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SATELLITE TELEMETRY OF TIDAL DATA IN THE HYDROGRAPHIC SERVICE OF THE ROYAL AUSTRALIAN NAVY

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Abstract

The Hydrographic Service of the Royal Australian Navy (RAN) is responsible for charting of the area extending from the middle of Indian Ocean to the equatorial waters of Papua New Guinea to the Antarctic, with tidal regimes varying from fully diurnal to fully semi-diurnal and from less than 1m to over 12m. Accurate tidal information is vital in surveying and charting, and to provide it, three years ago, Hydrographic Service RAN with assistance from InterOcean developed the then largest network of unattended INMARSAT-C telemetry units in the world by using an array of digital tide gauges linked to the INMARSAT-C satellite telemetry by a remote data acquisition system. This application of modern technology was a major step from the previous practice of manned tide camps.

During the last three years, the equipment has been further improved and modified to rectify minor problems encountered during that period. In general, the introduction of modern technology to tidal data acquisition and telemetry has been a success for the RAN hydrographers. Tide gauges, telemetry equipment and ancillary gear have proved their value, giving reliable service with low maintenance and operational costs.

1. INTRODUCTION

Hydrographic Service of the Royal Australian Navy is responsible for charting the area extending from the middle of the Indian Ocean to the equatorial waters of Papua New Guinea to the coast of Antarctica. Except for areas of concentrated navigational usage, a large portion of these waters remains inadequately charted. It is estimated that it will take at least until year 2050 to

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produce modern hydrographic charts covering whole of the Australian area of responsibility.

Accurate hydrographic charts are essential for safe navigation and tidal data is vital for the accuracy of the hydrographic surveys as it provides the information on changes in sea level. Depths shown on charts must allow for the fluctuations in water level, whether of tidal origins or not, and must be referred to a standard reference surface called datum. The datum is selected so that the level of water should not fall below it, such that there should never be any less water than the depth shown on a chart. This requires information which can be obtained only from lengthy observations of the water level. During a hydrographic survey, the height of water column above that datum must be determined to obtain depths corrected for temporal variations in water level. Thus, the tide gauges perform two functions - observations to determine the datum, and then to provide the height of water above that datum at the time of sounding.

Most of the surveys by the RAN Hydrographic Service are conducted in sparsely populated areas. Thus, Australian hydrographers (or droggies, as they are commonly known) cannot rely on permanent harbour tide gauges and must deploy their own. Until recently, this wasn't as easy as it sounds. The pneumatic/mechanical gauges in use could be deployed only in shallow water immediately off the shoreline to minimise the length of air line with its associated problem of air leaks, and the mechanical drives also gave a lot of trouble. The low accuracy of the graphs on a circular paper chart caused further headaches. In addition, to get the data from a gauge to survey ships required frequent boat trips or diverting a ship from its survey tasks. As a result, it was frequently easier to set up manned tide camps with sailors reading the water level directly from a tide pole in addition to making sure that the tide gauges were working correctly, and transmitting the data via radio. While this method provided reasonably reliable tidal information, it needed a lot of manpower which could have been utilised more productively elsewhere, especially since data collection by the traditional methods can be wearisome. Sir John HERSCHEL, while working as an astronomer at Cape Town in 1836, had this to say on the subject: "Observing the tides is the greatest bore upon earth, or on waters, and the greatest exhaustion of a man's patience and the trial of his temper." It can be so, even today.

With the commissioning of four Survey Motor Launches which carry minimal crews (2 officers and 10 multi-skilled sailors), the option of manned tide camps became untenable. It was determined that the most effective option for tidal data acquisition was to purchase digital tide gauges and data telemetry equipment. As the survey ships would require less visits to the tidal stations, this would increase surveying productivity, and the use of electronic data transfer and processing would reduce the intensive tasks of tidal data collation and interpretation.

2. EQUIPMENT

Tidal Section carefully examined the present and future requirements of the Hydrographic Service before preparing specifications for the new tidal data acquisition, processing and telemetry system. It had to be versatile to cope with operations of two large survey ships, four Survey Motor Launches, four smaller Survey Motor Boats, a detached survey unit with its own boat, Hydrographic School with another boat, and the Laser Airborne Depth Sounding (LADS) system. At that stage, LADS system was not operational, and it was expected that tidal data might need to be transmitted directly to the plane flying over the survey area.

As the survey operations frequently take place away from mainland or suitable islands or coral reefs, a bottom mounted tide gauge (BMTG) was needed. These gauges had to have operational depth limit of at least 200m and to produce depth data with an accuracy of 0.05%. Several deployment options were envisaged; from a free standing bottom deployment for long term data acquisition without telemetry, through shallow water installation with a hard wire connection to a shore telemetry station, to a bottom mounted gauge equipped with an acoustic modem for communication with surface telemetry buoy for retransmission of the data (see Figure 1). Data telemetry was to be in real or near-real time. Both, shore telemetry stations and the telemetry buoys had to be equipped with barometric pressure sensors to provide atmospheric pressure corrections to the depth data. At the same time, it was decided to purchase current meters for measuring tidal streams which are known to reach 16 knots in the North West of Australia.

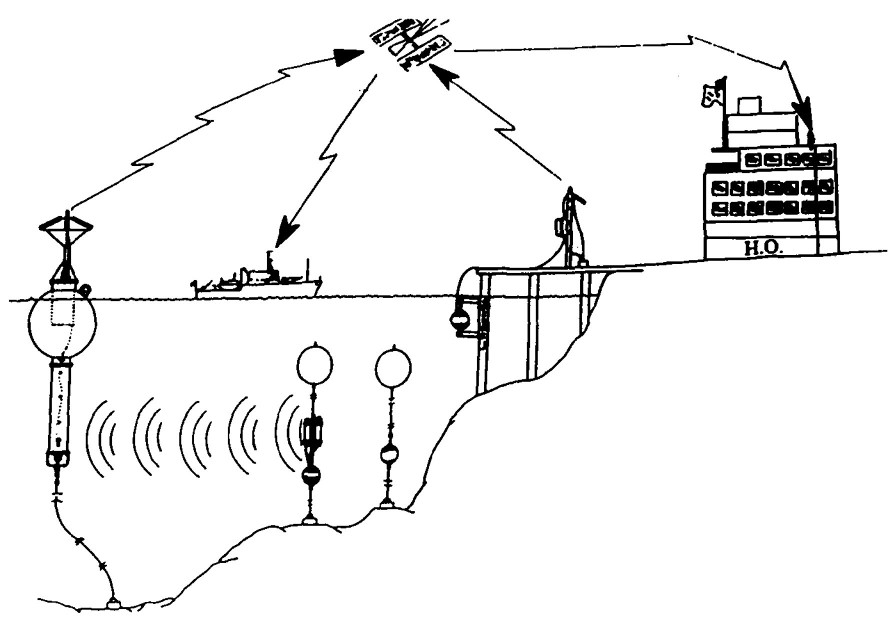

FIG. 1.- Deployment options of the RAN tidal data acquisition system.

The contract for the equipment was awarded to Seismic Supply International Pty. Ltd. of Brisbane (Australia), who are the local distributors of InterOcean S4 type tide gauges and current meters. Early trials were conducted with a VHF telemetry system, which determined quickly that while the total system worked as expected, it did not solve all the problems. Telemetry range was insufficient, which would still force the ships to travel towards the tidal station until it could receive the data. At the same time, it was determined that the LADS plane would not require direct telemetry of tidal data, and that its land-based data processing unit would need it only several hours after the plane's sortie, thus negating the requirement for real-time data telemetry. It was decided to go to INMARSAT-C messaging system at preset intervals.

Early in 1992, RAN took delivery of the complete system of measurement, recording telemetering and processing of tidal data. It consists of 24 InterOcean S4 tide gauges, 5 telemetry buoys, 7 shore telemetry units and 10 acoustic telemetry links for the collection and transmission of tidal data, together with 11 ship/land based telemetry data acquisition units for the reception and processing of the telemetered tidal data. In addition, 16 S4 current meters were acquired to be used as tidal stream meters. Sufficient numbers of acoustic releases, submersible buoys and other ancillary equipment were also purchased.

The ship/land units are all identical with most of the equipment contained in a rack-mount package. They consist of an EB NERA SATURN C Standard-C INMARSAT transceiver, interface electronics, laptop computer, and custom software for data acquisition and two-way communications with the buoys and shore stations. EB NERA Standard-C omnidirectional antennas are mounted on ship's mast. In addition to the units installed on ships, one unit went to the LADS land-based data processing unit and one to the Tidal Section at the Hydrographic Office, now in Wollongong near Sydney, to give its personnel a facility to oversee, and to control if necessary, all the deployed buoys and shore stations and the associated tide gauges.

Each telemetry buoy consists of the flotation buoy, mast with dual 22 w solar panels, EB NERA Standard-C omnidirectional antenna, strobe light, and radar reflector. An acoustic telemetry transducer is mounted in its lower extension. The buoy's central cylinder contains EB NERA SATURN C Standard-C INMARSAT transceiver, acoustic telemetry controller, barometric pressure sensor, microprocessor control unit, and a battery. Each buoy can handle acoustic telemetry to several submerged gauges but this is not required at present in the hydrographic survey operations.

The buoy control unit communicates with the BMTG via the acoustic telemetry unit and then stores the data in its memory. The data is then transferred to the SATURN C transceiver via a modified serial port for transmission to the ship and land based stations. The transceiver is switched off when not in use to conserve power. Every four hours, starting at UT 0000, the transceiver is powered up for 40 minutes to send data and to wait for instructions before powering down. If the data transmission is delayed by traffic or extended or retransmission of several blocks of data requested, the transceiver will operate beyond 40 minute limit. The control unit has sufficient memory to store up to 960 data samples in a maximum of 24 four-hour blocks. A data sample consists, in this case, of date and time, water depth and barometric pressure readings.

The shore telemetry unit consists of single 34W solar panel, EB NERA Standard-C omnidirectional antenna, usually mounted on a tower, and an electronic unit – a weatherproof enclosure containing EB NERA SATURN C Standard-C

INMARSAT transceiver, InterOcean model S110 interface for the tide gauge, barometric pressure sensor, and a microprocessor control unit. The power is normally provided by an external battery. The shore unit communicates with the BMTG via a hard-wired link and then stores the data in its memory. The transmission method and pattern is identical to these of the telemetry buoy.

Commands from the ship/land units allow for re-programming of the tide gauges to change the averaging period and recording interval via the telemetry link for both, buoy and shore station based installations. They also provide for the retransmission of one to 24 contiguous 4-hour data blocks corresponding with the last 96 hours of recorded data. Updated ship and land-based satellite address IDs can also be sent for automatic data reporting purposes. The system allows for an automatic confirmation of any received commands.

3. OPERATIONS

Hydrographic Service RAN has now a system where up to twelve tide gauges may be deployed at one time connected to satellite telemetry units. Naturally, each tide gauge station and each ship/land based data acquisition station has a unique address ID. It is believed that, at the time of purchase, this was the largest network of unattended INMARSAT-C satellite telemetry units in the world. So far the system was never used to its full capacity, with up to 5 tide gauge stations being connected to the INMARSAT telemetry at one time, but with the survey activity increasing, the additional capacity will be beneficial.

What should be appreciated is the fact, that RAN has to use the satellite telemetry in a very particular fashion – their operations require high mobility of the tide gauge stations which normally operate for a relatively short period of time at any location (rarely longer than 3 months). In addition, the remote location of most of the deployments, and relatively small capacity of the buoy batteries impose other restrictions. Despite all the buoys and shore telemetry units being equipped with solar panels, and a high level of insolation generally possible in Australia, there is not enough battery capacity to run the system in real time. While this is not absolutely necessary, the battery in a buoy cannot sustain frequent INMARSAT transmissions and the acoustic telemetry to the gauge at the same time. The slowness of the acoustic modem complicates the matter further. The situation with the shore telemetry units is easier as a large battery can be installed, and the hard-wired connection to the tide gauge does not impose any data transfer restrictions. However, to maintain uniformity of operation, a compromise solution, suitable for all sorts of installations, had to be found. The four hour interval between the transmissions was determined to be close to ideal. Operating at this interval, the buoy batteries hold enough power for the overnight transmissions, and then can be recharged during daylight. The size of an average transmission file containing 4 hours of data samples taken at 10 minutes interval is about 1kb, which keeps the cost of transmissions low, and allows for easy retransmission of several files within the standard 40 minutes operational period, if required.

Naturally, introduction of such a complex system did not happen without some teething problems. Most of them were connected with the operation of tide gauges and acoustic modems, the INMARSAT telemetry part having been relatively trouble free. Very early, it was discovered that the antennas needed additional waterproofing and ruggedising as they proved to be too delicate for RAN field operations. The long cables between a ship based telemetry station and an antenna mounted high on the mast were also found to be prone to damage.

A big part in commissioning the system was played by the personnel of the INMARSAT Coast Earth Station at Perth, Western Australia who guided the new users through the intricacies of the satellite system, supervised the early transmissions, traced problems – in general, they have been providing service of a very high calibre, and are one of the reasons for the success of the tidal data telemetry system.

The main reason however, is the ease of operation provided by the special communication software written for RAN by InterOcean which contains the EB NERA Standard-C command set. It has to be remembered that the RAN telemetry system, like the rest of their tidal equipment, is operated by personnel who are rotated frequently between these and other duties. The simplicity and reliability of operation is thus paramount to avoid the need for constant retraining.

So far, RAN has been using the INMARSAT-C telemetry for almost three years, and are pleased with the results. Sometimes, a garbled file is received, but a retransmission of it four hours later usually solves the problem. The transmissions go through Perth Coast Earth Station as a rule, but Singapore has been used on occasions. During trials, the data were telemetered from tide gauges deployed in north Australian waters not only to the ships and the Hydrographic Office, then in Sydney, but also to InterOcean headquarters in San Diego, California without any difficulties.

The equipment has been improved and modified during the last three years. The first change was the batteries in the buoys and shore stations – from the original 12V to 24V. It was found that the voltage drop during transmission was frequently so large with 12V batteries as to cause the station shutdown or nonsensical data being transmitted in very large files. Conversion to 24V cured this completely. The buoys now have a software facility for testing acoustic telemetry immediately before deployment, and are also provided with an external connection for battery charging, thus dispensing with the need for dismantling the central cylinder between deployments for this purpose. The only equipment in the INMARSAT-C telemetry system that occasionally breaks down are the antennas; they are still not as rugged as RAN would like.

During the three years of operation, RAN suffered some equipment losses, however no loss or damage could be traced back to the equipment failure. While malfunctions of acoustic releases have been reported, these have been usually caused by either operator's error or external factors not connected with the equipment. Some of the losses and damage have been caused by the fishing boats, some by other shipping. In addition, RAN Hydrographic Service operates frequently in the areas where any equipment left unattended, in or out of water, is liable to be pilfered, so this reason for the losses cannot be discounted.

4. CONCLUSION

In summary, the introduction of the InterOcean tide gauges, current meters and ancillary equipment together with INMARSAT-C telemetering of tidal data has been a success for the RAN Hydrographic Service. The new system performs as it was designed to do: it released the ships from the onerous duty of frequent visits to collect data from tide gauges, it allows the Tidal Section to check and control remotely the performance of the gauges from their office in Wollongong, and it is providing a large volume of high quality tidal data for analysis and sounding reduction as and when required. The system has been proven reliable, with low maintenance and operational costs.

The RAN tidal data acquisition system is in constant use. Hydrographic Service RAN is currently surveying the previously uncharted waters off Northern Australia, and accurate tidal data provided by the new system plays a vital role in these operations. In some locations, effective operations would be impractical without data acquired remotely from the tide gauges. In addition, the data obtained through the new tide gauges and current meters give RAN Tidal Section a better understanding of tidal processes in the areas which had insufficient information until now.

In general, RAN Hydrographic Service is satisfied with their tidal equipment, and is not only replacing the lost instruments, but also purchasing additional 10 S4 tide gauges to increase their tidal data gathering capability.

The new equipment is intended mostly for the support of LADS operations which developed into a very successful system providing high quality hydrographic data, but also requiring much more tidal support that originally envisaged. Additional gauges will be supplied to the survey ships for their operations, and some will be kept for the opportunity deployments, by RAN or other ships and organisations.