaned slides: Thorn EMI Electronics Ltd, Inmarsat (International Maritime Satellite Organisation), The European Space Agency, British Telecom PLC, Marconi Communication Systems Ltd, Service Argos, and Sonardyne Ltd.

Discussion

J. D. BOLDING (Lloyd's Register of Shipping): The author is to be congratulated on producing an easily read, well illustrated and informative paper on a topic which is increasing in importance within both the marine and offshore industries.

At Lloyd's Register of Shipping, we have an involvment in control and emergency shutdown systems of oil rigs and we are frequently being asked to consider telemetry systems for unmanned remote platforms. Installations of this type are usually arranged as satellites of a manned central platform from which all control functions are initiated. A further option includes the possibility of controlling the central and remote platforms from a shore-based control room to reduce further manning levels offshore.

Such systems require hardware redundancy and data checking as the author mentions in his introduction. Could he expand on this by explaining how data can be checked for integrity and what parameters other than data checks are appropiate for switching a duty telemetry link over to a standby link.

In considering links of this type, we strongly favour the inclusion of a monitor to record the usage of the link, number of errors detected, and other parameters which assist the operating staff to assess performance and maintain it in good working order. The author's views would be appreciated on the extent of checks he would recommend.

A problem which occasionally crops up in dealing with oil platform ESD systems is the question of delaying shutdown in the event of transmission loss of the telemetry link. One long-distance troposcatter link I have knowledge of shutdown an unmanned platform after only 5 s, while some line of sight microwave links of no more than a couple of miles distance have proposed a delay of many hours prior to automatic shutdown. I suspect the consequences of loss of the rigs concerned have influenced those decisions.

In such a situation heavy reliance is placed on the remote installation's transducers and other senors to provide all shutdown protection if a prolonged delay is envisaged prior to shutdown. In general we have felt that 5 min is an appropriate delay. What, in the author's experience, is a suitable delay for occasional loss of transmission?

In the marine field the future will see telemetry systems being commonly used for data interchange between ships and their owners' headquarters as well as their agents in all areas of ship operation and business. In designing such systems for new building does the author consider that shipowners need to bear in mind the projected worldwide network standard entitled 'Integrated Services Digital Network'? I understand this standard may taken ten years or more to come into common use. How does he see the standard developing and what other guidance can be offer on standards generally?

In seeking reduced manning and enhanced safety of tanker loading at tanker terminals, the use of portable equipment using radio telemetry links is becoming common. The hand-held portable indicator for the Saab radar tank sounding system is one example. Remote stopping of tanker loading via standard portable UHF radio is another. This is accomplished by keying in a tone on a particular channel of a portable radio, and a base station receiving the signal then intitiates controls on the shore-based installation which stop loading.

Does the author see such links being developed for controlling winches, deck equipment, engine room cranes and the like? If this is practical, what safeguards would be required?

Extensive use of computer technology on ships requires that a local area network be installed. I envisage the possibility of this network being extended to a variety of items of portable equipment.

A UHF radio system operating through strategically mounted satellite aerials in a similar manner to cellphone in car radio telephones would provide the reliability of propagation required.

When used for voice communications as well, such a scheme could be of advantage in reducing manning levels.

Just to push this suggestion to the limit, a recent exhibition in the UK demonstrated a car production line inspection scheme in which a human operator carried out a visual inspection on a car listening to prompts from synthesized speach generated by a computer. The human operator responded with his voice through a speech recognition system which recorded the result of the inspection on the computer's data base. Could such techniques be safely adapted for the control of the systems mentioned earlier?

M. USHER (Consultant): I should like to comment on the author's reference to the avoidance of complexity in telemetry systems. In my experience such complexity need not be a barrier to design progress. I have been associated with a most successful oilfield telemetry system with oilwell telemetry outstations controlled by a radio link to their respective computers, which in turn are linked by radio to a central control computer on the main offshore platform. Availability by appropriate redundant sub-systems is the key to success.

Referring to the use of UHF for offshore platform telemetry, I believe that fibre-optic systems might provide considerable advantages over radio in view of the latter's limitations caused by metal screening and radio hazards.

The use of marine satellites for the usual offshore telemetry transmissions would be costly. Does the author think that there will be enough channels for future North Sea developments, bearing in mind that the system was originally intended for use by merchant ships with limited usage time per call.

Finally, I should like to ask the author for his views on the future use of acoustic subsea telemetry systems along the lines of the acoustic control of subsea gas pipeline valves in the USA.

J. H. DAVIDSON: On the subject of using fibre optics, surely the advantage is that such systems are inherently intrinsically safe as opposed to hard-wiring curcuits, which would require IS barriers.

Some oil terminals insist that satellite communication systems onboard tankers are shut down whilst alongside. Would the author care to comment on this point, as it is the case even though the aerials are sited in a 'safe' area.

A. T. MITCHELL (Shell Seatex): The author mentions accuracy in relation to data and voice telemetry systems. Manufacturers' claims of accuracy are often tied to, but overshadowed by, claims of speed of transmission and are seldom comparable from system to system.

The author's reference to supposed accuracy of data over that of voice telemetry does, I feel, demonstrate the necessity to qualify the comparison, as indeed the author does in part by his mentioning of 'checking systems'. But what is really meant by accuracy?

The voice system can tolerate relatively major degradation in the signal while maintaining an output which can be correctly interpreted. While the accuracy of this voice link (input equipment to output equipment) may be described as poor, the accuracy of the system overall (man to man) may be described as good. The same system used for data may have an unacceptable level of accuracy. However, even the inclusion of checking systems will do nothing to improve the accuracy of such a system without some sacrifice in the level of performance.

My company has experience of various marine telemetry systems including some SATCOM based systems for data transmission from ship to shore on a worldwide basis. One of the prime considerations in the development and application of these systems (which is applicable to all telemetry systems employing 'hired' or 'metered' lines of transmission) is accuracy allied to performance. A common checking system employed on such systems is error detection with automatic retransmission. While high transmission rates and high accuracy can be claimed for and achieved from this arrangment, in practice the quality of the line of tranmission, the length of the data stream and the sensitivity of the error detection system can lead to unacceptable levels of performance if multiple retransmissions are required and the final 'per unit' cost to the user exceeds that of alternative methods of getting the information to its destination.

My experience has been that systems which offer some degree of message reconstruction, such as replacement of corrupted blocks of data by partial retransmissions or by error correction, also tend to live up to the user's best expectations, albeit at some higher level of investment.

Until recently the marine industry has had little call for the transmission of large amounts of data but, certainly within the Shell group, this is changing and there is a growing demand for efficient ship/shore lines of transmission, for example as an integral part of ship management and machinery condition monitoring systems.

It is hoped that this growing demand can be satisfied by properly engineered systems in which due attention is paid to required accuracy and performance. These factors should not be compromised unnecessarily simply to reduce the initial investment because an inadequate system with higher than budgetted running costs does more to undermine confidence in such systems, in the first year of operations, than any 'teething' problems which may normally be expected to arise.

Author's reply

To reply first to Mr Bolding's questions, data integrity can be checked in software by various redundancy codes, eg Hamming Beckman. In some cases this can correct errors in the data stream but is a trade-off against the amount of data that can be sent in any time frame.

Switching can be affected by failure of the input power, the output power, monitoring the data output, ie checking that the data is present, and by monitoring the modulation level.

A number of factors will influence an operator's decision on time to shutdown following the loss of the telemetry link. The degree of confidence one has in the remote system is an important consideration and I suspect that confidence levels will grow and that the time to shutdown will increase as commercial pressures become significant.

The rate of development of the 'Integrated Services Digital Network' standard, and whether it develops at all, will depend on how successful the different countries and companies are in persuading their customers to use the system. It will also depend on whether the various companies can agree a standard.

Radio control of winches and deck equipment etc. is already done both directly and indirectly. There is no difficulty using existing technology in safeguarding the system. Thorn EMI have already produced a working system which completely controls an unmanned ship. There are three such ships in operation and they are used for target practice by the Royal Navy. The Navy, of course, aim off in order not to sink what is a rather expensive piece of equipment!

There are already weather stations which give out information using a voice synthesiser. We are probably some way from the situation where a computer can receive critical instructions by voice.

It was not my intention to inhibit design progress when I made the comment that simplicity is the secret of reliability in telemetry systems. Mr Usher's comments are quite true in that in appropriate circumstances redundant sub-systems can be the key to success and certainly this is Thorn EMI's experience. However, it is also my opinion that many systems grow in complexity and sophistication at the whim of the engineer without actually achieving anything tangible except to reduce the reliability. It is the old question in value engineering — do you need it at all?

I pose the question, what percentage of data that is transmitted over the radio is actually ever looked at again? I suspect it may be a small percentage. I could give examples of information which is duplicated several times on tape recorders and is also transmitted by radio which will only ever be used years later. The question I would ask is why transmit it? The supporters of the system would say that you know it is working. My answer to that is even if it is not, could you afford to do anything about it? The argument progresses from there.

I agree with Mr Usher on the question of fibre-optic systems but it is interesting that the industry has not received them very enthusiastically. The point he is making about marine satellites is, I believe, a question of supply and demand. If the demand is there the manufacturers will provide the satellites to fulfil the demand.

Finally I am not familiar with the acoustic control of sub-sea gas pipeline valves in the USA but I am aware of certain attempts that are currently being made to introduce acoustic subsea telemetry systems in the North Sea. There are a number of developments going on in this area at the moment, some of which are commercially highly confidential.

In response to Mr Davidson, fibre optics are intrinsically safe and therefore in some respects do have advantages over hard-wire circuits. They are also less prone to interference from neighbouring circuits and for this reason have a lot of advantages. However the marine industry is very conservative and in some respects they do add complications which are often felt not to be justified by the advantages.

Some oil terminals I believe do have radio telemetry links and it may be possible that these could be interfered with by RF transmissions which may be comparatively powerful at close-quarters. In many cases the precaution of turning off transmitters is maybe a little over cautious.

Mr Mitchell makes a very fair point and I would answer it by giving one example. The Townsend Thoresen bow doors on their ferries used to be reported shut by a radio link. They now have three green lights to indicate their closure, as with aircraft undercarriage.

One of the problems that Mr Mitchell highlights is the conflict between performance and cost. So many systems are purchased on the lowest tender price that the level of sophistication described by Mr Mitchell is often discarded in favour of a cheaper alternative.

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