Introducing you to satellite operated Data Collection Platforms (DCP's)

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INTRODUCTION

The telemetering of information over long distances from unattended environmental monitoring equipment at remote sites can be difficult to carry out using conventional high frequency radio communication. This is because of the need to change frequencies to suit the time of day, because of the many forms of interference and because the appropriate radio frequency spectrum is usually very congested.

A popular means of telemetry over land has been to set up a series of "line-of-sight" *repeaters* and operate in the VHF, UHF or microwave bands.

By using a *satellite* as a repeater, large distances over land and sea can be covered with a single repeater in the sky. Trans-continental links for communication purposes have been operational for many years using this form of repeater. However, satellites able to handle reports from data collection platform (DCP's) have hitherto only been experimental. Within the next two years the operational phase for this type of activity will have been reached. This means that users can depend on the method for continuity of service, which is not guaranteed in an experimental system.

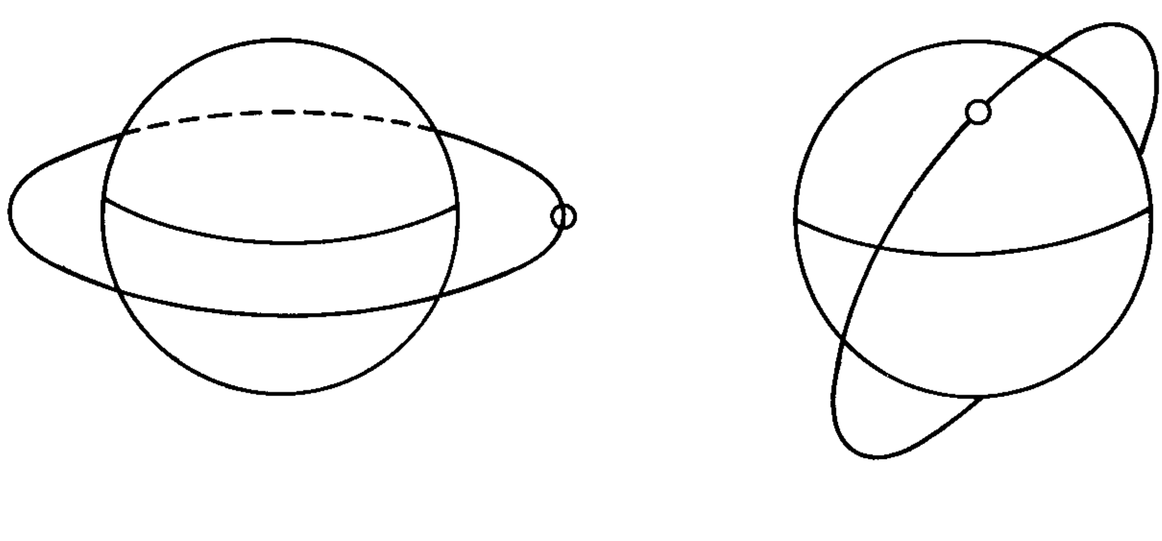

Fig 1 (A) *Geosynchronous equatorial orbit*
(B) *Near-polar orbit*

SYSTEM TYPES

Two types of operational satellites are presently envisaged for supporting environmental data collection platforms, namely :

1. *Geostationary satellites*

   These are satellites in an equatorial geosynchronous orbit as shown in Fig 1A. This means they remain in a fixed position relative to the earth's surface.

   The International Data Collection System (IDCS) comprises 5 geostationary satellites : SMS-2, GOES-1, METEOSAT, GOMS and GMS. Coverage of these satellites is shown in Fig 2.

   Geostationary satellites have the advantage that they are omni present, but their limitations are :

   - Line of sight limited to about Latitude 70° north and south of the equator.

   - At high latitudes the satellite can be obscured from the ground station due to nearby mountains in the line of site.

   - Having an altitude of some 36 000 km requires a ground station with either a powerful transmitter (say 50 watts) and omni directional antenna, or a lower power transmitter (say 5 watts) used with highly directional antenna. The former would be used mainly on a moving platform, such as a slip or buoy.

   - Position fixing and velocity determination of a moving DCP is not possible.

2. *Polar Orbiting Satellites*

   These satellites are in near-polar orbits as shown in Fig 1B. Their orbits are generally at a much lower altitude than for geostationary spacecraft.

   The ARGOS Data Collection and Location System will be carried by the following polar orbiting satellites: TIROS-N and NOAA-A to G.

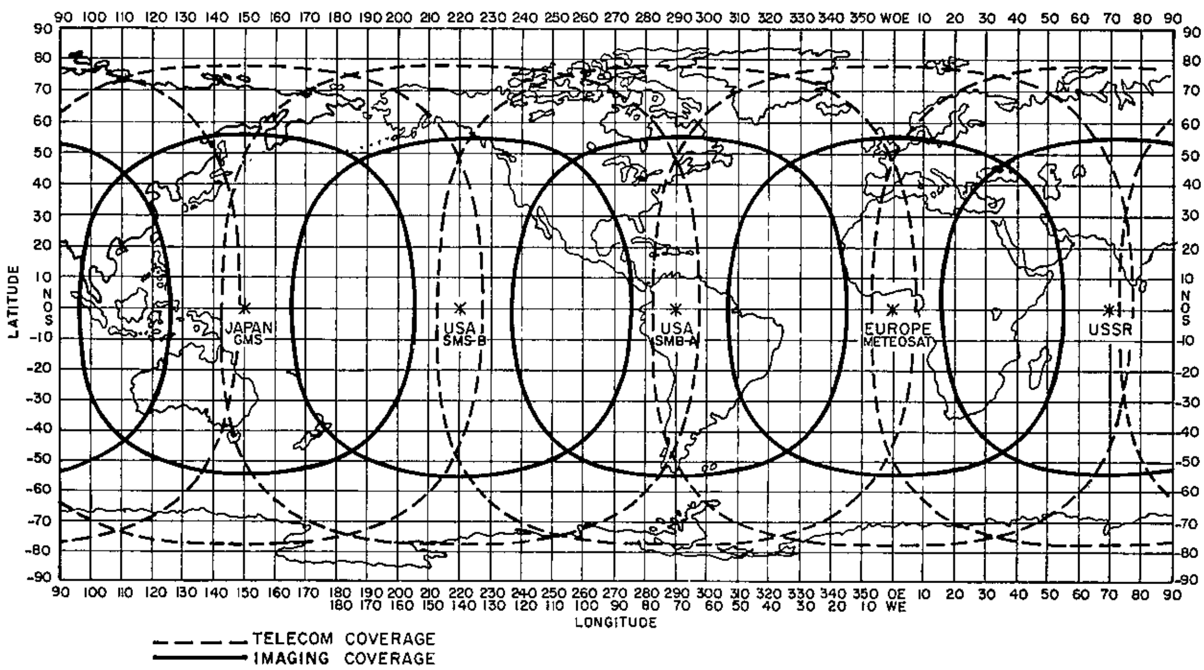

Fig 2.*The covering of IDCS satellites. Telecommunication coverage is shown by the dashed lines around each satellite position*

Polar orbiting satellites have the disadvantage that they are only within radio sight of the DCP during limited periods and that unless DCP reports are locally received there is an added delay between data acquisition by the satellite and dumping at an appropriate receiving station. Their advantages are:

- Global coverage from one satellite.

- Having an altitude of less than 1 000 km, a low power transmitter with onmi antenna is adequate.

- Position is fixing and velocity determination of a moving platform is possible.

One can combine some of the advantages of both types of satellites by having the DCP send its data more regularly via a Geostationary satellite but get its occasional position location through use of a polar orbiting satellite.

MODES OF OPERATION

Satellites can be used to relay DCP messages in 3 modes of operation :

1. Transmission from DCP to satellite in a predetermined time-slot (one-way transmission);

2. Interrogation of the DCP via the satellite (from a ground station) in a time slot that may be varied (two-way transmission);

3. The "Alert" mode, where a channel is kept permanently open for receiving a DCP warning signal, which is then immediately relayed to a ground station. This type of activity is very costly as it involves a continuous watch and dedicated receivers.

In 1 above, the satellite may either store the information on tape for later transmission to a ground receiving station or relay the data immediately.

GEOSTATIONARY SATELLITES

Of the Geostationary satellites, METEOSAT (supplied by the European Space Agency) will be the most useful for data collection platforms operating from Southern Africa and the surrounding seas because it will be placed above the equator on Greenwich Meridian. It has a capability of being moved 20^{o} East or West but communication coverage will remain adequate.

METEOSAT is scheduled to be launched during the last quarter of 1977 and its main mission is to provide images of the earth's surface every half hour in three bands of electromagnetic radiation : the visible, the infrered transparency window and the infrered water vapour absorption band.

In addition it will offer DCP users 33 communication channels for international requirements and 29 channels for regional use. Each of these channels is capable of providing permanently (except during eclipses) the transmission of a data flow of 100 bits per second. The international channels are primarily for platforms that may move out of the area of one satellite into the area of another.

METEOSAT provides all 3 modes of DCP operation given above but contains no tape recorder for later transmission of data as it is geostationary.

It is important to note that DCP's transmitting according to preset timers will have to follow a rigid time schedule and that clocks do not need resetting over a period of months. Ideally, southern African METEOSAT DCP participation should be co-ordinated i.e. the use of self-timed DCP's all operating on the same frequency but using different time slots. This eases the financial constraints as only one receiver is involved.

Detailed information on types of DCP's, modes of transmission, application for entering the system, etc are available in the DCP users guide published by the European Space Agency. Copies are available from Cooperative Scientific Programmes, CSIR.

POLAR ORBIT SATELLITES

The ARGOS system on TIROS-N *et seq* is described here. This system is a random access system and it depends on the fact that DCP's will transmit short bursts of data every 40 to 200 seconds. Transmission is in a one-way (DCP to satellite) mode only.

Since there will be a slight spread in frequencies and since transmission bursts are short compared with repetition rate, it has been possible to design a system capable of handling thousands of platforms distributed over the whole globe.

Acquisition of data is on a probability basis and varies with repetition rates, latitude, etc.

The aim is to have two satellites operational at any one time so that each spot on the earth is covered 4 times per day. Data acquisition can of course be many more times than this. For moving or drifting platforms accuracy of position fixing will be 3 to 5 km RMS and speed 0,5 to 1,5 m/s.

Transmission rate is 400 bits per second and each platform is permitted to transmit 4 to 32 eight bit data words in one burst.

The satellite stores this data for dumping later at the designated receiving ground station for further processing and distribution.

Detailed information is available from the ARGOS user's Technical Information Document and permission for admission to the ARGOS system may be addressed to the Cooperative Scientific Programmes, CSIR.

SOUTH AFRICAN PARTICIPATION

In order not to compete with normal communication networks, it is important to note that only data classed as environmental data may be passed through these satellites. The user is also responsible for meeting the national and international requirements of frequency allocation and licensing of his transmitters.

It is highly desirable that potential users in South Africa should channel their requirements through the Cooperative Scientific Programmes, CSIR.

EXPERIMENTAL SATELLITES SUPPORTING DCP'S AND REAL TIME TRANSMISSIONS

Nine countries are participating in the use of the three low orbit NASA satellites (LANDSAT 1, LANDSAT 2 and NIMBUS 6) for data collection from small, remote platforms. In addition to data relay, the advanced system on NIMBUS 6 locates moving platforms on buoys drifting in ocean currents and on ice floes, and on balloons circling the earth. Various other satellites such as USA's NIMBUS 3 and France's EOLE have supported DCP's in the past.

NIMBUS 6 and LANDSAT use random access data acquisition systems, but whereas NIMBUS 6 stores data for dumping at the next telemetry ground station, LANDSAT retransmits immediately so that the DCP and ground receiving station must both be in view of the satellite at the same time. The ground station owner also then has to do all the sorting out of finding his DCP data amongst whatever is transmitted.

Note that the ARGOS system also features a VHF beacon transmitting real time data at a low rate. Similar limitations as for LANDSAT will apply.

OPERATIONAL SATELLITES

The National Environmental Satellite Service (NESS) of the US National Oceanic and Atmospheric Administration (NOAA) operates the multi-satellite Geostationary Operational Environmental Satellite (GOES) System, which is "operational" in the sense that users can depend on it for continuity of service. The geostationary orbit of GOES provides full time service, unlike the lower orbit systems that provide intermittent service. However, the platform needed for GOES requires a more complex, and hence more expensive transmitter and antenna system.

EXISTING DCP'S (GLOBAL)

A NASA sponsored study has revealed that there are about 250 000 in-situ monitoring platforms which do not relay their data through satellites. The number of these platforms likely to be converted to use satellite DCP's will depend on the continued cooperation of the nations engaged in spacecraft development in order to guarantee the continuity of satellite service, and on the further development of low cost platforms.

ANTICIPATED COSTS

Platforms can be constructed by any agency or manufacturer. However, they must be certified by the appropriate space agency to be sure that they will operate properly within the whole system.

There are already a number of DCP manufacturers in the market and prices may vary considerably. Care needs to be exercised to be sure that price has not been traded for reliability. The hardware figures below are given without special certification. The Weather Bureau has for instance developed a meteorological sensor package and data logger costing about R5 000 which can be attached to a DCP.

In cases where data is automatically fed into a world network there may be a requirement by the particular agency (such as WMO) for calibration of the sensor concerned.

A guide to costs are as follows :

METEOSAT

Self timed low power DCP with directional Antenna		$ 7 000
Self timed high power DCP with omni Antenna		10 000
Interrogated and/or Alert	add	5 000
Stabilised platform for ship use	add	7 000
Sensor and power extra		

No charges will be levied for handling DCP data and messages except under certain specified conditions such as when special software has to be integrated for converting numbers to physical quantities or if telephone or telex has to be used. (See p 39 of user's guide.)

ARGOS

Low power DCP with omni Antenna	$ 2 000
Sensors and power supply extra	

No charges will be levied for handling DCP data in raw form except for costs of transmitting data to user.

Converting 4 x 8 bit words to physical quantities	$ 3
Position fixing of platform	17

Further details may be obtained from the "Users cost document".

NOTE: During the First GARP Global Experiment (FGGE) the French Meteorological Agency will underwrite the data conversion and position fixing costs for those users who are contributing data to the FGGE programme.

GOES/LANDSAT

The information below may be of some value in indicating the kind of sensors that are possible, as well as their cost.

One company offers a complete sensor package with alternate transmitters so as to be able to work to either LANDSAT or the GOES geostationary satellite.

Data collection platform

-	CDCP with LANDSAT Antenna	$ 4 200
-	Power Pack (includes 20-amp Battery, Solar Panel and Interconnect Cables)	395
-	CDCP Test Set (recommend one Test Set per Six DCP's)	1 500

Sensors

-	Snow Pillow	$ 1 227 *f*
-	Borehole Tiltmeter (includes Tiltmeter, Interface Electronics, Internal Battery and Solar Panel)	4 635 +
-	Event Counter Seismograph	4 666
-	Sea Current Speed/Direction	3 443
-	Sea Level Wave Height	5 110
-	Wind Speed Direction	1 022
-	Air Temperature	366
-	Water Temperature	322
-	Soil Temperature	322
-	Snow Temperature	322
-	Air Humidity	833
-	Water Level Sensor	1 020
-	Water Velocity Sensor	1 162

f One time charge of $4 914 required for signal conditioner.
\+ One time charge of $6 042 required for signal conditioner.

NOTE : All other measurements combined require $27 996 for signal conditioning.

-	Pyronometer	$ 894
-	Filter, FM Demodulator, Decoder Engineering/ Verification Testing	20 000
-	Recommended Spares for 15 above	23 612
-	Documentation for 15 above	16 000

Various other sensors are being evaluated for use with the CDCP. These include but are not restricted to :

- Rain Gauge
- Dew Point
- Barometric Pressure
- Water Quality (dissolved oxygen, turbidity, conductivity)
- Soil Conductance

CONCLUSION

The value of DCP's has already been demonstrated in agriculture, forestry, meteorology, oceanology, flood control and hydro-electric power generation, wild life sciences, environmental assessment, and in the collection of synoptic data for studying the means to predict earthquakes. Large networks of in-situ monitoring sensors are required for better resource management and environmental control. Satellites offer the best and lowest cost means to relay data from many of the widely scattered sensors to central locations where the data are processed.