A GLOBAL ENVIRONMENTAL DATA DISTRIBUTION SYSTEM

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ABSTRACT

This paper describes a global environmental data distribution system (GEDDS) which uses a single small satellite operating in a low polar orbit. The satellite collects environmental data from remotely located instrumentation platforms and distributes it to research laboratories and other interested organizations virtually anywhere in the world. A command link also allows principal investigators to control and calibrate platform instruments on a daily basis directly from their laboratory or office.

INTRODUCTION

A pressing need exists for a high capacity, real time communication system which can collect and distribute environmental data derived from instrumentation platforms located in difficult-to-access regions of the world. Ocean- and polar-based platforms are of particular importance. These platforms, which include surface buoys for meteorological measurements and moorings and drifters for physical and bio-optical measurements, are all being used at present. Because of the high cost to deploy and recover these platforms they are left untended, collecting and recording data for many months before the data are retrieved. With the growing worldwide concerns about damage to the environment, a significant increase in the number of platforms is inevitable during the next decade. The ability to retrieve data and control operation of the platforms on a daily basis would be invaluable to environmental researchers and to government agencies responsible for monitoring the environment.

Real time data from in situ sensors is important in calibrating data received from satellite-based imaging sensors. With billions of dollars planned for remote sensing satellites during the next decade, the need for real time in situ calibration data becomes increasingly acute.

For some applications a need exists to dynamically adjust the throughput as a function of specific events. For example, seismic instruments may be quiescent for long periods until an earthquake occurs; then the data throughput requirement increases manyfold for some period of time.

The system is capable of supporting acquisition of data from meteorological, oceanographic, geological and biological instruments. It also would telemeter data on air and water quality and from instruments which measure snow and water tables in wilderness areas. Availability of synoptic data from this broad range of scientific disciplines will greatly facilitate the development and maintenance of an ecological model of the earth. It should be very useful for investigation of possible global warming trends and for evaluating the effects of ozone layer depletion. It also can play an important role in assessing the global impact of environmental catastrophes such as the recent eruption of Mount Pinatubo in the Philippines.

SYSTEM CONCEPT

Sierracom has developed GEDDS, a concept we believe is an affordable solution to the needs expressed above. The system concept (Figure 1) consists of a transponder/processor package mounted on the environmental sensor platform and a satellite package consisting of collection and relay transponders and antennas plus a processor. The system is controlled by a ground-based system control center.

Figure 2 shows the orbital geometry for the system. The satellite travels in a nominal north-south orbit and completes approximately 14 revolutions per day. The satellite sequentially interrogates and reads out data from the sensor platform as it passes over. The received platform data are buffered, merged and transmitted through a Ku-band

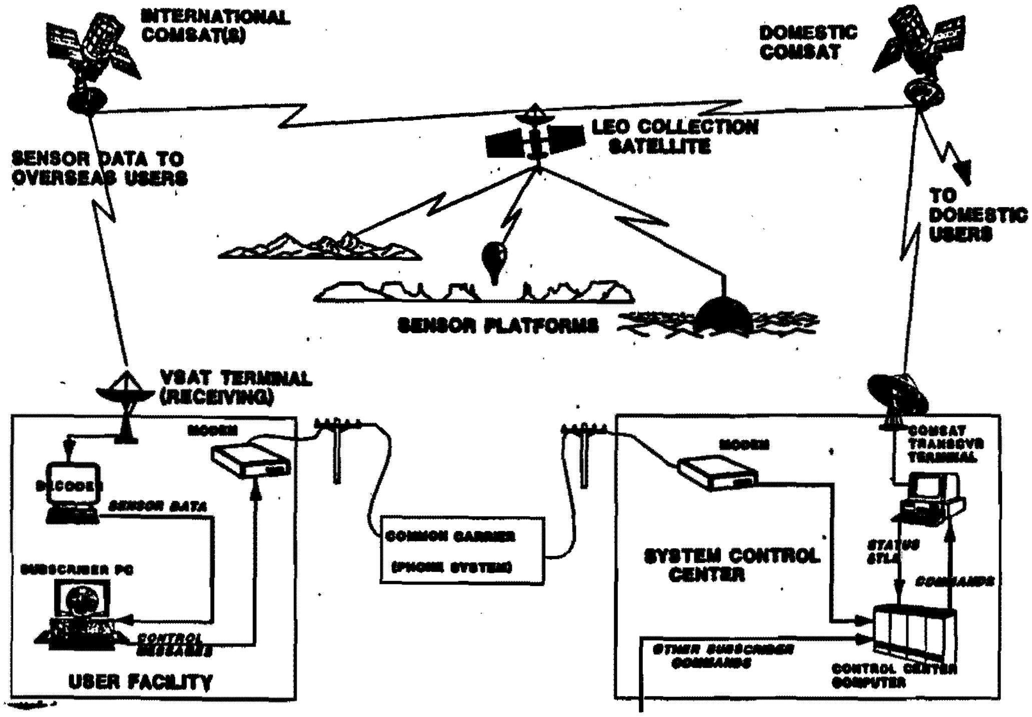


FIGURE 1. SYSTEM CONCEPT

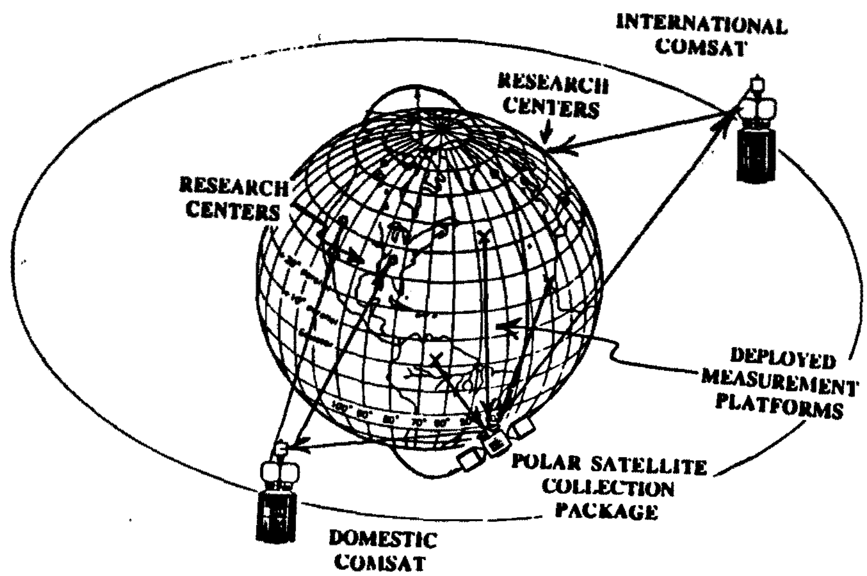


FIGURE 2. ORBITAL GEOMETRY

transmitter to a commercial comsat. The comsat rebroadcasts the integrated data to the system control center and the user community. The users access the signal using a standard small commercial Ku-band receiving terminal (VSAT). Note that each user theoretically has access to all of the data. Privacy, if required, can be achieved by encrypting platform data before it is transmitted to the collection satellite. Users not requiring near real time access can receive the data with some delay from the system control center through the telephone system.

The amount of data acquired from each platform depends on the length of time the platform transmitter is turned on. The satellite transmits an ID message as it passes over, which turns on the platform transmitter. Stored sensor data are then transmitted at a fixed 64 Kb/s rate for a preset time under control of the satellite processor. The readout time can be changed on the satellite by command from the satellite control center.

Requests for readout time changes and platform commands are initiated by the platform principal investigator. They are forwarded to the system control center via the telephone system. The control center analyzes the schedule change requests and develops an updated operational schedule which is transmitted via comsat to the satellite for storage and subsequent execution. The commands intended for the platforms are collected, merged and formatted. They are also relayed to the satellite where they are stored in the processor until the next access of the applicable platform. In addition, the control center develops required ephemeris and antenna pointing updates which are forwarded to the satellite.

GEDDS can collect and distribute in excess of 340 megabytes of data per day and can support more than 4,000 platforms (see Figure 3). It can collect from 8 to 800 kilobytes from each platform during a single access. A platform located at low latitudes can be accessed at least three times per day and platforms in the polar regions can be accessed up to 14 times daily. As previously stated, the amount of data collected during each access can be adjusted by command.

By contract, ARGOS, a satellite-based collection system developed in the mid-1970s and currently flown on the NOAA weather satellites, can only collect about 250 bytes per access. Also it has no command link for remote control of the platforms. Many of the existing platforms accumulate and store over 100 kilobytes daily, which is well beyond ARGOS capabilities.

As an option, GEDDS can provide precise location data using the Global Positioning System (GPS) to track drifting buoys and other moving platforms.

SENSOR PLATFORM PACKAGE

The sensor platform consists of a hemispherical coverage antenna, transponder, processor and sensor interface unit. The transponder receives the satellite signal and routes the demodulated digital data to the processor. The processor recognizes the platform address, turns on the transmitter and initiates transmission of sensor data stored since the previous access. It also decodes any received commands and routes them via the interface unit to the appropriate sensor package for execution. When the satellite signal disappears, the processor turns off the transmitter and resumes accumulating data for the next access. The sensor interface unit, in addition to routing commands, collects and formats sensor outputs for subsequent processing and storage by the processor.

Because the number of sensor platforms is large and deployment and recovery costs are high, reliability and cost are primary design drivers for the platform package. An untended operating life in excess of one year is reasonable. Low power consumption is also an important requirement. Solar power is not a viable alternative in the ocean and arctic environments so long-lived batteries have to carry the load.

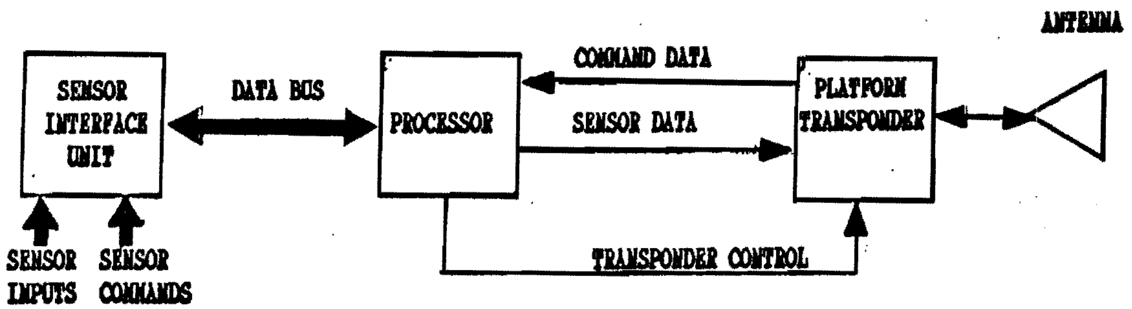
Characteristics of a baseline platform package are given in Figure 4. Operating frequencies in the vicinity of 1,500 MHz have been selected for the baseline platform-to-satellite link. The actual frequency band is not critical to the concept. Any allocated band from 400 MHz (ARGOS) to 2,500 MHz can be used. Within allocation constraints, the most important selection criteria is availability of proven low cost hardware.

SATELLITE PACKAGE

The satellite package consists of a collection

Parameter		Value
Daily available readout time	=	0.8 x 86,400 = 69,120 seconds
Readout rate	=	8 Kbytes/sec (64 Kbits/sec)
Acquisition time	=	6 seconds/access
Nominal readout time	=	10 seconds (example)
Number of available platform accesses/day	=	3 at 0 degree latitude 14 at > + 75 degree latitude
Nominal number of accesses/day	=	4,320 (based on 16 seconds/access)
Nominal platform throughput/day	=	240 Kbytes/day (3 x 80 K) (0 degree latitude) 1,120 Kbytes/day (14 x 80K) (> + 75 degree latitude)
Nominal total daily throughput	=	346 Mbytes/day (4,320 x 80 Kbytes)
Potential number of accesses/day	=	652 at 800 Kbytes/access to 11,520 at 8 Kbytes/access

FIGURE 3. GEDDS DAILY CAPACITY



Parameter	Value	Comments
Frequency band	1,500 Mhz*	Baseline
Modulation	Biphase	
Transmit data rate	64 Kb/s	
Transmit on time	1 to 100 secs	Commandable
Transmit power	5 watts	
Antenna gain	+2 dB	Hemispherical
Received data rate	2 Kb/s	
Receiver noise figure	3 dB	
Phase lock bandwidth	200 Hz	
Sensor inputs	TBD	
Analog		
Digital (RS232C)		
Discrete		
Sensor commands	TBD	
Digital		
Discrete		
Physical characteristics		
Weight	12 pounds	Excludes battery
Power	<10 watts, peak <10 mw, average	

*Any allocated band between 400 Mhz and 2,500 Mhz may be used.

FIGURE 4. SENSOR PLATFORM PACKAGE

antenna and transponder, a processor and a relay transponder and antenna. The collection antenna employs a fan beam which is steerable in discrete steps in the axis normal to the orbit plane. The collection transponder is essentially a mirror image of the platform transponder. It transmits address and command messages derived from the on-board processor and receives the sensor data from the platform transmitters.

The Ku-band relay transponder is functionally equivalent to a standard commercial duplex VSAT transponder. It receives and demodulates data forwarded by the system control center via geosynchronous comsat and it transmits the accumulated sensor data via the return path. The relay antenna is a 1.2 meter, two-axis steerable parabola. Pointing commands are received from the on-board processor. Figure 5 summarizes the baseline characteristics of the collection and relay transponders.

The processor accepts and stores ephemeris updates, daily operation schedules and platform commands. It outputs antenna pointing commands and platform address/command data at the specified times. It also sequentially receives, multiplexes, formats and buffers platform sensor data for subsequent relay to the users.

The platform hardware is conventional and uses concepts well proven in space. Estimated weight and power is 150 pounds and 75 watts. Selected redundancy will be used to achieve an operating life in excess of three years.

SYSTEM CONTROL CENTER

The system control center (Figure 6) is made up of standard commercially available equipment. It includes a standard Ku-band duplex VSAT, one or more work stations, a modem pool and a small telephone switchboard. It can be located anywhere in view of a commercial comsat, preferably at a government, university or other user facility where personnel and equipment can be shared to minimize operating costs.

CONCLUSIONS

An affordable concept has been described for a small satellite-compatible system to recover environmental data from in situ measurement platforms located in difficult-to-access parts of the world. No equivalent capability exists at present. It can provide a synoptic data base invaluable to researchers in developing a global ecological model. Improved long-term weather forecasting, earthquake prediction, pollution monitoring and calibration of space-based earth sensors are but a few of the potential benefits. It can be used in conjunction with GPS for location and tracking of drifting buoys and other moving platforms. It can also be used for emergency communications in difficult-to-access polar regions.

The system makes extensive use of existing commercial systems and equipment. All satellite requirements and equipment are based on proven technologies with extensive orbital experience. The projected cost of the system is an insignificant fraction of the published cost estimates for the planned NASA Earth Observation System (EOS). The capital investment for the system can be recovered over a period of time by operating it on a leased-service basis.

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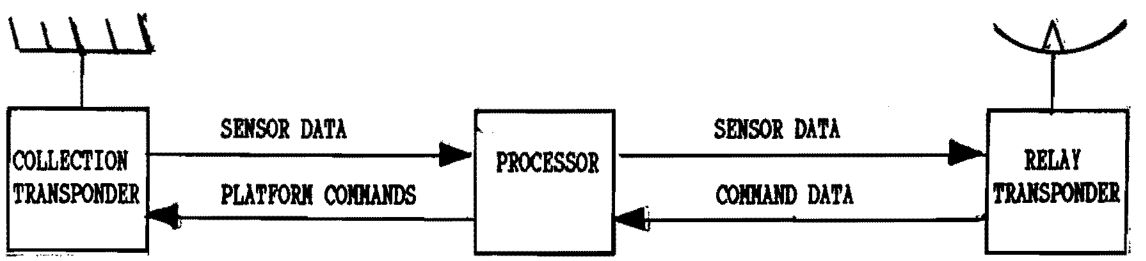

Parameter	Collection Transponder	Relay Transponder
Frequency band	1,500 Mhz*	14.25 Ghz transmit 12 Ghz receive
Modulation	Biphase	Biphase
Transmit data rate	2 Kb/s	64 Kb/s
Transmit power	5 watts	10 watts
Antenna gain (steerable)	17 dB 1-axis gimbal	42.5 dB 2-axis gimbal
Receive data rate	64 Kb/s	16 Kb/s
Receiver noise figure	3 dB	3 dB
Phase lock bandwidth	200 Hz	1,000 Hz

*Any allocated band between 400 Mhz and 2,500 Mhz may be used.

FIGURE 5. SATELLITE PACKAGE

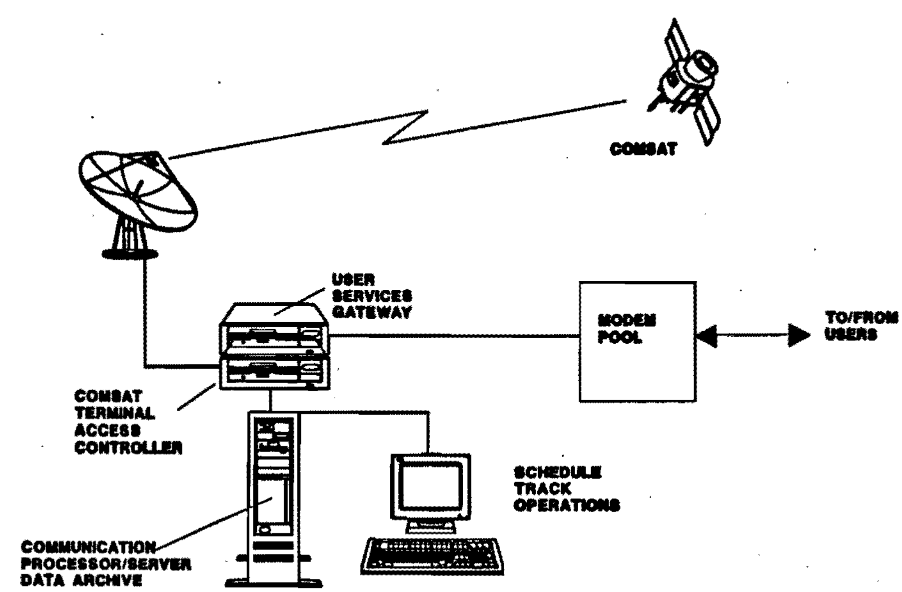

FIGURE 6. SYSTEM CONTROL CENTER