



Columbus Laboratories

(NASA-CR-158024) SURVEY OF UNIVERSITY PROGRAMS IN REMOTE SENSING FUNDED UNDER GRANTS FROM THE NASA UNIVERSITY-SPACE APPLICATIONS PROGRAM Final Report (Battelle Columbus Labs., Ohio.) 70 p HC A04/MF A01 G3/12 N79-14119 Unclas 15325

Report



FINAL REPORT

on

SURVEY OF UNIVERSITY PROGRAMS IN
REMOTE SENSING FUNDED UNDER GRANTS FROM
THE NASA UNIVERSITY-SPACE APPLICATIONS PROGRAM
(Report No. BCL-OA-TFR-78-3)

by

J. A. Madigan and R. W. Earhart

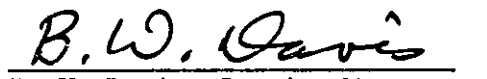
Sponsored by

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Space and Terrestrial Applications
(Contract No. NASw-2800, Task No. 27)

March 31, 1978

Approved by:


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FOREWORD

The study reported herein was carried out by Battelle's Columbus Laboratories for the NASA Office of Space and Terrestrial Applications, as a task under Contract No. NASw-2800. The work was done under the general supervision of Dr. A. C. Robinson, Battelle's manager for the contract. Task monitor in the Office of Space and Terrestrial Applications was Mr. Joseph A. Vitale, Manager, University-Space Applications Program, Technology Transfer Division, Office of Space and Terrestrial Applications.

In the course of this study, a number of persons were contacted for information on university programs in remote sensing. The authors are most appreciative of the cooperation of these individuals, since without their cooperation the study could not have been completed.

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INTRODUCTION

NASA's Office of Space and Terrestrial Applications (OSTA) is currently assessing approaches to transferring NASA technology to both the public and private sectors. As part of this assessment, NASA is evaluating the effectiveness of an ongoing program in remote sensing technology transfer conducted by 20 university contractors/grantees, each supported totally or partially by NASA funds. The University-Space Applications program within NASA's Office of Space and Terrestrial Applications has as its objective the demonstration of practical benefits from the use of remote sensing technology to a broad spectrum of new users, principally in state and local governments.

To evaluate the University-Space Applications program, NASA has a near-term requirement for data on each university effort including total funding, funding sources, length of program, program description, and effectiveness measures. Specifically, NASA requested Battelle to collect and organize the following information for each of the 20 university programs:

- (1) A description of the program including unique characteristics or capabilities which have been developed
- (2) Program duration
- (3) Funding from NASA and non-NASA sources since 1974
- (4) Measures of success such as the number and types of users of the facilities, data, and services, to the extent that such data are available.

It was recognized at the outset that a complete evaluation of effectiveness of the University Grants program is a complex undertaking well beyond the time and resources allotted to this study. Such an evaluation would require collection and analysis of data on the significance and relative efficiency of applications of Landsat data which have been instituted at the state and local level and an assessment of the degree to which such applications were instituted solely as a result of the grant program. In order to provide preliminary inputs to such an assessment, secondary indications of program success were collected, along with Program Manager's assessments of program effectiveness. These are

indicators only, and should not be interpreted as a complete or objective evaluation of the effectiveness of the University Grants program.

STUDY METHODOLOGY

Survey Format

A telephone survey was selected as the primary information gathering mechanism because of the short time requirement (NASA needed the data within 3 weeks), and because of possible misinterpretation of specific questions such as funding sources, which were easily clarified by conversation.

To facilitate and organize the data collection task, the form shown in Figure 1 was developed as a survey guide.

Data Collection for NASA Review of University Programs in Remote Sensing as a Part of a Review of Technology Transfer Activities				
University:	Program Manager:			
Laboratory:	Telephone:			
<u>Background</u>				
1. Duration/program inception date				
2. Program manager's overview/description of program				
3. Specific technologies within remote sensing				
4. Unique or unusual capabilities				
<u>Level of Effort Measures</u>				
1. Number of people at university associated with remote sensing				
2. Funding by year from all sources since 1974				
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA				
Non-NASA				
<u>Effectiveness Measures</u>				
1. Capabilities/relationships developed				
2. Types of users				
3. University courses/classes/degrees offered				
<u>Program Manager's Assessment</u>				

FIGURE 1. SURVEY GUIDE

Data Collection

Specific contacts at each university are given in Table 1. The manager of each university program was contacted, and the required information collected by telephone. As follow-up, some managers supplied written materials such as program reports and project descriptions. The data were organized from these sources into a standard format for each program. Summary sheets on each university are presented in this report in the section entitled Survey Findings.

TABLE 1. UNIVERSITY SPACE APPLICATIONS PROGRAM
PRINCIPAL INVESTIGATORS CONTACTED

University	Contact	Telephone
Alaska	Dr. John M. Miller/Geophysical Institute	907-479-7363
Arizona	Dr. Ken Foster/Office of Arid Land Studies	602-884-1955
California	Dr. Robert N. Colwell/School of Forestry & Conservation	415-642-5170
Colorado	Dr. Jack D. Ives/Institute of Arctic & Alpine Research	303-492-7909
Cornell	Dr. Warren Philipson/College of Engineering	607-256-4330
Florida	Dr. H. K. Brooks/Department of Geology	904-392-2231
Kansas	Dr. B. G. Barr/Center for Research, Inc.	913-864-4775
Louisiana State	Dr. C. A. Whitehurst/Division of Engineering Research	504-388-5309
Michigan/ERIM	Dr. Donald S. Lowe/Deputy Director	313-994-1200
Michigan State	Dr. Myles G. Boylan and Dr. Bill Enslin/School of Urban Planning	517-353-7195
Minnesota	Dr. William G. Shepard/Director, Space Science Center	612-373-5479
Mississippi State	Dr. W. Frank Miller/School of Forestry	601-325-2946
Nebraska	Dr. Marvin P. Carlson/Assistant Director, Conservation & Survey Division	402-472-3471
Oregon State	Dr. Barry J. Schrupf/Director, ERS Applications Laboratory	503-754-3056
Purdue	Dr. David A. Landgrebe/Laboratory for Applications of Remote Sensing	317-749-2052
South Dakota State	Dr. Victor I. Meyers/Director, Remote Sensing Institute	605-688-4184
Texas A&M	Dr. B. J. Blanchard/Director, Remote Sensing Center	713-845-5422
Utah	Dr. Merrill K. Ridd/Department of Geography	801-581-8218
VIMS	Dr. John Munday/Assistant Director	804-642-2111 Ext. 254
Wisconsin	Dr. James L. Clapp/Institute for Environmental Studies	608-262-1978

Summary Data

After the data were collected and standardized, a number of summary charts were developed in Vugraph format, at NASA's request, to facilitate discussion of the survey findings with management. These are presented later in this report in the section entitled Major Observations.

SURVEY FINDINGS

Information gathered on each university program was organized into a standard format, and is presented in this section. For convenience, the program summary sheets are organized in alphabetical order by university, with each program beginning on a separate page. In addition to outlining the NASA grant activities, the information obtained in the survey also reflects the interaction of grant activities with other remote sensing work performed at the several institutes and laboratories. It should be noted that NASA grant funding in a given year may not correspond exactly to university expenditures of these funds in that year. In most cases, block funding is employed which allows unspent funds to be utilized in subsequent years.

Figures reported in this study are funding levels rather than expenditures.

UNIVERSITY - Alaska

PROGRAM MANAGER - Dr. John M. Miller, Geophysical Institute

TELEPHONE - 907-479-7363

BACKGROUND

Overview

The institute was founded in 1947 to study the solid Earth and its upper atmosphere. The interest and background in remote sensing was derived from the sensors used to study the upper atmosphere and applied to research for state and local public needs under the NASA Grant.

Most applications addressed in remote sensing work at the institute are directed toward land use planning/Earth resources surveys and management.

Technologies Used

Technologies used are predominately conventional image interpretation using a combination of high altitude (U-2) photography and Landsat imagery. The scale of the imagery is usually adequate to the task.

Applications

Uses to date include application of Landsat imagery to 40 million acres of Alaska so that 4 to 10 million acres could be selected by the tribes under the Native Claims Settlement Act and to river ice problems. Landsat imagery was used to determine ice buildup on the rivers so that coal dust could be dumped by aircraft to encourage selective melting and thereby prevent floods. Because of the length of the rivers, this must be planned to achieve the maximum benefit from available aircraft time. The application of Landsat data to forest fire control was also demonstrated in the recent major fires to the extent that the State is in the process of getting an Alaskan Landsat processing capability. This appears to be the only program which has generated enough interest in near-real-time Landsat data use to get the state involved. This has occurred primarily because Alaska has such a large amount of sparsely populated land that remote sensing via Landsat is the only way of accomplishing tasks for which alternatives are available elsewhere.

Duration

The institute was founded in 1947-48; work in a formal remote sensing program started in 1972.

LEVEL OF EFFORTPeople at University

There are approximately 120 to 130 people involved in the Institute, but only 6 people involved on a part-time basis in remote sensing work under the grant.

Other Support

Some contacts with the NASA Fairbanks center are supportive in nature and considerable intangible support is received from the state government. Quantified estimates of the support are not made.

Funding

All funding has come from governmental units with Federal funds comprising approximately 85 percent of the total. The state has contributed approximately 7 percent and the boroughs also approximately 7 percent. Many of the boroughs are as large as most of the other 49 states.

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	--	100	100	200
Other				195
Private				5
	<u>---</u>	<u>---</u>	<u>---</u>	<u>---</u>
TOTAL	--	100	100	400

EFFECTIVENESSUsers

Users have been largely governmental units with most of the funding coming from the Federal government. Because much of the land is relatively unexplored, any work in remote sensing by any unit of government is of interest to others. Most of the work has been accomplished under the auspices of the U.S. Bureaus of Land Management and Indian Affairs. Because Alaska is a relatively new state and a large land area which would normally be under state ownership is still under Federal control until allocations are made, the state is not interested in funding Earth resources surveys. The program has generated enthusiasm in several state agencies, but until the state controls the land, little funding is likely to be forthcoming. Exceptions to this occur in land which is under state ownership, and the Federal government charges for management services such as fire control.

A historical review of Landsat data on the recent major forest fires indicated a major advantage could have been achieved if Landsat imagery had been available within a few hours of satellite passage. Because of this demonstrated advantage in this and other applications such as flood planning and control, the state is considering appropriating \$500,000 per year for a Landsat ground terminal.

Courses

No degree is offered in remote sensing, as it is viewed as a tool within other disciplines. Photographic interpretation is taught in the geology department (15-20 students per year) and the biology department (60-70 students per year). It is expected that similar instruction will be offered in the agricultural school, with potentially another 30 or 40 students per year.

PROGRAM MANAGER'S ASSESSMENT

The state is currently deficient in spending on remote sensing because land selection for state ownership is frozen. The situation appears to be improving even under this freeze since Landsat data are valuable for near-real-time management purposes. Major problems in Landsat data availability from NASA apparently will be reduced in the near future. The only other major problem now apparent is that non-federally sponsored U-2 flights have become too expensive for ready justification to the state government and the program must ride along on federally sponsored high altitude imagery.

UNIVERSITY - Arizona

PROGRAM MANAGER - Dr. Ken Foster, Office of Arid Land Studies

TELEPHONE -- 602-884-1955

BACKGROUND

Overview

The program concentrates on remote sensing for arid environments, particularly in desertification problems and in resource management, specifically ground water inventory and flash flood hazard inventory efforts. In addition, the program has backed the performance of considerable land use planning. Related to the program in remote sensing applications is a program in sensor design conducted by the University's Optical Sciences Department which includes undergraduate courses as well as research and development.

Specific Technologies

The remote sensing program conducts an applications program usually based on traditional photointerpretation techniques. The program has available to it a large variety of equipment and capabilities which might not be available if there were no interaction with the sensor development program. Among the equipment is a spot densitometer obtained from JPL. The program has also implemented the LARSYS program from Purdue. Overall, the facilities are considered to be above average, but not unique. Because of the scale at which they are able to operate in a low population density state, the program is able to make more use of Landsat and U-2 imagery than are programs in states with higher population densities.

Duration

The overall program in remote sensing applications was established in 1970 and NASA grant work was started in 1972. Approximately 30 projects have been undertaken.

LEVEL OF EFFORT

People at University

Approximately 10 people on a full-time equivalent basis work on remote sensing applications. The number of people involved on a part-time basis is substantially larger and includes an eight person university remote sensing committee representing eight different disciplines.

Other Support comes from JPL and Ames and is estimated to be about one man-month per year. The state government provides some cooperative support in investigations but a firm estimate is not available.

Funding

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	75	125	100	100
Non-NASA Funding (Fed., State, Local, Private)	-	50	75	150
Indian Tribes	<u>-</u>	<u>-</u>	<u>50</u>	<u>50</u>
Total	75	175	225	300

EFFECTIVENESS

Users

Federal government users of the program include the Bureaus of Indian Affairs, Reclamation and Land Management, and the Park and Soil Conservation Services. Federal interests in applications in Arizona also support the activities of the state agencies.

Actively assisted state agencies include the Water Commission, Oil and Gas Conservation, Fish and Game Commissions as well as the Land Department and Planning Department. The program has also assisted the Natural Resources Committee of the State Senate. Local government users include about three-fourths of the counties and two councils of city governments: Tucson and Scottsdale. The program has also assisted the Salt River Project to provide increased water supplies. Involvement in this project is both governmental and private since the implications of the water supply are so great.

Private sector involvement (providing some small funding) includes conservation groups (Nature Conservancy) and also geologists (consultants) who use the photographic files. The involvement on a contractual basis with two Indian tribes is considered to be approximately equivalent to a local government involvement in land inventory and land use planning.

Courses

The University offers 23 courses in remote sensing topics; about half of these courses cover remote sensing technology while the other half are oriented toward applications. The number of students per course is estimated at 15 or about 350 students per year. A Ph.D. minor or specialization in remote sensing is offered.

PROGRAM MANAGER'S ASSESSMENT

The program is very strong in conventional photointerpretation and map making. Because of costs and associated lack of demand, the program is not as strong as it would like to be in image processing. The manager feels that closer ties to avoid duplication are needed with the Arizona Resources Information System in the state government.

UNIVERSITY - California (Berkeley, Davis, Riverside and Santa Barbara)

PROGRAM MANAGER - Dr. Robert N. Colwell, School of Forestry and Conservation

TELEPHONE - 415-642-5170

BACKGROUND

Overview

The program started about 1947 using aerial photo technology and has had a long history in Earth resources, predominantly directed toward forestry and water management. Water management efforts include snow-cover and evapotranspiration studies for optimum water utilization in entire watersheds and for all requirements including agriculture. Recent work during the two-year dry period has attracted national attention to the potential of using remote sensing for water management. Work under the NASA grant began in 1970 and is carried out at four campuses of the University of California system: Berkeley, Davis, Riverside and Santa Barbara. In addition to water studies, remote sensing has been applied to fuel mapping of brush and timberland, fuel moisture estimation, cotton mapping from Landsat data, a citrus tree census, desert wilderness area selection, and assistance to state and county planners in brush management, highway and geothermal energy considerations, usually through land use mapping techniques.

Technologies

Much of the work in applications areas is conducted using conventional photointerpretation of Landsat and high-altitude imagery. The program has the capability of processing its own data tapes.

Duration

Program inception, 1947; NASA Grant, 1970.

LEVEL OF EFFORT

People at University

Approximately 60 people are involved on four different campuses.

Other Support

State agencies are currently providing about five man-years per year of employee time on cooperative projects; if a direct man-year including travel, per diem and direct fringe benefits is costed at \$20,000, this represents approximately \$100,000 per year. In addition, there is federal support which is not well quantified, but is estimated at one or two man-years per year.

Funding

Most of the project's funding comes from NASA and other Federal agencies, principally the Bureau of Land Management. In the past there has been some direct state funding, but not at the present time. All projects have been carried out for some level of government and there has been no involvement with the private sector. The closest activity to private sector involvement was the construction of an image enhancement apparatus for the Mexican Government.

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	—	—	90	245
Other NASA	500	550	655	471
Other Federal*	<u>250</u>	<u>250</u>	<u>150</u>	<u>150</u>
Total	750	800	895	866

* U.S. Bureau of Land Management.

EFFECTIVENESSUsers

All work has been directed toward potential government users of remote sensing. The principal current state work is for the California Department of Water Resources where the application is highly significant since 85 percent of California agriculture is irrigation dependent and California is one of the top agriculture states. The major Federal user of remote sensing applications is the U.S. Bureau of Land Management in California. Some work is also directed toward county and city planning.

Courses

No degree is offered in remote sensing work. Twelve to sixteen credit hours are offered in undergraduate schools and formal graduate course work is limited to 6 to 8 credit hours. Individualized study and/or research courses are also available. Students per year at the four campuses are estimated at 300, or about 75 per campus.

PROGRAM MANAGER'S ASSESSMENT

The problems which might be expected from a multi-campus program have not materialized and, in fact, the spirit of cooperation appears strong. The education and training is also strong and is focused on preparing students for the real world and moving them out without delay. The major problems occur in uncertainty and delays in awards, grants and contracts rather than in the level of funding. Most of these uncertainties are not technical but administrative; one example is a hold on Federal awards to U.C.-Berkeley from HEW associated with minority hiring.

UNIVERSITY - Colorado

PROGRAM MANAGER - Dr. Jack D. Ives, Institute of Arctic and Alpine Research

TELEPHONE - 303-492-7909

BACKGROUND

Overview

Grant activities have been concentrated in three areas:

- (1) Hazard mapping for avalanches and landslides in the Rocky Mountains
- (2) Spinoffs from this activity, specifically analyses of recurrence intervals for the hazard analysis
- (3) An environmental atlas for the Colorado front range for land use policy decisions.

Other work undertaken by the institute is more reflective of their title and about 50 percent of the effort is directed toward the U.S. and Canadian arctic, where applications tend to be concentrated in Alaska and theoretical studies are concentrated in Canada. Examples of the Alaskan applications studies are a Landsat mosaic of Petroleum Reserve No. 4 for the pipeline haul road impact assessment and remote sensing of sea ice for traffic studies. An example of a theoretical study in Canada is the determination that the unusually light colored rock visible in aerial and satellite photography is due to the death of rock lichen during the little ice age in the 17th Century. The distribution of this phenomenon has been used to model growth and decline of glaciation.

Efforts in alpine research include remote sensing and other studies in high mountains around the world, including the Alps, the Himalayas and Andes Mountains.

Specific Technologies

The program uses color enhancement of remote sensing imagery for detailed mapping, but has no unique or unusual capabilities. The program's expertise lies in its extensive mountain field experience and applying its research to needs of society.

Program Duration

The institute was founded in 1950 and remained a small operation until 1967 when a new director was obtained under the condition that the program would be expanded. NASA grant activity was initiated in late 1970.

LEVEL OF EFFORTPeople at University

The grant supports approximately six people on a full-time equivalent basis plus a small part of the institute director's time. The institute as a whole has approximately 65 people involved on either a full- or part-time basis. Seven faculty members spend 5 to 10 percent of their time on institute affairs and there are 5 post-doctoral students and 12 technicians.

Support from Other Institutions is relatively minor and consists of collaborative input from the state Division of Natural Resources and the state Geological Survey.

Funding by year for the entire institute is approximately \$1.8 million for 1977. Direct state funding is relatively small, \$64,000 per year for their mountain research station; direct county/local government funding averages about \$2,000 per year and has totaled \$12,000 over the life of the program. Most of the rest of the funding comes from Federal and/or international agencies.

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	75	125	100	100
Mountain Res. Sta.				
State	-	-	-	64
Other	-	-	-	66
Institutional Support	-	-	-	400
Grants and Contracts	-	-	-	1,170*
	<u> </u>	<u> </u>	<u> </u>	<u> </u>
TOTALS	75	125	100	1,800

* Federal Government (Primarily NOAA and NSF) and United Nations (UNESCO, UNEP)

EFFECTIVENESSUsers

The contacts and grant effort have been directed toward projects of interest to the Colorado Department of Natural Resources and State Geological Survey, but these agencies have not directly funded the program. Some minor county funding has been obtained. Federal funding of remote sensing activities tends to come from the U.S. Forest Service, both from operational offices and from the USFS Rocky Mountain Research Center at Fort Collins. Formal private sector involvement has been relatively limited as the institute prefers to avoid the type of work requested by the private sector; some of the students/associates, however, consult for private sector firms or work for private consultants. The program has, nevertheless, received two private sector contracts,

one for \$12,000 and another for \$50,000 with Vail Associates to perform ski area hazard assessments. Foreign funding is chiefly provided by the United Nations University.

Capabilities/Relationships

In addition to developing expertise in mountain and glacial research, the institute has concentrated on translating imagery information for use of planning agencies.

Courses and Students

The institute is part of the graduate school but does not offer a degree; all degrees are offered in traditional disciplines. Approximately six formal courses are offered in remote sensing to approximately 100 to 125 students per year.

PROGRAM MANAGER'S ASSESSMENT

The program's intended strength is in natural hazard work of all types and is considered successful in that specific area. The major deficiency in the program is that they do not have a faculty member with a strong background in remote sensing technology.

UNIVERSITY - Cornell

PROGRAM MANAGERS - Dr. Ta Liang, College of Engineering - 607-256-3438
Dr. Warren Philipson - 607-256-4330

BACKGROUND

Overview

Cornell's NASA grant activities were started in 1972 as a continuation and extension of the photogrammetry work which had been underway for approximately 30 years. The entire program concentrates on projects which potentially provide tangible benefits, do not compete with existing industry or commercial firms, and are not of a repetitious nature. Because data bases tend to be already available for state-wide surveys, the program has emphasized to a considerable extent work at the county and town level.

Specific Technologies

The program concentrates on photographic techniques and interpretation. An IBM 370-168 with an array processor is available for Landsat and other digital information.

Unique or Unusual Capabilities

None

Duration

NASA grant work initiated in 1972; program in photogrammetry was initiated approximately 30 years ago.

LEVEL OF EFFORT

People at University

3 part-time faculty
3 full-time equivalent analysts
1 senior research associate
3-4 hourly students
approximately 100 students in course work

Other Support

Very little; the U.S. EPA did fly a cooperative mission.

Funding

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	100	100	100
Other	10	15	15	15
TOTAL	110	115	115	115

EFFECTIVENESSCapabilities and Relationships

Because the data bases which would normally be established under the NASA grant for statewide use had already largely been completed with aircraft data, the program has concentrated on developing capabilities and data for use of counties and towns. The program has also concentrated on interpretation techniques which give reliable indications of subsurface conditions from remote sensing data, especially for soils. A typical county study provided data distinguishing active from non-active agricultural areas for a rezoning study. This type of activity also illustrates the emphasis of the program on work which can be shown to produce a specific action or benefit. The program also has performed studies for the State Departments of Health (Mosquito Control for Eastern Equine Encephalitis) and Environmental Conservation (pheasant range model to replace an inadequate 1970 study).

Courses

The University offers a variety of courses centered around photo-interpretation and has approximately 100 students in these courses. The advanced degree program includes doctorates in photogrammetric and geodetic engineering and also aerial photogrammetric studies and remote sensing. There is a seminar which features speakers from government and industry as well as other universities.

Types of Users

Work under the grant has concentrated on county and town governments, but has also included projects for state, Federal and industrial users of remote sensing. The principal private sector user has been the Taylor Wine Company for which a vineyard survey was performed. The NASA grant efforts are currently concentrated on localized projects.

PROGRAM MANAGER'S ASSESSMENT

The program has succeeded in demonstrating the benefits of remote sensing to decision makers in work under the grant, but much work for which remote sensing is appropriate cannot demonstrate this direct benefit. The program has also strengthened coursework at the University and is also strengthened in return by the seminar and newsletter on remote sensing activities. The grant has greatly assisted in the development of staff expertise. Little use has been made of Landsat data as it is not a problem-solving tool at the level in which the program works.

UNIVERSITY - Florida

PROGRAM MANAGER - Dr. H. K. Brooks, Department of Geology

TELEPHONE - 904-392-2284 (Ext. 2231)

BACKGROUND

NASA grant funding of the University of Florida remote sensing program began in 1976, though the University has had some activity in remote sensing as early as 1958. The program has been involved in two major areas of remote sensing; soil moisture and hydrology, and coastal engineering.

The program has developed an expertise in spectral shift correction for haze, used in studying evaporative processes of vegetation associated with water management. The procedures developed have been adapted by NASA for use at KSC.

LEVEL OF EFFORT

University Involvement

There are 12 faculty members involved in the project, which includes five or six different departments in the colleges of Arts and Science, Engineering, and the Institute of Food and Agricultural Science. Supporting staff consists of a full-time engineering technician and five graduate student research assistants.

Funding

Funding since 1976 is as follows:

	<u>Thousands of Current Dollars</u>	
	<u>1976</u>	<u>1977</u>
NASA Grant	200	100
Other NASA	*	*
University	20	20
	<u> </u>	<u> </u>
TOTAL	220	120

* Other NASA contributions include time on the Image 100 machine at KSC plus other services and facilities. The University contribution is primarily staff salary. Also, state agencies have provided some funding in kind. For example, the St. John Water Management District employs a man full-time for the project.

EFFECTIVENESSUsers/Relationships Developed

Though grant funds have only recently been initiated, a number of projects have been undertaken with state and local agencies. Some of these have resulted in recommendations on which decisions were based.

- A project was undertaken to delineate water recharge areas for Daytona Beach (Volusia County). The goal of the project was to identify hydrologic characteristics of the Daytona Beach water and sewer supply. The city of Daytona has accepted the project recommendations and has asked the county to institute a \$10 million water project based on the results. Using vegetation as an indicator, the survey contradicted previous geological interpretations of location of key water sources.
- Recommendations were made on harbor improvement in Clearwater, Florida, based on a water inlet analysis.
- A project is currently underway with Captiva Island to study erosion of the island area. This is a long-term analysis involving Lee County, the Army Corps of Engineers, and a private consultant hired by the County Erosion Control Board.
- A project undertaken with the St. John Water Management District will develop evaporative maps for water management decisions. Though 52 in. of rain per year fall on the area, 42 in. evaporates back into the atmosphere through plants, with a resultant impact on water management.

Courses and Students

The University offers four courses in remote sensing. Two courses are offered in civil engineering, while one course each is offered in geography and geology. Thirty-six graduate students and 41 undergraduate students are enrolled in remote sensing courses each year, while another 61 undergraduates are taking remote sensing segments as part of other course work such as geology.

PROGRAM MANAGER'S ASSESSMENT

Though grant funding was only initiated in 1976, at least one project with Daytona Beach has provided results on which significant decisions were made in the location of water sources. The program is becoming involved in areas that are likely to have high utilization, such as the development of evaporative maps for water management, erosion control measures based on remote sensing monitoring, and recommendations to state and local agencies on issues such as harbor improvement.

UNIVERSITY - Kansas, Center for Research, Incorporated

PROGRAM MANAGER - B. G. Barr, Director, Space Technology Center

TELEPHONE - 913-864-4775

BACKGROUND

The University of Kansas Applied Remote Sensing program (KARS) has been funded by the Office of University Affairs since 1972 under a Space Applications grant. Three main areas of concentration are wildlife habitat and environment, urban and regional planning, and agricultural and rural development. The program emphasizes decision-making projects with Kansas state and local agencies, based on the application of remote sensing to current problems. Most of the imagery used to date has been low and high altitude color and infrared, with some Landsat data as applicable. Almost no computerized Landsat data have been used.

There have been eight to 10 projects per year with state agencies, and 41 out of 100 counties in the state have been involved since the program started. Several workshops and seminars have been held with state agencies and regional planning groups, in addition to a governor's conference in 1972 and 1974.

LEVEL OF EFFORT

University Involvement

Three faculty members are involved in the program (1 full-time, 2 part-time) as well as two additional faculty contributing to the program as part of their own research efforts. Six to eight graduate research assistants also participate in the program.

Funding

Funding since 1974 is as follows:

	Thousands of Current Dollars			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	125	100	100
Other NASA	-	-	-	-
Federal	15	15	15	85*
State	15	15	15	50**
TOTAL	130	155	130	235

* Primarily EPA (\$70,000).

** Includes \$35,000 in pending state legislature funds.

EFFECTIVENESSUsers/Relationships DevelopedState and Local

The KARS program has worked on projects with 39 Kansas agencies, and maintains regular contact with 74 agencies. An additional 150 contacts can be drawn upon as needed. Several letters of support have come from state agencies, resulting in a bill in the Kansas legislature to provide state funds for the program (initially \$35,000/year).

Projects have ranged from wildlife management to rerouting garbage collection routes. As an example, one project involved the release of wildlife into new areas on the basis of ground cover assessment. Other projects included an endangered species assessment, and an irrigation study. Since 1972, 48 projects have been completed.

It was noted that NASA support for demonstration projects is essential, since the state will not support demonstration activities. States will, however, participate in demonstration programs backed by Federal funds, and will adopt applications that prove useful.

This program is viewed by Kansas as an excellent outreach program which has resulted in good state/university interaction. The state had usually regarded the University as too "research oriented", but with the KARS program, several products turned out have been used by state agencies.

The KARS program maintains a specific procedure for state involvement consisting of the following steps:

- (a) Make initial contact with agency
- (b) Discuss agency problem
- (c) Discuss available remote sensing inputs
- (d) Review how inputs will help problem
- (e) Propose a joint undertaking.

In several cases, agency personnel were brought to the University to work on the project. Considerable effort is placed on follow-up after the product (e.g., map, data, report) is produced. Follow-up with the actual decision-making process is then pursued.

Federal

In addition to state and local participation, the following Federal agencies have been involved in the program to varying degrees:

- U.S. Army Corp of Engineers
- Fish and Wildlife
- U.S. Department of Agriculture
- Soil Conservation Service
- Forestry
- Environmental Protection Agency
- U.S. Geological Survey.

Private

A number of so-called "service contacts" are made with the KARS program by private organizations and individuals. These calls average about 20 per month, and consist primarily of questions related to the availability and interpretation of EROS Data Center imagery. Typical questions are:

1. Where can information be obtained on remote sensing?
2. Does imagery over a specific area exist and how can it be obtained?
3. We have ordered a satellite image from EROS. Can you help us interpret it?

Many of these calls result from the broad exposure maintained by the program through a quarterly newsletter which has a circulation of 800 persons.

Courses and Students

Three courses in remote sensing are taught at the University. These include two geography courses and a continuing education course designed for high school teachers who want to incorporate remote sensing into coursework. Some one-time courses such as air-photointerpretation and terrain analysis are also taught. About 75 students were enrolled in remote sensing courses during 1977.

Within the KARS program, over 17 different university departments have been involved in the various projects undertaken since 1972.

PROGRAM MANAGER'S ASSESSMENT

The program has been valuable in promoting state/university interaction, and has formed the basis of an excellent outreach activity. Forty-eight projects have been accomplished with state and local agencies, giving visible results. Before the program, the state viewed university efforts as largely research rather than applications oriented. Many agencies have sent letters to the state legislature praising the program. As a result, the Kansas State Legislature is considering partial support of the program this year.

UNIVERSITY - Louisiana State

PROGRAM MANAGER - Dr. C. A. Whitehurst, Division of Engineering Research

TELEPHONE - 504-388-5309

BACKGROUND

Louisiana State University is no longer a NASA grant recipient under the Space Applications Program. Grant monies were provided for the years 1972 through 1976. During this period, the program was able to generate state involvement so that \$175,000 in equipment was provided by the state in 1977, and \$200,000 in state funds is expected in 1978 for operating expenses. Since 1976, the program has also been receiving \$75,000 per year in other NASA (Landsat) funds.

The program has concentrated on remote sensing applications to coastal zone problems. Specific applications include land use planning and water quality. The program has primarily directed its resources toward finding applications for uses of remote sensing that have already been developed. Related research at the University includes offshore remote sensing of ocean conditions (temperature gradients, waves) and a study of erosion of the Barrier Islands (supported by the Army Corps of Engineers). Other research includes an EPA project in Earth-bound remote sensors using a communication satellite as a relay.

LEVEL OF EFFORT

University Involvement

The remote sensing program at Louisiana State involves three professors, four graduate students, and six other student research assistants.

Funding

Funding for the program since 1974 is shown below:

	<u>Thousands of Current Dollars</u>				
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>
NASA Grant	75	75	75	-	-
Other NASA	-	-	75	74	74
Interior (OWRT)	-	47	47	-	-
Other Federal	45	-	-	-	-
State	22	9	-	175	200
TOTAL	<u>142</u>	<u>131</u>	<u>197</u>	<u>249</u>	<u>274</u>

EFFECTIVENESSUsers

Projects have been conducted for a number of state agencies. These include:

- Department of Transportation and Development
 - Coastal Zone Management
 - Port Authority (Superport Study)
 - Department of Public Works and Highways
- Department of Natural Resources
 - Energy
 - Minerals
- Department of Urban and Community Affairs

Courses and Students

Within the University, three courses are taught to a total of 50 students annually. Some course work in remote sensing is also built into segments of other courses such as geography.

PROGRAM MANAGER'S ASSESSMENT

None indicated.

UNIVERSITY - Michigan, Environmental Research Laboratory, Ann Arbor

PROGRAM MANAGER - Dr. Donald S. Lowe, Infrared and Optics Division

TELEPHONE - 313-994-1200

BACKGROUND

ERIM and predecessor organizations entered remote sensing early and their first civil application was an infrared aerial mission over a Hawaiian volcano for the USGS in 1962. ERIM has concentrated in sensor research and development, with lesser, but still significant, effort in interpreting and using data under sponsorship of Federal agencies. The NASA grant, undertaken in conjunction with Michigan State University in Lansing, was used to get the State of Michigan actively involved in remote sensing at a time when even low altitude aerial photography was little used. MSU was selected because of its location in the state capitol; accordingly, its investigators would have more opportunity to develop relationships with the State Government. ERIM, formerly a part of the University of Michigan, is now an independent entity.

Specific Technologies and Unusual Capabilities

ERIM has developed sensors; it has four aircraft which fly radars and multispectral scanners and has its own ground processing capabilities.

Program Inception

The NASA grant effort was undertaken in 1971.

LEVEL OF EFFORT MEASURES

1. ERIM remote sensing activities in general involve 5-6 joint appointments with University of Michigan, 30 graduate students and a total of 50 people.
2. ERIM usually provides assistance to others and usually does not require outside support.
3. Funding by year from all sources since 1974:

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	100	100	---
Civil Contracts	2,000	2,000	2,000	2,000
Military Contracts	8,000	8,000	8,000	8,000
TOTAL	<u>10,100</u>	<u>10,100</u>	<u>10,100</u>	<u>10,000</u>

EFFECTIVENESS

Capabilities/relationships developed specifically under the NASA grant are chiefly the ability to demonstrate that the State of Michigan can utilize remote sensing as evidenced by the growth of the Michigan State University program.

Users

ERIM is predominantly a Federal contractor. In civil or unclassified military work, its chief sponsors have been:

NOAA	U.S. Forest Service	UNDP/UNFAO
DOI	Naval Research Labs	Defense Mapping Agency
NSF	U.S. AID	

It has also performed work for the State of Michigan, Consumers Power and Chevron Oil.

Courses

The University of Michigan offers graduate degrees in remote sensing, including the PhD, as well as a variety of photointerpretation courses. The electrical engineering department offers courses in sensors. Approximately 114 students take courses each year.

PROGRAM MANAGER'S ASSESSMENT

The grant was a good program to get the State Government involved in remote sensing at a time when even low altitude photography was little used. The State was not ready, however, to utilize satellite imagery and efforts in that area have not been as fruitful. In a sense, the technology was too advanced for ready acceptance or adoption.

UNIVERSITY - Michigan State

PROGRAM MANAGER - Dr. Myles G. Boylan and Mr. Bill Enslin, School of Urban Planning and Architecture

TELEPHONE - 517-353-7195

BACKGROUND

The program was originally started in 1971 in cooperation with ERIM to determine whether remote sensing imagery could be effective for land use planning. The program has grown over the years to include remote sensing activities in three university departments and private industry (Bendix-Ann Arbor) in addition to the primary goal of involvement with state agencies. The university departments with at least one member active in remote sensing are:

- Forestry
- Soils Science
- Resource Development
- Botany and Plant Pathology
- Geology
- Geography
- Urban Planning/Architecture
- Computer Science

Specific Technologies

The program has concentrated on use of high altitude aerial photography. It has initiated efforts in pattern recognition with Landsat data.

Unusual Capabilities

The program specializes in integrating high altitude imagery with other information sources (e.g., low altitude imagery) and development of data bases.

Program Inception

1971 in conjunction with ERIM.

LEVEL OF EFFORT

People at University

- 2 co-principal investigators
- 8 faculty investigators
- 4 graduate student specialists
- 6-8 full-time equivalent graduate students (12-18 students)

- Highway Department funded a corridor analysis aerial survey
- Planning organization (12 counties) spent \$20,000 on color photography
- Three counties spent \$5,000 on color IR photography
- A consulting firm was founded and has a \$50,000/year volume.

PROGRAM MANAGER'S ASSESSMENT

Aerial photography, available at low cost in the past (e.g., USDA) was little used until the program was able to provide assistance.

The users are finding their analyses and conclusions based on imagery are being accepted. The imagery frequently speaks for itself.

High (and low) altitude IR color photography has become a useful tool. Users currently do not have confidence in Landsat imagery.

Weakness

The program needs formal recognition by the state and a guarantee of state support to a nucleus to provide continuity in the event of NASA grant termination.

Emphasis on applications for decisions and actions by users consumes available funding; the program cannot provide significant training or technology transfer other than on a reimbursable basis.

UNIVERSITY - Minnesota

PROGRAM MANAGER - Dr. William G. Shepperd, Space Science Center

TELEPHONE - 612-373-5479

BACKGROUND

Overview

The Space Science Center was founded in 1968 to undertake a variety of work in space science and technology related thereto. Work in remote sensing was started in July 1972. Current work in remote sensing is directed in three areas: a study of peatlands for the Minnesota Geological Survey; a study of causes of pollution in Lake Superior; and a soils survey. Work in forestry is no longer active, but produced good technical results while active.

Technology Used

Technology used is predominately Landsat and aircraft imagery from the EROS Center. Emphasis is on interpretation of Landsat imagery.

LEVEL OF EFFORT

People at University

Approximately 23 people, including graduate students, are involved in remote sensing. There are three co-principal investigators with five graduate students and 15 or 16 undergraduates organized in three groups, with one of the groups at the Duluth campus.

Other Support

Other support comes from the EROS Center and from the U.S. Army Corps of Engineers (Lake Superior Studies) as well as from the Minnesota DNR and Planning Agency. The support is intangible assistance and difficult to quantify.

Funding

Funding for the institute runs to approximately \$2 million per year, the majority from NASA. Funding for other remote sensing activities was approximately \$270 million in 1977 with 50 percent coming from NASA.

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	70	60	60	90
Other Remote Sensing				270 (50% NASA)
Other Institute Funding				1640 (Primarily NASA)
	<u> </u>	<u> </u>	<u> </u>	<u> </u>
TOTAL	70	60	60	2000

EFFECTIVENESS

Users

The remote sensing program has developed a wide range of both governmental and commercial users. The program has also been assisted by the fact that Minnesota Geological Survey is a part of the University and the program is cooperating with the MGS in a study of peatlands and also the use of wet lands for energy production through the growing of cattails. Cattails produce more usable energy per acre per year than does timber. The group at Duluth is studying the sources of Lake Superior pollution for the State EPA and the U.S. Corps of Engineers. The Lake Superior study also investigates beach nourishment and lake currents as part of an overall lake modeling effort. The third active group is conducting a soils survey for the State Agriculture Department as well as draught stress areas with a view toward crop management and crop production improvement. Another group, no longer active under the grant, did work in pine plantation management (aerial surveys for thinning) as well as disease and parasite detection. Vertical photography was found to be good for oak wilt detection but oblique photography was found to be necessary for Dutch elm disease detection. The Minnesota Geological Survey, not funded by the grant, uses Landsat data to study the effects and evidence of glacial overdraft and plate/crustal faults for mineralization detection. Sub-surface evidence of faulting with associated mineralization has been demonstrated with Landsat imagery and subsurface water was located in southeast Minnesota during the drought.

The program has had considerable contact with commercial interests, chiefly through the forestry group. Nine organizations including one trade association were involved in the forestry project.

Courses

Courses are departmentally organized, with the forestry department having the most students. Photogrammetry is taught in civil engineering and pattern recognition in the computer sciences department. A high-light of physics course with about 25% remote sensing content is taught to about 80 students per year. The number of students per year is estimated at about 300, with approximately 200 of them in the forestry courses where remote sensing applications are emphasized.

PROGRAM MANAGER'S ASSESSMENT

While the remote sensing program has made a large number and variety of contacts, the greatest success has been with the State Geological Survey and its work in remote sensing for resources and their management.

The major perceived weakness in the program is the lack of a side looking radar capability. There is also a problem obtaining newly collected imagery and other data while it is still timely.

UNIVERSITY - Mississippi State

PROGRAM MANAGER - Dr. W. Frank Miller, School of Forestry

TELEPHONE - 601-325-2946

BACKGROUND

Mississippi State University has been active in remote sensing since 1973. NASA grant funds were initiated in 1975. A number of projects have been undertaken in the areas of forestry (flood plain management), wildlife habitat, and land use planning. The program has emphasized the use of high-altitude aircraft visual imagery including color and infrared photography.

LEVEL OF EFFORT

University Involvement

There are six professors involved in the program which also utilizes a consultant, one secretary, and nine graduate student research assistants. Principal departments involved are Forestry, Geography, Computer Science, and Landscape Architecture.

Funding

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	-	100	100	100
Other NASA	46	4	8	6
University	8	5	5	5
State/Local	5	5	5	9
TOTAL	59	114	118	115

In addition to fiscal support, a number of state and local agencies have assigned personnel to the project. These include:

- Geological Survey of Alabama - 1 person
- Mississippi Research and Development Center - 2 persons
- Golden Triangle Planning and Development Agency - 4 persons
- Lowndess County Board of Supervisors - 1 person
- Mississippi Forestry Commission - 1 person
- Mississippi Parks Commission - 1 person

EFFECTIVENESS

Users/Relationships Developed

- A project was undertaken to locate a new state park using high-altitude imagery and intensive low level analysis. Based on the analysis, a \$0.5 million state park will be built.
- A cooperative project was undertaken with the U.S. Forest Service to develop a method of locating sites in need of tree planting for watershed protection (erosion control). Within a 5.7 million acre area, sites were identified with a high probability of requiring tree planting. The overall percentage of sites correctly identified in a sample area was 85 percent.
- A project was undertaken with the State Office of Science and Technology to identify and map ecological habitats in the Pascagoula Swamp area which are significant to forestry, game management, and recreation.

Courses and Students

Three courses in remote sensing are offered at the University in photogrammetry, forestry and resource management, and geography. In addition, remote sensing is offered as part of two other geography courses. Eighty-eight students were enrolled in remote sensing courses during 1977.

PROGRAM MANAGER'S ASSESSMENT

A number of projects have been undertaken in cooperation with state and local agencies. In some cases, such as the Natchez State Park project, the projects have resulted in decision-making on the basis of results. In other cases, programs are indicating promising results toward the implementation of remote sensing as management tools. Some of the areas to which attention is currently being focused include forest resource inventory, land-use planning, strip mining and reclamation monitoring, industrial siting, and determination of beetle infestation.

UNIVERSITY - Nebraska, Remote Sensing Center

PROGRAM MANAGER - Dr. Marvin P. Carlson, Conservation and Survey Division

TELEPHONE - 402-472-3471

BACKGROUND

The University of Nebraska has been funded under the Space Applications Program since 1972. In 1974 a remote sensing center was established within the Conservation and Survey Division of the University and a permanent coordinator of remote sensing was assigned to the division. In 1975, 3500 square feet were devoted to the Center. The Conservation and Survey Division of the University is actually the equivalent of state geological surveys in other states, and performs the state geological survey, water survey, soil survey, and climatological activities. Though funded and staffed primarily by the University, the Conservation and Survey Division serves both regulatory and management agencies and the general public. The Center also serves as the image library for the State of Nebraska, and represents the National Cartographic Center of USGS.

The Center uses a variety of high altitude and low altitude aircraft imagery, Landsat imagery, and some computerized remote sensing data. The Digital Image Rectification System (DIRS-NASA Goddard) has been acquired by the Center. Principal areas of remote sensing include land use mapping, hydrology, geology, and agriculture.

LEVEL OF EFFORT

The Center employs three full-time professional staff, and two clerical/technical staff. Twelve graduate students are supported as research assistants.

Funding

Funding for the program since 1974 is shown below:

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	125	100	100
Other NASA	35	35	23	--
University	50	50	60	65
State Agencies	46	15	29	31
	<u> </u>	<u> </u>	<u> </u>	<u> </u>
TOTAL	231	225	212	196

EFFECTIVENESSUsers/Relations Developed

The program has participated in projects with the following state agencies:

State Office of Planning and Programming
 Natural Resources Commission
 Department of Water Resources
 Department of Environmental Control
 Game and Parks Commission
 Department of Roads

Some of the major projects undertaken to date include:

- A first-order land-use classification map of Nebraska utilizing satellite imagery
- Second-order land-use classification of the Lower Platte South Natural Resource District using satellite and aircraft imagery
- Application of remote sensing to inventory irrigated land
- Delineation of major geological features in Nebraska
- Mapping of Sand Hills region for range management
- Wetlands inventory of Nebraska
- Evapotranspiration project for water management in the Platte River Basin
- Water quality of Nebraska reservoirs
- Routing of electric power transmission lines
- Thermograms of Lincoln and other cities for the public to determine home heat loss (more than 20,000 people have viewed their homes)
- Inventory of mining operations in Nebraska

The Center publishes a quarterly newsletter to update the community on recent activities and availability of services.

Courses, Students

Two courses are taught at the University in remote sensing; a general survey, and an applications course (special problems). About 30 students take remote sensing courses annually. Additionally, there is some remote sensing content in courses within the departments of geography, geology, civil engineering, and agriculture.

PROGRAM MANAGER'S ASSESSMENT

Services provided by the remote sensing center range from consultation with individuals on the availability of certain Landsat or aerial photography, to publishing maps, to applications projects such as power line routing, and experimentation with Landsat CCT data. Since the center is located at the university within the Nebraska Survey Division (geological, water, and soil surveys) it is well coupled to the regulatory and management agencies. The center was established largely due to the NASA grant, and has become the focal point for Nebraska remote sensing activity. The center serves as the image library for Nebraska and has developed liaisons with several state agencies. The number of successful applications projects undertaken attests to the usefulness of remote sensed data. The program currently draws about one half its support from the NASA grant, and the other half from the university and the state.

UNIVERSITY - Oregon State

PROGRAM MANAGER - Dr. Barry J. Schruppf, Environmental Remote Sensing
Applications Laboratory

TELEPHONE - 503-754-3056

BACKGROUND

Overview

The program, founded in 1968, has performed a variety of studies for federal, state and local governments in the areas of ground cover (forest and range) resources management, wildlife studies, and environmental quality. The environmental quality efforts have been conducted with the State Department of Environmental Quality and have been directed at pollution regulation. The program has also performed studies for county government; examples are land use studies for county planning agencies and tax assessors. Projects performed for state and local governments tend to be short, typically 6 to 18 months in duration.

Specific Technologies

The program uses Landsat and U-2 imagery for most of its projects. Little use is made of Landsat computer-compatible tapes (CCTs) in work for the state and local governments since those agencies cannot afford them unless Federal funding is also available for the project.

Unique or Unusual Capabilities

The program has a capability to reproduce relatively large numbers of maps and photos for field use at economical costs. The products can be scaled and annotated with symbols.

Duration

Program inception, 1968; NASA grant, 1972.

LEVEL OF EFFORT

Personnel

Eleven people work in the laboratory, with an equivalent of eight full-time positions. Additionally, five faculty members are strongly associated with the research activities of the lab, and represent

approximately one full-time equivalent researcher. The state and Federal government agencies also provide some cooperative assistance in areas of interest to those agencies; the level of assistance is estimated to total slightly less than two full-time equivalent positions.

Funding

The funding for the program comes from a variety of sources in addition to the NASA grant. The percentage breakdown is:

- 65% NASA grant and other NASA funding
- 21% Other Federal special projects, chiefly agricultural
- 5% State agricultural projects with Federal funding
- 4% State agricultural projects with state funding
- 5% State university cost sharing for the grant.

In 1972 there was also an ERTS task for about \$75,000, but significant non-grant funding began in 1976:

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	100	100	150
All Other	-	-	90	40
TOTAL	100	100	190	190

EFFECTIVENESS

Users

Federal users of the program include the U.S. Forest, Fish and Wildlife, Soil Conservation Services and the Bureau of Land Management. The work performed for the Federal government is generally useful to state and local governments in the area under study. State users of the program include the forestry, fish and wildlife, environmental quality, and land conservation and development agencies. Work has also been performed for county tax assessors in verifying changes from dry to irrigated farming and for state tax assessors in verifying timber severance taxes.

The major agricultural application has been in monitoring tansy ragwort infestation of grass and rangeland. This is particularly significant in Oregon since the state is a major producer of grass seed in addition to use of grassland for hay and forage. Individual consultants also have made use of the imagery files.

Capabilities/Relationships

The scale of operations in Oregon is sufficiently large that Landsat imagery is very useful and the program has used Landsat imagery extensively.

Non-Federal sponsors, however, cannot afford digital processing and this aspect of Landsat use has not developed to any significant extent. State relationships are good, but funding from state agencies for research projects strongly depends upon Federal pass-through funds.

Courses

No advanced degrees are offered in remote sensing, but there are several cooperative programs in geography and range management. A cooperative program in forestry has not been formally implemented. There is also a short-course program with 20 to 24 students per year. There are remote sensing courses totaling 28 to 34 credit hours, with a typical course having 4 credit hours. The number of students per year is estimated to be between 200 to 300.

PROGRAM MANAGER'S ASSESSMENT

Contact between the remote sensing study manager and the resource management as formalized in a small number of individuals is essential and the program has emphasized these working relationships. This relationship is particularly important in some studies which involve 300-400 individual tasks.

Projects meeting a time filter (6 to 18 months) imposed by the nature of the grant are relatively difficult to acquire and are typically planning studies. Resource management efforts typically require 3 to 5 years to achieve a steady pattern of actions which can be demonstrated from remote sensing inputs.

UNIVERSITY - Purdue

PROGRAM MANAGER - Dr. David A. Landgrebe, Laboratory for Applications of Remote Sensing (LARS)

TELEPHONE - 317-749-2052

BACKGROUND

Overview

The program was initiated in 1966 as part of a four-university group to initiate research in remote sensing. Purdue/LARS specialized within the group in the areas of agriculture and machine processing of data.

Specific Technologies and Unusual Capabilities center around the development of software (LARSYS) for an IBM 370-148 computer for processing of digital data and the development of terminals and terminal software for displaying and manipulating the data. A capability of making detailed spectral measurements from ground sites has also been developed for base line and ground truth work.

Duration

The program was started in January 1966, with four or five people. Work under the NASA grant was started in 1971.

LEVEL OF EFFORT

Number of People

Approximately 40 faculty members from 15 departments at the University are involved. The program currently has 50 graduate students and 60 undergraduates for a total of approximately 150 people in the program on a full- or part-time basis.

Other Support

There is no large support from other institutions or agencies. The U.S. Soil Conservation Service has one person stationed with the program to assist in a soil mapping project.

Funding

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	200	200	200	200
Other NASA				1200
Non-NASA				480
TOTAL	200	200	200	1880

The program has run at a total effort of about \$2 million over the past several years. State funding in 1977 was \$86,000 for research and \$80,000 for administration.

EFFECTIVENESS

Capabilities and Users developed over the life of the program include a strong local base in research in the technology of using remote sensing (e.g., the LARSYS program for processing data) and applying these capabilities to the needs of other organizations such as the State Departments of National Resources and Agriculture. They also work with foreign governments with 10 to 20 percent of the effort performed in conjunction with the U.S. Agency for International Development. Approximately one-third of the total program activity is for agencies other than NASA. There is also some private sector involvement with the St. Regis Paper Company which is performing an Applications Systems Verification and Transfer (ASVT) project in conjunction with LARS.

Courses

The University offers approximately 15 three-credit-hour courses which are taken by approximately 300 students per year. Monthly courses of one-week duration are offered to about 10 participants; about one-third of the participants are from NASA or other Federal agencies.

PROGRAM MANAGER'S ASSESSMENT

The use of a step-funded grant as opposed to a one-time grant has provided a measure of stability that is lacking in some of the other work undertaken. The step-funding has permitted projects of a long-term nature to be undertaken. The major problem with the grant is that the program is limited to one state and this inhibits joint programs with neighboring states.

UNIVERSITY - South Dakota State University

PROGRAM MANAGER - Dr. Victor I. Myers, Remote Sensing Institute

TELEPHONE - 605-688-4184

BACKGROUND

Overview

The program concentrates on Earth resources remote sensing: agriculture (except forestry), geology, hydrology, and water resources. The program also made the first energy conservation aircraft flight, in which heat or energy losses from residential and commercial buildings are detected and recorded. These records are then examined to provide planning information to attack the worst energy losses first.

The Earth resources applications are well-rounded, as is evidenced by applications such as the energy conservation flights. Other applications are typically addressed to more traditional uses of satellite and high altitude photography in areas such as soils assessments both for soil qualities and surface indications of subsurface water.

Other than the initial adaption of the aircraft infrared sensor for the energy conservation flights, no unusual or unique capabilities in remote sensing are used by the program.

Duration

The institute was founded in 1969 and NASA grant work started in 1972.

LEVEL OF EFFORT

People at University

Approximately 25 people are involved in the program. Ten to twelve professionals and/or facility members use the program as part of or a major base for their research, and there are eight to ten technicians. The program also supports three graduate students and eight to ten undergraduates.

Other Support

Approximately one person on a full-time equivalent from the U.S. State Department is involved in agricultural/Earth resources projects. While it is more difficult to quantify, support from EROS at the EROS Center is expected to involve one or two full-time equivalents.

Funding by Year

	Thousands of Current Dollars			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	100	200	150
NASA & Other Federal Funding	<u>300</u>	<u>375</u>	<u>325</u>	<u>450</u>
	400	475	525	600

Funding has shown a steady growth, but the program has not attracted significant state funding.

EFFECTIVENESSUsers

The NASA grant has adapted remote sensing to the needs of six state agencies, mostly those concerned with agricultural problems for which the soil quality and soil moisture determination capabilities are useful. Among these adaptations was a survey of soil quality for a tax assessment survey. The tax assessments for agricultural land were adjusted on the basis of soil quality.

The program also has received support from the Federal government for its resources work for the USGS in surface indications of subsurface water in the U.S. and in related work for foreign governments in desertification problems. (Egypt and the Sudan via the U.N. Food and Agricultural Organizations.) The program also has attracted a wide interest with a soil moisture workshop.

Courses

There is no structural remote sensing program and no degree is offered. Specialization within departments of geography, civil engineering, electrical engineering, agricultural engineering as well as plant science and soils science is encouraged. Approximately 200 students per year take remote sensing courses. Approximately 8 to 14 people from industry and government per year receive training in remote sensing techniques. The training periods range from 4 months to one year.

PROGRAM MANAGER'S ASSESSMENT

The Earth resources remote sensing group finds reasonable outside business in that most of its proposals are accepted. The major problems are not unique to this institution: there is a lack of support at all government levels for use of remote sensing as opposed to developments; the desire exists, but not the funding. When use funding is available, it tends to go into easy tasks, which is regrettable since many applications could get immediate congressional attention and thus potentially higher funding. There is also an institutional problem within NASA in that its programs tend to be oriented toward specific sensors or platforms rather than the spectrum of uses for instruments. Accordingly, user requirements are sacrificed to technical and fiscal constraints.

UNIVERSITY - Texas A&M

PROGRAM MANAGER - Dr. B. J. Blanchard, Director, Remote Sensing Center

TELEPHONE - 713-845-5422

BACKGROUND

The Remote Sensing Center of Texas A&M University was established early in 1968 as a consortium of the colleges of Agriculture, Engineering, Geosciences, and Science. The Center concentrates on the development and utilization of remote sensing technology over a broad range of applications. The Center has been funded under the space applications grant since 1971. Grant funds have primarily been used as seed money to conduct demonstration efforts in the disciplines of engineering, agriculture, oceanography, and geology. Research activities related to these disciplines include:

- Engineering
 - Development of sensor technology
 - Mapping of aquatic plants
- Agriculture
 - Development of soil moisture and plant monitoring systems (including soil water modeling capabilities)
 - Monitoring plant diseases
 - Rangeland monitoring including biomass condition and brush control
- Oceanography
 - Studies of wave height related to wind direction and speed
- Coastal zone studies
 - EPA grant to develop indices of pollution in coastal areas. The research is related to timber clearcutting and the changing nutrition load as a function of tannic acid runoff. Color of river outflow is distinctive.
- Water resources management
 - Watershead runoff
 - Flood plain condition

The Center utilizes a wide range of remote sensing data including Landsat and both high and low altitude aircraft data. A particular expertise of the Center is sensor development and microwave systems and measurement. An X-band radar system has been developed, which can be mounted in a truck. The Space Shuttle Imaging Radar (SIR) microwave sensor experiment for Orbital Flight Two (OFT-2) has been developed by the Center. This will be a Seasat-type L-band at wide angles using single polarization

for geological applications (SIR-A). The Center is currently seeking funding (\$50 million) for SIR-B which would be a double polarized system in X- and L-bands. The like and cross images in each frequency will relate to soil moisture and surface condition, primarily agricultural applications.

LEVEL OF EFFORT

University Involvement

There are 11 professionals involved at the Center at the current time, 5 full-time and 6 half-time. Additionally there are 8 undergraduates, 7 masters, and 8 Ph.D. students as research assistants. The half-time professionals share joint appointments as professors in various departments. This approach is designed as an aid to the educational process which goes beyond developing remote sensing technology and applications. Additionally, a number of professors work with the Center, but are not supported by the Center. These include a plant virologist and an expert in range science using the Center as a base for their research interests.

Funding

Funding for the program since 1974 is shown below:

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	125	125	75	75
Other NASA	213	238	350	460
Other Federal*	113	22	43	140
State & Local	50	100	110	90
TOTAL	<u>501</u>	<u>485</u>	<u>578</u>	<u>765</u>

* Includes Army Corps, EPA, NSF, Coast Guard

EFFECTIVENESS

Users/Relationships Developed

There have been a number of projects and cooperative efforts with state agencies. Some of the major recent projects and the state agencies involved are noted below:

- Coastal Wetlands Project
 - Texas Water Development Board
 - Texas Water Quality Board
 - Texas General Land Office
 - Texas Parks and Wildlife
 - City of Galveston

- Management of University of Texas Lands

Considerable Landsat CCT expertise has been gained in this project. This cooperative effort with the University of Texas helps to manage 2-1/2 million acres of land which has an estimated annual return of \$1 billion annually. Landsat data is used to estimate the percentage of brush cover (mesquite) which kills the range grasses.

- Cotton Root Rot Project

- Texas Agricultural Extension Service
- Bell and Fall County USDA Agents
- Private farmers
- Growers' Association

- Peanut Defoliation and Yield Estimation

- Texas Agricultural Extension Service
- Texas Agricultural Experiment Station

- Aquatic Plant Monitoring

- Trinity River Authority
- Texas Water Quality Board
- U.S. Army Corp of Engineers

- Texas Wildlife Survey

- Wildlife Department
- General Land Office

- City of Galveston Beach Erosion

- City of Galveston
- U.S. Army Corps of Engineers

In addition to state and local government projects, activity has been directed toward private users as well. For example, an information transfer program is under study directed at getting rapid range condition data to ranchers to facilitate herd management based on range condition.

Courses, Students

Texas A&M has about 120 graduate students enrolled in courses each year (60 per semester). Eleven remote sensing courses are offered in seven different departments. A remote sensing minor is currently planned.

PROGRAM MANAGER'S ASSESSMENT

The overall program at Texas A&M is involved in considerable non-grant NASA research, particularly in microwave measurement and system design. The NASA university grant funds, on the other hand, are applications rather than research directed. These funds provide essential seed money to develop demonstration programs for applications of remote sensing to special disciplines. Over the course of the NASA grant, a number of projects have been undertaken with state and local governments and in some cases also involving private organizations. The results of these projects have been well received. There are also other Federal agencies such as FPA currently funding research in remote sensing at the university. In addition to developing new users of remote sensing, an objective of the program is to benefit the educational process, particularly at the graduate level.

UNIVERSITY - Utah

PROGRAM MANAGER - Dr. Merrill K. Ridd, Department of Geography

TELEPHONE - 801-581-8218

BACKGROUND

The University of Utah began to receive grant funds under the University Space Applications Program in 1976. Utah has been active in remote sensing since 1973. Currently there are three projects under NASA grant funding. The first, the Price River study area, is a multi-disciplinary project involving:

1. Vegetation and soil mapping with regard to land and resource control
2. Rangeland productivity
3. Impact of development on wildlife resources

The project is oriented toward decision-making on road closures, oil and gas leases, and watershed erosion control. Color and infrared photography are used, and CCTs are utilized. The second project, a study of the Wasatch foothills, is designed to influence regulations and ordinances surrounding land development. The project is supplying local government with maps of faulting, flooding, and instability areas. The third project is a Landsat study of snowpack runoff. This will involve the state division of wildlife resources, state weather modification operations (a \$1 million per year cloud seeding operation), local water masters, and the Soil Conservation Service and River Forecast Center.

The University of Utah has developed an expertise in computer software techniques. Two current areas of research are signature extension beyond the known ground truth region, and mosaicing classified land use data into a quadrangle format (not a satellite format).

Other remote sensing work by the University extends to the foreign sector. Utah has been performing a land use map of Korea for the Republic of Korea, using Landsat CCTs. Utah performs modifications to the CCTs, and a contractor, Seiscom Delta, produces the maps from the modified CCT.

Another program at the University of Utah has been the development of a high-school level teaching program in remote sensing under NASA educational funds. The program, in six segments, can be taught as an entire course, or integrated into other courses. The segments include:

1. Introduction to Remote Sensing
2. Land Formation and Geology

3. Water
4. Agriculture
5. Urban Areas
6. Transportation

LEVEL OF EFFORT

University Involvement

Three faculty members are prime consultants on the remote sensing program and there are two additional part-time investigators. No faculty are on release time to the project; all maintain a full course load in addition to program activities. There are six graduate student research assistants.

Funding

Funding since 1974 is as follows:

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant			200	100*
Other NASA		15		
Federal,		5		
State	2			100
Foreign			32	102*
TOTAL	2	30	232	302

* Funds received in later part of 1977.
Unspent balance will apply to 1978.

EFFECTIVENESS

Users/Relationships Developed

NASA grant funding has only recently been initiated. State and local involvement is currently being developed. State agencies are beginning to use Landsat instead of aerial photography as a first cut in a go/no-go decision for power plant sites. Also, state funding has been obtained to perform a Landsat land-cover and terrain analysis (\$100,000).

Courses, Students

There is currently one graduate course in remote sensing with an enrollment of 17 taught at the University.

PROGRAM MANAGER'S ASSESSMENT

The NASA grant program has a critical impact on new applications areas. Backed by NASA funds, the university can approach the state for involvement in the applications. If the application proves successful, the state will adapt and eventually may fund the application. The state would be unlikely to become involved on its own funds in a demonstration effort.

UNIVERSITY - Virginia Institute of Marine Science

PROGRAM MANAGER - Dr. John Munday

TELEPHONE - 804-642-2111 Ext. 254

BACKGROUND

Overview

The institute is a graduate research facility of the State Universities of Virginia and formally part of the College of William and Mary. The areas of interest are estuarine and eastern shore inlets and their ecology and geology. Specific studies include circulation, shoreline erosion, sewage dispersal, dredging effects and wetlands protection and monitoring.

Because of a variety of problems, including the departure of the grant manager and the delays in getting the grant effort directed in suitable channels, the grant is being phased out. Remaining effort under the grant is being directed toward assisting the state government in establishing a state-wide information system. A bill to establish that system is in the legislature.

Technologies

The VIMS remote sensing program technology is directed primarily toward sensing in very small areas, occasionally as small as one or two acres. For this type of work Hasselblad cameras in aircraft are employed. Some use has been made of coarser resolution products from NASA programs, but in general they lack the resolution needed for the scale at which their efforts are concentrated.

Unique or Unusual Capabilities are concentrated in the area of small scale studies where they can respond rapidly to unusual phenomena in the institute's aircraft. In circulation or other water studies, they have made use of technology such as dye marking and buoys.

Program Duration

VIMS started a program in remote sensing in 1969 with funding from NASA Wallops Island and started on the grant program in 1972.

LEVEL OF EFFORT

People

Directly associated with the grant are two investigators, one graduate student, and a clerk typist. Others have been associated. At the

present time approximately 450 people are associated with VIMS and 75-80 have Ph.D.s.

Other Support

NASA (Langley) is estimated to provide the equivalent of several man-weeks per year. The state government is estimated to provide about two-man weeks per year in addition to the effort associated with the establishment of the Virginia Information System.

Funding

	Thousands of Current Dollars			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	100	100	100	~
VIMS Remote Sensing Efforts	-	-	800	1,000
Other VIMS Work	-	-	6,000	6,000
TOTALS	<u>100</u>	<u>100</u>	<u>6,900</u>	<u>7,000</u>

Approximately 70 percent of the institute's efforts are directed toward local and regional problems and studies and 30 percent toward national/Federal problems/studies.

EFFECTIVENESS

Types of Users

Aside from the effort toward establishing a Virginia Information System, most of the work completed has been directed toward Federal interests, specifically a study for the AEC on thermal conditions around a power plant, a Skylab imaging effort and work under a Wallops grant. Some minor funding has been received from the state for mapping (\$10,000) the information system (\$10,000) and approximately \$15,000 from private sector users of remote sensing capabilities.

Courses

The institute offers one course at the graduate level on Remote Sensing of the Environment with four or five students. Other information on courses was not readily available.

Research Output of the remote sensing effort; 56 papers published since 1969 has been the major strong point of the program.

PROGRAM MANAGER'S ASSESSMENT

The state infrastructure and the NASA program have not meshed well in the past. Part of the difficulty is attributed to the fact that Virginia has traditionally been a low budget state and another part is attributed to grant management problems at VIMS. The current program manager went to Canada to pursue some research in water quality at about the time the grant activity started. This effort was the later basis for the major use the institute has been able to make of Landsat imagery, but when the manager returned, the level of dissatisfaction with accomplishments under the grant was not repairable.

UNIVERSITY - Wisconsin

PROGRAM MANAGER - Dr. James L. Clapp - 608-262-1978 and
Dr. Fisher - 608-263-4786, Institute of Environmental Studies

BACKGROUND

The NASA grant has been used to develop capabilities in remote sensing of water quality. That portion of the program which deals with remote sensing of point sources of water pollution is relatively mature. Recent efforts have been directed toward sensing and measuring non-point sources, e.g., agricultural runoff. The program also has a wide variety of general remote sensing and interpretive programs; only one-third of the overall program is directly concerned with remote sensing. Much of the remainder is directed toward other types of environmental studies.

Specific Technologies within remote sensing used involve multispectral aerial scanning and thermal scanning using a thermal scanner on a State Department of Natural Resources DC-3. The institute also uses Landsat imagery.

Unusual Capabilities are limited to the thermal scanner on the DNR aircraft, which is operated cooperatively.

Unusual Circumstances at the inception of the program were limited to the passage of the Wisconsin law establishing the state EPA and providing strict limits on point sources of pollution.

Duration

The program was initiated in 1969 or 1970 with \$10,000 of local money to supply information and educational services to the University and state on environmental problems.

LEVEL OF EFFORTPeople

There are 12 faculty members involved on a part-time basis within the overall program and 3 full-time post-doctoral fellows as well as a full-time secretary. There are also about 20 graduate students and 6 undergraduates with part-time support.

Other Organizational Support is provided by the DNR at a level of about 3 full-time equivalent employees.

Funding

	<u>Thousands of Current Dollars</u>			
	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>
NASA Grant	160	210	192	185
Non-NASA				1800
	<u> </u>	<u> </u>	<u> </u>	<u> </u>
TOTAL	160	210	192	1985

The current total funding is about \$2 million per year including the NASA grant and various support in kind. An example of in kind support is about 50 hours per year of DC-3 time (for only the price of gasoline). The University also has purchased about 50 hours per year of Cessna-180 time and flown cooperatively with the state on state projects about 50 hours per year.

EFFECTIVENESS

Capabilities/Relationships developed over the course of the program are primarily the ability to serve the state government as a research and training center. The relationship with the state government and particularly with the state's DNR and EPA is very strong and cooperative.

Other Users include the state's Department of Transportation (highway study) as well as the Department of Agriculture for which they performed a survey of spruce hardworm infestation. In conjunction with the DNR and the utilities they have also performed a thermal plume survey.

Courses

The University offers both M.S. and Ph.D. programs in environmental monitoring. Specific courses are offered in analytical photogrammetry and automated mapping. Specific course offerings total 30 credit hours, which are jointly supervised and/or funded by the departments and the institute.

PROGRAM MANAGER'S ASSESSMENT

Remote sensing is a tool of decision through staff members in the University and state government. They have provided a useful tool. Their major problem is that the area of remote sensing is inherently interdisciplinary and they live in a discipline-oriented institution where tenure problems can arise with young faculty members.

MAJOR OBSERVATIONS

At NASA's request, a set of summary Vugraphs was prepared to be used by NASA in presenting the survey findings to management. The Vugraphs are presented in the following order:

- Survey Conclusions
- University Programs - Sources of Funding. 1974-1977
- University Programs Funding - Percent by Source 1974-1977
- 1977 Grant, Other NASA, and Non-NASA Funding, by University
- Students and Courses in University Remote Sensing Programs
- Faculty and Research Assistants in University Remote Sensing Programs
- University Programs - Major Applications of Remote Sensing
- University Programs - Non-Federal Involvement.

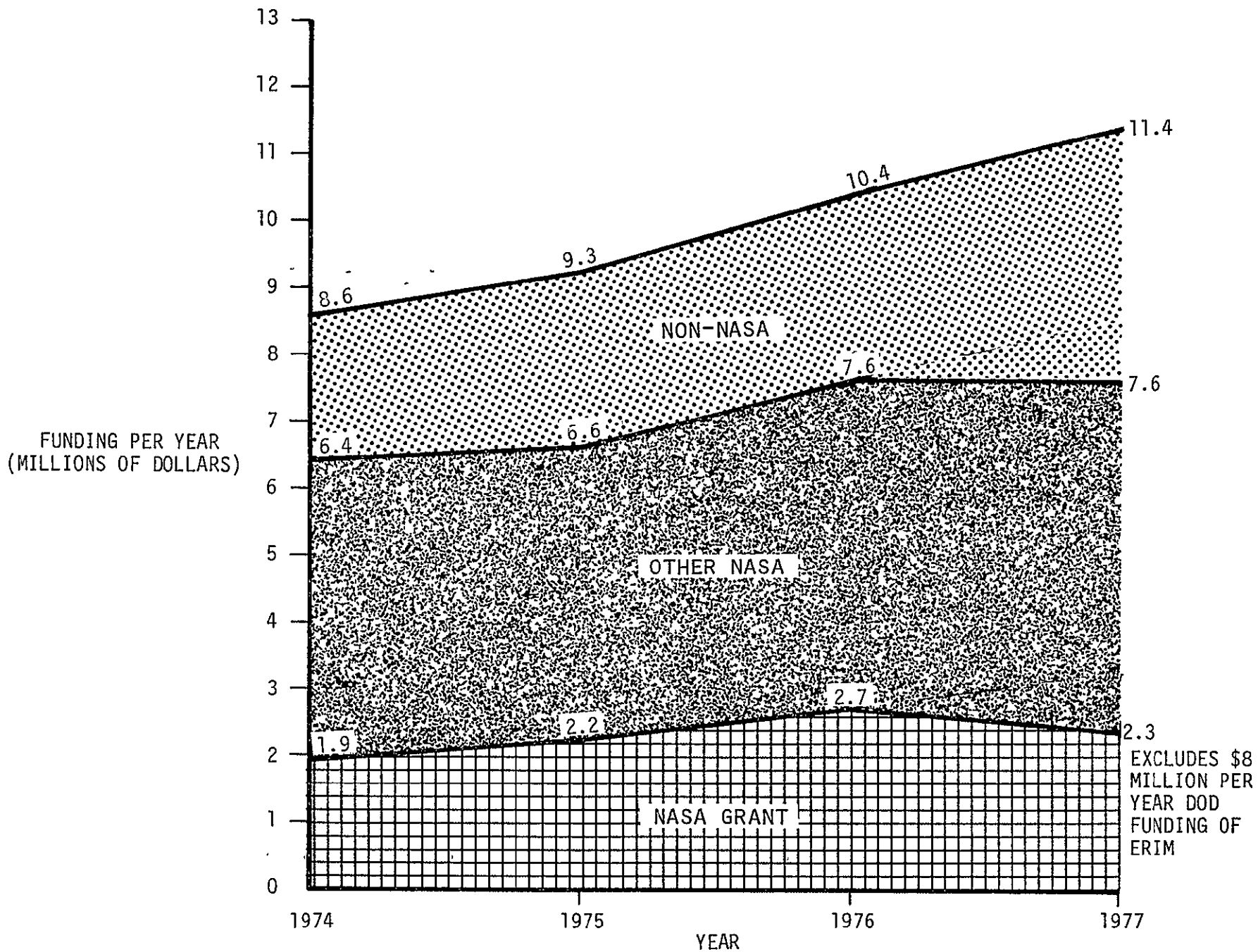
SURVEY CONCLUSIONS

- ALL OF THE PROGRAMS SURVEYED HAVE ATTAINED SOME LEVEL OF STATE/LOCAL INVOLVEMENT. ONE PROGRAM HAS WORKED ON PROJECTS WITH 39 STATE AGENCIES, MAINTAINS REGULAR CONTACT WITH 74 OTHERS, AND HAS 150 OTHER CONTACTS THAT CAN BE DRAWN UPON AS NEEDED. SUCH INVOLVEMENT DEPENDS ON SEED MONEY TO DEMONSTRATE APPLICATIONS BEFORE STATE/LOCAL AGENCIES WILL PROVIDE FUNDING.
- NASA GRANT FUNDING HAS REDUCED THE TIME WHICH WOULD OTHERWISE BE EXPECTED FOR STATE/LOCAL GOVERNMENTS TO BECOME OPERATIONAL USERS OF REMOTE SENSING. NASA GRANTS ARE THE BASE WHICH ASSISTS AND SUPPORTS UNIVERSITY PROGRAMS TO DEMONSTRATE PROVEN APPLICATIONS TO FIRST TIME USERS. THE STATES WILL GENERALLY NOT SUPPORT DEVELOPMENTAL/DEMONSTRATION PROGRAMS.
- STATE GOVERNMENTS ARE BEGINNING TO USE REMOTE SENSING TECHNOLOGY AND CAPABILITIES IN OPERATIONAL AREAS. CAPABILITIES HAVE, IN GENERAL, NOT BEEN INSTITUTIONALIZED IN THE SENSE THAT MANY PROGRAMS WOULD NOT CONTINUE IF NASA SEED SUPPORT WERE WITHDRAWN.
- ABOUT 9 PERCENT OF THE TOTAL FUNDING IN 1977 WAS FROM STATE & LOCAL SOURCES. ESTIMATES FOR PRIOR YEARS INDICATE THAT STATE FUNDING IS ACCELERATING AS REMOTE SENSING APPLICATIONS ARE BEGINNING TO BE APPLIED IN STATE & LOCAL PROGRAMS. IN MANY PROGRAMS, SIGNIFICANT NON-FINANCIAL SUPPORT IS CONTRIBUTED BY THE UNIVERSITY (FACULTY AND GRADUATE RESEARCH ASSISTANTS), AND BY STATE/LOCAL AGENCIES WORKING WITH THE UNIVERSITY.

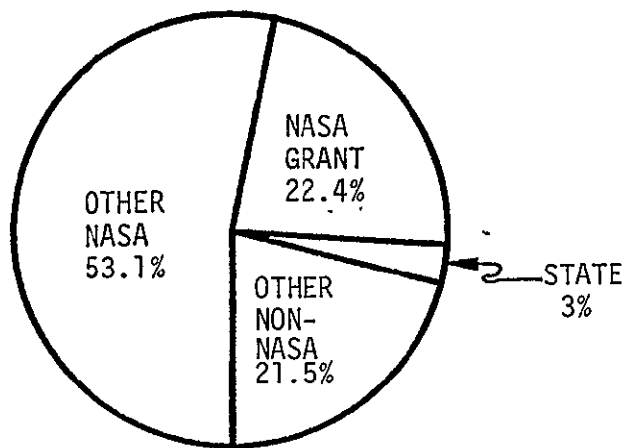
SURVEY CONCLUSIONS (CONTINUED)

- TOTAL FUNDING FOR THE UNIVERSITY PROGRAMS SURVEYED HAS GROWN APPROXIMATELY 50 PERCENT SINCE 1974. A LARGE PART OF NON-NASA FUNDING COMES FROM FEDERAL SOURCES TO DEVELOP APPLICATIONS WHICH ALSO INTEREST STATE, LOCAL AND PRIVATE USERS. NASA GRANT FUNDS HAVE BEEN AN IMPORTANT STIMULUS TO ATTRACTING NON-NASA FEDERAL FUNDS.
- THE PROGRAMS ARE ADAPTIVE TO THE EXPRESSED INTERESTS OF STATE/LOCAL GOVERNMENTS. THE DISTRIBUTION OF APPLICATION AREAS AND SPECIFIC EXPERTISE DEVELOPED REFLECTS STATE/LOCAL INTERESTS AND FUNDING PATTERNS. STATE/LOCAL PARTICIPATION IS DEPENDENT ON THE APPLICABILITY OF REMOTE SENSING TO NEAR TERM PROBLEMS.
- UNIVERSITY PARTICIPATION IN REMOTE SENSING IS LARGE AND GROWING. SOME UNIVERSITIES OFFER SEVERAL COURSES IN SPECIFIC REMOTE SENSING DISCIPLINES. OVERALL, DURING 1977, 137 COURSES WERE TAUGHT TO A TOTAL OF 2906 STUDENTS. 195 FACULTY MEMBERS AND 393 RESEARCH ASSISTANTS WERE INVOLVED IN THE RESEARCH PROJECT.
- 65% OF THE PROGRAMS HAVE MINOR PRIVATE SECTOR INVOLVEMENT WHICH RANGES FROM GEOEXPLORATION ASSISTANCE FOR THE MAJOR OIL COMPANIES TO RANGELAND PRODUCTIVITY PROJECTS WITH LOCAL RANCHERS.
- 25% OF THE PROGRAMS HAVE FOREIGN INVOLVEMENT. THE UNIVERSITY OF UTAH, FOR EXAMPLE, HAS A \$150K LAND-USE PROJECT WITH THE GOVERNMENT OF KOREA.

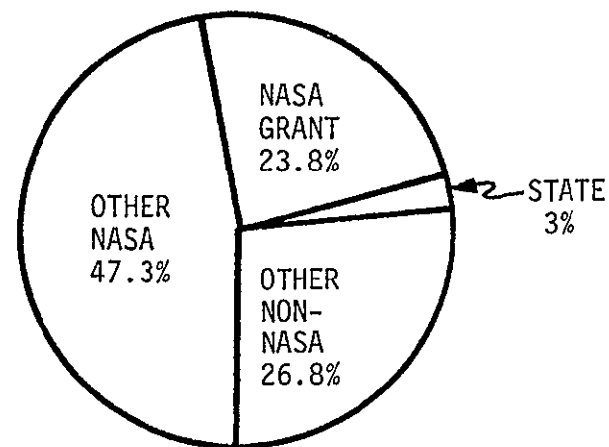
UNIVERSITY PROGRAMS - SOURCES OF FUNDING 1974-1977



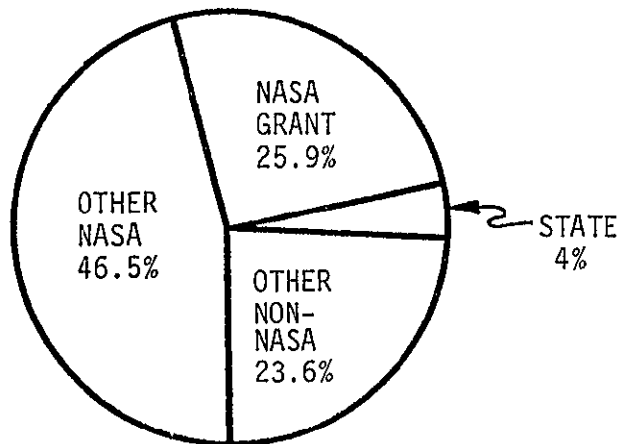
UNIVERSITY PROGRAMS - FUNDING - PERCENT BY SOURCE 1974-1977



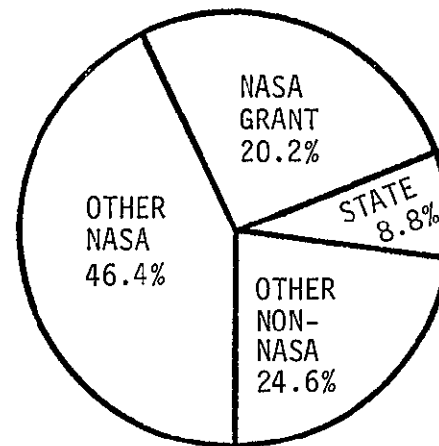
1974 - \$8.6 MILLION



1975 - \$9.3 MILLION

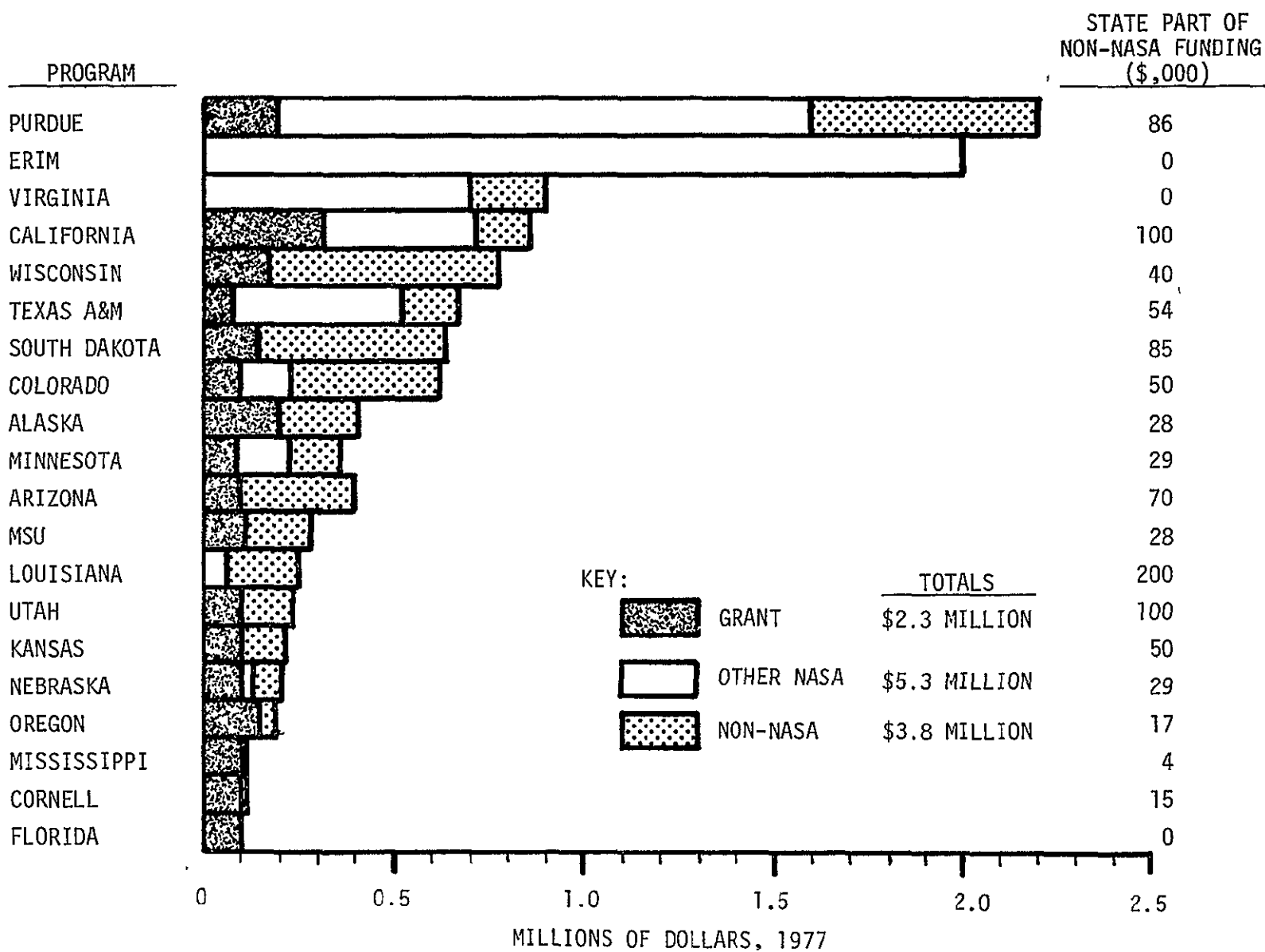


1976 - \$10.4 MILLION

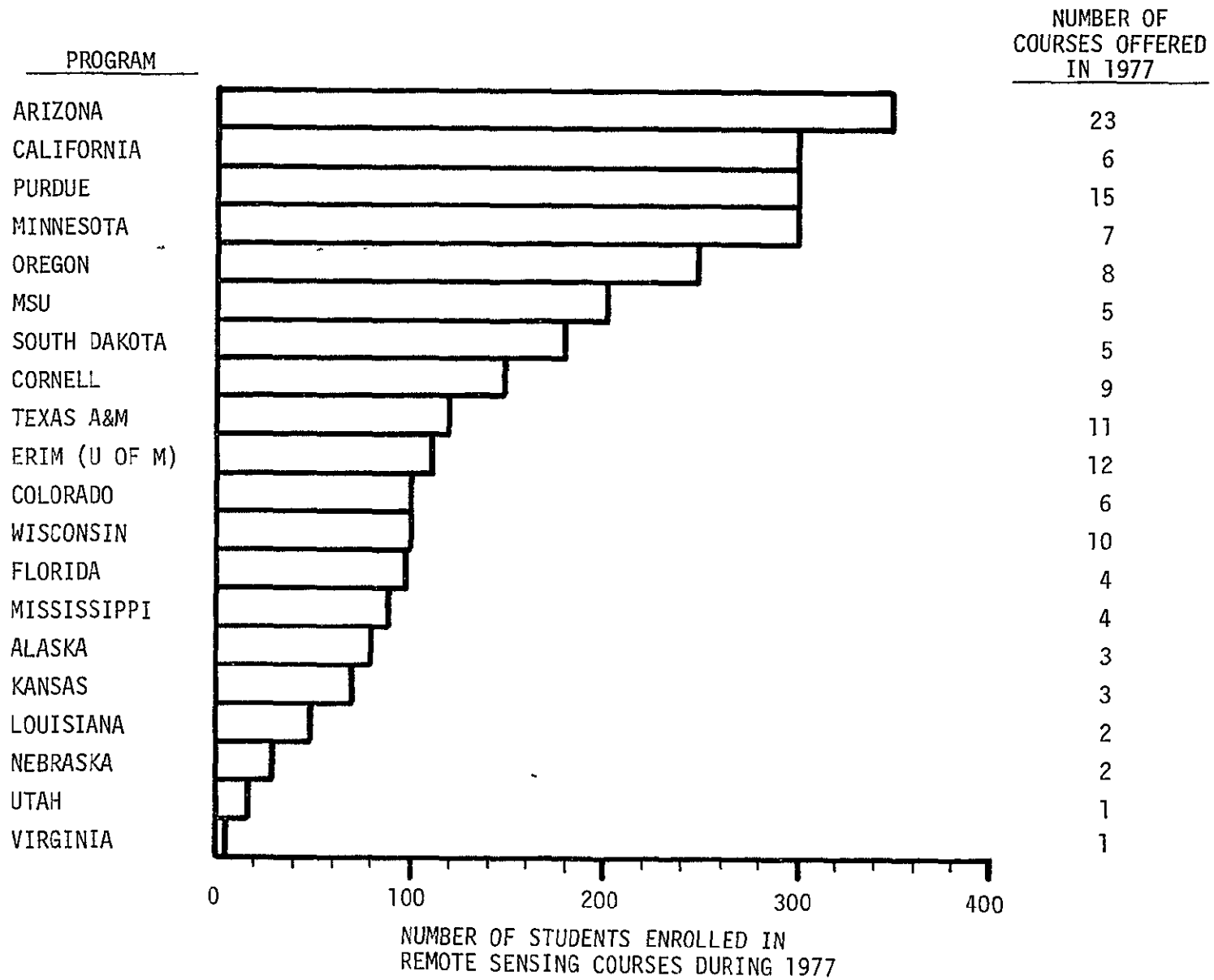


1977 - \$11.4 MILLION

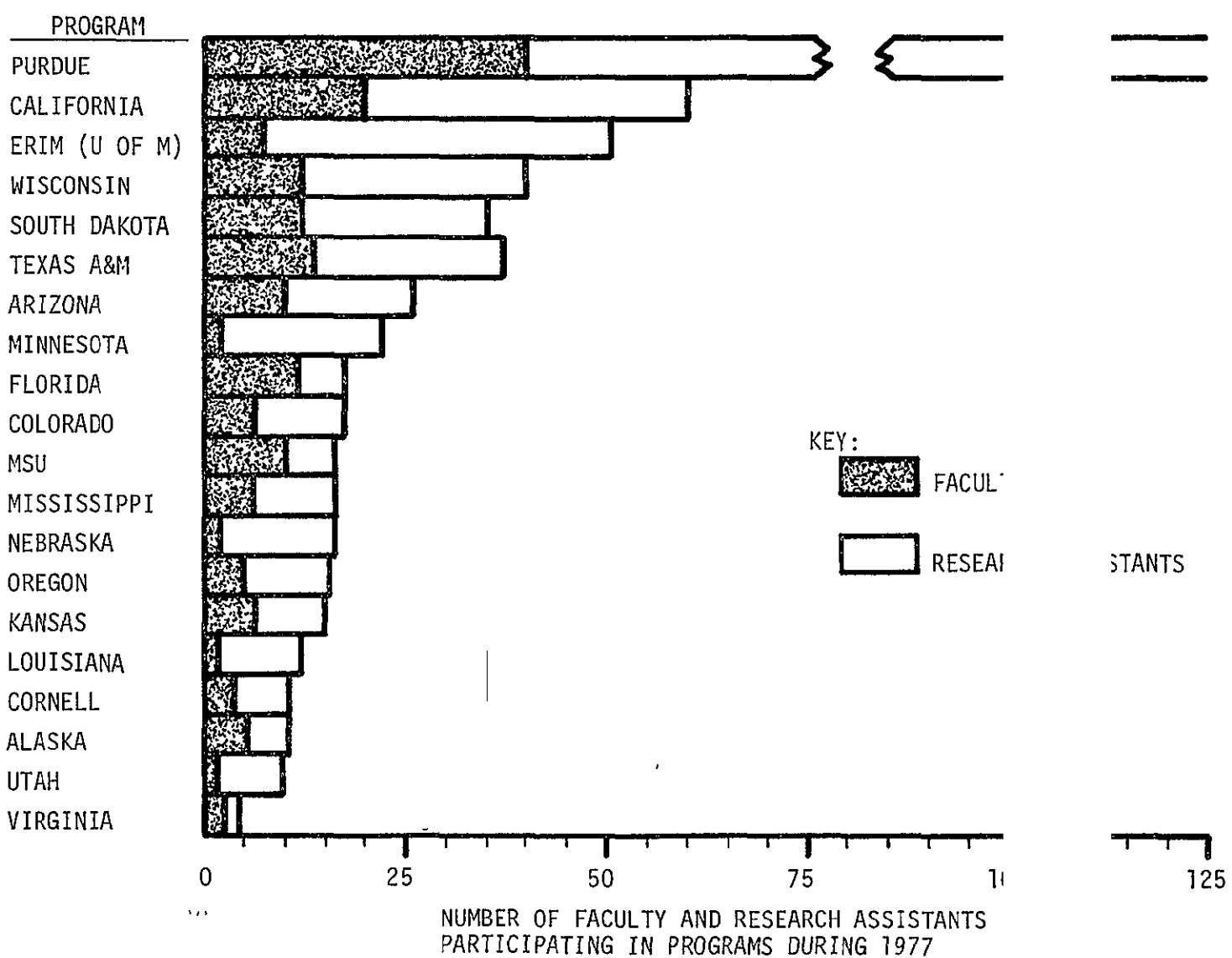
1977 GRANT, OTHER NASA, AND NON-NASA FUNDING, BY UNIVERSITY



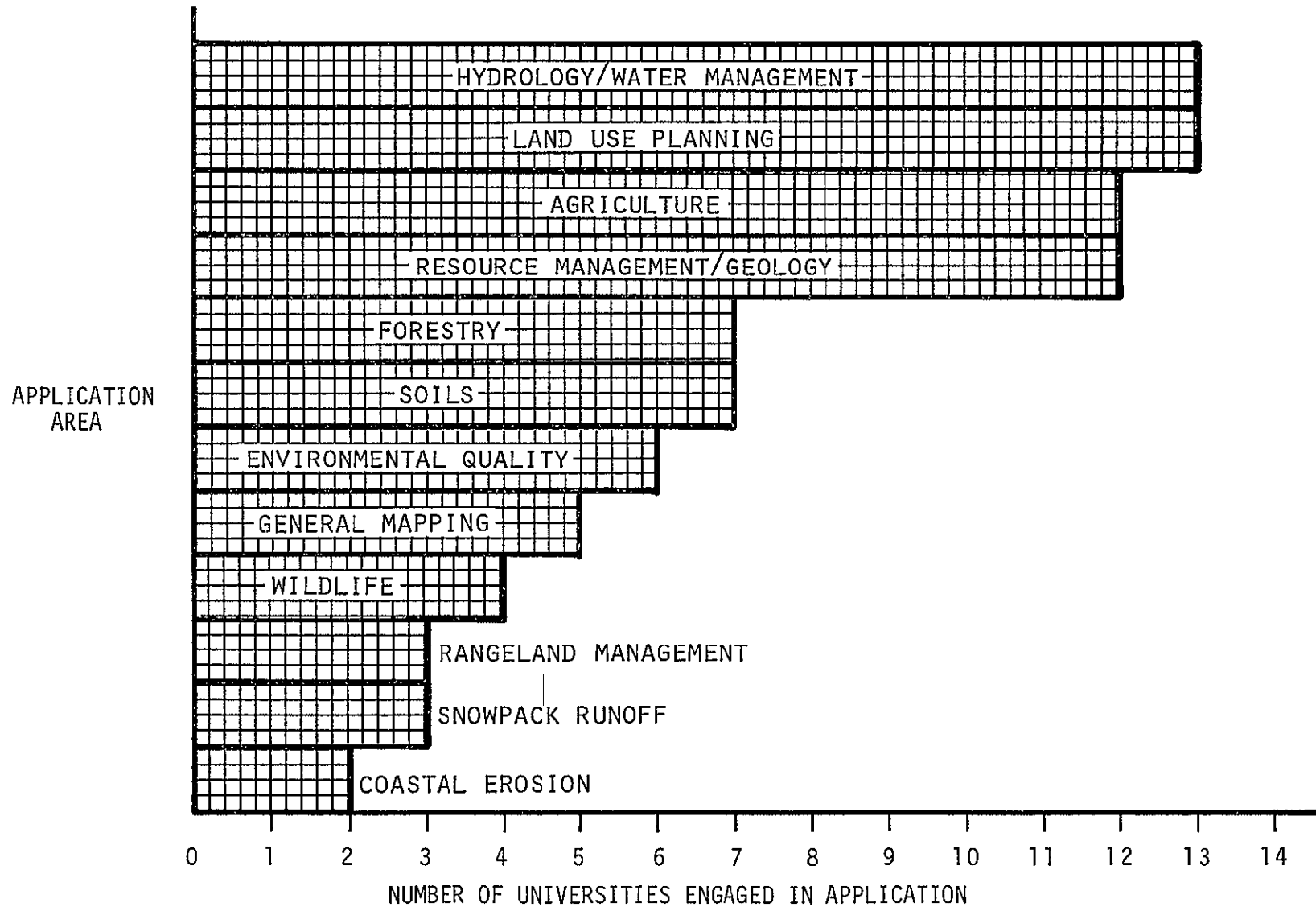
STUDENTS AND COURSES IN UNIVERSITY REMOTE SENSING PROGRAMS



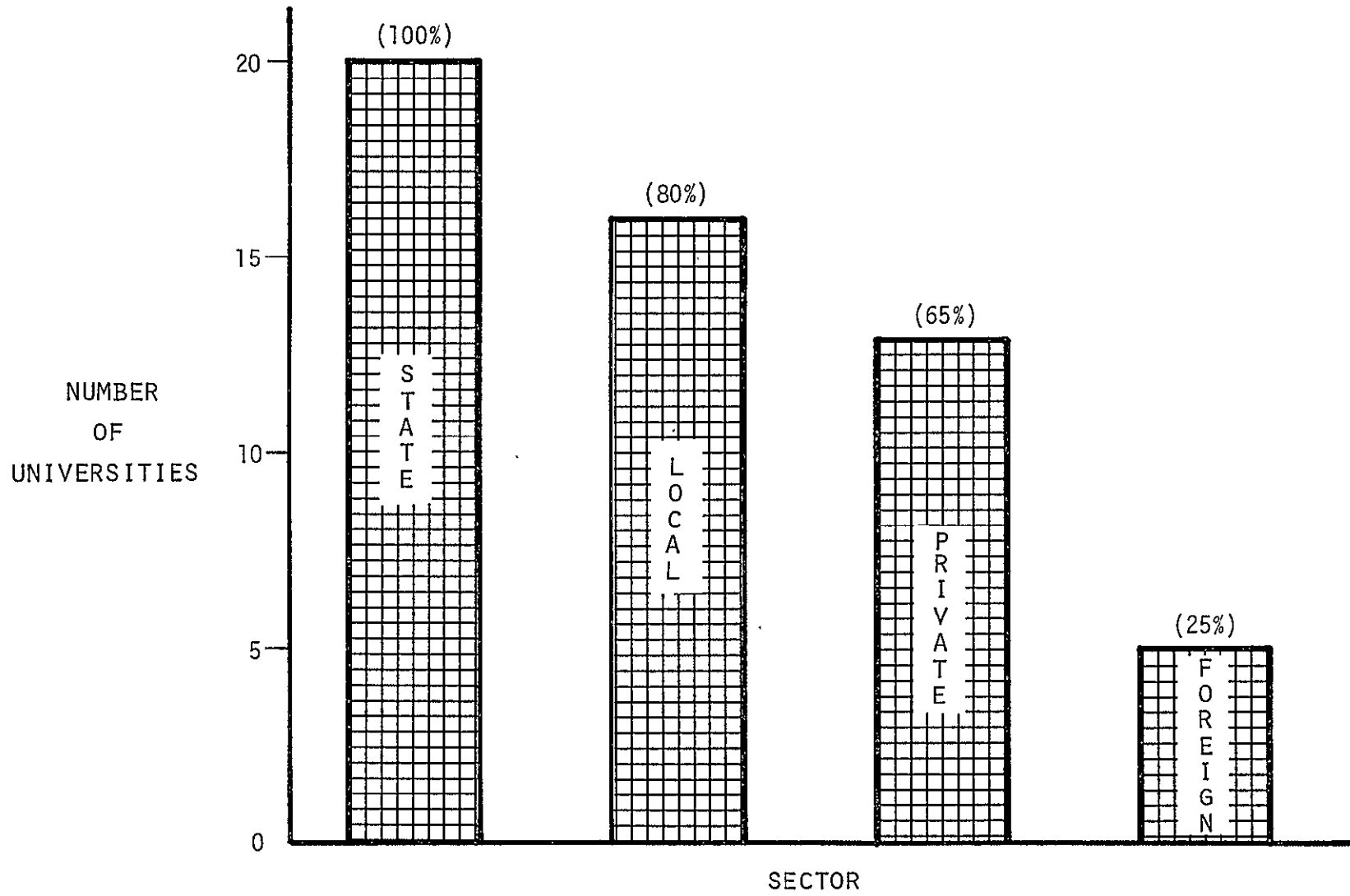
FACULTY AND RESEARCH ASSISTANTS IN UNIVERSITY REMOTE SENSING PROGRAMS



UNIVERSITY PROGRAMS - MAJOR APPLICATIONS OF REMOTE SENSING



UNIVERSITY PROGRAMS - NON-FEDERAL INVOLVEMENT





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