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HYDROLOGIC APPLICATIONS OF THE TIROS-N ARGOS DATA COLLECTION SYSTEM

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HYDROLOGIC APPLICATIONS OF THE TIROS-N ARGOS DATA COLLECTION SYSTEM

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INTRODUCTION

The Landsat data collection system has been used to relay hydrologic data in North America beginning in 1972 when Landsat-1 was launched. This project demonstrated that satellite data relay was an effective means of obtaining near real time data for water management purposes. More recently, the GOES data collection system has also been used for hydrologic data relay, but, since the GOES system presents some problems in rugged terrain or high latitudes, potential users are awaiting the Argos data collection system.

This paper compares the satellite data collection systems that are now in use or that will be in use by 1978, discusses some of the hydrologic sensors that have been used, and describes some applications of hydrologic data.

As hydrological applications seldom require position determination, this capability of the Argos system is not discussed.

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DATA COLLECTION SYSTEMS

Satellite data collection systems consist of three elements: a satellite-carried transponder, a small transmitter known as a data collection platform (DCP) and a data reception and distribution system. Various aspects of these elements can be compared for the four data collection systems that are now, or soon will be available. These systems are summarized in Table one.

Landsat

The system carried by the near-polar orbiting Landsat spacecraft was the one that, despite earlier experiments with other spacecraft, "sold" the hydrologic community on satellite data collection. Landsat permitted 64 bits of data from any remote location in North America to be retransmitted to a user on a near real time basis. The DCPs used with the Landsat system proved to be inexpensive, reliable and easy to install.

After the system had been in operation for awhile and user expectations increased as users became less awestruck, it was realized that there were three deficiencies in the Landsat system.

1. The fixed message length of 64 bits was inefficient for persons requiring less than that quantity of data in each message and posed problems for persons who wanted more data.
2. In mid-latitudes data were retransmitted only 3 to 5 times each day in the morning and the evening. (For northern Canada, use of the Alaska receive site enabled transmission of messages up to 11 times each day with only the after-midnight period missing.) This incomplete temporal coverage posed problems for some hydrologic applications.

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3. Despite its many excellent qualities, NASA considered that the Landsat system was experimental. Since the implication was that the service could be discontinued users were reluctant to proceed with large capital expenditures for DCPs.

The first deficiency was overcome by developing shift register memories for the DCPs. Data were stored in memory at intervals then transmitted from memory 64 bits at a time. Each time the DCP transmitted (every 90 or 180 s) a new set of data was transmitted.

Use of the memory also eased the problem with the second deficiency as it then became possible to obtain data for an entire day. However not all the data were transmitted in real time so a problem still remained.

The third deficiency remains unsolved although NASA will allow users to carry out experiments on a "quasi-operational" basis and the future of Landsat seems assured, at least for the next few years.

GOES

Unlike Landsat the GOES system is a fully operational system. As the satellite is in geostationary orbit messages can be transmitted at any time during the day although, in practise, a three hour (or occasionally a one hour) time interval is used. The spacecraft can also interrogate specially designed DCPs. The GOES system can also handle messages that vary in length.

Two weaknesses of the GOES system are:

1. Although temporal coverage is good, the spacecraft can only service 2/3 of a hemisphere. As the DCP antenna must be aimed at the spacecraft, in high latitude areas this can present problems. This is especially true in hydrologic applications as, most often, the site of interest is in the bottom of a river valley.
2. As the GOES DCPs require an accurate temperature compensated crystal oscillator (TCXO), this means that the DCPs are more expensive than those used in random access systems. Initiating operation of a GOES DCP is also a little more difficult than starting a random access DCP.

These weaknesses cannot be resolved but implementation of the European, Soviet and Japanese versions of the GOES spacecraft will provide coverage in all except high latitude areas. Also, the impact of the accurate TCXO on DCP prices is becoming less significant.

Commercial Satellites

In 1977 Comsat General Corporation, the US Geological Survey and Telesat Canada will conduct an experiment which calls for the use of the Anik satellite to retransmit data from 15 specially designed DCPs. An operational system based on commercial communications satellites is attractive since there is an enormous capacity now in orbit - hundreds of thousands of DCPs could be handled. Also the system could operate on a random access basis.

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Tiros-N Argos

The Argos data collection system carried by Tiros-N and subsequent satellites should meet many requirements for hydrologic data relay since it is an operational system and can transmit messages of varying lengths on a random access basis. At mid-latitudes the two-satellite configuration will provide data at intervals shorter than every three hours. Therefore the problems associated with using GOES (or other geostationary satellites) at high latitudes will be overcome quite nicely.

Assuming that the Argos system performs as expected, there are only two considerations that could prevent its widespread use in retransmitting data from hydrologic sensors located in mid to high latitudes.

1. The data distribution system must be capable of providing data on a real time basis. This could be accomplished using the vhf beacon or perhaps through user operation of a passive receive station that can handle the satellite's normal downlink frequency.
2. In the long term, system capacity may be reached if a large number of position location DCPs were operated in coastal areas. This would be less of a problem in North America than in other locations.

HYDROLOGIC SENSORS

The hydrologic parameter that is usually required for transmittal by satellite is water level. Aside from the intrinsic value of the water level data, this information is also used in the computation of river flows.

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Water levels are sensed by a float operating in a stilling well or by a pressure sensor that measures the hydrostatic pressure over a fixed point in the streambed - this pressure being proportional to water level. Water levels are usually encoded in parallel digital BCD format for transmittal.

Several other parameters have also been retransmitted by satellite. These are other streamflow related parameters, water quality parameters and meteorological parameters. Some examples are as follows:

Water velocities are sensed by acoustic velocity meters which measure the difference in travel time of acoustic signals transmitted on a diagonal path through a river. The velocity data are encoded as parallel digital BCD digits or as a 0 to 5 V analogue signal.

Water quality data such as water temperature, pH, specific conductance and dissolved oxygen are monitored by permanently installed sensors. The output signals are analogue voltages, generally in millivolt ranges. These signals must be amplified before connecting to a DCP.

Meteorological data such as precipitation, air temperature, wind speed, wind direction and relative humidity have been transmitted using a variety of sensors. Sensor outputs have been serial or parallel digital, and analogue voltages.

A common factor in all hydrologic sensors is that sensor outputs are easy to interface with DCPs and that the rate at which data are gathered is sufficiently slow that transmissions from a memory equipped DCP can be used to produce a complete record for a site.

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APPLICATIONS OF HYDROLOGIC DATA

Hydrologic data may be grouped in three categories, that is, historic data, real time data and forecast data.

Historic data are data that have on immediate use. Much of the routinely collected hydrologic data falls into this category. Such data tend to be used to produce statistics on long term trends, means, extreme values and so forth. This information has a multitude of users, for example, design of hydraulic structures and water licensing. Some experiments have been conducted with the use of satellites for collection of historical data thus eliminating the need for on-site recorders.

Real time data refers to data that have an immediate use such as operation of a dam or diversion canal. Satellite data collection systems have been widely used in North America for collection of such data.

Forecast data are data that are collected in near real time and used to forecast hydrologic events. Streamflow data can be used to produce water supply or flood forecasts. Or, as another example, meteorological and other data may be used to produce a forest fire hazard index. Satellite data relay has also been used to provide forecast data.

The Tiros-N Argos System should be able to provide sufficient data for any hydrologic application, at least in mid to high latitudes. In equatorial areas the GOES system would be preferable.

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CONCLUSIONS

Comparison of the Argos data collection system with other systems indicates that Argos should be able to overcome many of the drawbacks of the present systems. This, of course, will have to be demonstrated to the satisfaction of the potential users of the Argos system.

Hydrologic sensors that can be easily interfaced to data collection platforms are readily available. The use of such sensors has been amply demonstrated through other satellite data collection systems.

It has been said that people can get too much of almost anything except data, and hydrologic data is no exception. The Argos system will assist greatly in meeting hydrologic data needs.

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TABLE 1 - INTERCOMPARISON OF DATA RELAY SATELLITES

	LANDSAT	GOES	TIROS-N et seq.	COMMUNICATIONS
OPERATOR	USA-NASA	USA-WWW	USA/FRANCE - WWW	COMSAT CORP/DOMESTIC
STATUS	EXPERIMENTAL	OPERATIONAL	OPERATIONAL	DEMONSTRATION/OPERATIONAL
ORBIT	NEAR POLAR	GEOSTATIONARY	NEAR POLAR	GEOSTATIONARY
SATELLITES	TWO	TWO PLUS SPARE	TWO IN ORBIT	SEVERAL
GROUNDSTATIONS	SEVERAL	SEVERAL	SEVERAL	SEVERAL
NO. OF DCPs IN VIEW	1000	20 000	2000	300 000
TYPE OF TRANSMISSIONS	RANDOM SELF-TIMED	INTERROGATE, ORDERED SELF-TIMED	SELF-TIMED	SELF-TIMED
NUMBER OF TIMES	3 or 4 + PER DAY	ON DEMAND OR 3 TO 6 HRS	6 or 8 + PER DAY	EVERY 15 MIN. OR AS REQUIRED
DATA RATE	2400 BAUD	100 BAUD	400 BAUD	1200 BAUD
MESSAGE LENGTH	64 BITS	UP TO 2000	32 TO 256	64 BITS
FREQUENCY	401.55 MHZ	401.7 to 402 MHZ	401.65 ± 0.002 MHZ	5.925 to 6.425 GHZ
DATA INPUTS	PARALLEL DIGITAL, SERIAL DIGITAL, ANALOGUE	PARALLEL DIGITAL, SERIAL DIGITAL, ANALOGUE	PARALLEL DIGITAL, SERIAL DIGITAL, ANALOGUE	PARALLEL DIGITAL, ANALOGUE