GEORGE HANUSCHAK's COPY

AgRISTARS

FY 81&82

A Joint Program for Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing

---

Domestic Crops and Land Cover Implementation Plan (FOR FY81 AND 82)

Recipients of this report are reminded that FY 1982 budget estimates and recommendations contained herein are administratively confidential until made public by the President in accordance with Office of Management and Budget Circular No. A-10, as revised November 12, 1976.

NASA

DOMESTIC CROPS & LAND COVER PROJECT

PROJECT IMPLEMENTATION PLAN

Prepared by:

RICH ALLEN Rich Allen

Level III Project Manager

Approved by:

C. E. Caudill
C.E. Caudill, Chrm.
USDA

Date 12-2-80

W. E. Rice
W. E. Rice
NASA

Date 12-2-80

L E Hyatt
L. E. Hyatt
USDC

Date 12-22-80

for A. Watkins
A. Watkins
USDI

Date 12-4-80

TABLE OF CONTENTS

1. Introduction

The Domestic Crops and Land Cover Project will focus on two types of development. The first is the development of operational techniques for a crop acreage estimation procedure which has demonstrated success in a research mode. The second focus of the project will be the examination of land cover information needs of the U.S. Department of Agriculture and the development of Remote Sensing techniques to supply such information.

Research elements of the Project are of three types. The most evident activities to individuals outside the Project will be the efforts to develop operational crop acreage estimates techniques, to address the land use and land cover needs of USDA and other Agencies, and to develop supplemental uses of data products from these new procedures. However, success of these new developments will depend in large part on research elements which will explore improvements in data registration techniques, computer software and hardware considerations, clustering and classification techniques, and the examination of the need for data preprocessing techniques. The third type of research element concerns the evaluation of alternative sensors. Simulation studies and later evaluations of actual imagery will be conducted to explore the suitability of new sensors for the operational aspects above.

All USDA research efforts will be coordinated by ESCS. With the exception of some land cover research which will be directed from NSTL, all ESCS efforts, including those in the State Statistical Offices, will be directed by the Remote Sensing Branch of ESCS in Washington, DC. NASA installations working on the Domestic Crops and Land Cover Project are the Earth Resources Laboratory at the National Space Technology Laboratory, Johnson Space Center, and Ames Research Center.

2.0 STATEMENT OF PROJECT OBJECTIVES

2.0 Statement of Project Objectives

1. Project Element - Current Area Estimates for Major Crops

Task 1 - Full State Crop Estimates

A. Objective

Implement crop area estimation in full states for the purpose of substantially reducing the sampling errors of crop area estimates at the state and substate levels compared to conventional ESCS estimates.

B. FY 81 Emphasis

Crop area estimation in Kansas, Iowa, Oklahoma, and Missouri.

C. FY 82 Emphasis

Crop area estimation in four above-listed states plus two additional states to be selected.

2. Project Element - Registration

Task 1 - Scene-to-Scene Registration

A. Objective

The objective of this task is to develop algorithm(s) which do scene-to-scene registration equally well across the United States and still maintain the radiometric properties of the LANDSAT data. Selection of seed points should work within the EDITOR system format with accuracies of 40 meters RMS for a uniformly distributed control network of 200 points containing at least 85% of the scene.

B. FY 81 Emphasis

Complete assessment, procedure development and exploratory tests of registration technique.

C. FY 82 Emphasis

Adapt on-line and conduct pilot test.

Task 2 - Scene-to-Map/Ground Registration

A. Objective

Develop an automated process for registering LANDSAT MSS data to a map. The degree with which the procedure is automatic will depend on the algorithm used which in turn will depend on the accuracy and availability of the Goddard Space Flight Center (GSFC) registration of the MSS data.

B. FY 81 Emphasis

(1) Determine the accuracy and availability of the GSFC's geodetic registration information as contained on the LANDSAT CCT's.

(2) Develop an algorithm that can detect field boundaries within the LANDSAT data.

(3) Perform an exploratory experiment to use the GSFC's tick marks, the digitized segments, and the field boundaries to automatically register the LANDSAT MSS data to a map.

C. FY 82 Emphasis

If tick mark registration or the algorithm to detect field boundaries fail to meet the requirements:

(1) Define a procedure for developing and maintaining a library of base LANDSAT images registered to a map by the use of manually selected control points.

(2) Develop and implement a computer algorithm that can access and use the library for registering other LANDSAT data acquired over any part of the area contained in the library.

(3) Perform an exploratory experiment to test the procedures and algorithms of (1) and (2) above.

3. Project Element - System Improvements and Development

Task 1 - EDITOR Evaluation and Analysis

A. Objective

Identify and correct shortcomings in the current EDITOR system (software and hardware).

B. FY 81 Emphasis

(1) Make improvements to EDITOR system.

(2) Study EDITOR for processing and cost efficiencies

C. FY 82 Emphasis

(1) Implement improvements.

Task 2 - Future Design

A. Objective

Conduct a design study that addresses USDA/ESCS future needs.

B. FY 81 Emphasis

Investigate future systems design study.

C. FY 82 Emphasis

Conduct software development for ILLIAC IV replacement.

4. Project Element - Clustering/Classification Algorithms

Task 1 - Crop classification/clustering algorithms

A. Objectives

Evaluate current and investigate alternatives for sub-analysis district estimates.

B. FY 81 Emphasis

Complete evaluation of current method for sub-districts and complete proof-of-concept testing of alternative approaches.

C. FY 82 Emphasis

Implement the selected alternative(s) and conduct pilot test.

Task 2 - Land Cover Classification/Clustering Algorithms

A. Objective

Develop, test, and evaluate new techniques and improved software to increase the accuracy and precision of areal measurement, identification, classification, and mapping of land cover types.

B. FY 81 Emphasis

Develop, test, and evaluate textural/spatial procedures for classification.

C. FY 82 Emphasis

Use several algorithms that extract various types of spatial data from an image and develop a program that deduces information from these data through use of artificial intelligence models.

Task 3 - Consolidated Procedures for Area Estimation and Mapping

A. Objective

Develop a cost effective set of procedures for meeting both area estimation and mapping requirements.

B. FY 81 Emphasis

Assess results of tasks 1 and 2 of this element.

C. FY 82 Emphasis

Develop procedures incorporating both area estimation and mapping, and conduct proof-of-concept test.

5. Project Element - Product Use

Task 1 - User Participation and Evaluation of Product Use

A. Objectives

(1) Evaluate the inventory requirements and methods of various USDA and other federal agencies, for possible use of LANDSAT data and products in these efforts.

(2) Promote additional uses of the LANDSAT crop area classification and estimation project to public interests groups in order to spread

primary costs and improve cost-benefit ratio.

(3) Investigate the benefits of the land cover inventory and mapping project.

B. FY 81 Emphasis

(1) Continue contacts with other federal agencies to keep informed of their plans and methods for land cover inventory.

(2) Initiate a program to determine user needs and develop a user product evaluation program.

C. FY 82 Emphasis

Furnish products and implement program for user evaluation of products.

6. Project Element - Land Cover Inventory and Mapping

Task 1 - Land Cover Area Estimation

A. Objectives

(1) Investigate the use of conventional USDA/ESCS estimation technology for purposes of estimating major land cover types at the state and substate level.

(2) Utilize LANDSAT data as an auxiliary variable with ESCS ground data to reduce the sampling errors for land cover area estimates.

B. FY 81 Emphasis

Complete exploratory test for State of Kansas.

. FY 82 Emphasis

Complete pilot test for Kansas and additional state.

Task 2 - Land Cover Information Systems

A. Objectives

(1) Develop map accuracy indicators which quantify the classification mapping results.

(2) Develop/modify software or hardware packages that are required for pictorially displaying classification maps and associated map

accuracies, and to fulfill needs established within the Product Use element.

(3) To improve current capabilities and methods and develop procedures for detecting and monitoring changes in land cover through temporal, multistage remotely sensed data in diverse environments.

(4) Evaluate and/or develop software and procedures for the efficient input of remotely sensed data to existing geographic information systems and to interface remotely sensed data with other digital data files.

(5) Evaluate the utility of land cover information derived from remotely sensed data after it has been manipulated in geographic information systems and/or used in models requiring geographically referenced data.

B. FY 81 Emphasis

(1) Complete development of statistical indicators for assessing mapping accuracy of crop and land cover classifications.

(2) Complete exploratory test of land use change detection methods.

C. FY 82 Emphasis

(1) Develop and/or modify software/hardware for production of map products.

(2) Complete procedure development proof-of-concept testing for change detection/monitoring.

(3) Complete requirements definition and technique development for geographic informations system.

7. Project Element - Sensor Implementation and Evaluation

Task 1 - Thematic Mapper Procedure Development

A. Objectives

(1) Provide an evaluation of the anticipated utility of the TM, including a comparison with results obtained for crop and land cover estimates with MSS data.

(2) Make software modifications and develop techniques and procedures to take account of additional bands and finer spatial resolution.

(3) Adapt software and procedures to ESCS system and perform on-line pilot test(s) and LSAT.

B. FY 81 Emphasis

Complete evaluation of thematic mapper simulator data for test sites in Missouri, North Dakota, and Kansas.

C. FY 82 Emphasis

Complete evaluation of thematic mapper simulator data for two additional test sites to be selected during FY 81.

Task 2 - Procedure Development for Other Sensors

A. Objectives

(1) Assess the utility of using synthetic aperature radar (SAR) data for crop and land cover area estimation and mapping.

(2) Assess the utility of RBV data and LFC photography for land use stratification update.

(3) Present results in a manner that they will be meaningful input to future sensor system design.

B. FY 81 Emphasis

(1) Complete literature review.

(2) Acquire SAR data for two exploratory test sites.

C. FY 82 Emphasis

(1) Complete processing of data for first two test sites.

(2) Acquire SAR data for two additional test sites to be selected.

8. Project Element - Preprocessing Procedures

Task 1 - Evaluate and Implement Selected Preprocessing Algorithms

A. Objective

Evaluate and, if desirable, implement preprocessing algorithms such as for atmospheric haze correction, debanding, cloud masking, etc. that improve land cover classification and are cost-effective.

B. FY 81 Emphasis

Evaluate selected algorithms.

C. FY 82 Emphasis

Implement any algorithms that get positive evaluation.

2.2 Summary of Responsibilities Identified by Agency

Element/Task	Task Mgr.	Assess Tech.	Provide Remotely Sensed Data	Provide Ground Truth	Procedure Development	Proof-of Concept Testing	Adapt on Line	Establish Performance Criteria	Pilot Test
Major Crop Area Estimates	USDA	-	USDA	USDA	-	-		USDA	USDA
Registration	NASA	NASA USDA	USDA NASA	USDA	NASA USDA	NASA USDA	USDA	USDA	USDA
Systems Improvements	USDA	NASA USDA	-	-	-	-	USDA	-	-
Clustering/ Classification	NASA	NASA USDA	USDA NASA	USDA	NASA USDA	NASA USDA	USDA	USDA	USDA
Product Use	USDA	USDA	USDA		USDA	USDA		USDA	
Land Cover Inventory and Mapping	NASA	NASA USDA	USDA NASA	USDA	NASA USDA	NASA USDA	USDA	USDA	USDA
Sensor Implementation	NASA	NASA USDA	USDA NASA	USDA	NASA USDA	NASA USDA	USDA	USDA	USDA
Preprocessing	USDA	NASA USDA	USDA NASA	USDA	NASA USDA	NASA USDA	USDA	USDA	USDA

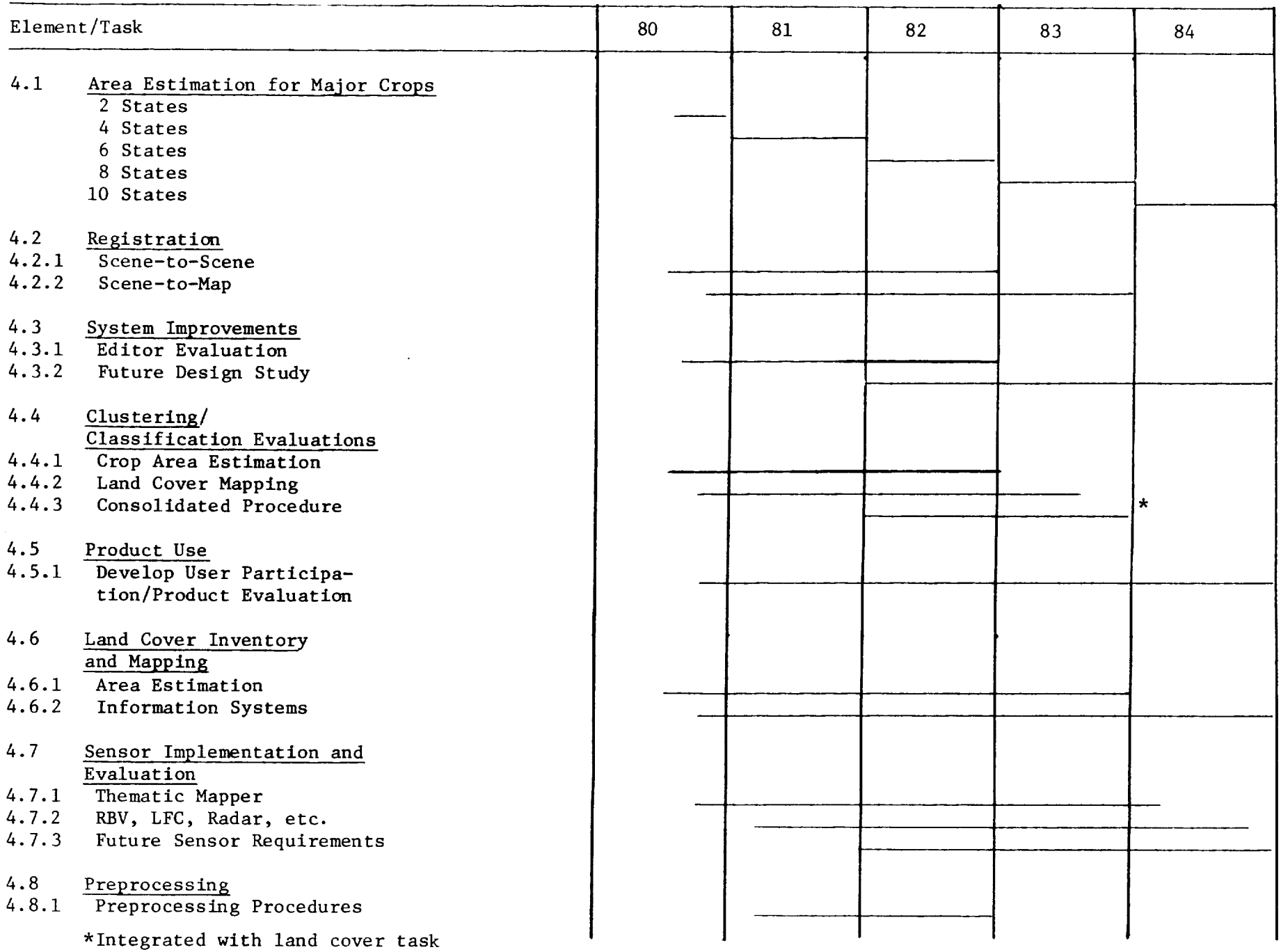
NASA Center assignments to the various tasks are given in each of the detailed task definitions (Section 4).

3.0 SUMMARY OF RESOURCES AND SCHEDULE

3.1 DOMESTIC CROPS AND LAND COVER PROJECT RESOURCES BY ELEMENT/TASK AND AGENCY

ELEMENT/TASK	FY 81				FY 82			
	$		MYE		$		MYE	
	ESCS	NASA	ESCS	NASA	ESCS	NASA	ESCS	NASA
Current Area Estimates for Major Crops								
Full State Crop Estimates	800	0	18.0	0	1200	0	22.0	0
Registration								
Scene-to-Scene Procedures	80	100	0.6	1.0	80	50	0.3	0.5
Scene-to-Map Procedures	50	60	0.4	0.5	50	150	0.2	1.0
Systems Improvements and Development								
Editor Evaluation and Analysis	240	50	1.0	1.0	200	40	1.05	0.8
Future Systems Design Study	0	0	0	0	50	15	0.2	0.2
Clustering/Classification Evaluations								
Improve Classification Capability for Crop Area Estimate	100	140	0.5	1.4	50	150	0.25	0.5
Land Cover Class/Mapping Algorithms	100	150	0.5	1.0	50	50	0.25	0.5
Consolidated Procedures for Area Estimation and Mapping	0	0	0	0.2	0	155	0	1.5
Product Use								
User Participation & Evaluation of Product Use	50	0	1.0	0	150	0	2.0	0
Land Cover Inventory and Mapping								
Land Cover Area Estimation	110	50	1.0	0.5	125	50	1.25	.5
Land Cover Information Systems	120	250	1.0	2.5	225	420	1.75	3.1
Sensor Implementation and Evaluation								
Thematic Mapper Procedure Develop.	125	100	1.0	0.8	100	200	0.6	1.6
Procedure Develop for Other Sensors (i.e.,SAR,RBV,LFC)	75	100	1.0	1.0	100	200	1.4	1.5
Future Sensor Needs/Requirements	0	0	0	0.1	0	20	0.1	0.2
Preprocessing								
Preprocessing Procedures	50	100	0.25	0.25	50	100	0.5	0.5
TOTALS	1900	1100	26.25	10.25	2430	1600	31.85	12.4

3.2 Domestic Crop and Land Cover Project Consolidated Schedule



3.3 DOMESTIC CROPS AND LAND COVER

WORK BREAKDOWN STRUCTURE

.06	.01	.01	.01	.00	.120560	.010560	.010560
					.120150	.010150	.320150
					.120050	.010050	.250050
					.120040	.010040	.030040
.06	.02	.01	.01	.00	.120065	.010065	.010065
					.120010	.010010	.320010
					.120005	.010005	.030005
					.200100	.050100	.020100
.06	.02	.02	.01	.00	.120040	.010040	.010040
					.120010	.010010	.320010
					.200060	.050060	.020060
.06	.03	.01	.01	.00	.120085	.010085	.010085
					.120105	.010105	.320105
					.120050	.010050	.030050
					.200050	.040050	.250050
.06	.03	.02	.01	.00	.120000	.010000	.010000
					.200000	.040000	.250000
.06	.04	.01	.01	.00	.120035	.010035	.010035
					.120045	.010045	.320045
					.120020	.010020	.250020
					.200140	.020140	.020140
.06	.04	.02	.01	.00	.120055	.010055	.010055
					.120035	.010035	.320035
					.120010	.010010	.250010
					.200150	.050150	.020150
.06	.04	.03	.01	.00	.120000	.010000	.010000
					.200000	.020000	.020000
					.200000	.050000	.020000
.06	.05	.01	.01	.00	.120035	.010035	.010035
					.120010	.010010	.320010
					.120005	.010005	.030005
.06	.06	.01	.01	.00	.120030	.120030	.120030
					.120020	.010020	.320020
					.120020	.010020	.250020
					.200050	.050050	.020050
.06	.06	.02	.01	.00	.120040	.010040	.010040
					.120010	.010010	.320010
					.200100	.050100	.020100
.06	.06	.03	.01	.00	.120050	.010050	.010050
					.200100	.050100	.020100
.06	.06	.04	.01	.00	.120020	.010020	.010020
					.200050	.050050	.020050

DOMESTIC CROPS AND LAND COVER (CON'T)

WORK BREAKDOWN STRUCTURE

.06	.07	.01	.01	.00	.120085	.010075	.010075	
					.120040	.010040	.320040	
					.200100	.050100	.020100	
.06	.07	.02	.01	.00	.120051	.120051	.120051	
					.200100	.050100	.020100	
.06	.07	.03	.01	.00	.120000	.010000	.010000	
					.200000	.050000	.020000	
.06	.08	.01	.01	.00	.120050	.010050	.010050	
					.200100	.020100	.020100	
.06	.06	.01	.01	.00	.120040	.020040	.010040	1/
.06	.07	.02	.01	.00	.120024	.020024	.010024	1/

Coding Explanation

6th Level Breakout:
- 12 Refers to ESCS Resources
- 20 Refers to NASA Resources

7th Level Breakout:
- 01 Refers to Washington, D.C.
- 02 Refers to Johnson Space Center
- 04 Refers to Ames Research Center
- 05 Refers to NSTL Earth Resources Laboratory

8th Level Breakout:
- 01 Refers to Civil Servants Salary and Support
- 02 Refers to Lockheed Support Contracts
- 03 Refers to EROS Data Center
- 25 Refers to Institute for Advanced Computations
- 32 Refers to Private Industry Contracts

1/ The last two breakout items refer to transfer of ESS resources to the NASA JSC Aircraft Office for photography coverage for DC/LC and EW/CCA sites and for radar data acquisition, respectively.

4.0 DETAILED TASK DESCRIPTIONS

4.1 Project Element - Current Area Estimates for Major Crops

4.1.1 Task 1 - Full State Crop Estimates

4.1.1.1 Description of Task

1. Background

Based upon ESCS research results from 1972-1979[1], and the crop area estimation projects in Kansas, Iowa, Missouri and Oklahoma during 1980-81, two additional states per year will be added to this task, provided Landsat data remains available. In 1985, a LSAT will be conducted over ten states. If timely and quality Landsat data are not available for the 1982 crop year, an alternative task plan is outlined in 4.1.1.8.

2. Objective

Implement crop area estimation in six states (Kansas, Oklahoma, Iowa, Missouri, Colorado, Nebraska) for the purpose of substantially reducing the sampling errors of crop area estimates at the state and substate levels compared to conventional ESCS estimates.

3. Scope

This task will begin with preparation for ground data collection in October 1981, and end with crop area estimation by December 15, 1982. It is intended that these estimates be available as improved acreage estimates for the ESCS Crop Reporting Board and the ESCS State Statistical Offices official estimates.

---

[1]Hanuschak, G., Sigman, R., Craig, M., Ozga, M., Luebbe, R., Cook, P., Kleweno, D., Miller, C., "Obtaining Timely Crop Area Estimates Using Ground Gathered and LANDSAT Data" USDA, ESCS, Tech Bulletin 1609, August 1979.

4.1.1.2 Research to be Conducted

Landsat data will be used as an auxiliary variable in a regression estimator as in the previous ESCS projects, where the primary variable is ESCS ground reported acres from the June Enumerative Survey. The procedures used to accomplish this task comprise the ESCS on-line capability, which is referenced several places throughout this document. This approach has reduced relative sampling errors associated with the June Enumerative Survey on the order of twofold to fourfold. Anticipated results for FY82 are crop area estimates for winter wheat in Kansas and Oklahoma and for corn and soybeans in Iowa and Missouri at the state and substate levels. ~~A possible supplement might be estimates for spring planted crops in Kansas.~~ All data security procedures of ESCS will be strictly enforced.

4.1.1.3 Responsibility

ESCS's Statistical Research Division will have primary responsibility with Rich Allen as Task Manager.

4.1.1.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
ESCS	[illegible]	[illegible]	[illegible]	[illegible]
NSTL	0	0	0	0

ESCS will select and acquire all LANDSAT data, collect ground truth, and analyze all data. NASA will not be involved in this on-line capability, except for interfacing the on-line/off line modes, which is discussed in 4.1.1.6.

4.1.1.5 Schedule and Major Milestones for FY81

Milestone	Location	Kansas & Oklahoma	Iowa & ~~Illinois~~ Missouri
Prepare for Ground data collection	ESCS/SRD	11/80-4/81	11/80- 4/81
Ground data collection	ESCS/SSO	3/81-6/81	5/81- 7/81
Ground data editing	ESCS/SSO	3/81-6/81	6/81- 7/81
Segment Digitization	ESCS/SSO	7/81 -8/81	7/81- 8/81
Acquire LANDSAT Data CCT's & B&W Transparencies	ESCS/SRD	4/81-7/81	7/81- 9/81
Register LANDSAT Scenes	ESCS/SRD	6/81-7/81	10/81
Analyze LANDSAT Data and Calculate Regression Estimates	ESCS/SRD	8/81-9/81	11/81-12/81
Write-up Research	ESCS/SRD	10/81-2/82	1/81- 3/82

Within the milestones the following time relationships must be met:

- LANDSAT CCT's, high contrast B&W positive film transparencies (all four bands), and 1:250,000 B&W paper products (bands 5 and 7) delivered to USDA/ESCS from USDI/EROS two to three weeks after satellite acquisition.

- Registration of LANDSAT scene to map base by ESCS one week to ten days after receipt of the data (CCT and transparencies).

- Analysis of LANDSAT data and calculation of crop area estimates two weeks after registration is complete using CRAY-1S ~~ILLIAC IV~~ for full frame classification.

- Submission of crop area estimates in a timely fashion to ESCS's Crop Reporting Board and State Statistical Offices.

4.1.1.6 Interfaces

The actual operation of the on-line capability will require no interfaces. However, the structure of the overall Domestic Crops and Land Cover Project requires numerous interfaces between the on-line and off-line mode. Many of the R&D tasks will use the data sets established for crop estimation. Also, proven technology developed and tested in off-line will be transferred and adapted on the on-line capability.

4.1.1.7 Data Requirements

Timely acquisition of usable quality LANDSAT data is absolutely crucial to the accomplishment of this task. As previously stated CCT's, transparencies, and paper products are needed by ESCS two to three weeks after satellite acquisition.

Full frame data are required for complete coverage (minus clouds) of the four states during the optimum time period for discrimination of the crops of interest. Data for Kansas and Oklahoma will be needed for the April 1-May 31, 1981 timeframe. Data for Iowa and Missouri will be needed for the July 15-

September 15, 1981 timeframe. This will be approximately 95 LANDSAT scenes. The number of scenes required will increase 20 - 40 scenes per year through 1984. A computer capability equivalent to CRAY-1S must be maintained and provided by NASA through FY83. Thereafter, a capability may be provided by USDA. The USDA will provide funds to ARC for CRAY-1S processing costs applied to this task and other related tasks within the Domestic Crops and Land Cover Project.

4.1.1.8 Alternate Plans

If LANDSAT data are not available for the 1982 crop year then ESCS will process LANDSAT II data from the summer of 1980 in a research mode for Missouri, Oklahoma, and Kansas, provided that the 1980 LANDSAT II data is of sufficient quality. If the 1980 data are either not of good quality or not available, then ESCS will train the Oklahoma and Missouri SSO's in digitization and plotting of sample segment field boundaries. In Iowa, the digitization and plotting software will be transferred from the Bolt, Beranek and Newman Data Processing Facility in Cambridge, Massachusetts to the PDP 11-70 in the ESCS State Statistical Office in Des Moines, Iowa. Also, Iowa and Kansas will examine the possibilities for other users of their digitization and plot equipment, and the EDITOR Software package.

If the 1982 LANDSAT data are of good quality but not delivered to ESCS in a timely fashion, then the estimates will be calculated after the Annual Crop Summary and used primarily as check data.

There will also be some other selected areas such as Red River Valley that will provide research experience with different crop types and field sizes if 1982 LANDSAT data are available.

These will provide research experience where there is a varied set of croptypes, most having small field acres. Alternative sampling schemes will also be analyzed. The success of this project is contingent on having 1982 LANDSAT data available.

4.2 Project Element - Registration

4.2.1 Task 1 - Multitemporal/Scene-to-Scene Procedures

4.2.1.1 Description of Tasks

Scene-to-scene registration is the process whereby LANDSAT image(s) is made to overlay another LANDSAT image of the same area taken at a different time. Of most value are those dates of images for different seasons which allow greater spectral separability of the crops and land cover under analysis. Successful completion of this task will allow more rapid and accurate scene-to-scene registration than is presently possible.

1. Objectives

The objectives of these tasks are to develop algorithm(s) which do scene-to-scene registration equally well across the United States and still maintain the radiometric properties of the LANDSAT data. Selection of seed points should work within the EDITOR system format (i.e., no CRT) with accuracies of 40 meters RMS for a uniformly distributed control network of 200 points containing at least 85% of the scene. Means of using the header annotation records to obtain geographic locations of matching control points should be developed.

2. Scope

Conduct a literature review during FY80 and assess the currently available methods and algorithms. Execute a test to compare mathmatical and statistical algorithms. A registration procedure

will be established and a report written by NSTL detailing the algorithms and elements of the procedure.

3. Probable Duration of the Task

Completion of this project element will be achieved by the end of FY82. Algorithm development was initiated in FY80 and testing will be conducted FY81. Additional improvements and development of a scene-to-scene map capability will be done in Phase II during FY82-84.

4.2.1.2 Research to be Conducted

The research effort should be targeted at providing registration algorithms of wide applicability so that they may be used in cropland, forested areas, urban areas, and deserts. It should include comparisons and evaluations of the selected methods and that currently used by ESCS.

At least two dates of data will be selected for each land cover type from among seasons most pertinent for that cover type.

A procedure/methodology for determining the registration accuracy was jointly developed in FY80 by NSTL and ESCS, and implemented by NSTL in an exploratory test.

After selection of a suitable registration method, further testing will continue in the pilot test mode. This phase will require selected analysis areas containing ESCS ground data and associated LANDSAT scenes. Comparisons of correlations, using Hotellings T^2 test, between classified pixels and ground data acreage from the unitemporal and multitemporal analyses would then determine the significance of

improvements attributed to multitemporal classification after scene-to-scene registration.

The final product of pilot test will be a full report detailing the mathematical and statistical formulae necessary to implement the multi-temporal registration as well as whatever computer programs are needed to achieve the aforementioned goals.

A positive evaluation of any scene-to-scene registration methods after pilot testing would lead to the incorporation of these methods/procedures into a LSAT together with other aspects of the DC/LC project.

4.2.1.3 Responsibility

1. The overall task manager will be at NSTL.

2. NSTL will provide:

(a) Technical and contract management of their assigned work within the task.

(b) Assessment of technology & experiment design.

(c) Development of procedures.

(d) Proof-of-concept test and evaluation.

(e) Support to pilot test accuracy assessment and performance evaluation.

(f) Support technology adaption.

3. ESCS will:

(a) Support the assessment, experiment design, procedure development, and proof-of-concept testing.

(b) Conduct Pilot Test.

(c) Perform Pilot Test accuracy assessment and performance evaluation.

(d) Establish performance criteria.

(e) Decide go-no-go for technology adaption to on-line.

(f) Perform technology adaption.

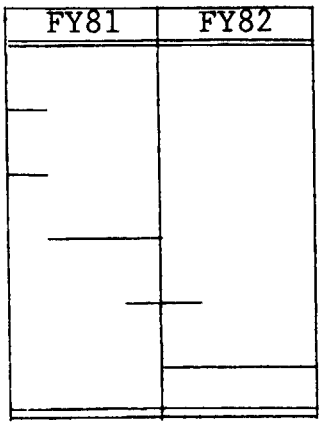
4.2.1.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	80	0.6	80	0.3
NSTL	100	1.0	50	0.5

NSTL civil service manpower will be responsible for technical and contract management for their assigned work. Most of the NSTL funds will be for contracts (both in-house and outside). These funds allow for NSTL data processing costs from procedure development through proof-of-concept testing.

ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their dollars allow for ESCS data processing costs involved for Pilot Testing and the adaption of procedures to on-line.

4.2.1.5 Schedule



4.2.1.6 Interfaces

Coordination with other AgRISTARS projects that require scene-to-scene registration will be needed.

4.2.1.7 Data Requirements

1. Acquisition

ESCS will provide funds for purchase of LANDSAT CCT's, and will provide ground truth for pilot test.

2. Preprocessing

N/A

4.2.2 Task 2 - Scene-to-Map Procedures

4.2.2.1 Description of Task

1. Objective

The overall objective of this task is to develop an automated process for registering LANDSAT MSS data to a map. The degree with which the procedure is automatic will depend on the algorithm used which in turn will depend on the accuracy and availability of the Goddard Space Flight Center (GSFC) registration of the MSS data.

2. Scope of Task

The scope of the task is defined in the following subtasks:

(a) Determine the accuracy and availability of the GSFC's geodetic registration information as contained on the LANDSAT CCT's.

(b) Develop an algorithm that can detect field boundaries within the LANDSAT data.

(c) Perform an exploratory experiment to use the GSFC's tick marks, the digitized segments, and the field boundaries to automatically register the LANDSAT MSS data to a map.

(d) Define a procedure for developing and maintaining a library of base LANDSAT images registered to a map by the use of manually selected control points.

(e) Develop and implement a computer algorithm that can access and use the library for registering other LANDSAT data acquired over any part of the area contained in the library.

(f) Perform an exploratory experiment to test the procedures and algorithms of (d) and (e) above.

The scope of these subtasks includes the following items:

- Ten different LANDSAT scenes will be used to determine the various accuracies of GSFC's tick mark registration.
- A boundary detection algorithm will be developed and implemented.
- One programmer will be required to become familiar with the EDITOR system formats in order to access and retrieve the segment registration data and to implement the boundary detection algorithm. This is to be done via remote TTY. Simultaneously, algorithm development will be done in the Earth Resources Laboratory Application Software (ELAS) subsystem on the NSTL's computer, which is equipped with a display device so that intermediate results can be displayed and analyzed.
- Manual control point selection for the library of base LANDSAT images will be done by ESCS. ESCS will also be responsible for the storage and retrieval of data to and from the library of base LANDSAT images. NSTL may assist ESCS in developing and implementing any algorithms for the automatic search and registration of LANDSAT data to the base set.

4.2.2.2 Research to be Conducted

1. Technical Approach

GSFC's registration accuracy of ten LANDSAT scenes will be examined by comparing the tick mark registration with ground control points independently chosen by ESCS. Several statistical analyses will be done to make an accuracy assessment. The results of these analyses will help determine the design of the algorithm which automatically registers the segment data to the LANDSAT data.

This latter algorithm will consist of the following steps:

(a) Transform the latitudes and longitudes of the segments into their LANDSAT row and column values as determined by the GSFC tick marks.

(b) Allow for some error in the initial registration and locate all boundaries in the LANDSAT data for a larger window.

(c) Find the best match of the digitized segment to a subset of points within the window.

An exploratory experiment will be conducted in which the digitized segment data for a multi-temporal data set will be registered using this algorithm. The exploratory experiment will test the dependability and accuracy of the algorithm.

The procedures and software for manually selecting control points and registering LANDSAT images to a map are already well established at the ESCS. Therefore, to

establish the library of base LANDSAT images the details of data formats, storage medium, etc., for storage and retrieval have to be worked out and the software developed accordingly. The algorithm that searches the library data set will probably use a correlation technique and be very similar to the scene-to-scene registration algorithm.

2. Anticipated Results

Barring scan line anomalies within the LANDSAT data, the GSFC tick mark registration is anticipated to be on the average within $\pm$ 2.5 pixels for scenes that have been registered using control points. This error would be well in an accepted range for defining a window that could be shifted until a "best match" with the digitized segment is found.

It is expected that not all segments can be matched within a given scene. However, the segments that can be matched should provide excellent registration for the unmatched ones.

In the cases where the GSFC registrations are not adequate or the previous algorithm fails to match segment data with their respective field boundaries, the library of base LANDSAT images would be used. This type of registration should yield accuracies similar to the scene-to-scene registration with the worse case being an additive error E, $E = E_{ss} + E_{sm}$, where E_{ss} is the scene-to-scene registration error and E_{sm} is the scene-to-map registration error of the library data set.

4.2.2.3 Responsibility

1. The overall task manager will be NSTL

2. NSTL will provide:

(a) Technical and contract management for their assigned tasks.

(b) Assessment of technology.

(c) Development of procedures.

(d) Proof-of-concept test and evaluation.

(e) Support to pilot testing.

(f) Support to technique adaptation.

3. ESCS will:

(a) Participate in experiment design, procedure development, and testing.

(b) Manual selection of control points for library.

(c) Conduct pilot test.

(d) Perform technique adaptation.

(e) Integrate acceptable techniques into a LSAT.

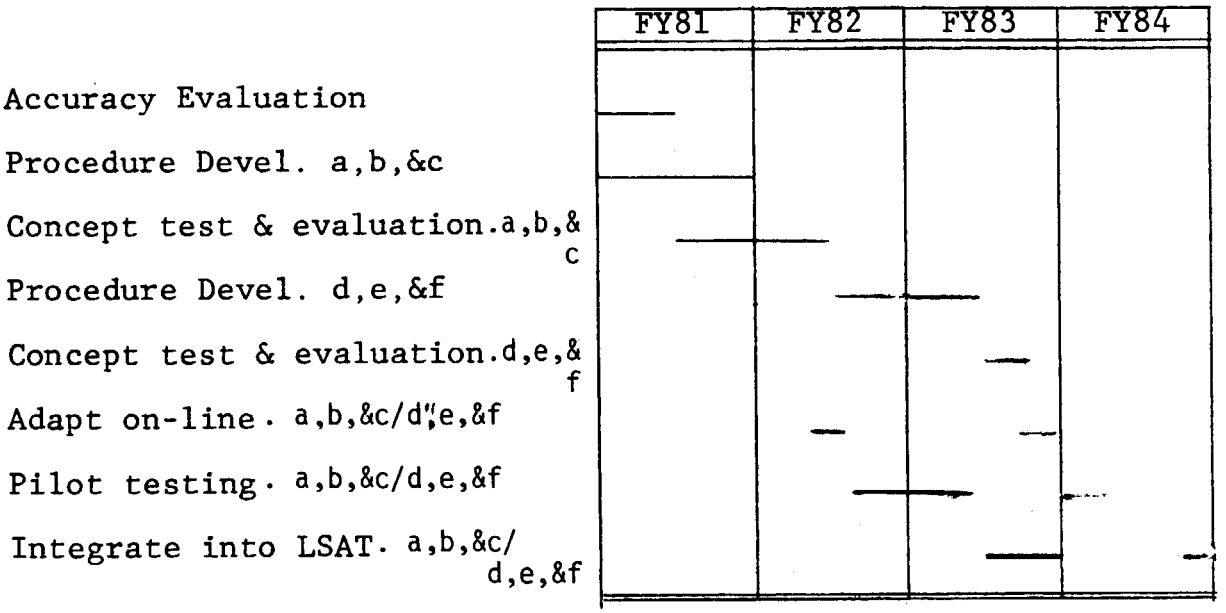
4.2.2.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
NSTL	60	0.5	150	1.0
ESCS	50	0.4	50	0.2

NSTL civil service manpower will be responsible for technical and contract management for their assigned work. Most of the NSTL funds will be for contracts (both in-house and outside). These funds allow for NSTL data processing costs from procedure development through proof-of-concept testing.

ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their funds allow for ESCS data processing costs involved for Pilot Testing and the adaption of procedures to on-line.

4.2.2.5 Schedule



4.2.2.6 Interfaces

Registration is required by other AgRISTARS projects, therefore, some interfacing is anticipated.

4.2.2.7 Data Requirements

ESCS will provide necessary funding to purchase the required LANDSAT scene for the selected analysis areas. The data should be obtained in a timely manner. Much of the data can be used from the "Current Crop Estimation in 2 States/Year" task.

1. Acquisition

LANDSAT CCT's and ground data for the selected areas will be provided by ESCS.

2. Preprocessing

The NSTL will determine what, if any, data preprocessing requirements must be met.

4.3 ELEMENT 3 - SYSTEMS IMPROVEMENTS AND DEVELOPMENT

4.3 Task 1 - Editor Evaluation and Analysis

4.3.1.1 Description of Task

1. Objective

The EDITOR software consists of two parts:

a. The ILLIAC IV code which constitutes about 10% of the total software.

b. The BBN code which does everything except the large scale processing on ILLIAC IV.

2. Scope

The ILLIAC IV code evaluation will be examined for possible evolutionary improvement. ILLIAC IV will be replaced in the future by an as yet undetermined machine such as the CRAY-1S, CDC Cyber 200 series, or Burroughs Scientific Processor. ARC will be conducting studies to determine the most suitable replacement hardware for present ILLIAC IV operations. The results of the ARC evaluation will be of particular interest to ESCS and the DCLC project. However, since image processing is only one of many tasks that ARC is considering, it will be beneficial to carry out a specific study of the suitability of these machines for ESCS's particular needs.

It is possible to move the BBN Code to a faster processor, a DEC System 20. An evaluation of the programming effort necessary and an analysis of the possible cost savings should be performed.

4.3.1.2 Definition of Research

Arrangements will be pursued to develop a contract which will convert software to an ILLIAC IV replacement. This contract would call for conversion of present ILLIAC IV functions, such as: maximum likelihood, classify, full frame unsupervised clustering, image block correlation (image-to-image registration) and frame segment aggregation. Test results will involve several frame classifications submitted at one time in order to evaluate fully hardware speed and costs. Improvements are being considered for the BBN code such as:

1. A standardized interface for off-line (digitization)
2. Use of automatic (digitization) hardware such as raster-scan video systems or laser-scanning line followers.
3. Test and evaluate CLASSY as a replacement for clustering.
4. Use of manual microcomputer-controlled off-line (digitization) systems.
5. Evaluate plotting procedures for improved efficiency.
6. Improve gray scale procedures by using dot-matrix printers.
7. Transport to, or use of, the DEC system 20.

4.3.1.3 Responsibilities

ESCS will define requirements for the specifically contracted evaluation of EDITOR procedures on alternative hardware with technical input and review from ARC. Continued review of the EDITOR software with possible extensions to other users

will be conducted by ARC.

Emphasis FY81

- ILLIAC IV replacement alternatives
- BBN improvements as listed
- Replacement systems design study
- Study EDITOR for processing and cost efficiencies

Emphasis FY82

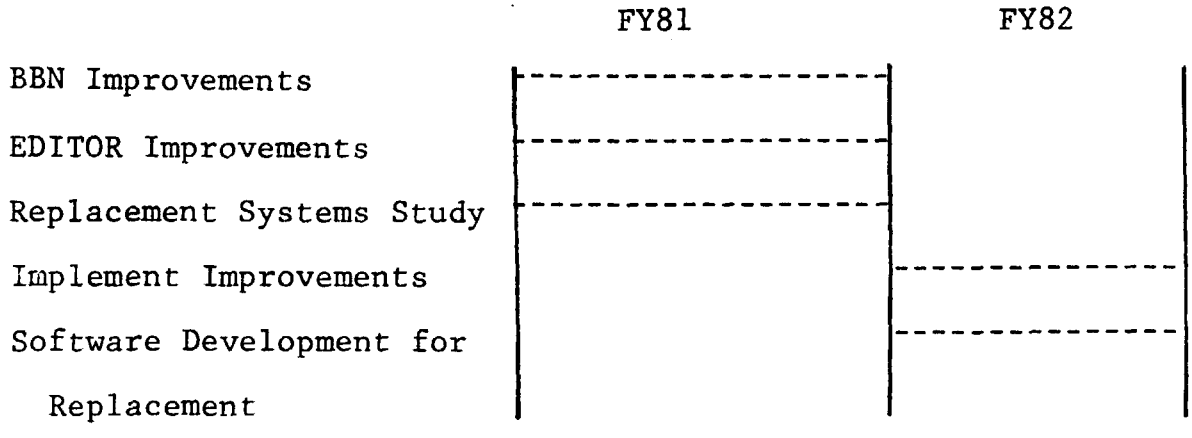
- Implement improvements
- Software development for the ILLIAC IV's replacement

4.3.1.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	240	1.0	200	1.05
ARC	50	1.0	40	0.8

ESCS resources will supply hardware evaluation contracting, in-house development of software and contract monitoring, and for assistance to ARC.

4.3.1.5 Schedule



4.3.1.6 Interfaces

Close coordination between ESCS and ARC

4.3.1.7 Data Acquisition

N/A

4.3.2 Task 2 - Future Systems Design Study

4.3.2.1 Description of Task

1. Objective

Conduct a design study that addresses ESCS future needs for crop and land cover estimation and mapping with LANDSAT acquired data.

2. Scope

The basis for a design study is the anticipated operational use of LANDSAT acquired data beginning in FY85 with a Large Scale Applications Test for ten states.

4.3.2.2. Research to be Conducted

The understanding of the EDITOR software system gained during task 1 will furnish the necessary background for this task. The design study will be oriented to a data processing capability to address ten states initially but with potential for expansion to the entire United States. The system design will begin in FY82 and be concluded in FY83. However, the formulation of equipment proposals should begin in time for equipment purchase during FY83. It is anticipated that the revised system would be implemented by the end of FY84 for use with the ten-state LSAT beginning in FY85.

4.3.2.3. Responsibility

1. The task manager will be ESCS
2. ESCS will:
   a. Define requirements
   b. Support ARC in design study
   c. Perform technology adaptation and implementation.

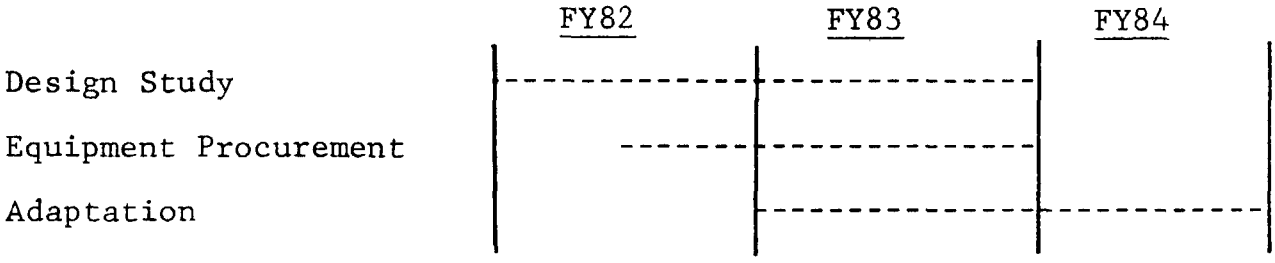
3. ARC will:

   a. Conduct design study as per ESCS requirements definition

   b. Support ESCS during adaptation and implementation

4.3.2.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	.0	0	50	.2
ARC	.0	0	15	.2



4.3.2.6 Interfaces

Close cooperation between ESCS and ARC.

4.3.2.7 Data Acquisition

N/A

4.4 Element 4 - Clustering/Classification Evaluations

4.4.1 Task 1 - Improve Classification Capability for Crop Area Estimation

4.4.1.1 Description of task

1. Objectives

   a. Evaluate sub-analysis district regression estimates

   b. Investigate alternative sub-analysis district estimates

2. Scope

   During FY81 data from only one or two study areas in the U.S. will be analyzed.

4.4.1.2 Technical Approach

ESCS's major overall objective under the DCLC program is the generation of accurate area estimates with measurable precision for crops and other land cover types. ESCS's current estimation method is regression estimation with LANDSAT classification results as the estimator's auxiliary variable

and ground data from ESCS's operational surveys as the estimator's primary variable. The utilized ground data are obtained by interviewing farm operators located in randomly selected areas of land called ESCS segments.

ESCS has demonstrated that regression estimation produces unbiased area estimates with measurable precision for areas referred to by ESCS as "analysis districts"; i.e., the LANDSAT acquisition(s) used for estimation are the same for every point

in the area and the area is "large" in the sense that the area contains a sufficient number of ESCS segments to reliably calculate needed regression coefficients. Through regression estimates for sub-analysis-district areas (sub-areas of an analysis district containing insufficient number of ESCS segments to reliably calculate regression coefficients) can be calculated, such estimates have the following undesirable properties:

- o Sub-analysis district regression estimates can be biased.
- o Mean square errors of sub-analysis district regression estimates cannot be estimated by distribution free methods using only operational type data.
- o When distribution free upper bounds for sub-analysis district regression mean square errors are currently calculated, the calculated bounds may be unusably large and
- o When additional distributional assumptions are made in order to estimate using only operational-type data, the mean square error of sub-analysis district regression estimates, it is presently not known if these distributional assumptions are valid.

The first phase of this task will be to estimate the biases and variances of sub-analysis district regression estimates in one or two research data sets. Such estimation will be possible because of the number of segments per analysis district will be many times greater than in operational situations. Biases will

be estimable because in the research data set(s) the sub-analysis district population totals will be known or capable of being estimated with extremely high precision. Variances will be estimable by repeated sampling methods. The estimated mean square error of the sub-analysis district regression estimates will be compared with current method upper bounds for the mean square errors.

The methods used to calculate biases and variances in the research data set(s) are, of course, not possible with operational type data. In the operational situation, mean square errors of sub-analysis district regression estimates can be estimated only if additional distributional assumptions are made. The research data set(s) will be used to determine if such assumptions are valid. This will permit the development of operational type methods for estimating or bounding more tightly the mean square error of sub-analysis district regression estimates.

The second phase of this task will be to investigate alternative sub-analysis district estimates. Candidate alternative estimators are (1) the synthetic estimator proposed by Cardenas, Blanchard, and Craig[1], (2) the CLASSY direct-proportion estimation, and (3) non-parametric direct-proportion estimators such as the bin method or the use of estimated posterior probabilities obtained from mean-square-error discriminant techniques.

1 "On the Development of Small Area Estimators Using LANDSAT Data as Auxiliary Information", Manuel Cardenas, Mark Blanchard, Michael Craig., ESCS, USDA. August 1978.

2. Anticipated results

The anticipated results from this task are the following:

- o Quantification of biases and variances of test case sub-analysis district regression estimates.
- o Development of improved methods to estimate or bound the mean square error of sub-analysis district regression estimates using only operational type data.
- o Comparison of mean square errors of sub-analysis district regression estimates with alternative sub-analysis district estimates.

3. Output Products

A report describing the research results and computer programs for performing required calculations will be the output products from this task.

4. Test Sites

Data sets for one or both of the following areas will be used in this task:

- o Six-county area in eastern South Dakota containing 252 quarter section ground truth sample segments with corresponding multitemporal LANDSAT data for July 26 and August 25, 1979,
- o Robeson County, North Carolina, with "wall to wall" ground truth and corresponding LANDSAT data of yet to be determined availability.

4.4.1.3 Responsibilities

1. The task manager will be JSC.
2. JSC will provide:
   a. Technical and contract management of their assigned work within the task.
   b. Technical integrity for task.
   c. Experimental design.
   d. Estimation of estimator biases and variances.
   e. Development and proof-of-concept evaluation of new procedures.
   f. Support for technology adaption.
3. ESCS will provide:
   a. Briefings on current procedures.
   b. Research data set(s).
   c. Go,no go decision for technology adaption to on-line.
   d. Technology adaption to on-line.

4.4.1.4

	1981		1982	
	$	MYE	$	MYE
ESCS	100	0.5	50	0.25
JSC	140	1.4	150	0.5

JSC civil service manpower will be predominately for technical and contract management for their assigned work. The JSC funds will be for in-house contracts. These funds allow for JSC data processing costs from procedure development through proof of concept testing.

ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their funds allow for ESCS data processing costs involved for data set preparation and adaption of procedures to on-line.

4.4.1.5 Schedule

	Desired Completion Date
Delivery of S. Dakota data set to JSC	12/1/80
Delivery of Robeson County data set to JSC	2/1/81
Completion of bias and variance estimation for sub-analysis district regression estimators	5/1/81
Completion of proof-of-concept testing of new MSE estimation/bounding methods for sub-analysis district methods	8/1/81
Completion of comparisons for alternative sub-analysis district estimators	11/1/81
Completion of report	1/1/82
Completion of on-line adaption	3/1/82

4.4.1.6 Interfaces

1. If the Robeson county data set is used, interfacing with AgRISTARS Foreign Commodity Production Forecasting project will be required as the Robeson county ground truth is being collected for the FCPF element.
2. The pilot test for this task will occur under the "current estimation for major crops (2 states/year)" task.

4.4.1.7 Data Requirements

1. Ground truth and LANDSAT data for the South Dakota data set have already been obtained.
2. Ground truth for Robeson county are being collected under the AgRISTARS Foreign Commodity Production Forecasting Project. Access to this data by DCLC researchers will be required. LANDSAT data for Robeson county will be obtained from EROS Data Center.

4.4.2 Task 2 - Land Cover Classification/Mapping Algorithms

4.4.2.1 Description of Task

1. Objective

Develop, test, and evaluate new techniques and improved software to increase the accuracy and precision of areal measurement, identification, classification, and mapping of land cover types.

2. Scope

The purpose of this task is to derive more and/or better information from satellite multispectral scanner data. Existing textural and spatial techniques will be examined. Software and procedures will be developed for utilizing selected techniques in improving land cover classifications and maps.

4.4.2.2 Research to be Conducted

Research will be conducted in extracting spatial information from the LANDSAT MSS data. The research will consist of a three-pronged approach.

The first approach will be a type of textural information extraction from the data by using a sliding window. The NSTL has already investigated one type of technique using the textural features as defined by R. M. Haralick, et.al. But there are different features that are more suitable for the sliding window approach and warrant further investigation.

The second approach will be the development of a spatial classification scheme. This scheme will consider the spatial context of a LANDSAT pixel before assigning the final class value.

This scheme will be different from both the LARS ECHO classifier and the LARS contextural classifier.

The third approach is a type of computer image interpretation scheme and will be the most complex. This scheme will include several computer-implemented algorithms that extract boundaries and edges from the MSS data, locate polygons and line networks, describe polygon shapes, and deduce information from the data based on artificial intelligence models.

4.4.2.3 Responsibility

1. NSTL will be the task manager and will:

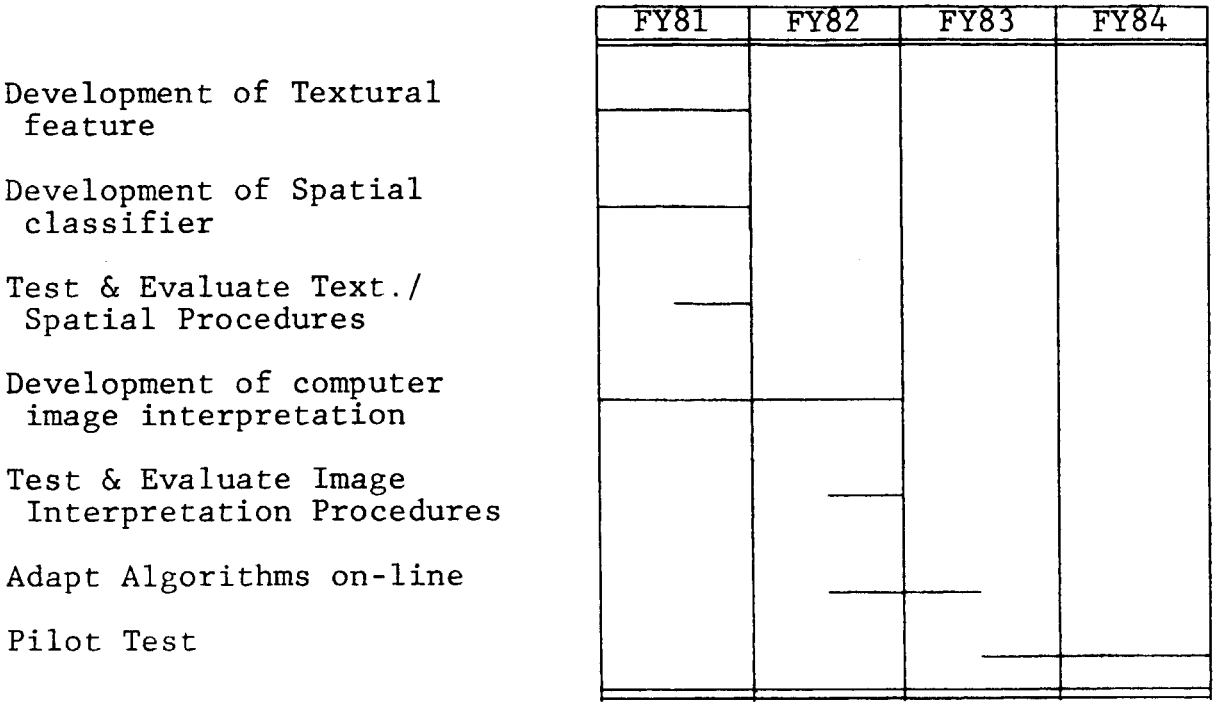
- provide technical expertise in assessing and modifying spatial techniques.
- Develop software for their implementation.
- Test and evaluate selected techniques.
- Report on findings/procedures resulting from this task.

2. ESCS will provide technical assistance and assess the improvements gained by applying the procedures developed under this task.

4.4.2.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	100	0.5	50	0.25
NSTL	150	1.0	50	0.5

4.4.2.5 Schedule



4.4.2.6 Interfaces

The technology developed under this task will become an integral component of Domestic Crop and Land Cover project elements 4.5 and 4.6. An interface will be established with the Renewable Resources Inventory Project, which has research requirements similar to those delineated in this task.

4.4.2.7 Data Requirements

Research will be conducted over test sites that have available ground truth for verification and assessment. Data sets will be used which have various land cover types and geographical settings with the initial testing being with Kansas data.

4.4.3 Task 3 - Consolidated Procedures for Area Estimation and Mapping

4.4.3.1 Description of Task

1. Objective

Develop a cost effective set of procedures for meeting both area estimation and mapping requirements.

2. Scope

This task is related to the results obtained from tasks 1 and 2 of this element. The major emphasis is to assess the results of tasks 1 and 2, and to incorporate the various techniques for the purpose of establishing a cost-effective set of procedures for both area estimation and mapping. The assessment of the task 1 and 2 results will begin in FY81, and will continue through FY82 when those tasks will be completed. After a set of incorporated procedures have been developed, a proof-of-concept test will be conducted over a limited data set. The procedures will then be adapted to the on-line system and integrated with the Land Cover Information Systems task (element 6) for pilot testing.

4.4.3.2 Research to be Conducted

The initial technique development and testing will be accomplished under task 1 (Crop classification/clustering algorithms) and task 2 (Land Cover Classification/clustering algorithms). Therefore, the main efforts under this task will be to examine this technique to identify and eliminate redundancy, establish the order in which various computer programs would be

used, and to develop a software module that would address all data processing steps for both area estimation and mapping as well as being compatible with land cover change detection and geographic information system applications. It is anticipated that the main effort after the assessment and design would involve software modifications necessary for interfacing all computer programs in the module for cost-efficient data processing.

4.4.3.3. Responsibilities

1. The task manager will be NSTL.
2. NSTL will provide:
    a. Technical and contract management of their assigned work within the task.
    b. Assessment and design.
    c. Development of procedures and software modifications.
    d. Proof-of-concept test and evaluation.
    e. Support of technology adaptation.
3. ESCS will provide
    a. Establish performance criteria.
    b. Support NSTL activities through proof-of-concept testing.
    c. Decide go-no-go for technology adaptation to on-line system.
    d. Perform technology adaptation.

4.4.3.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	0	0	0	0
NSTL	0	0.2	80	0.5
JSC	0	0	75	1.0

NSTL civil service manpower will be predominantly for technical and contract management for their assigned work. NSTL funds will be for in-house contract work for software modifications and data processing from procedure development through proof-of-concept testing.

ESCS civil service manpower will support their assigned work and provide for technical management. ESCS funds will also provide for adaptation of procedures to the on-line system and for pilot testing.

4.4.3.5 Schedule

	FY81	FY82	FY83
Assess tasks 1 & 2	———	———	
Develop procedures		———	———
Proof-of-concept test			———
Adapt on-line pilot test	Integrate with Land Cover Information Systems task		

4.4.3.6 Interfaces

Principal interfaces will be between NSTL and JSC with respect to tasks 1 and 2 results assessment and between NSTL and ESCS for remainder of task. It is anticipated that coordination with the Renewable Resources Inventory project and the Conservation Inventory research program will be needed.

4.4.3.7 Data Requirements

Landsat MSS data and ground truth data acquired for other tasks of the DCLC project will be utilized for this task.

4.5 Project Element - Product Use

4.5.1 Task - User Participation and Evaluation of Product Use

4.5.1.1 Description of Task

1. Background

The primary users of ESCS's LANDSAT crop regression estimates will be the ESCS Crop Reporting Board and ESCS State Statistical Offices and their State Cooperators. Any benefits from these estimates will be passed on to conventional users of ESCS crop area statistics such as farmers, economists, agri-business, and government agencies.

Further uses of the classified LANDSAT data would increase the value of the LANDSAT effort. The potential utility of the land cover estimation and mapping research also needs

2. Objectives

- Promote additional uses of the LANDSAT crop area classification and estimation project to public interests groups in order to spread primary costs and improve cost-benefit ratio.
- Investigate the benefits of the land cover inventory and mapping project.
- Evaluate the inventory requirements and methods of various USDA and other federal agencies, for possible use of LANDSAT data and products in these efforts.

3. Scope

An information program will be initiated to contact potential users and to determine user needs that are applicable

to the basic processing of classifying each pixel within a geographical area into a specific crop or land cover type. Finding and developing direct users will be a continuing effort during the AgRISTARS project.

4.5.1.2 Research to be Conducted

As the current area estimation task begins in each state, other Federal agencies will be notified and the State Statistical Office will contact other public agencies and organizations within the State. ESCS will invite likely public interests to meetings or orientations where the LANDSAT crop area estimation procedures will be discussed. Similar meetings of data users will be established to discuss the output from the land cover research, provided these products have measurable and acceptable precision.

These interest groups will be asked to present suggestions and proposals for (1) additional uses of crop and land cover area estimates, (2) additional uses of LANDSAT which might complement or be compatible with the crop and land cover area estimates, (3) changes in format of estimates and other special products to meet participant needs, and (4) data base or inventory and monitoring efforts which might potentially use crop and land cover area estimation outputs as "raw data" or an input data source. Individual consultations will follow to develop specific plans and test products.

ESCS will work with participants to determine format and details of proposed data needs and provide sample products

for the participant to test and evaluate. Participants will be encouraged to test and propose refinements needed or desired. Cost estimates for new products will be developed and participants will be asked to develop benefit estimates.

Secondary and complementing uses of LANDSAT allow the spread of basic "Core" costs of materials and processing over a wider benefit base. As the LANDSAT crop area estimates move from the research mode into a production effort, the benefits anticipated should justify costs of LANDSAT regression estimates and other uses. Some of the products will be associated with tapes of classified pixels where optimum strategies have been used to identify specific land covers. Digital overlay masks such as soil survey data, watershed boundaries, flood control areas, special zoning, etc., are anticipated for use to provide either summary statistics or classified LANDSAT data or to create other natural resources management information.

4.5.1.3 Responsibilities

1. The overall task manager will be from ESCS.

2. ESCS will:

(a) Inform within-state and federal potential users as to the nature of task 4.5, exploring possibilities for linkage with their programs and responsibilities.

(b) Produce various output products for examples.

(c) Interact with users established in (a).

(d) Develop a user test program with identified within-state and federal users.

(e) Create products oriented to serve the needs of participating users.

(f) Seek refinements and establish means for ongoing participation based on user evaluations.

3. NSTL will assist ESCS in developing user test programs.

(a) Assist in developing user products.

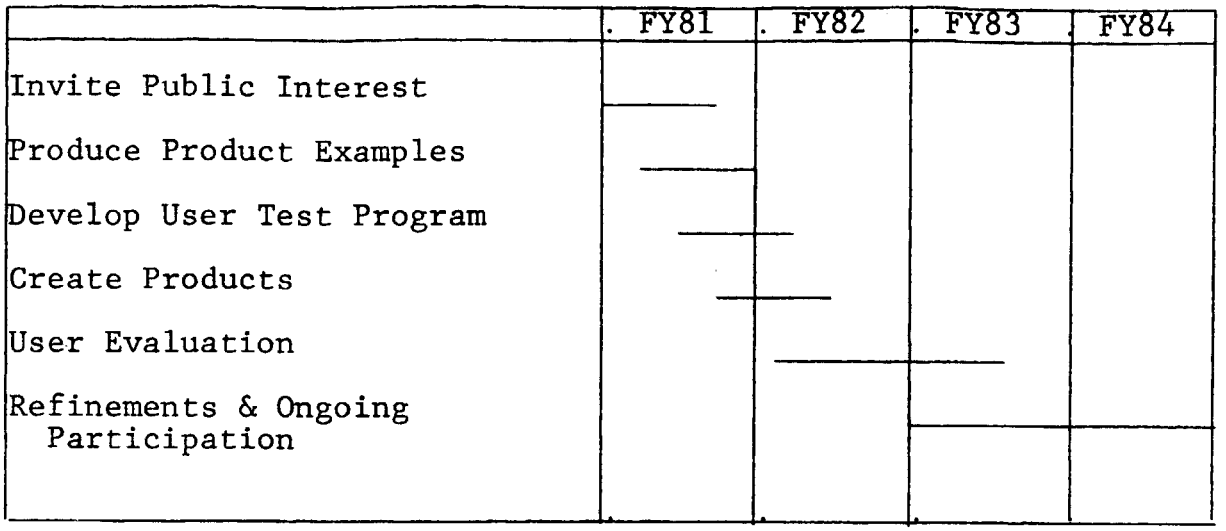
(b) Assist in refinements for continuing participant use.

4.5.1.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
ESCS	50	1.0	150	2.0
NSTL	0	0	0	0

The majority of costs will be for the production of various products. Costs may also be incurred in terms of salary for digitizing and plotting ancillary data, such as soils. Any new software or hardware costs for producing output products will fall under the land cover mapping task, in 4.6.2.

4.5.1.5 Schedule



4.5.1.6 Interfaces

State statistical offices involved in the product use element will mainly be those in the major crop acreage estimation element. New data users may benefit from specialized products available through NSTL and ARC. Users interested in geographic information systems or change detection will require interfaces with such tasks outlined in 4.6.

4.5.1.7 Data Requirements

No direct data requirements from primary AgRISTARS participants are expected. Secondary users may need to provide specialized ground data or other input items such as soils.

4.6 Project element - Land Cover Inventory and Mapping

4.6.1 Task 1 - Land Cover Area Estimation

4.6.1.1 Description of Task

1. Background

To date,the ESCS has experimented with providing crop acreage estimation at the state level using in part LANDSAT data and have an ongoing activity with a current system (hardware, software/methodology/and procedure) for providing estimates. Land cover information is an essential component of the resources, conservation, and commodity management baselines for various USDA agencies, e.g., USFS, SCS, ESCS, and ASCS. Recognition of land cover information needs and the potential of using the crop estimation technology, prompted the development of this task.

2. Objectives

- Investigate the use of conventional ESCS estimation technology for purposes of estimating major land cover types at the state and substate level.
- Utilize LANDSAT data as an auxiliary variable with ESCS ground data to reduce the sampling errors for land cover area estimates.

3. Scope

Land cover area estimation will be implemented on a state level. This implementation will be evaluated in terms of measurable precision, overall design, utility of the estimates, and problems encountered. Results obtained from this study will be used to direct the FY80 follow-on project.

4.6.1.2 Research to be Conducted

1. Technical Approach

In 1980, 43 Kansas segments in non-cultivated strata were sampled to supplement the 435 JES Kansas segments. The ground data collected for these additional segments was in accordance with the Anderson land cover classification system, Level I. During FY81 direct expansion estimates for major land cover at the state level will be calculated using the 478 segments. Some manipulation of the segment data is required to make the JES definitions and Anderson classification system compatible. The definition problem and the small number of non cultivated segments may limit the scope of the study's conclusions, but an initial indication of future sample size and allocation can be derived.

The second phase of this task is to use LANDSAT data as an auxiliary variable with the ground data and calculate regression estimates for the major land cover types. These estimates will be obtained over one or two scenes, rather than the whole state. Relative efficiences of the regression estimator will then be calculated.

4.6.1.3 Responsibility

1. The task manager will be ESCS.

2. ESCS will:

(a) Collect and digitize all ground data.

(b) Make available LANDSAT data that was acquired for the crop area estimation task and is applicable to land cover area estimation.

(c) Register all LANDSAT data, required by this task, to the ground data. This includes data acquired by NSTL.

(d) Derive estimates for the major land cover types.

(e) Report on the findings of this task.

3. NSTL will:

(a) acquire necessary LANDSAT data which was not obtained by the ESCS crop area estimation task.

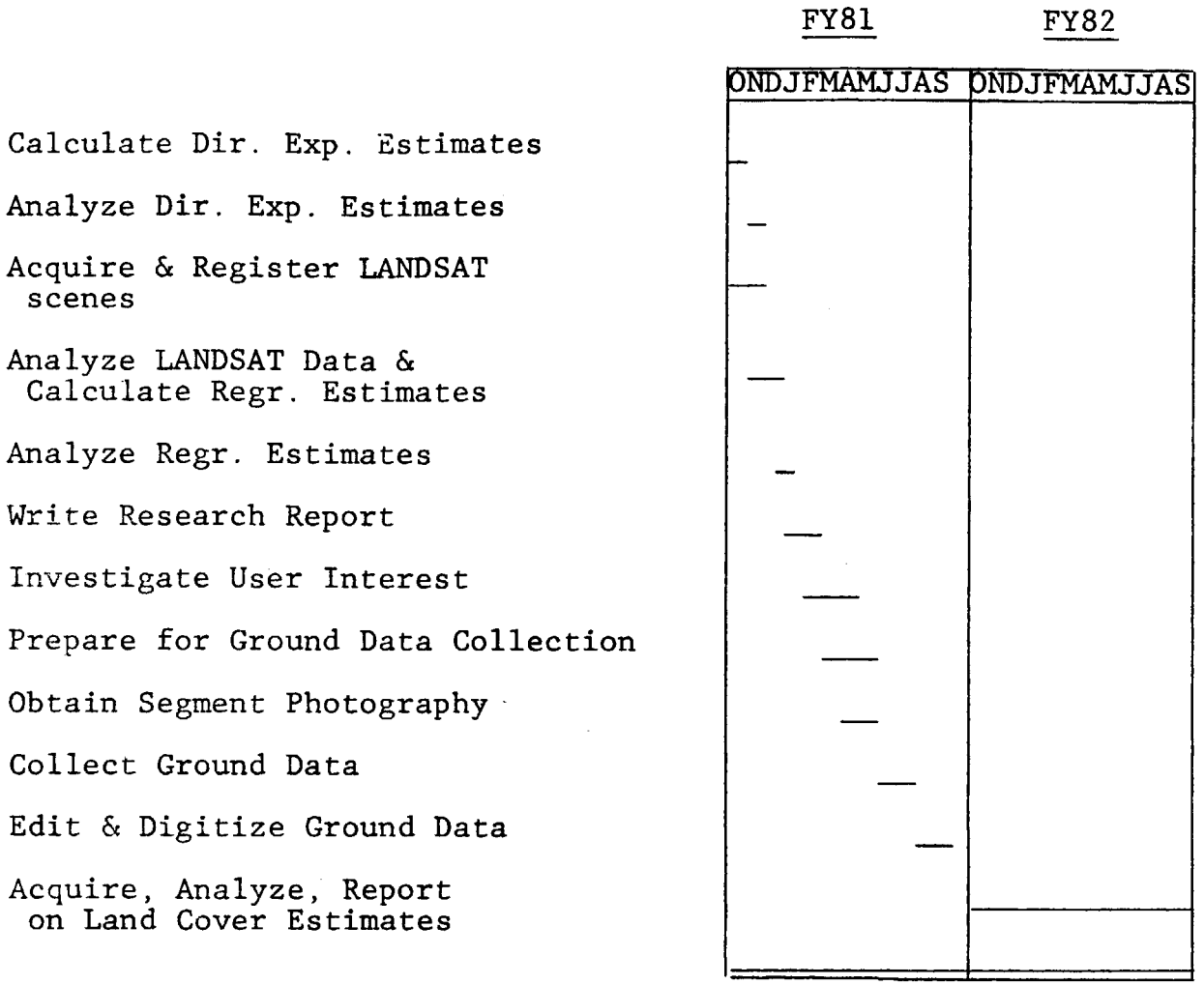
(b) Provide technical assistance in improving the land cover area estimation.

4. JSC Aircraft Office will acquire high altitude photography over ESCS specified segments. This acquisition in 1981 will be funded by exchange of ESCS resources.

4.6.1.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
ESCS	110	1.0	125	1.25
NSTL	50	.5	50	.5

4.6.1.5 Schedule



4.6.1.6 Interfaces

Communications will be established with the appropriate State Statistical Office. Interfaces will also be established with the Crop Estimation and Product Use elements.

4.6.1.7 Data Requirements

1. LANDSAT

- April, May or early June 1980 data will be provided by ESCS.

- Any other 1980 data will be acquired by NSTL.

2. Ground

- ESCS will provide all ground data.

3. Aerial Photography

- NASA will obtain high altitude photography for approximately 100 segments (1 X 1 mile) during Spring 1981.

4.6.2 Task 2 Land Cover Information Systems

4.6.2.1 Subtask 1 - Map Products

4.6.2.1.1 Description of Subtask

1. Objectives

- Develop map accuracy indicators which quantify the classification mapping results.

- Develop/modify software or hardware packages that are required for pictorially displaying classification maps and associated map accuracies, and to fulfill needs established within the Product Use element.

2. Scope

Future requests for quality land cover maps is anticipated. A capability will be developed for producing thematic maps at known scales and accuracy.

4.6.2.1.2 Research to be Conducted

1. Technical Approach

Currently, the DCLC project lacks statistical indicators for the mapping accuracy of crop or land cover classifications. The most commonly used terms are percent correct classifications or commission/omission error rates. These indicators can be very misleading because even a high percent correct classification can have a very low mapping accuracy.

R. Sigman[1] has proposed methodology for computing the probability that a LANDSAT pixel is correctly classified as a

[1]Sigman, R.: A Proposal for an ESCS data product for use in AgRISTARS land use research.

specific cover type. The derivation considers the probabilities associated with this pixel falling in all the land covers mapped in the classification. A software package will be developed for implementing this procedure on the NSTL system.

Other methods for determining map accuracy have been cited in the literature.[2,3,4] Some statistical indicators consider not only the probability that a pixel is correctly mapped to a corresponding ground data cover, but also the probability that a ground data point is correctly mapped to the corresponding pixel classification. The positional accuracy of a classified point in a map is also an important factor. Various map accuracy indicators will be assessed with particular attention given to those developed by Hellden[4]. Selected procedures will be implemented and tested on the NSTL system.

Software will be developed for taking a final classification and producing a map which pictorially depicts the map accuracy indicators. Additional software/hardware modifications for output products will be determined from the assessments in the Product Use element.

---

[2]Genevan, M. E.: Testing land use-map accuracy, Another Look: Photogrammetric Engineering and Remote Sensing, October 1979, pp 1371-1377.

[3]Hay, A. M.: Sampling designs to test land-use map accuracy: Photogrammetric Engineering and Remote Sensing, April, 1979, pp 529-533.

[4]Hellden, U.: A test of LANDSAT-2 imagery and digital data for thematic mapping, illustrated by an environmental study in northern Kenya. June, 1980, 63 pp.

2. Anticipated results

- Development and implementation of map accuracy indicators.
- Evaluation of the performance and utility of these indicators.
- Hardware/software capability to produce various map output products.

3. Output Products

- Report describing research results and the procedures for calculating map accuracies.
- Documented software for obtaining and displaying map indicators.
- Classification maps with known map accuracies.

4.6.2.1.3 Responsibility

1. NSTL will be the task manager.
2. NSTL will:

- Provide an assessment of map accuracy indicators.
- Implement selected indicators.
- Evaluate the utility of mapping accuracies.
- Develop software for providing various output products.
- Provide documentation on all software development.
- Produce products needed in the Product Use element of this plan.
- Write report describing research results.

3. ESCS will:

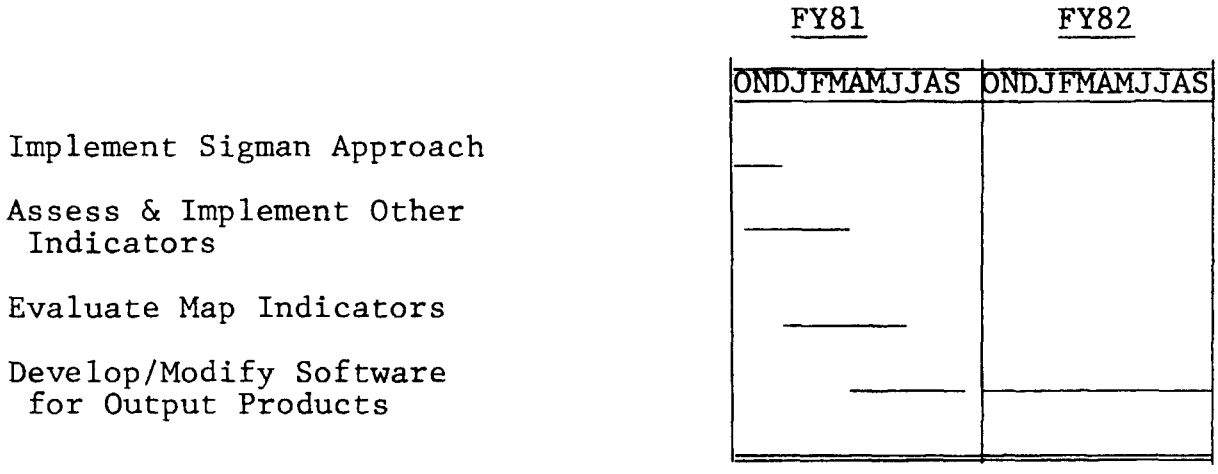
- Provide technical assistance in all aspects of task.

- Provide data sets for testing and evaluating map accuracy indicators.

4.6.2.1.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
ESCS	50	0.5	100	0.75
NSTL	100	1.0	150	1.0

4.6.2.1.5 Schedule



Initially, progress on this task must proceed rapidly so that a map accuracy indicator capability can be utilized in the FY80 Kansas land cover project.

4.6.2.1.6 Interface

Interfaces will be established with the Product Use element.

4.6.2.1.7 Data Requirements

ESCS will provide registered ground and LANDSAT data sets for this task.

4.6.2.2 Subtask 2 - Change Detection/Monitoring Capability

4.6.2.2.1 Task Description

Development of a change detection and monitoring system requires the assessment of changes in land cover as well as the location-specific identification of natural and man-induced changes in land cover features. Over a period of time a change monitoring system will result in the capability to provide accurate inventory updates based on ESCS requirements, trend and pattern assessments, and land utilization prediction.

1. The objectives of this task are:

- To improve current capabilities and methods and develop procedures for detecting and monitoring changes in land cover through temporal, multistage remotely sensed data in diverse environments.
- Develop and determine cost effective methods for storing and retrieving inventory information in a geo-based reference system for updating purposes.

2. Scope

Presently much attention is given to the potential utility of land cover change detection methods by certain R&D communities. Initially, candidate methods will be investigated; and promising techniques will be selected for more intense research. Procedure development

includes modifying (or designing) the software and operation on a representative computer system to establish a credible "proof-of-concept" level. Once each change monitoring method reaches this level, it should be documented and released for a pilot test. Accurate frame-to-frame (scene-to-scene) registration of data is essential to change monitoring procedure success, and all procedure research must early-on assess this fact. Ultimately, change will have to be stored and retrieved in terms of a geo-based reference system.

A comprehensive land cover data base, containing both remotely- and non-remotely-sensed variables will contribute greatly to effective change monitoring techniques. The addition of variables, such as soils or census, increases the dimensionality (and inherent accuracy) of the decision-making process, and, in a computer-oriented system, does not necessarily make it more time consuming or costly. This task should investigate only the practical utilization of data bases for change monitoring purposes. It is not the intention to develop an all-encompassing national data base for ESCS use, but only to develop and test data bases of limited area and number of variables to support specific change monitoring procedure research.

4.6.2.2.2 Research to be conducted

1. Technical Approach

Three current methods of change detection will be employed in FY81 for candidate evaluations based upon accuracy, user needs, costs, etc., criteria. The three methods are:

(a) Post classification differencing - where spectral data from 2 different dates are reduced to user-defined land cover groupings via automated signature development and maximum likelihood classifier algorithms. These 2 dates are then registered cell-to-cell and compared for changes in specific land cover distributions.

(b) Direct change classification - where scenes from 2 dates are registered, then classified, producing a mapped area of change classes which are then determined as to type of change.

(c) Radiance Value Shift - involves overlaying 2 dates and then testing for distance and direction changes in the cell-by-cell reflected signal response of various representative cover types.

Other procedures are under development for testing by FY82, and continued investigation of change monitoring capabilities will take place through FY83.

2. Test Sites

Two exploratory test sites have been defined for the testing of these current techniques. The first encompasses an area of rapidly increasing crop land in an area of extensive bottomland hardwoods in the fertile, alluvial plains of the Mississippi River primarily within the bounds of Catahoula and Concordia Parishes, Louisiana. Data representing a five-year interval from October 1974 to October 1979 with corresponding CIR aircraft coverage will be used to analyze results of the techniques

over this area. The second test site is in an area of semi-arid rangeland under intensive conversion to irrigated cropland in the vicinity of Garden City, Kansas. Data from August 1972, August 1975, and August 1978 will be used for identification and quantification of change areas in this region with the techniques developed. A third possible test site in a different region with other change types will be selected in FY82.

4.6.2.2.3 Responsibilities

1. The overall responsible agency will be NSTL as task manager.

2. NSTL will provide:

(a) Technical & contract management of their assigned work within the task.

(b) Technical integrity for task.

(c) Assessment of change detection/monitoring technology.

(d) Experiment design.

(e) Development of procedures.

(f) Proof-of-concept test & evaluation.

(g) Support pilot test accuracy assessment and performance evaluation.

(h) Support design specification development for LSAT.

(i) Support technology adaption.

3. ESCS will:

(a) Conduct Pilot test.

(b) Perform Pilot test accuracy assessment and performance evaluation.

(c) Develop design specifications for LSAT.

(d) Support the assessment, experiment design, procedure development, and proof-of-concept testing.

(e) Establish performance criteria.

(f) Decide go-no-go for technology adaption to on-line.

(g) Perform technology adaption.

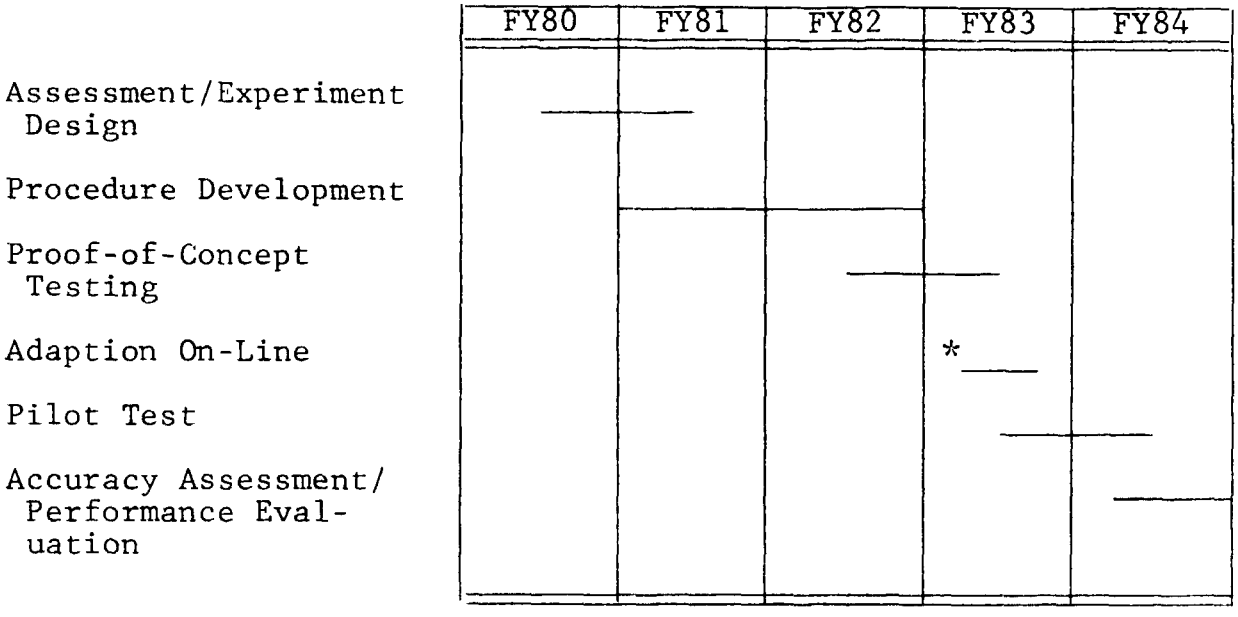
4.6.2.2.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	50	0.3	75	0.5
NSTL	100	1.0	120	1.1

NSTL civil service manpower will be predominately for technical and contract management for their assigned work. Most of the NSTL funds will be for contracts (both in-house and outside). These funds allow for NSTL data processing costs from procedure development through proof-of-concept testing.

ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their dollars allow for ESCS data processing costs involved for Pilot testing and the adaption of procedures to on-line.

4.6.2.2.5 Schedule for Change Detection



*go-no-go (Adaption on-line)

4.6.2.2.6 Interfaces

1. One factor of utmost importance to change detection is the ability to register LANDSAT data (2 or more dates). This activity is covered by the registration task that is carried as a separate task in this plan to be given high priority in FY81. Therefore, although the assessment of the various requirements began in FY80, the selection of specific change detection techniques and their subsequent evaluation and procedure development was delayed until FY81 in order to take into account the registration technique evaluations.

2. It is anticipated that the same change detection techniques that are evaluated and tested with LANDSAT MSS data will also apply to LANDSAT TM data. Therefore, the TM task of this plan will contribute to the assessment and procedure development of the change detection task.

3. The classification/clustering task will provide inputs to this task for change interpretation and classification.

4. The evaluation of current USDA inventories and requirements task will provide an input to the change detection assessment effort.

5. The results from the task will be integrated with the Product use task. The technology development here will be the bases for data products for the user.

4.6.2.2.7 Data Requirements

1. Data Acquisition

Most of the data will be provided through the Estimation of Major Crops (2 states/year) Task. Additional scenes may be required, not more than 10 per year. TM scenes will be required late in the project (83 and 84). The format for both MSS and TM data will be CCT's and B/W images (high contrast from 1 band).

Aircraft requirements may be defined during the technology assessment of this task and will be submitted in FY81.

2. Data Preprocessing

None

3. Data Distribution

TBD

4.6.2.3 Subtask 3 - Geographic Information Systems

4.6.2.3.1 Description of Task

1. Objectives

- Evaluate and/or develop software and procedures for the efficient input of remotely sensed data to existing geographic information systems and to interface remotely sensed data with other digital data files.

- Evaluate the utility of land cover information derived from remotely sensed data after it has been manipulated in geographic information systems and/or used in models requiring geographically referenced data.

2. Scope

The usefulness of land cover information derived from remotely sensed data is greatly enhanced when input to a geographically referenced, computerized information system so that it can be correlated with other data, e.g., soil, slope, aspect, elevation, population density, etc. A geographical information system will be implemented and various types of information will be evaluated in terms of land resource management decisions, change detection methodology, and land cover area estimation and mapping. The intent of this task is to conduct research over small geographical areas, and not to develop an all encompassing, nationwide data base.

4.6.2.3.2 Research to be Conducted

1. Technical Approach

The Earth Resources Laboratory Applications Software (ELAS) is a geobased information system developed by NSTL.

The data base stores input parameters by a selectable cell size which is geographically referenced to the Universal Transverse Mercator (UTM) grid. Applications programs are used to manipulate these parameters to provide various types of land resource information.

ELAS will be the working environment for the following research:

- Implement and run 2-3 management models, such as soil erosion, land suitability, carrying capacity. Results will be evaluated in terms of accuracy and utility to users.
- Investigate the contribution of geographic information bases to change monitoring techniques.
- Evaluate the role of geographic information systems in land cover area estimation, mapping and output products.
- Develop efficient procedures for producing and inputting ELAS compatible data types, such as digitized soils or terrain data.

4.6.2.3.3 Responsibility

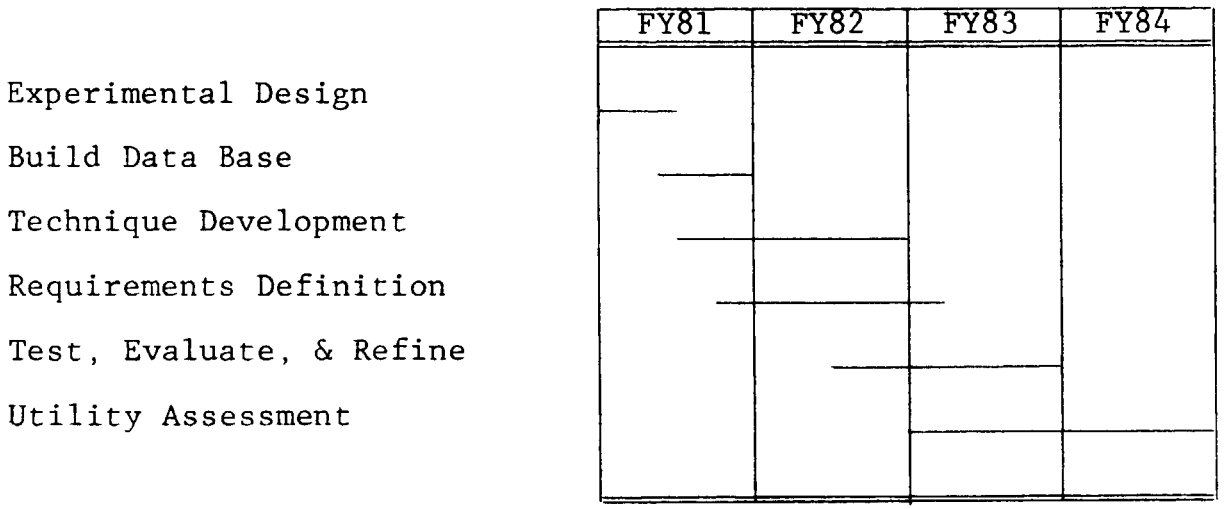
NSTL will be the task manager and will develop experimental designs for conducting the above research.

ESCS will assess existing USDA systems and define potential uses and requirements for a geographic information system.

4.6.2.3.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
ESCS	20	0.2	50	0.5
NSTL	50	.5	150	1.0

4.6.2.3.5 Schedule



4.6.2.3.6 Interfaces

Interfaces will be established with all tasks dealing with crop/land cover estimation and mapping, product use, change detection, and TM studies.

4.6.2.3.7 Data Requirements

Various data types will be required. The exact data formats and sources is dependent upon the scope of the individual research efforts conducted within this task.

Both ESCS and NSTL will be responsible for meeting data requirements. This will include:

- Providing data routinely collected or utilized by each agency.
- Establish channels for obtaining data that are not routinely collected or assimilated by each agency.
- Provide financial and manual resources for getting data in a format suitable for ELAS.

4.7 Project Element - Sensor Implementation and Evaluation

4.7.1 Task 1 - Thematic Mapper Procedure Development

4.7.1.1 Description of Task

1. Objectives

(a) Provide an evaluation of the anticipated utility of the TM, including a comparison with results obtained for crop and land cover estimates with MSS data.

(b) Make software modifications and develop techniques and procedures to take account of additional bands and finer spatial resolution.

(c) Adapt software and procedures to ESCS system and perform on-line pilot test(s) and LSAT.

2. Scope

The evaluation of LANDSAT D Thematic Mapping data will be addressed through the acquisition and evaluation of aircraft-acquired TM data during FY81 and FY82. Emphasis will switch to LANDSAT D Thematic Mapper data in FY82 and 83 with LANDSAT TM data being employed in pilot tests and LSAT's during FY84 or 85. The same basic techniques that receive a positive evaluation with LANDSAT MSS data in the pre-pilot test states will be applied to LANDSAT TM data. A comparison between the use of LANDSAT MSS and LANDSAT TM data will be made with respect to both performance and data processing costs.

4.7.1.2 Research to be Conducted

1. Technical Approach

The use of a TM simulator will help lay the ground work for development of TM procedures, identify problem areas, determine scope of modifications to the various techniques and system components, provide a reasonable evaluation of the anticipated utility of the TM, and establish a performance criteria and evaluation methodology for the TM utility.

The TM simulator data will be used to assess the capability to satisfy the following:

- Separability of major crops
- Small field areas and land cover units
- Separation of various land cover types
- Area estimation
- Mapping accuracies

During the first part of FY81, emphasis will be given to the analysis of existing Thematic Mapper Simulator data. This will include:

(a) Data collected with the JSC NS001 during September 1979 in northern Missouri which has been made available to ESCS,

(b) Data collected with the NSTL TMS during August, 1980, in North Dakota (Walsh County) and Kansas.

Additional Thematic Mapper Simulator data will be collected with the NSTL TMS during FY81 over test sites selected in consideration of the following factors.

(a) Conditions under which problems related to spatial or spectral characteristics of the MSS were experienced or are anticipated (e.g., small fields, crop stress).

(b) Utilization of test sites selected for research with other sensors, e.g., SAR, RBV, LFC.

When possible, these test sites will be selected so as to fall within the states for which crop estimates have been or are being made under Element 1 of this project implementation plan. Two sites will be selected for TMS data acquisition during FY81, and two more will be selected for TMS data acquisition during FY82. TMS data acquisition during FY82 will be coincident with LANDSAT D TM data acquisition.

Data processing and analysis of TMS data will be conducted as follows:

- NSTL acquires TMS data and creates geo-referenced data tape.
- ESCS acquires ground data and digitizes ground truth segments.
- Using NSTL's geo-referenced TMS data, ESCS creates a tape of ground-truth by TMS pixel.
- Using ESCS's tape, NSTL inputs ground truth data into NSTL's processing system and produces a land cover classification.

After a classification has been derived from TMS data, the accuracy will be verified and an assessment of the utility of the TMS data will be made. This assessment will include a comparison with information derived from MSS data.

In the course of processing and analyzing TMS data, software and procedures will be tested with respect to handling the 7 bands of data and 30 meter resolution of the Landsat TM. These procedures will then be applied to Landsat D TM data during FY83.

Testing and evaluation of these procedures will be done off-line and on-line using Landsat D Thematic mapper data. The off-line test will consist of proof-of-concept testing using two scenes in each of four states which are representative of various information needs and regional conditions. Assuming that the performance criteria are met the procedures will be integrated for on-line use. The on-line test will be a pilot test conducted with scenes covering two states per year beginning in 1983. An evaluation of accuracy and performance will be performed jointly by ESCS and NSTL. ESCS will evaluate TM utility on the basis of anticipated success for LSAT. Design specifications should be a fall-out of this effort.

2. Anticipated Results

The anticipated result from this task will be an assessment of the potential improvements for crop area estimation and land cover inventory and mapping that may be attributed to the improved spatial and spectral resolution of the Thematic Mapper, and a set of software and procedures that are appropriate for processing and analyzing TM data.

3. Output Products

The major products of this task will be a set of procedures for processing TM data and a detailed report covering TM assessment and testing.

4.7.1.3 Responsibility

1. The task manager will be NSTL.

2. NSTL will provide:

(a) Acquisition, digitization, and geo-referencing of TMS scanner data.

(b) Scan-angle/sun-angle correction of TMS scanner data, if necessary.

(c) Estimation of crop and land cover areas from TMS & TM scanner data and LANDSAT data.

(d) Investigation of improved land-use information capabilities of TMS & TM data over MSS data using NSTL's processing system.

(e) Report of the findings of their assigned work.

3. ESCS will provide:

(a) Estimation of Missouri crop and land-cover areas from NS001 scanner data and LANDSAT data using EDITOR.

(b) Ground-truth data in EDITOR format and in an input format suitable for NSTL processing.

(c) EDITOR registration of LANDSAT MSS data.

(d) Report of the findings of their assigned work.

4.7.1.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
ESCS	125	1.0	100	0.6
NSTL	100	.8	200	1.6

NSTL civil service manpower will be predominately for technical and contract management for their assigned work. The NSTL funds will be for in-house contracts. These funds allow for NSTL data processing associated with digitization, geo-referencing, and radiometric corrections of TMS scanner data and with data analysis using NSTL's processing system.

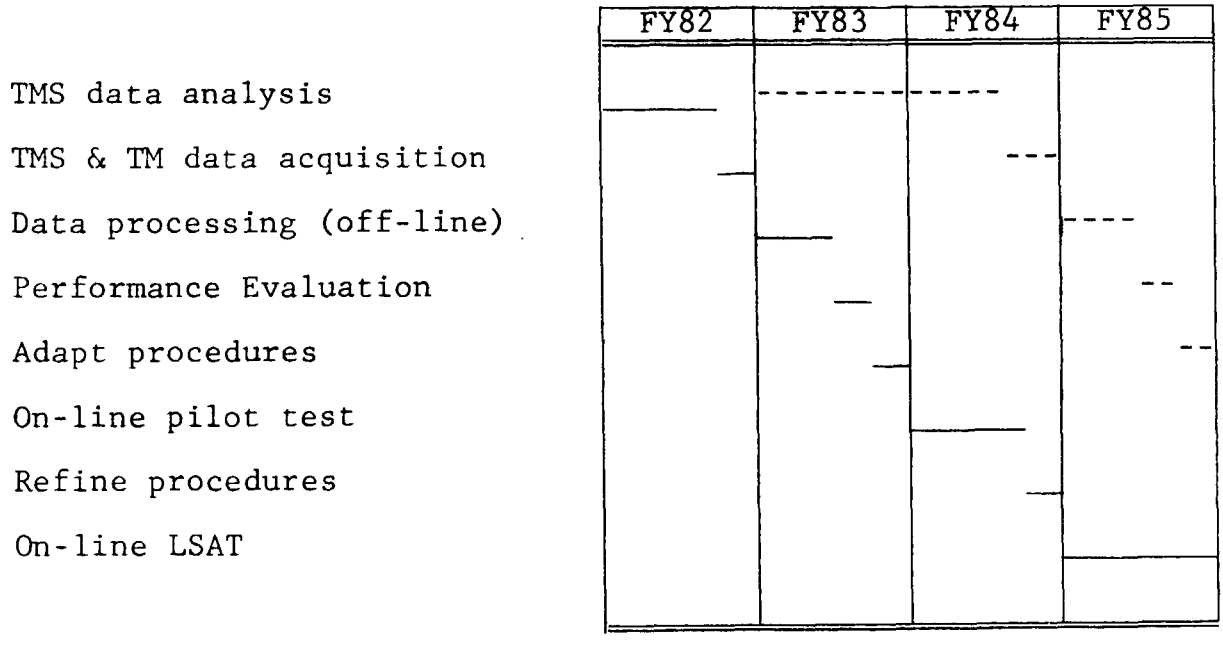
ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their funds allow for ESCS data processing costs involved for data set preparation and EDITOR data analysis.

4.7.1.5 Schedule

FY81 Events	Desired Completion Date
ESCS analysis of NS001 data	1 NOV 1980
NSTL delivery to ESCS of digitized, geo-referenced and radiometrically corrected TMS scanner data	1 DEC 1980
ESCS report on NS001 analysis	15 DEC 1980
ESCS compilation of Walsh County,N.Dakota ground truth data set in EDITOR format	1 JAN 1981
ESCS registration of MSS data	1 FEB 1981

FY81 Events	Desired Completion Date
ESCS delivery to NSTL of ground-truth data in input format suitable for NSTL's processing system	15 FEB 1981
NSTL EDITOR analysis of Walsh Co.,N.Dakota TMS and MSS data	1 APR 1981
NSTL investigation of land use information applications using NSTL's processing system	1 MAY 1981
NSTL report	1 JUL 1981
NSTL acquisition of TMS data for two additional test sites	1 APR 1981 to 31 AUG 1981
ESCS acquisition of ground-truth data for two additional test sites	1 JUN 1981 to 31 AUG 1981

FY82 to FY85 Schedule*



*Dashed line shows alternative schedule should Landsat D TM data not become available until FY84.

4.7.1.6 Interfaces

1. It is anticipated that the other projects within AgRISTARS will have TM requirements similar to this project. Interfaces will be established with these projects so to eliminate redundancy.

2. Clustering/classification task will work closely with this task, so that algorithms and procedures can be developed and applied to both simulated and TM data.

3. The land cover mapping subtask will integrate tested techniques and procedures developed for TM.

7.7.1.7 Data Requirements

1. Acquisition

- Simulator data for this task will be selected from previously acquired TM data and 4 to 5 additional missions with the NSTL TMS.

- Several scenes of TM data, both tapes and high contrast band photos, will be required for testing procedures developed with the simulated data.

2. Preprocessing

The simulated data may require preprocessing to eliminate platform distortions and other inherent problems.

4.7.2 Task 2 - Procedure Development for Other Sensors (i.e., SAR, RBV, LFC)

4.7.2.1 Description of Task

1. Objectives

(a) Assess the utility of using synthetic aperture radar (SAR) data for crop and land cover area estimation and mapping.

(b) Assess the utility of RBV data and LFC photography for land use stratification update.

(c) Present results in a manner that they will be meaningful input to future sensor system design.

2. Scope

Aircraft and Seasat acquired SAR data will be registered to LANDSAT MSS and TM data, processed with pattern recognition programs, and the results will be compared with those derived from each independent data set. LANDSAT III RBV images and Shuttle Large Format Camera photography will be evaluated as a tool for stratification. This work will begin in FY81 with the intent that the assessments will be completed in time for meaningful input to future sensor design.

4.7.2.2 Research to be Conducted

1. Technical Approach

Assess the existing technology and related research applied to integrating radar data to the estimation and mapping

process of crops and land cover. Determine which processes and techniques have the most promise in improving classification accuracy. Determine what modifications are necessary for the selected techniques. Establish the performance criteria for test and evaluation in conjunction with an evaluation methodology for determining utility.

In the literature-review portion of this task, remote sensing journals and symposium proceedings will be reviewed for agricultural applications of SAR data. Particular attention will be directed to cataloging optimal radar bands, polarization modes, equipment parameters such as power requirements, and processing algorithms such as filtering techniques and registration procedures.

Test sites will be selected in consideration of existing SAR data, location of other test sites (e.g., TMS), and the characteristics of SAR data with respect to its potential for classification improvements. Some possibilities of this nature include:

(a) Irrigated versus non-irrigated cropland.

(b) Flooded (e.g., paddy rice, marshland) versus dryland conditions.

(c) Drilled crops versus row crops.

(d) Cultivated versus non-cultivated.

(e) Even-aged versus all-aged forest.

Data will be acquired for various frequencies, polarization, and look-angles. This will include SEASAT SAR L-band,

Aircraft-acquired C, X, and L band, and Shuttle Imaging Radar (SIR) L-band. Two aircraft missions will be flown in FY81, and two additional missions will be flown during FY82. It is anticipated that SIR data will become available during FY83.

Data analysis will entail a pattern recognition approach to classification utilizing multi-frequency, multi-polarized data to create a multi-channel data set and by registering SAR data (SAR and MSS), results attained with the merged data will be compared with results attained with the single-sensor data.

The analysis of SAR data will be the principal focus of this task with secondary emphasis given to the assessment of the utility of digital RBV data, and the examination of Shuttle Large Format Camera (LFC) photography for land use stratification. It is anticipated that RBV digital data will become available during FY81, and LFC data will be available during FY83.

2. Anticipated Results

The anticipated results of this task are as follows:

(a) An assessment of the utility of SAR, RBV, and LFC data for crop and land cover inventory and mapping.

(b) The development of techniques and procedures for processing these data.

(c) The utilization of resulting information for future system design.

3. Products

A report that addresses the anticipated results outlined above.

4.7.2.3 Responsibility

1. Task manager will be NSTL.
2. NSTL will provide for:
   (a) Processing of SAR, RBV, and LFC data.
   (b) Digitization and digital correction of SAR data.
   (c) Analysis of data information content.
3. ESCS will provide for:
   (a) Purchase of data and/or cost of mission.
   (b) Ground-truth data collection & digitization.
   (c) Regression estimation for MSS and SAR/MSS data sets.

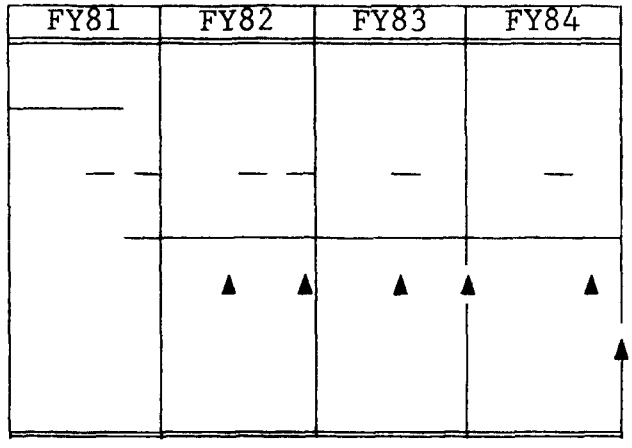
4.7.2.4 Resource Requirements

	FY81		FY82	
	$	MYE	$	MYE
NSTL	100	1.0	200	1.5
ESCS	75	1.0	100	1.4

NSTL civil service manpower will be predominately for technical and contract management for their assigned work. Most of the NSTL funds will be for in-house contracts and aircraft expenses. These funds allow for NSTL data processing costs from procedure development through proof-of-concept testing.

ESCS civil service manpower will support directly their assigned work and provisions for technical management. Their funds allow for ESCS data processing costs involved for Pilot testing and the adaption of procedures to on-line., and the acquisition of SAR data for one mission.

4.7.2.5 Schedule



4.7.2.6 Interfaces

1. This subtask should interface with both the land cover mapping and classification/clustering tasks. If it is anticipated that the Radar data will be used as an auxillary variable in the classification process.

2. AgRISTARS supporting research will have similar activities for both Early Warning and FCPF. It is anticipated that the data sets, procedures, preprocessing, and resources can be combined for the Radar work.

4.7.2.7 Data Requirements

1. Acquisition - Two aircraft missions will be required in both FY81 and FY82. It is anticipated that NASA aircraft/SAR systems will be utilized when possible, but it may be necessary to acquire some aircraft-acquired SAR data under contract. It is anticipated that Shuttle acquired SAR data will become available in FY83. Existing SEASAT L-band SAR will be utilized if available for selected test sites.

2. Preprocessing - NASA will arrange for the digitization of SAR data, and perform necessary digital corrections.

4.7.3 Task 3 - Future Sensor Needs/Requirements

4.7.3.1 Description of Task

1. Objective

To define needs/requirements for future sensors for crop and land cover applications.

2. Scope

This task will account for the results of having used a variety of sensor systems (Landsat MSS, Landsat RBV, TMS, aircraft acquired X, L, and C band SAR, Seasat L band SAR, Landsat TM, and Shuttle SAR and LFC) for a variety of geographic/surface conditions throughout the DCLC project. The assessment of these results will be made for the purpose of providing input for the design and operation of future satellite sensor systems.

4.7.3.2 Research to be Conducted

This task constitutes an assessment of the results of using various sensors for various surface conditions for crop and land cover classification and mapping, and for change detection and geographic information system applications. The results will be examined with respect to factors that are pertinent to sensor design such as the following:

1. spatial (e.g., sizes of thematic crop and land cover targets in various geographic locations and surface conditions).
2. temporal (e.g., when are the most appropriate times to acquire data and what orbit frequencies are pertinent)
3. spectral (e.g., optimum bands, band width, and spectral regions).

4. multi-sensor (e.g., improvement of information by merging data from 2 or more different sensors).
5. data type (e.g., advantages of stereo coverage, and digital versus image).

Attention will also be given to assessing the impact of certain sensor parameters (e.g., number of bands, spatial resolution) on data processing activities.

There will be no integration and pilot testing. The thrust of this task is a documentation effort drawing on the results of other tasks within this project. It is not anticipated that the end result of this task, in itself, will provide all information needed for future sensor system design, but that it will contribute significantly to such information.

4.7.3.3 Responsibilities

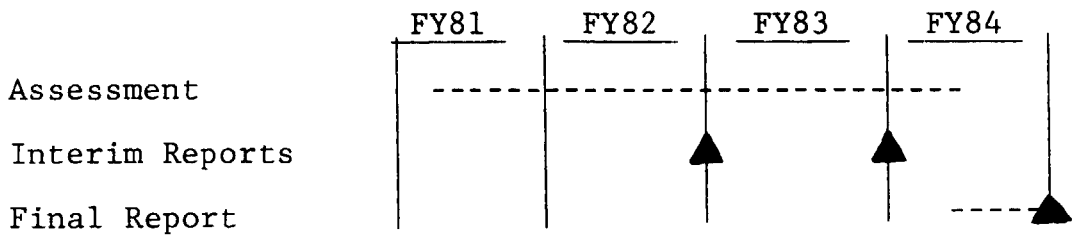
1. NSTL will be the task manager.
2. NSTL will be responsible for the entire task.
3. ESCS will provide results from pilot tests, LSAT's, and other aspects of the DCLC project for which ESCS has responsibility. ESCS will also review all conclusions before they are finalized.

4.7.3.4. Resources

	FY81		FY82	
	$	MYE	$	MYE
ESCS	0	0	0	.1
NSTL	0	.1	20	.2

NSTL Civil Service manpower will perform the technical assessment and limited contract management for their assigned work. Most NSTL funds will be for the in-house contractors to provide for data processing costs. ESCS civil service manpower will support their assigned work.

4.7.3.5 Schedule



4.7.3.6 Interfaces

Only interfaces will be internal to DCLC project.

4.7.3.7 Data Requirements

None