A "BIG PICTURE" FOR RESOURCE MANAGEMENT
A VIEW OF EARTH FROM SPACE

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It is indeed an honor to visit with you here in Las Cruces and to participate in the 17th Annual New Mexico Water Conference. The importance of water can hardly be overemphasized as this conference bears witness. Man's endeavors in the development of water resources have been exciting events in the history of technology. The irrigation system of the Sumerians, dating from 4000 B.C., and the aqueducts of Rome at the start of the Christian Era were early milestones in a quest that today reaches for water from the sky and for water from the sea.

And still another phase is beginning with a new vantage point provided in the search for resources. The new vantage point is provided by a view of the Earth from Space. I would like to spend a few minutes this morning describing the NASA Earth Observations Program. This program, while perhaps less dramatic than the lunar landings, represents a major attempt by NASA to bring space technology to bear on earth problems and to provide new data sources to those responsible for management of earth resources.

Let us look now at man's management of his resources and environment. His activities have changed the environment in the past and will continue to do so for the foreseeable future. The results of these efforts are mixed; some ways man has managed his resources have been serious failures while others seem good. We have only to recall the creation of the dust bowl of the 1930's as an example of a serious failure. Many changes appear good, at least for the present. The conversion of forests to farmland in both the United States and in Europe, and the reclamation of land from the sea as carried out by the Dutch appear to be useful environmental modifications without bad side-effects. However, the time over which we judge success is short and history may render a different verdict.

The technology of our age, however, has added a new dimension--the power to make larger and faster changes to our environment than ever before. The changes we initiate could conceivably tip natural systems beyond the capacity of the natural control mechanisms. The point I would like to draw from all this is the following:

As our ability to perturb our environment expands so must our ability be extended to monitor the environment and to predict the consequences of our actions upon it.

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Now gathering information upon which to base resource development or environmental decisions is certainly nothing new. Whether we are talking about a search for gold with a pick and a pack mule, a search for water with a willow twig, or a search for oil with an airborne magnetometer, the approach is the same -- you take some sensing device, place it in or near some part of the earth and make an observation. What the Earth Observations program is attempting is simply an extension of coverage and an extension of sensitivity.

Let me deal with coverage. That is, how much of the earth can we survey with a given technique? A man standing on the ground can examine only a few square yards at a time. The well-developed techniques of standard aerial photography can provide images which include a square mile in a single frame. Certainly this is some improvement, but it takes a lot of such photos to cover New Mexico. Suppose we utilize high altitude aircraft, however. Now, typically an area 14 miles on a side can be surveyed -- or about 200 square miles in a single frame. With such a technique a statewide survey in a few days is quite feasible. Let us, however, go higher still and view the earth from a spacecraft. Now a scene some 100 miles on a side can be captured -- 10,000 square miles on a single exposure. At last we have the basis for rapid surveys at a regional or national level.

Now you will say, "This is all very well, but you can't see as much from so high up." Yes - and - No. If we gathered, over an area of 10,000 square miles, all the data which could be seen by the man on the ground, the mass of data would be indigestible. Low level sampling is always possible for spot checks anyway. What is added by the high level coverage is the broad or synoptic view in which features, unsuspected from close view, are often detected.

A good example of this was noted during the Gemini program. A photograph, which I will show you presently, was obtained over Lake Titicaca on the border between Bolivia and Peru. This photo showed a huge volcano not identified on the most recent map. It showed also a shoreline shape quite different from the maps. This example points out how surface observations alone can be incomplete. Another point which can be made is that remote locations and high mountains are no obstacle to observation by satellite.

Next let us consider sensitivity. Our eyes and conventional films are sensitive only to the narrow "visible" portion of the electromagnetic spectrum. Many important characteristics of the earth are not revealed by the way in which the surface reflects sunlight which is all that our eye or the camera sees. For example, the temperature of a body determines the emission of energy in the infrared. By sensing at wavelengths of 8-14 microns one can, with a knowledge of its emissive properties, determine the temperature of the surface being observed. Another class of information can be obtained in the microwave region. This can be done either by sensing natural emissions or by irradiating the scene purposely as with radar.

For a number of years now effort has been applied to developing sensors to detect emissions in these various wavelengths. In addition to sensors operating at specific wavelengths, such as the infrared, another class of sensor has been developed to detect emissions simultaneously in many wavelengths. These devices are termed multispectral sensors. Such devices and high altitude platforms or satellites provide the basic technology for remote observations of the earth with wide coverage and with unprecedented sensitivity.

Now the first step in utilizing this new technology was to determine just what could be sensed by the various instruments. For several years the Manned Spacecraft Center was involved with numerous University and Government scientists in exploring this basic question. Let me cite two examples in the area of hydrology:

1. Shallow ground water aquifers in glacial drift affect the local surface temperature distribution. The cool areas associated with such aquifers could be located by sensing in the thermal infrared (8-14 microns).
2. Vigorous plant growth reflects strongly in the near infrared (.9 to 1.1 microns). Using color infrared film it was possible to determine the volume of saltcedar plant material in the flood plain of the Gila River. Many other investigations in geology, geography, oceanography, and other disciplines showed similarly promising results. Such research efforts have been sufficiently succesful to indicate that practical applications could be made.

At the Manned Spacecraft Center we have been working for about a year now to develop such applications in conjunction with user agencies. The objectives of this activity are twofold: First, we want to develop experimental applications of this remote sensing technology, and second, we want to develop and test a method for making such applications. The approach is simple in concept. We choose to work in concert with duly constituted operating agencies. This helps to assure the implementation of the results if some success is achieved. We picked a small number of specific problems, each problem concerned with some decision required by the agency.

For convenience, our initial efforts are being pursued in the region around Houston, NASA Test Site 175. This area covers some 15,700 square miles of the Texas coast, an area about the size of Switzerland. For our purposes it offers a very reasonable selection of targets. Each application is pursued by an interdisciplinary, interagency team. We consider it of utmost importance to work applications as joint ventures and involve representatives of the user agency.

I will conclude with a series of slides that will show you some of the types of data gathered in our program, and the areas where we are working to develop applications.