EXPERIMENTS USING A CONVERTIBLE DATA COLLECTION PLATFORM

U.S. GEOLOGICAL SURVEY

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ABSTRACT

Experiments under the sponsorship of the U.S. Geological Survey in the use of a convertible data collection platform (CDCP) were performed by 13 organizations. Success in its use was related directly to the resources applied by the experimenter. After design faults were corrected by the manufacturer, most of the problems encountered were associated with power supplies, sensor, and sensor interfaces. In general, the CDCP and the Geostationary Operational Environmental Satellite systems performed as specified. Based on the experience gained, the Bonneville Power Administration is embarking on an operational implementation of the system, and the other organizations are continuing experimental deployment.

BACKGROUND

Measurements of geophysical, environmental, hydrologic, and meteorologic parameters have long been a costly and sometimes difficult aspect of many research and operational activities of both the Government and private sectors. The expense of such data collection comes from the large number of sites where information is needed and the requirement for either on-site personnel or trips to collect recorded data. The instances where ground-based telemetry systems have been employed have shown them to be expensive and not very reliable. In addition, the wide geographic dispersion of the data collection points has made centralized data processing and analysis difficult. As many sources of information are located in remote areas, data have been lost due to equipment malfunctions between routine service calls.

In the late 1960's and early 1970's, the National Aeronautics and Space Administration (NASA) undertook the installation of satellite telemetry relay systems as a means of ameliorating these problems. The first of these systems was used to track and position balloons and buoys. Further experiments and improved technology led to the development of a data collection system specifically designed for relay of ground-based measurements. This was the Landsat (formerly called the Earth Resources Technology Satellite (ERTS)) system.

THE LANDSAT DATA COLLECTION SYSTEM (DCS)

The Landsat DCS was one of the first spacecraft telemetry systems designed specifically to collect data from a sensor system at the measurement site. Although initially justified as a system for collection of ground-based measurements needed for ground truth to accompany Landsat imagery, the system proved itself to be useful for the collection of information desirable for more conventional needs. Several design parameters which might have been satisfactory if the system had been used for its original intent, namely as an ancillary data-gathering device used in conjunction with imagery, were disadvantageous when the system was used only for in-situ data collection. Among these parameters was the requirement for mutuality in visibility between spacecraft and ground reception station and spacecraft and data collection platform (DCP). This requirement led to nonuniform collection times and nonsynoptic reporting. In addition, the DCP transmitted instantaneous data which was limited to eight coded sensor readings of eight bits each. Therefore, even if the system were operating perfectly, much data would be lost and reliance on recorded-type data would have to be retained (National Aeronautics and Space Administration, 1971).

In an effort to alleviate some of these problems, the U.S. Geological Survey (USGS) developed a memory device for use with the DCP. The device stored data on a first-in-first-out basis that were regularly entered during a several hour period. However, if the spacecraft was not in position to receive the transmission or if the transmission encountered interference, the data were lost. An additional problem prevented the Landsat DCS from being considered for operational use. Because NASA considered the spacecraft experimental, there was no guarantee that the satellite series would be continued. For this reason, few organizations were willing to invest in the capital equipment needed for operational use.

THE GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE (GOES) DCS

During the period that the Landsat data collection system experiment was being conducted, the National Oceanographic and Atmospheric Administration (NOAA) was developing a system of its own, designed to operate on a geosynchronous spacecraft. The advantages of geosynchronism alleviated many of the data collection problems associated with the Landsat system. Because the spacecraft was always in view of both the receiving station and the collection platform, the system could transmit at specific times. In addition, the availability of multiple frequency channels allowed a large capacity system (10,000 platform messages/6 hours) (Flanders, A.F., 1973). The GOES design also permitted longer messages which, in turn, required memory to play an important part in the data collection platform design. Another advantage of the system was its ability to interrogate platforms by command. Since this aspect is designed to be used for emergency

operations only, it is not further discussed. One other point important to note in this system is its operational nature. Multiple spacecraft in orbit provide for redundancy in case of failure, and because the system is operational and expected to continue for many years, capital costs can be amortized over a longer time. The additional feature of centralized data reception lends itself to centralized data processing, which in almost all instances is an advantage to a user of large amounts of data.

HISTORY OF THE CONVERTIBLE DATA COLLECTION PLATFORM (CDCP)

In an effort to aid in the policy decisions faced by DCS experimenters and potential users, the USGS undertook an engineering study to lessen the risk associated with which system to choose, Landsat or GOES. At the time the program was conceived, the Landsat DCS was a tried and proven system with an uncertain future and the GOES system was untested but had potential for a long-term operation and might better fit user needs. To reduce the risk associated with capital equipment investments for either system, the USGS issued a contract based on an unsolicited proposal to Ball Bros. Research Corporation,[1] Boulder, Colo. The contract was to design, develop, and manufacture a prototype data collection platform capable of operating with both the Landsat and GOES systems. This platform was the CDCP. The contract was successfully completed, and a prototype platform was delivered and tested by the USGS. Based on this experience, the USGS decided to go ahead with a large-scale deployment of this new platform.

A production contract, competitively won by LaBarge, Inc., Tulsa, Okla., was issued by the USGS, and as part of the contract the USGS procurred several platforms to be used for experiments. The production CDCP incorporated the results of experience gained from development of the Landsat DCP and included the innovation of microprocessor control.

THE LABARGE CDCP

The LaBarge CDCP consisted of the CDCP power system (user-supplied), a CDCP test set, transmitting antennas (GOES and Landsat), the CDCP unit, and user-supplied sensors and interface electronics, if needed. The CDCP is packaged in a sealed stainless steel cylindrical drum, 11.5 inches in diameter and 14.5 inches high, and includes pin

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[1]The use of manufacturer, brand, and firm names is for description only and does not constitute endorsement by the U.S. Geological Survey.

connectors on the top for sensor, power, test set, and antenna inputs. Each platform has the capacity for analog data utilizing two memory words of four bits each and digital data using four memory words. The platform stores a combination of analog and digital data in a memory as large as 208 words. Utilizing the microprocessor control, the CDCP can be programmed by means of the test set to accept analog data from as many as eight sensors or digital data from as many as four digital recorders, or a combination of analog and digital data. These data can be entered in multiples of 6-minute or 15-minute increments. As many as 255 increments can be stored in the buffer memory. The data can be transmitted at intervals ranging from 15 minutes to 63 hours and 45 minutes (255 increments, each 15 minutes long). The power supply required is 12-VDC $\pm$ 1.5-VDC.

THE CONVERTIBLE DATA COLLECTION PLATFORM EXPERIMENT

In March 1975, the USGS announced the availability of the LaBarge CDCP's for experimental use. This announcement was issued in order to expand the types and numbers of applications for use of the satellite telemetry technology. The only stipulation attached to the loan of the CDCP equipment was that the organization that received the CDCP's would have to furnish periodic progress reports and that the measurements telemetered through the system would be of geophysical, meteorological or environmental parameters.

Responses and inquiries regarding this announcement came from a broad spectrum of potential users, both in organizations which received the announcement directly and in organizations that had heard of the announcement through other sources. The background of the respondees ranged the entire gamut from previous Landsat DCS users to those with no experience in telemetry data collection. In addition, some requests were received from the Water Resources Division (WRD) of the USGS. After most of the WRD requests were satisfied, the following organizations were selected to receive the CDCP equipment for experimentation:

Organization	Application	Number of CDCP's
Michigan State University	Pesticide Application Management	3
National Park Service	Water Quality and Meteorology	4
University of Chile	Hydrometeorology	3
USGS EROS Data Center	Hydrometeorology	4
USGS-WRD, Glaciology Project	Glaciology	2

USGS Geologic Division, Office of Earthquake Studies	Earthquake Research	7
Water and Power Resources Service	Hydrometeorology	3
Bonneville Power Administration	Hydrometeorology	5
USDA-Forest Service Firescope Program	Forest Fire Meteorology	2
Chevron Oil Field Research Corporation	Oceanography-Oil Well Platform	1
University of Alaska	Volcano Monitoring	2
Ohio River Valley Water Sanitation Commission	Environmental Hydrology	2
USGS Geologic Division, Branch of Theoretical and Applied Geophysics	Magentic Observatories	2

Decision criteria for selecting the above experimenters included not only application but geographic location. The USGS-WRD acted as the primary interface with NOAA for establishing time allocations within the dedicated GOES channels which were assigned. In addition, The USGS agreed to use its computer to provide data communication so that some of the experimenters could get their data back. Most non-USGS users and almost all non-U.S. Government users made their own arrangements for receipt of data from NOAA.

Since CDCP's are basically radio transmitters, Federal Communications Commission licences were required in order to operate them. All Department of the Interior users obtained their licences via the Departmental Office of Telecommunications. Similar procedures were used by other U.S. Governmental users. Non-Government users had to make application directly to the FCC, and this caused some lengthy delays during the experiment startup phase.

A series of training sessions, beginning in November 1975, were held by LaBarge for users of their platforms. These sessions were held at the LaBarge plant in Tulsa, Okla. and at other locations throughout the country. The training program was necessary in order to provide insight into the unique interfacing and power requirements of the platform and to provide demonstrations of the programming of the platform's microprocessor. Programming to accommodate timing

requirements and interface formats is accomplished by means of the LaBarge test set, an item of hardware separate from the platform. At least one test set was sent to each user.

Manufacturing delays caused late delivery of the platforms to the users. In several instances, platforms arrived at their destination at a time either too late to accomplish the experimental objective during that particular year or at a time when adverse weather and logistics precluded immediate installation.

Many users of the platforms experienced difficulties during the checkout phase. In some instances, problems were caused by faulty components, and in other instances design faults were found. These difficulties necessitated return of the platforms to the manufacturer for reworking, and the users experienced further delays in their plans for experimentation.

The delays led to cancellation or premature termination of several experiments due to loss of funds or shifts of personnel.

SUMMARY OF EXPERIMENTAL RESULTS

Thirteen of the fifteen organizations that received platforms experimented with them. Two platforms were not tested, primarily because personnel changed or budgets were restricted between the time the proposal for experiment was approved and the time when the platforms were received.

One experiment, conducted by Chevron Oil Field Research Corporation, cannot as yet be classified as to successfulness since the platform is still in a laboratory bench-test due to delays caused by personnel shifts. Nine experiments can all be considered successful to some degree. Although no formal reports from the Bolivian experiment have been received, correspondence indicates that it was successful. The Bonneville Power Administration is the only experimenter to complete the experiment phase and consider the system operational, although the Water and Power Resources Services and the University of Chile experiments may be considered to be almost in the same category. Since most of the experiments were not conducted at permanent installation sites, it is difficult to determine what the term operational means in this context. If experimental success is determined by a conversion to an operational mode, only one experiment meets this criterion. However, if usefulness of the system to accomplish a specific task is the criterion, then most of the experiments can be considered successful.

Three experiments were failures, but for different reasons. The USGS magnetic observatory experiment is in this category because the platform did not meet the technical requirements for data collection of this type. The Ohio River Valley Sanitary Commission experiment failed because the system did not operate for a sufficient time to either prove or disprove its usefulness. The University of Alaska volcano monitoring experiment failed because the harsh environment of the active volcano's atmosphere corroded the equipment and made it unusable.

Similar technical problems faced most of the investigators and it is the belief of this author that an effective working group to share experiences of the various organizations might have reduced somewhat the efforts required by individuals. An interagency working group has since been established to overcome this problem at the Federal level and to publish a newsletter for public distribution.

Once the technical problems with the CDCP components supplied by LaBarge were solved and repairs made (a lengthy process), almost all problems experienced by investigators were in the sensor or power-supplies. Sensor technology and requirements are so broad they almost prohibit standard sensor packages, but an effort should be made in the future to provide for more flexibility in the CDCP input interface. With respect to power supplies, consideration should be given to developing a reliable source of portable power. This may even be a family of power sources (for example, wind, solar, battery) to accommodate various environmental conditions. It probably would also make engineering sense to provide the power supply as part of the CDCP package as a user option, thus eliminating one major problem. The following sections provide synopses of the experimental results.

RESULTS OF EXPERIMENTS

Michigan State University

The purpose of the experiment was to obtain near real-time soil temperature data in order to understand pest insect development rates and thereby know when to apply pesticides.

Platforms were deployed in three locations: East Lansing, Gull Lake and Cass City, Mich. Thermisters were used to measure soil temperature at five depths ranging from the surface to 6 inches below the surface. The data were collected every 30 minutes. The climatic environment included temperature ranges of from -15°F to +90°F, 20- to 25-inches of annual precipitation, and winds up to 30 miles per hour.

Problems developed in the sensor interface equipment when the duration of the drain on the 12-volt supply to the external electronics exceeded 70 seconds prior to instrumentation polling. If allowed to continue, the power drain would have amounted to two to three times that available for the platform. This problem was corrected by installation of a 60-second power delay in each of the external interface electronic assemblies.

Two of the three LaBarge platforms failed during the test. These were repaired by the manufacturer. In addition, two of the gel cell batteries failed and were replaced by the manufacturer.

The CDCP was extremely useful in evaluating an on-line pest management system. The incorporation of the CDCP in the system provided a unique data collection capability.

National Park Service

The National Park Service conducts research and environmental monitoring as an aid in the planning and managing of relatively undisturbed land under their jurisdiction. Many of the Nation's parks, although quite large and in some instances quite isolated, are nevertheless affected by man. In an effort to understand these affects, the Park Service employs monitoring systems. The remoteness of many of the monitored sites influenced the decision by the Park Service to test the CDCP/GOES system as a means of obtaining real-time information to aid in their management decisions.

The Park Service experiment was divided into four phases. Phase I had the following objectives:

1) Establish feasibility of a portable continuous monitoring station;
2) Meet a 60-day or greater maintenance cycle requirement;
3) Provide near real-time capabilities;
4) Provide dependable values; and
5) Simplicity.

To accomplish Phase I, four CDCP's, each with two multisensor packages, were deployed in the Great Smokey Mountains National Park. The first package was a water quality monitor package that measured dissolved oxygen, hydrogen ion concentration, oxidation reduction potential, temperature and conductivity. The second package was a meteorological package that measured wind direction and speed, temperature, dew point, surface pressure and cumulative precipitation. In addition, the CDCP's contained a power-source monitoring sensor.

The operational experience with the system, to date, indicates that with the exception of vandalism and several other problems associated with vandalism, the majority of problems were caused by failures in the sensor/interface packages and the power supplies. The data obtained are comparable to data manually sampled at the site although the experimenters are hestitant to conclude that this will be true over the long-term. System reliability cannot be predicted due to the short time of operation, but it is felt that downtime could be significantly reduced if a complete parts inventory were maintained.

Based upon the results of Phase I, the following assessments of the original objectives were made:

1) It is feasible to employ these portable continuous water quality and atmospheric monitoring stations;
2) These units meet the 60-day or greater maintenance cycle;
3) These units provide near real-time (every 3 hours) data response capabilities;
4) Values are comparable to field survey data collected using standard methods; and
5) The units are not as simple to operate and maintain as had been hoped; however, if sufficient spare components are stocked, service and maintenance delays will be minimized.

Thus, the Phase I objectives (acquisition, calibration, testing, and positioning) were sufficiently met.

University of Chile

This experiment was unique in several ways. It utilized the Landsat spacecraft DCS. The University of Chile modified an existing STADAN tracking and receiving site, originally built by NASA, to receive and process the DCS data. Finally, the program grew into a multiuse, multipurpose system.

The purpose of the experiment was to demonstrate the use of spaceborne data relay to the Government agencies and industrial concerns of Chile. The three sites chosen for the initial demonstration were the:

1) El Yeso Dam;
2) Rapel Dam; and
3) Navy Mole, Valparaiso.

The El Yeso Dam is located about 90 miles southeast of Santiago in the Andes Mountains. The Dam is at about 10,000 feet above sealevel in an area with a severe winter climate. The purpose of the experiment was to determine the amount of snow melt which feeds the impoundment and is utilized for agricultural irrigation. A sensor measured wind

speed, air temperature, humidity, snow temperature and solar radiation. The station operated successfully for 4 months before being moved to the Eschaurren Glacier, several kilometers away.

The second site was the Rapel Dam, a large hydroelectric generating plant. At the last report, this station operated for 7 months without problems. The parameters measured were river stage, air temperature, humidity, wind speed and solar radiation.

Finally, the third site was at the Navy Mole in Valparaiso. This station also operated for 7 months without problems, according to the last report. The sensors at the station were designed to measure coastal meteorological data such as sea level, water temperature, air temperature, air pressure and wind speed. The only problems encountered were those associated with the sensor interface during the startup phase.

Because the results from the experiment were so successful, the Chileans procurred 12 additional platforms of which 3 are operating in the Antarctic Palmer Peninsula (Araya, 1978). The experimenters are now shifting to the GOES system for areas beyond the range of their receiving stations.

USGS/EROS Data Center (EDC)

The purpose of the EROS Data Center experiments were twofold. One was to test the CDCP in a typical hydrometeorological installation but in a severe climate such as that found in the upper Great Plains region. The second was to use the sites in conjunction with training conducted by the Applications Assistance Branch of EDC.

Of the four CDCP units that EDC had, one was in a backup and the other three were placed in sites at the Redfield James Valley Research and Extension Center at Redfield, on the James River near Huron, and at the Sioux Falls airport observation well, all in South Dakota. The CDCP at the Redfield site collected air and soil temperatures as well as precipitation data. The CDCP at the James River site measured river stage, and the Sioux Falls site measured water table depth. Instruments utilized were a Fisher Porter rain gauge and Frontier electronic thermometer, which measures ambient air temperature and soil temperature at six depths ranging from 2 to 72 inches. At Huron and Sioux Falls, standard digital stage recorders provided the input to the CDCP. Data at the Redfield and Huron sites were updated every 15 minutes and transmitted every 3 hours, whereas data from Sioux Falls were collected hourly and transmitted every 3 hours.

The Redfield CDCP was initially installed below ground in order to maintain a platform temperature above 20°F, but water seepage into the installation damaged the interface and led to a shutdown in May 1978, after 6 months of operation. As a result, the platform is now installed

above ground in a double-insulated enclosure. All three platforms experienced the extreme temperature variations typical of the climate. Interface problems were encountered with the Redfield CDCP, which required contractor repair, but no interface problems were experienced with the platforms at the other sites. All four CDCP's experienced mechanical/electronic problems which required return of the CDCP's to LaBarge for correction. Two of the platforms were be returned twice. The average turnaround time for the LaBarge repairs was 3 months.

Operational delays occurred in the NOAA data transfer interface during the startup phase but were solved.

In general, the experiments indicate that the systems were useful when operational. The data provided valuable information for South Dakota agriculture and demonstrated spacecraft technology to the agricultural community. The Sioux Falls CDCP also provided valuable information concerning water table decline during summer drought periods.

USGS-WRD Glaciology Project

The intent of the glaciology application of spaceborne telemetry was to measure and transmit meteorologic, stream-flow, and subglacial water-pressure data. These data required eight analog channels, which were updated every 15 minutes. The CDCP's were located at the South Cascade Glacier research station in the North Cascade Mountains of Washington State. Because environmental conditions were severe, installation and checkout could only be accomplished during the summer months.

Successful preliminary tests were conducted during the summer of 1978. During these tests wind speed, direction, and atmospheric pressure were relayed.

During these tests two problems were encountered which caused delays in the implementation of the full experiment. The first problem was a large voltage drop due to the length of the supply cables which ran from the station battery bank to the platform. The second problem was that the platform design did not provide adequate signal ground isolation and, therefore, required more interface electronics than were originally planned. Both problems are solvable and the solution is being implemented.

USGS Office of Earthquake Studies

The experiment of the Office of Earthquake Studies was a continuation of experiments conducted on the use of spacecraft data relay under the Landsat program. The purpose of the experiment was to continuously monitor surface deformation in remote areas. Of the seven CDCP's loaned to the experimenters, three were used for spares. The other four were distributed as follows:

1) Middleton Island - Gulf of Alaska;
2) Cape Yakataga - South Central Alaska;
3) Yakutat - South Central Alaska; and
4) Fig Tree Valley - Anza Borrego Desert, Calif.

This was the only United States experiment conducted under the CDCP program to use the Landsat spacecraft DCS.

The sensor utilized in the experiment was a two-component shallow borehole tiltmeter which measured surface tilt associated with surface deformation near active faults. This tilt was transformed into changes in voltages on a pair of orthogonal sensing electrodes placed on the lens surface of a finely tuned bubble level. The output was converted from a 0 to $\pm$8VDC to a 0 to +5VDC input to be compatible with the CDCP.

Because the experiment used the Landsat spacecraft as the relay, the transmissions were relayed about 4-5 times/day with 4-5 data points received per successful transmission. The Alaskan stations experienced moderate temperatures and heavy rainfall due to the temperate nature of the Alaskan coast. The California site experienced very high summertime temperatures, 125°F, and little or no rainfall.

Power-supply problems were the only ones which contributed to station downtime. Measurement accuracy was not as good as expected. This lack of accuracy was due to the compression of the analog value range needed to match the CDCP interface. This problem has solutions, one of which is to shift to a digital output sensor.

Generally, the experiment was considered successful and, in fact, data could not have been obtained from the Gulf of Alaska site with any other equipment on a cost-effective basis.

Water and Power Resources Service

The U.S. Department of the Interior, Water and Power Resources Service, carried the CDCP experiment technologically further than any other experimenter in this program. There are many reasons for this; however, the three main reasons were experience, resources, and need. The Service has had a great deal of experience utilizing the CDCP and was one of the principal investigators utilizing the Landsat DCP. This experience has been carried forward to the CDCP/GOES system. The Service has an experienced engineering team and able contractor support, both of which were needed to carry out the goals of the experiment. Finally, real-time meteorological data from remote areas was genuinely needed in order to carry out the Service's objectives.

The experiment in which the CDCP's were employed was the Sierra Cooperative Pilot Project (SCPP) and the subexperiment which directly utilized the CDCP was the development, installation and testing of the Automated Environmental Surface Observation Platform (AESOP). The sponsor for these experiments was the Service's "Project Skywater". This project is the Service's precipitation management research program, which is designed to determine the feasibility of weather modification to meet the demands of the Nation for clean water. The project is concerned with developing socially acceptable technologies for enhancing snowfall in the mountains and rainfall during the growing season.

The AESOP was conceived when it became apparent that the standard meteorological reporting network was extremely sparse in most Project Skywater sites. The AESOP was meant to supplement the normal NOAA and Federal Aviation Administration reporting stations and to emulate manned meteorological stations in every way possible; that is, real-time reporting of hourly measurements of the same parameters using similar methods in making those measurements. The AESOP was originally designed for summertime application as part of the High Plains Cooperative Program (Price, G.R. and Scheetz, V.R., 1977), but with the advent of the SCPP it was decided to test the AESOP in the severe wintertime Sierra environment.

The AESOP is composed of the CDCP and transmitting antennas, data sensors, power source and interface electronics. The sensors are very high precision devices that measure wind speed and direction, temperature, humidity, air pressure, and precipitation. Three complete sets of hourly data are held in the memory of the platform, and the oldest data set is purged each hour as new data are added. The entire contents of the memory is transmitted hourly, so that each hour the present data and those from the previous 2 hours are transmitted. The AESOP power supply is standard 120-VAC, plus standard battery backup and optional solar cells. The interface circuitry was designed to provide data using averaging intervals and formatting to conform to standards of the Federal Meteorological Handbook of Surface Observations and the design manual for NOAA's Remote Automation Meteorological Observation Station.

The three sites for the AESOP's were at Sunflower Hill, Onion Creek and Mosquito Ridge, all in the Sierra Nevada in the American River Basin in California. Because the snowpack can be very deep, two of the AESOP's were placed on 20-foot towers and one on a 10-foot tower. Statistics show that 1 year in 10, even the 20-foot tower would be under snow.

Data from the AESOP's correlated well with those from manned observations. Occasional power outages were related to a recently developed solar power supply. Processed data was sent by NOAA directly to the Water and Power Resources Service Offices in Denver and the SCPP Offices via conventional high-speed data lines.

The AESOP's have generally proven to be valuable tools to the field director and forecasters during the SCPP field season by providing real-time information on the surface meteorology, including precipitation, in the test area. Real-time decisions based on these data can now be made. It is planned to add as many as five more AESOP's to support the SCPP.

Department of Energy, Bonneville Power Administration

The Bonneville Power Administration experiment was unique in that it was keyed to the potential use of the CDCP/GOES system for a routine operational activity, namely the collection of hydrologic and meteorologic hydromet data.

The Columbia River Treaty with Canada and a memorandum of understanding between U.S. Government agencies led to the requirement that the Bonneville Power Administration (BPA) establish a hydromet network in the Pacific Northwest. The program for the installation and operation of this network was to be accomplished in four phases with Phase I starting in 1969. By 1976, three of the four phases were complete, and the stations in operation utilized microwave or VHF radio relay to transmit the data. In studying the phase IV implementation, it was determined that 9 of the 12 proposed sites did not have reliable VHF paths to nearby BPA microwave links. Alternative communications systems were evaluated including meteorburst, but the cost was prohibitive. It was at this time that BPA proposed the experiment to test the CDCP/GOES system for this purpose.

The five CDCP's that were used in the experiment were located as follows: One unit was used as a spare and another unit placed on the roof of the BPA building in Portland, Oreg. to be used as a test and demonstration unit; one unit was placed at Summit, Mont. and another at Ukiah, Oreg. Both of these sites experience extremely cold wintertime temperatures. The last unit was placed at McNary Substation, Oreg. in an area that experiences very high summertime temperatures. All platforms were delivered, and the last one at McNary Substation was activated in November 1976. The only meteorological parameter measured was rainfall, although measurements of battery voltage, cabinet or shelter temperature, and a reference voltage were made and transmitted. Data were collected every 15 minutes and were transmitted every 3 hours. The data link from NOAA returning to BPA was via telephone dialup, and although some difficulties with this link were experienced at first, they disappeared as new and updated equipment was brought on line at NOAA. During the experiment, four of the platforms were returned to the manufacturer for repair - three for design modifications and one because a crystal oscillator was faulty.

Temperature and performance correlations were performed, and it was observed that when the temperature fell below 5°F, the crystal oscillator caused the carrier frequency to drift. This was corrected by adjustments. High temperature had no significant effect on the system.

During the test, the data returned averaged 92 percent and during the final 4 months of the experiment was 96 percent. All problems associated with return messages not received were determined to be due to either the sensor interface or the NOAA/BPA data stream.

Based upon the experience gained in the experiment, BPA has proposed to implement phase IV of their hydromet system using the GOES system. To aid in accomplishing this, the USGS transferred the title of the experimental platforms to the BPA (Bonneville Power Adminstration, 1978).

USDA Forest Service Firescope Project

The purpose of the experiment was to test the feasibility of using CDCP's in a network of meteorological stations in the Firescope area of Southern California to provide data input to a computer simulation of wildland fire spread.

Two platforms were located in San Bernardino Mountains of southern California. The environmental conditions were typical of temperate mountainous terrain. Air temperature, relative humidity, and wind speed/direction data were relayed at 3-hour intervals.

Several weeks after installation, the platforms experienced a timing problem which was corrected by the manufacturer. A faulty solar panel regulator caused excessive battery drain. This problem was corrected. There were some problems which resulted in readout descriptions such as "unexpected message received" or "expected message not received". The experimenters believe this to be an anomaly in the data link not associated directly with the CDCP. The special signal conditioning unit which was used to interface the sensors with the CDCP failed, and USDA is currently contracting for an improved version.

The test and experiment ran from July 1975 to April 1976 and was considered to be successful and useful.

Chevron Oil Field Research Corporation

The object of the experiment was to monitor wave heights measured from an offshore oil platform. The experiment is similar to one conducted successfully using the Landsat system. Personnel shifts and platform alterations have caused delays to the point that as of this writing the platform is still in the laboratory checkout phase. However, experience based on Landsat DCP's suggests that the experiment should be successful if brought to completion.

University of Alaska

The purpose of the experiment was to monitor atmospheric pressure and temperature, as well as soil temperature, on an active volcano in Alaska. Although the CDCP and sensor package were tested in the laboratory and were apparently working upon installation, no messages were received via the GOES spacecraft. The experimenters were unable to visit the site on Mount Wrangell for 5 months. Upon revisit it was discovered that the harsh chemical atmosphere had virtually destroyed the installation, making further experimentation impossible.

Ohio River Valley Water Sanitation Commission (Orsanco)

This experiment was intended to relay water quality parameters via the GOES satellite to the Orsanco Office in Cincinnati, Ohio. The experiment was largely unsuccessful.

The primary problem encountered with the LaBarge CDCP's was their inability to properly store bits in the transmit interval memory. A clock in the CDCP controls an output pulse at precise 6- or 15-minute intervals. (15-minute pulses were used in this application.) These output pulses are stored in a memory counter. When a specified number is attained, the function (transmit cycle) occurs and the memory is zeroed. The problem that occurred was that extraneous bits (more than one per 15-minute interval) entered the memory advancing the cycle by an additional 15 minutes. There was no way for the computer to check a reference value and reset or shut down, or even determine that its time cycle was incorrect. After several phone conversations with LaBarge engineers, both CDCP's used in the experiment were returned to LaBarge for modifications. The CDCP's were returned twice, but the modifications failed to correct the problem. The result of the malfunction was that one or more of the 15-minute transmission periods were early, interferred with other transmissions, and sounded alarms at the receiving station during each transmission. Also, no usable data were obtainable after a failure. The system usually failed less than 2 weeks after each startup.

Only one unit was field tested after its return from LaBarge. Neither unit experienced problems under laboratory conditions, leading to a conclusion that stray electromagnetic interference (EMI) might be a cause of the problem.

The computer interface for the return link of the data was never used because of these transmission problems.

Because of this experience and a change in personnel, ORSANCO decided to terminate the experiment.

USGS Geologic Division, Branch of Theoretical and Applied Geophysics

The purpose of the experiment was to relay data on the Earth's magnetic field. The sensors to be employed were magnetometers. After a technical evaluation, it was decided that the resolution and frequency of sampling of the relay system was not adequate. Therefore, it was decided that the only potential use of the CDCP would be for gathering housekeeping data. This use is currently under consideration.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDIES

Based upon the success of the experiments conducted under this program, it can be concluded that the convertible data collection platform can play a significant role in obtaining data from remote areas. As no future spacecraft of the Landsat series will have a DCS, the CDCP should be modified to eliminate those portions associated with the Landsat DCS, thus eliminating complexity and reducing costs. More attention should be given to flexibility in the input to data collection platforms to accommodate a larger variety of sensors without the need for elaborate interface electronics. A significant effort should be made to develop a more reliable family of power supplies. The technology of satellite data relay should be promoted in order to bring in new users and develop new applications. More effective coordination is required among users of these systems to prevent duplication of problem solving effort. Finally, additional effort should be devoted to providing:

- Adequate technical support to operate the equipment;
- Additional training for maintenance and installation personnel; and
- Improved maintenance and repair of equipment.

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