DATA RELAY SYSTEM SPECIFICATIONS FOR ERTS IMAGE INTERPRETATION 1/

by

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INTRODUCTION

Experiments with the Data Collection System (DCS) of the Earth Resources Technology Satellites (ERTS) have been developed to stress ERTS applications in the Earth Resources Observation Systems (EROS) Program. To date (December, 1970), the active pursuit of this policy has resulted in the design of eight specific experiments requiring a total of 98 DCS ground-data platforms. Of these eight experiments, six are intended to make use of DCS data as an aid in image interpretation, while two make use of the capability to relay data from remote locations. Preliminary discussions regarding additional experiments indicate a need for at least 150 DCS platforms within the EROS Program for ERTS experimentation. Results from the experiments will be used to assess the DCS suitability for satellites providing on-line, real-time, data relay capability.

The rationale of the total DCS network of ground platforms and the relationship of each experiment to that rationale will be discussed herein. Technical details of the DCS capability (Daniel, 1970) will not be discussed.

DESIGN GOALS

One of the key elements in determining ERTS performance requirements was, and is, the capability of satellite sensors to monitor change in terrestrial features. Changes occur in important features

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of all disciplines which will make use of ERTS data, but the time-frame of change varies from a few minutes or hours for water features to geologic time for some land features. The concept of time-rate-of-change is also important to the DCS. Ground data planned for relay in each of the experiments are applicable to one or more of several goals tentatively grouped into two broad categories of Interpretation Aids and Real Time Uses.

INTERPRETATION AIDS

Ground-sensed parameters which fulfill goals basically categorized as Interpretation Aids, are those which furnish quantitative information regarding:

1. Conditions within an image or image set (solar radiation, air temperature, wind, etc.).
2. Changes in successive images (water levels, precipitation, etc.).
3. Image features (areal extension of point-collected water quality data).
4. Applicability of images to the problem or experiment (water levels are high, low, median, etc.).

Categories 1 and 4 require the collection of background data concurrent with imagery in order to fully satisfy requests for imagery representing specific climatic or hydrologic conditions.

All four of these categories have application to image interpretation whether there is a functioning DCS or not. A report on Apollo 9 photography (Powell and others, 1970) is an example of the use of ground data to help interpret imagery. All hydrologic data within the photographed area for the time of overflight, as well as all historical data for the area, were used to formulate a conceptual working model of the geohydrologic system in that area. This will be a typical and significant use of all ERTS-A data, but it can be done within a leisurely paced time-frame. When interpretation of the imagery must proceed in real time, the DCS is required in order to shorten the data collection process. Additionally, a conceptual or mathematical model of the system being studied must already be in existence. The criteria for experiments with the DCS related to interpretation are: (1) relayed parameters must relate to one or more of the four stated categories; (2) a working model of the image area must be in existence; and (3) interpretation must be done in near real time (hours or a very few days).

REAL-TIME USES

The other advantages of the DCS, which include ground-sensed parameters useable in real time, are:

1. Ground sensors may be located where they cannot be physically reached in a reasonable time frame (mountainous or estuarine environments).
2. Data may be used by management units for operational decision-making (hydroelectric power development, municipal water supplies, etc.).
3. Data are the basis for standing requests for imagery collection and/or precision processing for specific climatic or hydrologic conditions (ERTS data management).
4. Ground sensors are useful in determining proper exposure or probability of successful exposure of satellite sensors (net or total radiation in ERTS spectral bands; oceanic turbidity near shore for effect on bottom detail).

The last reason specifically relates to satellite sensor management of which little may be done with ERTS-A (excluding tape recorder usage). However, experimentation with these sensors on ERTS-A will allow development of techniques for managing forthcoming operational satellites.

These uses are intrinsically time-related and hence require a real-time data relay system. The sole criterion for experiments with the DCS related to real-time uses is that the DCS be an economic method of data collection at the present time.

In "real world" considerations from a manager's point of view, very few management uses of data can be satisfied with the once-every-12 hour capability of ERTS-A for data collection. Most users will eventually require an on-line capability. Therefore, the performance of the DCS in all the experiments will be used to determine the effectiveness and applicability of an ERTS relay system to the economic alternative of a series of orbiting satellites, geosynchronous satellites, or combination of the two. Each of these alternatives would supply an on-line data relay capability.

PLANNED EXPERIMENTS

There are, to date, eight planned DCS experiments for ERTS, each of which satisfies one or more of the design goals. These experiments represent the major disciplines of hydrology, geology, and geography and will be discussed in the order of listing in Table 1.

DELAWARE RIVER BASIN

This experiment is essentially a microcosm of the entire DCS rationale. The primary purpose is to obtain near real-time data from water-quality monitors and water-level monitors in the basin, to correlate the values with near real-time imagery (as obtained), and to use this information in the management decision processes of the Delaware River Basin Commission. Data from the platforms will also be used in the interim of image overflights as input to management decisions. The experiment will focus primarily on the following questions: Is bulk processed imagery satisfactory for management purposes or is precision-processed imagery required? What logistical problems arise in supplying either type of imagery in real time? How are decisions modified with real-time imagery and real-time data? Therefore, the experiment will add two dimensions to current operations: 1) The dimension of near real-time (12 hours), and 2) the areal extension of point-collected water-quality data.

REGIONAL ECOLOGICAL TEST SITES

Central Arizona, South Dakota, and Lake Ontario (numbers 2-4 in Table 1) are regional test sites for ERTS that will have a few platforms for image interpretation purposes. Because there will be intensive ground truth collection programs at these sites during image orbits, there is a need to be able to assess the ground conditions prior to the overflight. Using data relayed from key sites in the test area, a decision can be made regarding whether conditions warrant a large, manned effort in the area during image overflights. Therefore, the investment of a small amount of money in platforms has a potential benefit of saving several times that amount in unnecessary ground truth collection as well as providing ground truth at key locations.

SAN JUAN MOUNTAINS

The DCS will provide near real-time data in this mountainous Colorado region for use in assessing the efficiency of the atmospherics research being conducted there. Climate extremes will provide a good operational test of the DCS platforms in a hostile environment as well as providing more up-to-date data than are presently available. Image analysis will also be aided in assessing snow moisture conditions on an areal basis.

VOLCANO MONITORING

Experiments 6 and 7 will both be conducted on volcanoes in the Cascade Range in Washington, and in Central America, but in general these experiments will not be using the same platforms. One set of platforms will be located at optimum sites for measuring the number of seismic events and tilt, while the other set will be located at optimum sites for measuring subsurface temperature. These two experiments will utilize the capability of the DCS to relay data from remote locations with the short-term goal of adding to the knowledge of eruptive processes and the long-term goal of eruption prediction at these and other volcanoes.

HOUSTON

The Geographic Applications Program will relay data from eight platforms in the Houston, Texas area for two primary purposes. The first is to provide an intensively instrumented solar radiation test site to determine methods of image processing to reflect atmospheric attenuation conditions. Results from this site will be used to develop methods of extrapolating solar radiation data from a single monitor to larger areas. Successful experimentation would have the impact that recorded solar radiation data from several agencies' ongoing programs (e.g. the National Weather Service's network of ground stations) could be used for image processing control in many other parts of the country. The second purpose is to develop criteria for management of satellite sensors in order to operate those sensors only under acceptable conditions as indicated by real-time solar radiation data.

RELATIONSHIP TO AIRCRAFT PROGRAM

For several of the experiments relating to image interpretation, aircraft imagery in the ERTS spectral bands is required in order to finalize the local DCS networks. As aircraft data are obtained, the local networks of ground sensors (in some cases these number in the hundreds) will be analyzed to determine which types of sensors and how many of each type are desirable for DCS instrumentation. After this preliminary analysis, the final choice of sites will be made. During the actual experiments, aircraft flights are needed at some sites during ERTS image overflights for integrated ground, air and space data collection. Therefore, many of these experiments will be included in the aircraft program.

SUMMARY

The EROS Program plans experiments with the DCS requiring 98 ground platforms but indications are that this number will shortly be increased to 150. Uses of the DCS can be basically categorized as interpretation aids or as near-real time data collection. Although only the Delaware River basin experiment embraces nearly all of the possible reasons for using the DCS, each of the remaining experiments relates in a particular manner to the total rationale.

REFERENCES CITED

Daniel, J. F., 1970, Satellite (ERTS-A) network of ground data sensors: A user-oriented experiment: National Symposium on Data and Instrumentation for Water Quality Management, Univ. of Wisconsin, July 1970. Preprint No. 29, 12p.

Powell, W. J., Copeland, C. W., and Drahouzal, J. A., 1970, Delineation of linear features and application to reservoir engineering using Apollo 9 multispectral photography: Alabama Geological Survey Information Series 41, 37p.

Table 1. -- EROS DCS Networks For ERTS Experimentation

Experiment Location	Discipline	Purpose	Parameters	Number of Platforms
1. Delaware River Basin, Pennsylvania, New Jersey	Hydrology	Water Management	Water Quality Stream Stage Reservoir Stage Ground-Water Stage	20 ERTS-A
2. Central Arizona	Hydrology	Arid Hydrology	Precipitation Solar Radiation Air Temperature	2 ERTS-A 4 ERTS-B 6 Total
3. South Dakota	Hydrology	Snow and Ice, Shallow Aquifers	Ground-Water Stage Air Temperature Solar Radiation	2 ERTS-A 4 ERTS-B 6 Total
4. Lake Ontario, New York, Canada	Hydrology	Prototype Ocean, Circulation	Water Quality Current Velocity and Direction Solar Radiation	2 ERTS-A 4 ERTS-B 6 Total
5. San Juan Mountains, Colorado	Hydrology	Atmospherics Modification	Precipitation Snow (water equivalent) Wind Stream Stage Rime Ice	12 ERTS-A
6. Cascade Range, Washington, Central America	Geology	Volcano Monitoring	Seismic Events Tilt	10 ERTS-A 20 ERTS-B 30 Total
7. Cascade Range Washington, Central America	Geology	Volcano Monitoring	Temperature	5 ERTS-A 5 ERTS-B 10 Total
8. Houston, Texas	Geography	Image Evaluation	Solar Radiation	8 ERTS-A
				98 Total