BENEFIT AND IMPACT OF THE ARIZONA LAND-USE EXPERIMENT

EXECUTIVE SUMMARY

by

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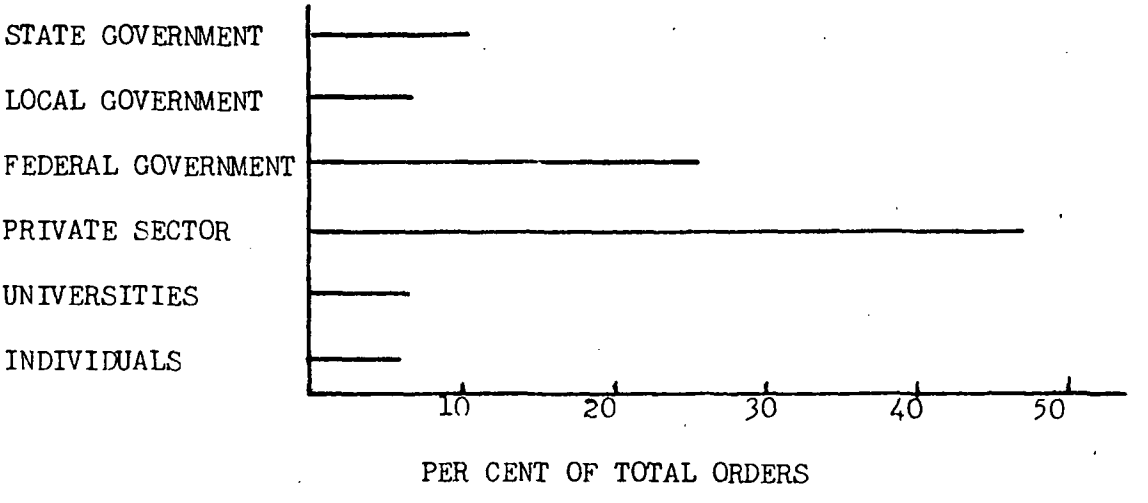
Remotely-sensed information on the land and its uses has been available from various NASA aircraft and spacecraft programs for about five years. Considerable research has been conducted on the techniques of identification of land use, crop type, and geographic features using this data, and electronic means of interpretation of the data are well advanced. The transfer of this data to the citizens and its use and benefit are less well understood.

The present study was undertaken to determine the benefits and impact of the Arizona Land-Use Experiment on the people of Arizona and to examine the process of the technology transfer to the political and private sector of the Arizona community. Since the remotely-sensed data in use in Arizona consisted of a blend of spacecraft and aircraft information it was hoped that the role of the aircraft in the transfer process would be identified and its benefit be determined in a real-world situation. In addition, the role of the institutional arrangements set up in Arizona to facilitate the transfer of remotely-sensed information to the user community was examined.

The Arizona Land-Use Experiment (ALUE) resulted from a three-part agreement between the state, NASA, and the U.S. Department of the Interior. NASA agreed to photograph the entire state using the U-2 aircraft, USDI agreed to construct orthophotoquad maps from the imagery, and the state of Arizona undertook to introduce the information to the user community and to use it in present and future state programs. The U-2 flights began in 1972 and by mid-1973 the orthophotoquad maps began to become available for use within the state.

THE USER PROFILE

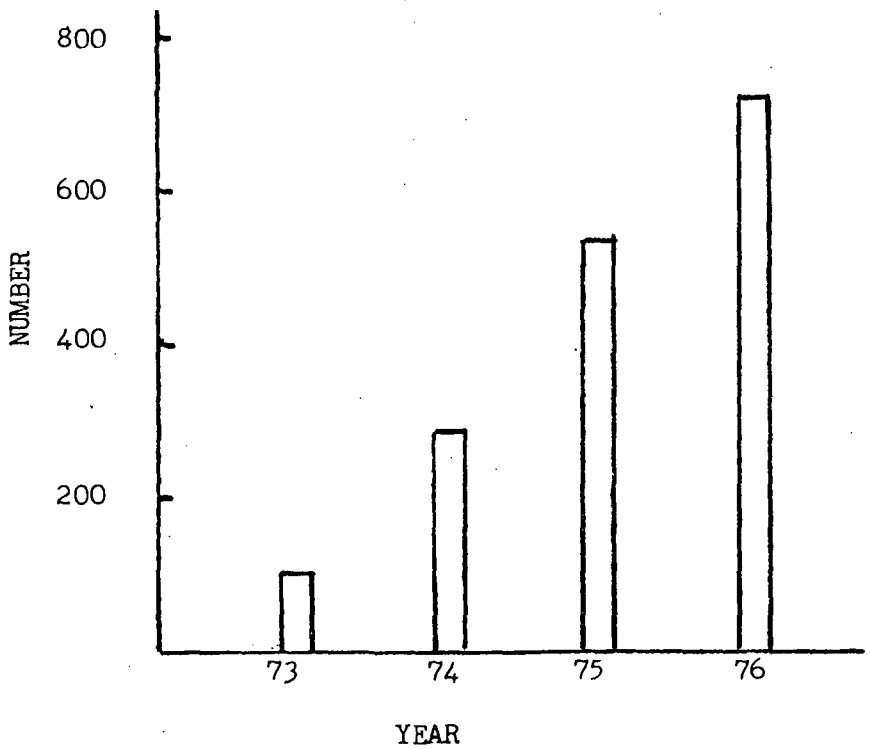
Users of the remotely-sensed information represent almost every facet of Arizona's governmental, business, and private community. The distribution is shown in the following chart.



DISTRIBUTION OF ORDERS PLACED FOR ORTHOPHOTOQUADS

The largest single group is clearly the private sector companies. In addition to the direct use the private sector companies make of the data, they also furnish much of the finished product information to the government groups. The reason for this is that there is a scarcity of trained people within the government groups to interpret the information contained in the imagery and to transfer this information to finished product formats; vegetation maps, for example.

Although over 7,500 orthophotoquad maps have been sold by the state to the users, a better measure of the number of users is obtained from a count of the number of people using the Arizona Resources Information System facility which was set up by the state to help the users. This information is shown on the following chart.



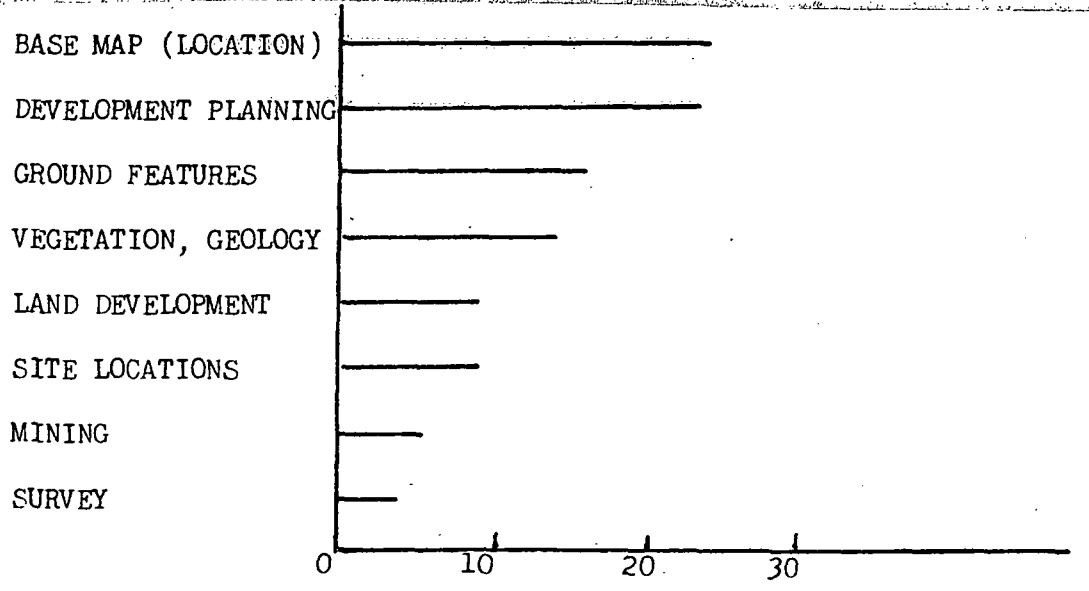
NUMBER OF USERS UTILIZING ARIS FACILITY PER YEAR

It can be seen that the use of the facility is large and that it is increasing almost linearly with time. This is a very strong indication that the technology is well accepted and that the acceptance process is still going on. After the technology is well adopted the use rate should reach some constant value.

BENEFIT AND USE OF REMOTELY-SENSED INFORMATION

GENERAL

The information produced by the Arizona Land-Use Experiment has been put to a very wide variety of uses by governmental groups, the private sector, and by individuals. As expected most of these uses involve the land and its resources. Within the governmental groups it is the secondary products of the imagery, the vegetation maps, land use maps, geology, maps of flood prone areas, and the location information on the orthophotoquads that have had the major impact upon the decision making process. Within the private sector companies major use is in the design studies of large projects involving the land and in determining the impact of these projects on the environment. The kinds of uses are summarized on the following chart in a general way and the specific uses and benefits are given in the following paragraphs.



USE DISTRIBUTION OF ORTHOPHOTOQUADS

USE AND BENEFIT TO COUNTIES AND TOWNS

The major use of the remotely-sensed information by the counties and towns is in the area of land use and potential use. Counties and towns using this information encompass 88% of the population and 66% of the land area of the state, and the use is spreading rapidly to the more remote regions. The secondary products of the remotely-sensed information, maps showing land use, vegetation type, flood hazard, and geologic formations, are used by these governmental groups to set up regulations for land use and to enforce its compliance. These tools have been a major help in controlling the run-away development of land that has taken place in the last ten years. Also, this new information has given the counties and towns a major tool to combat land fraud which has been epidemic in Arizona within the last decade.

USE AND BENEFIT TO STATE GOVERNMENT

Almost every mission agency, commission, or department of the State government makes use of the remotely-sensed information. The information is an every-day tool in land transactions, forms the basis for automobile accident prevention measures, used as basis of assessing environmental impact of major projects, to encourage geologic exploration, and as a tool to provide sound, reliable information to allow better planning and the formulation of state policy involving land and its use.

The major benefit is in providing sound information as a base for policy and regulative decisions. It provides the justification for regulative actions, and has been used to provide information and problem definition for legislative actions. Use of this information allows compliance with federal regulations, and in some instances is credited with substantial savings of staff. Direct savings are difficult to measure but lie within the $1.0-5.0 million per year range.

USE AND BENEFIT TO FEDERAL AGENCIES IN ARIZONA

The federal government owns or administers about 70% of the land in Arizona and the following federal agencies are active users of the Arizona Land-Use Experiment derived information:

Department of Agriculture, Crop and Livestock Reporting Service

Department of Agriculture, Soil Conservation Service

National Forests

Department of the Interior, Bureau of Land Management

Department of the Interior, Geological Survey

National Park Service

Much of the public lands administered by the federal agencies is in remote areas and most of this land consists of very rough terrain. It is very difficult to determine land quality and potential use from on-the-ground surveys, thus the information obtained from the Arizona Land-Use Experiment offers a cost effective way to obtain information on the vegetation cover, timber, brush, geology, and watershed areas. The major use by the federal agencies is in the production of

land inventories of various kinds. Since the orthophotoquads give very accurate location information and the infrared imagery produces good information on land type, both of these tools have served as the backbone of the land inventory systems. These inventories in turn are used to determine the impact of various ongoing and proposed projects upon the environment. They are also widely used to determine flood prone regions, form the basic system for the location of trails and roads during fire seasons, and are used for location and definition of areas where corrective action must be taken to combat natural or man-made damage to the region. They are also used to determine regulative action and as a compliance tool. The major benefit has been to provide sound information for policy formulation and for the various management decisions that must be taken from time to time.

USE AND BENEFIT TO THE PRIVATE SECTOR

Private sector companies are the largest, most active, and fastest growing users of the information supplied by the Arizona Land-Use Experiment. The information is used in the design phase of almost every project involving the use of land, and to evaluate the impact of these projects upon the environment. The benefit to these users is large and lies in the savings in costs and time through the elimination of costly ground survey phases of the design of these projects. Most companies estimate that the use of the remotely-sensed information reduces initial design costs by about 1/3 to 1/2

of that using older methods. The estimated magnitude of these savings in design and evaluation of environmental impact is at least $10 million per year and may be at least twice that figure. In addition, the benefits from better land utilization through better water distribution and use could be many times this large when the full benefit is realized.

THE TECHNOLOGY ACCEPTANCE PROCESS

The remotely-sensed information on the land provided by the Arizona Land-Use Experiment is widely accepted and used in Arizona, and the benefit to the Arizona government and private sector community is very large by any standard of measurement. During the course of this investigation several factors which bear upon the success of the acceptance process were noted and will be summarized in this section.

The more important principles that lead to the successful acceptance of new technology, at least in the present case, were:

a) Strong motivation by the user.

b) Applicability to specific user problem.

c) Ease of application and credibility.

d) Belief that benefit will be substantial.

In Arizona the motivation to obtain accurate detailed information on the land and its present and potential use was driven by population pressures and the need to comply with a variety of regulations both local and federal. The remoteness and undeveloped nature of much of the land had precluded the gathering of this information in times past.

The applicability principle is very important in the early stages of the acceptance process since success with early applications is a major factor in the spread of use of the new technology.

Applicability also concerns the role of the remotely-sensed data in the solution of the user problem. If it plays a major role, the impact of its successful use will be large and this will contribute to other uses of like kind.

Although each of the four criteria must be met if a new technology is to be accepted successfully, the ease of application and credibility criteria requires the most effort on the part of those trying to introduce the technology and probably is the least understood. In the present case, most of the governmental groups were ill equipped to interpret the imagery and to produce the final products, maps showing specific information for example. Institutional arrangements must be provided to fill this need and train the user. In Arizona, about half of this work was done by private sector companies for groups able to pay for the service from their budgets. The Arizona Resources Information System was set up by the state to provide help to the user if the user had the people but lacked the special training. The University of Arizona Office of Arid Lands Studies was given the task of producing final products from the raw information for groups lacking both the people and the monies in their own budgets. The Office of Arid Land Studies was partly supported by the state--through the University--and partly by federal grants. Some of its support also came from local governmental groups. They utilized graduate students who, upon graduation, join the work force skilled in the application of this technology.

This institutional arrangement was tailored to the specific needs of Arizona and worked extremely well. It had a major role in the acceptance process, and it is doubtful if the acceptance would have advanced as rapidly as it has without this arrangement.

New technology cannot be imposed upon any system by an outside group. To be successful the acceptance process must be self generating from within the user community. Thus the credibility and understandability of the new technology are critical ingredients in the acceptance process. It is in this area that the proper mix of aircraft and spacecraft derived information is so critically important. It is important because the major benefit of the remotely-sensed information to governmental groups results from the impact of this information on the decision making process. Before a decision maker will use this information as the basis for a major decision it first must be understandable to them and its credibility must be proven.

The basis of the above statement was determined from the use patterns uncovered in the present investigation. It was found that the use of the remotely-sensed information followed a common thread, almost independent of the decision making group. At first the orthophotoquads were used as tools to locate land features or boundaries of interest to the group. The great wealth of information contained on the imagery gave rise to the desire to extract and use more than

simple location information. This led the decision making groups to use the information derived from the combination of the orthophotoquads and the infrared imagery on land use, vegetation type, geology, soil type, or water run-off patterns as a basis for their decisions on the use of land and upon its value. Ground truth information was provided during this initial period, generally through low-level aerial photographs of sample regions.

During the later stages of this investigation, another use pattern began to emerge that illustrates another important function of the high-altitude aircraft derived information. A large number of the land managers and decision making groups exhibited a reluctance to accept and use Landsat computer generated scenes when first introduced to this information. Decisions on the use of land have a high economic impact upon the community or upon the individuals involved, and the negative affects of a bad decision are something the decision maker must live with for a long time. Major decisions are made with great care. Moreover, land managers are trained to live in a world of sight and sound and to make their decisions on the basis of hard information. It is difficult for them to make the step between "We examined the land and this is the situation" to "The satellite and the computer saw something and this is what we think it saw." The high altitude image from the aircraft forms the bridge between the satellite and the familiar low-altitude photograph. Once the decision makers are used to depending

upon the high altitude imagery to determine land value or flood prone regions, it is a small step for them to accept the satellite information. A number of instances were encountered where the initial reluctance was overcome by projecting a satellite scene and a U-2 produced image to the same scale to demonstrate that both gave reliable information.

It is difficult to understand why the high altitude aircraft image is so effective in the acceptance of Landsat information, but it may lie in the resolution likeness of the two pieces of information. When low altitude photography is directly compared with satellite imagery the loss of resolution is a shock to most people. Most managers feel that they need high resolution. In reality, most of the information they use does not require high resolution, but it appears to require an intermediate step to make this point clear at least in the beginning of the acceptance process.

It appears from the results of this investigation that aircraft form an important part of the technology acceptance process and that the proper use of high and low altitude aircraft falls into separate regimes. The low altitude photograph for ground truth and for the use in small area regions, several square miles, and the high altitude image for large regions, hundreds of square miles, where reasonable resolution and location information are of prime importance.

High altitude images also form the bridge between the satellite and the more conventional methods of information gathering. In any event, the extensive use of U-2 information in Arizona has opened the way for extensive use of Landsat information as it is made available to the state.