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LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)

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BASELINE DOCUMENT

LACIE PROJECT PLAN

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National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

AUGUST, 1975

LARGE AREA CROP INVENTORY EXPERIMENT

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Organization of the Project Plan

Specific sections of the plan are: Section 1, Introduction, which presents a concise background statement of events leading to LACIE, the objectives, scope and an Executive Summary for the familiarization of top agency management; Section 2, Project Documentation, identifies a consistent set of documentation of various types for each of the several levels of management; Section 3, Technical Approach, is a description of the major technical elements of the project, and of user objectives; Section 4, Management Plan, delineates the management structure and relationships, and project control mechanism; Section 5, Project Plan Amendments, relates how amendments will be approved and controlled; Section 6, References, is a tabulation of applicable documents.

The appendices contain copies of the Contingency Plan and Project Schedules.

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ACRONYMS

ADP	Automatic Data Processing
AES	Application Evaluation System
CAMS	Classification and Mensuration Subsystem
CAS	Crop Assessment Subsystem
CCB	Change Control Board
CCEA	Center for Climatic and Environmental Assessment
CCT	Computer Compatible Tape
DAPTS	Data Acquisition, Preprocessing and Transmission Subsystem
DSAD	Data Systems and Analysis Directorate
EOD	Earth Observations Division
ERIPS	Earth Resources Interactive Processing System
ERPO	Earth Resources Program Office
FAO	Food and Agricultural Organization
GDSD	Ground Data Systems Division
GSFC	Goddard Space Flight Center
ICD	Interface Control Document
ISRRS	Information Storage, Retrieval and Reformatting Subsystem
JSC	Lyndon B. Johnson Space Center
Landsat	Land Satellite (an Earth-looking satellite)
LACIE	Large Area Crop Inventory Experiment
MSS	Multispectral Scanner
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PFC	Production Film Converter
R&D	Research and Development
RT&E	Research, Test, and Evaluation
S&AD	Science and Applications Directorate
SR&T	Supporting Research and Technology
T&E	Test and Evaluation
USDA	United States Department of Agriculture
WMO	World Meteorological Organization
YES	Yield Estimation Subsystem

SHORT GLOSSARY OF REMOTE SENSING TERMS

ADP - Automatic data processing, such as computer-aided computations.

CCT - Computer compatible tapes containing digital Landsat-1 data. These tapes are standard 1/2-inch wide magnetic tapes in 9-track 800 bits per inch packing density. Image sample segments measuring 6 X 5 nautical miles will be recorded on the LACIE CCT. Up to 120 sample segments will be recorded on CCT which represents those sample segments surveyed in a 24 hour period.

ERIPS - Earth Resources Interactive Processing System, a system at JSC which allows real-time interaction by an investigator with several digital spectral analysis procedures. Major subsystems include pattern recognition by maximum likelihood classification, image registration, image composition, image manipulation and display.

Landsat - The first Land Satellite. Landsat-1 was launched into a circular, sun-synchronous, near-polar orbit at an altitude of approximately 494 nautical miles (915 kilometers) in June, 1972. It orbits the earth 14 times a day and views the same scene every 18 days.

Landsat-1 Scene - The collection of the image data of one nominal framing area (185 km square) of the Earth's surface; this includes all data from each spectral band of each sensor.

Multispectral scanner spectral bands - The division of the visible and near-infrared portions of the electromagnetic spectrum into discrete nanometer segments.

Channel	Landsat-1&2	Wave Length [nanometers (nm)]	Description
1	Band 4	500-600	visible green
2	Band 5	600-700	visible red
3	Band 6	700-800	reflective infrared
4	Band 7	800-1100	reflective infrared

Pixel - Picture element, refers to one instantaneous field of view (IFOV) as recorded by the multispectral scanning system. On the Landsat-1 system it is equivalent to approximately 0.44 hectare (1.09

acres). One Landsat-1 frame contains approximately 7.36×10^6 pixels, each described by four radiance values.

Scene Registration - The ability to superimpose points in two images of a scene taken at two temporal times.

Spectral Response - The spectral radiance of an object sensed at the satellite and recorded the multispectral scanner system.

Test Field - The spatial sample of digital data of a known ground feature selected by the investigator used to validate the statistical parameters generated from training field samples.

Training Field - The spatial sample of digital data of a known ground feature selected by the analyst, from which the spectral characteristics are computed for use in supervised multispectral classification of remotely sensed data. The statistics associated with training fields form the input to the maximum likelihood ratio computations and, in a sense, "train" the computer to discriminate between samples.

SECTION 1
INTRODUCTION

This document is the project plan for a Large Area Crop Inventory Experiment (LACIE). LACIE results will contribute to a future operational system for a global crop inventory using remote sensing and computer technology.

Development of the crop inventory system includes participation by three major departments and agencies of the U.S. Government: U.S. Department of Agriculture (USDA), National Aeronautics and Space Administration (NASA), and National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce. The terms of this participation are described in the Interagency Memorandum of Understanding.

The LACIE (forerunner of an operational system) will focus on wheat production in the U.S. and selected countries. The document is intended to serve as a basis for review and approval by management. Upon approval, it will further serve as the baseline document for project implementation plans. Such implementation plans will specify how LACIE is to be executed.

1.1 BACKGROUND

There is widespread interest in developing a more effective and timely method than is presently available to inventory the available global food supply. This interest arises as a result of expanding and shifting global markets and ever-increasing population pressures. Planting, marketing, aid, and transportation decisions in producing countries are all based on crop inventory information which is often available only after harvest and is frequently of uncertain accuracy in the less developed countries. A more timely and more accurate inventory at or before harvest would enable more rational decisions. Also, crop disasters can occur anywhere on the globe and such events must be anticipated as effectively as techniques and resources permit.

A crop inventory system utilizing remote sensing technology and the global meteorological system appears to offer great potential for upgrading existing information-gathering capabilities and for contributing to a long-range solution of the food supply problem. Remote sensing techniques should first be developed for establishing an inventory of a specific crop, such as wheat, and then be applied to other crops.

The wheat-growing countries of the globe are vitally interested in a more accurate and timely method than is presently available for estimating global wheat production, as is the United Nations Food and Agricultural Organization (FAO) with its general interest in global food supplies. These and other users would realize great benefits from more timely and accurate information to plan better the utilization of available supplies and to make early and timely decisions in such areas as domestic production requirements and international trade.

In view of these potential benefits, the design objective chosen for the LACIE system is to provide global wheat production forecasts with an improvement in accuracy, confidence, and timeliness.

In order to estimate wheat production, two components of production must be determined: Yield, the amount of wheat (bushels, metric tons, etc.) for a given areal unit (acres, hectares, etc.) of harvested crop and the areal amount of harvested crop. Simply stated, production is area times yield.

The inventory system proposed for the LACIE relies on a remote sensing estimate for wheat area and, where possible, substantial areas of crops affected by catastrophic meteorological conditions and an agro-meteorological modeling approach for yield estimation. The remote sensing estimate for wheat area will be based on the computer-aided processing of multispectral scanner (MSS) data acquired by the Landsat, an Earth-looking satellite. Yield estimates will be based on regression models and meteorological parametric inputs obtained at ground meteorological stations in the World Meteorological Organization (WMO) network, and from weather satellite imagery interpretation.

A careful review and analysis of the remote sensing technology (Reference 1) indicates that wheat production inventories over large areas appear technically feasible. More specifically, the approach proposed for LACIE will, with a reasonable degree of confidence, permit the expansion of the available technology from the relatively local areas for which it has been developed and tested to the larger areas for which it will be applied.

In this expansion effort, activity related to acreage estimation will be focused on the development of methodology to acquire training statistics for inaccessible areas and the extension of these statistics over large regions. In addition, operational procedures must be developed 1) to minimize the impact of cloud cover interference on Landsat data acquisition and 2) to facilitate the management and analysis of the large data volumes anticipated.

For yield estimation, the major focus will be the development and testing of yield models over regions to be surveyed by the LACIE. Considerable effort will be devoted to the development of the historic yield and meteorological data base required for yield model development and the use of meteorological satellite data to supplement the meteorological data obtained by the WMO network. A careful evaluation will be made of impacts on the accuracies of the yield predictions arising from the totality of factors not directly accounted for in the current models. Where possible, the individual impacts of factors such as fertilizer practice and catastrophic events such as insects, disease, et cetera, will be evaluated.

1.2 OBJECTIVES AND SCOPE

1.2.1 Primary Objectives

The LACIE is an interagency experiment in the use of Earth Resources Technology and meteorological information for the following objectives:

A. To demonstrate an economically important application of repetitive multispectral remote sensing from space.

B. To test the capability of the Landsat, together with climatological, meteorological, and conventional data sources, to estimate the production of an important world crop.

C. Commencing in 1975, validate technology which could provide timely estimates of crop production.

1.2.2 Secondary Objectives

The LACIE secondary objectives are primarily technical in nature. These specific objectives encompass the design, development, and management of a demonstration experiment to provide a timely continuum of production information for evaluation by the USDA. Specific objectives are the following:

A. To provide from an analysis of Landsat data acquired over a sample of the potential crop-producing area in major wheat-growing regions, estimates of the area planted to wheat; similarly, from an analysis of historical and real-time meteorological data over the same regions, provide estimates of wheat yield and combine these area and yield factors to estimate production.

B. To provide data processing and delivery techniques so that the selected samples can be made available to the LACIE analyst teams for initiation of analysis no later than 14 days after acquisition of the data.

C. To provide a LACIE system design that will permit a minimum of redesign and conversion to implement an operational system within the USDA.

D. To monitor and assess crop progress (calendar) from surface data base and evaluate the model potential for yield from surface data.

1.2.3 Scope and Phasing

The scope of the LACIE is established to assess production estimates for major wheat-producing areas. Landsat-1 multispectral data will be employed to develop and test the system procedures, subsystem interfaces, and personnel training prior to system start up. Landsat-1 data will also be used for system component testing prior to launch of Landsat-2 in early 1975.

Closely related, and underlying the statement of scope is the time phasing of the LACIE. The experiment will span approximately 3 years and will progress from a phase I which will concentrate on a system test to determine wheat area within regions of the U.S., wheat recognition tests in selected other areas, and yield determination over selected regions in the U.S.; through phases II and III which will operationally test LACIE capabilities to determine area, yield, and production for other major wheat-producing areas. Associated with these phases within the LACIE scope are ancillary goal-oriented activities which support USDA's requirements. These are the following:

A. Periodic crop assessment during the growing season from planting through harvest.
B. Accuracy commensurate with USDA requirements.
C. Supporting Research and Development (R&D) program to improve methodology and performance.
D. Objective test and evaluation program to quantify results from R&D.

A graphic representation of the LACIE scope and the related time phasing is presented in Figure 1-1.

1.3 EXECUTIVE SUMMARY

1.3.1 Background

National and worldwide concern over food supply has spurred interest in better crop inventory information to support production and marketing decisions. Initial studies of the applications of satellite remote sensing data indicate that a major opportunity now exists to utilize such data in an improved crop inventory system. The dominant position of wheat in human nutrition and international commerce makes it a logical crop for an experiment to explore this opportunity.

1.3.2 Approach

The technical approach to the LACIE is to estimate production of wheat on a region-by-region basis where production is the product of area and yield. Initial attention will be given to the U.S. The decision to expand the activity to include countries other than the U.S. in the experiment will be preceded by an evaluation of the work and progress to date. Both of these components, area and yield, will be estimated for local areas and aggregated to regional and country levels. Area will be derived by classification and mensuration of Landsat-2 MSS data acquired on a sampling basis over regions in which wheat is a major crop. Maximum use will be made of computer-aided analysis to provide the most timely estimates possible.

Yield will be estimated from statistical models which relate crop yield to local meteorological conditions, notably precipitation and temperature. Initially, these data will come from the NOAA World Meteorological Network of ground stations, and from NOAA meteorological satellite systems.

This project will result in the assembly of a crop inventory system, largely from available components designed for R&D, rather than operational use. However, the experience gained should allow, as a concurrent effort, the development of a user-oriented operational system and the prediction of the performance and cost of such a system.

1.3.3 Products

The basic product of the crop inventory system will be a report of production of wheat anticipated at harvest. Such reports will be produced several times each year and monthly through the growing season. The USDA will develop procedures for the use and distribution of the reports.

Reports in the nature of R&D reports on the LACIE project will be written by each of the participating agencies on their participation in the project at the end of each year of system operation. A final project report will address the cost effectiveness of the system using Landsat-derived data in comparison with the system presently in use.

1.3.4 Experiment Participants and Management

This experiment will be an interagency program with participation by the USDA, NOAA, and NASA. Each agency will fund its own activity. An Executive Steering Group will provide policy guidance. Agency Project Managers will provide overall management of resources assigned to LACIE from their agency.

Operational management of the program will reside at the NASA Lyndon B. Johnson Space Center (JSC), under the day-to-day direction of the LACIE Manager. Lead responsibility for the various program elements will be allocated as follows:

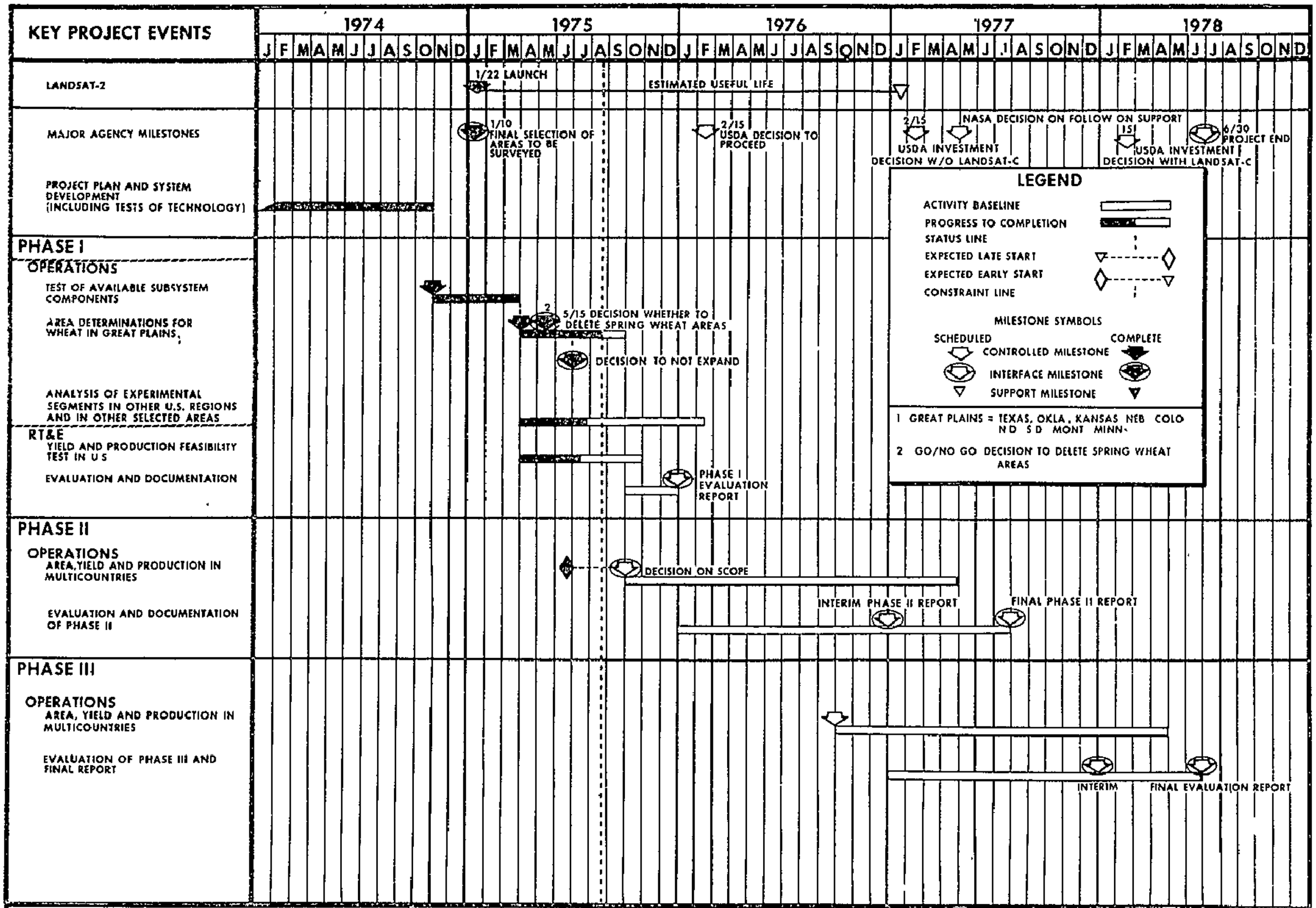
A. USDA - User requirements definitions, ground truth and historic data acquisition, statistical sampling analyses, control and release of production estimates, and cost-effectiveness analyses.
B. NOAA - Acquisition and processing of real time and historic worldwide meteorological data from ground network and data environmental satellites; analysis of the foregoing data to provide seasonally adjusted crop calendars and yield prediction throughout the growing season.
C. NASA - Project Technical Management; inventory system requirements definition,

design, implementation, operation, and performance reporting; area classification and mensuration technique development, implementation, and operation; Landsat satellite data acquisition, processing, registration, and quality checking.

1.3.5 Schedule

The master Level I planning schedule for the LACIE is shown in figure 1-1.

LACIE SCHEDULE LEVEL 1



STATUS AS OF 6/20/75

Figure 1-1.- LACIE master Level I planning schedule.

SECTION 2
PROJECT DOCUMENTATION

The management of the LACIE activity will require a consistent set of documentation of various types for each of the several levels of management. The levels and classes of documentation are described in the following paragraphs. Table 2-I gives examples of the documentation in each level and class.

2.1 DOCUMENTATION LEVELS

Documentation appropriate to each management level will be developed. The levels are defined as follows:

A. Level I is the top-level management concerned with policy, scope, guidelines, and interagency resolution functions.
B. Level II consists of appointed project managers from each agency primarily dealing with project objectives, system performance, resources, configuration control, and major scheduled milestones.
C. Level III is the LACIE Manager concerned with project implementation, integration, planning, budgeting, scheduling, and reporting.
D. Level IV is made up of the project subelement functional managers dealing with the detailed technology development, implementation, and operation of the LACIE system.

2.2 DOCUMENTATION CLASSES

For convenience, documentation is grouped into various classes where each class fulfills a particular function. These classes are the following:

A. Requirements Documentation, which defines the general or specific functions to be performed by elements of the project.
B. Implementation Documentation, which defines plans, technical approaches, and procedures for accomplishing the specified requirements.
C. Task Description Documentation, which is concerned with a detailed description of the specific tasks to be carried out (Tasks are assigned to individuals or small groups within the project. This documentation is

identified with Levels III and IV of management.)

D. <u>Control Procedures Documentation</u>, which is that required to maintain management control of the project in accordance with defined policies stated in the management guidelines.

E. <u>Reports</u>, which describe technical progress, system performance, and the utility of results.

SECTION 3
TECHNICAL APPROACH

This section of the document is intended to describe the major technical elements of the LACIE. Article 3.1 summarizes the requirements of the agricultural application proposed for the LACIE and the technical approach. Article 3.2 describes the constraints which the LACIE must satisfy. Articles 3.3 through 3.6 describe the LACIE system, evaluation plans, the supporting research effort, and organizational interfaces required to execute the technical approach.

3.1 LACIE APPLICATION OVERVIEW

The general approach to be followed within the LACIE is to carefully define specific user requirements to be satisfied, develop a system built on existing technology to satisfy these requirements, and design a method for evaluating the degree to which the user requirements are satisfied. The Application Evaluation System (AES) combines a crop inventory system and a preliminary design suitable for evaluation.

3.1.1 Summary of User Objectives

The user objectives which underlie and support a statement of LACIE technical goals are presented in context of USDA short term and long term information requirements. Specific user objectives are to:

A. Determine the utility of Landsat, meteorological, and ancillary data as information sources which augment, in a timely manner, conventional techniques used in determining wheat estimates.
B. Assure that analyst and system procedures are developed in response to user requirements and are geared to an anticipated operational concept.
C. Evaluate the preliminary system cost and benefits in terms of data objectivity, timeliness, and accuracy in the satisfaction of policy and program decisionmaking processes of the U.S. Government prior to committing resources to an expanded effort.

D. Determine the investment feasibility of implementing an expanded LACIE system within the USDA based upon specifications prepared from previously implemented user requirements.

These generalized user objectives, along with the technical objectives, form a basis for the LACIE design concept and system elements which support that concept. These interrelationships are further defined in the following subsections.

3.1.2 Summary of Project Technical Design

The purpose of this article is to summarize the key elements of the project and the technical design proposed.

Two basic operations must be accomplished: (1) the areal extent of wheat (hectares, acres, etc.) must be estimated and (2) the yield (metric tons, quintals etc.) per unit area determined. Within the LACIE, the AES will be designed to evaluate the capabilities of remote sensing technology to satisfy the crop inventory application objective.

The determination of the area distribution requires that the AES be able to recognize wheat, and measure its areal extent.

Current recognition techniques (both conventional interpretive and computerized) are based upon training a classifier (human or computer) on a known area which is representative of the feature to be classified and then upon extending this classification to surrounding unknown areas. The ground truth (known classes) necessary to train the classifier will not be obtainable from in situ observations in wheat-growing regions other than the U.S. Analyst interpretation of Landsat imagery and a method of accurately extending signatures from interpreted regions using computer-assisted techniques will be developed.

In addition, analog areas will be selected for accomplishing the extension to the wheat-growing regions of countries where adequate ground truth is unavailable. These areas will be used to train and test the classifier. The statistics generated for the analog areas will be used to classify inaccessible wheat-growing regions.

To reduce the total data-processing requirement to a manageable level, the production assessments will be based upon a spatial and temporal sample of the total Landsat data acquired. Selection of the specific sample areas will be made via a spatial sampling strategy. Selection of the specific Landsat acquisition times for which data is to be processed for wheat identification will be made via a temporal sampling strategy.

Wheat-yield forecasts will be based on the historical response of yield to changes in the meteorological variables within the strata for which the forecast is made. Trends in the historical yield due to accountable factors, such as increased fertilizer use or improvements in agricultural technology, will be projected in these forecasts.

3.1.2.1 Research, test, and evaluation. The initial AES system design will be based upon the most promising computer registration, classification, areal measurement, and other techniques which can be implemented in a timely fashion. A supporting Test and Evaluation (T&E) effort will evaluate these techniques during the period of their implementation to establish their performance and assist in the redefinition of the procedures for their use. This T&E effort will utilize, as control data, ground truth and other known agromet information from selected sites distributed over the varying wheat-producing regions of North America.

In addition, the T&E phase will include assessments of the capabilities of the most promising automatic data processing (ADP) techniques to process spacecraft MSS data and identify several major food crops under a wide range of agricultural and meteorological conditions, and quantitatively compare these capabilities.

In parallel with the design and implementation of the AES and during phase I of the Project, a support R&D activity will be conducted by the participating agencies and various supporting universities. The thrust of this activity will be directed toward improving the initial system performance. Performance improvement will be sought in three major areas as follows:

A. Wheat classification and area measurement techniques
B. Yield estimation techniques
C. Production estimation techniques

The T&E effort will thoroughly evaluate the results of the R&D program before implementation into the AES.

3.1.2.2 Output products. The output products that will be derived from this project will be periodic assessment of the area, yield, and production of wheat from specified regions. The final definition of these output products will be determined based on the user application requirements established by the USDA.

The wheat assessment reports will contain the area of wheat that has been classified along with the variance of the estimates and identifications of stages of wheat growth and identification of all source data used to derive assessments. An estimate of the yield will also be included in the assessments. The wheat production estimate will be provided with each assessment, but only the final output assessment will be based upon results after crop maturity. Thus, the accuracy of the wheat assessment reports should improve from the early season predictions.

3.2 SYSTEM CONSTRAINTS

The activity required for the development of remote sensing applications and the subsequent transfer of the technology to a potential user are very much affected by the resources, facilities, and so forth of the organizations developing the technology and, to a reasonable extent, should be affected by those constraints envisioned for the potential user agency. The following subarticles will attempt to define, first, the constraints known for potential users of LACIE-generated information and, subsequently, the operating constraints of those agencies participating in the development of the LACIE.

3.2.1 Imposed System Constraints

The total LACIE effort is a joint application of the NASA, NOAA, and USDA resources to develop a global wheat production information system which is responsive to the requirements of the USDA. The operational connotation implied is in itself an imposed constraint along with the available resources committed to the LACIE by the participating agencies.

The global aspect dictates the restriction on the availability of aircraft- or in situ-acquired ground observations for classifier training and system evaluation. In the United States and in other countries as they become cooperators in the LACIE, the utilization of in situ-acquired data has not been ruled out. However, an attempt will be made to minimize the dependence on such data for crop area and yield.

The LACIE system itself will run in a mode which requires data analysis in a timely fashion that will be supportive of current crop reporting schedules. This mode of operation recognizes, however, that some backlog of data to be analyzed or degradation in performance is to be expected in the event of the failure of major system components.

Constraints, such as satellite platform and sensor capabilities, data analysis capabilities, data handling and information management capability, user requirements, and personnel constraints are covered in more detail in the following agency constraints.

3.2.2 NASA Constraints

The Earth Observations Division (EOD) within the JSC Science and Applications Directorate (S&AD) and the Ground Data Systems Division (GDSD) within the JSC Data Systems and Analysis

Directorate (DSAD) and the Goddard Space Flight Center (GSFC) will cooperate in the LACIE.

The EOD along with the USDA and NOAA will have responsibility for the design of the AES analysis procedures and the subsequent data analysis for wheat production forecasts. As will be shown in a subsequent section, the data processing load required to obtain near-real-time production estimates with accuracies which meet USDA user requirements, in conjunction with the desired operational manpower level available for data processing, implies the necessity for data processing procedures which require a limited amount of human intervention. Such a constraint is believed to be consistent with that envisioned for an eventual operational system.

The GDSD will have the responsibility for the design, provision and implementation of the hardware/software necessary to support the EOD requirements for the AES. The major constraints defined here are the available GDSD manpower resources, data processing facilities (IBM 360/75 and mass storage), tape to image capabilities, and the data processing software which can be made available to support the project requirements in consideration of the project schedule.

The GSFC will have primary responsibility for the Landsat data acquisition, geometric preprocessing, initial data quality screening, and data transmittal to the JSC. The GSFC will acquire MSS data over each sample unit as defined in article 3.3.4, Crop Assessment Subsystem. The GSFC will screen this data for electronic quality and cloud interference. Data sets will be acquired multitemporally and placed in spatial registration to one pixel root mean square at the GSFC.

Five major project constraints have been defined by the GSFC.

A. The registration accuracy requirement and the state of the art in correlation and registration technology constrain the GSFC to register no more than one-one hundredth of a

Landsat frame during any one processing run (10- by 10-n.m. blocks).

B. Resource constraints permit approximately 20,000 registration jobs per year.

C. Data handling and resource constraints permit no real-time retrieval of stored Landsat frame portions.

D. Landsat positional and altitude uncertainties produce Landsat nadir location uncertainties of ±3 nautical miles at the Earth's surface for nominal orbital altitude.

E. The Landsat ground track is maintained to within ±18 km of nominal.

3.2.3 <u>NOAA Constraints</u>

The model (or models) finally chosen for operational use in the Yield Estimation Subsystem (YES) are constrained to use only meteorological surface and satellite data which are operationally available to NOAA. The specific nature of the data and the final format of the model (or models) will be submitted for review to the YES Advisory Group as work on the development of the yield model progresses in the YES.

3.2.4 <u>USDA Constraints</u>

The USDA constraints are influenced by several factors. These factors dictate the grouping of contraints into three primary elements. These are: (1) general, (2) statutory, and (3) technical. A brief summation of each is presented in the following articles.

3.2.4.1 <u>General constraints</u>. The general constraints associated with the LACIE are keyed to time. The USDA late involvement in the LACIE will result in an extended time period to staff start-up activities which include resource allocation to the project, preparation of detailed user requirements which will result in a sampling scheme that can be extended to other countries and other crops as the need arises, a common system baseline plan, and ground accuracy requirements. Other time-associated constraints are USDA decision points which are reflected in figure 1-1.

3.2.4.2 <u>Statutory constraints</u>. Specific USDA statutory guidance levies a significant constraint on aggregated data control within the LACIE system. Impact of these constraints shall be considered in the following activities associated with the project:

A. Data base design.
B. Application software and procedures.
C. Aggregated data construction, formatting, and transmission.
D. Handling of specified data by contractor and other personnel.
E. Release of data produced by the LACIE, including any of its subsystems.

Further definition of these constraints shall be specified in USDA policy memoranda.

3.2.4.3 <u>Technical constraints</u>. Because of the USDA goal of moving the LACIE toward satisfaction of an operational mission, several technical constraints are imposed upon design and development tasks. They are the following:

A. System, application, and data base support software will conform, to the extent economically feasible, with the USDA or National Bureau of Standards language specifications.
B. LACIE subsystems must be fully integrated for operational testing throughout the system development process.
C. The USDA requirement for a geographic orientation to the LACIE data base dictates accurate registration of sample segments by corner coordinates to a common cartographic baseline.

3.3 LACIE APPLICATION EVALUATION SYSTEM

A stratified sample approach will be used as an initial basis for estimating the areal distribution of wheat and the yield per unit area throughout the country. Based on historic data, the major wheat-growing regions in the country will be determined and subdivided into "strata" which are homogeneous with regard to wheat-planting density (area wheat/area land) and strata which are uniform in the response of plant yield to climatology. Alternative methods for stratification, from an operational point of view, will be considered. Once these strata are determined, sample units will be allocated to the strata and Landsat MSS data will be acquired over each of the sample units at four different periods during the wheat-growing season. The Landsat MSS data will be analyzed, using classification data processing techniques, to determine the proportion (by area) of wheat contained in each sample unit. The proportion figures will be used to estimate the area of wheat within each stratum, each region, and the country.

In order to determine the yield as a function of location within a stratum, meteorological predictor variables such as precipitation, maximum and minimum temperatures, et cetera, will be determined by the analysis of data from meteorological data. Extension of this information to areas remote from these stations through the use of meteorological satellite data will be investigated. These data will be used in agro-met models to determine the yield, as a function of location, within the stratum. Production within the stratum will be estimated by an appropriate mathematical combination of the stratum yield and area estimates.

The production estimates for a geographical area (country, wheat-growing region, etc.) will be obtained by an aggregation of production estimates to zones (collections of strata with similar growing season), regions (collections of zones), and country.

The estimates, area, yield, and production will then be assessed for their precision (confidence) and accuracy. The cost for obtaining these estimates will also be computed. The performance will be characterized by quantifiers, such as coefficients of variation, bias, mean square error, and by indicators such as comparison to historical acreages, yields, et cetera, for the region and visual inspection of the results.

The regional production, yield, and acreage estimate reports verified, as previously discussed, will then be disseminated monthly, from planting through postharvest, to the USDA for their use and evaluation.

The hardware/software/analyst system which performs the crop inventory will be referred to as the Application Evaluation System. Five subsystems will be defined and described in detail in the sections to follow (fig. 3-1.)

3.3.1 Data Acquisition, Preprocessing, and Transmission Subsystem (DAPTS)

3.3.1.1 General. The DAPTS will be located at the JSC and will be responsible for the coordination, collection, and acquisition of all data necessary to meet the data requirements of the LACIE AES, the System Evaluation effort and the Research, Test, and Evaluation (RT&E) effort. Catagories of data to be acquired will be defined to the DAPTS by the other subsystems as well as the quality, quantity, frequency, and time of acquisition, et cetera. In addition, the DAPTS will perform all "standard" preprocessing operations on the data acquired prior to insertion into the JSC Information Storage, Retrieval and Reformatting Subsystem (ISRRS) and provide for the transmission of all data required into the JSC ISRRS. Standard preprocessing operations means the preparation of data which are common to all elements of the LACIE; that is, AES and RT&E. The acquisition and preprocessing of MSS and real time meteorological data will be accomplished at centers outside the JSC. Field, historic, and aircraft data will be preprocessed at the JSC.

3.3.1.2 Historic Data. Statistical and historical agricultural data for the LACIE will be provided by the USDA. Historical meteorological data will be provided by the NOAA.

Several categories of background information and data will be required for the LACIE. The general geography of the region under study will be needed as well as data such as topographic, vegetative, climatic, soils, hydrologic, general cultural, economic data, and land use practices.

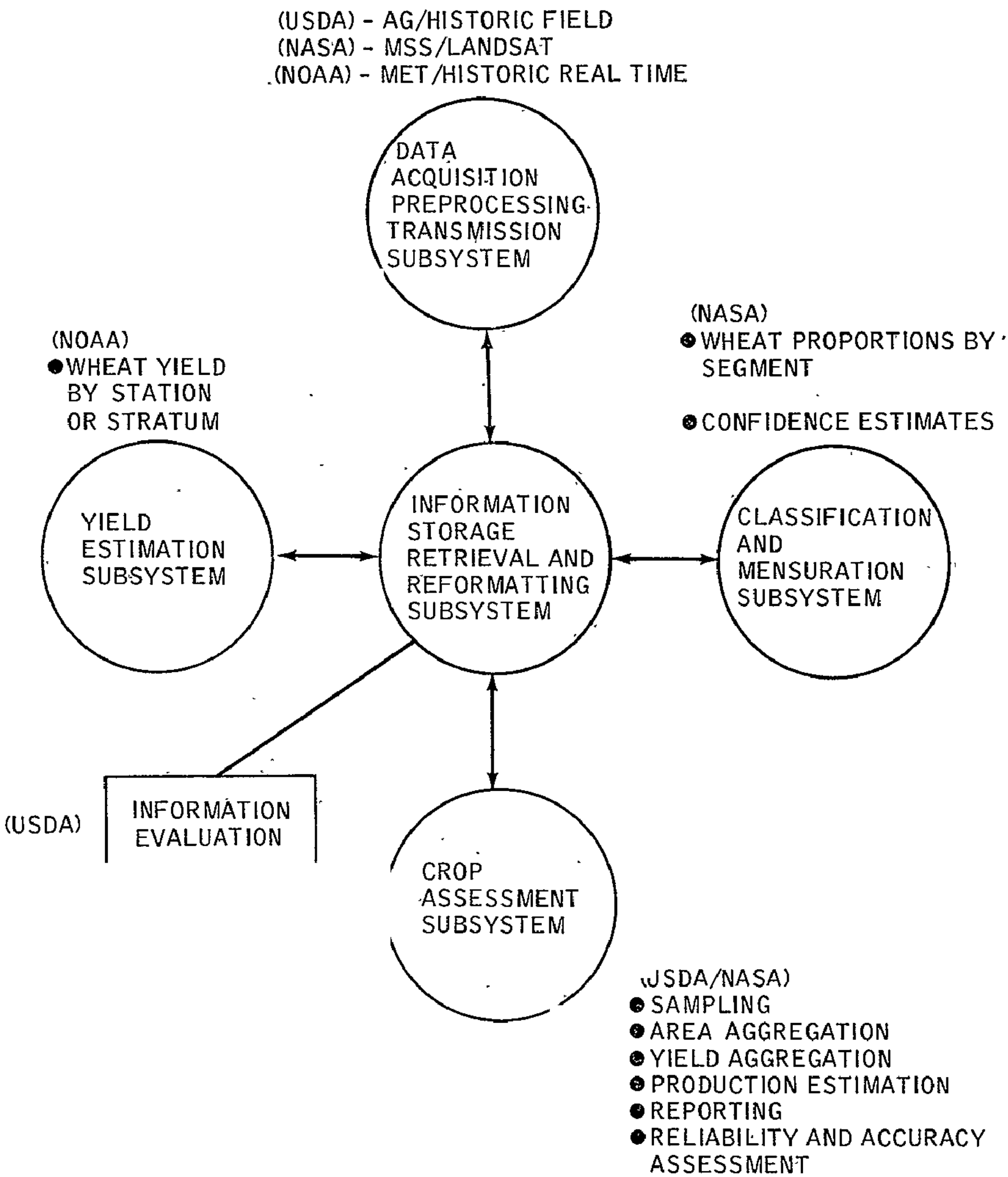


Figure 3-1.- LACIE application evaluation system configuration.

A second category of data required will be agricultural and agricultural statistical information. Data on agricultural land use practices, types of crops planted in the area of study, crop calendars, seeding and planting practices, transportation and storage routes and facilities, fertilizer uses and practices, knowledge of plant diseases prevalent within the region, and prevailing meteorological condition before and during the growing season are included as types of information desired. Also required will be past records on area, production, and yield of wheat and other crops within the area of study, to determine patterns, if any, for present and future crop predictions.

Much of the agricultural statistical and some types of general geographic information will be furnished by the USDA.

3.3.1.3 Field data. Field data, consisting of in situ field identifications of crop type, condition, area, et cetera, are required to support the design, development, and operation of the AES. Field data will be used in the LACIE only for evaluation purposes and analog signature extension. These data will be collected by the USDA over the intensive test sites. Intensive test sites are small areas located throughout the wheat-growing regions of North America that will be visited periodically in order that the above observations can be recorded.

3.3.1.4 Landsat data. NASA/GSFC will acquire, preprocess, and transmit Landsat MSS data as required by the LACIE.

The following Landsat MSS data will be acquired:

A. Data each 18 days, throughout the growing season of wheat within the designated intensive test sites.
B. Data as required over global areas for purposes of RT&E.
C. A specified number of 5- by 6-nautical mile sample segments according to specific requirements of the Classification and Mensuration Subsystem (CAMS) and Crop

Assessment Subsystem (CAS) within LACIE constraints for four phases of wheat growth.

D. Full frame data for development of sampling strategies and contextual information by analysts.

The Landsat data preprocessing will consist of those steps necessary to prepare Landsat data for transmission to the JSC ISRRS. The raw Landsat MSS data will be received at GSFC either directly from the satellite or through the Alaskan or Goldstone ground stations. Maximum time from acquisition to receipt of data at GSFC is expected to be about 4 days. The GSFC processing (LACIE preprocessing) is expected to be completed within 24 hours. The general data flow is defined in the following paragraph.

The video data will be shipped from the ground receiving station to the NASA Data Processing Facility, converted to digital format, and recorded on high density digital tape. During this step, radiometric correction and cloud cover assessment will be performed. Specifics concerning format and header information are contained in the JSC/GSFC Interface Control Document (ICD). Data will be shipped to the JSC on a daily basis.

To perform automatic analysis of Landsat data from more than one pass, the data must be digitally overlaid so that a particular point on the ground has the same line/column coordinates in all data sets to be simultaneously processed. The provision to register data sets is being incorporated in the preprocessing. For each segment, the GSFC will compute parameters for image generation by the JSC tape-to-film converter. These parameters will be used to produce imagery which is optimum for analyst interpretation of training segments, editing of nonagriculture on all segments, and visual data quality checks on all segments.

3.3.1.5 <u>World Meteorological Organization (WMO) network data</u>. The NOAA will provide required summaries of meteorological observations collected from the synoptic network from stations located in the

LACIE areas of interest to be used in updating cropping calendars and operating yield prediction models. The CCEA will insure that the interfaces are established to gather, preprocess, and transmit all real time WMO data to be used by the subsystems of the LACIE.

3.3.1.6 Environmental satellite data. The NOAA will provide limited amounts of data from environmental satellite to support the research, test, and evaluation effort. The DAPTS will provide the interface to preprocess and transmit this data over the selected areas identified by RT&E. If a suitable methodology can be developed for use of the data from environmental satellites during the lifetime of LACIE, then NOAA will make such data available on a routine basis.

3.3.1.7 Ancillary data. Ancillary data will be provided as follows.

The USDA shall, within the framework of the user requirements, provide ancillary data necessary to develop and/or validate acreage, yield, and production data (e.g., crop calendars, ground truth, historical trend data, current statistics, etc.).

3.3.2 Classification and Mensuration Subsystem (CAMS)

3.3.2.1 General. The CAMS, under JSC management, is responsible for classification and area mensuration of wheat for sample segments defined by the CAS. This will be done by determining the proportion of the area in each sample segment identified as potentially wheat.

The responsiblities of CAMS are as follows.

A. To develop and implement procedures, methods, and techniques for the interpretation, classification and mensuration of Landsat MSS data.
B. To determine, for each acquisition of each sample segment, those classes distinguishable from wheat and those classes not distinguishable from wheat.
C. To estimate the proportion of the segment area distinguishable as wheat at each of four growth stages.

D. To develop and utilize an evaluation technique to appraise the reliability of each segment's wheat proportion estimate to be used by the CAS.
E. To design and conduct training for personnel selected to operate the CAMS.

3.3.2.2 Approach. The proportion of wheat in each sample segment will be determined by performing multispectral/multitemporal pattern recognition ("classification") on each sample segment acquired. The pattern recognition algorithm will be implemented on a digital computer and will utilize manual training in order to distinguish wheat from nonwheat.

Training of the algorithm will be accomplished by inputting to the computer training fields for which spectral/temporal radiance distributions ("signatures") are characteristic of wheat and nonwheat. These training fields may be located in the following ways:

A. By analyst interpretation of Landsat MSS imagery to locate areas of wheat and nonwheat.
B. By ground observation from domestic areas in which the signatures of wheat and nonwheat are analogous to those in the foreign region to be classified.

In order to operate the CAMS, several operational procedures will be developed. These include analyst interpretation procedures, ADP procedures, signature extension procedures, and CAMS integrated operations procedures. All procedures will be followed without deviation, except as directed by the CAMS manager. Procedures will be updated as required.

All procedures will be tested for throughput rate and effect upon classification accuracy by use of Landsat data from intensive study sites. This data will be used to simulate the procedures in an operational working mode; throughput rates and classification accuracy will be recorded.

The analyst interpreter's task will be to interpret Landsat imagery from both single pass and registered multidate sample units for approximately 20 percent of the 5- by 6-nautical mile sample segments. Within each sample segment, the line and column coordinates for a sufficient number of wheat fields and nonwheat fields will be provided to the ADP analyst.

The analyst interpretation procedures will specify clearly the output required from the interpreter's task, that is, generic classes to be identified (wheat, nonwheat, unidentifiable, etc.), number of fields within each class, field coordinates, et cetera. The procedures will also specify to the interpreter a precise method for obtaining and using Landsat imagery, cropping calendars, historical data, current meteorological data, et cetera for crop identification.

ADP procedures will be developed in order to permit smooth flow of data within the CAMS while maintaining consistent classification accuracies. As a minimum, these procedures will address the following:

A. Statistics computation
B. Cloud, cloud shadow detection
C. Classification
D. Detection of bad training data
E. Quality control
F. "Designated other" identification
G. Rework decisions
H. Evaluation of classification

The ADP analyst will use the field coordinates and crop type identifications and train a maximum likelihood classifier to subsequently distinguish wheat from nonwheat in each of the sample segments.

Signature extension procedures will be developed in order to make it possible to classify segments using statistics from other segments as training data. In order to develop such procedures, extension using unaltered signatures will be tried and tested. Alternate procedures, such as mean-level adjustment and sun-angle corrections, will also be used and tested, as will analog sites.

In order to evaluate signature extension, the various extension methods will be used to obtain classification results using, as a minimum, Landsat intensive study sites. Required outputs will include classification results using various procedures along with estimated classification accuracy degradation curves developed from classification results obtained from testing.

In order to permit smooth flow of data through the AES, procedures will be developed to integrate the CAMS into the overall system.

3.3.3 Yield Estimation Subsystem (YES)

3.3.3.1 General. The YES will be managed by NOAA with the primary responsibility of the design, implementation, testing, and operation of agricultural-meteorological (agro-met) models to obtain yield estimates for each of a number of strata to be specified by the CAS as historic data are available for development. In addition, the YES will provide seasonally-adjusted crop calendars and meteorological reports to support local signature development and signature extension.

3.3.3.2 Yield models. The initial yield model(s) will be "statistical" in nature and will consist of yield estimates based on regression analysis in which historical data series of yield and weather observations (such as temperature and precipitation) are used to estimate coefficients. Thus, wheat-yield forecasts will be based on the historical response of yield to changes in the meteorological variables within the strata for which the forecast is made. Trends in the historical yield due to nonweather factors, such as increased fertilizer use or improved seed varieties, will be projected in these forecasts. As the program progresses and as technology permits, models may be expanded to include additional critical factors. For some areas these factors might include soil moisture and solar radiation. At some point in the future, it may be possible to include a comparison of the appearance of the crop (physiological development of the plant, as derived from remotely acquired data) to its yield. It is anticipated that both a simple linear model that requires only weekly or monthly summaries of meteorological data inputs and a more complex, nonlinear, time-dependent model that may require daily meteorological measurements will be developed and tested.

Sequential activities involved in the development of wheat-yield models will include the following:

A. Determination of boundaries of the strata over which wheat responds relatively uniformly to its environment as data availability permits.
B. Choosing the parameters to be used for yield prediction (parameters may vary in time and place).
C. Choosing the form of the model (model may vary with phase of growing season and location).
D. Determine coefficients to be used with models.
E. Program the model(s) for computer operation.
F. Test model(s).

3.3.3.3 Data inputs and processing. An integrated data base is essential for successful development and testing of yield models by YES and for incorporation of yield factors into production estimates by the CAS. Data must be formatted and computer programs written so that transfer to processing centers will be facilitated, and data can be incorporated into ongoing activities, both developmental and operational.

Categories of data (based on data source) needed for the YES development stage include: historical agricultural and meteorological data, real-time meteorological data, and current agricultural data (non-Landsat). Real-time meteorological data, and current agricultural reporting data will be used in the YES operations.

3.3.3.4 Data and product output. Certain "finished" products are implied in the preceeding statements on YES responsiblities, yield models, and tasks; namely, yield models, (e.g., regression equations showing the relationship of yield and weather/nonweather variables) plus nonquantifiable factors in specified areas, yield estimates, crop calendars, and signature extension analysis. Detailed requirements for these YES products, including content, format, due dates, and delivery points will be specified by subsequent CAS and ISRRS requirements documents and implementation plans.

So that the CAS may properly perform its specified task of assessing the accuracy of the YES results, the YES will incorporate all data, documentation, and preliminary analyses into the ISRRS. The yield and calendar models will be located at the Page Building in Washington, D.C. Transfer of resulting data between the Page Building and JSC will be in accordance with ICD specifications and agreements.

3.3.4 Crop Assessment Subsystem (CAS)

3.3.4.1 General. The CAS, managed by the USDA and resident at JSC, will consist of multidiscipline analyst/software capabilities for which responsiblities include:

A. Providing, on a monthly basis, the area, yield, and wheat production from planting through postharvest. Phase I responsiblities will be area estimation for the Applications Evaluation effort, as well as yield and production for the T&E and R&D efforts. Phase II responsiblities will include area, yield, and production reports in the AES.
B. Development of a sampling strategy and definition of sample segments for area calculations and WMO stations for yield estimates.
C. Insuring that related LACIE subsystem's outputs will be properly compatible within the crop reporting system for eventual transfer into a USDA operational environment.
D. Providing criteria and procedures for the assessment and evaluation of LACIE products in terms of USDA requirements and in consideration of established performance goals and cost benefit criteria.

E. Investigating discrepancies in the LACIE area, yield, and production reports identified by the USDA evaluation of the information contained in these reports. (If the source of the discrepancy is determined to be within the AES, the CAS will analyze and report the causes and make recommendations.)

The CAS, within the LACIE functional structure, will interface considerably with the other LACIE subsystems to achieve the above objectives.

3.3.4.2 CAS functions. The following actions will be required in fulfilling the CAS responsibilities:

A. Definition and delineation of sampling areas:
   1. Preferred sampling areas
   2. Contingency areas
B. Insure adequacy of sampling strategy for LACIE requirements:
   1. To accomplish the estimations, the CAS will develop and utilize a sample strategy to select the number and location of the sample segments required to estimate accurately the wheat area.
   2. The sample strategy will be tested on a limited basis prior to phase I.
   3. The results of the sample strategy will be monitored during phase I operations and the strategy will be improved as required for use in phase II.
C. Define CAS ground truth requirements.
D. Monitoring and evaluating of the CAMS and YES products and development activities (CAS will track AES parameters sufficient to provide an assessment of the reliability and accuracy of the area, yield and production estimates.)
E. Integration of the CAMS and YES products into final wheat production estimates:
   1. In phases I and II, the CAS will operate the crop-area aggregation model to obtain monthly estimates of area by strata, zone, region, and country. The area aggregation model will produce estimates based on values determined by the CAMS processing of Landsat-2-acquired MSS data.

2. In phase II, the CAS will operate the crop-yield aggregation model to obtain monthly estimates of yield by stratum, zone, region, and country. The yield aggregation model will produce yield estimates based on yield values for each station defined by the YES, aggregated to values for strata, zones, region, and country. The segment aggregation and mensuration procedure is needed in order to have an orderly method of combining segments results to arrive at area estimates. Such a procedure must consider missing segments due to cloud cover, as well as the number of passes obtained for each segment.

The first step involved in developing these procedures will be detailed requirements of the goals to be met by such aggregation and mensuration procedures. These goals will then be transformed into a set of aggregation and mensuration procedures. To assess the performance of these procedures, simulation methods will be used to estimate the error of the final estimators. In order to perform such a simulation, historical data, sampling strategy, data acquisition probabilities, classification accuracy, yield errors, aggregation errors, and data from intensive study sites will be used to estimate errors introduced into area estimation. These, and all subsystem performance analyses, will be directed by the LACIE T&E effort.

3. In phase III, the CAS will operate the crop-production assessment model to obtain monthly estimates of crop production by strata, zone, region, and country. The crop-production assessment model will produce production estimates based on the products of area and yield determined by the CAS and the YES, aggregated to production values for strata, zones, regions, and country. Production estimates for a geographical area (country, region, et cetera) will be an upward aggregation of production estimates of its subareas. Production

estimates within the smallest subareas will be performed by simply multiplying the area of the crop of interest, within that subarea, by the estimated yield within that subarea. In order to interface the yield strata and the acreage strata, it will be necessary to relax the yield strata and calculate a variational fit to the scalar field of yield so that the function of yield can be integrated to get productions. The smallest subareas will be area strata. Production within a country or the next lower political subdivision of that country will be accomplished by aggregating the production calculations for all of the subareas of that subdivision or country. The units of these results will be in metric tons per subarea. Subsequent similar calculations should be performed on all of the subareas within the country or next lower political subdivision of that country. The resulting products for all of the calculations should then be summed and the final figures should be in units of metric tons.

F. Assistance to the Washington USDA LACIE staff in the following areas:
   1. Identify additional information processing support software/hardware requirements for the USDA based on operating experience and user requirements.
   2. Develop T&E criteria and procedures for the LACIE system
   3. Supervise the application of criteria and procedures in (2) above to a USDA test bed system.
   4. Participate in and monitor ongoing research and development efforts.

3.3.5 Information Storage, Retrieval, and Reformatting Subsystem (ISRRS)

3.3.5.1 General. The ISRRS, resident at JSC, will consist of both electronic and physical storage/retrieval capabilities for which responsiblities are the following:

A. The storage and retrieval of all ADP data as required by each subsystem within the AES, the T&E effort, and the R&D effort.
B. The storage and retrieval of all non-ADP data, that is, imagery, historic data, et cetera, as required for support of the AES, and the RT&E efforts.
C. The execution of all data preparation functions which are "custom" in the sense that they are peculiar to one or more subsystems, for example, the conversion of Landsat-2 tapes to film imagery.

The ISRRS shall provide a common data interface for all subsystems defined in this section and for other data interfaces external to the LACIE AES. Additionally, the ISRRS design shall, to the maximum extent possible, insure that commonality is maintained with USDA hardware, software, and procedural requirements. Specific ISRRS support functions to the LACIE are defined in the following sections.

3.3.5.2 Electronic storage/retrieval. The ISRRS will have the capability of operating in both a readily accessed mass data storage and data tape library. The design specifications of the electronic storage/retrieval element shall encompass the following attributes:

A. Data element dictionary - The ISRRS will provide a dictionary of all data elements contained within electronic storage system. This dictionary will be used in the implementation of data editing, validation, purge, performance tracking, and security procedures.
B. Integrated structure - The LACIE is characterized by multiple users of identical data, and as such, shall provide the operational efficiency inherent to an integrated structure of data files, records, strings, and elements.
C. Data base quality testing - Some data units, notably the Landsat MSS data, are acquired on more than one occasion. The raw and processed data from each occasion are

assessed for quality. The assessed quality is added to the data element identifier. If the quality of a unit exceeds that of its presently stored counterpart, the old data unit is transferred to a tape that will be archived. The new data unit will be stored in its place. If the quality of the new unit is less than or equal to that of the old, the new data unit is stored on the archive-bound tape.

D. Data base purge control - Purge criteria will be proceduralized by the prime user(s) of data files, records, or elements. These procedures and their associated time tables shall dictate data base purge. Unless otherwise specified, all purged data will be forwarded to the archives. Data purged from the mass data storage will be transferred to a tape designated for archive storage. Tapes released from the tape library will be sent to the archive. The directory function will be utilized to verify that archive-bound material does not duplicate anything already stored. Duplicate tapes will be returned to service.

E. Fail-safe operation - Periodic and on-demand recording of the state of the computer portion of the subsystem is required. The system checkpoint will contain everything required to duplicate the computer status at the time the checkpoint was taken. The system checkpoint must be recorded on a medium such that it is available for reestablishment of the system in the event of a system failure.

In the event of a system failure, the computer system is required to be reestablished automatically to any specified state from state of last system checkpoint to state of last data-base transaction within 10 minutes after notification of the specified state. Notification will be transaction number of LAST, if last transaction.

F Performance auditing - The performance of the ISRRS will be evaluated in terms of the time required to respond to user requests, the accuracy of the response, and the time and accuracy of internal functions. A transaction log will be maintained indicating the period of time for which the mass data storage and retrieval unit is in communication with other subsystems.

The tape and physical libraries will maintain timeclock records of user requests received and answered. This data will regularly be stored into the electronic data storage (tape or mass).

The time required for tape duplications and process film conversion will be logged into the electronic data storage (tape or mass).

G <u>Data access control</u> - A system will be provided to guard against unauthorized retrieval or update of information stored in the data base. Firm access control procedures will be developed from inputs from the subsystems as to the criticality of data access and update. Access control of the electronic mass data storage will be provided by the Data Base Manager. Tape and physical library security will be maintained by the librarian who will be responsible for verifying requests for these data.

3.3.5.3 <u>Physical storage/retrieval</u>. Elements of the total LACIE data base will be provided in document form. These data will be supplied on a one-time basis on a regular schedule. The one-time-only data will include: descriptions of Landsat data, historical meteorological data, historical production data, et cetera. In addition, the library will maintain a file of imagery data obtained from the Production Film Converter (PFC).

A complete set of active and inactive data source documents will reside in an archive at JSC. The accessing, accounting, use, and purge procedures of this archive shall be based on the premise that it will be possible to reconstruct the entire data base should the need arise. The archive shall consist of two sections, a physical (hardcopy) file and a tape (ADP) file. The data will be stored in a manner that will permit access to any tape or document without shifting other data.

3.3.5.4 Physical storage/electronic storage interface. This interface takes three general forms: (1) content directory maintenance or automated indices to the location of all data both active and inactive, which are in the data base and the archive; (2) scheduling which involves maintaining computer generated lists of related data units as required by each subsystem (The scheduling function will notify the appropriate subsystem whenever a subset of data is available for processing. In those instances when the subsystem has arranged for automatic processing of data as it becomes available, the scheduling function will serve organizer processor activities in a logical manner. The scheduling function will provide summaries of scheduled and completed activities as necessary.); (3) data handling, imagery generation and validation whereby the ISRRS will catalog and index all incoming Landsat, field and histroic, and meteorological data. Quality checks will be performed to assure, for example, that data tapes are readable and contain no parity errors. Tape copy operations will be performed to provide redundant data sources.

Generation of imagery products to aid data analysis will also be accomplished. Intermediate data products such as field definition data will also be prepared for input to other subsystems.

Any data reformatting not accomplished by the DAPTS, and which is necessary for interface with other subsystems, will be accomplished by the ISRRS.

3.4 SYSTEM EVALUATION

3.4.1 Information Evaluation

3.4.1.1 General. This function will be conducted at the USDA LACIE Headquarters, with prime responsibility within the USDA and participation by the NASA and NOAA. Within this function the USDA will be responsible for the evaluation of the timeliness and utility of the acreage, yield, and production information produced by the AES.

3.4.1.2 <u>Specific</u>. Within the information evaluation function, the USDA is responsible for evaluating the timeliness and utility of area, yield, and production information produced within the LACIE AES; for setting forth the USDA policy as related to release of area, yield, and production information produced within the LACIE AES, to all organizations or individuals not in direct support of the LACIE AES; for definition of systems specifications necessary to support the design of an applications system within the USDA; for integrating information produced within the LACIE AES into ongoing operational activities associated with the appropriate functional agencies and services within the USDA; for performing a cost/benefit analysis of acreage, yield, and production information produced within the LACIE AES; and for analysis and evaluation of the applicability of the LACIE AES to the derivation of area, yield, and production information pertaining to crops other than wheat.

A. <u>LACIE Information Evaluation</u> - Implement the USDA Information Evaluation Plan for periodic evaluation of the timeliness and utility of area, yield, and production information produced within the LACIE AES. (Provisions will be made for documenting the results of the USDA evaluation of the LACIE information for the purposes of providing the LACIE AES with a measure of the relative value of each LACIE information product to the USDA; suggested improvements or changes in format, frequency and accuracy and precision of LACIE information products; and recommendations related to the potential utilization of LACIE-type information within ongoing operational activities associated with the appropriate functional agencies and services within the USDA.)

B. <u>Cost/Benefit Analysis of LACIE-Type Information</u> - Perform a cost/benefit analysis of area, yield and production information produced within the LACIE AES.

3.4.2 Systems Performance Evaluation

Systems performance evaluations will be performed to provide management information leading toward improved system design and operation. The performance of the AES will be evaluated from a cost, efficiency, and effectiveness viewpoint. The system shall track and record operational parameters and overall performance will be evaluated by a simulation model to determine the impacts caused by a change of an operational parameter. The parameters to be monitored and recorded by all subsystems for input to the simulation model are computer times, manpower, data throughput parameters, and material and equipment usage. All parameters are to be operational parameters as differentiated from those associated with LACIE development.

3.5 RESEARCH, TEST, AND EVALUATION

To provide continuing technological improvement in the AES, an RT&E effort will be conducted in parallel with the AES effort. This effort will consist of both a short term effort, in which techniques will be developed and modified to fit phase I of the project, and a long term effort, in which the techniques developed will not be applicable until phase II or III of the effort. The JSC Supporting Research and Technology (SR&T) Program at the universities will provide a large part of the effort required to perform the R&D. The overall R&D effort will be directed to improvement in technology in the general areas of determination of wheat production, determination of wheat yield, and determination of area in wheat.

Once a new technique is developed as a result of an R&D effort, that technique will be evaluated by the T&E effort for possible subsequent use on the LACIE AES. In addition, the T&E effort will estimate, prior to actual use by the AES, the performance of AES components. The purpose of this latter evaluation is to determine preferences in analysis procedures where choices exist in the system and to identify problem areas.

3.5.1 Research

Within the general research areas of wheat production, wheat yield, and wheat area, several major R&D objectives have been defined as crucial to the development of technology suitable for the LACIE.

3.5.1.1 Wheat production. The determination of wheat production is, in essence, an estimation process in which wheat area estimates and yield estimates are combined to obtain an estimate of wheat production. The major R&D effort in this area is aimed at the definition of a spatial sampling strategy for both area and yield estimation and at developing aggregation methods for determining area, yield, and production by stratum, zone, region, and country. An additional R&D effort is required to determine the cumulative effect of subsystem errors on the accuracy of the final production estimate.

3.5.1.2 Wheat yield. R&D in this area will focus on the development of procedures for using historical data, conventional meteorological data, satellite-acquired meteorological data, and MSS data to estimate wheat yield and crop calendars as a function of location within major wheat-growing regions.

3.5.1.3 Wheat area. The bulk of the research effort, at least in the early phases of the LACIE development, will be devoted to development of ADP and analyst interpretation procedures for performing wheat area estimation. The major research topics to be covered are described as follows:

A. Minimally biased acreage estimation - Since the purpose of the LACIE is to obtain a wheat inventory, of which the wheat area estimate is a part, the development of computationally practical and statistically sound methods for estimating area is essential to the development of the LACIE. Therefore, this research effort will concentrate on developing estimation procedures which have desirable statistical properties such as small bias when compared to alternative estimation procedures, or whose bias decreases asymptotically as the sample size increase, and desirable computational properties such as small computer processing time and small computer storage requirements. A related research area is estimation of the fraction of wheat acreage that is actually harvested. This estimate is required because yield models provide the yield from harvested acreage, not from the planted acreage.

B. Signature Extension - Wheat area estimation procedures require that multispectral signatures be used in some phase of the estimation procedure. In the LACIE, these signatures are to be obtained through the use of analyst interpretation of Landsat imagery with the aid of an analyst interpreter. Such manual techniques, however, are time consuming and costly and therefore should be minimized as a part of the overall inventory estimation process. It is therefore desirable to be able to use wheat spectral characteristics from one geographic location to estimate wheat area by ADP methods in several other geographic locations. This process of training the classifier in one area and classifying in another is called signature extension. The research effort in signature extension will concentrate on determining and understanding the physical variables which influence the spectral response of wheat (and other crops) through field measurements studies, and/or developing ADP methods for normalizing, or in some cases altering, these measurements to remove the influence of extraneous variables. This research shall be coordinated with development of yield parameters. Once the physical factors which determine signature extension have been defined and weighted, signature extension strata (geographic regions in which signature extension is possible when sun angle and atmospheric effects have been corrected will be defined for all major wheat-growing regions.

C. Integration of ADP Analysis Procedures with Analyst Interpretation Procedures - Operation Interpretation Procedures - Operation of the

LACIE incorporates integrated analyst interpretation and ADP analysis procedures. Ideally, the two procedures should complement each other by properly mixing the strength of one to compensate for the weakness of the other. This is precisely the goal of the research effort in this area. Research topics will include the development of new techniques for generating computer processed imagery which aid the visual and intellectual processes to discriminate wheat from its confusion crops and the development of improved analyst interpreter procedures which make use of preliminary computer crop classifications as in a cluster map. An additional topic is concerned with the detection and removal of bias in the training statistics produced by current analyst interpretation techniques.

D. Supporting Research.- In addition to the above three main research topics there is a need for certain other research efforts to support the development of the LACIE. The major research topics in this area that will be pursued are the following:

1. The development of processing techniques relatively insensitive to the loss of data values from cloud cover interference or data acquisition malfunctions.
2. The determination of crop biological growth time phases and the impact of available meteorological data to determine sampling times at which maximal discrimination of wheat from its confusion crops is possible. (In addition, a research effort will be devoted to estimating crop calendars which predict crop growth at selected geographical locations.)

3.5.2 Test and Evaluation

A major T&E program will be devoted to evaluating components of the phase I operation of the LACIE. The purpose of this effort is as stated in article 3.5. Included as primary tasks in this evaluation are the following:

A. Evaluation of the wheat area estimation procedures to be used in the CAMS. (This effort will include an evaluation of the analyst interpretation procedures by quantifying their effect on the wheat area estimate, an evaluation of the alternative classifier configurations which are to be a part of the AES, and an evaluation of system performance in signature extension applications.)

B. The construction of experimental designs to evaluate the AES. (This effort will concentrate on evaluating components of the AES from measurements made on the system during its operation. No attempt will be made to perform a real-time systems analysis that could, for example, be used to correct system operations, rather, in a post operation mode the purpose will be to identify critical system variables and to isolate problem areas.)

C. Spatial sampling plan evaluation. (This task will evaluate the LACIE spatial sampling plan to be used in the area estimation procedure and certain alternatives to that plan with the purpose of identifying critical LACIE variables which are affected by these sampling plans.)

D. Evaluation of Wheat Yield Models. (Initially this effort will concentrate on the evaluation of the Thompson, the Baier, and the Haun yield models.)

In cases where part of the SR&T task involves the evaluation of a new technique that was the product of a research effort, the test and evaluation is responsible for providing or approving the experimental design. This responsibility is part of the RT&E policy to see that all new candidate techniques for the LACIE have been sufficiently tested to insure that their inclusion into the LACIE system will result in an improvement in operation.

SECTION 4
MANAGEMENT PLAN

4.1 MANAGEMENT STRUCTURE AND RELATIONSHIPS

Three levels of management are planned for the LACIE with NASA, USDA, and NOAA participation at each level. Figure 4-1 depicts the structure of the organization at the general level.

4.1.1 Executive Steering Group

In order to provide management guidance and control for this interagency effort, an Executive Steering Group is established, composed of one appointed member and one alternate from each of the participating agencies. The Executive Steering Group is responsible for the following:

A. Assuring interagency responsiveness on matters of national and international policy communicated via appropriate existing channels.
B. Formulating and approving interagency policies and procedures governing: the conduct of the LACIE, the coordination of the LACIE public information activities, the publication of scientific and technical LACIE documentation, and such subsidiary arrangements as may be required to accomplish the purposes of this agreement.
C. Approving all public information releases pertaining to the LACIE.
D. Securing resources as agreed upon for the implementation of the LACIE.
E. Coordinating and approving, within agency guidelines, any major redirections, changes, extensions, or deletions from the scope of the LACIE

4.1.2 Agency Project Managers

In order to focus the technical expertise of each participating agency and to provide an interagency staff for the Executive Steering Group, each agency will appoint a senior project manager. Working together, the Agency Project Managers will have the following responsibilities:

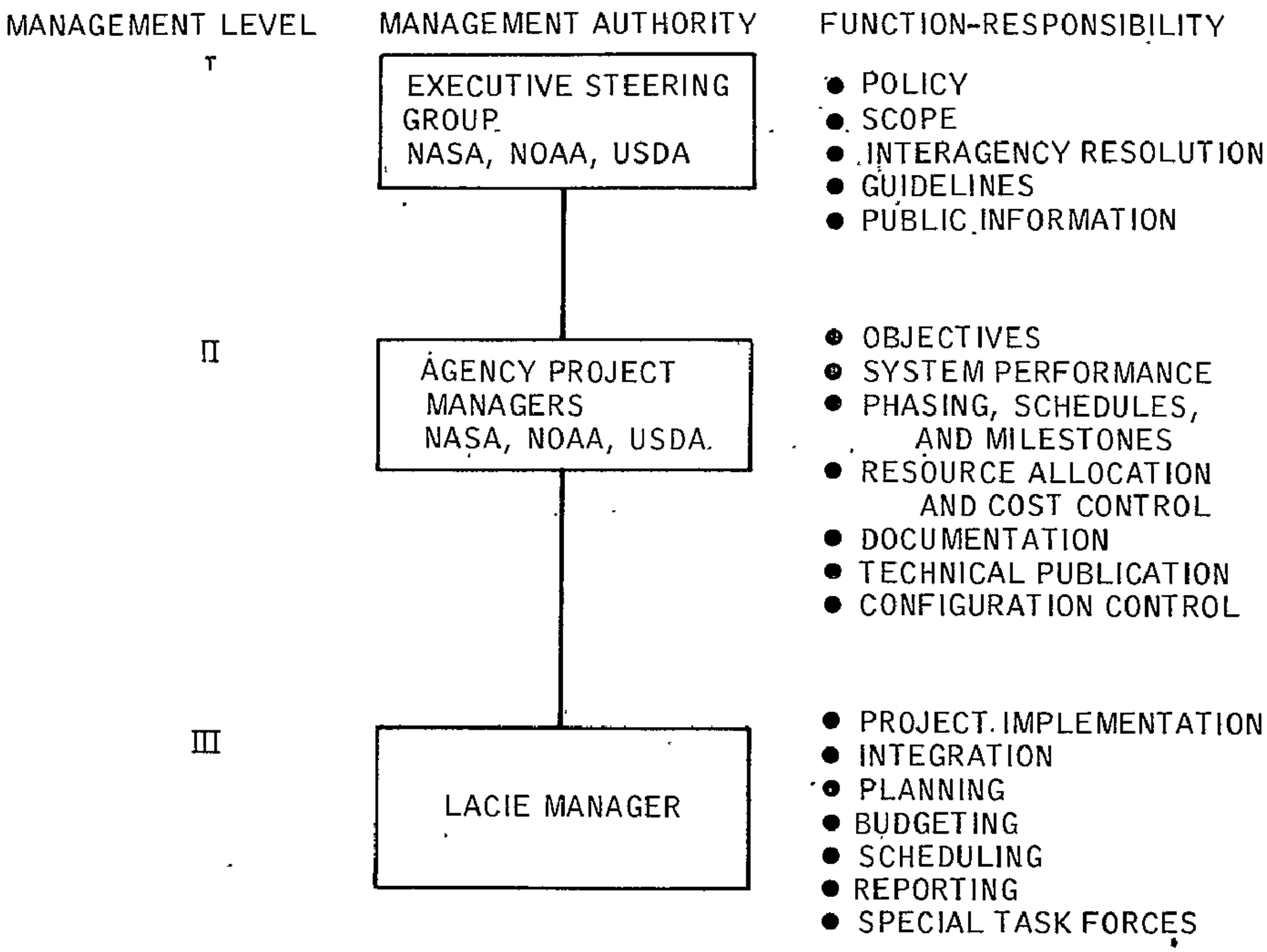


Figure 4-1.- LACIE management structure.

A. Overall management of the fiscal and human resources assigned to the LACIE by the respective participating agencies.
B. Guidance and assistance in the preparation of the LACIE project plans and schedules.
C. Review of the LACIE progress against approved plans and schedules.
D. Approval of scientific and technical publications concerning the LACIE.
E. Coordinating all proposed public information activities and releases pertaining to the LACIE and making recommendations to the Executive Steering Group thereon.

4.1.3 LACIE Manager

The LACIE Manager will be selected by the NASA and will be the general day-to-day manager of the project. The project management will be centered in NASA facilities at the Johnson Space Center, Houston, Texas. The NASA, NOAA, and USDA will assign staff support to the LACIE Manager who, under guidance from the Agency Project Managers, is responsible for the following:

A. Integrating interagency activities to meet LACIE goals and milestones and preparing project plans.
B. Preparing necessary budgets, schedules, and reports, making technical assignments, and allocating resources within the project.
C. Establishing and managing special task forces, as necessary, to examine such problems as yield model selection, and special contractual needs.

The LACIE Manager will have line assistants, staff, and performing elements in the project organization as shown in figure 4-2.

The joint staff will be totally integrated at the working level under the supervision of the LACIE Manager whether at the JSC or at other locations. Each agency will have an administrative organization for their personnel assigned to LACIE. Technical direction will follow the lines shown in the project organization (fig. 4-2). Personnel from participating agencies will be assigned to a specific element of the project and

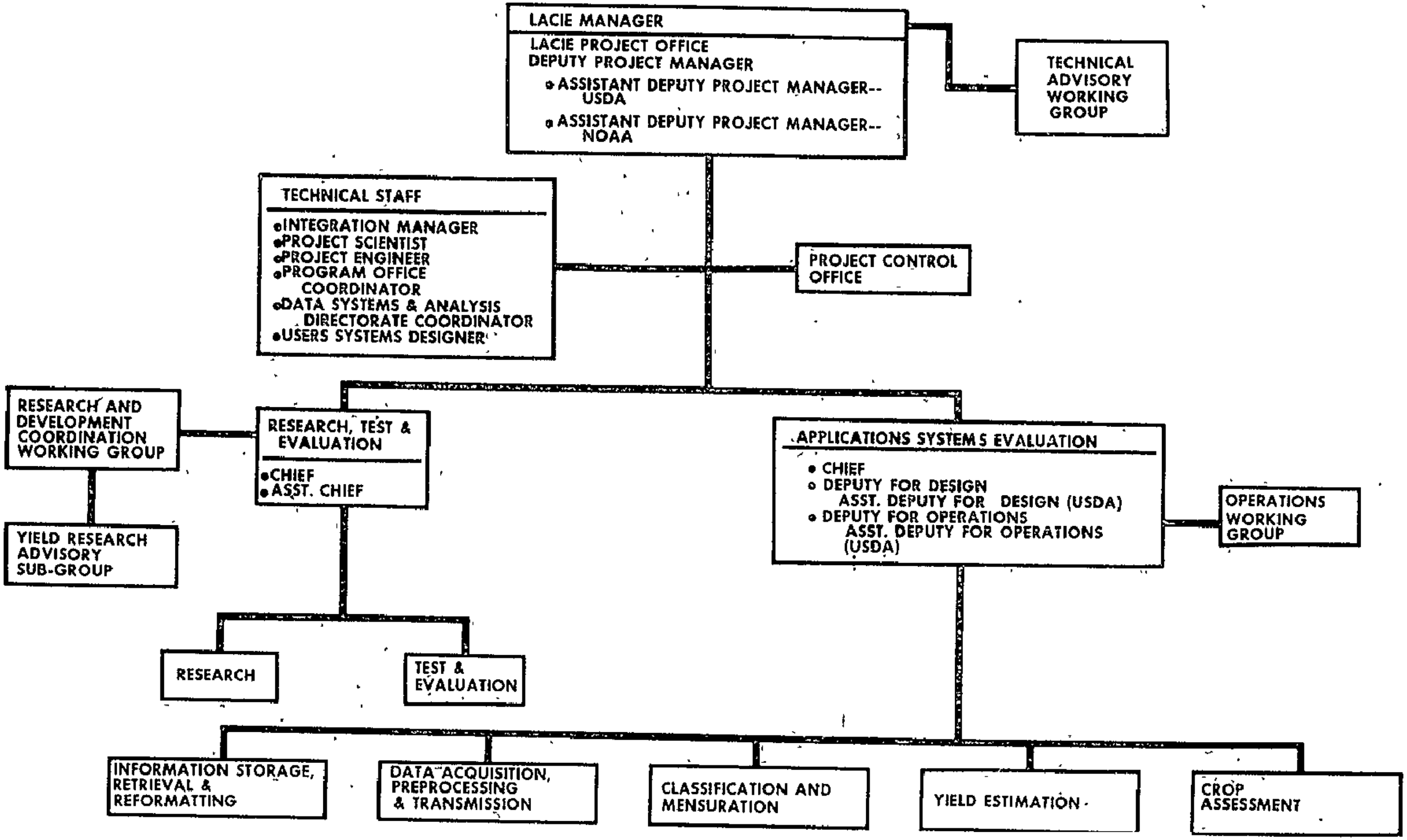


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Figure 4-2.- LACIE project organization.

will, regardless of affiliation, receive their day-to-day technical direction through the managers of such project elements.

4.1.4 Participating Agency Support

The LACIE project organization described in the preceding paragraphs is essentially an ad hoc organization which represents a streamlined approach for efficient allocation and use of resources directly in support of LACIE while maintaining adequate visibility for all agencies. Each participating agency will be allocating additional effort on tasks indirectly supporting LACIE and these may be best performed in main line elements of the organization. The Agency Project Managers will have their own line and staff elements to conduct or monitor such indirect efforts and will in turn report to appropriate points in their own organizations. The agency-unique organizations for both direct and indirect support are described in the following paragraphs.

4.1.4.1 USDA. The LACIE-related USDA organization is shown in figure 4-3. Relationships to operational agencies within the USDA is by way of negotiated task assignments.

4.1.4.2 NASA. The LACIE-related NASA organization is shown in figure 4-4. Relationships to operational elements is by way of task assignments levied by the Earth Resources Program Office.

4.1.4.3 NOAA. The LACIE-related NOAA organization is shown in figure 4-5. Relationships to operational elements is by way of negotiated task agreements.

4.1.5 Working Groups and Task Forces

A number of areas of project interest require either the special skills of persons not dedicated to the project or coordination across agency lines outside the direct project organization. The mechanism of a working group or task force will be employed to assure coverage

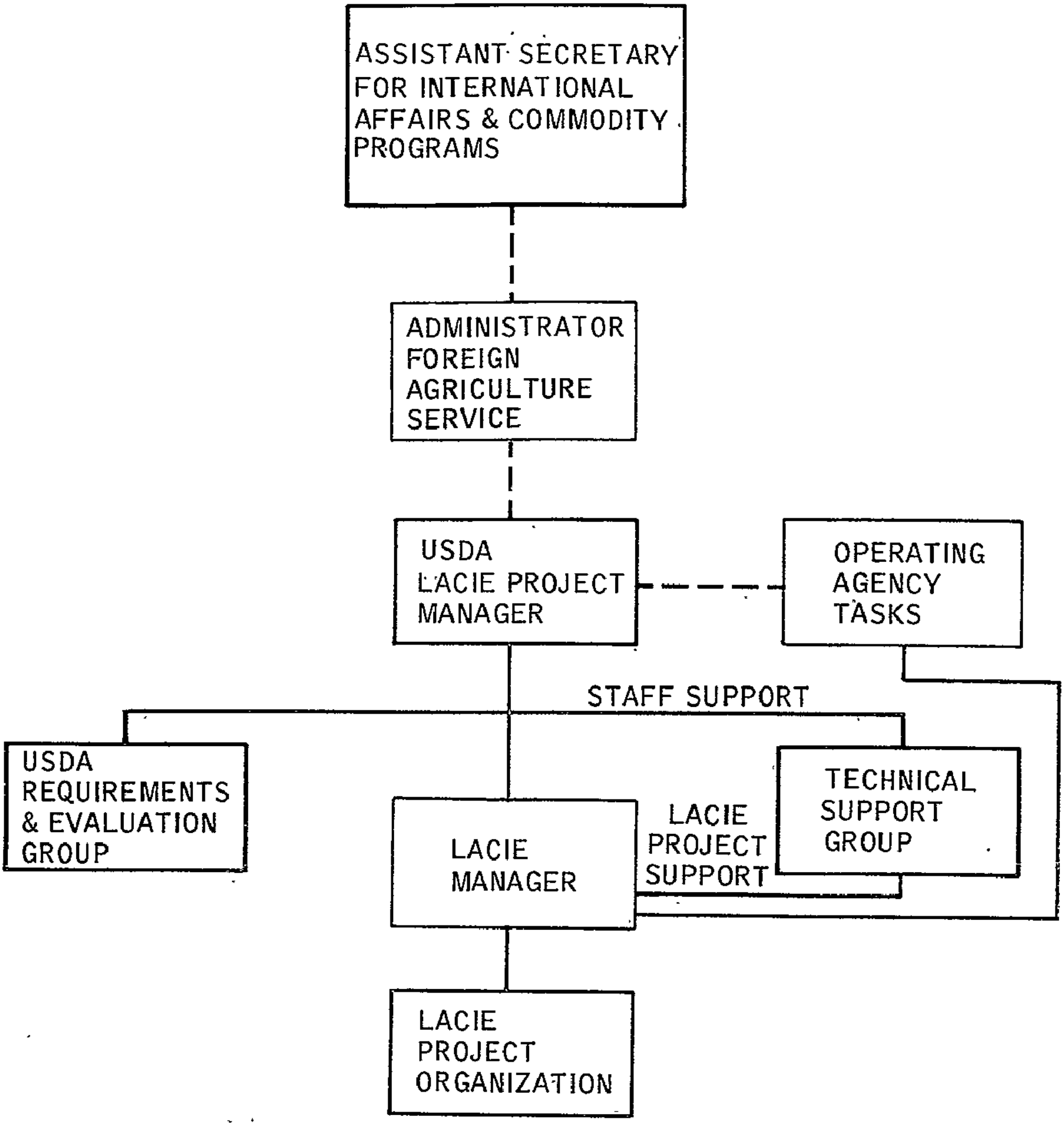

Figure 4-3.- LACIE-related USDA organization.

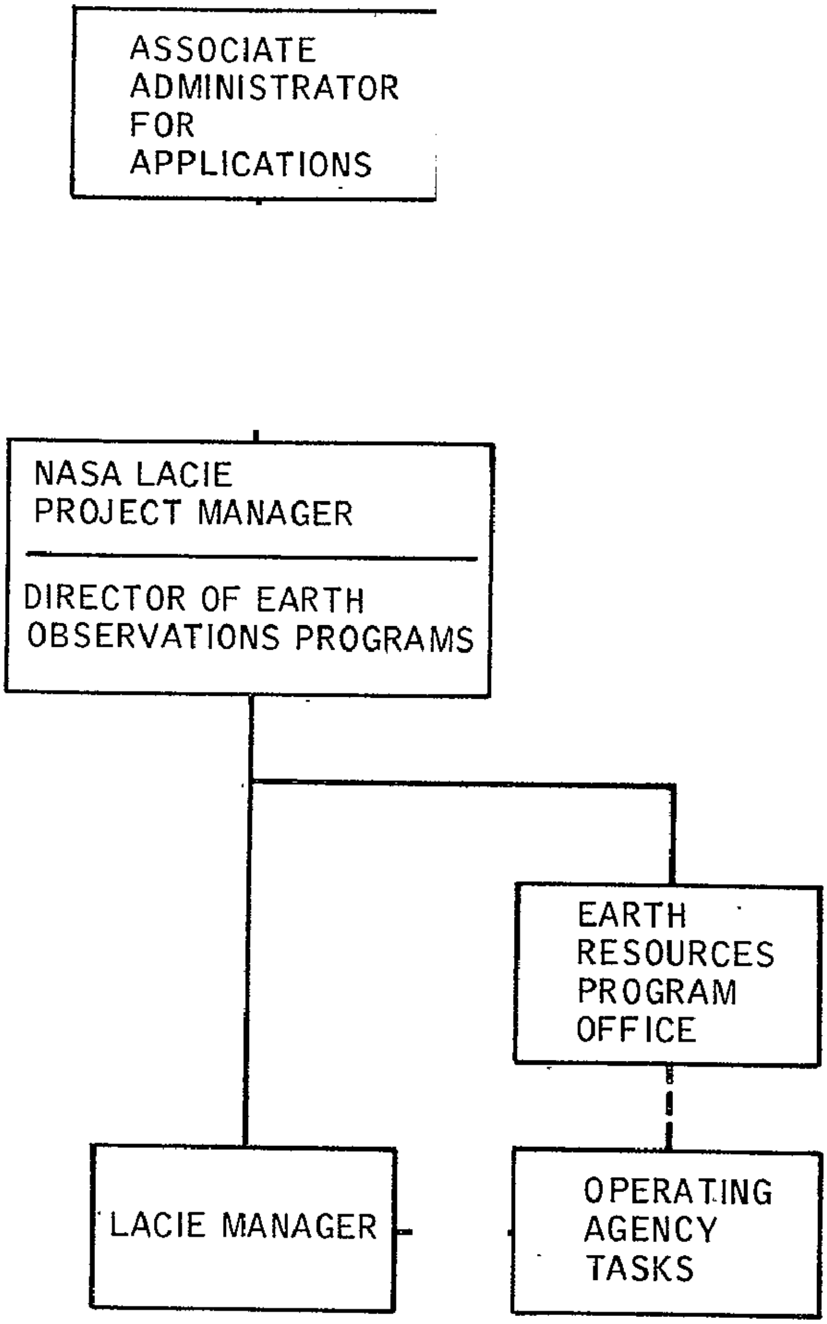

Figure 4-4.- LACIE-related NASA organization

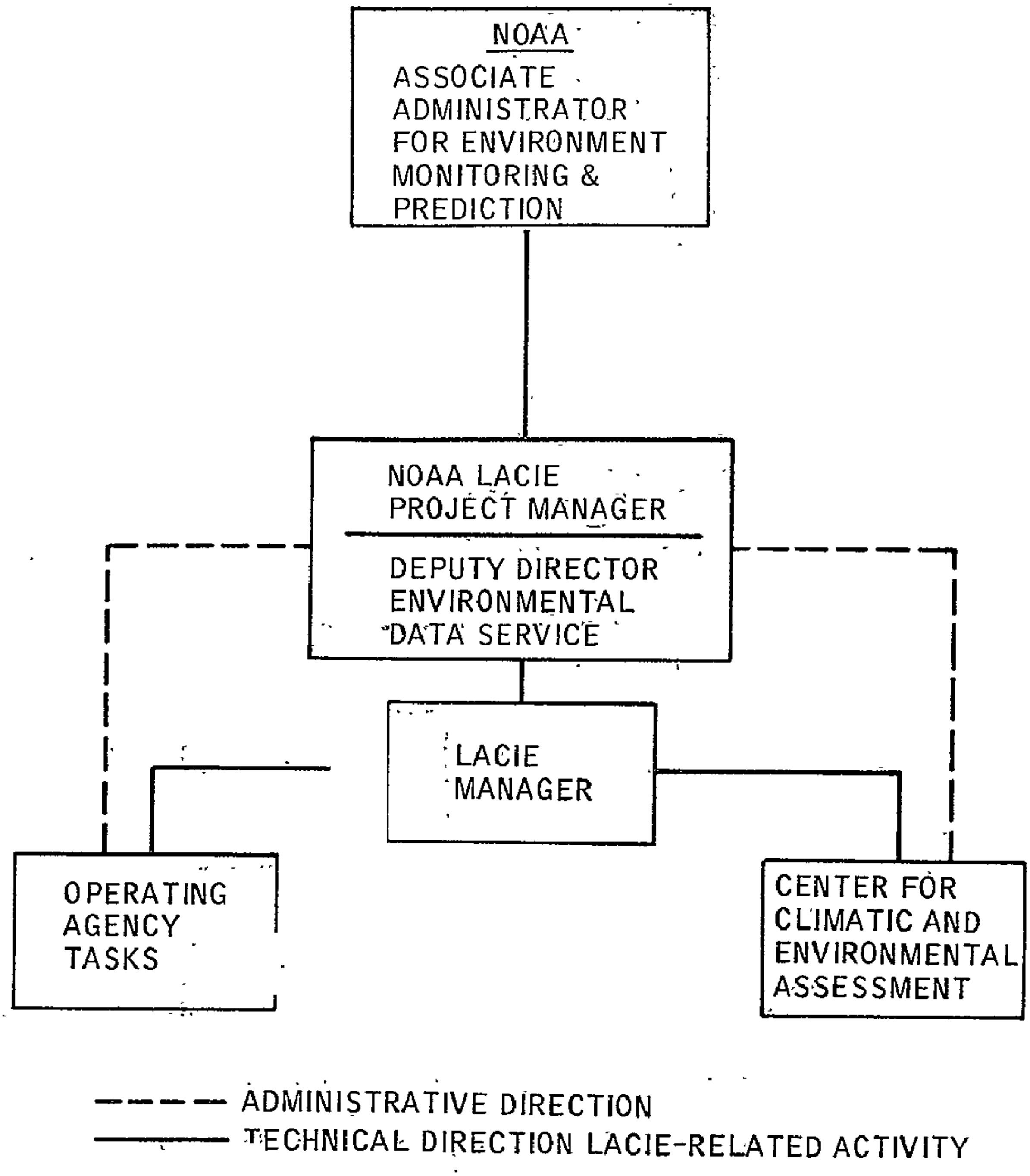

Figure 4-5.- LACIE-related NOAA organization.

of such areas. The term working group applies when a continuing function is required to be performed throughout all or much of the project. The term task force applies when a specific task of short duration is to be performed.

4.2 RESOURCES

4.2.1 NASA Resources

4.2.1.1 Hardware. NASA will operate the Landsat-1 and Landsat-2 satellite systems that acquire multispecitral scanner data for the LACIE. These data will be relayed to the GSFC for preprocessing into computer compatible tapes (CCT) on existing equipment modified for the LACIE. The GSFC will be required to dedicate a portion of its Landsat data processing facility to the project. In addition, new procedures and equipment will be required to perform image editing, data quality assessment, image to image registration to within a pixel, and transmission of the Landsat data sets to the JSC.

Earth Resources aircraft presently available within the NASA will be used to augment ground truth data by the acquisition of photographic data over selected intensive test sites in the United States.

A significant portion of the JSC computing resources will be required. A two machine configuration of IBM 360-75s will satisfy the Earth Resources Interactive Processing System (ERIPS)-type interactive and automated batch mode production functions such as classification, area determination, composition for temporal analysis, yield, production assessment, information storage and retrieval, and report generation. Mass storage consisting of 18 each IBM 3330 disks is used for the data bank. In addition, a special peripheral device, the array processor, will speed up processing existing machine configurations.

Building 17 will be equipped with interactive consoles to allow analysts to interact with the LACIE data system.

Certain RT&E functions of the project will use a portion of the available time of the JSC's Univac 1108 and 1110 computers.

The JSC production processing system film recorder will serve as the primary facility for producing output products such as daily quality/analysis images and postclassification maps. The LACIE currently has access to one PFC.

4.2.1.2 Software. The JSC is employing a modification of the IBM Information Management System to support LACIE information storage and retrieval and other application programs. The majority of the operational software is being custom designed by the Data Systems and Analysis Directorate for JSC's Real Time Operating System. Modifications to existing software will be prepared to operate with LACIE format data blocks and companion ancillary header data.

4.2.1.3 Data. Data for the LACIE will be the following:

A. Landsat-1 and Landsat-2 A data set is defined as the Landsat multispectral data acquired over one unique geographic area (a sample segment) at a single time. The area to be surveyed is as outlined by the current data collection plan (i.e., approximately 4800 segments each 5 by 6 nautical miles per biological phase).

B. Aircraft Data High-altitude-aircraft photographic coverage is required over selected intensive test sites each biological phase throughout the life of the project.

4.2.1.4 Personnel. The NASA estimates of personnel required for the successful completion of LACIE have been reviewed with NASA Headquarter, Office of Applications.

4.2.1.5 Support services. Support service for the LACIE will be the following:

A. Supporting contractors A major portion of the effort required to execute this project will be derived from support contractor personnel. The man-year levels of such effort have been estimated by fiscal year and by organization.

B. Supporting studies Various aspects of the project effort will be executed by non-NASA organizations on an individual contract basis.

4.2.1.6 Facilities. NASA will provide office facilities for project participants assigned to JSC. JSC Photographic Technology Division facilities will be employed for film-processing activity.

4.2.2 NOAA Resources

4.2.2.1 Hardware. NOAA Hardware will consist mainly of existing computer/EDP facilities. Additions to existing meteoroloical communications facilities will be established for the purpose of providing needed meteorological input to JSC, to the Page Building 2 in Washington, D.C., and to the Center for Climatic and Environmental Assessment (CCEA) in Columbia, Missouri.

4.2.2.2 Software. This will consist of: (a) computer algorithms for operating weather/yield YES models; (b) computer algorithms to be developed by CCEA for use at the World Weather Watch Building, Suitland, Maryland, for the purpose of extracting selected meteorological data from the global communications system available to NOAA; (c) algorithms to be used to extract selected data from the NOAA meteorological satellite system.

4.2.2.3 Data. NOAA will process the following meteorological data in a format compatible with requirements for: (1) input to YES weather/wheat models, and (2) for use of NOAA staff at JSC to provide advice on adjustment of crop calendars because of anomalous weather, and (3) CAMS analysts to make arrangements for communications facilities to handle these data and others that may be necessary for LACIE operations.

4.2.2.4 Personnel. The level of NOAA Civil Service personnel has been identified. This includes personnel to be assigned to JSC to support the LACIE effort.

4.2.2.5 Facilities. Worldwide surface and upper air meteorological communications system available to NOAA through facilities at the World Weather Watch Building, Suitland, Maryland; plus, NOAA/Federal Aviation Administration meteorological communications facilities within the U.S.

One or more meteorological satellites, probably NOAA 3 and 4, will be available in the project time scale. The processing facilities of NOAA are being coordinated and are assumed adequate to meet the needs of the project.

NOAA will provide (or arrange for) computer facilities at: (a) Columbia, Missouri, for use in the YES CCEA model development effort (this will be a terminal on the University of Missouri Computer network; plus, the capability of submitting larger computer runs through a university facility on campus); (b) Page Building 2, Washington, D.C.; (c) National Climatic Center, Asheville N.C. (for preparation of certain meteorological data bases).

4.2.2.6 Support services. NOAA will let contracts for development of weather/yield models for regions that cannot be done with CCEA facilities. Technical monitoring will be performed by the CCEA.

4.2.3 USDA Resources

The USDA estimates of resources required in support of the LACIE are predicated on the successful achievement of critical management milestones. Resource commitments and/or definitions are discussed in the following articles.

4.2.3.1 Hardware/software. During the initial phases of the LACIE all hardware and software will be provided by the NASA/NOAA. Following the preliminary evaluation of technical results, the USDA shall select a computer system from within the existing inventory and commence detailed hardware/software specifications necessary to commence orderly conversion of LACIE modules.

Additionally, augmentation of existing USDA systems may be economically feasible. This augmentation could be achieved through procurement/lease of additional general purpose front-end systems and their associated communication linkages. If this approach seems feasible, existing USDA procurement/lease vehicles shall be utilized.

4.2.3.2 Data/data base. To the extent practical, and within the limits of technical feasibility and available resources, data formats and structures shall conform to those guidelines established by the USDA for data processing systems to be selected for LACIE follow-on systems. Associated with the specification of USDA resources to support data/data base are those personnel required to support ground truth and historical data gathering activities. This manpower requirement shall be coordinated through the USDA LACIE Project Manager.

4.2.3.3 Personnel. The level of personnel resources to carry out the project have been estimated by functional organizations. All personnel resources are Civil Service.

4.2.3.4 Facilities. All administrative and ADP facilities required to support USDA personnel at the JSC will be provided by the NASA on a nonreimbursable basis. USDA Washington facilities are provided under an intradepartmental memorandum of understanding. At such time as the USDA elects to commence transfer of LACIE technology into an operational mode, the requirement for facilities will be satisfied by USDA. USDA Washington will provide office facilities for NASA and NOAA personnel involved in information evaluation.

4.2.3.5 Contract support. Any contractual support porcured by the USDA in support of the LACIE shall be negotiated through the Agency Project Manager. Technical monitoring will be carried out either by the USDA-LACIE staff at JSC or Washington as appropriate.

4.3 PROJECT CONTROL MECHANISM

The Agency Project Managers will conduct project reviews on alternate month intervals. The reviews would include such items as schedules, resources, plans, and operational status.

The LACIE Manager will conduct monthly project reviews encompassing requirements, operational status, schedules resources, and plans, both implementation and operations.

Any changes to resources expenditures within NASA will be approved through the Earth Resources Program Office (ERPO) Configuration Control Board Mechanism (CCB).

In addition to the above mentioned controls, Major Event Reviews will be conducted. These reviews would be concerned with such items as subsystem readiness, data system tests, and initiation of various phases or milestones.

The Agency Project Managers would also have to conduct CCB meetings to consider such items as changes in the general system level requirements, performance goal parameter alterations, major deviation in project resource requirements, and changes to approved schedules which impact the successful accomplishment of the project.

The LACIE Manager will conduct monthly CCB meetings to consider such items as functional and detailed requirement changes, detail schedule changes, control documentation changes, resources requirement impacts, and staffing changes.

A general chart of the elements to be controlled at each level is given in table 4-I.

4.4 LACIE BUDGET

Each participating LACIE agency will fund its own share of the experiment's activity.

TABLE 4-I.- LACIE PROJECT CONTROL ELEMENT MATRIX, ELEMENT TO BE CONTROLLED

Level	I Executive Steering Group	II Agency Project Managers	III LACIE Manager	IV Functional elements (branches, subsystems)
Schedule	General milestone Gantt chart	Gantt chart depicting system development and operations phases 1 and 2	Generalized flow chart - groups of fragnet functions	Fragnets
Requirements	General policy-level requirements	General system-level requirements, performance goals, scope, and operational phases	Functional and detailed requirements to be levied on each performing organization (USDA, NOAA, DSAD, etc.)	Subsystem requirements (design, performance, operations, testing documentation)
Tasks	None	None	Tasks at next greater level of detail than Project Plan	Subtasks of the level III tasks
	Memorandum of Understanding (MOU), summary plan, summary results	Documentation depicting the operational/approach to be used for LACIE; e.g., Project Plan, and Results of the Experiment	Defines documentation describing branch activity requiring PMT review. Operational Plans, Detailed Results	Defines the documentation to be done by the subsystem manager, reviewed by Branch Head
Organization Chart	General structure showing: Executive Steering Group, Agency Project Managers, LACIE Manager	Structure depicting SRPO, USDA, NOAA, Agency Coordinators, and LACIE Project Organizations	Structure chart depicting the project organizations	Structure showing subsystem breakdown, including contractors
Control/procedure document	Management guidelines	Program, CCB mechanism, review procedures	Project CCB mechanism ICD's, quality control procedures	System and subsystem procedures documents; facilities requests

SECTION 5

PROJECT PLAN AMENDMENTS

The amendments generated against this document will be presented to the Agency Project Managers for approval when sitting in concert as a Level II Change Control Board. The approved items will be returned to the LACIE Project Manager for publication, distribution, and maintaining a control copy on file.

SECTION 6
REFERENCES

1. Production forecasting feasibility assessment using remotely sensed and ancillary information (in publication).

APPENDIX A

CONTINGENCY PLAN

INTRODUCTION

The LACIE Contingency Plan addresses two major areas and some selected subareas. The major areas are crop production and equipment malfunctions.

Previously, contingency plans were designed to address preservation of life and accomplishment of mission objectives. With these criteria, the element of extreme urgency and rapid response was a factor. The LACIE plan shall deviate from the established format in that it will address the singular objective of experiment accomplishment.

System malfunctions, not covered by this plan, will be forwarded to the Project Management Team (PMT) for consideration. Using a moderate amount of time to formulate a solution, recommendations and implementation plans will be initiated and, where required, forwarded to Level II management for approval. No attempt is currently being made to predefine the time and manpower required to initiate Contingency Plan solutions since activity described at this time will undoubtedly be modified due to the dynamic nature of the experiment.

TYPES OF CONTINGENCIES

The LACIE Contingency Plan addresses two distinct types of potential trouble areas: crop anomalies and system malfunctions. Both domestic and foreign crop anomalies are considered, and reduced production figures are addressed. System malfunctions of the Landsat-2 satellite and certain pieces of equipment involved in its data flow are addressed.

GENERAL CONTINGENCY ACTIONS

If a major global wheat producing territory currently scheduled for participation in LACIE should encounter severe weather or other conditions that would adversely affect production, additional data taking and analysis could be initiated over the affected area. The decision to direct additional attention to this area, however, would require direction by LACIE Level II management.

Should a territory not currently participating in the LACIE sustain severe crop production abnormalities, then new data could be acquired and analysis undertaken. The additional effort required, both financially and in manpower, would require LACIE Level I management direction.

If abnormal conditions in the U.S. should cause areas to be classified disaster areas, the LACIE could be used to determine the extent of damages by providing a more intensive analysis. If, for instance, a severe drought occurred in the High Plain of Texas, the LACIE response could entail the acquisition and analysis of full frame imagery to delineate the extent of the area affected, priority operations of the yield model for those stations within the affected areas to establish an initial estimate of production deviation, and the development of special reports. Should the crops to be analyzed or the areas to be monitored differ from the original LACIE selection, the decision would require Level I management direction.

Should anomalies occur requiring Level I or II management redirection, the PMT would coordinate LACIE activities to assess impact, resources, and reaction time for the contingent situation. This assessment would require a moderate amount of time for formulating and operational approach, and, after concurrence by directing management, these modified procedures would be implemented.

The following LACIE systems failures would require alternate methods of operation to continue data processing.

1. Should Landsat-2 fail to deliver multispectral scanner spectrometer (MSS) data before acquisition of 90 percent of the data for the 1974-75 Northern Hemisphere crop year, LACIE shall use Landsat-1 data retrospectively to analyze a complete crop year.

2. In the event of failure of the MSS after acquisition of 90 percent of the data for the 1974-75 Northern Hemisphere crop year, LACIE will complete the analysis for the year to the extent possible using Landsat-2 data already acquired. Full frame data for the LACIE territories will be acquired and stored to permit retrospective worldwide analysis in the following year. An ad hoc task force will be identified to study the feasibility of conducting a real-time wheat area estimate with return beam vidicon (RBV) data. Implementation of this alternative is expected to require a minimum of 1 year.

3. Should GSFC become unable to process and forward Landsat-2 data for a period in excess of 30 days, the making of wheat area determinations will continue using prior classification results if available or, in their absence, using historical data. When the system is again operational, processing will be resumed on current data and backlogged data will be processed retrospectively, if required, to bring the quality of classification results to an acceptable level.

4. If the production film converter (PFC) fails, the passive microwave imaging system/data acquisition system (PMIS/DAS) in building 17 will serve as a short-term backup for processing a limited number of segments per day. When appropriate capabilities exist at the USDA laboratory at Salt Lake City, the laboratory will be used as a backup facility. Additionally, both units may be used to supplement normal operation should the need arise.

5. Any additional anomalies that occur shall be considered operational problems and fall within the jurisdiction of day-to-day activity. Prompt remedial action would be initiated; however, the anomaly itself would not be classified as a contingency.

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