091972

LARS PROGRAM REVIEW
for
Provost H.F. Robinson
September 19, 1972

The Laboratory for Applications of Remote Sensing

Purdue University
Lafayette, Indiana

LARS PROGRAM REVIEW

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Appendices

Educational Activities by LARS Staff

I. Introduction

Although LARS provides a research facility which readily facilitates truly interdisciplinary research involving widely dispersed fields, it also unavoidably provides an educational facility which

A. Attracts scientists as visitors from many parts of the world who seek advice from the LARS staff, frequently requiring several days of staff attention, explanation and discussion.

B. Provides a live demonstration resource of remote sensing technology and application for several formal university classes in such diverse areas as Forestry, Geosciences, Agricultural Economics, Agronomy and Electrical Engineering. Resources are available in such activities as photo-interpretation and automatic data acquisition, processing, analysis and interpretation; in some cases "hands on" training experience is available.

C. Provides a funded research program and facility for a large number, 19, academic professional staff of the University, who apply to their teaching programs the knowledge gained in their remote sensing research activities.

D. Provides funding for salaries, equipment and operational expenses for graduate students, currently 27, and their thesis research from many areas of the University.

E. Provides an experienced, capable staff and facility utilized in offering seminars, symposia, workshops, training programs, visiting scientists, short courses, etc. for interested scientists.

F. Expedites the development of educational aids such as audio visual training aids, etc. of use to University teachers.

G. Provides job training and salaried part-time jobs of a technical nature for many undergraduate students .

H. Makes available to University teachers a continuous flow of unfolding research information on remote sensing technology and its applications as well as new understanding of natural phenomena revealed through the science of remote sensing.

II. Graduate training expedited by LARS staff and facilities.

A. Graduate assistants funded by LARS September 1, 1972.

Aeronautics	1
Agricultural Economics	2
Agronomy	4
Computer Science	2
Electrical Engineering	10
Forestry	1
Geosciences	7
Total	27

B. Degrees granted to graduate students using LARS facilities and under guidance of LARS staff members in 1971-72 academic year.

Agricultural Economics

Douglas Trunnel	M.S.
Larry Smith	Ph.D.

Agricultural Engineering

Gerald Birth	Ph.D.

Agronomy

Eric Stoner	M.S.
Phillip LeBlanc	M.S.

Civil Engineering

Ken Martin	M.S.

Computer Science

Don Schricker	M.S.

Electrical Engineering

Fred Phillips	M.S.
Patrick Ready	Ph.D.
Arthur Wacker	Ph.D.

English

David Nelson M.S.

Geosciences

William W. Reid M.S.

C. Titles of Thesis Research Problems 1971-72

Clevenger, John, E.E., "Low Cost Field Spectroradiometer." Ph.D. in progress. LeRoy Silva, Professor.

Emmert, Richard, E.E., "A Study of Conjugate Point Determination Techniques for Multitemporal Image Overlay." Ph.D. in progress. Clare McGillem, Professor.

Ewart, Noralyn, Agr. Econ., "The Role of Crop Estimate Information in the Determination of Price in the Soybean Market." Ph.D. in progress. Ludwig Eisgruber, Professor.

Gerhold, James, Ento., "Detection of Potato Leaf Hopper Damage on Soybeans by Remote Sensing Techniques." M.S. completed. R.M. Hoffer, Professor.

Kumar, Ravindra, Aero., "The Emissive Properties of Stressed Vegetative Canopies." Ph.D. in progress. LeRoy Silva, Professor.

LeBlanc, Phillip, Agron., "Optimum Time of Year for Identification of Land Classes Using Multispectral Data." M.S. completed. Chris Johannsen and Joe Yahner, Professors.

Murray, William, Geos., "Scattering in Atmospheric Haze Layers." M.S. in progress. Gerald M. Jurica, Professor.

Phillips, Frederick, E.E., "Calibration Techniques in Thermal Scanning." Ph.D. in progress. LeRoy Silva Professor.

Ready, Patrick, E.E., "Multispectral Data Compression Through Transform Coding and Block Quantization," Ph.D. completed. Paul Wintz, Professor.

Robertson, T.V., E.E., "The Use of Context in Multispectral Image Processing." Ph.D. in progress. P. Swain, Professor.

Scherr, B., Agr. Econ., "Systems Analysis of Joint Applications of Remote Sensing." Ph.D. in progress. Ludwig Eisgruber, Professor.

Smith, L., Agr. Econ., "Remote Sensing Information Requirements, Potential Impact and Beneficiaries in the Soybean Industry and the Economy." Ph.D. in progress. Ludwig Eisgruber, Professor.

Stockton, John, Agron., "Multispectral Reflectance and Thermal Emission from Soils of Different Internal Drainage Classes." M.S. in progress. Marion Baumgardner, Professor.

Stohr, Chris, Geos., Applications of Remote Sensing to Geosciences." M.S. (specific title to be selected.) T. West, Professor.

Stoner, Eric, Agron., "Measuring Reflectance from Maize Canopies with Multispectral Reflectance and and Infrared Photographs," M.S. completed. Marion Baumgardner, Professor.

Trunnell, D., Agr. Econ., "Optimum Subsampling Ratios for Remote Sensing Experiments." M.S. in progress. Ludwig Eisgruber, Professor.

Vanderbilt, Vernon, E.E., "The Reflective Properties of Stresses Vegetative Canopies." Ph.D. in progress. LeRoy Silva, Professor.

Wacker, A.G., E.E., "The Minimum Distance Approach to Classification," Ph.D. completed. David Landgrebe, Professor.

Wilkenson, David, R., E.E., "A General Controlled Source," Ph.D. in progress. LeRoy Silva, Professor.

Woodring, Stanley, Geos., "Applications of Remote Sensing to Geosciences" (specific title to be selected) T. West, Professor.

Zalusky, James, E.E., "Electrical Properties of Soils as a Function of Available Soil Moisture Profiles." Ph.D. in progress. Floyd V. Schultz, Professor.

Zimmerman, Thomas A., E.E., "A Fast Response Temperature Sensor for Tornado Probes," Ph.D. completed. LeRoy Silva, Professor.

III. Other Educational Activities at LARS.

A. "Short Course, Remote Sensing, Technology and Applications" July 31-August 11, 1972.

Because of the world-wide demand from many scientific fields for an advanced Short Course in remote sensing technology as developed and advanced by LARS personnel, a Short Course was offered to interested University graduates. The Course was offered in two segments, one each week, in a way to provide a complete unit in each of the two, two-week sessions and also providing a two week course with continuity.

From the attached brochure it can be seen that the Physical Basis of Remote Sensing was emphasized the first week and Analysis of Remote Sensing Data by Automatic Techniques the second.

Thirty three scientists enrolled for the first week and forty seven for the second with thirty of the group staying for both weeks. Fourteen of the class came from foreign countries. The reaction to the course was very good as judged by a rating sheet completed by the participants.

B. Visiting Scientists, Individual Training Programs

Many requests come to the Laboratory from scientists in this country and from over the world who wish to work in the Laboratory with the LARS staff in order to gain special training and experience to enable them to apply remote sensing technology to problems in their home countries. The demands for this kind of help have increased markedly with the successful activation of the ERTS program with its large spectral data gathering capacity on a world-wide basis.

LARS could offer an outstanding educational service to scientists over the world if the Laboratory and the University administration should decide this to be a proper function and if procedure can be developed to expedite such a program. Currently because of lack of clearance on proper procedure to carry out this training function, the Laboratory is refusing requests, many of them from established scientists in different parts of the world.

C. Formal University Courses Dealing with Phases of Remote Sensing.

1. Courses with definite emphasis on remote sensing.

Civil Engineering
577 Engineering Aspects of Remote Sensing.
cr. 3. Prof. Lindenlaub

595 Selected topics in Electrical Engineering.
cr. as arranged. Staff.

696 Advanced Electrical Engineering Projects.
cr. as arranged. Staff.

Forestry

558 Remote Sensing of Natural Resources.
cr. 3. Prof. Hoffer.

579 Remote Sensing Seminar.
cr. 0 or 1. Prof. Hoffer and Staff.

2. Courses related to remote sensing.

Agronomy

565 Soil Classification and Survey.
cr. 2. Prof. Zachary.

585 Soils and Land Use.
cr. 2. Prof. Yahner

598 Special Problems.
cr. as arranged. Staff.

655 Soil Genesis and Classification
cr. 3. Prof. Franzmeir.

Civil Engineering

503 Photogrammetry.
cr. 3. Prof. Mikhail.

603 Advanced Photogrammetry.
cr. 3. Prof. Mikhail.

Electrical Engineering

500 Random Variables and Signals.
cr. 3. The graduate committee.

504 Electromagnetic Field Theory.
cr. 3. The graduate committee.

506 Electrical Properties of Materials.
cr. 3. The graduate committee.

547 An Introduction to Statistical Communication Theory.
cr. 3. Prof. McGillem and Staff.

554 Electronic Instrumentation and Control Circuits.
cr. 3. Prof. Ogborn

556 Semiconductor Devices.
cr. 3. Prof. Thompson.

557 Integrated Circuit Fabrication Laboratory.
cr. 3. Professors Neudeck, Silva and Staff.

563 Information Processing.
cr. 3. Prof. Patrick and Staff.

568 Introduction to Artificial Intelligence and Pattern Recognition.
cr. 3. Prof. Fukunago.

576 Fundamentals of Signal Description.
cr. 3. Prof. Landgrebe.

Forestry

557 Aerial Photo Interpretation.
cr. 3. Prof. Miller.

L.A.R.S.

Fy 1971-72

- Staff include 106 people from 15 academic department.
- Has approximately $1,100,000 in capital equipment not including a $1,500,000 computer installation.
- Had an operating budget of approximately $1,800,000 expensed as follows:

A) Research

Salaries:		
Engineering	$324,471.35	
Agriculture	205,727.95	
Science	41,611.87	
Technology	9,549.96	
H.S.S.E.	4,497.92	
Total Salaries		$ 585,859.05
Fringe Benefits		49,937.55
Overhead		348,167.18
Supplies and Expenses		627,033.03
Capital		141,110.83
Total Research		$1,752,107.64

B) Supporting University Funds

1. General Funds	
Salaries	$12,376.33
Supplies and Expenses	22,597.90
Capital	10,238.15
Total General Funds	$45,212.38
2. Cost Sharing [3% of NASA (SR&T)]	$32,686.83

NASA (SR&T) Expenses by Department and School

July 1, 1971 - June 30, 1972

Engineering

	Aero	C.E.	E.E.	TOT Eng.
All Salaries	$2,350.00	$4,129.67	$106,938.89	$113,418.56
F.B.	3.38	10.22	8,919.43	8,933.03
Overhead	1,409.77	2,472.01	61,674.40	65,556.18
	$3,763.15	$6,611.90	$177,532.72	$187,907.77

Agriculture

	Agr.	Ag.Econ	Ag.Eng	Ag. Info	Fors.	Hort.	TOT Agrcltr.
A.S.	$136,295.14	$12,552.70	$12,000.00	$8,300.01	$35,220.10	$1,360.00	$205,727.95
F.B.	15,624.53	1,084.45	805.99	575.75	3,360.50	212.85	21,664.07
O.H.	81,155.97	7,521.96	7,023.00	4,976.57	20,950.47	811.92	122,439.89
	233,075.64	21,159.11	19,828.99	13,852.33	59,531.07	2,384.77	349,831.91

Science

	Comp.Sci.	Stat.	Geoscience	TOT. Sci.
All Salaries	$6,923.68	$1,115.00	$21,327.20	$29,365.88
F.B.	10.00	1.12	1,519.20	1,530.32
Overhead	4,150.80	613.25	12,631.90	17,395.95
	$11,084.48	$1,729.37	$35,478.30	$48,292.15

Technology

	AV.Tech	TOT.Av.Tech
All Salaries	$9,549.96	$9,549.96
F.B.	603.57	603.57
Overhead	5,651.19	5,651.19
	$15,804.72	$15,804.72

H.S.S.E.

All Salaries	$4,497.92	$4,497.92
F. B.	6.30	6.30
Overhead	2,705.40	2,705.40

E.E.S.

	D.P.	Bio.	Meas.	Admin.	TOT. E.E.S.
All Salaries	$ 47,403.71	$12,841.70	$ 4,079.43	$145,059.55	$ 209,384.39
F. B.	593.35	229.75	44.46	15,060.59	15,928.15
O. H.	28,436.18	7,693.29	2,440.50	86,832.37	125,402.34
S & E	530,277.61	8,208.56	18,612.44	39,630.33	596,728.94
CAP.	60,919.53	----------	80,050.15	141.15	141,110.83
TOT.	$667,630.38	$28,973.30	$105,226.98	$286,723.99	$1,088,554.65

Summary (SR&T)

Salaries:		
Engineering	$113,418.56	
Agriculture	205,727.95	
Science	29,365.88	
Technology	9,549.96	
H.S.S.E.	4,497.92	
E.E.S.	209,384.39	
Total Salaries		$ 571,944.66
Fringe Benefits		48,665.44
Overhead		339,150.95
Supplies & Expenses		596,728.94
Capital		141,110.83
Total SR&T		$1,697,600.82

Department of Transportation (D.O.T.)

Expenses by Department

July 1, 1971 - June 30, 1972

	Geoscience	C.E.	E.E.S.	TOT. D.O.T.
All Salaries	$12,245.99	$1,078.00	$590.40	$13,914.39
F.B.	1,101.94	163.61	6.56	1,272.11
Overhead	7,968.48	676.98	370.77	9,016.23
Supp. & Exp.	---------	-------	30,271.82	30,304.09
	$21,316.41	$1,918.59	$31,271.82	$54,506.82

General Fund Expenditures

July 1, 1971 - June 30, 1972

	0003-10-1280X	0003-17-1280X	TOTAL
All Salaries	$298.44	$12,077.89	$12,376.33
S & E	7,416.82	15,181.08	22,597.90
CAP	3,730.69	6,507.46	10,238.15
TOT	$11,445.95	$33,766.43	$45,212.38

L.A.R.S. Research Staff
(Number and Expense by Department and School)
July 1, 1971 - June 30, 1972

	Number	Salaries	Total School
FACULTY			
Agronomy	4	$53,787.30	
Ag. Economics	1	6,316.16	
Forestry	1	11,182.76	
Horticulture	1	1,360.00	
Agriculture	7		$72,646.22
Civil Engineering	2	2,961.72	
Electrical Engineering	5	61,697.60	
Engineering	7		$64,659.32
Geoscience	5	21,471.50	
Statistics	1	1,115.00	
Science	6		22,586.50
	Total Faculty	20	$159,892.04
PROFESSIONAL			
Agronomy	4	$54,031.49	
Ag. Engineering	1	12,000.00	
Ag. Information	1	8,300.01	
Forestry	2	8,391.70	
Agriculture	8		$82,723.20
Electrical Engineering	1	2,192.94	
Engineering	1		$2,192.94

Engineering Exp. Sta.	9	$112,681.32	
Engineering Exp. Sta.	9		$112,681.32
Aviation Technology	1	9,549.96	
Technology	1		9,549.96
	Total Professional	19	$207,147.42

GRADUATE STUDENTS

Agronomy	4	$14,965.52	
Ag. Economics	2	6,236.54	
Forestry	3	15,645.64	
Agriculture	9		$36,847.70
Aero. Engineering	1	$2,350.00	
Civil Engineering	1	2,240.00	
Elect. Engineering	12	42,900.00	
Engineering	14		$47,490.00
Geoscience	5	$12,101.69	
Computer Science	2	6,923.68	
Science	7		$19,025.37
English	1	$4,497.92	
H.S.S.E.	1		$4,497.92
	Total Graduate Students	31	$107,860.99

Undergraduate Students (Employed in E.E.S.)

Students From: Dept. or School			
Engineering Sciences	1		
Elect. Engineering	6		
Mech. Engineering	2		
Nuclear Engineering	1		
Aero. Engineering	1		
Freshman Engineering	1		
Computer Science	1		
Science	4		
H.S.S.E.	2		
Agronomy	1		
Ag. Economics	2		
Bio. Chemistry	1		
Geoscience	1		
TOTAL Undergrad. Stu.	24		$60,266.96

OTHER

Agronomy	2	$13,510.83	
E.E.S.	9	37,032.46	
Elect. Engineering	1	148.35	
Total Other	12		$50,691.64

Summary

Research Staff Salaries and Source of Funds

July 1, 1971 - June 30, 1972

	SR&T	D.O.T.	TOTAL
Faculty	$150,638.05	$9,253.99	$159,892.04
Professional	207,147.42	------	207,147.42
Grad. Students	103,790.99	4,070.00	107,860.99
Undergrad. Students	59,676.56	590.40	60,266.96
Other	50,691.64	------	50,691.64
TOTAL	$571,944.66	$13,914.39	$585,859.05

Professorial and Professional Staff
FY 1971-72

I. Professorial Staff

A. Agriculture

1. M. F. Baumgardner-Associate Professor of Agronomy
2. L. M. Eisgruber-Professor of Agricultural Economics
3. R. M. Hoffer-Associate Professor of Forestry and Conservation
4. C. J. Johannsen-Assistant Professor of Agronomy
5. J. B. Peterson-Professor of Agronomy (post-retirement appointment)
6. C. B. Roth-Assistant Professor of Agronomy
7. P. S. Tresch-Assistant Professor of Horticulture

B. Engineering

1. D. A. Landgrebe-Professor of Electrical Engineering
2. J. C. Lindenlaub-Professor of Electrical Engineering
3. E. M. Mikhail-Associate Professor of Civil Engineering
4. F. V. Schultz-Professor of Electrical Engineering
5. L. F. Silva-Associate Professor of Electrical Engineering
6. J. C. Trinder-Visiting Associate Professor in Civil Engineering
7. P. A. Wintz-Professor of Electrical Engineering

C. Science

1. V. L. Anderson-Professor of Statistics
2. R. L. Frederking-Instructor of Geosciences
3. G. M. Jurica-Assistant Professor of Geosciences
4. D. W. Levandowski-Associate Professor of Geosciences
5. W. N. Melhorn-Professor of Geosciences
6. T. R. West-Associate Professor of Geosciences

II. Professional Staff

A. Agriculture

1. A. H. Al-Abbas-Research Agronomist in Agronomy
2. M. E. Bauer-Research Agronomist in Agronomy
3. G. S. Birth-Research Engineer in Agricultural Engineering
4. T. Builta-Technical Editor in Agricultural Information
5. J. E. Cipra-Research Agronomist in Agronomy
6. F. Goodrick-Data Analyst in Forestry and Conservation
7. S. J. Kristof-Research Agronomist in Agronomy
8. R. P. Mroczynski-Photo-Interpreter in Forestry and Conservation

B. Engineering

B. F. Robinson-Research Engineer in Electrical Engineering

C. Engineering Experiment Station

1. P. E. Anuta-Associate Manager of Data Reformatting Research
2. H. L. Grams-Manager of Computer Operations
3. K. Himmelberger-Applications Programmer
4. W. C. Hockema-Computer Operations Supervisor
5. S. K. Hunt-Manager of Applications Programmers
6. T. L. Phillips-Program Leader: Data Processing Programs
7. G. F. Santner-Research Statistician
8. W. R. Simmons-Associate Manager: Data Reformatting Development
9. P. H. Swain-Program Leader: Data Analysis Research

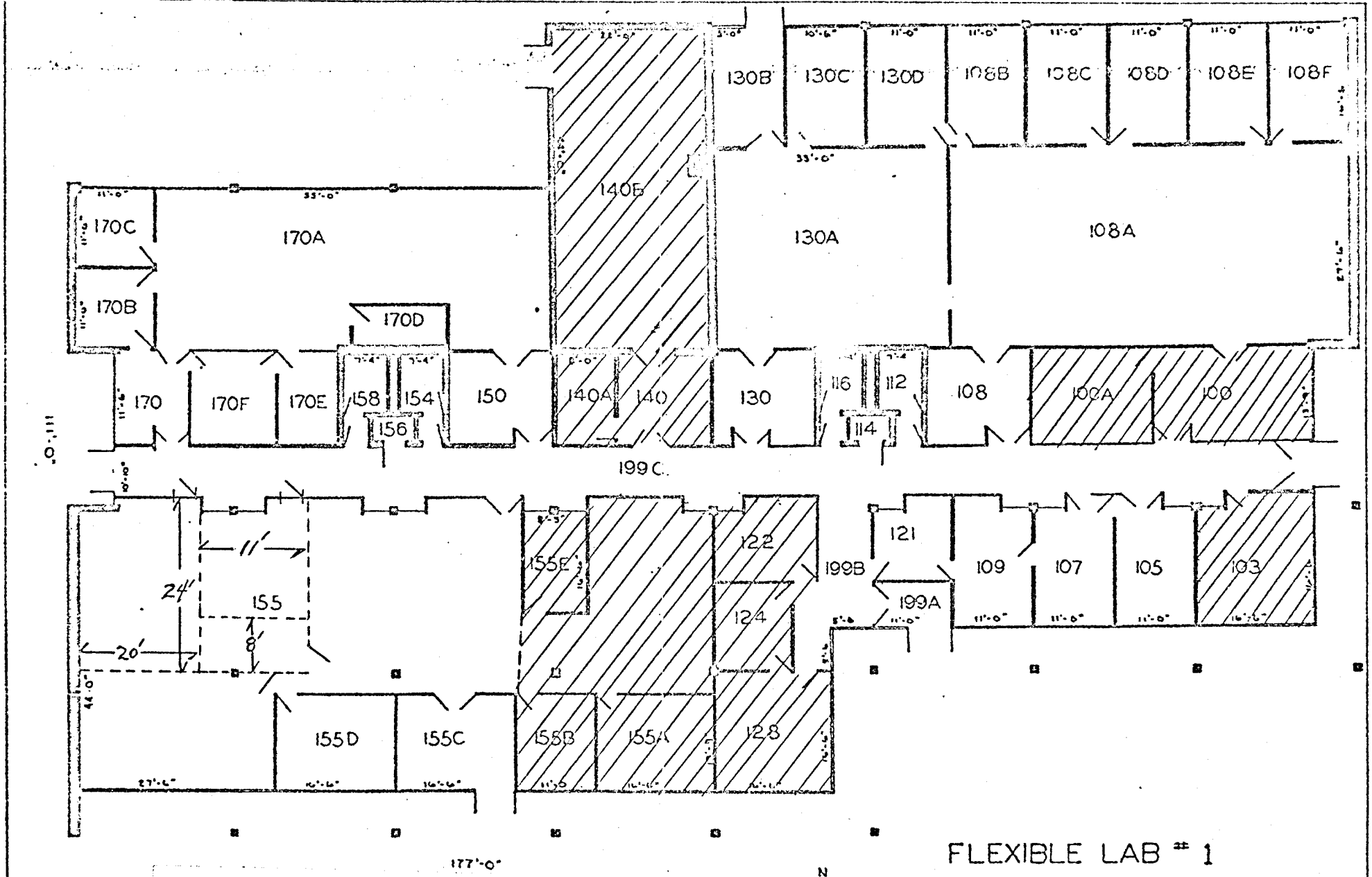
D. Technology

T. A. Martin-Systems Manager in Aviation Technology

SPACE

Space	Sq. ft.	Cost/sq. ft.	Total (annual)
Flex Lab I	9,602	$4.50	$43,074
Flex Lab II	6,994	3.90	27,276
TOTAL	16,566		$70,350

- The L.A.R.S. space is rented from PRF by Purdue University.
- Sources of rental funds are from Physical Plant's Reserve for Rental.
- Utilities are paid by Physical Plant.
- Janitorial services are provided by Physical Plant for the Flex Lab II space, and PRF provides janitorial service in its rental figure for Flex Lab I.
- Funds for telephone rental are provided to L.A.R.S. via general fund allocations.
- Remodeling plans are indicated on the floor plans by the dotted lines. Permission was granted by Dr. Ford for remodeling as indicated and funds have been transfered from the Provost's Reserve.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PROPOSED PARTITIONS
FLEXIBLE LAB # 1
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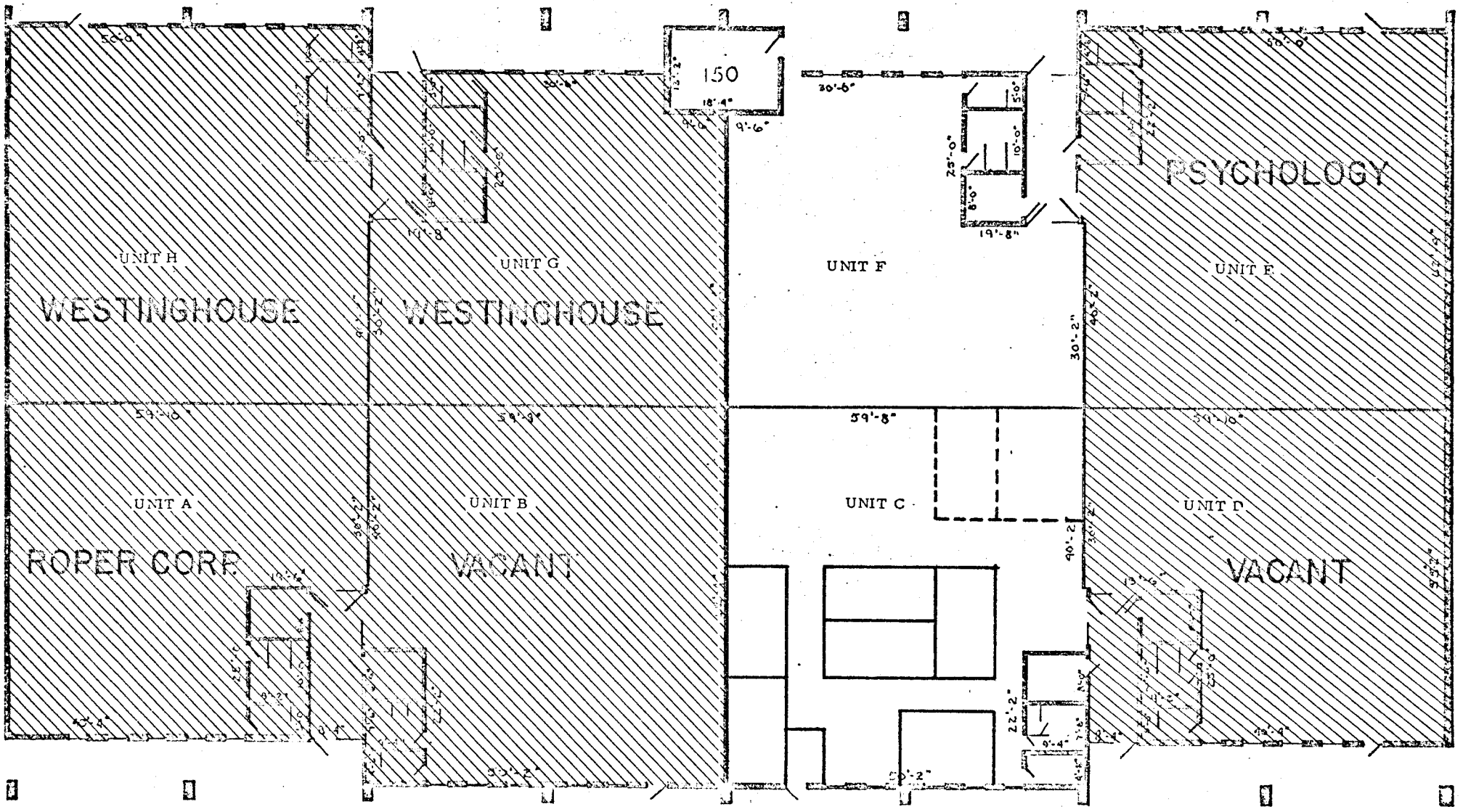

FLEXIBLE LAB. NO. 2

FUNDING SUMMARY-CURRENT

September 12, 1972

Type	PRF	70-71	71-72	72-73	73-74	74-75	Total
	6071	135,000	65,000				200,000
	6395	665,000	70,000	65,000			800,000
	6395-1	750,000					750,000
	6395-2		670,000	70,000	60,000		800,000
	6395-3		922,571				922,571
	7070-4			248,453	75,000	60,000	383,453
	7070-5			10,890			10,890
	7070-6			550,000			550,000
SR&T Subtotal		1,550,000	1,727,571	944,343	135,000	60,000	4,416,914
ERTS							
Wabash Valley				128,531	74,977		203,508
INSTARR				131,387	54,745		186,132
Central States				41,499	17,291		58,790
NE-69				25,412	10,588		36,000
ERTS Subtotal				326,829	157,601		484,430
D.O.T.		29,073	47,484	17,600			94,157
Other							
Visiting Scientist Program			14,000				14,000
Short Course				12,000			12,000
Total		1,579,073	1,789,055	1,300,772	292,601	60,000	5,021,501

FUNDING SUMMARY-POTENTIAL

• Development of Techniques for the Analysis of the Reflectance of Plant Canopies-G. S. Birth and F. V. Schultz: approximately $117,000.

• Development of Educational Materials in the Area of Remote Sensing-John Lindenlaub: no established amount.

• ARPA Research in Multispectral Image Analysis-P. A. Wintz and D. A. Landgrebe: approximately $500,000/year.

• L.A.R.S./NASA/USGS(ILLIAC)-D. A. Landgrebe and P. H. Swain: September 1, 1972-August 31, 1973 for approximately $65,000.

• Dept. of Transportation-T. R. West: November 1, 1972-December 31, 1973 for approximately $85,000.

• Efficient Encoding of Multispectral Scanner Data-P. A. Wintz: August 1, 1972-July 30, 1973 for approximately $42,000.

• The Relationship Between Crop Diversification and Such Factors as: Use of Insecticides, Disease and Infectation, and Soil Erosion and Fertility-L. M. Eisgruber: January 1, 1973-June 30, 1973 for approximately $46,000.

Airborne Scanner System Status

Attached to this memo, for your reference, you will find a copy of a report which describes the dependency of the future research program at LARS on a dedicated aircraft system. In order to bring you up to date on the status of this project, the following is a summary of the current activity in the aircraft system program.

Firm quotations have been received on the following components of the aircraft system. They are:

1.	Scanner conversion project	$150,000.00
2.	Airborne tape recorder	17,120.00
3.	Aircraft modification cost	24,250.00
4.	Control console	5,100.00
5.	Supporting laboratory	6,690.00

Total estimated cost of the system is only about $5,000 in excess of the original estimated cost of $210,500.00 that was made approximately one year ago. This is well within inflationary increase estimates. The current time schedule in the aircraft system calls for a December 1, 1972 target date for the letting of the scanner modification contract. The potential contractor on the scanner modifications, Texas Instruments Corporation, has submitted a quotation good until February 14, 1973. They also have promised a delivery date of 8 months after receipt of the order for the scanner modification. If the scanner contract is awarded on December 1, test flights for the aircraft system could begin in the summer of 1973, and the aircraft system would be fully operational by the spring of 1974.

There appears to be no serious problem in the acquisition of the appropriate DC-3 aircraft for a projected cost of $25,000.00. A number of these aircraft are available on the market, and a suitable aircraft could be made available in a very short time after commitment to the program.

DEPENDENCY OF FUTURE RESEARCH AT LARS ON A DEDICATED AIRCRAFT

Imagery secured by aircraft as well as by satellite is essential to remote sensing research.

The Purdue-NASA Laboratory for Applications of Remote Sensing has reached a stage of competency justifying its designation as a "Center of Excellence" by NASA. It is giving the country leadership in research in instrumentation and in data processing and analysis. No remote sensing facility in the country approaches in its operational procedure the interdisciplinary involvement which exists at LARS, either in completeness of involvement or in breadth of disciplines represented. With excellent modern equipment on hand, an experienced and capable professional staff and an operational procedure which abets cooperative input by leading scientists in many areas of Purdue University, the laboratory is at the threshold of national leadership in research in applications of remote sensing science. The most limiting feature to the achievement of this goal is the lack of an aircraft under the control of the laboratory.

To research the potential application of remote sensing the entire system of platforms must be available including those provided by an aircraft as well as those by a satellite. This is especially true where temporal aspects are important to the investigation as frequently is the case in applications research. Although leasing the time of an aircraft equipped for remote sensing such as the Michigan C-47 should be adequate theoretically for certain limited studies, in practice dependence on such an arrangement is extremely inefficient and costly in manpower. The reason is simple. Institutions with an aircraft at their disposal tend to create many constructive research uses of their own. Priorities on these projects then interfere with those of other institutions who contract for the aircrafts services. Because many of these projects must be done at certain definite optimum times, priorities for use at such specific times become difficult and often impossible to satisfy. The problem is further complicated by vagaries of the weather.

Examples of failure of contracted aircraft to secure essential imagery for LARS research projects.

For example a plan to cooperate with the Indiana Department of Natural Resources in studying possible thermal pollution of the Wabash River by a power plant was frustrated because of a conflict in priorities for the Michigan aircraft. In 1970 a corn blight mission provided spectral scanner data just before the Cayuga Power Plant went into operation. A second flight was planned immediately following opening of the plant but during that week the plant was shut down. Because a 6- to 12- month lead time was needed in scheduling flight missions, the rescheduled flight was set for the summer of 1971. When this time arrived, corn blight flights took priority in all available aircraft time. As a result no data have been collected in this study since the

power plant began operating in mid-1970.

In 1970 a well-planned experiment to evaluate the possibility of estimating wheat yields from remote imagery could not be carried out because the Michigan aircraft was not available at the needed scheduled times because of weather conditions and other priorities on intervening dates. Thus much effort and time was wasted in planning, selecting a suitable location, gaining land owner cooperation and securing ground truth.

In the last flight mission of the corn blight experiment the Michigan plane was sent to Florida on a contract mission during the first week of the mission because timing was important to that research program which had contracted for the plane. When the plane became available, the corn blight mission was flown late. This was very unsatisfactory because corn was being harvested rapidly in the southern segments at that time.

Projects in progress or proposed by LARS which depend upon a dedicated aircraft.

Studies in progress or contemplated by personnel at LARS which depend heavily on the flexibility provided by a completely dedicated aircraft may be grouped as follows:

I. Instrumentation research on airborne acquisition systems.

In research programs that involve remote sensing data acquisition systems it is frequently necessary to perform investigations on the data acquisition system itself as well as on the subsequent data analysis procedures. Up to now LARS has not been able to perform significant research on line scanner systems simply because it does not have access to its primary data source, the University of Michigan research aircraft.

A. Modifications of line scanner.

If LARS had control of a dedicated aircraft system it would, of course, be able to make modifications on the line scanner itself for the express purpose of experimenting with various scanner configurations. Examples of typical investigations that could be undertaken with a dedicated scanner aircraft system are as follows: 1. A study of various reflective calibration references, that is, incandescent sources compared to spectral discharge sources. 2. A study of point calibration sources as compared to diffuse calibration sources. 3. A study of detector types as related to specific experimental investigation. 4. The relationship of thermal detector signal-to-noise performance as related to thermal reference calibration source placement. 5. Channel gain control monitor control and monitoring techniques as related to specific target types.

These are examples of just a few of the studies for which past research at LARS has indicated a need for further investigation.

These studies are, of course, impossible to do unless an aircraft is under direct control and supervision of the researchers. In addition, the development of an airborne digital recording system requires considerable operational experience with a dedicated aircraft system in order to produce an optimum design. Eventually line scanner systems with digital recording and airborne digital control of the experiment should be employed in remote sensing technology. Efficient development of such systems requires that the aircraft and the data analysis system be under the jurisdiction of the same laboratory.

B. Sensor data and data processing interaction.

An important aspect of airborne line scanner imagery acquisition is the relationship that exists between the scanner configuration and the subsequent data analysis techniques. For example, the configuration of the calibration reference sources in the scanner will affect the way in which the data is calibrated and processed in subsequent analysis. Geometric corrections applied to the scanner data are not only influenced by the difficulty of processing such corrections but are also strongly influenced by the geometrical-mechanical configuration of the scanner itself. In order to develop efficient data analysis preprocessing and classification techniques it is essential to run experiments concerning the relationship between scanner configuration and data quality. This means that controlled experiments involving special scanner configurations and the resulting data product are necessary. Such experiments can only be carried out if one is able to make special modifications on the scanner; that is, one is required to have control and access to the scanner to make such modifications. Experiments of this type can only be accomplished when one has control of a dedicated aircraft system.

Another advantage of a dedicated aircraft system is that the close relationship existing between the data acquisition phase and the data analysis phase of the experiment increases the probability of obtaining accurate correctly calibrated data sets. The value of remotely sensed data is enhanced when coordinated line scanner imagery and photographic imagery are obtained under controlled conditions and the users of the data have full knowledge and control over the parameters of the data acquisition system.

II. Evaluation of plant characteristics

A. Crop production estimates.

Ability to estimate yields of certain major crops in promising enough to justify an intensified research effort. The economic benefits from such a capability would be great in savings resulting from more efficient planting schedules, early changes in planting plans to meet market demands threatened by poor yields or crop failures, and more rapid and accurate market predictions.

The Statistical Reporting Service of the USDA is interested in the prospects of this type of yield evaluation.

To be successful such a study would depend upon a dedicated aircraft because of the need to take imagery frequently, avoiding as much as possible time lag from scheduled flights because of weather.

B. Research in monitoring crop disasters.

The spatial and temporal capabilities of remote sensing are both important in evaluating the intensity, occurrence, boundaries and, if the scene is changing, the rate of change of a disasterous situation such as crop disease, drought, insect infestation, etc. Research is needed to perfect the mechanics of such survey techniques. Here again the timing of flights and the freedom to send an airborne platform to the affected area on short notice, diverting it from more routine studies if necessary, must be in the hands of the experimenters.

C. Spectral characteristics of plant communities in relation to their seasonal development.

Success in evaluating any plant-related phenomena such as the spectral characteristics of a field crop depends on first knowing how the spectral properties of the crop in the field change during the growing season. For example it was especially noted during the Corn Blight Watch Experiment that the radiation from a corn field was very different at early stages of growth compared with radiation at full canopy. The seasonal interrelationships of soil and plant radiation must be worked out for specific situations and generalized. This can be done only if an aircraft platform is available on a timely basis.

III. Research on value of remote sensing as an aid in soil classification and mapping.

A. Possibilities of aid to USDA, planning groups, etc. in surveying land and expressing results in useable maps.

This kind of study potentially has great practical benefits. Soil surveys as now made are costly and time-consuming, the only aid the surveyor on the ground gets is from black and white aerial photography which shows him field boundaries, trees, houses, streams and contrasting light and dark soils. The prospects for infrared and scanner imagery revealing many aspects that would help him interpret the soil and landscape without so much time in the field are good. However, to research this adequately the area being studied needs to be flown at certain precise times in relation to maturity of vegetation, exposure of the soil by tilage and moisture condition of the soils. The frequency of coverage by satellite would not be adequate and the failure to get the Michigan plane at the right times would result in great wastes of man-power

and effort, quite possibly delaying the study by a year at a time.

B. Research on mapping slowly-drained areas.

Possibilities are promising for distinguishing soils in the landscape with different rates of water percolation and drainage. There is evidence that a day or two after a rainstorm soils with different moisture contents can be sorted on a spatial basis by thermal infrared data. If this is found to be true and feasible, the technique can be put to many practical uses. To investigate the possibilities it is necessary that sensing equipment be available to fly to certain areas on two or three days notice.

IV. Land use studies.

A. Research on monitoring energy budgets over rural and urban areas.

Much research is being done to express the summation values of the energy available over certain segments of the year. One value, "growing degree days" is being used to study the energy necessary to produce maturity of certain crops. It is also being used to determine service and supply needs of heating units in urban settings. It is believed these values could be secured more readily and efficiently by remote sensing. Also it is quite possible that better parameters could be selected and estimated. To accomplish this, a platform would have to be available almost continuously, since diurnal effects would be important as well as day by day changes.

V. Environmental studies.

A. Investigating the feasibility of monitoring contamination of the Wabash River and other bodies of water, by silt, industrial wastes, thermal liquids, sewage, etc.

Such monitoring is promising. To do the research necessary to perfect the procedures would require temporal control of the sensing platform.

B. Tracking and evaluating effects of natural disasters such as tornadoes, hurricanes, floods, snow and ice storms and droughts.

It is obvious that timeliness of sensing would be essential to such activities.

C. Measuring and mapping pollution from indirect evidence.

Changes in foliage characteristics of trees and crops are often indicative of damage from pollutants. Concentrations of algae in ponds and reservoirs reflect nutrient levels in runoff and drainage waters.

Examples of promising research projects not activated because of unavailability of dedicated aircraft.

Projects or Contracts

1. Corp of Eng. - Louisville Office. William Kreisel fly agricultural area in Cole County, Illinois in March and April, 1972 to locate field tile lines. A proposed reserviour site would cover some tile line outlets. This project would have provided the opportunity to determine if tile lines could be successfully located by thermal infrared or visible wavelengths.

2. Strip mine Survey in Indiana. - Conducted by legislative Task Force to study coal mining industry in Indiana and pollution problems posed by abandoned mining operations.
Preliminary work completed using high altitude color infrared photography should that different stages of mining could be detected. Contract by Mr. A. J. Proctor, Senior Research Analyst, Legislative Council who wanted us to fly selected areas.

3. Location of buried cables and pipelines. Mr. Ray Lohsl, Rural Electrician Association. R.E.A. is currently spending millions of dollars repairing lines which have been cut by other utilities or repairing cables or pipelines damaged by their work crews. He would be interested in conducting flights in several counties in Indiana to determine if buried cables or pipelines could be accurately located within five feet by detecting soil disturbance, heat differences or the effect of heat differences.

4. Detection of Nematode Infestation. Project proposed by Dr. Glenn Bergeson and C. J. Johannsen to USDA 1968 Project would have utilized detailed ground observations on controlled nematode populations in growing crops and correlated with photographic and/or scanner data. Timeliness of aircraft coverage at key times was essential for the success of this project. Proposal was turned down when it was indicated that aircraft was not dedicated.

5. Alfalfa weevil. During the spring, 1969, a photographic flight was conducted near New Albany, Indiana to see if effects of alfalfa weevil could be detected. Four film types were exposed simultaneously over controlled infestations of weevil. This project was performed jointly with the Entomology Department, Purdue University.

Results showed that the effects could be seen on film but differences were difficult to measure because of film variation and processing differences. The data were obtained, however, because an aircraft was available.

Additional proposals were formulated on the possibility of establishing alfalfa plots close to Lafayette and obtaining scanner data over the plots. This would have given more quantitative data. Specific ground infestation such as moisture and temperature conditions could have been monitored. These proposals were never written because it was realized that the plots would have to be flown within a 24 - 48 hour time period during the infestation in order to obtain the information needed. Scheduling the weevil infestations and aircraft at the same time would not be possible unless the aircraft were readily available to the experiment.

6. Palm Sunday Tornadoes - 1967

Several LARS staff flew with State Climotologist, Larry Schoal, over the areas in Indiana affected by the tornadoes. Over 10 rolls of color and black and white film were exposed of the damage. Much was observed and learned about tornadoes just studying this photography.

Aircraft flights taking continuous photography and multispectral data at that time would have been very valuable to the weather bureau. Contracts could have been obtained from the weather bureau at that time if an aircraft had been available.

7. Simulated Hail Damage.

In the summer, 1970, Dr. James Vorst, Purdue Agronomy Department, established some soybean plots near the Weather Station at the Agronomy Farm. An Insurance Company was sponsoring his work to study the effects on soybean yield of stripping leaves in simulation of hail damage at different times of the growing season. Scanner data were collected over these plots but data were never obtained at the wanted time. Flights were made usually several days or weeks after the desired time. A more detailed project could have been negotiated covering flights at different altitudes, different times of the day and specific times of the growing season if an aircraft had been available.

8. Kanakakee River Study.

During 1970, the Soil Conservation Service and Deparmtnes of Natural Resources expressed interest in obtaining photography over the Kanakakee River basin. A study needed to be conducted to determine pollution sources, areas requiring dredging, wildlife development, etc.

LARS was contacted by Mr. John Chenowith, Soil Conservation Service, and Mr. Frank Lockard, Director of Fish and Wildlife, Indiana Department of Natural Resources. Their most immediate project is to complete a map of the wetland areas in LaPorte County, a portion of the Kanakakee basin.

Potential contracts for remote sensing researcher if LARS has its own airborne sensor.

1. Land use inventories of counties
Department of Natural Resources
Indianapolis, Indiana

2. Possibility of cooperative program to obtain multispectral data and color IR photography over White County, Indiana.
Soil Conservation Service
U. S. Department of Agriculture
Indianapolis, Indiana

3. Possibility of cooperative program to use remote sensing to improve, revise, and update regularly the national Conservation Needs Inventory
Soil Conservation Service
U. S. Department of Agriculture
Washington, D. C.

4. Multispectral scanner and photographic missions over site of geographic interest.
Department of Geography
Indiana State University
Terre Haute, Indiana

5. Possibility of multispectral scanner and photographic missions on time sequential basis of Wildcat Creek Watershed-Lafayette Reservoir Study
Corp of Engineers
Louisville, Kentucky

6. Land use and land capability inventories, soils mapping in large sugar cane development scheme
Dominican Republic

7. Multispectral studies of soils and tropical savanna in the Llanos Orientales Centro Intermericano de Fotoruterpretacion
Bogata, Colombia
(Test sites for ERTS)

8. Multispectral studies of soils and geology test sites for ERTS
A. Region around Montalban, Spain
B. Region around Merida, Spain
Contract with International Institute of Aerial Survey & Earth Sciences
Enschede, The Netherlands

Remote Terminal System Status

Studies have been undertaken to determine how to most efficiently make the technology of machine processing of earth resources data available to the user community. This technology is made available through hardware, software, and the knowledge how to use the system. Procurement of hardware and implementation and maintenance of a large software system are both expensive and, in the case of the software, require a special data processing expertise. It was possible to train each new LARS staff member individually in the use of the system. However, this technique is too expensive and slow for larger groups of people.

These problems led to the design of a specific experiment in the transfer of technology whereby a user scientist need only have input and output data processing devices. Thus, it is possible to centralize computational and data storage capability. This results in at considerable cost advantages in implementation and maintenance of hardware and software, and facilitation of training through commonality of data format, terminology, and simplicity of communication. Standard training methods and training materials could be developed thus reducing the teacher time per pupil.

The experiment was authorized two years ago by NASA Headquarters. On January 1, 1971 an IBM System/360 Model 67 time-share system was placed online with a minimal configuration. The experiment was delayed during the 1971 Corn Blight Watch Experiment, but the final hardware was recently installed and the preparation of training materials has begun.

A remote terminal has been installed at Goddard Space Flight Center. It will be brought online as soon as the proper telephone equipment has been installed.

VISITORS TO THE

LABORATORY FOR APPLICATIONS OF REMOTE SENSING

July 1, 1971 - June 30, 1972

Over-all Summary

FEDERAL AGENCIES	71
STATE AGENCIES	5
PURDUE	25
OTHER UNIVERSITIES	61
INDUSTRY	35
FOREIGN COUNTRIES	28
NEWS MEDIA	1
EDUCATION	1
MISCELLANEOUS	6
20th ANNUAL LAND SURVEYORS CONFERENCE	159
TOTAL	392

LKV
9/15/72

SUMMARY OF VISITORS TO THE LABORATORY FOR APPLICATIONS OF REMOTE SENSING

July 1, 1971 - June 30, 1972

FEDERAL AGENCIES

Agricultural Stabilization and Conservation Service - U.S.D.A.	1
NASA - California	2
NASA - Goddard Space Flight Center	3
NASA - Manned Spacecraft Center	37
NASA - Wallops	1
National Oceanic and Atmospheric Administration - Environmental Data Service	2
Naval Reserve	6
U. S. Army	4
U. S. Army Corps of Engineers	1
U. S. Army Topographic Command	2
U. S. Bureau of Census	2
U.S.D.A.	2
U. S. Geological Survey - Indiana	2
U. S. Govt. Employee	3
U. S. Dept. of Commerce	1
U. S. Dept. of Surveys	1
Willow Run Laboratory and Indian Space Research Organization	1
Total	71

STATE AGENCIES

Bureau of Sport Fisheries & Wildlife		1
State Division of Planning		3
State Highway Commission/Research and Training		1
	Total	5

OTHER UNIVERSITIES

Boise State College - Idaho	1
California State Polytechnic College	1
Colorado State University	1
Fort Lewis College/Durango, Colorado	1
University of California - Davis, Calif.	1
Berkeley, Calif.	1
Earlham College - Indiana	1
Indiana State University	9
University of Illinois	22
Iowa	2
Kansas State University	1
University of Kentucky	4
University of Massachusetts	1
University of Michigan	2
University of Minnesota	1
University of Missouri	1
University of Nebraska	3
North Dakota State University	1
Ohio State	2
Rice University - Texas	1
University of Rodchester - New York	1
University of Tennessee	1
Texas A & M University	1
University of Wisconsin	1
Total	61

INDUSTRY

Barnes Engine Co.	1
Bellcomm Inc.	1
Biggs Pump Supply	1
CIBA - Geigy	3
Culligan	1
ESL Incorporated - Sunnyvale, Calif.	2
Exotech - Wash. D. C.	1
General Foods - White Plains, N. Y.	1
Tarrytown, N. Y.	1
Hazeltine Corp.	2
Hewlett Packard	1
Hoosier Photo	1
IBM	1
Kansas Farm Bureau	1
Leeds & Northrup	1
Lockheed/MSC	4
Lockheed/NASA	1
Logicon	1
Mr. Tom's of Illinois	1
Optronics	1
Para-Tone Inc.	1
Penn Central Railroad	1
REA	1
Rixon Association - Dayton, Ohio	1
Sims-Berry Air Service	1
Total	32

INDUSTRY (cont.)

The Hilieber Company		1
Typoservice Corporation		1
United Aircraft		1
	Total	3

FOREIGN COUNTRIES

Afghanistan - Kabul University	1
Australia - CSIRO	1
Brazil - V.F.R. - Pecnambuco	1
Balboa, Canal Zone - Smithsonian Tropical Research Institute	1
Bulgaria - FAO - Sofia - Poushkaron Institute of Soilscience	1
Canada - Canadian Center of Remote Sensing	1
Dept. of Agricultural Engineering - Univ. of Manitoba - Fort Carry, Manitoba	1
England - Economics Intelligence Unit Ltd. - London	1
EMI Electronics - Feltham, Middlesex	2
India - Agricultural University - Coimbatore	3
Shuil E. Roy - New Delhi, India	
Italy - E. Fariella - Telespazio - Head of Special Projects Studies & Consulting Division	3
Israel - Technion University	1
Japan, Tokoyo - Chief of Photogrammetry Laboratory - Govt. Forest Experiment Station, Ministry of Agriculture & Forestry	1
Jerusalem - Hebrew University	
Philippines - Manila - Office of the President	1
National Computer Center	2
Sweden - Taby - AGAAB	1
Thailand - FAO	1
Royal Forest Dept. - Bangkok	1
Soil Survey Division, Land Development	2
Applied Scientific Research Corporation	1
West Germany - Institute of Soil Biochemistry	1
Total	28

NEW MEDIA

Exponent Newspaper

EDUCATION

Carl Vineyard - Harrison High School

MISCELLANEOUS

Tom Moorman - Glen Dean, Kentucky

David Foster - R.R. 2, Waddy Kentucky

Phil Clark - Auburn Road, Ft. Wayne, Ind.

Chris E. Daugherty - Montpelier, Ind.

H. F. Huddleston - Wash. D. C.

Steven Stauffer

ATTENDEES OF THE 20TH ANNUAL LAND SURVEYORS CONFERENCE - 159

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