George Hanuschak

AgRISTARS

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

Domestic Crops and Land Cover

November 1981

PROJECT IMPLEMENTATION PLAN FOR FISCAL YEARS 1982 AND 1983

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Lyndon B. Johnson Space Center
Houston, Texas 77058

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15. Supplementary Notes

16. Abstract

The Domestic Crops and Land Cover Project focuses on two particular types of development. The first focus is to develop operational techniques for the Statistical Reporting Service (SRS) of USDA to improve the statistical accuracy of crop acreage estimates through combining probability samples of ground data with satellite data. The second major focus of the project is on the procedures to address some of the land use and land cover information needs of other Agencies of the USDA. Alternative classification, sampling and estimation procedures will be developed to focus on these land cover information requirements.

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DOMESTIC CROPS AND LAND COVER

PROJECT IMPLEMENTATION PLAN

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1.0 Introduction

The Domestic Crops and Land Cover Project focuses on two particular types of development. The first focus is to develop operational techniques for the Statistical Reporting Service (SRS) of USDA to improve the statistical accuracy of crop acreage estimates through combining probability samples of ground data with satellite data. The second major focus of the project is on the procedures to address some of the land use and land cover information needs of other Agencies of the USDA. Alternative classification, sampling and estimation procedures will be developed to focus on these land cover information requirements.

During the first two years of the project many significant accomplishments have been achieved. The State Statistical Offices (SSO's) of SRS were able to demonstrate the ability to edit and digitize ground data in a real time fashion. Improvements in classification procedures for crop identification, studied in the first year of the project, were implemented into the software system for the second year. Considerable progress has been made in comparison of procedures for meeting the data registration needs for the DCLC Project in the first two years. Necessary definitions for collecting land cover data for various federal and state agencies were developed and preliminary research projects utilizing these definitions were implemented.

There have been some adjustments in the Implementation Plan for FY82 and FY83 from previous versions. The Land Cover Inventory and Mapping Element has now been broken into five subtasks to best depict the research efforts underway. A newly defined task under the current area estimates for major crops will involve cooperation with other researchers in California on much different crop acreage estimation problems than the full state estimation task centered in the Midwest and Great Plains. A one year comparison study of selected small area estimation procedures is included in this year's plan under the Clustering/Classification Evaluation Element.

Some of the project tasks for FY82 focus specifically on information needs of the Soil Conservation Service (SCS) of USDA. SCShas rather broad interests in land cover needs from detailed soils information to inventory and monitoring of land use classes. These efforts to address SCS needs will help to better focus the land cover research under the DCLC project.

The various elements, tasks and subtasks differ somewhat in the extent that multiple year planning is possible. Where schedules of activities can be forecast into FY84 this information has been provided. However, for most items the emphasis is on FY82 with an estimate of resource needs for FY83.

2.0 Project Objectives

DCLC research for the FY82 and FY83 is a mixture of three types of efforts. Work will continue to develop and test procedures which show operational promise for crop acreage and land cover estimation. In support of these estimation efforts will be continued work to improve such necessary steps as data registration, clustering and classification alternatives, preprocessing techniques, and computer software and hardware alternatives. A third type of research element involves examination of alternative sensors. Research studies involving thematic mapper simulation and micro-wave sensors will be continued.

Following are listings of project objectives for FY82 and FY83. These listings are by no means exhaustive. The listings are arranged by project element. However, there are a number of interfaces among elements and work on one element will often support the objectives for other elements.

2.1 FY82 Objectives

Crop area estimates for major crops.

- Calculate improved estimates of winter wheat harvested acreage for three states and planted acres of corn and soybeans in three states.
- Implement improvements in analysis procedures for making crop acreage estimates using Landsat and probability selected ground data.
- Evaluate feasibility of data registration and segment shifting operations by SRS State Statistical Office personnel.
- Calculate improved acreage estimates for rice, small grains and other crops in the Sacramento Valley of California.

Registration

- Finish exploratory testing of multitemporal registration procedure alternatives.
- Continue testing and enhancement of Automatic Segment-to-Map algorithm (ASMA).

System Improvements and Development

- Acquire video and computer hardware for automatic digitization of segment and field boundaries.
- Utilize automatic digitization procedures for winter wheat segment digitization - evaluate for best alternative procedure for corn and soybeans segments.
- Install digitization and plotting software in the Iowa State Statisticial Office.
- Convert all necessary software and procedures from the ILLIAC IV computer to the CRAY 1S.
- Evaluate the suitability of a microcomputer stand alone digitization station.

Clustering/Classification Evaluations

- Investigate direct proportion estimators in comparison with various regression estimators for subanalysis district crop area estimators.
- Conduct evaluation of the Battese-Fuller estimator for subanalysis district crop area estimates.
- Evaluate and improve the Contextual Information Classifer (CICL) for land cover classification.
- Assess software for evaluating a shape classifier for land cover classification.

Product Use

- Create land cover map products for one or more small geographic areas in Kansas.
- Meet with potential land cover information users in Kansas to review and evaluate map products.

Land Cover Inventory and Mapping

- Create probability sample direct expansion area estimates of major land cover categories in Kansas.

- Create regression estimates of Kansas major land cover categories based on classified Landsat data.
- Conduct 1982 Land Cover Survey for Missouri in conjunction with the SRS June Enumerative Survey.
- Compare Landsat classification of land cover with actual wall to wall land cover data for one county.
- Develop map accuracy indicators for evaluating classified Landsat thematic maps.
- Develop procedures for comparing four methods of detecting land use change.
- Extract information from various geographic sources as candidate information for Soil Conservation Service Multiresource Inventory and Soil and Water Resources Conservation Act needs.

Sensor Implementation and Evaluation

- Continue thematic mapper simulator studies over new test areas to estimate suitability of the thematic mapper to SRS needs.
- Evaluate aircraft synthetic aperture radar data collection in 1981 for SRS needs.

Preprocessing

- Finish test of atmospheric preprocessing alternatives begun in 1981.
- Select and evaluate a scanner correction algorithm for future testing.

2.2 FY83 Objectives

Crop Area Estimates for Major Crops

- Expand crop acreage estimation efforts to eight states if possible.
- Implement procedures for reducing costs of analysis efforts for major crop estimates.
- Continue research work with rice and small grains in the Sacramento Valley of California.

Registration

- Study use of automatic scene-to-map algorithm for scene to scene applications.

- Conduct exploratory test of scene-to-scene on line procedures.

System Improvements and Development

- Concentrate on optimization of small scale and large scale analysis software.

- Evaluate processing results from thematic mapper data and make any needed adjustments in software or handling procedures.

Clustering/Classification Evaluations

- Complete comparison of subanalysis district estimation alternatives for crop area estimates.

- Adapt contextual information classifier and other land cover classification algorithms on line for exploratory testing.

Product Use

- Develop revised land cover map products for review by Kansas potential data users.

- Develop basic map products of selected Missouri areas for review by potential data users.

Land Cover Inventory and Mapping

- Calculate land cover estimates for Missouri based on probability ground data and on Landsat data combined with ground data.

- Evaluate map product accuracies for Kansas and Missouri product use element products.

- Evaluate land cover information alternatives with the Soil Conservation Service.

Sensor Implementation and Evaluation

- Conduct parallel comparison of MSS and TM data from Landsat D satellite.

- Evaluate available synthetic aperture radar and large format camera data.

Preprocessing

- Complete evaluation of effects of preprocessing alternatives on clustering and classification results.

- Adapt selected preprocessing procedures into the EDITOR software system.

2.3 Summary of Responsibilities

Work on the DCLC Project has been a shared effort of the Remote Sensing Branch and selected SSO's of the SRS along with researchers located in the NASA installations at the National Space Technology Laboratory in Mississippi, at the Johnson Space Center in Houston, and at the Ames Research Center in California. In FY82 the Goddard Space Flight Center will also conduct some of the DCLC research.

With the exception of the Current Area Estimates for Major Crops and the Product Use elements for which SRS provided almost exclusive management there is some sharing of management responsibility for each element. However, SRS provides overall management of the Systems Improvement and Development element and the Preprocessing element. NSTL serves in the key management role for the Registration. Sensor Implementation and Evaluation, and Land Cover Inventory and Mapping elements. NSTL and JSC share management responsibility for the Clustering/Classification Evaluation element.

SRS has the responsibility for providing almost all ground truth, for establishing performance criteria, for contacting potential users of outputs, for establishing and conducting pilot tests, and for adapting procedures on line. SRS and the NASA Centers share the responsibilities for providing remotely sensed data for assessing present technology, for developing procedures and statistical tests, for testing at the proof of concept level.

Detailed responsibilities for each element, task and subtask are included in the specific writeups in Section 4 of this plan.

3.0 Summary of Available Resources

The following three tables itemize resources available in FY82 and FY83 plus present a consolidated schedule of research activities. The Dollar and Staffing Resources table has been specified to the subtask level. However, the Work Breakdown Structure does not provide for a subtask level so subtask details have been aggregated to task totals.

SRS funds in the Work Breakdown table have been broken out into categories for Landsat purchases, processing costs, equipment purchases, and cooperative agreements as well as civil servant salaries and related costs. The NASA costs for each center are shown as a single item for each task or subtask since most funds are for support contractors.

3.1 Dollar and Staffing Resources by Task or Subtask

Element and Task or Subtask	FY 82 $ SRS	FY 82 $ NASA	FY 82 MYE SRS	FY 82 MYE NASA	FY 83 $ SRS	FY 83 $ NASA	FY 83 MYE SRS	FY 83 MYE NASA
Current Area Estimation								
Full State Crop Estimates	1200	0	20.2	0	1245	0	21.0	0
Other Crop Estimates	250	0	2.0	0	200	0	2.0	0
Registration								
Multitemporal/Scene-to-Scene	20	50	0.3	1.0	0	0	0	0
Scene-to-Map	20	50	0.3	1.0	0	50	0	1.0
Systems Improvements and Development								
EDITOR Evaluation and Analysis	340	40	1.6	1.0	190	40	1.5	1.0
Future System Design Study	20	~~15~~ 10	0.2	~~0.2~~ .1	20	15	0.2	0.2
Clustering/Classification Evaluations								
Evaluation of Alterative Estimates	40	~~255~~ 225	0.1	~~0.5~~ .3	20	255	0.1	0.5
Comparative Study of Battese-Fuller Estimator	85	0	1.1	0	0	0	0	0
Land Cover Classification/Mapping Algorithms	25	70	0.3	1.4	25	100	0.3	2.0
Consolidated Procedures for Estimation & Mapping	0	40	0	0.8	10	75	0.1	1.5
Product Use								
User Participation and Evaluation	40	0	0.4	0	50	0	0.4	0
Land Cover Inventory and Mapping								
State Level Land Cover Estimates	230	15	2.0	0.3	200	25	2.0	0.5
Land Cover Estimates with Field Verified Data	0	50	0	1.0	0	0	0	0
Map Products	35	100	0.4	0.5	35	90	0.4	0.4
Change Detection/Monitoring	10	~~175~~ 150	0.1	3.5	10	195	0.1	3.9
Geographic Information System	10	~~300~~ 250	0.1	5.0	10	400	0.1	7.0
Sensor Implementation and Evaluation								
Thematic Mapper Procedure Development	40	~~400~~ 300	0.5	4.5	40	450	0.5	4.9
Development for other Sensors	25	~~245~~ 175	0.2	2.5	25	275	0.2	2.8
Future Sensor Needs	0	25	0	0.2	10	77	0.1	0.8
Preprocessing								
Preprocessing Procedures	10	~~70~~ 50	0.1	0.5	10	70	0.1	0.5
TOTALS	2400	~~1900~~ 1600	29.9	~~23.9~~ 20.4	2100	2117	29.1	27.0

3.2 Consolidated Work Schedule

Element and Task or Subtask

Current Area Estimation
- Full State Crop Estimates
- Other Crop Estimates

Registration
- Multitemporal/Scene-to-Scene
- Scene-to-Map

Systems Improvements and Development
- Editor Evaluation and Analysis
- Future System Design Study

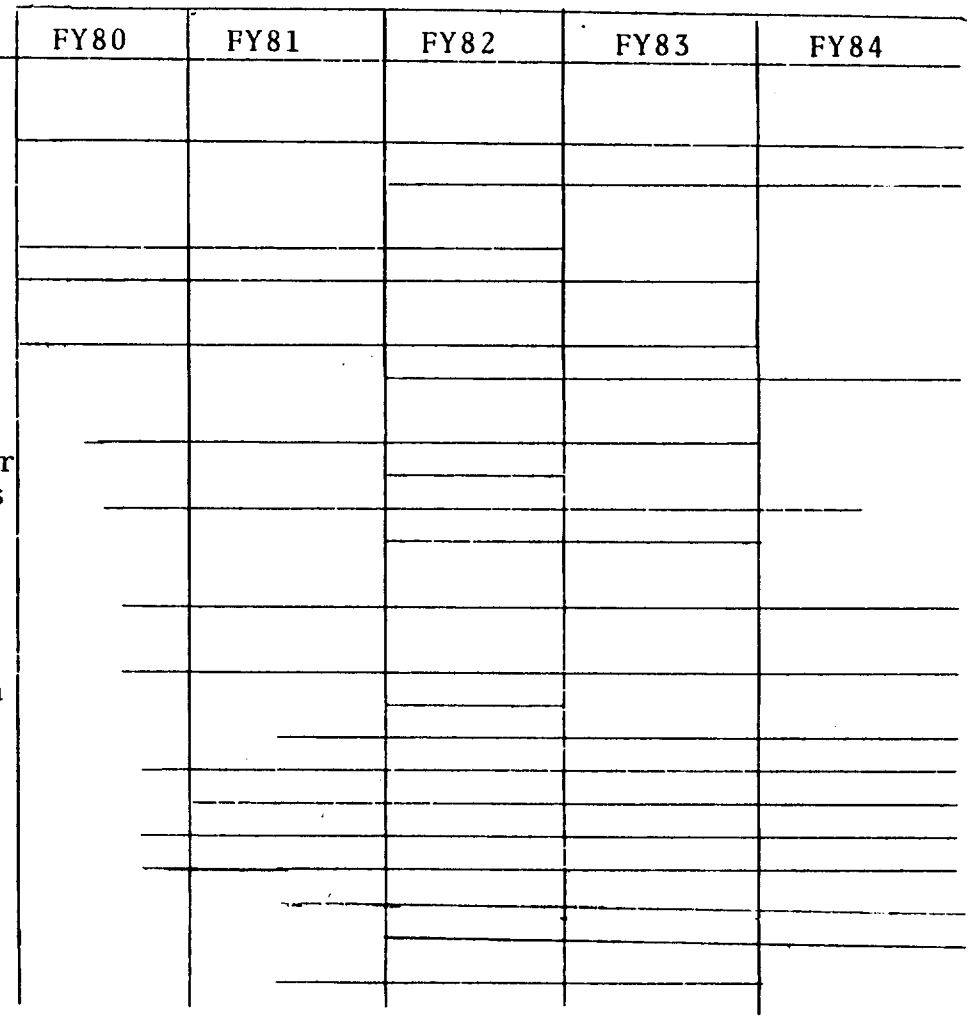
Clustering/Classification Evaluations
- Evaluation of Alterative Estimates
- Comparative Study of Battese-Fuller Estimator
- Land Cover Classification/Mapping Algorithms
- Consolidated Procedures for Estimation & Mapping

Product Use
- User Participation and Evaluation

Land Cover Inventory and Mapping
- State Level Land Cover Estimates
- Land Cover Estimates with Field Verified Data
- Map Products
- Change Detection/Monitoring
- Geographic Information System

Sensor Implementation and Evaluation
- Thematic Mapper Procedure Development
- Development for other Sensors
- Future Sensor Needs

Preprocessing
- Preprocessing Procedures



3.3 Work Breakdown Structure by Task

	Element	Task					
.06	.01	.01	.01	.00	.120810	.010810	.010810
					.120040	.010040	.030040
					.120080	.010080	.250080
					.120270	.010270	.320270
.06	.01	.02	.01	.00	.120095	.010095	.010095
					.120005	.010005	.030005
					.120100	.010100	.070100
					.120010	.010010	.250010
					.120040	.010040	.320040
.06	.02	.01	.01	.00	.120015	.010015	.010015
					.120005	.010005	.320005
					.200050	.130050	.020050
.06	.02	.02	.01	.00	.120015	.010015	.010015
					.120005	.010005	.320005
					.200050	.130050	.020050
.06	.03	.01	.01	.00	.120090	.010090	.010090
					.120060	.010060	.250060
					.120190	.010190	.320190
					.200040	.140040	.250040
.06	.03	.02	.01	.00	.120020	.010020	.010020
					.200015	.140015	.150015
.06	.04	.01	.01	.00	.120085	.010085	.010085
					.120040	.010040	.320040
					.200225	.020225	.020225
					.200030	.020030	.770030
.06	.04	.02	.01	.00	.120015	.010015	.010015
					.120010	.010010	.320010
					.200070	.130070	.020070
.06	.04	.03	.01	.00	.200040	.130040	.020040
.06	.05	.01	.01	.00	.120030	.010030	.010030
					.120010	.010010	.320010
.06	.06	.01	.01	.00	.120095	.010095	.010095
					.120005	.010005	.030005
					.120020	.010020	.250020
					.120060	.010060	.320060
					.120050	.010050	.450050
					.200065	.130065	.020065
.06	.06	.02	.01	.00	.120045	.010045	.010045
					.120010	.010010	.320010
					.200400	.130400	.020400
					.200100	.140100	.020100
					.200075	.330075	.020075
.06	.07	.01	.01	.00	.120035	.010035	.010035
					.120005	.010005	.320005
					.200225	.130225	.020225
					.200100	.330100	.020100
					.200075	.140075	.020075
.06	.07	.02	.01	.00	.120020	.010020	.010020
					.120005	.010005	.320005
					.200245	.130245	.020245
.06	.07	.03	.01	.00	.200025	.130025	.020025
.06	.08	.01	.01	.00	.120010	.010010	.010010
					.200057	.020057	.020057
					.200013	.020013	.770013

Coding Explanation

6th Level Breakout:	12 Refers to SRS Resources 20 Refers to NASA Resources
7th Level Breakout:	01 Refers to Washington, DC 02 Refers to Johnson Space Center 13 Refers to NSTL Earth Resources Laboratory 14 Refers to Ames Research Center Laboratory 33 Refers to Goddard Space Flight Center
8th Level Breakout:	01 Refers to Civil Servants Salary and Support 02 Refers to Lockheed Support Contracts 07 Refers to University of California at Berkely 25 Refers to Institute for Advanced Computations 32 Refers to Private Industry Contracts 45 Refers to NSTL Earth Resources Laboratory

4.0 Task and Subtask Writeups

An effort has been made in the current Project Implementation Plan to include brief summaries of FY80 ~~and FY81~~ progress, where applicable. There are a number of changes in emphasis for FY82 based on FY81 experiences.

Personnel and dollar resources are specified for each task or subtask. The detailed breakdown of dollar resources is included in Section 3.3 of this plan rather than by individual task.

4.1 Project Element - Current Area Estimation for Major Crops

4.1.1 Task 1 - Full State Crop Estimates

4.1.1.1 Description of Task

1. Background

Based upon SRS 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, if Landsat data and funding remain 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, Colorado, Illinois and Missouri) for the purpose of substantially reducing the sampling error of crop area estimates at the state and substate levels compared to conventional SRS 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 SRS Crop Reporting Board and the SRS State Statistical Offices official estimates.

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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 SRS projects, where the primary variable is SRS ground reported acres from the June Enumerative Survey. The procedures used to accomplish this task comprise the SRS 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. Ancitipated results for ~~FY82~~ FY83 are crop area estimates for winter wheat in Colorado, Kansas and Oklahoma and for corn and soybeans in Iowa, Illinois ~~and~~ Missouri, and [illegible] at the state and substate levels. All data security procedures of SRS will be strictly enforced.

4.1.1.3 Responsibility

SRS's Research Division will have primary responsibility with ~~Rich Allen~~ George Hanuschak as Task Manager.

4.1.1.4 Resources

	~~FY82~~ FY83 $	MYE	~~FY83~~ $	MYE
SRS	~~1200~~ 1400	~~20.2~~ 21.0	~~1245~~ 1600	~~21.0~~ [illegible].0
NSTL	0	0	0	0

SRS 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

Milestone	Location	Colorado, Kansas & Oklahoma	Missouri, Iowa & Illinois
Prepare for ground data collection	SRS/RD	11/81- 4/82	11/81- 4/82
Ground data collection	SRS/SSO	5/82-6/82	5/82-7/82
Ground data editing	SRS/SSO	6/81-7/82	6/81-7/82
Segment Digitization	SRS/SSO	7/82-9/82	7/82-9/82
Acquire Landsat Data CCT's & B&W Transparencies	SRS/RD	4/82-7/82	7/82-10/82
Register Landsat scenes	SRS/RD	6/82-7/82	10/82-11/82
Analyze Landsat data and calculate Regression estimates	SRS/RD	8/82-9/82	11/82-13/82
Write-up research	SRS/RD	10/82-2/83	1/83-3/83

Within the milestone calendar 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 (band 5 and 7) delivered to USDA/SRS from USDI/EROS two to three weeks after satellite acquisition.

° Registration of Landsat scene to map base by SRS 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 for full frame classification.

° Submission of crop area estimates in a timely fashion to SRS'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 SRS two to three weeks after satellite acquisition.

Full frame data are required for complete coverage (minus clouds) of major crop areas of the six states during the optimum time period of discrimination of the crops of interest. Data for Kansas, Colorado and Oklahoma will be needed for the April 1 - May 31, 198[illegible] timeframe. Data for Iowa, Illinois ~~and~~ Missouri will be needed for the July 15 - September 15, 198[illegible] timeframe.

This will be approximately 115 LANDSAT scenes. The number of scenes required will increase 20 scenes per year through 1984.

A computer capability equivalent to Cray-1S must be maintained and provided by NASA through FY84. 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 Plan

If Landsat data are not available for the 1983 crop year then the following projects are planned.

1. Acquire 1981 ASCS photos for segments for Missouri and Oklahoma and photo interpret them for land cover, and then calculate land cover area estimates using ground data only and also ground data plus Landsat.

1. Large scale test of off-line segment digitization and/or auto-digitization using historic segment data.

2. Put segment digitization and plotting software up on the Iowa State Statistical Office PDP 11/70.

3. Design and implement a study to reduce the costs and labor associated with the regression estimator.

If the 1983 Landsat data are of good quality but not delivered to SRS in a timely fashion, then the estimates will be calculated after the Annual Crop Summary and used primarily as check data.

4.1 Project Element - Current Area Estimation For Major Crops

4.1.2 Task 2 - Other Crop Estimates

4.1.2.1 Description of Task

1. Background

Research into areas which are important with respect to crops other than winter wheat, corn, and soybeans is needed to prepare strategies for future applications of Landsat information. Further research is planned for multitemporal application in areas where there are more than one or two major crops. The State of California offers a wide variety of crops in any given area and also a large percentage of cloud-free scenes during the growing season.

Earlier Landsat based studies in California have included area frame construction research (1976 data), estimates of cotton and barley planted area (1976 unitemporal data in Kings and Tulare counties), a repeatibility study in Kings and Tulare in 1977, estimation of cotton, alfalfa, grapes, small grains, and tree fruits and nuts with 1980 unitemporal data for Merced and Fresno counties, and a multitemporal 1980 study that looked at both cultivated and non-cultivated land cover in the Imperial Valley region. For crops estimation purposes, the latter study focused on cotton, sugar beets, alfalfa and all wheat.

In addition to its status in fruit and vegetable production, California is an important producer nationally for cotton (#2), sugar beets (#1), alfalfa seed (#1), barley (#3), all wheat (#12) and rice (#2). Rice estimation using SRS methodology has been studied only once previously (Arkansas 1978). Since the rice crop in California is primarily located in the Sacramento Valley, this will be a very useful area for further research.

2. Objective

This current effort will study the application of Landsat based area estimation to the rice crop in the Sacramento Valley area in California using multitemporal Landsat data from the 1982 crop season. In addition to improved reliability for estimates of rice and other crops major to the region, studies will be made on the breakdowns by county of irrigated versus non-irrigated small grains and on the usefulness of Landsat generated land cover map products.

3. Scope

This task will begin with preparation for ground data collection in late 1981 and end with crop estimates in late 1982. It is intended that these estimates be available to the SSO and the Crop Reporting Board for setting the official end of season estimates. County level estimates will be provided where possible. Irrigation breakdowns and land cover map products should also be available for use on a timely basis.

4.1.2.2 Research to be Conducted

Landsat digital data for a three scene area will be computer classified with respect to major cover types and irrigation practices found in the Sacramento Valley. Training data for this classification will be obtained from both locating JES segments and from ground truth prepared by the California Department of Water Resources (DWR). Various approaches to classification and to the creation of map type products will be utilized to determine the optimum products for the major land covers and breakdowns desired. Crop estimates will be generated using the classified data as an auxiliary variable in a regression estimator.

4.1.2.3 Responsibility

1. The task manager will be SRS, Research Division, Remote Sensing Branch (RSB).

2. SRS will:

(a) collect JES ground data.

(b) conduct manual and machine edits of ground data from JES.

(c) select and purchase appropriate current multitemporal Landsat products.

(d) conduct small scale analysis for regression estimates.

(e) prepare large area estimates for major crops and breakdowns by county.

(f) assist with breakdowns by irrigation practices and with creation of land cover mapping products.

3. ARC will:

(a) assist with digitization of ground truth boundaries.

(b) process large scale classifications.

(c) assist with preparation of ground truth.

(d) assist with preparation of map type products.

4. U.C. Berkeley/DWR will:

(a) assist with preparation and digitization of ground truth, especially with respect to irrigation practice and land covers not found in the JES segment data.

(b) implement classification strategies using methodology not currently available in the EDITOR system, such as the use of prior estimates and other ancillary data in the classifiers.

(c) coordinate objectives for and creation of map type products.

(d) assist with breakdowns of land covers by irrigation practices.

4.1.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	250	2.0	200	2.0
ARC 1/	0	0	0	0
UCB/DWR1/	0	0	0	0

1/ Inputs from ARC, UCB and DWR are from non AgRISTARS sources.

4.1.2.5 Schedule

Milestone	Main Location	Dates
Questionnaire Preparation	SRS/RD	10/81 -12/81
Ground Data Collection and Editing	SRS/SSO	4/82 - 7/82
Segment Digitization	UCB/DWR	7/82 - 9/82
Landsat Acquisition	SRS/RD	7/82 10/82
Registration of Landsat	SRS/RD	7/82 -11/82
Classification and Analysis	SRS/RD UCB/DWR	10/82 -12/82
Creation of Output Products	UCB/DWR SRS/RD	10/82 - 2/83
Writeup Research	UCB/DWR SRS/RD	2/83 - 3/83

4.1.2.6 Interfaces

Communication will be established with the California State Statistical Office, NASA-Ames, California Department of Water Resources, and the University of California at Berkeley. Interfaces will also be established with the land cover and product use elements of the DCLC Project. ARC inputs will be funded by other ongoing programs rather than AgRISTARS.

4.1.2.7 Data Requirements

1. Landsat

(a) current year (1982) multitemporal data will be provided by SRS.

(b) previous year (1976) multitemporal data will be provided by UCB/DWR.

2. Ground

(a) SRS will provide 1982 JES segment data

(b) UCB/DWR will provide ancillary data from previous studies in this region.

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 and assess the currently available methods and algorithms. Execute a test to compare mathematical and statistical algorithms. A registration procedure will be developed and 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 FY83. Algorithm development and initial exploratory testing was completed in FY81. Additional improvements and development of a scene-to-scene map capability will be done during FY82-83 with a goal to adoption on-line in FY82.

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 SRS.

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 by NSTL and SRS, and implemented by NSTL in an exploratory test in FY81.

After selection of a suitable registration method, further testing will continue in the exploratory test mode. This phase will require selected analysis areas containing SRS 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 the 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 exploratory testing would lead to the adaption of these methods/procedures into an on-line program such as the CDC 7600 computer or the CRAY 1S computer at ARC.

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) Exploratory testing and evaluation.

(e) Support of adaption on-line as well as accuracy assessment and performance evaluation.

3. SRS will:

(a) Support the assessment, experiment design, procedure development, and exploratory testing.

(b) Support adaption on-line.

(c) Conduct Pilot Test.

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

(e) Establish performance criteria.

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

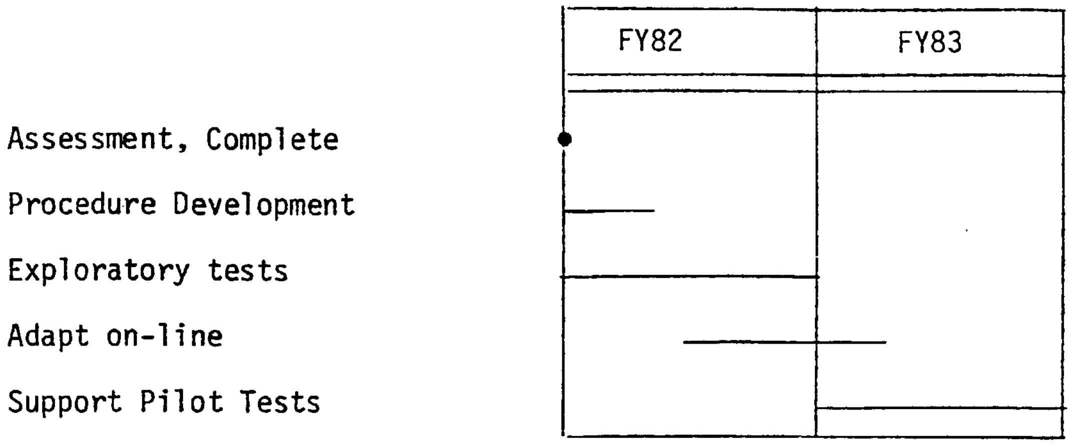
4.2.1.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	20	0.3	0	0
NSTL	50	1.0	0	0

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.

SRS civil service manpower will support directly their assigned work and provisions for technical management. Their dollars allow for SRS 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

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

2. Preprocessing

N/A

4.2 Project Element - Registration

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 SRS segment data to Landsat MSS data. The degree with which the procedure is automatic will depend on the algorithm used which in turn will depend on the accuracy of a given initial registration and the data characteristics.

2. Summary of 1981 Results

During the last year, a study was made to determine the accuracy of the P-format registration provided by the HOTINE tick marks of the CCT's. The results of this study are reported in AgRISTARS report number DC-Y1-04069 entitled "An Evaluation of MSS P-Format Data Registration."

The conclusions in that report are stated as answers to three questions.

a. Is the registration accuracy of the MSS data adequate for the scene-to-map registration task of the AgRISTARS DCLC project?

No, because the scene-to-map registration task requires an error of less than a pixel for each SRS segment within the scene. Therefore, a more precise local fitting will be required for each segment. However, the registration of the P-format Landsat MSS data that have been registered using the control points in the Master Data Processor (MDP) can be used as a starting point for an algorithm that will automatically register the SRS segment data to the Landsat MSS data. If the algorithm uses a search window of 10 Landsat columns by 10 Landsat rows, then out of the 12 Landsat scenes analyzed in this study, 8 would fall within the window search area of this algorithm.

b. Does the registration accuracy depend heavily upon the quality assessment number?

The quality assessment number is not necessarily a good indicator of the registration accuracy. Examples are given in the report to substantiate this claim.

c. What problems are associated with using the registration information on the CCT's and can these problems be "worked around" for the scene-to-map task of the AgRISTARS DCLC project?

The potential documented problems of bypassed control points in the MDP, the scan line start problem, and the light source switch were enumerated in report DC-Y1-04069. When there are problems with the registration defined by the tick marks, the algorithm would compute low correlations for all attempts to match the segment data with the Landsat data within the 10 x 10 window. This would be an indication to the analyst that there is a problem with the data set and that the data set will have to be registered by another technique.

During 1981, an algorithm was developed that enhances field boundaries within the Landsat data. This algorithm is part of the process used in the Automatic Segment-to-Map algorithm (ASMA).

The edge values are output at every 1/2 Landsat row and 1/2 column in the vicinity of the segment data. A gradient calculation is used for the edge enhancement process.

The ASMA uses the enhanced edges from the Landsat and the reconstructed segment from the SRS segment calibration file and tries to find the best match. The segment is shifted $\pm$ 10 Landsat rows and $\pm$ 10 Landsat columns from the initial registration.

During 1981, 30 SRS segments from Landsat scene 21980 - 16264 were shifted both manually and by ASMA. The shift numbers from ASMA were compared with the shift numbers found by two SRS personnel working independently.

Out of the 20 June Enumerative Survey (JES) segments, the results from ASMA were either identical or very close to at least one of the SRS personnel 17 times. The algorithm was stumped 3 times.

3. Scope of Remaining Tasks

a. Investigate the problems associated with ASMA being unable to successfully shift three of the 20 JES segments used in the exploratory experiment.

b. Investigate incorporating into ASMA a second stage test of within field dispersion to be used in conjunction with the boundary information.

c. Program ASMA to compute some type of confidence number associated with the shift numbers.

d. Implement the revised ASMA on the CDC 7600 at the Ames Research Center.

e. Test ASMA using a maximum of seven scenes from the California study area or elsewhere.

f. Evaluate the registration accuracy of more geometrically - corrected scenes using a procedure similar to the one described in report number DC-Y1-04069.

g. Investigate using the scene-to-scene technique to find new shift numbers based on the one scene where the segments were previously shifted.

4.2.2.2 Research to be Conducted

1. Technical Approach

The second stage test of within field dispersion will be determined by computing the variances of the edge data within each field for a given shift. Where the boundary values are high and the variances are low should indicate a good match between the SRS segment data and the Landsat data.

A 'confidence number' can be defined in terms of the magnitude of the sum and variance that determines the 'best match' with respect to the other sums and variances. The confidence number along with the other shift numbers should indicate when the algorithm has been stumped.

2. Anticipated Results

It is expected that not all segments can be matched within a given scene using the ASMA. However, it is anticipated that the algorithm should be able to determine which segments cannot be matched.

4.2.2.3 Responsibility

1. The overall task manager will be NSTL

2. NSTL will

(a) Provide technical and contract management for their assigned tasks.

(b) Assess technology.

(c) Develop procedures.

(d) Test and evaluate proof-of-concept.

(e) Support pilot testing

(f) Support technique adaptation.

3. SRS will:

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

(b) Conduct pilot test.

(c) Perform technique adaption

(d) Integrate acceptable techniques into a LSAT

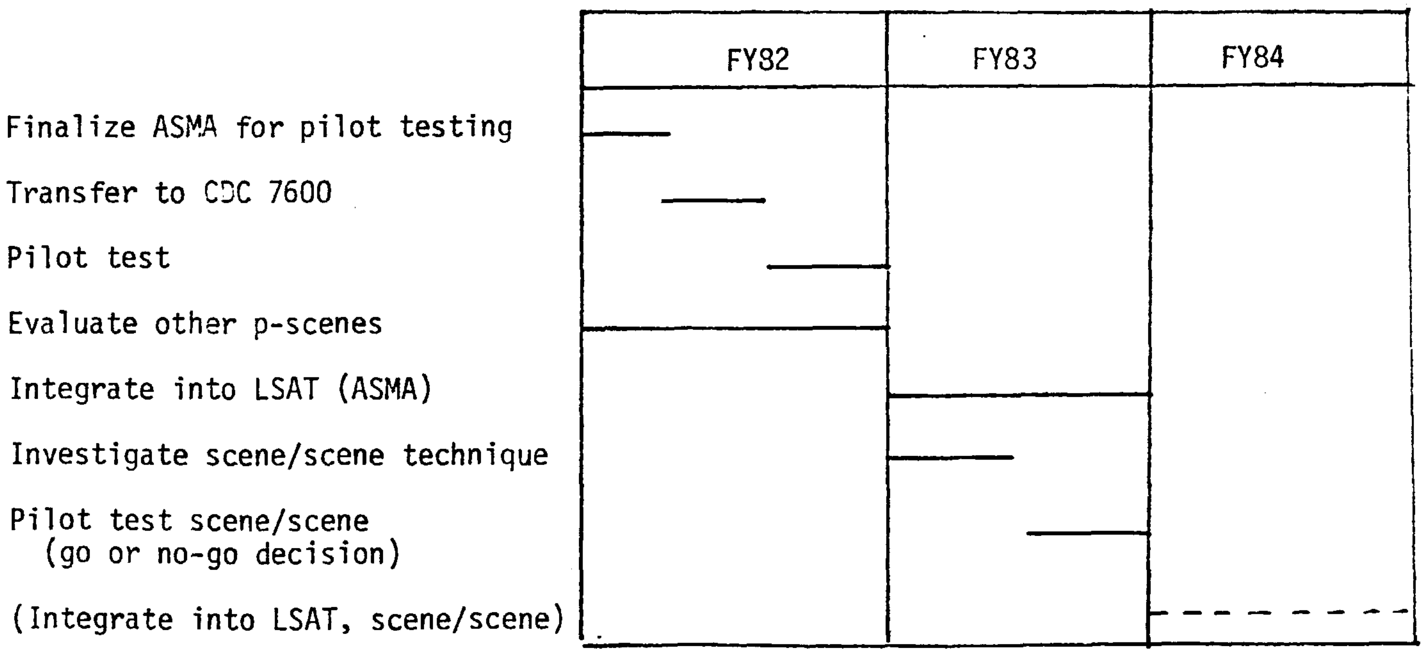
4.2.2.4 Resources

	FY81		FY82	
	$	MYE	$	MYE
NSTL	50	1.0	50	1.0
SRS	20	0.3	0	0

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.

SRS civil service manpower will support directly their assigned work and provisions for technical management. Their funds allow for SRS data processing costs involved for Pilot Testing and the adaptation 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

SRS 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 California study.

4.3 Element 3 - Systems Improvements and Development

4.3.1 Task 1 - Editor Evaluation and Analysis

4.3.1.1 Description of Task

EDITOR is a collection of unique computer software designed to capture geographic field boundaries, extract windows of Landsat data corresponding to ground locations, determine relationships between ground and satellite data through clustering and classification techniques, and to classify entire scenes of Landsat data. EDITOR was designed and programmed in part under contract and in part by SRS and NASA personnel. A particular emphasis of EDITOR is the implementation of procedures up to and including wall to wall Landsat digital classification without requiring image processing interface equipment. EDITOR is used by NASA/AMES, the U.S. Geological Survey, and others in addition to use by SRS.

1. Objectives

This task is intended to evaluate the present EDITOR code for suitability to user needs and to explore modifications, improvements and extensions of the EDITOR system. As a part of this objective additional hardware and software alternatives will be evaluated.

2. Scope

The EDITOR software consists of two main portions:

a. The ILLIAC IV code which is primarily used for the large scale wall to wall classification of Landsat scenes. This code is so named since it was originally developed for implementation on the ILLIAC IV computer. This constitutes about 10 percent of the total EDITOR software.

b. The BBN code which performs all of the data entry, handling, and classification operations for small scale analysis.

The EDITOR software system was set up to utilize the unique features of a "supercomputer" such as the ILLIAC IV and the relative low cost of a minicomputer configuration such as that available through BBN. It is possible to perform all EDITOR operations including large scale classification on the BBN computers but this would require a 12 hour or so computer job on BBN compared to two minutes on an ILLIAC IV comparable machine. Conversely, it is possible to perform most small scale analysis steps on an ILLIAC IV type machine but this is an inefficient use of a vector processing machine.

All new procedures developed, tested and accepted the DCLC project will be implemented into the EDITOR system.

3. Accomplishments

A number of improvements and additions to the EDITOR system have been made during the first two years of the DCLC project. The CLASSY procedure which was evaluated in FY80 was installed into EDITOR for FY81. The number of users of SRS resources accessing EDITOR more than doubled during FY80 and FY81 so it was necessary to convert several large computer resource usage jobs to a batch only format to execute after prime shift hours. The expansion of the number of users also increased the amount of effort devoted to monitoring priorities of various users. As more states have been added under Element 1.1 analysis procedures have been standarized to streamline them and reduce the amount of time required for analysis.

One of the major features affecting the EDITOR system during FY80 and FY81 was the decision by NASA to replace the ILLIAC IV computer. Replacement of the ILLIAC by a CRAY-1S computer has required an evaluation of the program versions written for the ILLIAC and conversion of these to operating versions for the CRAY-1S The ILLIAC IV was phased out at the end of FY81 with expected sometime during the first quarter of FY82. Programs have been converted to run EDITOR on a CDC 7600 which will be the interim mainframe process or and which will serve as the production backup to the CRAY-1S.

In conjunction with the plans to replace the ILLIAC IV and in an effort to gain more information on processing alternatives for an operational system SRS issued a FY81 contract with Control Data Corporation (CDC) for a test of large scale EDITOR processing on a CYBER computer. (CYBER was a leading competitor to the CRAY-1S in the selection of an ILLIAC IV replacement.) The CDC contract will allow evaluation of modifications made by CDC to run the EDITOR routines as well as information on operation throughput and costs.

A new technique which was studied in FY81 for probable addition to the EDITOR system was automatic digization. Various video systems were evaluated which would allow replacement of the time and labor intensive manual digitization procedures currently utilized. A report on the automatic digitization findings and conclusions, "An Autodigitizing Procedure for Ground-Data Labelling of Landsat Pixels" was presented at the ERIM Symposium.

Another area of new development during FY82 was the effort to develop software versions of EDITOR programs which might be installed as stand alone off-network procedures on micro or minicomputers. One development in this area was the configuration of a stand alone digitization station which utilizes a micro-computer and a graphics ternimal rather than interactive processing on the main computer network for digitization operations. At the end of FY81 equipment had been acquired and programs compiled but the station was not yet in operation.

4.3.1.2 Research to be Conducted

A key focus of research efforts during FY82 and FY83 will be the implementation of all EDITOR software on the CRAY-1S computer and the evaluation of the CRAY versus the CDC 7600 and CDC CYBER computers. The stand alone digitization procedure under development will be evaluated as a method of controlling costs and making better use of limited resources. In a similar vein, EDITOR digitization and plotting software will be installed on a PDP 1170 minicomputer in the SRS Iowa State Statistical Office. The necessary video and computer software equipment for automatic digitization will be acquired and tested.

Emphasis FY82

-Install CRAY-1S software

-Test stand alone digitization

-Install software on Iowa SSO computer

-Acquire and test automatic digitization equipment

-Explore cost effective analysis procedures

Emphasis FY83

-Pilot test of automatic digitization procedures

-Evaulation of CRAY-1S programs for efficiencies

-Install additional procedures on inhouse minicomputers

4.3.1.3 Responsibility

SRS will define requirements for any specifically contracted program development or modification. SRS will acquire equipment for automatic digitization operations. ARC and SRS will share responsibility for evaluation and modification of CRAY-1S versions of EDITOR code. Review of EDITOR software with possible extension to other users will be conducted by ARC.

4.3.1.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	340	1.6	190	1.5
ARC	40	1.0	40	1.0

SRS manpower resources will provide for software development, software modifications, and coordination of research efforts with ARC. SRS dollar resources will provide for automatic digitization equipment, computer resources on the CRAY-1S and BBN computers for program development and maintenance, and contract assistance to ARC. ARC manpower resources will provide for programming, preparation of program specifications, and monitoring of support contractors.

4.3.1.5 Schedule

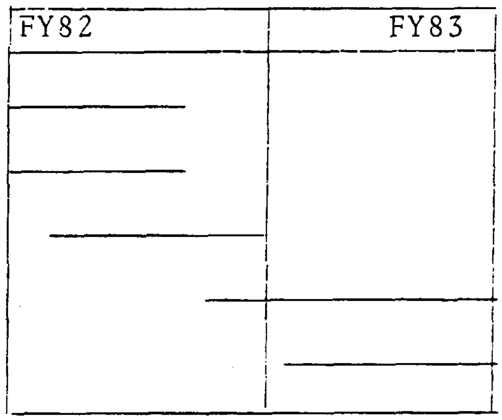
Implement CRAY-1S routines

Install programs on PDP 1170

Acquire/test auto-digitization

Evaluate CRAY-1S improvements

Install new minicomputer routines



4.3.1.6 Interfaces

Since the EDITOR software system is used for all production processing of the DCLC project suggestions for EDITOR improvements or modifications may come from any of the other tasks or subtasks of the DCLC project. Maintaining the CDC 7600 or CRAY-1S large scale processing capability is particular important to the Major Crops Area Estimates element.

4.3.1.7 Data Requirements

This task does not require any ground or satellite data itself. One particular analysis run, accomplished on the ILLIAC IV before its removal, has been established as the benchmark for performance testing of the CDC 7600 and CRAY-1S program versions.

4.3 Element 3 - Systems Improvements and Development

4.3.2 Task 2 - Future System Design Study

4.3.2.1 Description of Task

SRS has utilized the facilities available through NASA/Ames (the ILLIAC IV computer and the ARPANET processing network) for procedure development and research. However, the ARC facilities are designed for research purposes and SRS must consider the acquisition of alternative processing capabilities for an operational structure.

1. Objectives

This task is established to evaluate developments and experiences from all other DCLC elements in terms of possible hardware and software configurations which can satisfy SRS (or USDA needs).

2. Scope

An operational processing system for DCLC would at a minimum allow for the processing of crop area and land cover estimates for ten states which is considered to be a large scale applications test (LSAT) for DCLC. However, any configuration chosen should have the potential for expansion to additional states and have potential for serving USDA users in addition to SRS.

3. Accomplishments

Although this task was not slated for initiation until FY82 certain experiences from the first two years of the DCLC project have already provided important information to be utilized in the design study. For instance, the equipment selected and installed in state statistical offices for digitization and plotting can not be maintained with local service in each location and FY81 experiences demonstrated the needs for fallback plans for equipment downtime. Also, the expansion of the DCLC project to date with network users in at least eight locations has caused overcompetition for system resources during prime working hours while time was readily available on off-peak hours.

4.3.2.2 Research to be Conducted

Procedures and equipment utilized in Task 4.3.2.1 will be closely evaluated in terms of the effectiveness of automatic digitization versus on-line procedures, practicality of analysis procedures on inhouse minicomputers versus network processing, and costs and timeliness of performing such operations such as registration and segment shifting in SSO's rather than in a central location. As analyses are completed for classification of land cover estimates, the equipment and processing needs of these procedures will be compared with comparable requirements for crop area estimates for identification of possible operational configurations.

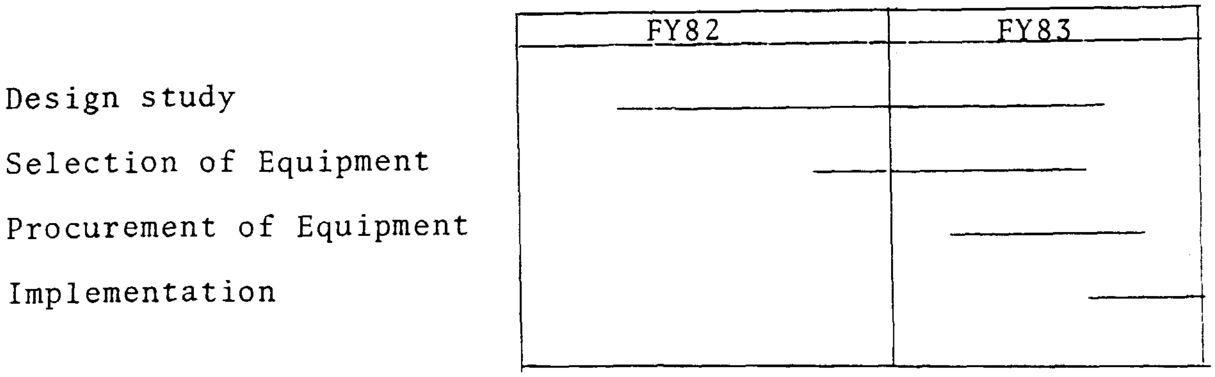
4.3.2.3 Responsibility

SRS will be responsible for evaluation of experiences of research conducted under other DCLC elements and the implications for operational needs. SRS will acquire needed equipment or data processing resources for testing of alternative procedures. ARC will be responsible for identification of alternative hardware or software options.

4.3.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	20	0.2	20	0.2
ARC	15	0.2	15	0.2

4.3.2.5 Schedule



4.3.2.6 Interfaces

The design study is dependent upon results from the Crop Area Estimation and Land Cover Inventory and Mapping elements. Experience with the new automated digitization approach will also be important to the design study efforts.

4.3.2.7 Data Requirements

No Landsat or ground data is required for this task.

4.4 Project Element - Clustering/Classification Evaluations

4.4.1 Task 1 - Improve Classification Capability for Crop Area Estimation

4.4.1.1 Subtask 1 - Evaluation of Alterative Estimators

4.4.1.1.1 Description of Subtask

1. Objectives

a. Evaluate subanalysis district regression estimates

b. Investigate alternative subanalysis district estimates

2. Scope

During FY82 data from only one or two study areas in the U.S. will be analyzed.

4.4.1.1.2 Research to be Conducted

1. Technical Approach

SRS'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. SRS's current estimation method is regression estimation with Landsat classification results as the estimator's auxiliary variable and ground data from SRS'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 SRS segments.

SRS has demonstrated that regression estimation produces unbiased area estimates with measurable precision for areas referred to by SRS as "analysis districts"; i.e., the Landsat acquistion(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 SRS segments to reliably calculate needed regression coefficients. Though regression estimates for subanalysis-district areas (subareas of an analysis district containing insufficient number of SRS segments to reliably calculate regression coefficients) can be calculated, such estimates have the following undesirable properties:

o Subanalysis district regression estimates can be biased.

o Mean square errors of subanalysis district regression estimates cannot be estimated by distribution free methods using only operational type data.

o When distribution free upper bounds for subanalysis district regression mean square errors are currently calculated, the calculated bounds may be unusably large.

o When additional distribution assumptions are made in order to estimate using only operational-type data the mean square error of subanalysis district regression estimates, it is presently not known if these distributional assumptions are valid.

The first phase of this task will be devoted to the study of the properties of classifier-derived segment estimates which are needed to insure that given regression estimators, of the type studied in FY81, are unbiased and can offer significant variance reductions over direct expansion estimates when applied to subanalysis districts. It is expected that these studies will suggest ways to modify classifier design so that regression estimators of the EDITOR, Cardenas, and Battese-Fuller variety have these desired properties. It may also happen that these studies may suggest ways to modify the regression estimators to better meet these objectives. Variance estimators will also be derived if it is anticipated that previously derived estimators do not apply.

These new classifier and estimator designs will be evaluated over research data sets representative of analysis and subanalysis district data. Variances and biases will be estimated by repeated sampling methods. Comparisons will be made to estimates of variances from the derived variance formulas.

The next phase of this study will investigate direct proportion estimators. The fundamental ideas developed in the FY81 studies will be revised to allow for a sample obtained at the district level to be applied to subanalysis district estimates. These approaches will be evaluated over the same research data sets used above and comparisons in terms of bias and variance of these estimators with those of the regression variety discussed above will be made. Also, variance estimators will be investigated and their performance will be evaluated.

2. Anticipated Results

The anticipated results from this task are the following:

- Definition of classifier and subanalysis district acreages estimators which are an improvement over the current EDITOR estimator.
- Methods to estimate the variance of each estimator.
- An evaluation of the performance of all proposed

designs over a research data base.

3. Output Products

A report describing the research results and computer program 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:

- 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.
- Robeson County, North Carolina with "wall-to-wall" ground truth and corresponding Landsat data collected in 1980.

4.4.1.1.3 Responsibility

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. SRS will provide:

(a) Briefings on current procedures.

(b) Research data sets.

(c) Go/no-go decision for technology adaption to on-line.

(d) Technology adaption to on-line.

4.4.1.1.4 Resources

	1982		1983	
	$	MYE	$	MYE
SRS	40	0.1	20	0.1
JSC	255	0.5	255	0.5

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

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

4.4.1.1.5 Schedule

Task	Desired Completion Date
Delivery of detailed technical approach	11/2/81
Determination of classifier properties which lead to conditionally unbiased regression	3/1/82
Development of classifier designs and improved regression estimators along with estimators of variance	6/1/82
Completion of the evaluation of regression estimators	11/1/82

Task	Desired Completion Date
Development of methods to relate district and subdistrict mixture models	3/1/82
Design and evaluation of improved district estimators complete	11/1/82
Final report	2/1/83
Completion of on-line adaptation	3/1/83

4.4.1.1.6 Interfaces

The Robeson county data set was collected in support of the Foreign Commodity Production Forecasting (FCPF) project. Thus, any results from work under this task will be shared with the FCPF project.

4.4.1.1.7 Data Requirements

Both candidate data sets are available presently for use in this task. No other data sets are anticipated for FY82.

4.4 Project Element- Clustering/Classification Evaluations

4.4.1 Task 1 - Improve Classification Capability for Crop Area Estimation

4.4.1.2 Subtask 2 - Comparative Study of the Battese-Fuller estimator

4.4.1.2.1 Description of Subtask

1. Background

During FY81 and continuing into FY82, NASA/JSC carried out an evaluation of the regression and Cardenas estimators on county level data. Results indicate that the variance of the regression estimator is being overestimated. Moreover, the Cardenas estimators do not seem to possess smaller variances than the regression estimator. Alternative county estimators are still needed and the software is available for the proposed Battese-Fuller estimator to be put into the EDITOR system.

2. Objectives

(a) Obtain empirical estimates of the bias and mean square error for the Battese-Fuller estimator.

(b) Obtain comparative information on the variances of regression, Cardenas, and Battese-Fuller estimators.

3. Scope

This three-fold comparison will be carried out on the existing South Dakota 1979 data set. Since this data set is already in EDITOR usable form, the analysis function can start as soon as the software testing for the Battese-Fuller program is completed. The actual Battese-Fuller analysis should begin by mid October 1981 and end in mid FY82. Comparisons will be made with the other estimators as their outputs are available from NASA/JSC.

4.4.1.2.2 Research to be Conducted

1. Technical Approach

A repeated sampling technique will be used to empirically estimate the bias and mean square error of the Battese-Fuller small area estimator. F-tests will be performed to compare Battese-Fuller variances with Cardenas and regression estimator variances.

4.4.1.2.3 Responsibility

1. The task manager will be SRS/RD.

2. SRS will:

(a) Implement Battese-Fuller software into the EDITOR system.

(b) Calculate Battese-Fuller estimates and their properties.

(c) Evaluate and compare those with their counterparts from regression and Cardenas family estimators.

(d) Write a report on the findings of this task.

4.4.1.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	85	1.1	0	0
NASA	0	0	0	0

4.4.1.2.5 Schedule

Implementation of Software	9/81 - 10/81
Calculation of Battese-Fuller Estimates	10/81 - 1/82

Comparison with other Estimators	1/82 - 4/82
Write-up	4/82 - 6/82

4.4.1.2.6 Interfaces

Communication with NASA/JSC (See 4.4.1) to obtain comparative results from other estimators.

4.4.1.2.7 Data Requirements

Landsat data consists of a two scene areas in eastern South Dakota with acquisition dates July 26 and August 25, 1979. Ground data consists of enumerated field and crop information from a 6-county area in South Dakota containing 252 quarter section sample segments.

4.4 Project Element - Clustering/Classification Evaluations

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.

3. Summary of 1981 Results

The first approach of extracting textural information from Landsat data using a 5 by 5 sliding window was investigated.

An algorithm was developed that used the first principal component of the Landsat data as the input. Within each 5 by 5 window, the algorithm used the 9 different 3 by 3 windows possible. A mean and variance were computed for each of the nine 3 by 3 windows. An output value for the center of the 5 by 5 window was determined by using the variance of the 3 x 3 window whose mean was closest to the value of the center pixel of the 5 by 5 window.

After reviewing the data output by this algorithm, it was determined that this approach would probably not yield the textural information that was desired. Therefore, no further investigation is planned for this approach for this task.

The second approach uses spatial classification schemes and the preliminary results look promising. The Contextual Information Classifier (CICL) was developed by Maria Kalcic of NSTL and uses any one of three different methods to reclassify a Landsat image. A description of CICL and the results of using it on Landsat data will be documented in an upcoming report.

Only preliminary work has begun on the third approach of computer image interpretation. A literature search has been conducted and reference material has been reviewed on many different types of algorithms for doing image analysis based on shape, polygons, edges, and other ingredients of image interpretation schemes.

The shape classifier of Ernesto Bribiesca has been of special interest for this approach. During 1981, Dr. Bribiesca visited the NSTL and made a presentation of his shape classifier. During fiscal year 1982, he plans to return and bring the software to implement on a NSTL computer system.

4.4.2.2 Research to be Conducted

The CICL algorithm will continue to be refined and evaluated during the upcoming year. (The description and evaluation of CICL will be documented in an upcoming AgRISTARS report.)

Development of the computer image interpretation scheme will continue by incorporating different existing algorithms and developing new algorithms into one system.

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

4.4.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	25	0.3	25	0.3
NSTL	70	1.4	100	2.0

4.4.2.5 Schedule

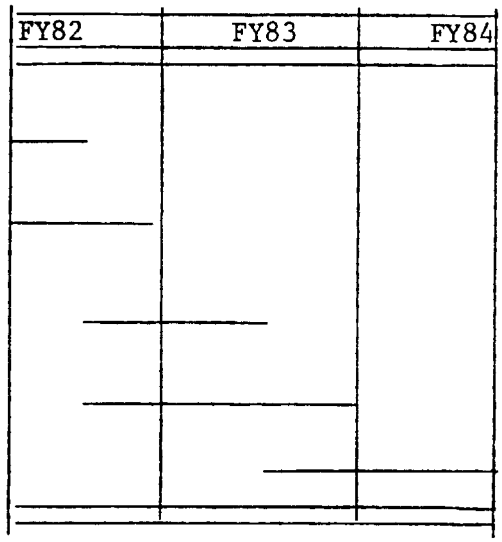
Refine CICL and Evaluate

Development of Computer image interpretation

Test & Evaluate Image Interpretation Procedures

Adapt Algorithms on-line

Pilot Test



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 any other AgRISTARS Projects which may have 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 Project Element - Clustering/Classification Evaluations

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 crop area estimation and land cover mapping requirements, if feasible.

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 began in FY81 and will continue through FY83. After a set of procedures has been developed, an exploratory 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 Geographic 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/Mapping Algorithms). The main efforts under this task will be to identify and consolidate those software modules that would address all data processing steps for both area estimation and mapping of land cover. Programs should be compatible with land cover change detection and geographic information system applications. Software modifications necessary for cost efficient data processing will be carried out where possible.

Data processing will be conducted on a 1980 growing season data set from Robeson County, North Carolina. Wall-to-wall field verification data is available for all major land cover types. Regression estimates using sampled JES data in conjunction with Landsat MSS data will be evaluated using both the JSC EDITOR-based system and the NSTL/ERL-based ELAS system. Similar sampling schemes will be employed to assure comparability for regression estimates.

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. Experimental design and assessment
   c. Development of procedures and software modifications
   d. Exploratory test and evaluation
   e. Support of technology adaptation
3. SRS will provide:
   a. Performance criteria
   b. Support of NSTL activities through exploratory testing
   c. Go/no-go decision for technology adapation to

on-line system

d. Adaptation of technology

4.4.3.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	0	0	10	0.1
NSTL	40	0.8	75	1.5

NSTL civil service manpower will be used predominatly 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.

SRS civil service manpower will support interface coordination and provide assistance in technical management.

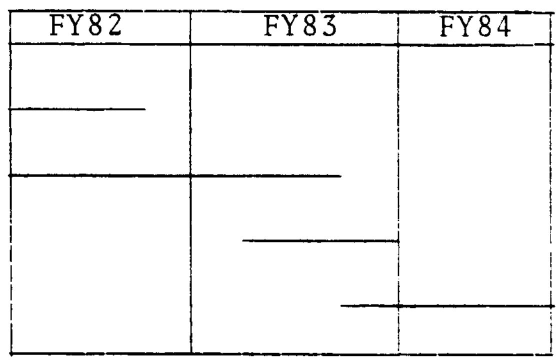
4.4.3.5 Schedule

Assess Tasks 1 and 2

Develop Procedures

Exploratory Test

Adapt On-Line Systems for Pilot Test (integrate with 4.6.2)



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 SRS for remainder of task. Also, coordination with the conservation inventory project 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 1-User Participation and Evaluation of Products

4.5.1.1 Description of Task

1. Background

Landsat crop regression estimates are used by SRS in establishing the state level crop estimates. If the methodology for obtaining these estimates could be expanded to provide non-crop land cover data, the basic "core costs" of materials and processing could be spread over a wider benefit base. The benefits anticipated for providing land cover data will help justify costs of the Landsat crop estimates.

2. Objectives

o 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.

o Investigate the benefits of the land cover inventory and mapping project.

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

In FY81 several federal and state (Kansas) agencies were contacted with regards to the Kansas Land Cover Study. Many of these people provided input in developing the land cover definitions for the survey.

During FY82 a rapport will be developed with these potential data users. State and regional land cover area estimates will be provided for their use and assessment. SRS will work with participants to determine formats for developing land cover maps over small geographical areas. SRS personnel will also help participants in interpreting and using estimate and map products.

These various agencies 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.

4.5.1.3 Responsibility

1. The overall task manager will be from SRS.

2. SRS 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) Create products oriented to serve the needs of participating users.

(e) Develop a user evaluation program.

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

3. NSTL will assist SRS in developing user evaluation programs.

(a) Assist in developing user products.

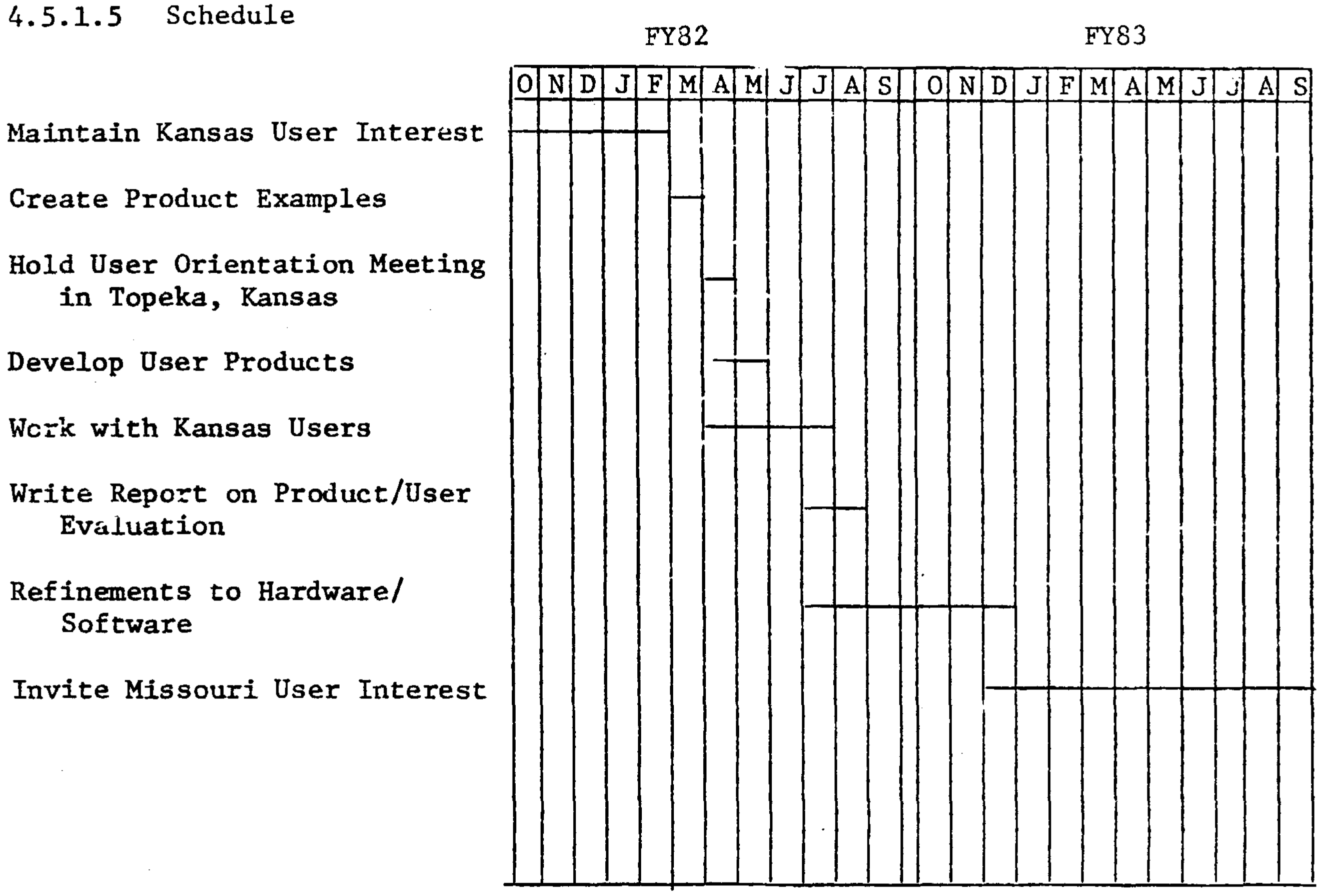
(b) Assist in refinements for continuing participant use.

4.5.1.4 Resources

	FY82		FY83	
	$	MYF	$	MYE
SRS	40	0.4	50	0.4
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

All of the Kansas land cover product use activities will be done in coordination with and under the auspices of the Kansas State Statistical Office.

4.5.1.7 Data Requirements

No direct data requirements from primary AgRISTARS participants are expected.

4.6 Project Element - Land Cover Inventory and Mapping

4.6.1 Task 1 - Land Cover Area Estimation

4.6.1.1 Subtask 1 - State Level Land Cover Estimates

4.6.1.1.1 Description of Subtask

1. Background

To date, the SRS 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 procedures) for providing estimates. Land cover information is an essential component of the resources, conservation, and commodity management baselines for various federal and state users. Recognition of land cover information needs and the potential of using the crop estimation technology, prompted the development of this task.

2. Objectives

o Investigate the use of conventional SRS estimation technology for purposes of estimating major land cover types at the state and substate level.

o Utilize Landsat data as an auxiliary variable with SRS 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.

4.6.1.1.2 Research to be Conducted

1. Technical Approach

During the 1981 Kansas June Enumerative Survey (JES) land cover information was collected along with the crops data. A land cover survey manual was written which describes the 22 land cover terms. The land cover data from the 435 JES segments will be analyzed during FY82. State level direct expansion estimates will be obtained for major land cover types. Landsat data, covering the entire state, will be acquired and used as an auxiliary variable with the ground data to provide regression estimates. The relative efficiency between the two estimates for each land cover type will be determined and assessed. The Landsat land cover classifications and estimates will be used in the Product Use Task, 4.5.1.

The second part of the this task is to develop the Missouri Land Cover Study. Land cover terms will be defined that are pertinent to the landscape of Missouri. A land cover survey manual will be written and ground data collected during FY82. These data will be edited and digitized in preparation for analyses during FY83.

4.6.1.1.3 Responsibility

1. The task manager will be SRS.

2. SRS 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. (see Subtask 2).

4.6.1.1.4 Resources

	FY82 $	FY82 MYE	FY83 $	FY83 MYE
$RS	230	2.0	200	20
NSTL	15	0.3	25	0.5

4.6.1.1.5 Schedule

Finish Kansas Field Edit and Digitizing

Calculate & Analyze Dir. Exp. Estimates

Acquire (ERL) and Register(DC) Landsat scenes (whole state)

Analyze Landsat Data & Calculate Regr. Estimates

Analyze Regr. Estimates

Write Report on Estimates

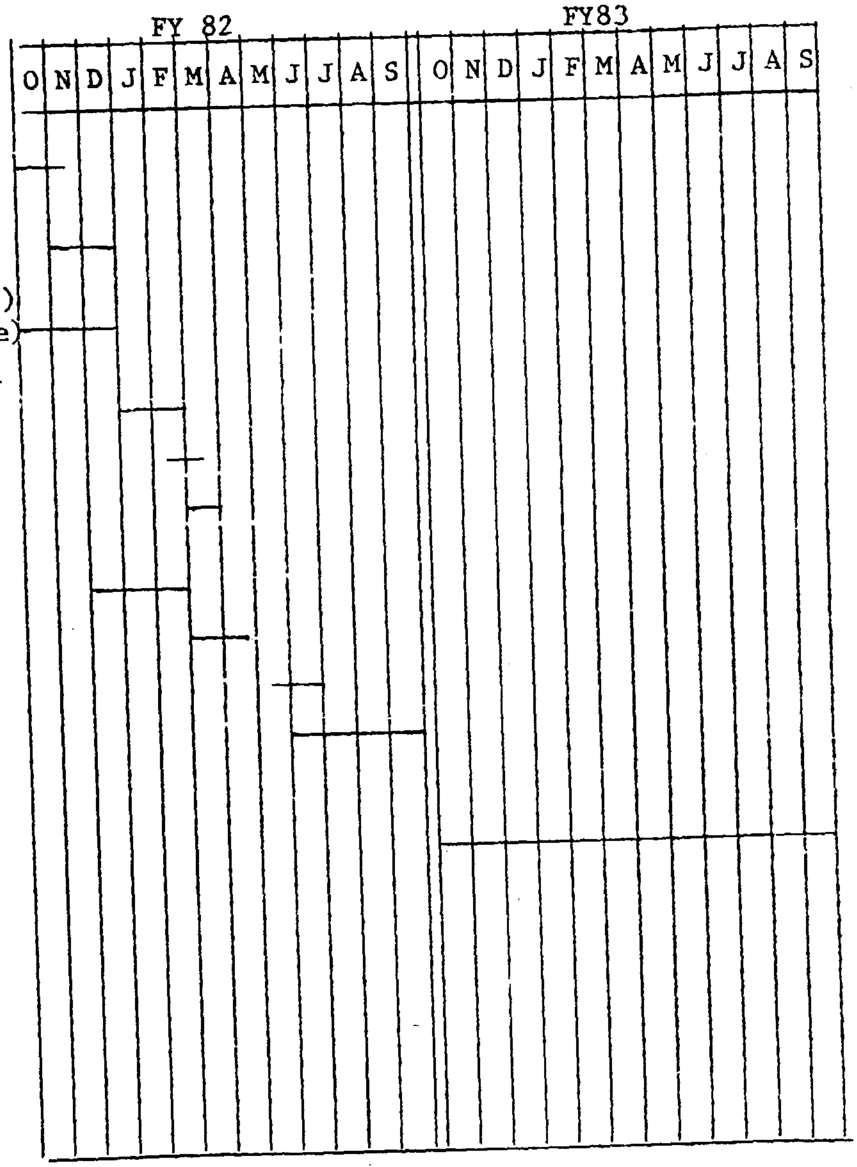
Develop Missouri Land Cover Definitions

Prepare Ground Data Manual

Collect Ground Data

Edit & Digitize Data

Acquire, Analyze, Report on Land Cover Estimates and Products for Missouri



4.6.1.1.6 Interfaces

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

4.6.1.1.7 Data Requirements

1. Landsat data acquired for crop area estimation will be provided by SRS. Any other 1981 data will be acquired by NSTL.
2. Ground data from the 1981 June Enumerative Survey in Kansas and the 1982 June Enumerative Survey in Missouri will be provided by SRS.

4.6 Project Element - Land Cover Inventory and Mapping

4.6.1 Task 1 - Land Cover Area Estimation

4.6.1.2 Subtask 2 - Land Cover Estimates with Wall-to-Wall Field Verified Data

4.6.1.2.1 Description of Subtask

1. Background

The availability of wall-to-wall ground reference data for Robeson Co., North Carolina provides an opportunity to examine several problems related to land cover inventory and mapping using multi-date Landsat data and area frame sampled segment data. Previous work points to possible under-representation of the spectral diversity among land cover types in typical JES sample segments. Spectral overlap problems among land cover types have also been found to complicate land cover mapping using Landsat data.

2. Objectives

o Define an adequate sample size (number of JES segments) for total land cover mapping using multi-date Landsat data.

o Determine the effect of stratifying fields according to soil survey information for the purpose of minimizing spectral overlap problems that may be caused by soil background reflectance differences or differing crop management practices.

3. Scope

Land cover mapping will be evaluated on a county level for map accuracy and area estimates.

4.6.1.2.2 Research to be Conducted

1. Technical Approach

Multidate Landsat data and JES segment data for both cropland and non-cropland cover types are available for the 1980 growing season for Robeson

County, North Carolina. The Landsat data are from September 9, 1980 (primary scene) and June 11, 1980 (secondary scene). Approximately 1870 segments covering all of Robeson County were field enumerated for cropland cover type and later were photointerpreted for identification of non-cropland cover types.

Landsat data will be used to obtain a land cover classification of Robeson County for the purpose of area estimation. The wall-to-wall field verification data will be used to define an adequate sampling scheme for spectral class labeling using several statistical class development procedures as follows:

a. Use SRCH, an unsupervised procedure which collects training statistics from homogeneous fields by passing a 3 by 3 window through the data to define spectral classes for the entire county.

b. Use PTCL, an unsupervised procedure which collects training statistics pixel by pixel to define spectral classes for the entire county.

c. Use WCCL, an unsupervised procedure which collects training statistics on a pixel-by-pixel basis to define spectral classes within previously defined soil strata derived on a field-by-field basis from the modern soil survey of Robeson County. This approach is aimed at minimizing spectral overlap problems among crops which may be aggravated by soil background reflectance differences or differing crop management practices on the widely varying Ultisols, Inceptisols and Histosols predominant in Robeson County.

The spectral class statistics derived from procedures outlined above will be used to classify the whole county using a maximum likelihood classifier. The CICL contextual information classifier will be applied as a post-classification refinement technique to improve the integrity of field definition.

4.6.1.2.3 Responsibility

1. The task manager will be NSTL/ERL

2. NSTL will:

(a) Make available Landsat data and soil survey data.

(b) Register multiple Landsat scenes to each other.

(c) Analyze Landsat and segment data to derive land cover maps and area estimates for the major land cover types.

(d) Report on the findings of this task.

3. SRS will:

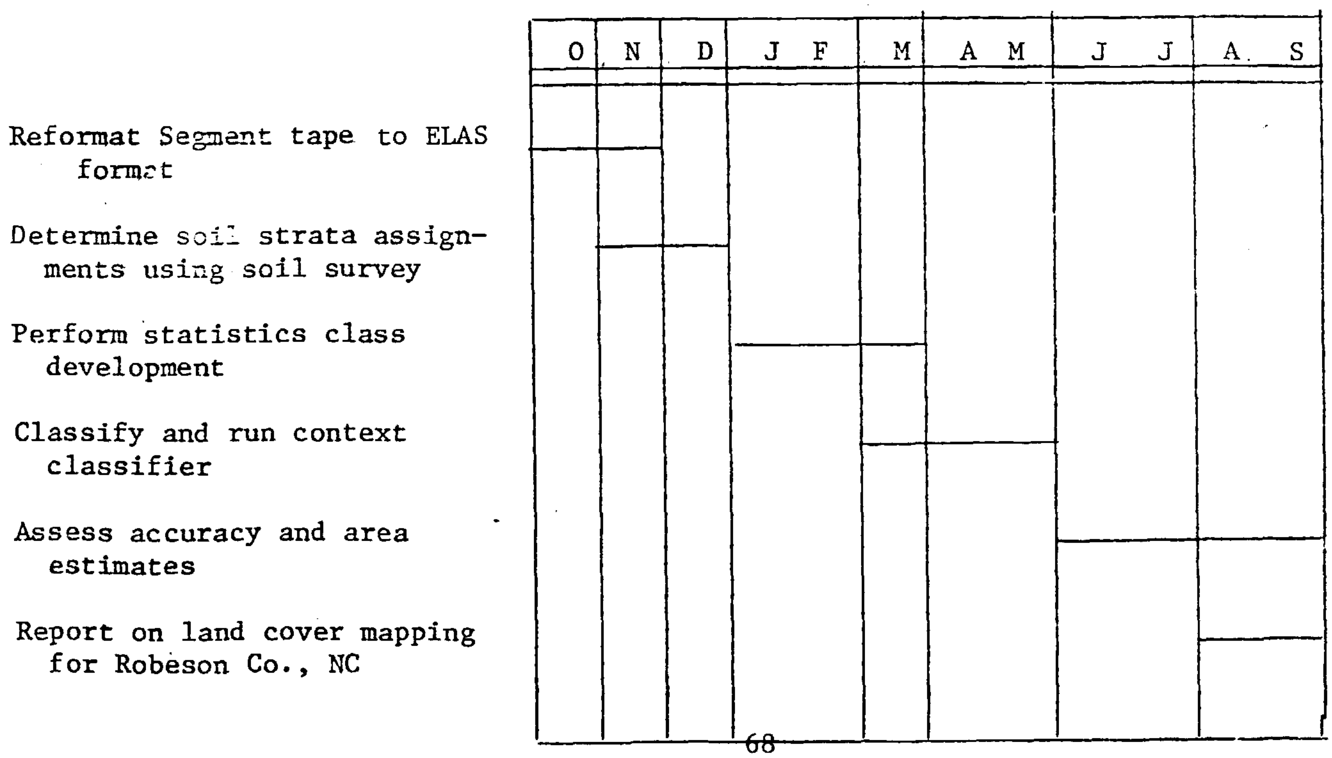
(a) Register Landsat data to the ground referenced segment data.

(b) Provide technical assistance in handling JES segment data.

4.6.1.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
NSTL	50	1.0	0	0
SRS	0	0	0	0

4.6.1.2.5 Schedule



4.6.1.2.6 Interfaces

Results from this subtask will be helpful in comparisons to other land cover tasks.

4.6.1.2.7 Data Requirements

The Robeson county Landsat and ground data have been acquired and will be available for the subtask.

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

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

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

o Evaluate and produce map products in support of Product Use element in this plan.

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 specific cover type. The derivation considers the probabilities associated with each 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.

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

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.

Assessment and/or implementation of the following indicators were completed in FY81.

1) CONTINGENCY TABLE
2) HELLDEN
3) GINEVAN
4) HAY
5) ANALYSIS OF VARIANCE
6) COVER TYPE ODDS
7) HORD AND BROONER
8) T/F TESTS OF HYPOTHESIS
9) VAN GENDEREN AND LOCKE

2. Anticipated results

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

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[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.

o Using feedback from the Product Use element, develop map products at various scales, both color and black and white; develop relative cost factors in map production; compare Cromalin versus Optronics products; and evaluate other map product production equipment.

3. Output Products

o Report describing research results and the procedures for calculating map accuracies.

o Documented software for obtaining and displaying map indicators.

o Classification maps with known map accuracies.

4.6.2.1.3 Responsibility

1. NSTL will be the task manager.

2. NSTL will:

o Provide an assessment of map accuracy indicators.

o Implement selected indicators

o Evaluate the utility of mapping accuracies.

o Develop software for providing various output products.

o Provide documentation on all software development.

o Produce products and other information needed in the Product Use element of this plan such as:

(a) Maps at various scales

(b) Color and black and white products

(c) Color products by Cromalin vs. Optronics

(d) Other type map production equipment

(e) Cost factors associated with production of map products

o Write report describing research results.

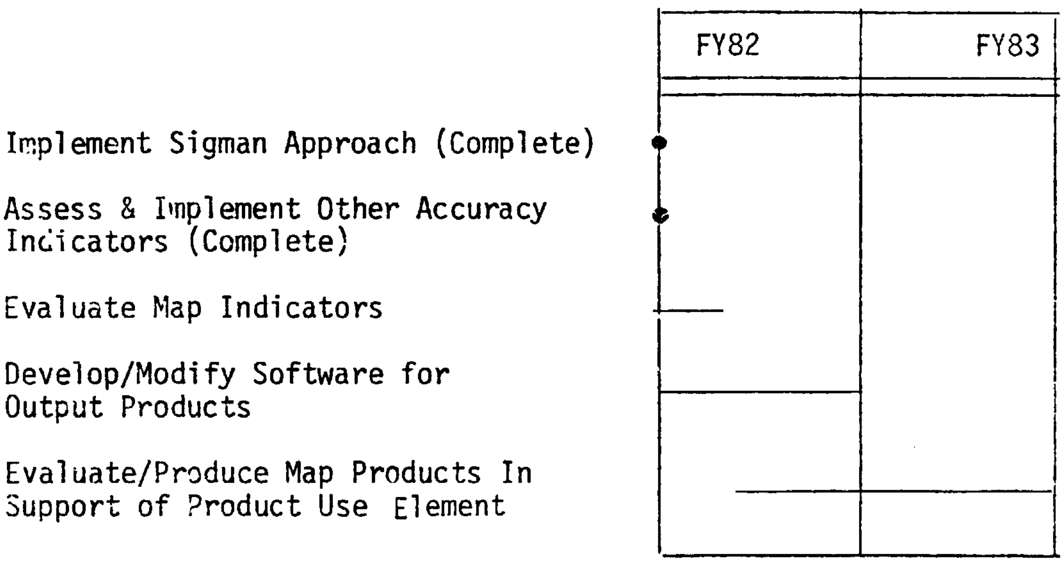
3. SRS will:

- o Provide technical assistance in all aspects of task.
- o Provide data sets for testing and evaluating map accuracy indicators.

4.6.2.1.4 Resource Requirements

	FY82		FY83	
	$	MYE	$	MYE
SRS	35	0.4	35	0.4
NSTL	100	0.5	90	0.4

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 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

SRS will provide registered ground and Landsat data sets for this task.

4.6 Project Element - Land Cover Inventory and Mapping

4.6.2 Task 2 - Land Cover Information Systems

4.6.2.2 Subtask 2 - Change Detection/Monitoring Capability

4.6.2.2.1 Description of Subtask

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 SRS requirements, trend and pattern assessments, and land utilization prediction as well as information useful to SRS in updating land cover strata boundaries and area sampling frames which should result in improving acreage estimates.

1. The objectives of this task are:

a. 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.

b. Develop and determine cost effective methods for storing and retrieving inventory information in a geo-based reference system for updating.

c. Determine those bandwidths and data transformations most useful for delineating change in various vegetative cover conditions.

d. Compare the land cover change detection capabilities of Landsat MSS data with those of TMS/TM data.

2. Scope

Presently much attention is given to the potential utility of a variety of land cover change detection methods. Initially, candidate methods will be investigated and promising techniques will be selected for more intense research. Several of the candidate methods were investigated in FY81 and four techniques were tested on one test site. Procedure development includes modifying (or designing) the software and operation on a representative computer system to establish a credible exploratory test level. Once the change monitoring method reaches this level, it should be documented and released for adaption on-line. 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 SRS 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

Four current methods of change detection were employed in FY81 for evaluations based upon accuracy, user needs, costs, etc., criteria. The four 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 miximum likelihood classifier algorithms. These 2 dates are then registered cell-to-cell and compared for changes in specific land cover distributions.

b. Composite Classification Direct Change - 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.

d. Regression Model - a model is developed through a step-wise regression procedure that, allowing sampling rate constraints, best describes the fit between time 2 (latest) data as a function of time 1 (oldest) data. The residual error of the predicted value and the actual observed value is then output to a data file. Higher residual values indicate higher degrees of change. A critical value is determined and pixels are designated a change or no change status based on their residual value.

These procedures have been developed in FY81 and tested in the Louisiana test site. Continued investigation of change monitoring capabilities will take place through FY83 and FY84 in other test sites with different change conditions.

In addition to developing and testing change detection procedures for various change conditions, discriminant analysis techniques will be used to define the appropriate bands and data transformations. The change detection capabilities of Landsat MSS data will be compared with those of TMS/TM data, and a determination of whether spectral or spatial factors cause these differences will be made.

2. Test Sites

Five exploratory test sites have been defined for testing during procedure development. The first site encompasses an area of rapidly increasing crop land in an area of extensive bottom-land 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 have been 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. A four county area, Finney, Kearny, Grant and Haskell counties will serve as a test site to determine changes in the SRS count units. SRS will digitize strata and count unit boundaries for the 4 county site and furnish the tape to NASA. 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 procedure development test site in a different region with "cropland/pasture to urban" change will be selected in FY82 and Arizona a likely choice. The fourth and fifth test sites are in central Pennsylvania and central Maine, and have been selected to develop procedures for monitoring changes associated with forest disturbances (i.e., clear-cutting and related harvest activities, fire, wind throw, insect defoliation/mortality). Additional test sites will be selected for exploratory tests to begin in FY83 after all procedures have been evaluated.

4.6.2.2.3 Responsibility

1. NSTL will serve as task manager.

2. NSTL will evaluate change detection techniques using data for the Louisiana, Kansas, and Arizona test sites, and GSFC will evaluate change detection techniques for the Pennsylvania and Maine test sites.

3. SRS will:

a. Define potential uses, requirements and applications for change detection techniques within USDA.

b. Digitize the SRS strata and count unit boundaries for the Kansas test site.

c. Establish performance criteria.

d. Support the assessment, experiment design, procedure development, and exploratory testing.

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

f. Perform technology adaption.

g. Develop design specifications for LSAT.

h. Perform Pilot test accuracy assessment and performance evaluation.

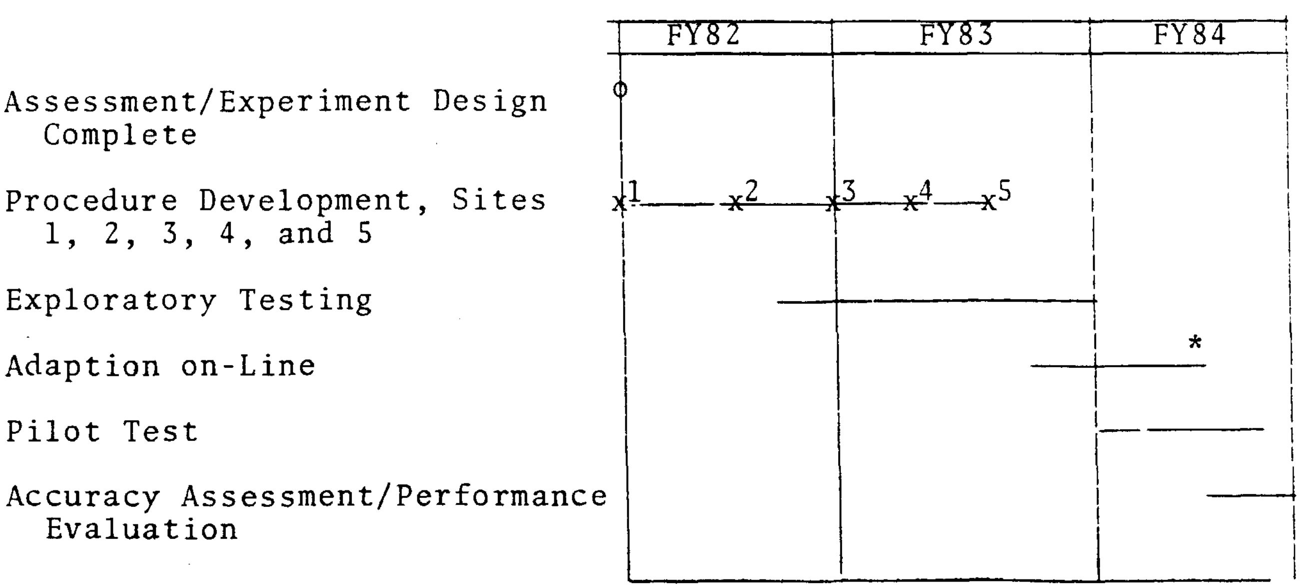
4.6.2.2.4 Resources

	FY82		FY83	
	$	MYE	$	MYE
SRS	10	0.1	10	0.1
NSTL	100	2.0	120	2.4
GSFC	75	1.5	75	1.5

NASA civil service manpower will be predominately for technical and contract management for their assigned work. Most of the NASA funds will be for contracts (both in-house and outside). These funds relate to data processing costs from procedure development through exploratory testing and support of adaption on-line.

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

4.6.2.2.5 Schedule



*go/no-go operational decision

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 and was developed in FY81.

2. It is anticipated that the same change detection techniques that are evaluated and tested with Landsat MSS data will also apply to Thematic Mapper data. Therefore, TMS data acquistion for the Thematic Mapper Procedure Development task (4.7.1) will be coordinated with this 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. SRS will provide interfaces with other USDA agencies and will provide liaison between this project and those agencies.

5. The results from this task will be integrated with the Product Use task. The techology development here will be the basis for data products for the user.

4.6.2.2.7 Data Requirements

Most of the data will be provided through the Current Area Crop Estimates Element. Additional scenes may be required, not more than 10 per year. TM scenes will be required late in the project (FY83 and FY84). 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.

4.6 Project Element - Land Cover Inventory and Mapping

4.6.2 Task 2 - Land Cover Information Systems

4.6.2.3 Subtask 3 - Geographic Information System Application to Inventory and Monitoring

4.6.2.3.1 Description of Subtask (This subtask writeup is preliminary - DCLC Researchers and Soil Conservation Service are developing a final implementation plan.)

1. Objectives

o 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.

o Evaluate the utility of land cover information derived from remotely sensed data after it has been manipulated in geographic information systems for specific applications.

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 (GIS) will be implemented and various types of information will be evaluated in terms of land resource conservation 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.

The first application for which the ELAS geographic information system concept will be tested is the SCS-Multiresource Inventory as conducted for the appraisal required by the Soil and Water Resources Conservation Act (RCA).

The first step will be to select test sites that represent several Major Land Resource Areas (MLRA's). Within each test site the location of all previously established Primary Sample Units (PSU's) will be defined. These PSU's, which range in size from 40 to 640 acres, will be located in both the oldest and most recent Landsat MSS data available. Land cover change detection techniques will be applied to these Landsat MSS data sets for the purpose of separating those PSU's within which the land cover changed from those with no change, and the accuracy of this categorization will be determined. If this technique proves to be satisfactory, a method for incorporating it into the inventory for the 1985 appraisal will be devised.

In addition to Landsat MSS data, other remotely sensed data including Thematic Mapper Simulator (TMS), Synthetic Aperature Radar (SAR), Return Beam Vidiocon (RBV), Large Format Camera (LFC) will be brought into the PSU data base implemented through the geographic information system. These various sources of remotely sensed data will be evaluated, both independently and in combination, for their information content with respect to USDA-SCS Inventory and Monitoring data needs. This evaluation will relate to both the 10 parameters on which information is collected for the entire PSU, and the 18 parameters for which information is currently collected at randomly selected points within the PSU. In cases where modern soil surveys are not available for the PSU, techniques for using the various sources of remotely sensed data in conjunction with other available data (e.g., topography, geomorphology) will be developed as a tool to aid soil mapping.

This work will be closely coordinated with other NASA research currently being conducted in soil delineation especially with respect to the mid-IR region as encompassed by the Thematic Mapper, and the microwave region as encompassed by existing and future Synthetic Aperture Radar systems.

Techniques will be developed and tested to integrate the various data sources from both remotely sensed data and ground observations so as to produce information needed for the RCA appraisals. These techniques will range from simple queries (e.g., acreage of row crops by soil and slope) to the implementation of models or equations (e.g., Universal Soil Loss Equation).

During FY82, the main effort will focus on extracting information from the various existing sources of remotely sensed data and bringing that information together with other pertinent information on soil, topography, etc. into a PSU data base for the Multiresource Inventory as needed for the RCA appraisal.

During FY83 additional information from remotely sensed data not available during FY82 (mainly TM and SAR) will be evaluated, and all data base information and the manner that it can be manipulated with geographic information system software for RCA information purposes will be evaluated. Effort during FY84 will be concentrated on the adaptation of this technology to operational use for RCA Appraisal information needs, and other applications that may be identified during FY82 and FY83.

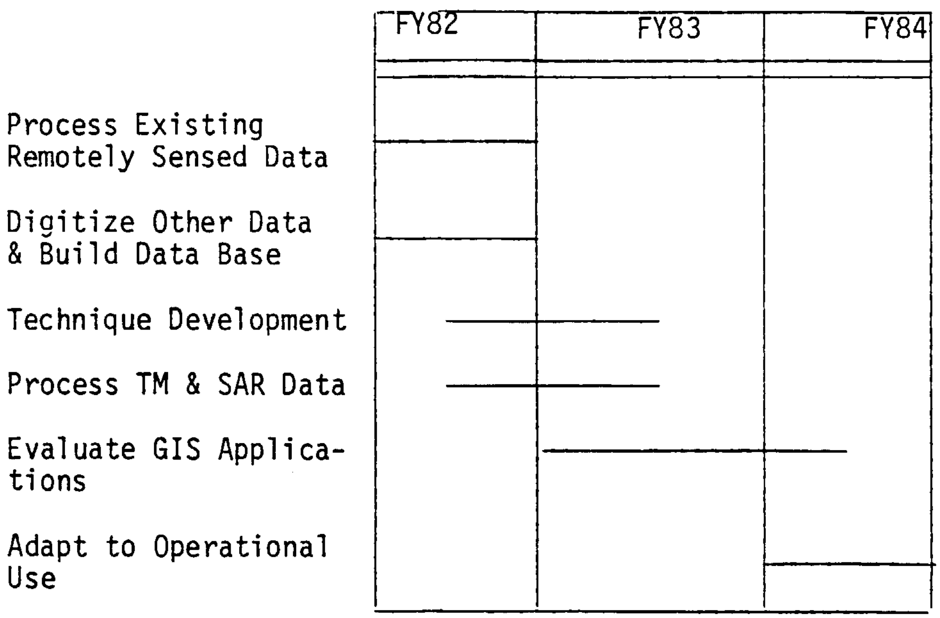
4.6.2.3.3 Responsibility

NSTL will be the task manager, but SRS will be responsible for defining potential uses and requirements for geographic information system applications by other USDA agencies and for providing the liaison between the project and those agencies.

4.6.2.3.4 Resource Requirements

	FY82		FY83	
	$	MYE	$	MYE
NSTL	200	4.0	300	6.0
ARC	100	1.0	100	1.0
SRS	10	0.1	10	0.1

4.6.2.3.5 Schedule



4.6.2.3.6 Interfaces

Interfaces will be established with all DCLC tasks dealing with crop/land cover estimation, mapping, product use, change detection, TM and SAR procedures. Other related AgRISTARS projects include the Conservation Inventory task of the Conservation and Pollution project, and the Soil Moisture project. Liaison between SRS and SCS will be provided through SCS personnel assigned to SRS or assigned to coordinate with SRS.

4.6.2.3.7 Data Requirements

Various data types will be required. The exact data sources and formats is dependent on the scope of the individual GIS applications that will be defined for this task.

In general, NSTL will furnish the remotely sensed data, and SRS will furnish other data routinely collected by USDA agencies, especially with respect to the SCS Multiresource Inventory. SRS will also arrange with SCS for the digitizing of available soils data.

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.

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

2. Scope

The evaluation of Landsat D Thematic Mapper data will be addressed through the acquisition and evaluation of aircraft-acquired TM data during FY82. Emphasis will switch to Landsat D Thematic Mapper data in FY83 and 84 with LANDSAT TM data being employed in pilot tests in FY85. 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:

- o Separability of major crops and land cover types.
- o Small field areas and land cover units.
- o Area estimation
- o Map Products

Test sites in the following states have been selected for TMS missions so as to encompass the surface features listed:

N. Dakota - mainly agricultural with potatoes, sunflower, flax, barley, and spring wheat.

Kansas - cropland (winter wheat, corn, soybeans, sorghum), pasture/range, and urban residential.

Mississippi - swamp and bottomland, hardwood forest with some marsh and intermingled cropland (soybeans and winter ryegrass) and pasture.

S. Carolina - southern pine with mixed pine/hardwood, upland hardwood with intermingled cropland and pasture.

Idaho - mainly forested with white pine, birch, Douglas fir, and hemlock.

Pennsylvania - predominately eastern mixed deciduous forest

Maine - predominately eastern coniferous forest

Missouri - predominately agricultural, mainly soybeans and corn, but with some woodlots and forested bottomland.

TMS data will be acquired for each season for the forested test sites and twice during the growing season for agricultural test sites. NSTL will acquire TMS data for all test sites except the Idaho site, but will furnish an existing summer 1981 TMS data set to ARC. ARC will acquire additional seasonal data for the Idaho site.

Responsibilities for the acquisition of ground truth will be as follows:

ORGANIZATION	SITES
NSTL	S. Carolina Mississippi
GSFC	Pennsylvania Maine
ARC	Idaho
SRS	N. Dakota Kansas Missouri

NSTL will also finish processing a TMS data set acquired over a forest/range area in Colorado, and GSFC will finish processing of data sets acquired for Maryland and N. Carolina test sites.

In the course of processing and analyzing TMS data, software and procedures will be developed and 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 beginning in FY83. The effects of topographic parameters on spectral signatures will also be determined.

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 FY85 An evaluation of accuracy and performance will be performed jointly by SRS and NSTL.

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.

4.7.1.3 Responsibility

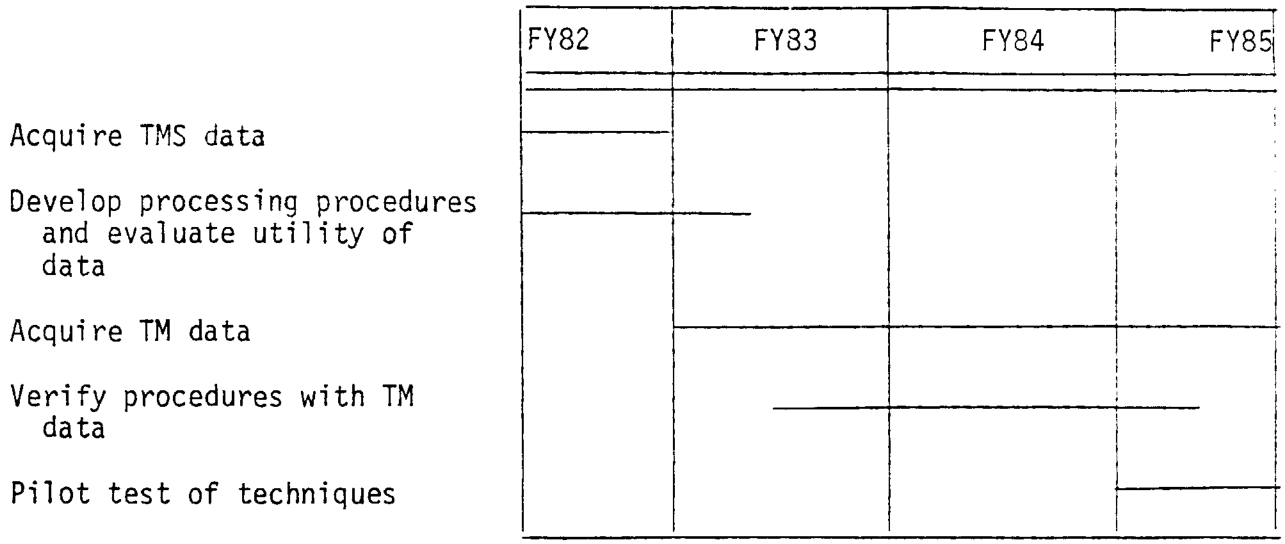
The task manager will be NSTL, but SRS will provide for coordination with other USDA agencies to furnish routinely collected ground truth.

4.7.1.4 Resource Requirements

	FY82		FY83	
	$	MYE	$	MYE
NSTL	225	2.0	275	2.4
GSFC	100	2.0	100	2.0
ARC	75	0.5	75	0.5
SRS	40	0.5	40	0.5

NASA 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 radimetric corrections of TMS scanner data and with data analysis using NSTL's processing system.

4.7.1.5 Schedule



4.7.1.6 Interfaces

The main interfaces will be with other tasks within the DCLC project, mainly the Classification/Clustering element, but efforts will also be coordinated with the Conservation Practice Inventory task of the Conservation and Pollution project.

4.7.1.7 Data Requirements

Cloud free TM data will be required for each season for the forested sites and for a minimum of three cloud-free acquisitions at key times during the growing season for agricultural test sites.

TMS and ground truth data requirements have been outlined previously.

4.7 Project Element - Sensor Implementation and Evaluation

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 began 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 various 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. Three aircraft missions were flown in FY81 acquiring X-band SAR data for three surface conditions as follows:

(1) Truck garden area in Florida

(2) Paddy rice area in Louisiana

(3) Forest area in S. Carolina

Four additional aircraft missions will be flown during FY82 and FY83, and it is anticipated that SIR data will become available during FY83. Seasat L-Band SAR data has been acquired for the S. Carolina and Louisiana sites.

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 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) Land cover classification from SAR, RBV, and LFC data.

(b) Digitization and digital correction of SAR data.

(c) Analysis of data information content.

3. SRS will provide for:

(a) Ground-truth data collection and digitization.

(b) Regression estimation for MSS and SAR/MSS data sets for crop area estimation.

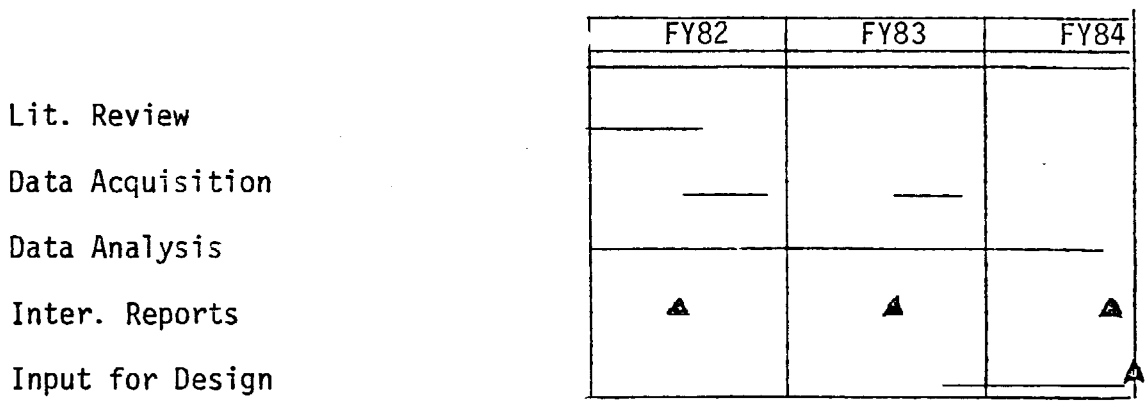
4.7.2.4 Resource Requirements

	FY82		FY83	
	$	MYE	$	MYE
NSTL	245	2.5	275	2.8
SRS	25	0.2	25	0.2

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.

SRS funds provide for civil servant manpower and data processing costs involved in ground truth digitization and regression estimation.

4.7.2.5 Schedule



4.7.2.6 Interfaces

1. This subtask should interface with both the Land Cover Mapping and Classification/Clustering elements. If it is anticipated that the radar data will be used as an auxillary variable in the classification process.

2. The AgRISTARS Soil Moisture Project will have similar activities for agricultural test sites. It is anticipated that the data sets, procedures, preprocessing, and resources can be coordinated.

4.7.2.7 Data Requirements

1. Acquisition -Four aircraft missions will be required in FY1982 and FY1983. It is anticipated that NASA aircraft/SAR systems will be utilized when possible, but it may be necessary to acquire some aircraft-acqauired 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 when available.