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BENEFIT AND IMPACT OF THE ARIZONA LAND-USE EXPERIMENT

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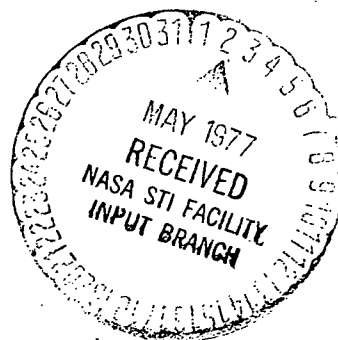


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INTRODUCTION

Within the last two decades Arizona has changed from an agrarian to a modern industrial state. The population has doubled and is still growing at five per cent per year. This population pressure and the increasing awareness of the importance of preserving the quality of life has brought about evolutionary changes that have touched every aspect of Arizona life. The older way of doing things, where the affairs of the community were settled by a few influential citizens and sealed by a handshake, has given way to the methods of modern management. The formalism of modern management coupled with the increased demand by the federal government for regulation compliance has created an overwhelming demand for accurate information about the natural resources, the environment, and upon the impact of proposed man-made changes.

The need for information about the land and its resources is more acute in Arizona than it is in many other areas due to the land ownership situation in this state. Seventy per cent of the land is either owned or held in trust by the federal government, twelve percent is owned by the state, and only eighteen per cent is in private hands. If these lands were contiguous the problem of land management would be much simpler than it is with the actual case where the lands are scattered in smallish parcels all over the state. This comingling of land parcels and the population pressures cause a constant demand to trade parcels among the ownership groups, and generates an additional need for information on the value and potential use of the land. Moreover, much of the land is undeveloped, is located in remote regions, and was surveyed in pioneer times; thus even location of boundaries is a problem.

In the 1960's when photographs from early space flights of the earth's surface gave the hint that reliable detailed information on the land and its resources could be obtained in this way, hopefully at a fraction of the cost of traditional methods, Arizona was among the first to begin activity to define the usefulness of this information and to work out methods for its introduction into state programs.

This early work was carried out mostly at the University of Arizona with the cooperation of NASA and the Department of the Interior. In 1971 Governor Williams, the former governor of Arizona, requested that NASA and the Department of the Interior join with Arizona to obtain aircraft generated information that could be used in advance of satellite information to promote and evaluate the usefulness of this new tool in the State's management decision process.

In 1972 the Arizona Land-Use Experiment was initiated by joint agreement among NASA, the U.S. Department of the Interior, and the State of Arizona in which NASA would supply remotely sensed information from high altitude flights of the U-2 Earth Resources Aircraft using cameras in the same spectral bands as the sensors to be used in the satellite system, the Department of the Interior would produce orthophotoquad maps from the U-2 imagery, and the State of Arizona would introduce this information into present and future state programs. U-2 flights began in 1972 and by mid-1973 the orthophotoquad maps were available for use by the State of Arizona.

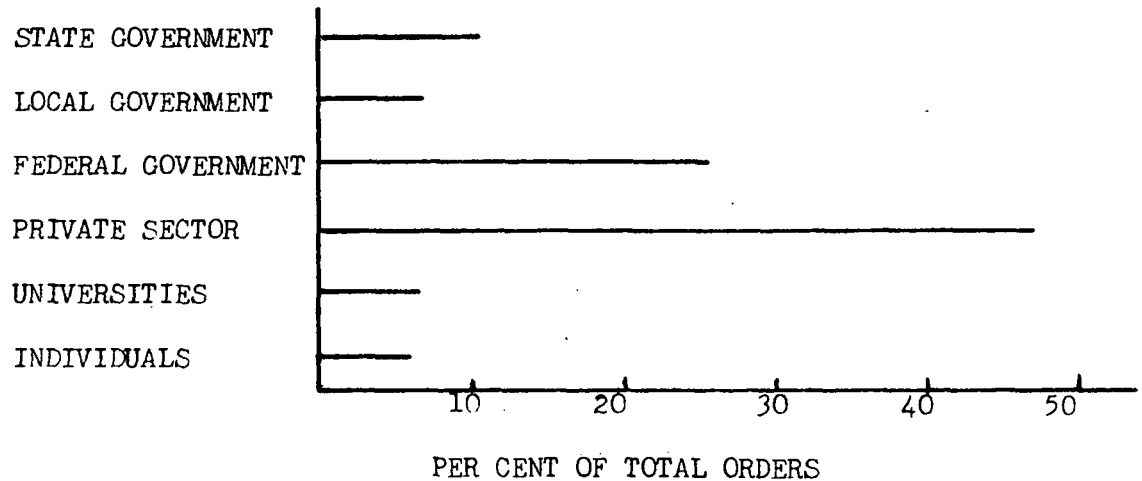
Concurrent with the aircraft flights the State of Arizona set up the Arizona Resources Information System (ARIS), funded by the State Legislature, to carry out orthophotoquad and U-2 imagery distribution and to introduce this information into state programs and to the general public. At the same time the University of Arizona's Office of Arid Lands Studies started their Applied Remote Sensing Program to transform the information contained on the maps and the imagery into useful management tools. The University of Arizona's effort was funded partly by the University and partly from grants from NASA, U.S. D.I., Bureau of Land Management, National Park Service, and from local governmental groups. In addition, the Department of the Interior opened their Applications Assistance Facility in Phoenix to make available the vast store of remotely sensed information from their Sioux Falls central data facility. Coordination and information exchange among these groups was facilitated by the Governor's Policy Advisory Committee. The Policy Advisory Committee consisted of representatives from the University of Arizona, the Department of the Interior, the heads of the nine state mission agencies, and the Project Directors of the information introduction groups, and, of course, the Governor. Interested committees from the State Legislature also had representation on this Committee. A more complete discussion of the institutional arrangement used to introduce this new technology into the Arizona community is given in Appendix A of this report.

The present study was initiated to determine the benefits and impact of the introduction of remotely sensed information into the Arizona governmental and private community. Moreover, it was hoped that this study would shed some light upon

the acceptance process and give some detailed information on how this information is used by state, federal, and private sector managers in coping with day-to-day management problems. Since the study effort was very limited, no attempt was made to determine the details of each and every use; rather the user community was identified and selected user groups were examined in some detail by holding discussions with the people who have the responsibility of making decisions that involve the use of this new information. Discussions were also held at the working level to determine the details of the acceptance process and how this information fitted into the management system. Also of great interest were examples of things that could be accomplished using the new level of information that were not possible, or simply too costly to attempt, using the older traditional methods. Shortcomings of the information also were uncovered. The results of this study are discussed in the body of the report.

THE USER PROFILE

Users of the information represent almost every facet of Arizona's government, business, and private community. The distribution of users is shown on the following chart taken from the ARIS files on purchasers of the orthophotoquads.



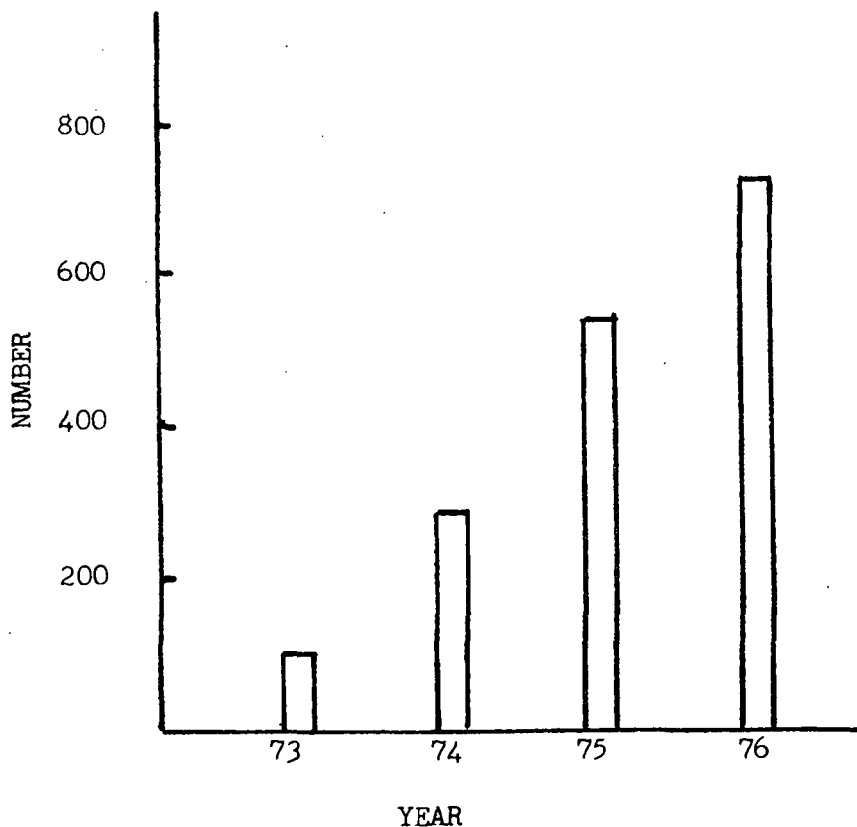
DISTRIBUTION OF ORDERS PLACED FOR ORTHOPHOTOQUADS

Two things are immediately apparent from the above chart; the large use by the private sector companies, and the seemingly small use by the state governmental groups. A telephone survey confirmed the large use by the private sector companies, and the methods used by state agencies explains the apparent small usage by them shown on the chart.

Most of the state agencies obtained their orthophotoquads early in the program directly from the Department of Transportation who produced the maps from the negatives and do not show up in the ARIS files; in addition the state agencies procure their orthophotoquads in large orders, and the ARIS files give information by user order only. Moreover, it was found during our interviews that many of the state people simply use the ARIS facility instead of buying the orthophotoquads. ARIS is located within a block or two of most of the state offices. The actual use by the state agencies is about equal to that of the federal government agencies.

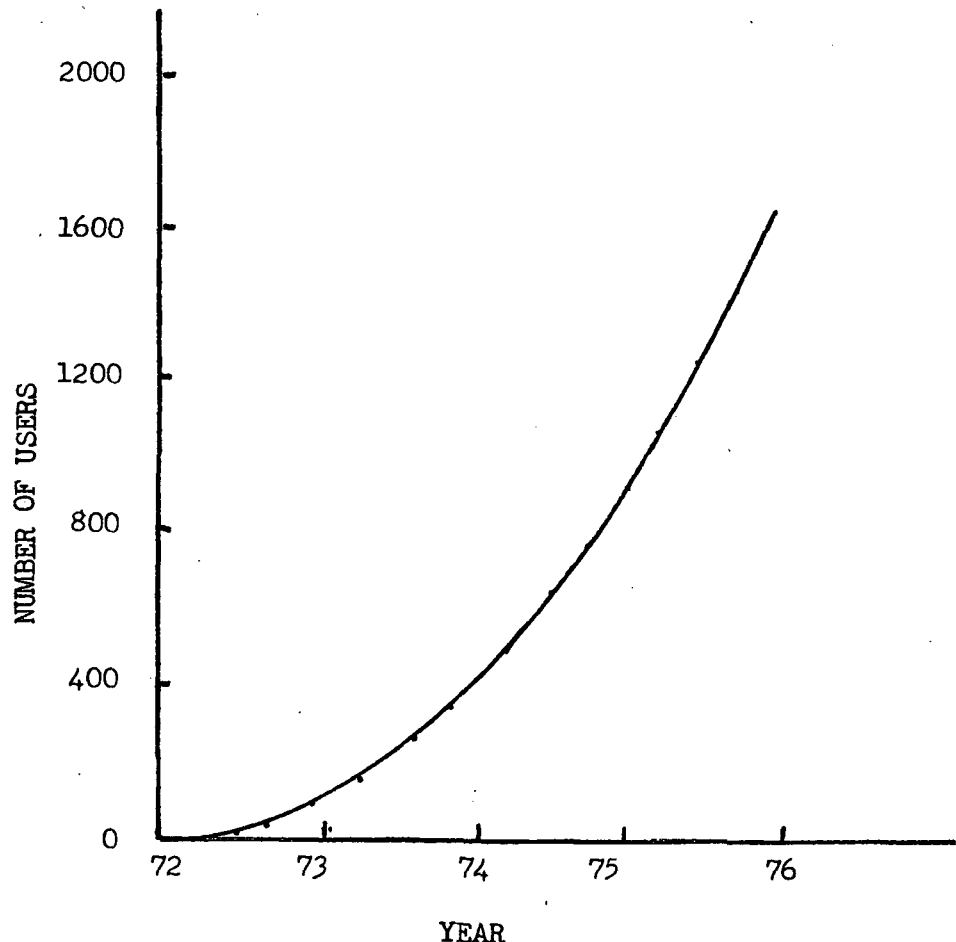
It was not until a number of the private sector companies were interviewed that the reason for their heavy use of ALUE data became apparent. Most of these companies are involved in project planning or in the preparation of environmental assessment work for proposed projects, and they typically do this work for the governmental groups or for large concerns who do not have this special skill in their planning departments. The use by the private sector is very large and will be discussed in detail later.

Something over 7,500 orthophotoquad maps have been sold by ARIS since its inception in 1972, but due to the large use of these maps and imagery at the ARIS facility, a better measure of the magnitude of the use is obtained by examination of the numbers of users who have availed themselves of the facility. This information is shown on the following charts.



NUMBER OF USERS UTILIZING ARIS FACILITY PER YEAR

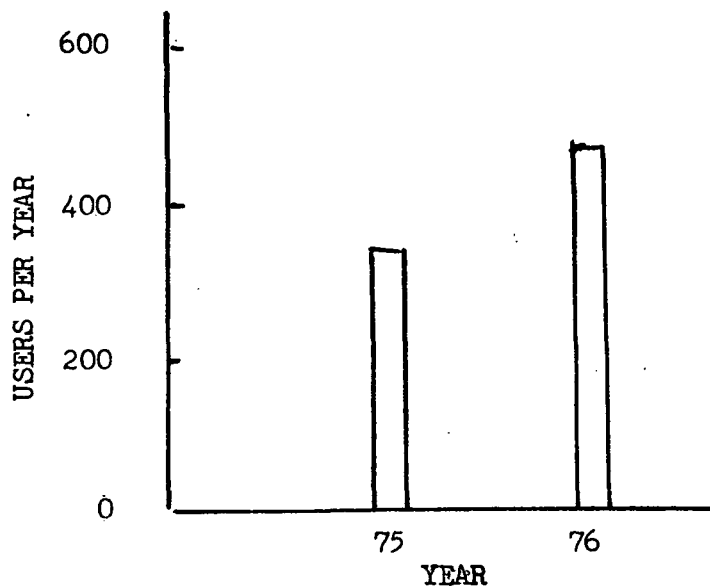
It can be seen from the preceeding chart that the use of the facilities is large and that it has increased almost linearly with time since the facility was opened. Although the use is presented for the entire year, an examination of the use by months during 1976 shows that the use trend is continuing, or beginning to increase over that shown. This point can be more easily seen if the same data is replotted to show total use, and this information is given on the next chart..



TOTAL USE OF ARIS FACILITY SINCE INCEPTION

Probably the most interesting point shown by these charts, in addition to the magnitude of the use, is that the use rate is still increasing. This indicates that the acceptance of the technology is still going on, and that, when compared with acceptance rate curves from other technologies, shows that the eventual use at maturity should be at least twice the present usage. A rather complete discussion of this subject is given in "Civil Aviation Research and Development Policy Study" DOT & NASA, NASA SP-266, 1971.

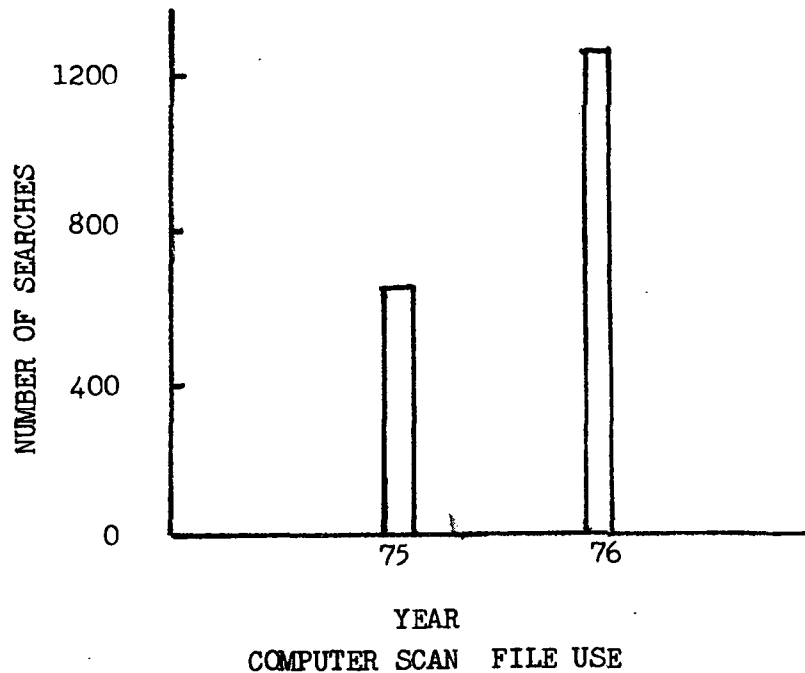
While ARIS maintains a file of imagery for use at its offices, copies of the imagery must be obtained from the U.S. Department of the Interior's Data Facility in Sioux Falls. The EROS Applications Assistance Facility located in Phoenix has computer search facilities that allow users access to the Sioux Falls data. They also provide general assistance to the users. As might be expected this facility accommodates a large number of users. Data on the use is available for the years 1975 and 1976 and are shown on the following chart.



NUMBER OF USERS--APPLICATIONS ASSISTANCE FACILITY

The reader is cautioned not to add the usage of the ARIS facility presented earlier to the AAF usage and attempt to obtain total usage in this way. While there are some users that use the AAF facility and do not use ARIS, the two facilities provide slightly different services. Orthophotoquads are available at ARIS and not at AAF, while imagery is obtained through AAF and not through ARIS. At the present time there are active plans to combine the two facilities within the state system.

The above chart does show the same use trend shown earlier by the ARIS use data; the use is increasing and does not show any signs of saturation. This point can be more clearly shown if the use of the computer search file is examined. This usage is shown on the next chart.

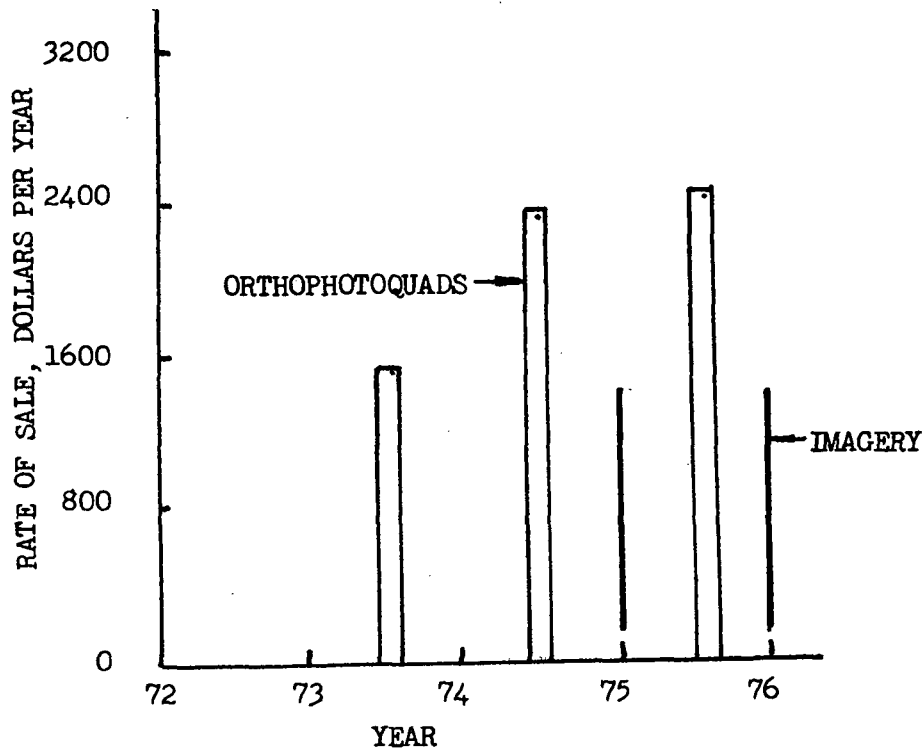


The computerized scan file allows the user to find the particular image he needs in his work, to examine the image, and if useful, to order the image from the EROS data center. The use of this facility represents a serious use by a user as it indicates that the user has gone beyond the looking-at-pictures stage of his work. Sales of imagery from the AAF center in Phoenix amount to about \$14,000 per year and have not changed much since the search file was located here in January 1975. At a minimum this indicates a linear use rate, at least up to the present time.

The use of the computerized scan facility shown on the above charge gives total usage of the imagery by governmental and private sector companies located in Arizona, but may well represent projects located outside of the state as many of these companies work on projects in foreign countries. An attempt to recover data on the use within Arizona boundaries from the computer at EROS main data center was unsuccessful. The EROS data center computers would require some programming to recover this data, and they have no plans to make this change at the present time. This computer problem also precludes any chance to separate the use of aircraft generated imagery from spacecraft generated imagery for the state of Arizona.

It is possible to conclude, from this chart and from the constant level of sales of the imagery, that the use of this information by the Arizona community shows no signs of saturation; in fact just the opposite seems to be the case.

In an attempt to refine the use within Arizona, the sales of orthoquads since the program started was examined. Orthophotoquad sales probably represent serious use of the information as casual users can obtain short time use of these maps at the ARIS facility without charge. Also, these maps are somewhat expensive, about \$8.50 each for a 7-1/2 minute quad which covers about a hundred square mile area. The rate of sale of these maps is shown on the next chart.



SALES OF ORTHOPHOTOQUADS AND IMAGERY PER YEAR

It can be seen from this chart that the sale of the orthophotoquads is still increasing even though this information is about three to four years old. Since the value of the orthophotoquads is bound to decrease with time, as they show land status during the 1972-1973 time period, the sales increase shown on the above chart must indicate a spreading of the use of this information within the Arizona community. This point was borne out by interviews of the users where in many cases the value of this information was just being realized. The sale of the imagery from the EROS Applications Assistance Facility are also shown by the solid lines and represent a sales rate of about one half of that of the orthophotoquads. Again these data do not indicate any decrease in use that might be expected after the technology is matured and users have obtained their libraries of information.

The data on the use of the remotely sensed information presented in this section support several important conclusions:

- a) The data is widely used within the Arizona community.
- b) The use of the information is growing linearly with time.
- c) The technology is still within its acceptance period.
- d) The high use rate over an extended time period indicates that the technology is useful and beneficial.

USES OF REMOTELY-SENSED INFORMATION IN ARIZONA

GENERAL

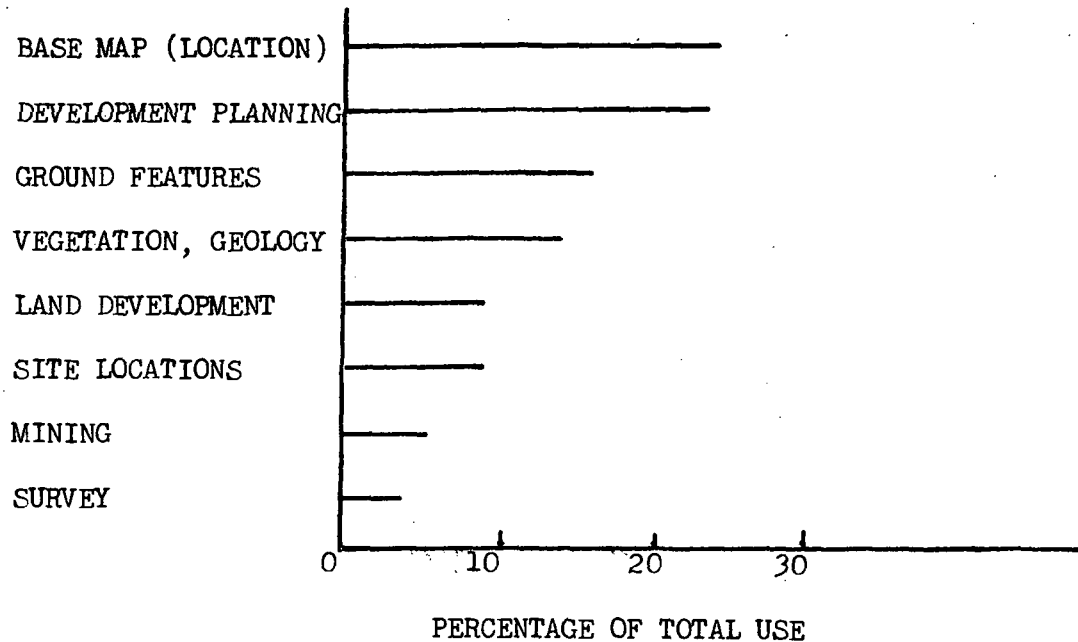
When the orthophotoquads were first introduced into Arizona in 1973 the predominate use was to locate natural land features and man-made objects. The first use by the Arizona Department of Transportation, for example, was to locate rural roads in the remote areas of the state. Locations of boundary lines, water diversion structures, stock watering holes, appeared as some of the early uses. As time went on, it became apparent that the combined use of the orthophotoquads and the infra-red imagery could be used to accurately identify ground features and vegetation types and use in this area began to grow. As this information began to grow and become available the use began to spread into the land development area. Also, the great benefit of this information in the preparation of environmental assessment statements began to be realized, and the use rapidly spread into this important field.

Early in 1975, ARIS conducted a survey of its purchasers of orthophotoquads to determine the range of use being made of these maps. The survey consisted of questionnaires sent out to 243 users taken from the orthoquad file. The users were taken in chronological order and the questionnaires were mailed in two groups at different times to test for the effect of sample size on the results. The response to the survey was 45% and represented 79 different organizations. The classes of users and their response to the survey is shown in the following table.

GROUP	NO. OF INQUIRIES SENT	PERCENTAGE RETURNED
State Government	24	29
Local Government	15	20
Federal Government	61	52
Universities	14	36
Private Sector	116	51
Individuals	<u>13</u>	<u>31</u>
	243	45%
Overall return		

The questionnaire was open ended in that the users were asked to list the uses they had made of the orthophotoquads, how well the orthophotoquads had served their intended purpose, and to make some statements of benefits and new uses. In

addition, they were asked to list shortcomings. While the complete survey and its results will be given in Appendix B of this report, some of the more interesting findings will be included here. The distribution of uses of the ortho-photoquads is given in the following chart.



USE DISTRIBUTION OF ORTHOPHOTOQUADS

Much the same use pattern was found in the benefit survey taken in 1976, but there is some drift away from use of this information as a feature location tool, at least for simple feature identification, toward the more sophisticated use of the information in the determination of soil types, vegetation types, and their applications in determining land value and potential land use. Moreover, the combination usage of the U-2 information with the Land-sat information to determining changes or use dynamics is beginning to emerge as an extremely useful tool.

The results of this survey are interesting but no distinction was made among the orders of the use of this information. To a man or a department charged with the responsibility of producing a vegetation map of some area, the use to him is in the easy identification of vegetation types and their location on the land being surveyed. The finished product, the vegetation map, has in turn many uses. It can, and is used as a basis for decisions in the planning function, to determine the probable impact of man-made changes upon the

environment, to determine potential use of the land, and as the basis for taking corrective actions if the area is under attack by over grazing or by pests or disease. The list is endless and more uses of the information are turning up as time goes on. This is probably the driving reason behind the continued use of this information and probably accounts for the increase of the user group discussed earlier. It is also from these secondary uses that the main benefits flow.

One of the motivations of the present study was to determine the progression of uses of the information provided by the Arizona Land-Use Experiment as the project matured. During the investigation it was found that the use followed a common thread, almost independent of the user group involved. The first use made of the orthophotoquads in almost all cases was to use these maps as tools to locate features or boundaries that the group had some interest in. The great wealth of detail on these orthophotoquads in turn gave rise to the desire to extract more information than just simple location. The next stage in the use was to combine the orthophotoquads with the imagery in order to obtain detailed information on land use or potential from vegetation cover, soil type, geology, or water run-off patterns. Following and during this step there was a period of ground truth, either formal or informal, where the managers or decision makers became convinced that the information provided was accurate and usable. After these steps had been taken real use in the day-to-day problem solving began to take place. It is at this stage where benefits begin to emerge.

During the latter part of the investigation another use pattern began to emerge, that in the long run may well prove to be the most important benefit of the Arizona Land-Use Experiment. This pattern indicated the key role played by the aircraft produced information in the introduction and acceptance of the Landsat data as a valuable tool. It is perhaps a little difficult for engineers and scientists to understand the reluctance of a land manager to accept and use Landsat information as a basis for his decisions on land use, land trades, or upon the impact of a new project on the environment. The facts of life are that decisions on the use of the land have a high economic impact upon the community or upon the individuals involved, and the negative effects of a bad decision are something that the land manager must live with for a very long time. Major decisions are made with great care. Moreover, land managers are trained to live in the world of sight and sound, their decisions are made on the basis of hard information, and it is difficult for them to make the step between "I saw it, and this is the situation" to "the satellite saw it, and this is what I think the satellite saw." The aerial photograph forms the bridge between the two systems simply because a photograph is more familiar than a computer printout. Once the land manager is used to depending upon aerial photographs to determine land

use and therefore land value, it is a small step for them to accept the satellite information. During the course of this investigation this situation has been encountered several times.

The uses of the remotely-sensed information by the various user groups will be summarized in the following paragraphs of this section of the report and the details will be given in the Appendices.

USE BY COUNTIES, CITIES, AND TOWNS

Pima County Planning Department. To survey undisturbed vegetation and soil conditions in the pre-urbanized semi-arid regions of the county, and to monitor ecological stress on the national forests and monuments due to the city of Tucson urban encroachment.

Tucson Planning Department. To determine the drainage configuration and hydrological characteristics of the Pantano Wash and its tributaries. Specifically to determine which regions were the most susceptible to flooding and erosion, changes occurring as a result of increased urban development, and to help in determining which methods might be best used to reduce flood damage within the Pantano drainage system. In addition, to determine the vegetation and wildlife habitat along the wash and its tributaries. Land use and soil type were also determined within this region.

Cochise County Planning Department. To determine crop types and land retired from agriculture and to determine extent of water runoff from the various irrigation techniques used in the Douglas basin.

Mohave County Planning Department. To produce a land use map of the city of Kingman and of the Davis Dam region. In addition, to produce a map showing drainage east of Davis Dam.

Tucson Airport Authority. To determine land use, geology, vegetation, soil type in the region surrounding the Tucson airport for use in evaluating proposed expansion of that facility.

Apache County. Prepare land-use map of the county and to determine extent of flood hazards in urbanized areas and in areas of potential subdivisions.

Graham County. To delineate areas subject to flooding along the Gila River between Solomon and Pima, Arizona, and to determine watershed boundaries of the tributaries feeding the Gila River from Tidwell to Talley.

Yuma County. To produce land-use maps of the county and to determine flood hazard areas.

Yavapai County. To produce a county-wide land-use map from the aircraft imagery and to begin to compare this map with Landsat scenes to determine land use dynamics. To define the flood hazard in the urbanized region surrounding Camp Verde and Cottonwood along the Verde River, West Beaver Creek, and West Clear Creek drainages.

Maricopa County Association of Governments. Used early aerial photography to determine land use patterns to produce urban planning maps. Presently investigating Landsat to determine usefulness of this technique to determine dynamics of land use in this rapidly growing area.

Maricopa County. District Attorney's Office uses orthophotoquads and imagery to determine extent and details of simple land fraud in county, and as a tool for the presentation of this evidence to grand juries and trial juries. Also uses these tools in presentation of evidence in many other criminal cases involving location and details of investigations.

Apache County, Town of St. Johns. Used the orthophotoquads and imagery to prepare contour map of region to redefine flood plain of the Little Colorado River and for use in planning expansion of town facilities to meet sudden expansion brought on by construction of major power plant located near town.

A more complete discussion of the details of the use made of the remotely-sensed information is given in Appendix C of this report and in "Applied Remote Sensing Program to State and Local Governments," Johnson, Foster, Mouat, and Clark, OALS Bulletin No. 10, Office of Arid Lands Studies, University of Arizona, 1975.

Summary of Use in Counties and Towns. Up to the present time the use of remotely-sensed information has extended to eight of the fourteen counties in Arizona and many of the counties not presently using this tool plan to use it in the future. The main problem with the use of this information by county and local governments is the lack of trained personnel to produce management tools from the raw imagery. The University of Arizona's Office of Arid Lands Studies has taken the lead in producing use and status maps from the imagery for use by the various counties. This is a major contribution and it is very doubtful if the degree of acceptance and use of this information by the local governmental groups would have occurred without the dedicated effort by this group. Again, this group's work illustrates the need

to provide some form of interpretive service within any state system if this new technology is to be accepted and used at the local governmental level. The private sector can and does produce this kind of product, but the problem of finding the local tax dollars to pay for the service is severe for small towns and remote counties where the need may well be acute. In this area, the University of Arizona provides an extremely valuable service to the people of Arizona and support of this group should receive high priority.

The uses by local government groups listed in this section include only work initiated by these groups. Both the state government and the federal agencies programs have generated information and management tools that are used by the local governmental groups. The Arizona Department of Transportation's Accident Location, Identification, and Surveillance Program is an example of this type of use, where the state maintains the data base, but it is used both by the state and the local communities. If uses of this type are included then it can be said that all of the county governments use the information generated through the Arizona Land-Use Experiment.

USE BY THE ARIZONA STATE GOVERNMENT

Arizona Department of Transportation. The first major use of the information from the Arizona Land-Use Experiment by the Department of Transportation was to compile the location, condition, and accident location on all of the roads in Arizona. This was a major undertaking as most of the roads in Arizona had never been located with respect to an accurate location system, and moreover many of these roads date from pioneer days and even their ownership was in doubt. Without the orthophotoquads it is very doubtful if this project could have been accomplished.

The use of this system enables the Department of Transportation and the local community to determine road condition, accident location, and exact jurisdiction in the planning of road repairs or alterations.

The department also uses the orthophotoquads and the imagery for planning new roads, freeway linkages with local roads and to determine probable future transportation needs of the state. In the past the highway department has used their computerized map making capability to make contour maps from the imagery to accuracy standards of the USGS and plan to make more of these maps to complete the state set whenever funding becomes available.

Arizona Land Department. The Land Department uses both the orthophotoquads and the imagery as its main tool in determining land use, land type and, therefore, land value. They also use the information to determine and record water well location and to estimate, from vegetation condition, the probable water use. The use of this information has evolved over the last few years to the point where they only occasionally use ground crews to determine land use or land value. Since the Land Department administers almost nine million acres of state land, this represents a very large and important use of the remotely-sensed information, probably the largest single use of the information by any state agency.

In addition to use in their day-to-day work, the land department has undertaken some specific projects utilizing the remotely-sensed data. One such project was to produce a map delineating the geothermal reservoirs in southern Arizona, in cooperation with the University of Arizona. Others are in the planning stage.

Arizona Department of Revenue. The Department of Revenue uses the orthophotoquads and the imagery to locate and identify the extent of use of the land by subdivisions, farm land, and industrial use. The majority of the use within this department is to aid in the land assessment process. This use takes the form of identification of uses not reported for tax purposes, and to verify the reports sent to the department by the tax payers. Due to the age of the imagery obtained in 1972-1973 time period, the usefulness to this department is not as helpful as it could be, and they are actively seeking to develop the Landsat information to obtain data on changes that take place in land use patterns. If this method of obtaining information is successful the Department of Revenue plans to make major use of it.

Arizona Office of Economic Planning and Development. OEPAD uses its orthophotoquads and the imagery in their day-to-day work of reviewing the environmental impact of proposed changes in land use or industrial development within the state. They also act as an information exchange between the counties and towns within the state needing the remotely sensed information and ARIS to facilitate the application of this technology. The town of St. Johns, mentioned earlier, was made aware of the information through this route. In addition, they also make use of this information in their own planning, or in providing policy support to the governor. In 1974, for example, they produced an inventory of the remote subdivisions within the state using this information, which defined the magnitude of the problem so corrective legislation could be drafted. This was a

sizeable undertaking as there are some 2,500 remote subdivisions containing over 700,000 lots in Arizona.

More recently they have funded and managed a program to obtain thermal scans of public and private buildings in Phoenix and Tucson to determine the magnitude of the heat losses from buildings in order that corrective action could be started and that the public could be made aware of the magnitude of the problem. These scans were obtained from low altitude aircraft flights and were not part of the Arizona Land-Use Experiment, but these kinds of projects probably would not have come about except for the knowledge gained from the use of remote sensing techniques.

Arizona Water Commission. The Water Commission compiles the state's water resources, supplies and uses. At present the Commission is charged with the responsibility of generating a computerized data bank to provide access to this information. To carry out its functions the Commission works with many of the state and federal agencies and with the state university system. Remotely-sensed information is widely used to generate the information in two use categories; flood assessment and control, and determination of water availability and use. In both of these functions it is the combined use of the infra-red imagery together with the orthophotoquads that have proven to be the most useful tools. The orthophotoquads furnish location information while the imagery furnishes identification of watershed areas through vegetation patterns and the location and extent of alluvial fans, and defines flood areas through identifiable changes in soil type. Water use can be estimated from the extent of irrigation regions which are easily identifiable from the imagery. While the Commission gathers its data from many sources, it does support work in the use of remotely-sensed information. Specifically, a project with the Office of Arid Lands Studies to assess the impact of water impoundment structures on vegetation, another to study the application of remote sensing techniques to assess wildlife management potential and status, and a third to study the hydrology of earth stock tanks on a semiarid watershed. In addition, they used the information on flood control generated through the various counties mentioned earlier in this section of the report.

Arizona Oil and Gas Conservation Commission. The Oil and Gas Conservation Commission regulates the development and production of oil, natural gas, and geothermal resources for the purpose of conservation and protection of waste of these resources and as such serves as the state's data base for information on this subject.

They regularly use the orthophotoquads as a tool for the location of wells and to show regions of potential production. In addition, they have used a combination of the orthophotoquads and the imagery to produce maps showing the distribution and geometry of large-scale folds within the Colorado Plateau tectonic province in Arizona. The motivation to produce these maps was to encourage exploration for oil and gas within this region.

Arizona Bureau of Mines. The Bureau of Mines has the responsibility of acquiring, disseminating, and applying basic geologic data to enhance the understanding of Arizona's mineral resources, to assist in controlling its use, and to help develop the resource. It was placed under the authority of the University Board of Regents when it was formed and its present director is also the dean of the University School of Mines. Historically, it has always used remotely-sensed information, as aerial photography from conventional altitudes is a major tool of exploratory geology. The high-altitude imagery from the Arizona Land-Use Experiment offers a scale intermediate between the conventional imagery and that acquired from Landsat. Many geologists, engineers, and students in the Tucson area are using the ALUE information through the Office of Arid Land Studies. Recently the use has become so extensive that a new office, located in the Bureau of Mines/College of Earth Sciences, has been opened. They have a very complete collection of all of the U-2 imagery as well as receiving the Landsat scenes. This information is used as a tool to produce maps showing the various mineral resources in Arizona.

Arizona Solar Energy Research Commission. The Solar Energy Commission has the responsibility to promote the development of solar energy in the state. Its main use of the remotely-sensed information is to locate sites for proposed solar installations and to use these maps to display amounts of solar radiation, locations of measuring stations, and other information throughout the state.

Summary of Use by Arizona State Government. In summary, most of the State Departments, agencies and commissions that have need for the type of information provided by the Arizona Land-Use Experiment are actively using the information. In some of the departments this information has become a day-to-day tool and the acceptance of this new technology is complete, in others the use is still growing. While the survey did not cover each and every department or commission, it did cover enough of them to justify the above statement and to indicate the order of the impact this experiment has made in the Arizona state government. As time goes on, the 1973 information will lose some of its value,

simply due to age, and this fact is well known to the departments actively using the information. Due to the wide use of this remotely-sensed information, this government group represents a ripe field ready for the introduction of Landsat information. The reader is referred to Appendix D for details on many of these uses.

USE BY FEDERAL AGENCIES IN ARIZONA

The federal government owns or administers about 70% of the land in Arizona and it would be expected that they would use the information gained from the Arizona Land-Use Experiment in the management of these lands. A detailed interview survey was made of several of these federal agencies to determine the type of use, the extent of the use, and to try to determine the degree of acceptance of this technology within the federal agencies in Arizona. The following paragraphs will give a short description of the findings and the details will be given in Appendix E.

U.S. DEPARTMENT OF AGRICULTURE, Crop and Livestock Reporting Service. The crop and livestock reporting service performs an extremely important function as it makes accurate forecasts of the size of the crops and number of livestock to be marketed. As the forecast has a major effect upon the market prices, the accuracy of the forecast is vitally important to the state. In order to produce an accurate forecast the service determines the area planted in each crop and takes statistical samples of the crop during the growing season. In the past their forecasts were very accurate and they were able to depend upon the farmers to report the acreage planted in each crop. Recently, there has been a number of rather rapid changes in the areas brought to production status, and in the areas taken out of production. The service has used the orthophotoquads together with the imagery to prepare a cropland atlas of the various crops in Arizona. While this atlas served its purpose well in the 1973-74 period, changes since that time have decreased its usefulness.

When the idea of using Landsat information to update their information was first discussed with them, they did not feel it would be useful due to the rather poor resolution compared to the resolution they were used to working with. Recently ARIS demonstrated to them the usefulness of Landsat data by showing 1973 scenes taken from the U-2, 1973 scenes from ERTS-1, and 1976 scenes from Landsat (suitably enhanced) and they are now convinced that Landsat information will be very useful to them and are actively working to obtain enhanced Landsat imagery. This is another example of the use of U-2 imagery forming the bridge between the older methods and the new technology.

U.S. DEPARTMENT OF AGRICULTURE, Soil Conservation Service. The Soil Conservation Service is charged with the responsibility to preserve the soil from the various natural and man-made forces that tend to degrade its quality. This requires soil inventories to be kept up to date in order that changes can be detected. The Service has recently completed an inventory of the entire state using the orthophotoquads and imagery, low-level aerial photography, and satellite imagery, but states that the U-2 produced information was the key to their system.

NATIONAL FOREST USE. There are seven National Forests in Arizona and they occupy about 16% of the land in the state. Tonto National Forest, in central Arizona, is one of the largest of these, and it was investigated in some detail to determine the extent of use of remotely-sensed information.

Tonto National Forest is a relatively new user of the ALUE information. Their use has been to locate trails, roads, and campgrounds, and make general inventories of the forest. They use both the orthophotoquads and the imagery in their work, and have just started to determine the various types of grazing lands under their control using this method. In connection with their inventory of the forest grazing lands they are also identifying the watering holes for livestock and wildlife.

U.S. DEPARTMENT OF THE INTERIOR, Bureau of Land Management. The Bureau of Land Management administers about 13 million acres of federally owned land in Arizona, which makes it the largest land management organization in the state. The Bureau is a fairly extensive user of ALUE information, some departments make intensive use of it, and other departments are just beginning to use the information. The Bureau of Land Management represents an organization in transition from the older methods to the new, at least at the working level. The orthophotoquads and the imagery are used to make land use, soil inventories, vegetation inventories in much the same way as other land management groups. The Bureau is presently engaged in a large program to produce Management Framework Plans for all of their land, and the use of the imagery both from aircraft and satellite will figure prominently in this project. Potentially, BLM will be a major user of remotely-sensed information.

U.S. DEPARTMENT OF THE INTERIOR, Geological Survey, Water Resources Division. The water resources division has been an active user of the ALUE information since before the information became generally available, since they were the group which organized the EROS Applications Assistance

Facility in Phoenix. One of their major uses of the information is to define the winter snowpack for use in predicting the water yield of this resource. Another use of the information is to define the watershed of the major rivers and streams in Arizona. These data are presently being used to help construct a computer model of the watershed and snowpack feeding the system of Salt River dams used to regulate the water to the Salt River Valley agricultural area.

NATIONAL PARK SERVICE USE. National parks use the information in much the same way as do national forests, but in at least one instance the use is somewhat more intensive than that found in the national forests, and thus will be discussed. The Petrified Forest National Park became concerned about the damage to the natural vegetation due to encroachments of visitors and inroads upon the land by imported plants and weeds and have a joint program with the Office of Arid Lands Studies to interpret the U-2 imagery to construct a detailed vegetation map of the park, of the plant species present and their associated communities; and to develop and monitor a program to inhibit exotic plant species invasion and to maintain the native communities. This requires a very detailed use of the imagery but, if successful, may open up new uses.

Summary of Use by Federal Agencies. Most of the federal agencies in Arizona charged with the responsibility of administering federal lands make use of remotely-sensed information. While there is some Landsat use, the predominant use is of the U-2 produced information. The federal agencies are newer users of the information than the state groups, but the use is expanding. Several of the agencies are good candidates for the introduction and acceptance of Landsat information due to their use of the Arizona Land-Use Experiment information. Moreover, compliance with some of the new federal legislation will force the use of this new technology as it offers the only cost effective way to gather the needed information.

USE BY INDIAN TRIBES OF ARIZONA

Twenty-six percent of the land in Arizona is made up of Indian Reservations. These reservation lands represent a very valuable resource and the Indian Tribes are very interested in its wise use. They expressed an active interest in the Arizona Land-Use Experiment very early in the program, but the use of this information to date has

consisted mostly of the location of boundaries, of roads, waterholes, and to define encroachment onto tribal lands which have resulted from imperfect definition of boundaries. Very recently there has been a revival of interest within the Indian community and they are now in the process of project formulation to use the remotely-sensed information for resource management, and to train their own people in its use. This new program is discussed in detail in Appendix F.

USE BY PRIVATE SECTOR COMPANIES

The largest and by far the most active users of the information derived from the Arizona Land-Use Experiment are the private sector companies. At first, this was a somewhat unexpected finding of the surveys and a number of these companies were contacted to discover the reason behind the heavy use of the information. It was found that the private sector companies use the information in the planning phase of almost every project which utilizes any sizeable piece of land. They use the information for direct planning purposes and to assess the project's impact upon the environment. In addition, they use the information to determine zoning changes which may be needed and to support their claims of compliance. In addition, many of these companies are highly skilled in the use of this information and they prepare environmental impact assessments for others, either the government groups or other commercial users. A detailed discussion of their uses is given in Appendix G.

Arizona Public Service Company. Arizona Public Service Company is a privately owned utility which supplies power to 325,000 customers in central Arizona and owns and operates its own power plants. In addition, it owns and maintains its power transmission lines which stretch over great distances as its power plants are located, in the main, in remote parts of the state. Population growth and increasing industrialization has resulted in the need for expansion of these transmission lines, and it is in the design of new lines and in assessing their environmental impact that APS makes heavy use of the orthophotoquads and the U-2 imagery.

Use of the ALUE information is not just to determine the environmental impact but, also, to determine the engineering and construction costs. It is the balance between engineering and construction costs and environmental acceptability that is being evaluated. In a typical case of a power line stretching several hundred miles, several thousand square miles of territory are examined; typically these studies cost from one half to one million dollars.

Salt River Project. The Salt River Project is a membership owned utility that supplies irrigation water and electric power to its 240,000 customers. It owns and maintains about 700 miles of transmission lines within the state and is undergoing a major expansion program, some two billion dollars within the next five years, and a good bit of this expansion is in its power distribution system. SRP makes major use of the orthophotoquads and the imagery in the location and design of these power lines. Its use of the information is much the same as that of the Arizona Public Service Company described earlier.

Southwest Forest Industries. This company and its subsidiaries process, harvest, and sell forest products from trees to the finished product, and have extensive land holdings in the Western and Southern parts of the United States. They are presently making major use of the ALUE information to harvest large stands of timber in Northeastern Arizona. They are using the U-2 imagery and the orthophotoquads in the re-harvesting of a forest that was logged some 80 years ago. The remotely-sensed information is used to identify the boundaries of old leases, roads, trails, old railroad rights-of-way, and the conditions of bridges and roadbeds. In addition, it is used to identify stands of timber ripe for cutting. In a general way this information is used to plan the harvesting operation, and is considered a major tool by the planners.

Gitter-Louviere Engineering, Inc., Consulting Civil Engineers. This is a small firm of civil engineers who make use of the ALUE information in their major activity which is making surveys and preparing plans for subdivisions and recreational area development in Northern Arizona. They make use of the ALUE information in the following ways:

- a) Large-scale searches for areas generally suited for subdivision.
- b) Detailed surveys of land type, vegetation cover, access roads, and ground water supplies of the better candidate areas.
- c) Presentation of findings and recommendations to their customers.

They believe that remotely-sensed information is the most useful new tool for civil engineering studies that has been developed in the last 20 years.

Sergent, Houskens, and Beckworth, Consulting Engineers. This firm handles land development projects, but have not used the ALUE information on past projects. They have, however, obtained copies of the imagery and orthophotoquads

of the areas of future interest and plan to use the information in the planning of future developments.

This firm is typical of many who are just becoming aware of the cost saving possible through the use of remotely-sensed information over the more conventional methods. The information spreading among these groups seems to be by word-of-mouth of success stories among peer groups, which is a very effective mechanism in the technology acceptance process.

Keith Shrives, Consulting Engineer, St. Johns, Arizona. Mr. Shrives is a civil engineer, who heads a small group of engineers and surveyors that serve the Northeastern part of Arizona. They have done much of the work brought about by the sudden expansion of the town of St. Johns caused by the construction of a Salt River Project power plant located near the town. They use the ALUE information and the products developed from it as a design tool for the expansion of the town facilities. In Mr. Shrives opinion this information provides civil engineers with a very valuable tool, and he has stated that he plans to use it on other projects in Northeastern Arizona.

Wirth Associates, Planning and Design Consultants. Wirth Associates is a young, active, group who provide both the technical and management talent to address all factors relevant to overall project design. They handle the economic, social, and environmental concerns in addition to providing the planning and design function. Their headquarters are located in Billings, Montana with field offices in Phoenix, Arizona; Denver, Colo.; Cheyenne, Wy. and San Diego, Ca. Remotely-sensed information is a standard tool for them, and they are representative of a new breed of company who use this information to prepare environmental assessment statements for groups who do not possess the necessary talents in-house. They were the most highly skilled organization in the use of the information encountered in the survey, and they would very much like to see projects like the Arizona Land-Use Experiment extended to other states as it was so valuable to them in their work in Arizona.

Page Land and Cattle Company. The Page Land and Cattle Company is one of the largest cattle ranches in the Southwest. The Arizona part of their holdings is something over one million acres. They first used the orthophotoquads to inventory water tanks, ponds, and other sources of water for their cattle. In the course of this study, they soon discovered from the use of the infra-red imagery that they could easily trace water run-off regions or alluvial fans that fed

their water-holding stock tanks. They are presently designing additional water storage basins which will allow them to better utilize their grazing lands. This use of remotely-sensed information has led to their investigation of the use of Landsat information for better range land management. They are a prime candidate for the application of Landsat information to range land management.

Pioneer National Title Insurance Co. Pioneer is a large company that handles the capital generation and insurance of industrial site development, recreational area development, and large subdivisions. Their interest in the orthophotoquads and the imagery is the ability to obtain an independent check on the value and potential growth of the areas they insure. They have made a study of the value of remotely-sensed information to fulfill this function and believe it will be a valuable tool for them. At the present moment they have not utilized this information, but plan to use it in the future.

Summary of the Use by Private Sector Companies. Private Sector Companies represent the largest, most active, and the fastest growing use of the information supplied by the Arizona Land-Use Experiment. The information is used mostly in the design phase of projects involving the use of land, and to evaluate the impact upon the environment of these projects. In some cases, the design work is done by the company developing the project, and in other cases it is done by companies who specialize in this type of work.

While the survey covered only a limited number of private companies, those surveyed covered the following fields:

- a) Utility companies
- b) Forest industries
- c) Consulting engineers
- d) Design and Planning
- e) Cattle ranches
- f) Financial

In all of these companies the use followed the same thread found in other groups, use of the orthophotoquads for location purposes and of the imagery for land use features.

SHORTCOMINGS OF THE INFORMATION PRODUCED BY THE ARIZONA LAND-USE EXPERIMENT

One of the strengths of the interview method of obtaining information is that the users are very free to express their opinion of the usefulness of the information and of its faults and shortcomings. Almost every user contacted had some comment concerning the shortcomings of the present information. When viewed in perspective, these complaints did not seem to inhibit the use of the information in any major way, but because some of the shortcomings are correctable they will be stated here in the hope that they may be avoided in future projects and corrected in the present case. Probably the major complaint expressed was that the user did not have enough trained people to fully utilize the information, or that there was not enough time to convert from the older ways of doing things to the use of the new technology. In the strict sense this is not a shortcoming of the information or its format but rather a shortcoming of the acceptance process. As the remotely-sensed information has proven to be very useful, this problem will disappear with time, and in defense of the acceptance system in use in Arizona, it must be said that the University of Arizona has recognized the problem and is working upon its solution by offering classes in the interpretation and use of this information. Their program will include work through the Masters level. In addition, Arizona State University and Northern Arizona University are planning to offer similar classes starting in 1977.

The second most voiced complaint about the information was the difficulty and the time required to obtain the imagery from the EROS Data Center in Sioux Falls. These complaints ranged from resigned acceptance of the slowness of the Federal system to outright rage that the system could be so slow. Just what can be done about this problem is unclear, but it is one of the most serious causes of delay or abandonment of the use of this information.

Another complaint, frequently heard, was that the images themselves were of poor quality. The EROS Data Center is blamed for this also, even though the blame may well be unjust.

During the course of the investigation some groups that could have made use of the information, but were not, were contacted in an attempt to discover the reason for the lack of use. The majority of these groups simply were unaware of the existence of the Arizona Land-Use Experiment or of the information produced from it. This is hard to understand as many times other departments within their organization were making use of the information. In an attempt to help this situation, the University of Arizona's

Office of Arid Lands Studies and ARIS are both planning to hold workshops on the use of this information. It is worth pointing out that the press of Arizona have given the Arizona Land-Use Experiment a good bit of coverage since the project was started, and a number of the columnists have devoted space to the project from time to time. In addition, a number of the professional societies have held national meetings in Phoenix, and have presented papers describing the experiment. One of the positive results of the present investigation was to make a number of these potential user groups aware of the institutional arrangements set up in Arizona to foster its use.

There is a rather serious complaint about the age of the information, and that its usefulness is declining because changes in land use since 1973 are not contained in the orthophotoquads or the imagery. Many of the users want to have the state, or parts of it, re flown. Most recognize the difficulty of doing this, and blame it on NASA; others seem willing to begin to use the enhanced Landsat data. At the present time, the state is working with NASA to introduce the Landsat information into the Arizona system of users.

In retrospect, the positive comments on the usefulness of the information far outweigh the complaints, and steps are being taken to correct some of the shortcomings. It is hoped that the service provided by the EROS Data Center will improve in the months ahead.

BENEFIT AND IMPACT

There are several ways that the benefits of new technology may be viewed. One commonly used way is to view benefits through the eyes of the cost accountant. In this method the assumption is made that whatever is to be done has some known value and the benefit comes from the reduced cost of doing the job at hand. This method works well whenever the value of the product produced can be quantified easily, but is of limited use whenever the benefits are a mixture of the intrinsic and the easily measurable. In some studies of the cost effectiveness of remotely-sensed information systems the emphasis is put on the reduced cost of obtaining data from the remote system compared to some more conventional system. In this scheme the satellite, the aircraft, and the pick-up truck are matched in a race to obtain data on land use, for example. In this fable the satellite wins handily and the pick-up truck loses miserably, generally by several orders of magnitude. The fallacy in all of this is the presumption that data, of itself, has value. In fact, data and the information produced from it have little or no value unless it is used for something. In this section of the report, the benefits resulting from the use of the information provided from the Arizona Land-Use Experiment will be presented. The types of benefits will be identified and some comments will be made about the magnitude and impact of these benefits upon the Arizona Community.

Benefits themselves are a mixed bag. The most easily understood and measured are the ones that result from using this new method of information gathering in some phase of a well known project and counting the cost saving. On the other end of the spectrum is the benefit resulting from the preservation of some natural resource or scenic area. There is little agreement upon the dollar value attached to the preservation of wilderness areas for future generations, although most would agree that it is beneficial. Midway between these two extremes lies an area of use where the benefits are difficult to assess, at least in any real way. This area of use is regulation compliance. Concern for the protection of the environment together with the scarcity of money to fund projects have increased the amount of information needed for planning purposes by several orders of magnitude within the last decade. In some instances, the sheer weight of information needed to plan and justify projects has increased to the point where this facet alone may be the deciding factor on whether to proceed. In several instances the availability and low cost of the remotely-sensed information have relieved this situation. To the project planner the remotely-sensed information is a benefit, but the nagging doubt remains about the need for all of this information in the first place.

Much of the information produced by the Arizona Land-Use Experiment is used in the decision making process that determines the uses or regulation of the use of land and its resources. Generally, the presumption is made that better decisions result from better and more complete information in the hands of the decision maker. While this is probably true in the general case, it is impossible to prove for a specific decision simply because there is little basis for comparison. Therefore, decisions made on the basis of good information are presumed to benefit the community, but only the passage of time will allow this point to be proven in any hard way.

The point of this discussion is that the benefits and real impact of the application of remotely-sensed information cannot be neatly fitted into the cost accountants balance sheets. The value of the benefits, therefore, depend upon mature human judgement that weighs the intrinsic and the easily quantified, and strikes a balance with the costs.

BENEFIT AND IMPACT BY COUNTIES, CITIES AND TOWNS

<u>Pima County.</u>	Regulation of land use. Formed basis for regulating urban encroachment on semiarid lands.
<u>City of Tucson.</u>	Regulation of land use. Restricted development in flood prone areas.
<u>City of Tucson.</u>	Justification of airport expansion with acceptable impact upon environment.
<u>Cochise County.</u>	Regulation of land use. Restricted development to regions not subject to flooding.
<u>Mohave County.</u>	Regulation of land use. To control development in flood prone areas.
<u>Apache County.</u>	Regulation of land use. Determine compliance of new subdivisions with regulations.
<u>Apache County.</u> <u>Town of St. Johns.</u>	Regulation of land use. Definition of flood plain led to approval of grants, loans, and loan insurance for town expansion. Saving of 1/3 cost of facility expansion projects designs.

<u>Graham County.</u>	Regulation of land use. Used definition of flood plain boundary as basis for regulation of new subdivisions.
<u>Yuma County.</u>	Regulation of land use. Restricted development in flood channel areas. Established standards for protective structures and drainage ways. Agriculture only allowed in flood prone areas. Allows agriculture to be conducted without threat of land speculation.
<u>Yavapai County.</u>	Regulation of land use. Erosion and flood regulations to protect public from speculators selling land unsuitable for housing.
<u>Maricopa County.</u>	Regulation of land use. Justification of greenbelts, lot sizes, and drainage requirements.
<u>Maricopa County.</u>	Obtaining convictions in land fraud cases and other criminal trials.

Summary of Benefits and Impact upon Counties, Cities, and Towns.

While these benefits may not seem spectacular, they are unquestionably of great importance to the counties and towns of Arizona. For the first time, these political divisions have accurate tools to base land use regulations on and to justify their actions on solid information. These tools have been a major help in controlling the runaway development of land that has taken place in the last ten years. It has also given them a major tool to combat land fraud which has been epidemic in Arizona in the last ten years. It is worth pointing out that most of these groups only obtained these tools within the last year or two, and the benefits are just now beginning to be felt. The impact of this new information and the tools it develops is large by any scale of measurement. The counties and towns using this information encompass 88% of the population of Arizona and 66% of its land area. There is every reason to believe that these benefits will continue to grow within the regions already having the tools, and that regions not now having the tools will obtain them. Navajo County is presently making arrangements with the University of Arizona's Office of Arid Lands Studies to obtain land use maps. It is worthwhile pointing out that most of these counties obtained their tools as a result of work done by the Office of Arid Lands

Studies and represents a very valuable contribution to the people of Arizona by their university system.

BENEFIT AND IMPACT UPON STATE GOVERNMENT

Arizona Department of Transportation. ALUE information made possible the Department of Transportation's Accident Location, Identification, and Surveillance System (ALISS). ALISS is used to determine where accidents happen and is a basis for corrective action. Present fatality rate is only 58% of that ten years ago before ALISS was in operation. Present economic loss due to motor vehicle accidents is estimated at over \$200 million per year. While ALISS can only share in the credit for the saving of life and property, even a small contribution is a large benefit. For example, if the contribution to this reduction in life and property by ALISS is only 25% the contribution would be \$50 million and 170 people's lives per year.

Potential benefits from information include ability to produce contour maps at 1/4 to 1/10 the cost using old methods. Costs of preparing contour maps vary depending upon the terrain and the scale, but to prepare 7-1/2 minute quadrangle maps to USGS standards costs about \$5,000 to \$10,000 per square mile by standard methods. To date not too many of these maps have been prepared, but the potential savings are large.

Arizona Land Department. The Land Department administers about 9.6 million acres of state land and has an income from that land of some \$12 million. ALUE information is used as a standard tool by the department in land transactions and one benefit is having good information about the land to use in setting lease rates and in land trades. No estimate is available on dollar cost of benefit. Land Commissioner feels major benefit is in being able to carry increasing work load without increasing staff. The impact of the ALUE information on the land department is large by any measure, see Appendix D.

Arizona Department of Revenue. State and local taxes in Arizona amount to about \$1-1/2 billion per year with the state collecting about 65% of the total. ALUE information is used in the appraisal process and even a small contribution due to better or more accurate information is a large sum. No estimate is available on the dollar value of the benefit from this source.

Arizona Office of Economic Planning and Development. Benefit is simply better information being used in the planning function.

Arizona Water Commission. Benefit comes from better information on which to develop state water policy. One direct benefit has resulted from the Office of Arid Lands Studies of vegetation in the region of water diversion structures, in that now structures are built to allow water to slowly seep through structures thus minimizing impact upon vegetation. Another is location of ground cracking and settling due to ground water withdrawal.

Arizona Oil and Gas Commission. Geologic maps produced for the Commission by the Office of Arid Lands Studies have generated more exploration for energy and minerals in Arizona. No finds have been reported. Benefit is renewed activity in this field.

Arizona Bureau of Mines. Important new tool for geologic exploration for regions of potential mineral concentration. Also tool to provide basis of regulation of mining activity. Very heavy use by mining community indicates potential benefit.

Arizona Solar Energy Research Commission. Provides clear concise presentation of sites for solar energy power plants. Provides information on impact of solar energy developments on surrounding communities.

Summary of Benefits to State Government. Major benefit is in providing sound information as a base for policy and regulative decisions. Provides basis for justification of regulative actions, and has been used to provide information and problem definition for legislative action. The active growing use rate by state agencies indicates a major impact on the activities of the state in the area of land use and regulation, and on assessment of the impact of projects involving use of land upon the environment and economic life of the community.

BENEFIT TO FEDERAL AGENCIES IN ARIZONA

U.S. Department of Agriculture. Benefits to the Department of Agriculture maps, vegetation maps, and land use maps produced using ALUE information to determine corrective actions to be taken on land clearing for brush

control, overseeding to control water run-off, and for treatment of diseased areas. These maps also result in a saving in the field coordination activities of the department. These benefits are all in the general area of providing tools to the decision makers on land condition, corrective actions, and regulation compliance. There is a large potential benefit in the area of crop harvest forecasting when the Landsat information becomes an every-day tool.

Bureau of Land Management, U.S. Department of the Interior. Benefit to this agency is in the determination of land use, land type, vegetation cover, and in wildlife management. The benefit is of two kinds, one saving of time and money in producing these maps and in the actions taken as a result of this detailed information which is available to decision makers. In addition, they reap considerable benefit in the use of this information in the preparation of environmental impact statements on proposed projects involving their land. Costs in this area are estimated to be reduced by about 1/2 by the use of the ALUE data.

National Forests. Inventories of the forests produced from the ALUE information have resulted in several kinds of benefits: Fast, accurate location of trails needed to bring equipment and men to fire areas, to accurately locate extent of flood damage and plan clean-up work, and general information to the public who use the forests. Another benefit to the public results from the use of these accurate maps to identify regions of the forest closed to the public in times of high fire danger.

Use of the imagery resulted in the assessment of the damage to the forests by off-the-road vehicles and have resulted in strict regulation of the use of these vehicles. Forestry officials feel this is a major benefit in the preservation of the natural beauty of the desert terrain which was being seriously damaged.

Use of the maps and imagery to accurately assess the extent of usable range land has resulted in a benefit in the setting of range grazing fees and in the control of overgrazing of the forest grasslands. In addition, a sizeable benefit may be realized when the program to increase the waterholes is finished. The ALUE information allowed this project to be designed at very low costs compared with other, older methods.

Geological Survey, Water Resources Division, U.S. Department of the Interior. Benefit to this agency is accurate determination of the area of the Arizona snowpack and of the watersheds that feed the Salt River. Benefit is in the use of this accurate information in a computer model of this watershed. Saving of one percent of the water is estimated to be worth three million dollars in increased crop value per year. System has not been in operation long enough to yield actual savings over those of older methods of control.

National Park Service Benefit. The Park Service benefit is in the same areas as those of the National Forest discussed earlier. The parks are very heavily used by the public, some 15 million persons visit the Arizona parks per year. The maps and the imagery are used to assess the damage to the park vegetation by the visitors and are used as the basis for taking corrective action. In addition, they are used to determine the extent of encroachment of non-native vegetation on the habitat of the natural plants and are used to plan corrective actions to preserve the native plants. These benefits are intrinsic in nature and do not have an easily estimated dollar value. In these cases the extent of the use can be taken as a measure of the benefit, at least in the minds of the park managers.

Summary of Benefit and Impact on Federal Agencies. In general the benefit and impact of the Arizona Land-Use Experiment on the Federal Agencies in Arizona is much the same as those to the state agencies discussed earlier. The benefit comes from the use of sound information as a base for policy and regulative decisions. The use and benefit in planning of projects and in the assessment of environmental impact is also large, but again, these benefits are in the area of the intrinsic and it is difficult to assess the dollar value, at least at this time. The impact upon the Federal agencies is sizeable as indicated by the heavy use discussed in earlier sections of this report. A more complete discussion of the details of the specific benefits is given in Appendix E of this report.

BENEFIT TO THE PRIVATE SECTOR

Utility Companies. Benefits to this industry result from use of the information in the design and environmental impact assessment of power transmission lines and pipe lines over long distances. Use is extensive and some idea of the magnitude of the benefit can be obtained from some sample uses. One company budgeted one million dollars for initial studies of the environmental situation and they estimate

that the costs would have been three times this amount without the ALUE information. In another case \$500,000 was spent in initial environmental studies before the information became available; company estimates indicate that the work could have been done for \$100,000 using the information supplied by the Arizona Land-Use Experiment. Benefits also are realized in the actual design of power line placement, where cost savings of 1/2 to 1/3 of the older methods are estimated. Potential benefits in the future appear to be large also; one company has budgeted two billion dollars on expansion of facilities within the next five years and intend to take full advantage of the ALUE information in the design phases of the work.

There is another intrinsic benefit to this industry. Before the ALUE information became available the costs and time required to meet the environmental regulations was so large that it was beginning to have an influence upon the decision making process on the desire to expand facilities to meet the increased demand for energy. The availability of the ALUE information has relieved this situation somewhat.

Consulting Civil Engineers and Planning and Design Companies. Probably the largest single use sector is represented by this group. While actual dollar magnitudes of the benefit are not available, estimates of the savings of time and money on the design and environmental assessment of projects involving land use by these companies give some indication of the magnitude. Arizona construction industry does about 1.4 billion dollars per year and non-residential and heavy engineering construction accounts for about \$760 million. Initial design studies and environmental assessment costs are estimated to run 3 to 5% of total costs or about 30 million. Good estimates by several of these companies indicate that the use of ALUE information can cut these costs in half at the very least, thus indicating a potential benefit of about \$15 million per year. Although a complete survey of these companies was outside of the scope of the present study, the use by private sector companies indicate that much of the use was in this area. Mail surveys indicate that the private sector companies make up 50% of the total user group and use in this area of work is indicated by 50% of the users surveyed. It is not unreasonable to assume that at least half of the initial studies and nearly all of the environmental assessment work make use of the ALUE information which would put the total benefit to this group in the 10 million dollar range. Of course, these are rough estimates but the order of the benefit is large by any set of numbers.

Timber Harvesting Companies. Total income by timbering companies in Arizona is about \$44 million per year. Most of this timber represents second-growth trees which means that the forests have been logged at least once before. Most timber companies utilize the old roads for the present operation, and it is in the planning phase of these operations that a benefit is realized by using ALUE information. One company surveyed in detail indicated a saving of about \$300,000 and about one year's time by use of ALUE information over older methods. This was a large operation in Northeastern Arizona, but no estimates of the probable income from the project are available; therefore, about all that can be said about the magnitude of the benefit to this group of companies is that it is greater than \$300,000.

Cattle Ranches. Cattle production on the range is a large industry in Arizona running about \$500 million per year. The number of cattle is limited by the usable range pasture grass which is in turn limited by available water for the cattle to drink. In other words, cattle will only range near water holes. In order to grow more cattle the distribution of water holes over the available grass land must be increased. The ALUE information is being used by the private ranches to design expansion of this watering system by damming up streams and washes to fill ponds during the rainy season. These projects are just getting underway and there are no estimates available on the size of the benefit expected, except that most of the ranches feel it is well worthwhile and worth the investment of time and money to undertake the project; however even a 10% expansion of this industry would be a sizeable benefit to the state.

Summary of Benefits and Impact to Private Sector Companies. The benefits to this group of users is large and lies in cost savings in initial design studies on projects involving the use of land and in assessing the impact upon the environment to meet regulations of this type. Of course, use of the new information provided by the Arizona Land-Use Experiment also saves time, as in many areas of application the use of ground crews to gather information is nearly eliminated. In addition to saving money and time, this information has permitted private companies to cope with the increasing demand for justification of new project brought on by increased government regulations.

The dollar value of the benefit is in the order of \$10 million per year, and could easily be much larger. This is a highly competitive field and companies engaged in initial design of projects and their justification and environmental assessment will not, understandably, reveal magnitudes of the savings involved. These estimates are arrived at by interviews with several of the companies (given in Appendix G and from economic data taken from the Arizona Statistical Review, 31st Annual Edition, Valley National Bank of Arizona, 1975) together with the size of the industries involved.

APPENDIX A

INSTITUTIONAL ARRANGEMENTS FOR THE INTRODUCTION OF REMOTELY-SENSED INFORMATION INTO ARIZONA

Introduction. Institutional arrangements for the application of any new technology into an ongoing user system are the single most important factor in the success of its adoption. There are at least two important reasons for this: One, the correct institutional arrangement allows the new technology to be introduced and understood by the user community, and two, since no new technology is ideally suited to a specific set of uses, the correct institutional arrangement allows the technology to be adapted to the special needs of the users. In the main, the adaptation process must be accomplished by the user community in order for the new technology to become their tool. New technology cannot be forced upon a system of users, they themselves must accept it and take the lead in its use.

Remotely-sensed information has been widely accepted and used in Arizona and the institutional arrangements for its introduction can justly claim a large share of the credit. Since technology introduction and acceptance is an extremely important part of the utilization process, the arrangements used in Arizona will be reviewed with the hope that the review will be useful in other like projects. In addition, some of the shortcomings will be pointed out, again with the hope that these shortcomings can be avoided in future projects.

The Institutional System Used. Three separate groups were used to introduce and foster remotely-sensed information into Arizona's governmental and private sector system. They are: The Office of Arid Lands Studies of the University of Arizona; the Department of Interior EROS Applications Assistance Facility, located in Phoenix; and Arizona Resources Information System within the Arizona Department of Revenue in Phoenix. Information exchange among these groups and with the user community was formalized by a Policy Advisory Committee appointed by the Governor of Arizona. The Policy Committee consists of the heads of the nine State agencies, the University of Arizona, the U.S. Department of the Interior, and the Project Director of the Arizona Resources Information System. One other important ingredient in this group was the strong personal interest of both of the Governors of Arizona in the success of the project since it was started in 1972.

While the objective of these organizations was to introduce and foster the use of remotely-sensed information in Arizona, the style and methodology differed among the groups. In

order to make differences clear and to point out the inter-relationships which have contributed to the success of this venture it is interesting to trace the history of these groups since the beginning, and to point out how the interest in application of remotely-sensed information got started in this state. The background, the specific objectives of the three groups, their projects and some of the benefits will be given in the next section.

Background. In the early 1960's photographs from the early space flights of the earth's surface indicated that much could be learned about our resources using this technique. As a result of these photographs the university and space communities began to explore ways to exploit this new opportunity. Toward this end, NASA initiated a series of projects to define the usefulness of this new tool, to define the needs and interests of the user community, and to provide remotely-sensed data from high-altitude aircraft to the user community and to university research workers in advance of the earth resources satellite system. There was a high interest in this problem in Arizona due to the need for better management of their land and the proximity of several military groups who had used Arizona as a testing ground for military remote-sensing systems.

Office of Arid Lands Studies.

The University of Arizona was given a NASA grant to study this problem in 1970, two years before the first earth resources satellite was launched. The objectives of this grant were:

- a) To establish a multidiscipline resource and environment team in Arizona capable of utilizing remote-sensing data and to define the problems of the region.
- b) To provide an exchange of information.
- c) To determine the future information needs of the Arizona resources and environment community, and prepare recommendations on the facilities, instrumentation, and training that should be developed to support the community.

In 1971 the University of Arizona started the Applied Remote Sensing Program which was supported by a second NASA grant entitled, "Applications of Remote Sensing to State and Local Governments." The objectives of this program are:

- a) Work jointly with local and state agencies whose responsibility lies in planning, zoning, and environmental monitoring.

- b) Assessment of the application of remote sensing techniques to specific agency problems, their solution, and the resulting policy decisions.

As a result of the work done under these early NASA programs it became evident that high-quality remotely-sensed data would be very valuable as a tool for local and state governments before the satellite information became available, and the decision was made to utilize high altitude aircraft to supply this data on a trial basis. Arizona was chosen for this project, and in 1972 an agreement was entered into by the State of Arizona, NASA, and the U.S. Department of the Interior to generate the data and to promote its application to problems of the state. The program was known as the "Arizona Land-Use Experiment" in which NASA would photograph the entire state from high-altitude aircraft, the U.S. Geological Survey would produce ortho-photo quadrangle maps from the aircraft imagery, and the state of Arizona would incorporate this information into ongoing and future State Agency Programs.

Arizona Resources Information System.

In 1972 the Arizona Resources Information System (ARIS) was set up to carry out the Arizona part of the agreement. The objectives of the ARIS program were:

- a) To provide a centralized information bank for use by state agencies in their daily operation, and to participate in information sharing with federal agencies, local governments, and private enterprises.
- b) Provide a standardized geodetic coordinate base and digital map output of the state for the ARIS users.
- c) Centrally locate governmental remote sensing capability and provide assistance to ARIS users.
- d) Study and evaluate new applications for remote sensing techniques as applied to state agency operations.
- e) Maintain an historical, environmental record of the state from remote sensing for future reference.

The Arizona Resources Information System was part of the Office of the Governor and its first director was Mr. Carl C. Winikka who had previously been employed by the Arizona Department of Transportation which contains the states major map making capability. The first major job of the new group was to coordinate the project to transform the U-2 imagery into orthophotoquad maps and to introduce both the maps and the imagery into the state's mission agencies and the public. The support for the new group was supplied by the State

Legislature who appropriated \$408,000 for its operation during its 1972-1973 session. As the orthophotoquads became available ARIS also instituted a number of programs to introduce these maps into the ongoing and future state programs.

The Arizona Land-Use Experiment generated wide interest in Arizona at that time, partly due to the active support it received from the Governor, the press and scientific societies. As a result of this public support, it was not long before ARIS began to generate an active body of users which has characterized its operation since that time.

EROS Applications Assistance Facility.

The EROS Applications Assistance Facility is operated by the Department of the Interior's Earth Resources Observation System (EROS) with the objective to promote and help users and potential users of remotely-sensed information to solve their problems. The Facility is located in Phoenix, Arizona and is staffed and funded by EROS.

The Department of the Interior was one of the first federal agencies to become interested in the application of remote sensing in Arizona. In 1970 they established the Arizona Regional Ecological Test Site Program at the request of NASA to consolidate research efforts designed to test and evaluate air and spaceborne sensor methods and applications to environmental and resource problems of southern Arizona. This interest led EROS to become a member in the three part agreement which led to the Arizona Land-Use Experiment. In addition, they provided support to the University of Arizona to gain the university's talents and interest in this problem. The size of their support matched the support provided by NASA in this early period.

During 1972-1973, EROS set up their main data center near Sioux Falls, South Dakota to handle all of the NASA generated space and aircraft imagery, but it was realized that additional regional centers would be needed to supply the information to the users. In this light EROS organized the Applications Assistance Facility Program which consisted of nine centers located throughout the United States. One of these centers is located in Phoenix.

The Applications Assistance Facility in Phoenix had two objectives:

- a) To provide public access to the Sioux Falls data base and,
- b) to provide assistance and advise to the user groups.

In order to provide this function a computer browse file was provided which has access to all of the data stored in the

Sioux Falls facility. The facility also is equipped with color viewers, zoom transfer scopes and stereo viewers.

The Phoenix Applications Assistance Facility also houses microfilm reference copies of the extensive Department of the Interior aerial mapping photography, NASA aerial photography, and the Gemini, Apollo, Skylab, and Landsat space imagery that is archived at the EROS Data Center. Computerized geographic searches of this data base and public assistance in ordering copies of these data from the EROS Data Center are provided. Moreover, scientific personnel at the Facility are available for the assistance of users in applying remote-sensed data to resource and environmental problems.

PRESENT STATUS

Office of Arid Lands Studies.

The University of Arizona's Applied Remote Sensing Program has, since its inception, carried out cooperative programs with local, state and federal agencies. The projects are designed to have decision-making impacts as a principal goal. After the projects have been completed it is their hope that the involved agencies will either use these new techniques in house, or will turn to private industry to produce similar products. Since 1974 they have created a core staff to work specifically on these projects, but the Program utilizes graduate students wherever possible within the project framework. They have a director and an assistant director supported by the University, one professional, one technician, and four research assistants supported from Program funds.

The support for the Applied Remote Sensing Program was originally from a NASA grant (still in effect), but recently has grown to include grants from the Bureau of Land Management, the National Park Service, Indian reservations, Councils of Government, state and local agencies. Very recently they also obtained a grant from the Office of Technical Assistance, Economic Development Administration (EDA), U.S. Department of Commerce. The group has been very active in working with a wide variety of users as indicated by a list of the projects as follows:

1976

- a) Natural Resources Inventory of the Papago Indian Reservation and Eastern Pima County.
- b) Heat Loss Monitoring for the city of Tucson.
- c) Vegetation Mapping...Safford District.
- d) Remote Sensing Analysis of the Petrified Forest.

1975

- a) Assessment of the Impact of Water Impoundment and Diversion Structures on Vegetation in Southern Arizona (ongoing in 1976).

1974

- a) Remote Sensing Techniques Applied to County Land Use and Flood Hazard Mapping. Apache, Graham, Yavapai, and Yuma Counties (in progress during 1975).
- b) Southern Arizona Riparian Habitat: Spatial Distribution and Analysis (in progress during 1975).
- c) Northeast Arizona Oil and Gas Study.
- d) Tucson International Airport Master Planning Study.
- e) Mohave County Land Use Planning.

1973

- a) Delineation of Geothermal Reservoirs in Southern Arizona.
- b) Development of Forest Stocking Equations by Multiple-Stage Remote Sensing.
- c) Advanced Land Use Planning in Pima County.
- d) Study of the Hydrology of Earth Stock Tanks on a Semiarid Watershed.

In addition to its project work ARSP also functions as a service organization keeping individuals and agencies informed about remote sensing techniques by means of a newsletter distributed to about 1,000 individuals, technical paper presentations, and help to individuals from the staff and the available imagery and library sources at the Arid Lands Office. The library sources are extensive, for example they receive the Landsat imagery every 18 days from NASA.

Benefits

The benefits from this project to the state of Arizona are considerable by any standard of measurement. As mentioned earlier, their main objective is to complete projects that will result in important policy or management decisions.

A short list of the resulting decisions is included below, and a more complete discussion of the impact and benefit of their work is given in the following reference: Mouat, David A., Miller, David A., and Conn, Jeffery S.; Applied Remote Sensing Program Annual Report, OALS Bulletin 13, Office of Arid Lands Studies, University of Arizona, June 1976.

Graham County: Used topic maps to change federal floodplain boundary that was in error. Developed zoning criteria for areas subject to flooding.

Yavapai County: Used results of project work to restrict and control speculative land subdivision.

Yuma County: Used information to develop new criteria for zoning of floodplain lands.

Apache County: Used information to check subdivision compliance with drainage regulations.

Arizona Water Commission: Work resulted in new designs for water impoundment structures to minimize or eliminate impact upon vegetation and wildlife.

State Land Department: Used information as basis for sale of mesquite fuelwood sales.

Arizona Resources Information System (ARIS).

The main thrust of the ARIS program since its inception has been to make the information generated through the Arizona Land-Use Experiment available to the wide variety of users throughout Arizona. In contrast to the University of Arizona group, ARIS has produced only a small number of specific application products in-house, but have concentrated their efforts to helping user groups generate their own application products. In this way, they have generated a large number of users in both the private sector and within the government community. Their user group is very large and represents a wide range of uses. Their files indicate that over 1,600 users of various kinds have used their facilities and information since their inception.

A study of the uses and benefits of the Arizona Land-Use Experiment indicate that ARIS is meeting the objectives of their charter and that the benefits to the people of Arizona are very substantial. Specifically, they have completed the project to provide orthophotoquad maps of the entire state, make the imagery, in several spectral bands, available for use, have provided the tools necessary for the users to view and use the imagery, and have maintained a file of this information which is accessible to the users from a

centralized location. Most importantly, they have studied and applied to sample problems the new imagery becoming available from the Landsat Satellites which promises to extend and increase the benefits to the people of Arizona beyond those possible from the aircraft information generated by the Arizona Land-Use Experiment.

ARIS is presently located within the Arizona Department of Revenue. The former Governor of Arizona moved ARIS into its present organizational home because he felt that that department had a need for information on a very wide variety of subjects and, since many of the other state agencies use information generated in the Department of Revenue, that location would foster wide use of the ARIS information. Although this move was made a couple of years ago, it is only recently that the Department of Revenue is making major use of this resource. The other state agencies, on the other hand, have increased their use of the information. Control of ARIS programs by the Department of Revenue has been minimal in the past, probably due to the small amount of use they have made of ARIS information. This lack of control has had two effects; one, the Arizona Resources Information System has expanded its interest in Landsat information and has probably worked more closely with the wide variety of users than it might have had if the parent department had taken a stronger hand, and two, ARIS was not strongly supported in the legislative budget hearings by the parent organization and as a result their budget suffered somewhat. As a result of the legislative questioning of the benefits and needs for ARIS, the governor's office is presently re-examining the entire problem of the correct organizational home for ARIS, and the Department of Revenue has taken a strong interest in its function as a parent and is preparing a strong budget defense of ARIS for the upcoming legislative session.

There is a lesson to be learned from this experience. If an agency with the objective of promoting the application of remotely-sensed information is placed within a larger parent organization, the parent organization must be willing to support its new child and allow it to work with other agencies and groups, but at the same time must be enough of a user of the information to be able to generate a strong defense of the group to state legislatures and other governmental bodies who question the benefit of any group using tax funds. It is very difficult for the information generating group to defend itself as all of its arguments are self serving by definition. Their defense and support must come from their user groups to be credible.

Oddly enough some good came from the legislative review of the need to continue ARIS. The Governor and his staff became interested enough to examine the entire problem anew, and the Department of Revenue began to realize that they had

need for the information that their own group was generating. As a result of these reviews ARIS now has a new lease on life and the Governor and the home agency is strongly supportive of ARIS undertaking the job of introducing the Landsat information into the state, and to take over the functions of the EROS Application Assistance function, which is being phased out in the Phoenix region. The traditional function, that of supplying help and information to user groups also seems to be receiving strong support from both of these groups.

EROS Applications Assistance Facility.

The Applications Assistance Facility, as mentioned earlier, was started in Phoenix about 1972-1973 to make the data stored in the Sioux Falls facility easily available to users in central Arizona. From its inception it has assumed a low profile and has allowed the state agencies and ARIS to take credit for much of its work. There is little doubt that this attitude on the part of AAF has contributed to the introduction and use of remotely-sensed information, but there is some question as to whether by doing so it did not contribute to its own demise. This facility is being phased out and most of its functions are being assumed by the state, namely ARIS. That AAF made a major contribution can be attested to by the number of users that contacted the facility since its inception. Since they started in 1973 they have run about 100 searches a month of the Sioux Falls Facility files for Arizona users, given technical assistance to between 25 and 75 users at their offices, and taken care of from 40 to 100 telephone calls for help and assistance per month. If these numbers are added up over the lifetime of the program they are very large indeed, some 2,000 searches of the Sioux Falls facility for example.

While the costs of operating the facility are not available, they only employed two people. The director, Mr. Herbert Schumann, is a man of exceptional talent and understanding of Arizona's problems and his loss to the program will be strongly felt. It is unfortunate indeed that the region is losing a man of Mr. Schumann's talents at a time when the Landsat information introduction into Arizona is just beginning.

LESSONS LEARNED FROM THE ARIZONA EXPERIENCE

It is not often that one is able to look back on a program without wishing that things had been done differently. With the present program to introduce remotely-sensed information into the life of the Arizona community, one can almost say if the program was to start anew today that little could be

changed. Of course, things could always have been improved, and one area that should have been strengthened is the information dissemination aspect of the program. Information flow even within one organization is one of the most difficult functions of any management. Information flow within and among state, federal and the private sector is even more difficult. The information about the present program seemed to flow in fits and starts. During the present survey of the benefits and impact of the Land-Use Experiment, we found time and time again that groups having similar needs for the information were almost completely unaware of it even though it was in active use in other segments of their own organization. Within the private sector the same things seems to occur. Some companies make active use of the information, feel that it is a major tool and makes money for them while other companies, engaged in similar businesses, will not be aware of the information or its availability. One of the unexpected benefits of this survey is that it has increased the use of the ARIS information simply because we have discussed its use with so many people.

There is no perfect solution to this problem but newsletters, presentation of papers at scientific and engineering societies, and workshops help a great deal. It is important to keep an active program of information dissemination as an ongoing activity. This was the principal recommendation to the Governor's office when asked to point out deficiencies in the program. Implementation of this recommendation is being carried out.

The program in Arizona has been reasonably well balanced between help to the user community and the production of finished products for the user community. The University of Arizona's Office of Arid Lands Studies have produced finished products for many of the users with the hope that they will impact the decision making process and will encourage the users to produce their own end use products or tools, or encourage them to have these use maps, flood control maps and etc. produced by the private sector. ARIS and AAF on the other hand have not produced finished products from the information, except in rare cases, but have concentrated their efforts in help to the user community. It is necessary to do both of these things, and the balance is about correct as judged from the number of private firms who are now engaged in converting the raw information from the imagery to end use products, and from the understanding and use we find within both the state agencies and the federal system.

It is important, also to educate students at the university level in the use of this information. The University of Arizona is doing this, but ARIS has not used many students in its programs. Recently they are beginning to set up programs with the local universities to utilize graduate students.

APPENDIX B

USER MAIL SURVEY

The following are the results of the questionnaires mailed to purchasers of orthophotoquads. A time lag between order date and the mailing of the questionnaire was allowed so as to give purchasers time to make use and evaluation of the product. The questionnaires were mailed on an order-by-order basis and addressed whenever known to the specific individual user rather than his organization. This was true in the great majority of cases and contributed in part to the reasonably high response rate.

Of 243 questionnaires mailed, 110 were returned, a rate of 45%. Since questionnaires were mailed on an order-by-order basis, many users were sent more than one. Of the 110 questionnaires returned, 79 different organizations were represented. The distribution of questionnaires is as follows:

	<u>Sent</u>	<u>%</u>	<u>Ret'd</u>	<u>%</u>	<u># of Organi- zations</u>	<u>%</u>
State Government	24	9.9	7	6.4	5	6.3
Local Government	15	6.2	3	2.7	3	3.8
Federal Government	61	25.1	32	29.1	18	22.8
Universities	14	5.8	5	4.6	5	6.3
Private Sector	116	47.7	59	53.6	44	55.7
Individuals	<u>13</u>	<u>5.3</u>	<u>4</u>	<u>3.6</u>	<u>4</u>	<u>5.1</u>
	243	100.0	110	100.0	79	100.0

Question by Question Results

- A. Describe the intended use(s) of the orthophotoquads as you anticipated while planning your project:

Number of answers 100/110 = 90.9%

	<u>#</u>	<u>%</u>
Base Map	23	23
Development Planning	22	22
Ground Features	17	17
Vegetation, Geology	13	13
Land Development Patterns	9	9
Site Locations	9	9
Mining	4	4
Survey	<u>3</u>	<u>3</u>
	100	100

- B. How well did the orthophotoquads fulfill the desired results expected? Please rank from 1 (best) to 5 and comment.

Number of answers 103/110 = 93.6%

	<u>#</u>	<u>%</u>
1	26	25.3
2	33	32.0
3	31	30.1
4	6	5.8
5	<u>7</u>	<u>6.8</u>
	103	100.0

Average = 2.4

Almost 90% considered the orthophotoquads to be useful for their intended purpose.

- C. Describe any unexpected uses and benefits obtained from the orthophotoquads:

	<u>#</u>	<u>%</u>
Positive response	41	37.3
Negative response or no answer	<u>69</u>	<u>62.7</u>
	110	100.0

Almost 40% experienced an unexpected benefit, a reasonably high percentage.

- D. Describe any shortcomings noted in your application of the orthophotoquads:

	<u>#</u>	<u>%</u>
None	21	19.1
Inconsistent quality	38	34.6
Insufficient detail	16	14.5
Scale not large enough	3	2.7
No answer	<u>32</u>	<u>29.1</u>
	110	100.0

About 50% of the users pointed out some problem with their orthophotoquad, but were still able to make good use of them. Most of the shortcomings were involved with the photographic quality which is seemingly more highly correlated to the geographical area involved than to the specific requirement for high resolution for a given project.

- E. Were you able to complete any tasks through the use of orthophotoquads which could not have been done without them?

	<u>#</u>	<u>%</u>
Yes	31	28.2
No or no answer	<u>79</u>	<u>71.8</u>
	110	100.0

- F. Did you realize a cost benefit because of the use of orthophotoquads?

	<u>#</u>	<u>%</u>
Yes	52	47.3
No or no answer	<u>58</u>	<u>52.7</u>
	110	100.0

- G. Do you foresee multiple uses of your orthophotoquads in your operations?

	<u>#</u>	<u>%</u>
Yes	66	60.0
Maybe	9	8.2
No or no answer	<u>35</u>	<u>31.8</u>
	110	100.0

- H. We would welcome any additional comments you would care to make:

Number of answers 38/110 = 34.5%

	<u>#</u>	<u>%</u>
Negative Comments:		
Quality Lacking	10	9.1
Too long between order & receipt	6	5.4
Need orientation on map	<u>7</u>	<u>6.4</u>
	23	20.9
Positive Comments:		
Update them every 5-10 years	6	5.4
Useful with topo quads	3	2.8
Worth the cost	<u>6</u>	<u>5.4</u>
	15	13.6
No Comment	<u>72</u>	<u>65.5</u>
	110	100.0

The general overall conclusion is a favorable reaction of the users per the survey. The large number of repeat orders and the variety of uses within many fields of interest is also of importance. The majority of returned questionnaires came from the private sector.

APPENDIX C

USE AND BENEFIT TO LOCAL GOVERNMENT

USE BY MUNICIPALITIES AND TOWNS

Arizona contains only two large municipalities, the Phoenix region and the Tucson region. The rest of the state is served by small towns of a few thousand population and generally separated by several miles. Many of these towns are centers of ranching or farming activities, but some serve as centers of recreational areas. The population of most of these towns is relatively stable; however, the towns near recreational areas fluctuate seasonally in a predictable way. It would seem, at first glance, that the need for planning and hence the need for planning tools would be relatively small. There are, however, forces at work that plunge some of these towns into a sudden planning activity for which they are ill prepared. One of these forces is the gradual population increase of Arizona that proceeds at a steady 5% per year, and one or more towns will find that it must respond to the pressure and expand. This requires new water systems, new sewage systems, roads, and a general examination of the zoning situation. The other force is the sudden development of some natural resource that causes an impulse-like increase in the population. The manner in which one small town reacted to the building of a large power plant near its borders will be the subject of the following section of this progress report and some of the uses of the U-2 produced imagery and orthophotoquads by the municipalities will be discussed later.

ST. JOHNS, ARIZONA

St. Johns, Arizona is a town of 1,301 people located near the New Mexico border in Eastern Arizona. It is located on the west bank of the Little Colorado River on a relatively flat plateau about 5,000 feet above sea level. The population is very stable, only a 1% change was registered between the 1960 and 1970 census. The town is the center of a cattle ranching community, the ranches are large and the ownership is very stable. There is little or no opportunity for the children to obtain jobs when they become of employable age, and most leave to seek employment elsewhere. So the town is much as it was decades ago with little activity of any type, except for the raising of cattle. This situation changed drastically a year or two ago when the Salt River Project, a large Arizona utility company, decided to site a large coal-fired electrical generation plant near the town border. The decision to locate the plant in this particular area was due to the

availability of coal from the Black Mesa coal deposits, the availability of water, and the lack of opposition to the plant by the people of St. Johns. In fact the people of St. Johns worked very hard to have the plant located near its borders as they believe it will provide jobs for its young people, serve as a base to attract other industry, and of course increase land values due to the sudden demand for housing and all of the other services required to support the sudden influx of workers and their families.

THE COMMUNITY IMPACT

Estimates of the impact on the population, the housing demands, and on the additional students have been made by both the Salt River Project and by the people of the town. These estimates vary somewhat, but by any set of numbers the impact is large. The town presently has a population of 1,300, at the peak of the construction period the plant will employ over 2,000 workers. This peak will last for approximately three years, and at the end of that period the plant will employ about 300 workers. Due to the remoteness of the area most of the temporary and all of the permanent workers will be housed in St. Johns or the immediate vicinity.

The Salt River Project estimates that this will create a housing demand in excess of 2,000 units compared to the 350 presently located in the town. Most of this housing demand will be of a temporary nature, but the increase in permanent housing is estimated to be from 300 to 500 units. The main uncertainty is in the estimated number of service people that will be required to meet the needs of the worker community. Most of the estimates agree that the final stable population of the town will be about 3,500 to 4,000 compared to the present 1,301.

THE COMMUNITY RESPONSE

The St. Johns community was well aware of the project in time to prepare orderly plans to cope with the impact. They obtained the services of a firm of civil engineers to prepare plans for the increased services they would need, and the city council spent many hours discussing the new zoning demands, the new schools, and other services to be provided by the community. The people of St. Johns were fortunate in many ways as the population is largely cattle ranchers and others who are familiar with land and its use, and moreover, were used to dealing with private operations that require planning and the generation of capital required to carry out their ventures. Capital generation is a severe problem for a town faced with this type of an impact. The tax base is small and there is great difficulty in raising

money by bond issues due to the small population. The town therefore turned to the Arizona Office of Economic Planning and Development for some assistance in this phase of the operation.

In due course the town identified the various federal agencies that can provide the means to generate capital needed for the expansion of the town facilities. They applied to HUD, EDA, EPA, and several others for grants, loans, and of great importance for federal insurance for real estate loans necessary to develop the housing units needed. The federal insurance for loans is extremely important as no large amount of private capital can be raised without it, and some \$30 million would be required to complete the necessary housing. All federal help was rejected because the town of St. Johns was, according to the federal authorities, located in the flood plain of the Little Colorado River. It was at this point that the U-2 imagery and the orthophotoquads became of great benefit to the town.

THE ROLE OF THE U-2 PROJECT

St. Johns was judged by the federal authorities to be in the flood plain of the Little Colorado River on the basis of an old map, prepared many years ago, which was simply in error. Washington, D.C. is a long way from St. Johns, and it turned out to be impossible to convince the federal government that St. Johns was on high ground west of the river and not in any flood plain short of preparing a contour map, having the flood plain redefined, and resubmitting all the loan and grant applications.

In order to define the flood plain, about 4,000 acres had to be mapped, and because this region is rather flat, the contours had to be accurately defined. Estimated costs of preparing this map were in the vicinity of \$50,000 which the town did not have, and moreover, could see no way to borrow. The town contacted the Arizona Resources Information Service (ARIS) to see what could be done about producing a map that would satisfy the federal government in a shorter length of time than conventional methods and without having to spend \$50,000. In order to prepare an accurate contour map one has to define the X, Y, and Z coordinates of the land. It is rather straightforward to obtain the Z or height coordinate from a low altitude aircraft equipped with a stereoscopic mapping camera, but it is very difficult to obtain the X and Y coordinates due to the distortion at the edges of the picture. In this case, the X and Y positions were obtained from the U-2 produced orthophotoquads and the Z or height position was obtained from a low level flight during February of 1975.

In order to determine reference heights some of the old U-2 panels were reinstalled and some additional ground reference points were surveyed. This information was used by the Arizona Department of Transportation, together with their computer mapping system to complete the needed contour map. The map proved, what all of the townspeople knew, that St. Johns was not in the flood plain of the Little Colorado River, the federal authorities approved the grants, loans and insurance for the real estate loans, and the town is proceeding with its plans to meet the inrush of people.

BENEFITS

Several kinds of benefits resulted from this project. The first direct benefit was that the town of St. Johns obtained a map that cost less than \$10,000 instead of the estimated \$50,000 for a map obtained by conventional methods. It is worth pointing out that the \$50,000 is a hard estimate that was obtained from a firm of civil engineers who offered to produce the map for that price if no other method could be found. Secondly, having the map allowed them to obtain about \$2,000,000 in grants and loans, and moreover allowed them to obtain loan insurance for their housing unit development, which will amount to some \$30,000,000.

There are at least two secondary benefits that are worthy of mention. One is that the contour map is in constant use in the design of the sewer system, the water system, the roads, and by the housing developers to design the needed subdivisions. Mr. Keith Shrives, the civil engineer who is doing most of the design work, stated that the availability of the map is saving him valuable time. He estimates that he is able to complete designs in about 1/3 of the time required before the map was available. In addition, the Arizona Department of Transportation has produced a contour map of the same area using only U-2 information and have checked the accuracy of that map with the one produced by the combination of techniques. While the maps produced using only the U-2 information do not have the accuracy of the St. Johns map, they are within the accuracy required by the USGS 7-1/2 second quadangle maps (the scale of the original orthophotoquads). These maps could be produced at less than 1/10 of the costs of contour maps produced by conventional methods. They are presently trying to determine if they can obtain the funds to carry on this project for other towns and the Arizona Office of Economic Planning and Development is trying to determine the number of towns that need these maps.

PHOENIX METROPOLITAN REGION

URBAN LAND USE PLANNING

The Maricopa Association of Governments (MAG) maintains a staff of planners who prepare urban land use maps and plans for the Phoenix Metropolitan area. This area is relatively large (1600 square miles) and contains the following towns: Phoenix, Scottsdale, Mesa, Gilbert, Chandler, Glendale, Peoria, Tempe, El Mirage, Surprise, Youngtown, Sun City, Tolleson, Avondale, and Goodyear.

MAG maintains status maps of land use and makes recommendations on future use of the land. They depend heavily upon aerial photography to keep their information up to date, but do not make much use of the U-2 information at the present time. The reason is quite simple, they are mostly interested in the dynamics of the region and the U-2 photo flights are simply too old to be of much help in this regard. In addition, the Phoenix area is one of the most photographed regions in the country, due in part to the fact that until recently the Air Force fleet of U-2 aircraft were based in this region, and there are twenty private aerial photo companies based in Phoenix. MAG obtains much of the aerial photography they use by simply borrowing photos that have been produced for other reasons, and while this supplies their minimum needs they would very much like to develop some other low cost method.

From their standpoint, an ideal system would be U-2 overflights about once a year to provide land use dynamics information, but they see no way to raise the necessary funding if they have to pay for the flights. They are presently hopeful that the Landsat images, after suitable enhancement, may provide them the information they need at a low cost. At present, however, they are not making use of Landsat images, but are looking forward to the results of the NASA funded project "Multi-Source Land Use Information Pilot Study (NAS 5-22238) in the hope that the resolution and identification of land use will be sufficiently detailed for their use. Dr. Michael Castro, of the ARIS staff is the project coordinator for this project for Arizona, and plans to make the result available to them.

In summary, it appears that the land use information needed by MAG is in reasonably good shape and that the orthophotoquads do not meet their needs. There is some hope that Landsat information will be useful in the future.

LAW ENFORCEMENTLAND FRAUD

Earlier in this survey it became apparent that the orthophotoquads and the images were useful in land fraud investigations. In an attempt to understand how these new tools benefited the law enforcement agencies, their use was discussed with the Maricopa County District Attorney's Office. Maricopa County comprises 55% of the population of Arizona and the District Attorney's Office carries a heavy load of land fraud cases. These land fraud cases have many complexities, but in its simple form the developer simply claims in his advertising literature, and to his customers, that the development is a desirable place to live and that certain things will be built to make the development attractive. Golf courses, lakes, and parks are among the items generally offered by the developers. Many times the land that the developer is offering is located in remote regions and the buyer simply does not inspect the region. More often than not the land is unable to support the promised development.

In one case the developers were selling lots in an old dry lake bed filled with washes, gullies, and ravines which were subject to flash flooding. Their maps and advertising showed beautiful trees and a meandering brook, with paved roads winding through the area. They also showed a beautiful lake that they were going to build by damming up a non-existent creek.

Mr. Tom Collins, assistant district attorney, obtained four orthophotoquads showing the area, prepared an overlay showing the so-called subdivision and this exhibit was able to clearly show evidence of fraud. He was also able to show that the map filed with the county to obtain approval for the subdivision in no way corresponded with their true lot locations. In Mr. Collins opinion, this kind of evidence is invaluable in obtaining indictments from grand juries and convictions from trial juries since the evidence is so clearly shown, so easy to understand, and so unambiguous.

In terms of benefit, Mr. Collins points out that the use of these maps saves the time of transporting a jury to a remote location to view the actual subdivision which is sometimes almost impossible to accomplish, and in his view are actually more understandable to laymen than actual viewing the scene in person. In addition, these maps have official status and can be introduced as evidence much more easily than an aerial photograph since land description information can be transferred to the orthophotoquads and there is no argument about the actual location. Mr. Collins tells us that they plan to use these orthophotoquads in future cases and they are now used in almost every case in which needs to

display this kind of information exist. It should be pointed out that there are types of land fraud in which this kind of information is not critical; for example, where a good lot is sold several times and the evidence is mostly sales contracts. However, land fraud cases make up a major portion of the work load of the District Attorney's Office in Arizona at the present time and these attorneys view the orthophotoquads and the U-2 imagery as a very valuable tool in gaining convictions in these cases.

EVIDENCE PRESENTATION IN GENERAL CRIMINAL CASES

In almost all cases where a crime has been committed, the location of the crime, the location of the police, location of the point of arrest of the suspect, and much other location information must be presented to trial juries. In many cases this information is presented in words or with the use of sketches. Since the orthophotoquads have become available they have been used with great success by the Criminal Investigation Division of the Maricopa County District Attorney's Office. Mr. Evan A. Wilson, Assistant Chief Investigator states that they are one of the best tools he has found as a visual aid when presenting cases to a jury. He maintains a file of the orthophotoquads in his office and has used them many times in the past and claims he will continue to use them in the future.

Mr. Wilson mentioned several cases in which he had used the orthophotoquads to good advantage and pointed out two in which he credits them with a major role in obtaining convictions.

In one case he was able to show a pattern of burglaries in a ten block area and was able to connect these crimes to one person. In his mind, the use of the orthophotoquads in showing this pattern to the jury had a major role in obtaining a conviction. In another case, there appeared to have been some contention by the defense that the suspect could not have traveled that far since committing the crime. Mr. Wilson was able to prove that the suspect, who was caught after a roundabout 30 block chase, was in fact the person who had committed the crime.

USE BY COUNTIES OF ARIZONA

Use by counties in Arizona has been extensive and has been described elsewhere. The reader is referred to the publications of the University of Arizona Office of Arid Lands Studies for details of this use. Two good summary reports of this subject are: Johnson, Jack D., Foster, Kenneth E., Mouat, David A. and Clark, Robin; Applied Remote Sensing Program to State and Local Governments, Office of Arid Lands Studies, University of Arizona Bulletin 10, 1975, and Mouat, David A., Miller, David A., and Conn, Jeffery S.; Applied Remote Sensing Program Annual Report, OALS BULLETIN 13, University of Arizona, Office of Arid Lands Studies, June 1976.

APPENDIX D

USE AND BENEFIT TO STATE GOVERNMENT

THE ROLE OF REMOTELY-SENSED INFORMATION IN TRANSPORTATION

The Arizona Department of Transportation consists of five divisions and administers exclusive control and jurisdiction over the State's transportation system. It employs about 2,500 people and has an annual budget of about \$200 million. The Highway Division is the largest of the divisions and was the original motivator of the Arizona Resources Information System (ARIS), furnished its first director, and served as the state's technical arm in the conversion of the U-2 photography to the orthophotoquad maps.

One of the main reasons the Highway Department needed the information provided by the Arizona Land-Use Experiment was to implement their Accident Location, Identification, and Surveillance System (ALISS).

In 1966 the United States Congress enacted the Highway Safety Act which called for an aggressive program in each state to reduce the numbers of traffic accidents, deaths, injuries, and the fantastically large accompanying economic losses. At that time, Arizona, like many other states, was administering a continuing program of traffic safety with little, if any, effect.

Moreover, the estimated Arizona fatality rate per vehicle mile driven was some 30% higher than the national average. This situation was further complicated by the fact that the rural roads within the state accounted for 63% of the fatalities but only had some 22% of the accidents. The roads within the state were poorly located with respect to any standard reference system, and the rural roads were sometimes known by several local names. In addition, there was the difficulty of determining which jurisdiction applied to which road.

In order to cope with the accident situation and comply with the 1966 Highway Safety Act, the State faced the task of locating all of the roads within the state on some standard coordinate system, determining their condition in some standard way, locating the jurisdiction that applied to each road, and determining the locations of the accidents and their probable cause. Many of these roads had evolved from old pioneer trails and were in regions of the state that had never been adequately mapped. It was estimated that to complete this job roughly one half of the state would have to be mapped and that this would cost about \$15 million and require nine to ten years to complete using conventional

map making methods. Due to the cost and time required, conventional methods were not a viable solution to the problem. It was realized, however, that high quality maps could be made from U-2 imagery for less than one million dollars and within one year. Thus the Highway Department began to sponsor the Arizona Land-Use Experiment as a method of obtaining the orthophotoquad maps that they needed for this job.

As the orthophotoquads became available in 1973, they were immediately used to determine road location, condition, and jurisdiction to implement the Accident Location, Identification, and Surveillance System Program. The Highway Department considers the ALUE information the heart of the ALISS system and their view of its benefits is supported by the fact that they carried the first Director of the Arizona Resources Information System on their personnel complement and paid his salary for four years.

The analysis of the information made available by the ALISS system is used to determine areas having high traffic accidents and to determine where corrective action should be taken. The action is in several forms, additional safety devices, signs, more traffic enforcement, and in road improvements if this seems to be the cause of the high traffic accidents.

The traffic accident rate has been reduced in Arizona since the advent of the ALISS system, and while it is difficult to determine what portion of this improvement is directly chargeable to the ALISS system, the fact remains that it is certainly one of the major reasons for the decrease. The reduction is sizeable. In 1966, the fatality rate per 100,000 miles traveled was 7.3; today it is 4.2.

THE ROLE OF REMOTELY-SENSED INFORMATION IN THE ARIZONA WATER PROBLEM

Water is a double-edged concern to Arizona, too much during the summer rainy season and too little the rest of the time. During the mid-summer months rain-bearing clouds sweep up from the Gulf of Mexico and produce violent thunderstorms. The storms move across the state by some random walk process and dump large amounts of water in an unpredictable way. This produces random flooding of remarkable severity in limited areas. Due to the random nature of the process no part of the state escapes local flooding for long periods. In order to protect populated regions and rich farm areas, flood control structures are constructed and maintained in large numbers.

The other side of the problem can be simply stated: Arizona consumes three times the water that falls upon the state as rain or snow. The extra water is obtained from underground reserves. Large amounts of water are stored beneath many of the Arizona valleys. It is estimated that these storage basins contain over one billion acre feet of water and with an annual consumption of about two million acre feet (about 90% used by agriculture) there is no danger of running out of water in the near future. The problem is that since much of this excess water is not returned to these aquifers the water table is sinking (some 100 feet in the last 30 years) and the water must be pumped from depths in excess of 200 to 300 feet. The sinking water table is causing settling of the land and severe cracks are beginning to appear in many areas.

In order to solve some of these problems, the Central Arizona Project has been undertaken to bring about one million acre feet of water from the Colorado River per year into central Arizona. The Central Arizona Project is presently under construction and consists of canals and water storage dams, and of course, represents a sizeable investment by the state and the federal government.

The Arizona Water Commission

The Arizona Water Commission is the state's water planning agency. In addition, it is empowered to measure, survey, and investigate the state's water resources. It also recommends actions to the State Legislature and makes policy recommendations to the Governor. Also, it is in the process of developing a computerized water information system in cooperation with the University of Arizona.

Use of the Arizona Land-Use Experiment Information. The information produced by the U-2 overflights has been used widely in various aspects of the Arizona water problem. The use follows the thread found in other projects; project planning, environmental impact statement preparation, and the location of water diversion structures and their influence upon the vegetation.

Use and Benefit in Flood Control. Since their introduction into the state during 1973-1974, the orthophotoquads have been used in the flood control planning process as a method of locating natural and man-made structures and features to define the region to be protected and to help in defining the watershed area. The method used to define the watershed area is from vegetation patterns and the location of alluvial fans produced by running water. The infrared imagery has been widely used for this purpose. The major

benefit resulting from the use of these information sources is that the use of expensive ground crews can be almost eliminated in the preliminary planning and when ground crews are used their function is to check the accuracy of the near final or final plans. Planners have become so accustomed to using these tools that they are hard pressed to estimate the benefits in terms of ground crew costs saved. Their best estimates seem to range from elimination of 1/2 to 2/3 of the ground crew costs. It is almost impossible to get a reliable estimate of ground crew costs in any general way. This is due to the extremely variable effectiveness of a ground crew on any given project due to the differences in terrain, access bility, and specific function. We have obtained some reasonably reliable, specific estimates of savings on specific jobs and they seem to range from 25% to 50% saving on design costs but are almost impossible to generalize. Moreover, consulting engineers that we have contacted claim that the greatest benefit is in the time saved and the ability to examine a greater number of options before having to make a final decision. The benefit estimates range from 1/2 to 1/3 of the normal design time. It is emphasized that these figures are little better than guesses on the part of the people we contacted. There is little doubt that there is a benefit and that the benefit is substantial or the designers would not be using the new information.

The second use and benefit of the imagery and the orthophotoquads is in the location of flood control structures. Many of these flood control, or water diversion structures, were erected in pioneer times and no records are available. Some are in poor repair, some may be doing more harm than good. The imagery and the orthophotoquads have been used to improve this situation.

A third use of the imagery and the orthophotoquads in the flood control problem was to lay to rest the controversy over the impact of these water diversion structures upon the native vegetation both upstream and downstream of the structure. This is part of the overall argument one always encounters when water is diverted from its natural course. A study of the vegetation change problem was conducted by the University of Arizona, Office of Arid Land Studies and it was found that in some cases the water diversion structures altered the natural vegetation pattern and in other cases it did not. At first glance, this result did not seem to be of much help until it was pointed out that as a result of the study, water diversion dams are now designed to allow water to slowly seep through them thus solving the problem to most people's satisfaction.

Use and Benefit in the Water Supply Problem. One of the problems in determining how much water is available is to determine how much is used and the location of the use. This is a simple job in towns and cities or in agricultural communities where water is supplied by well defined irrigation systems. It is not so simple when the water is withdrawn from private wells. In recent times anyone drilling a well must be granted permission and supply the state data on the water withdrawal. Unfortunately many of the wells date back to pioneer days and have never been part of the official record. It is possible to determine with reasonable accuracy the water used for agricultural purposes by measuring the extent of the irrigated land. Many of these unregistered wells have been found using the imagery produced by the ALUE project and the state now feels that they have a reasonably accurate count on the number of wells in the state and their water producing capability. This record is part of the computer generated information system now under development.

Another use of the imagery is to locate and define the extent of the cracking of the ground caused by the settling brought on by the depletion of the underground water. This has become a serious problem for a number of regions of the state. These data were generated by ARIS, using the ALUE information and have been supplied to the local governments and building safety groups to allow corrective actions to be taken. Since the location of these cracks is now known, their rate of growth can be easily checked by the local groups.

The Central Arizona Project to bring water from the Colorado River into central Arizona has been required to produce environmental impact statements on every aspect of their work. The ALUE information, orthophotoquads and imagery have been widely used in this effort as they have been in all other major projects in the state. The use and benefits of this type of use has been discussed elsewhere and the use in this project follows the previous experience and will not be discussed as a separate item except to say that the benefit has been large.

The Water Commission works closely with the Arizona Department of Fish and Game, State Archeology Department, and the U.S. Department of Agriculture on water problems and the use of the information derived from the ALUE project within these groups is much the same as it is within the Water Commission.

THE ROLE OF REMOTELY-SENSED INFORMATION IN LAND MANAGEMENT

The Arizona State Land Department is responsible for the planning, development, and protection of all forests and natural resources located on state land. The department administers the 9.6 million acres of state owned land with an operating budget of about two million dollars and a complement of 97 people. The land represents a money-making resource for the State and is managed much as private holdings would be. The annual revenue from these lands amounts to about \$12 million per year.

The major problem of the management of this land lies in location and the wide varieties of use of the land. The state obtained the land in 1912 from the federal government, at the time of statehood, and the lands are widely scattered, much of it in alternate sections. Although the legal descriptions of the land gave its location with respect to township and range, its actual location in the remote regions of the state was in question.

When the orthophotoquads became available, the Land Department made extensive use of them to determine exact location because for the first time they had a tool that allowed location of land features with an accuracy of better than thirty feet. For the first time they were able to determine exactly where the state land was located in these remote regions and in addition to determine the land type and potential use. This is important as much of this land is leased to the public and lease fees are set by the land value.

Use of the orthophotoquad maps and the imagery has increased within the Land Department over the years to the point where it is now a standard tool in all of the land transactions, is used to determine potential land use, evaluate environmental impacts of various projects, and to set use fees for the land. This is one of the departments of state government where this new technology is completely accepted. The land commissioner credits the new technology with allowing him to cope with the increased workload brought on by the population pressures since 1973 without having to increase his staff. The best estimate of the saving is that they would have to increase their staff about 25% if the new technology had not been developed and used.

ROLE OF REMOTELY-SENSED INFORMATION TO THE ARIZONA
DEPARTMENT OF REVENUE

Although ARIS is located within the Department of Revenue for administrative purposes, the Department of Revenue has not made much use of the ARIS information in the past. Recently, due to the high cost of ground crews, the department has become interested in a more economical way to perform its land assessment function. The department's primary interest is in changes that have taken place in land use activity and because the ALUE information gave status of use in the 1973 time frame they felt it was of little use to them. Recently ARIS has made several presentations to the Director of the Department of Revenue in which they used the orthophotoquads and the U-2 imagery to show land status and the newer enhanced Landsat imagery to show changes in land use which have taken place since that time. Two actions resulted from these presentations. One action is a review of land use using the orthophotoquads to determine land uses missed in the older assessment procedures. In this project they have found a number of active uses of land that did not appear on the tax rolls and this experience has shown the value of remotely-sensed information to tax collectors.

The second action that resulted from these presentations came about as a result of being shown U-2 produced infra-red images of irrigated farm lands taken in 1973 and enhanced Landsat scenes taken in 1976 colored to show the irrigated lands in red to correspond to the colors of the U-2 imagery. The U-2 imagery showed the land in great detail so that familiar features could be easily identified in addition to the irrigated fields. The Landsat images, projected alongside the U-2 imagery, did not contain the wealth of detail shown by the U-2 work, but they did show clearly the changes that had taken place during the three year period. The detail was good enough to make reasonable estimates of the acreages of the new land that had been brought into production. Fallow lands are assessable at 10% of market value while irrigated lands are assessable at 100% of market value, so these changes were of great interest to the tax assessors.

As a result of these presentations a number of projects are being started by the Department of Revenue to obtain and utilize enhanced Landsat maps of Arizona, and one of these showing irrigated lands is high on the list to be obtained in cooperation with NASA. The preceeding discussion is almost a textbook example of the value of the U-2 imagery to introduce the Landsat information into the management system of a state. It also illustrates the value of a live demonstration in dissemination of the value and usefulness of the remotely-sensed information. This is not an isolated case, we have seen it happen many times in the course of this investigation.

APPENDIX E

USE AND BENEFIT TO FEDERAL AGENCIES IN ARIZONA

BUREAU OF LAND MANAGEMENT, U.S. DEPARTMENT OF THE INTERIOR

The Bureau of Land Management administers almost 13 million acres of land in Arizona and, therefore, represents the largest land management organization in the state. Nationally, BLM administers almost 500 million acres of federally owned lands, and is dedicated to a policy of multiple-use-management of that land. This makes BLM potentially a major user of land-use information generated by remote sensing, and thus, it was decided to interview and study this organization in some detail. This decision was motivated by the fact that in 1969 BLM undertook a massive program to develop a land-use planning system. The end product of this plan is to produce a management framework document for all of its lands which contains the land managers decisions and a commitment to a specific course of action. It details, by resource activities, the particular combinations and patterns of multiple use considered best for a given area of land. It establishes land-use allocations, coordinating guidelines and constraints for management, and the objectives to be achieved in the use of an area of public land. BLM feels that these Management Framework Plan documents (MFPs) and the supporting documents are a very valuable tool. They guide the land-use decisions required in daily BLM operations; they are the basis for planning coordination with other governmental entities and the private sector; they provide the framework for detailed resource action programs; and they aid in the environmental assessment process. The program is about 20 to 30 percent completed at the present time, but will extend into the 1980's, thus the time frame is right for the use of remotely-sensed information from the aircraft and Landsat systems.

In addition to the Management Framework Plan, the 1970 National Environmental Policy Act requires a detailed study assessing the potential environmental impacts of a specific proposed action prior to such action being initiated. In Arizona BLM is scheduled to complete 13 Environmental Impact Statements on grazing lands prior to 1981. This program requires a massive effort on BLM's part to generate the necessary base information.

As is always the case, this new function is laid on an already busy staff and almost every means of generating the required information is being used. The bulk of the work seems to have fallen to the Division of Resources who provide the base data to the Planning Staff. Historically

BLM has used field surveys and information supplied to them by the users of the land to determine present and future use of their lands. Some of the groups within BLM have made considerable use of ALUE data in the past, while other groups are just becoming acquainted with the potential of this new information. For example, Mr. Glenn Martin, Natural Resources Specialist, who supervises the wild, free-roaming horses and burros for BLM has used both the orthophotoquads and the imagery to determine the condition of the range, water holes, fences, etc. for several years, while the people in the land appraisal group make very little use of this information. This is in contrast to the state land department, who use the remotely-sensed information as a major tool in land appraisal. BLM represents an organization in the process of transition from the older methods of information gathering into the new field of remote sensing. It is interesting that shortly after our survey of BLM, orders for very large numbers of orthophotoquads and imagery were received by ARIS from BLM. In addition, some dozen or so visits to ARIS have been made by BLM personnel to view the imagery and to become familiar with the services available to them since we completed our survey of the BLM offices in the Phoenix area. The BLM represents a very ripe field for a cooperative program with NASA to utilize Landsat or newer aircraft information to help them with some of their special problems. ARIS is working with BLM at the present time to identify some of the areas where such a program might be generated.

PRESENT USE OF U-2 GENERATED INFORMATION WITHIN BLM

Division of Resources. The Division of Resources serves as the principal staff for all resource function activities and related ecological matters. It gathers and maintains resource information on all resource disciplines, forestry, range, wildlife, watershed, recreation, lands, minerals, and surface protection. They have used the imagery, mainly the infra-red and the orthophotoquads in the past to determine ground cover in the Safford District. They are presently planning a major program in the Arizona Strip District to inventory the soils and vegetation. This is part of the Management Framework Plan mentioned earlier. They plan to utilize the ALUE information, Landsat data, low altitude flights, and ground crews. The ground crews will do the ground truthing, which will comprise some 100 sample areas within this two million acre region. The ground crews are presently undergoing training. They plan to use the orthophotoquads for location information, the U-2 infra-red imagery for groundcover information, and the satellite information for change information since the U-2 flights were undertaken. Another motivation to use the Landsat

information is that if successful the cost of obtaining vegetation or ground cover maps is about 1/10 of the present costs. Actual cost comparisons are difficult to make, however some estimates may be of interest. BLM feels that the cost of making these surveys using ground crews only would be prohibitive due to the remoteness of the area and the rough terrain. A good accurate vegetation map can be prepared from U-2 imagery for about \$1.00/square mile including ground trips to check the accuracy of the maps. Estimates of preparing maps of this quality using local knowledge and ground crews vary from ten times that amount to three times the amount. The cost of preparing a similar map from Landsat information, electronically processed, is estimated to vary from \$0.10 to \$0.25 per square mile. It is thought that the accuracy of the Landsat maps will be acceptable for BLM use, and if this is true, there is a great motivation to use this method. These costs do not include the costs of obtaining the aircraft imagery, nor do they include the cost of building and launching a satellite and obtaining the data. They also assume that the bulk of the cost of the computer software will be available free from NASA or someone else. All-in-all there is considerable interest in obtaining maps of vegetation by this method due to the lure of low cost and the saving of time. It is worthwhile to point out that the confidence in accomplishing this task is mostly built upon the experience with the aircraft imagery which has proven so useful.

If the Arizona Strip project is successful in utilizing Landsat data, the project will be expanded to include all of Arizona, and ultimately to the rest of the federally owned lands in the United States. There is, therefore, considerable interest in this project within BLM.

Management of Wild Free-Roaming Horses and Burros. BLM has the responsibility of providing wildlife habitat management for the maintenance and improvement of food, water and cover for wildlife on its lands. One aspect of this problem was examined in some detail and will be covered in this section.

Wild horses and burros are protected in Arizona, and the herd consists of some 50 wild horses and about 2,000 burros who range over some three million acres extending from the Nevada border to the Mexican border. The horses are not much of a problem, but the burros multiply rapidly and overgraze their range and in the process destroy much of the native vegetation. In order to minimize this problem, the condition of the range must be constantly checked and, if found to be overgrazed, the burros must be moved to a new area. This is a never-ending job. Mr. Glenn Martin, Natural Resource Specialist, spends about 400 hours in a helicopter per year keeping track of his herds and the condition of the range. He uses the U-2 imagery to

determine probable new locations to move his herd into when the old range is overgrazed. The orthophotoquads are used to locate trails, water holes, roads, and fences in order to ease the job of burro herd management. The use of this information has greatly reduced the time he has to spend in the air surveying future ranges and he feels that the information has been a great help in wildlife management.

This use of the U-2 information was one of the first cases tried within BLM on the use of remotely-sensed information in wildlife management, and by all accounts it has been successful and they plan to expand its use to other animals.

FUTURE USE OF REMOTELY-SENSED INFORMATION WITHIN BLM

The 1970 National Environmental Policy Act requires that any proposed change in the status or use of BLM administered land be examined for its potential environmental impact. Since the BLM lands are very extensive, some 500 million acres nationally, this law has a major impact upon the way BLM does business. In the past, most of the Environmental Impact Statements were prepared by the persons who were proposing projects on BLM land. Thus most of the information was prepared by the private sector and was examined by BLM. In the recent past, BLM has decided that it must take a larger role in this activity. What this means is that BLM will either prepare its own EIS's or will generate enough of its own information to determine the accuracy of the private sector supplied data.

The preparation of an environmental impact statement requires a large amount of detailed information. The present use of the land must be determined and its future use estimated, soil type determined, wildlife habitat estimated, geology determined, impact upon water and air quality, and a host of other things. Discussions with people who prepare these environmental impact statements indicated that U-2 imagery is a most valuable tool in the gathering and presenting of this information. The U-2 imagery fills a unique need for the preparation of impact statements for power lines or pipe lines that typically stretch over hundreds of miles. For a typical case of a power line or pipe line, three to seven alternate routes are investigated in enough detail to evaluate the probable cost and environmental acceptability. These lines are typically over a hundred miles in length and may require the examination of the land in a corridor 20 to 30 miles wide. Therefore, the land and its use must be examined over an area of several thousand square miles. Improved and enhanced Landsat imagery may fill this need in the future, but at present U-2 imagery strikes the correct

balance between too much detail provided by low level flight photographs and the lack of detail and resolution of the present Landsat information. Moreover, the very large amount of information needed makes electronic interpretation difficult in its present state of development, but human interpreters using U-2 imagery are able to cope with this problem. The orthoquads and the U-2 imagery provided by the 1972 flights over Arizona are widely used for the preparation of environmental impact statements, but the information provided by these flights show the land and its use as it was at that time. Arizona is experiencing a period of rapid growth and the changes since that time are, of course, not present on this older imagery.

There is a need for the type and kind of information provided by U-2 overflights by land managers in the Western States and the capability to provide this information is available at the Ames Research Center of NASA. What is badly needed is a joint program with the BLM and other federal land managers and NASA to supply this information until the Landsat system is proven to be capable of fulfilling this demand. This is not a simple program to implement as much of the actual work in the preparation of these environmental statements is done by the private sector through the use of information at hand, or of low-level flights. Private utility companies almost always contract this work to consulting firms who specialize in this type of work and some way must be found to include the private sector in the agreement, or in some way make the use of government produced imagery attractive to them. While this may be difficult it is by no means impossible, as the U-2 information is very valuable to them as a tool.

There is good reason to believe, due to the recent improvement in the Landsat information, that the satellite derived information will eventually replace the aircraft generated imagery, simply because of the costs involved in a well developed satellite system are lower than an aircraft system. It is important to recall that for this particular problem the satellite system has a way to go, and the need is present. Moreover, the use of aircraft imagery is the best way to introduce satellite information into a system of human beings. The step from windshield surveys to computer generated information is very large, and we have found time and time again that it is only after a management group has used the aircraft imagery that they will accept the satellite system information. This may be difficult for scientists and engineers to understand and accept, but it is nevertheless true. Land managers are trained to live in the world of sight and sound, their decisions are made on the basis of hard information and it is very difficult for them to make the step between "I saw

it and this is the situation" to "The satellite saw it and this is what I believe the satellite saw." The photograph forms the mental bridge between the two systems simply because they are more familiar. Once land managers are used to depending upon photographs to determine land use and therefore value, it is a small step for them to accept the satellite produced information.

The Bureau of Land Management is faced with the problem of producing Management Framework Plan documents on all of their land by the mid-1980's. Since they manage about 500 million acres of federal land, this is a very large order. Although the information required is very large, the detail is probably somewhat less than required to produce environmental impact statements, and the Landsat information system seems to be made to order. BLM can be counted upon to be a very large user of this information if it is accurate and believable. It would seem that a program on the local level similar to the Northwest Project would be an extremely valuable tool to introduce and validate the satellite information. Since the EROS information center in Phoenix is being phased out and the equipment and many of the functions are being taken over by the State of Arizona, it might be very useful to consider a Northwest type project with BLM which could be coordinated by ARIS. ARIS is willing to undertake this function and has the skills and equipment necessary. This would represent a departure from the normal arrangement where the federal government helps the states, but in this case it makes good use of in-place equipment and skills and might be a useful thing to do. Since ground truth and validation is a major part of any project of this kind, and the U-2 imagery are a great help in the ground truth problem, this project could well make use of this resource. At any event, the idea should be explored with BLM and with Dr. John DeNoyer of EROS. Such a project would be easy to implement in the already planned Arizona Strip survey starting in 1977.

U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, WATER RESOURCES DIVISION

The Water Resources Division of USGS has played a major role in the ALUE project. They were the branch of USDI that took the lead role in coordinating the USDI part of the original three-part agreement between Arizona, USDI, and NASA to obtain the U-2 overflights and to produce the orthophoto-quads. In addition, they undertook the operation of the Department of Interior's EROS Application Assistance Facility (AAF) located in Phoenix. The Phoenix AAF houses microfilm reference copies of the extensive USDI aerial mapping photography, NASA aerial photography, and the space imagery from Gemini, Apollo, Skylab, and Landsat.

Computerized geographic searches of this data base and public assistance in ordering copies of these data from the EROS Data Center in Sioux Falls, South Dakota are also provided by AAF. At present this facility is being phased out by USDI due to budget problems, but most of the functions are being assumed by ARIS. Details of AAF and its functions have been described elsewhere, see for example Winikka, Carl C., Schumann, Herbert H.: Arizona Land-Use Experiment, Proceedings of the NASA Earth Resources Survey Symposium, June, 1975.

In addition to their involvement in the AAF Data Center, the Division of Water Resources have made extensive use of the information in their own programs. One of these programs is to provide water runoff information on the Arizona snow pack. One of the major uses of the orthophotoquads was to accurately define the area of the snow pack as no accurate maps of this remote region were available until the orthophotoquads were finished in 1973. Another use is to define the extent of the watershed of each of the streams leading into the Salt River Project water system. This definition of the watershed led to the placement of water gauging systems on certain of the key streams and rivers feeding the system of dams within the Salt River Project. Data from these gauging systems is transmitted from the remote sites by satellite to the Phoenix facility where it is used to determine the control of the water storage and release from this series of dams. This is an extremely large system of dams and their proper control is critical to the water supply in the rich agricultural area in the Salt River basin and to the water supply to Phoenix and surrounding towns. On one occasion during the heavy flooding of 1973-1974, this system is credited with saving the city of Phoenix from extensive flood damage.

In summary, this information was used to define the extent of the watershed, to define the area of the watershed of individual streams, in the placement of instrumentation on key streams, and is presently being incorporated into a computerized model of this watershed system. Water is an extremely valuable resource in Arizona. The yield from the crops which depend upon the water from the Salt River Project is about \$300 million per year and a loss of yield can be tied directly to the availability of water. Errors in management (allowing water to escape to avoid flooding when the storage capacity was adequate, for example) can be translated almost directly into loss of crop yield. Thus a 10% error could cost the state some \$30 million. The new system has not been in operation long enough to obtain statistical data on the improvements in water management, but even a few percentage points is very valuable. One percentage point represents about \$3 million.

It is a bit difficult for people in regions where water is plentiful to appreciate the close tie between water availability and yield of crops. In this region farmers grow crops all year long and will not plant if they do not receive assurances that water will be available. Therefore, the crop acreage as well as the yield per acre is tied to the water supply. Water management in Arizona is tied to crop output as well as being useful to control flooding.

The USGS is also using the orthophotoquads to correct older maps of the state and have made contour maps from the U-2 imagery. They plan, but are not funded, to complete the topographical mapping of the state. Elevation can be obtained from the overlapping U-2 images to the accuracy needed in USGS maps at 1/10 to 1/3 the cost of conventional methods. If this project is ever funded the benefit from the U-2 imagery will be substantial.

DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

The Soil Conservation Service, as the name implies, is charged with the responsibility to preserve the soil from the various natural and man-made forces that tend to degrade its quality. These degradation forces, erosion, disease, and pollution from natural or man-made sources, are constantly at work. One of the functions of the Soil Conservation Service is to measure the changes and to take corrective action. It has been the practice of the Soil Conservation Service to inventory the soil condition and classify the various soil types by area. This requires the determination of boundaries between the various soil type areas. This means the determination of the specific areas of sand dunes, caliche, brush, forest and other specific classifications.

The U.S. Soil Conservation Service is beginning to use the new information on its major projects, one of which was surveyed and will be discussed in the following section.

Mr. R. Clark, River Basin Planning Leader, is responsible for the soil classification, area determination, and corrective measures in the river basin region of the federal lands within Arizona. Mr. Clark uses low-level aerial photography, satellite imagery, and the U-2 imagery and orthophotoquads in building up his identification system. He stated that the U-2 information is the key to his entire system of identification and boundary determination.

One project Mr. Clark has completed is a soil type map for the entire state of Arizona. By use of the U-2 information

he has determined the boundaries of the various soil types and has reduced this map, by the use of overlays, to a size suitable for field work. These maps are used by soil engineers in the field to coordinate decisions on which areas require corrective action, land clearing for brush control, overseeding to control run-off after local floods, and treatment for diseased wooded areas.

The U-2 produced information is, in Mr. Clark's mind, their major tool for their studies of erosion, seeding, brush control, fencing, tree planting, flood control, drainage patterns to determine water run-off areas, and for the determination of the effectiveness of control measures taken.

In terms of benefit to the Soil Conservation Service or to the country, we obtained the answer we have been given many times by people who are using this new information. The new information has allowed them to do things that would have been almost impossible to do in the past. Therefore, the things they are doing are new and they do not have a background of experience to use in assessing an overall benefit. All of these people believe that the benefits that will result from the availability of these new tools is and will be large. In spite of the difficulty of obtaining reliable numbers for these benefits, some estimate, bounded by reasonable limiting assumptions, will be made in later phases of this study.

NATIONAL FOREST USE

National Forests occupy about 16% of the land in Arizona. There are seven National Forests and one of the largest of these, the Tonto National Forest, occupies almost 3 million acres out of a total of 11-1/3 million acres devoted to national forests in the state. The Tonto National Forest lies mostly North and East of Phoenix and extends from the low deserts to the timber covered mountains that make up the Northeastern section of the state. As the Tonto National Forest contains an extensive group of man-made lakes, it is heavily used by the population of central Arizona as a vacation area, and a weekend recreation region. The resources of the forest are also utilized by the citizens as is the case with other national forests. Cattle grazing, mining, and timber harvest is carried on in a controlled manner.

In an attempt to gain an understanding of the present and possible future use of the orthophotoquads and imagery by National Forests, Mr. Ralph Beene, Assistant Forest Engineer, Tonto National Forest, was contacted and a meeting was held

with him to discuss forest problems and the possible benefit to the National Forests brought about by this new technology.

The Engineering Department of the Tonto National Forest has a very broad range of responsibility for the well being and operation of the forest. The location, condition, and maintenance of the road and trail network; construction and maintenance of the campgrounds; the leasing of grazing lands; drainage and flood control is within their area of responsibility.

Tonto National Forest is a relatively new user of the U-2 generated information. They have been using the imagery directly and the orthophotoquads for about nine months. Of the two types of information the imagery is the most useful as the color allows identification of features to be made with ease, a valuable asset for them, and the orthophotoquads give them an accurate location standard once the feature is identified.

One use, which they regard as very beneficial to them and to the general public, is the completion of an inventory map of the forest showing the roads, trails, campgrounds, danger areas, fishing streams and lakes, types of terrain, and special interest areas. Without the new information they consider this project would never have been completed due to limitations of manpower and funds. This map inventory is extremely beneficial in location of trails during fire fighting, in order to get equipment to the scene; to accurately locate flood damage and assist in clean-up work; and for general information for the general public who use the forest. During the fire season, these maps are used to identify regions of the forest closed to the public. This information is given to the public on a daily basis through the use of television and local newspapers.

Another use of direct benefit to the public in general was to identify the damage to the forest by the unrestricted use of off-the-road vehicles. It was not until the imagery became available to them that they were able to assess the extent of this damage. In regions of the country where the rainfall is high enough to allow vegetation to grow up and cover damaged areas in a season or so, damage inflicted to the land by off-the-road vehicles is reversible. In a desert region, with rainfall of less than 5 to 6 inches per year, damage done by these vehicles to the desert plants and to the contours of the land will be evident for decades due to the extremely slow growth of the vegetation. A typical desert cactus will only grow about one inch per year and if ground contours are disturbed they may never return to their original shape. The use of the U-2 imagery allowed the extent of the damage to be assessed and displayed

and have resulted in a very strict policy on the use of these vehicles in the National Forest. They can be operated only on trails and dirt roads set aside for their use.

A sizable fraction of the land in the Tonto National Forest is suitable for the grazing of both cattle and sheep, and it has been the practice to lease grazing rights to ranchers. Heretofore, the size of these leases were estimated, as no method was available to accurately determine the area of land actually usable as range pasture. The U-2 imagery has given them a tool to make a reasonably accurate determination of the size of these areas, and as the lease rates are based upon area, they can now lease this land on a more businesslike basis than in the past. It is their belief that more revenue will be obtained in this way; however, this project is just getting underway and they could make no estimate of the eventual change in the revenue from this source.

Mr. Beene also felt that they could increase the size and effectiveness of their range by using the imagery to determine the number of water holes now present and to determine where new water holes could be located to provide more drinking water for the domestic animals and for the wildlife. Ranchers are already utilizing the imagery for this purpose and the National Forest people plan to do the same thing.

Mr. Beene also emphasized that they were just beginning to use the imagery and felt strongly that as time went on and more uses were discovered the benefits would greatly increase. It appears, on the basis of this one case history, that the people who administer the national forests are deriving a benefit from the Arizona Land-Use Experiment information. It is allowing them to do a more effective job of management than they would have been able to do without this new tool. It allows them to measure and quantify their land in a way that has not been available in the past. Being able to "see" their land allows them to make more effective use of the resources of the forest and also greatly aids the detection and solution of problems. Benefit to a national forest is difficult to measure in dollars. National forests are not a revenue gathering organization, but function to preserve a national resource, and to allow controlled use of that resource in such a way as to benefit as many people as possible with minimum deterioration. The major benefit of this new tool then is to make more effective use of the forest, a slowly developing benefit, and in the control or prevention of disasters such as fire, flood, or the onset of blight or disease. The benefit from the use of this new technology will only be evident, in the larger sense, after it has been in use for a number of years; however, it is encouraging that it is being actively utilized.

APPENDIX F

USE AND BENEFIT TO INDIAN TRIBES OF ARIZONA

Twenty-six percent of the land area of Arizona is made up of Indian Reservations. The Indian population of the state is about 120,000 and is divided among some 13 individual tribes. The reservation lands represent a very valuable resource to the tribes, but the management of the lands vary from the use of the most modern methods to methods that have not changed since the white man came to Arizona. The land type varies from rich irrigated farm land to open desert and contains almost all of the coal, gas and oil resources of Arizona. The Indian tribes are extremely interested in the wise use of these valuable resources and early in the Arizona Land-Use Experiment expressed an interest in applying the results of the experiment to their lands. They were one of the groups in Arizona to obtain the orthophotoquads and the U-2 imagery.

The orthophotoquad maps and the imagery have been mostly used to define tribal boundaries, identify commercial operations that, due to the imprecise location of these boundaries, have been operated on tribal lands. Little use of the information appears to have been made in the broad sense. This lack of general use seems to have been the result of lack of trained personnel to translate the data into useful management tools.

The University of Arizona, who have in the past taken the lead in transferring new technology to the Indian community, has undertaken the task to translate this information and transform it into a form useful for a variety of uses for the Indian community. Even more recently, the Arizona Resources Information System (ARIS) has started a program to train selected members of the Papago Indian Tribe in the use of remotely-sensed information. The Papago Indian Reservation, located in South-Central Arizona, comprises almost three million acres of land and represents a wide range of uses. The Papago Tribal leaders feel that training members of the tribe to use remotely-sensed information will help in gaining acceptance for this new tool. They feel that the Landsat information will be very valuable to them as a range management tool.

The University of Arizona Program is being undertaken by the Office of Arid Lands Studies and in June 1976 they initiated the Laboratory of Native Development, System Analysis and Applied Technology (NADSAT) with funding provided by the Office of Technical Assistance, Economic Development Administration (EDA), U.S. Department of

Commerce. The purpose of the grant and the program is to assist the American Indians of the Southwest by providing technical assistance for more effective utilization and economic development of Indian land resources. The methodology used by the Office of Arid Lands Studies is to first invite the Indian tribes to become involved in the program, to visit the tribal lands and show examples of the use of the remotely-sensed data, and to attempt to identify some specific problems of interest to the tribe. Once a need is identified and agreement is reached that remote-sensed data can contribute to its solution, the problem is given project status. One such project has been initiated in August 1976, and the results of the initial survey indicate that several others will reach this stage early in 1977. The formal project mentioned is a resource inventory of the Papago Reservation.

In its simplest form, the project will use U-2 imagery and the orthophotoquad maps as the main data base, but will use Landsat information to update the U-2 information and to determine changes that have taken place since the U-2 flights. This method has now become almost a standard method for projects of this kind, and indicates that a combination of aircraft and satellite information forms the best of all data bases. A complete description of the project is given by Foster, E. Kenneth, Norvelle, Michael E. and Johnson, Jack D. "Quarterly Report of Work Performed under EDA Grant No. 99-6-0955," August 1976. Office of Arid Lands Studies, University of Arizona, Tucson, Arizona.

APPENDIX G

USE AND BENEFIT TO PRIVATE SECTOR COMPANIES

Private sector companies are the largest and most active users of the information produced by the Arizona Land-Use Experiment. Several of the users have been interviewed in detail and these details are given in the body of Appendix G.

Identification and Harvesting of Pulpwood. Southwest Forest Industries is presently making major use of the U-2 imagery and orthophotoquads to harvest large stands of timber in Northeastern Arizona. This company and its subsidiaries harvest, process, and sell forest products from the tree to the finished product, and have extensive land holdings and processing plants in the Southern and Western parts of the United States. This new project involves the reharvesting of a forest that was logged some 80 years ago. Since the original operation, the forest has regrown and the roads and old boundary lines have become blurred with time. The new project must re-identify the old boundary lines of the old leases, the rights-of-ways used earlier, old roads, and old railroads in order to plan the harvesting operation. In addition, they must identify tree type, size, and the extent of the various stands of timber together with their precise location. When it is remembered that these old leases, surveys, and roads date back to the 1885-1890 time period, it is a formidable task.

The U-2 imagery and the maps produced from it is used in several ways: To identify the extend and location of the forest ripe for cutting; to identify the old roads and plan for their restoration; to determine where new roads must be constructed; to identify and locate the old railway line and to determine the condition of bridges, old cuts and fills, washouts, etc.

The identification and location of the timber stands was a straightforward job from the U-2 imagery. Foresters have been using aerial photography to identify timber type and yield for a long time, and the availability of the imagery simply meant that they did not have to re-fly the territory. While the detail in the U-2 imagery was not as good as they would have liked for this specific part of the job, it had one advantage generally not found in low level photography, the precise location of the timber stands could be easily determined with respect to the old road locations.

The planning of the road system was greatly facilitated by the use of the U-2 imagery and the resulting maps as it was

found that the old roads were clearly visible as was the condition of the old roadbeds. The location of washouts, landslides, and heavy growth could be seen and, therefore, the types of equipment needed could be determined as well as estimates of the time required to repair the road damage. This information was obtained without having to send in ground crews. If ground inspection and survey crews had been necessary, it would have been a costly and time consuming operation as the country is too rough for vehicular traffic, even four-wheel drive jeeps.

Of particular interest is the fact that Southwest Forest Industries had leased the rights to an old railroad, which was actively used in the 1800's and had been completely abandoned in the 1930's. The old railroad is some 100 miles long and winds through rough, inaccessible terrain, and its restoration and use was considered critical to the economic success of this venture. Again, as was the case with the old logging roads, the U-2 imagery showed the location of the railroad, the condition of the old bridges, places where the tracks were washed out or covered with landslides. Again the imagery was the key to rapid and accurate planning of the restoration of the railroad.

One unexpected bonus resulted from the availability of the imagery and the orthophotoquads. Some time after Southwest Forest Products had leased the old railway line they were visited by a representative of the local Indian tribes who stated that parts of the old railroad were located upon reservation property and could not be used without permission from the Indian Nation. Moreover, they were informed that the Indian Tribes were in the process of blocking any rebuilding of the railroad by court action until the matter was cleared up. This presented a problem of considerable magnitude as the legal determination of ownership could be a very lengthy affair as all of the boundary lines in that part of the country had been determined by a very old survey of doubtful accuracy. Moreover, due to the many uncertainties involved, the decision might well be decided in favor of the Indian Nations. As it turned out, Southwest Forest Industries found they could locate the Indian Reservation boundaries using the imagery, from differences in land grazing patterns between the Indian usage and that of the local ranchers, and by the precise location of several natural landmarks. These boundaries and the location of the old railroad was considered to be so graphically displayed by the imagery that they invited the Indian representatives to view the imagery with them, and to see for themselves that the old railroad was, in fact, not on Indian lands.

After viewing the imagery, the Indians agreed that the railroad was not on their land and withdrew their threat to take court action. It is said that the sigh of relief could be heard for miles around.

As a result of the experience they have had with the U-2 imagery and the orthophotoquads, Southwest Industries would like to obtain U-2 coverage of all their land holdings in other states, and have become very strong supporters of the Arizona Land-Use Experiment. In fact, Mr. Kent Bingham, chief forester, made an interesting statement about his experience with the imagery. He stated that a tool of this kind represents the most significant advance in operational forestry in several decades.

As this project is in the planning stage, it is only possible to estimate the savings that the Arizona Land-Use Experiment has made possible in this phase, and these savings are substantial. First of all, the availability of the U-2 work saved the cost of performing an independent photographic aerial mission to determine the details of the area. However, this saving should probably not be counted as it would have been very difficult to do from low altitude, as it is extremely difficult to make accurate survey maps in this manner and Forest Products Industries would probably have used the traditional ground survey method. According to their statements they saved about one year of time in the planning phase plus the costs of the survey which they estimate would have been at least \$300,000. Just what the year gained in the harvesting of this timber resource is worth is hard to tell as it depends upon the market for forest products, price changes, and the availability of company manpower. For this reason it is only possible to give the direct saving in terms of dollars, the saving in terms of a more efficient, complete planning job is hard to judge and, therefore, this saving or benefit is intangible.

Subdivision Planning. Within the last year or two, Arizona has experienced a sudden increase in subdivision planning. The requirement for increased planning comes about from several sources within the state. Foremost among these is the reforms that have been put into effect recently to correct some of the abuses of the past. Also important is the realization that every subdivision impacts the natural environment and makes a demand upon the services provided by the state and local government long before the new community is able to pay its own way. This new planning involves much more than just laying out of streets and dividing the plot of land into lots. The general suitability of the land to support a subdivision in terms of availability of water, suitable roads, freedom from floods, sewage disposal, and the demands of the new community for scarce energy are factors that have to be considered. The rather relaxed rules of the decades of the fifties and sixties spawned a proliferation of remote subdivisions, which for the most part were on land unsuitable for that

purpose. Moreover, these subdivisions have a population capacity greater than the total projected population of Arizona through the year 2000. Many of these lots were sold and later found to be of little or no real value and the resulting situation has given rise to a land scandal of major proportion. Recently the State Legislature has passed a series of laws in an attempt to curb these illegal practices, and authorities at all levels are rigidly enforcing these new standards.

In order to cope with this new work load most planning departments throughout the State are using the orthophotoquads to determine location, land suitability, and the proximity of services before issuing building permits. In particular some of the engineering firms are making use of the orthophotoquads and the imagery to economically determine land features and generate the information needed to meet these new standards. The details of the method are outlined in the next section.

Gittner-Louviere Engineering, Inc. CONSULTING CIVIL ENGINEERS

Gittner-Louviere is a small firm of civil engineers whose major business is making surveys and preparing plans for subdivisions and recreational area development in Northern Arizona. They make use of ALUE information in the following ways:

- a) Search for regions that are generally suited for subdivision.
- b) Make detailed surveys of the better candidate areas.
- c) Present findings and recommendations to their customers.

The general decision on which regions are ripe for subdivision depends upon a variety of factors outside of the realm of the information supplied by any map or photograph, but the ALUE information does play an important part. For example, what is the character of the land, what is its present use, does it lie within a flood plain, and what are the condition of roads and how much road construction is needed? These engineers have been able to determine the location of aquifers from the imagery and are able to gain valuable information as to the probable depth of water from a study of the vegetation. They state that they are able, by the use of this information, to avoid costly hydraulic surveys and to be able to drill wells with confidence. Unfortunately, not enough wells have been drilled using this information to gain a quantitative measure of the increased

success ratio over standard methods; however, drilling of deep wells (generally 700 to 1,000 feet) is an expensive project and these engineers are convinced their methods will be successful. It appears doubtful if this method of locating wells will come into general use until the method has proven successful for some time.

After an initial decision has been reached that an area meets the general criteria for subdivision very detailed surveys are made of the local area. Again the infrared is used to determine local land features, water run-off patterns, soil condition from local vegetation to determine what should be planted for landscaping and ground cover. In one instance the infrared imagery was used to locate gravel deposits that could be used during the construction phase and avoid the costly transportation problem.

It has been found again and again during this study that one of the uses of the orthophotoquads and the imagery was to improve the effectiveness of the presentation of the results of a study or a proposed land use. These engineers also use the imagery for the same purpose with great effectiveness.

The benefit of this new information to this young firm of engineers is very great. It is a new tool which they can and do utilize to give them a competitive advantage over the older firms, and as a result of its use they have been very successful. Business is booming they say, and are very pleased that they are pioneering its use. For example, one of the partners, Mr. Gittner believes that this is one of the most useful tools for civil engineers that has been developed in recent years, and he sees growing use of it in the civil engineering business. How fast the use of this information will be picked up by other firms is difficult to state at present, but this company recognizes that this will happen and that they may lose some of their advantage when it does. They are somewhat reluctant to disclose all of their methods for this reason. During the discussion with them, this was very evident and they would only discuss their projects in very general terms.

One of their statements about the imagery and the orthophotoquads was that the usefulness would be very much improved if contour lines could be determined from the imagery. Also they have the standard complaint that the imagery is not detailed enough to determine fine features, but they do recognize the problem of trying to obtain large scale and good resolution.

Range Land Management. One important and potentially very beneficial use of the ALUE information is to extend useful areas of cattle and wildlife pasture. In much of the Western United States the growth of grass depends upon seasonal rains. In Northern Arizona these periods of rainfall are insufficient to provide running streams or natural lakes spaced closely enough together to provide drinking water for livestock or wildlife. Therefore, the useful range is limited to those areas close enough to water to provide a daily drink for the animals. It is the practice to dam up small streams or dry washes in order that they will fill up during the rains to provide the needed water. In the past, this has been done based upon local knowledge of the terrain. Large cattle companies are now using the ALUE information to ease this job.

Page Land and Cattle Company.

The Page Land and Cattle Company is one of the largest cattle companies in the Southwest. They control, through leases and direct ownership, over a million acres in Arizona alone. They first used the orthophotoquads to inventory water tanks, ponds and other sources of water for their cattle. In the course of this inventory, they discovered they could easily trace water run-off regions or alluvial fans that fed their ponds and water storage basins. These watersheds need to be a certain size in order to supply enough water for the cattle during the time the pasture grass is suitable for grazing, but should not be so extensive as to overflow and cause damaging washouts. In addition they should not interfere with the water rights in streams below. They are presently locating new watershed areas which they plan to dam up and extend the usefulness of their range land. This project is just getting underway and at the present time they do not have an estimate of the extent of the expansion of the usable range, but they feel it will be sizable.

In addition to the direct benefit resulting from making more range land productive, the use of the orthophotoquads allows the planning of the damming operation and eliminates a present time consuming riding over the range to locate trails for the earthmoving equipment. They are presently studying ways to use the imagery for range grazing control. The use and familiarity with the U-2 imagery has made them aware of the potential use of satellite imagery for range grazing management and they are presently investigating its use. They are not too happy with the service they receive from the data center in South Dakota, but are working with the Arizona Resources Information System to clear up this problem.

Public Utility Use, Arizona Public Service. Arizona Public Service Company is a privately owned public utility company which supplies power to 325,000 customers in central Arizona. They own and operate a number of electric power generating stations throughout the state. In addition, they own and maintain power transmission lines stretching over large distances. Due to the population growth within the state new power transmission lines are constantly being constructed. APS has made major use of both the orthophotoquads and the Landsat imagery in their transmission line placement and construction. They have made the statement to us that without the orthophotoquads and the Landsat information, the construction of new transmission lines within the state would be nearly impossible, or at the very least, extremely costly as compared with the costs using this new technology. This is a somewhat surprising statement and was unexpected. In order to understand the basis for this statement, it is necessary to digress for a moment and explain how transmission lines used to be designed and the very different requirements now placed upon the design and location.

In past times, before the recent concern for the protection of the environment, transmission lines were placed along rather well known routes. Generally along railroad or highway rights-of-way or at least over flat country which avoided rough mountains. The design was mainly concerned with costs and engineering difficulty. The surveys needed could be done with relative ease. With the rise of concern for the protection of the environment, the situation changed drastically. In addition to the old factors of cost and engineering difficulties, the environmental impact had to be carefully evaluated. Instead of simply being concerned with one route, the present designer must consider a number of routes and select the one which is environmentally acceptable and yet can still be built at a reasonable cost to the users of the electric power. In order to make these engineering studies the land ownership and value over all the possible routes must be evaluated, future use of the land had to be estimated, land features and physiography evaluated, geology and soil type determined, vegetation and biotic communities determined, wildlife evaluated, historic and archaeologic sites located. In addition, impact of the proposed transmission lines upon the recreation and scenic beauty of the landscape had to be assessed. In simple terms, the transmission line almost has to be put someplace where it disturbs nothing and cannot be seen. It is easy to understand the welcome this new technology received by those facing the above tasks.

Some estimates of the benefit in terms of cost to the utility company can be made by examination of one particular transmission line stretching from Cholla, Arizona to Saguaro, Arizona, a distance of about 200 miles across

country which had not been well surveyed in the past. The corridor contains some of the roughest terrain in the Western States. Beginning in late 1972 before the availability of the orthophotoquads it was estimated that approximately \$500,000 would be required for the initial engineering and environmental studies. The orthophotoquads began to become available as the study progressed as did information from the Landsat satellite. This information was used to complete the study of the corridor and APS now estimates that the study could have been done for \$100,000 if the information had been available earlier. This is one area where the availability of this new technology allowed an important effort to be completed which would have been almost impossible using the old time-honored techniques. The information available from Landsat and the orthophotoquads is used more or less continuously both on relocating of older transmission lines and on the studies of new proposed routes. It is planned to make a more detailed study of the transmission line location benefits in the future in order to better quantify the benefits resulting from this application.

Public Utility Use, Salt River Project. The Salt River Project is the major supplier of irrigation water in the State of Arizona and was formed in 1903 as an outgrowth of an older private system which had its beginnings shortly after the Civil War. In 1912 the project started to sell hydro-electric power to its members. The power production and distribution part of the Project has grown over the years, and they now have the capacity to produce over 600 megawatts from their combination of steam and hydro-electric plants. They also buy and distribute large blocks of power. The Project supplies power to approximately 240,000 customers. They own and maintain over 700 miles of transmission lines in addition to their use of the Federal grid.

The Salt River Project (SRP) is faced with much the same problem as the Arizona Public Service Company described earlier. Construction of new power transmission lines is a continuing requirement to keep pace with the growing population and the added demands upon electric power as a replacement for the natural gas supply which is dwindling. They make major use of the orthophotoquads and the Landsat imagery in much the same manner as the other utilities and consider the new technology to be a major factor in their ability to cope with the rising costs of construction and the increasing need to meet environmental requirements. Again it was difficult to obtain overall estimates of the benefits at this meeting, but some numbers are available from a few examples. This part of the survey will require some careful work with the upper levels of the management as the working level people are not able to give overall estimates of benefit. In one example project, a \$68 million

new transmission line placement, one million is budgeted for initial studies of the environmental situation, and they estimate that without the new technology made available through the Arizona Land-Use Experiment and the Landsat imagery the cost of just this portion of the work would be about three million dollars. This does not count the savings in the actual construction costs which might result from good information on the actual placement of towers. Transmission towers are placed one-quarter mile apart and cost about \$85,000 each; therefore, the misplacement of towers tends to run the cost of the line above the budget level. When towers are placed in wild country a slight error in a survey can cause large over-runs. It is their opinion that the accuracy of the orthophotoquads is so superior to the information they used to work with that this problem can now be avoided.

SRP has budgeted \$2.0 billion for expansion of facilities within the next five years, mostly in additional transmission lines from the Four Corners Region. The Four Corners Region is a multi-state power generation complex located near the junction of Arizona, New Mexico, Colorado, and Utah borders. Some of this money will be spent in plant expansion, but the major use of the orthophotoquads and Landsat information will be in the planning of the transmission line expansions. This indicates there will be an increased use of this information for some time to come.