FOREIGN AGRICULTURE SERVICE, DEPARTMENT OF AGRICULTURE, CROP CONDITION ASSESSMENT*

Introduction

The Foreign Agriculture Service (FAS) is one of two Federal agencies that can be said to be utilizing remote-sensing satellite data in a daily operational format. Its unique qualities as an operational program have been and are that, although like many other Government users, it acquires, processes, and analyzes repetitive Landsat data, FAS is the only agency routinely having a requirement to produce a product in *near real time.*

FAS has been notably successful in managing the transition from limited use of data derived from a research and development (R&D) system to full integration of data from an operational system. If the R&D system is built and tested by one agency, but the operational system is to be managed by another, then appropriate cross-agency responsibilities for managing the transition must be devised. In addition, the hardware and software incorporated in the R&D system are usually more advanced than what the user agency requires or can even use. The success of FAS in effecting this transition provides a model that the Federal Government, as well as State and municipal governments, might follow.

The FAS Mission

The primary FAS mission is to develop, maintain, and expand foreign markets for U.S. agricultural commodities. To accomplish this mission, FAS maintains a worldwide agricultural intelligence and reporting system to provide timely and accurate information on world agricultural production and trade. The information provided by FAS enables U.S. farmers and traders to adjust to changes in world demand for U.S. agricultural products. The information is also used by the Department of Agriculture (USDA), other Federal agencies, the Congress, and others in the formulation of foreign market development and export sales policies, and in developing strategies for negotiating international trade agreements.

Product

Current information covering principal agricultural commodities that has been developed by USDA analysts is made available to the public through the following kinds of publications:

- FAS *circulars* for major commodities (scheduled and unscheduled). These circulars contain as a minimum the current official USDA acreage, yield, and production estimates.
- Weekly *roundups* that provide interim updates between the release of the scheduled circulars, particularly with regard to unusual or unexpected events which may impact production.
- *Foreign Agriculture Magazine* (monthly) that publishes articles on foreign agricultural matters of general interest.

The scheduled "circulars" and the "Weekly Roundup" reports are released on a predetermined schedule to provide equal access by all users. The current FAS remote-sensing program was initiated in 1973 with the conception of the large area crop inventory experiment (LACIE). LACIE was a joint cooperative effort among USDA, the National Aeronautics and Space Administration (NASA), and the National Oceanic and Atmospheric Administration (NOAA). The goal of LACIE was to develop, test, and evaluate a system for predicting foreign wheat production through the use of Landsat satellite data, weather and agricultural data, and advanced data processing technology. LACIE began with the signing of an interagency memorandum of understanding in 1974, and ended in 1978. Each participating agency contributed funds and personnel to the project.

The project was directed by a three-agency, high-level, executive steering group, with LACIE project management assigned to a project management team (PMT) made up of senior technical managers from each of the agencies. The NASA technical manager was responsible for day-to-day operations, but management decisions were made by the joint PMT.

The LACIE approach was to: 1) develop wheat area measurements from analysis of randomly selected Landsat sample segments; 2) estimate yield through use of weather-related regression yield models; and 3) multiply area by yield to develop regional and country production estimates.

The USDA LACIE project team developed a set of USDA user requirements based on 1) interviews with FAS commodity analysts, embassy attaches and management, 2) reviews of the FAS operational forecasting systems, and 3) discussion with users of FAS global crop information. These requirements were evaluated

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for accuracy and timeliness and presented to the executive steering group. However, because the then-current Landsat technology (ERTS 1) would not fully meet USDA user requirements, the requirements were modified, at the insistence of one of the technical agencies, to a level thought to be achievable.

Results

During its lifetime, LACIE produced wheat production estimates as follows: U.S. Great Plains in 1975, **1976,** and 1977; Canada in 1976; two Soviet Union indicator regions in 1976; and the entire Soviet Union in 1977 and 1978. Generally, all of the winter wheat and the Soviet spring wheat estimates were acceptably close to official USDA figures. However, the U.S. and Canada spring wheat estimates failed to meet the LACIE accuracy objectives. The poor performance on spring wheat was largely due to the compressed growing season **for spring wheat and the presence of other "confusion crops."** The results of LACIE were reported at a symposium that was held at the Johnson Space Center in October 1978.

Hardware and Software Considerations

Technology transfer in any environment carries a certain element of risk. The relative novelty of space data collection and analysis for foreign agricultural applications significantly increased this risk factor. Therefore, a policy was adopted that was calculated to minimize financial risk to USDA while retaining maximum flexibility to deal with technological contingencies. The three major elements of this policy were:

1. All **hardware and software procured to support the design** would be commercially available "off-the-shelf" and vendor-maintained.
2. Discrete functions were designed to operate on a single mini computer, yet retain the capability for interfunction communications.
3. All **application** programing was to be modular and would conform to Federal and Department standards for information processing.

Management Approach

FAS applied management by objective and structured decisionmaking to the transition from R&D to a user test and subsequently to full operation. The professional staff was involved in the technology transfer process, starting with the initial planning process. Without this involvement, successful transfer of technology would not have occurred.

Long-Range Planning

The long-range (5-year) management plan guided all activities in the transition to operational application of space-acquired data. Commencing in 1978, a series of yearly management plans were initiated. These plans contain, on a year-by-year basis, the next level of resource detail and task description.

Major problerns.-The problems encountered in the transition to space-aided data collection were not just technical in nature, but encompassed the entire scope of institutional reactions toward implementing a new technology:

External:

- timely receipt of Landsat data from NASA
- timely receipt of meteorological data from the Air Force; and
- lack of R&D assistance to transfer activities

Internal:

- education of end user; and
- establishment of means to provide FAS meteorological data from the World Food and Agricultural Situation Board within 24 hours.

Continuing problems. –R&D support to technology transfer activities, and physical separation of analytical functions from the end user of a product. The data base generally available to the FAS **analysts is:**

- **Landsat—3 days to 3 weeks after acquisition;**
- **weather station reports-24 hours after receipt by NOAA; and**
- **environmental satellites—34/48 hours after acquisition.**

These data are further supplemented, where and when available, from on-ground observations (ground truth) for areas of interest, but these inputs are limited and in some cases unavailable, Examples of the analytical products derived from this variety data sources are:

Narrative assessments of:

- crop and pasture conditions and probable impacts on production;
- outlook for water for irrigation; and
- planting and/or harvest conditions.

Maps that show:

- crop stress lines;
- plots of vegetative index numbers, including comparison to baseline years;
- snow cover, temperature, and potential winterkill lines; and
- precipitation and soil moisture, and deviation from baseline years.

Color displays:

These use several media, including photographs, color graphics terminals, video tape recorders, and overhead projectors. Examples of color products are:

- analyzed Landsat data;
- current and historical soil moisture;
- current and average crop calendars;
- soils information; and
- daily precipitation for selected 10-day periods,

FAS management by objective requires the development of long-range objectives as a basis for defining longer term goals, which in turn form the basis for the planning documents described.

Management Planning

This activity builds on the long-range planning for the transition from R&D to an operational system. The 5-year management plan, originally developed to guide the transition, is reviewed annually in light of FAS objectives and requirements, revised as necessary, and presented to management for approval.

Short-term. -An annual management plan translates the appropriate portions of the 5-year plan into a plan for the coming fiscal year that contains tasking schedules and resource requirements.

Contingency Planning

This process identifies potential barriers to the orderly progress of crop estimation and estimates the probability of their occurrence. Plans are then developed to avert or minimize the consequences.

An appropriate example of such a situation is the anticipated lack of multispectral scanner (MSS) data between the demise of Landsat-3 and the operational readiness of Landsat-D. In anticipation of such an event, a contingency plan was developed which involves the use of the **NOAA-6 and NOAA-7 satellite sensors as alternate data sources. Correlations between the Landsat and NOAA-6 data, and a hardware system to accept, process, and analyze the data are currently under development.**

Budget Planning

In addition to management and operations planning, the Crop Condition Assessment Division (CCAD) had developed a long-range financial plan that projects CCAD'S operations and systems replacement costs for the next 5 years. This 5-year financial plan is updated annually. The plan is used to prepare realistic CCAD cost estimates as input to the FAS and USDA budget process, and to develop procurement strategies for replacing computer systems as they become obsolete.

Problems

The problems encountered in developing and implementing the operational system are essentially the same as those encountered during the transition from R&D to operational status. However, their effect is even greater, given the requirement to provide short turnaround data analysis and reporting. Again, problems can be divided into those internal to FAS and those that are external:

Negotiating arrangements with NASA to:

- Furnish Landsat data within 48 hours after collection. (To date, NASA has been unable to meet FAS timing requirements.)
- Accept and process FAS orders for repetitive and one-time Landsat data collection.

Unanticipated changes in Landsat data format. Originally, NASA announced that the data would be delivered in a high-density digital product tape (HDDT), on which radiometric and geometric corrections and resampling had already been accomplished. Then, NASA and the U.S. Department of the Interior (USDI) jointly announced that the standard tape format would be changed to HDDT archival tape, on which only the radiometric corrections had been made. As a result, FAS was forced to divert approximately $250,000 from its planned system enhancement to modify the scene processing unit to accommodate the new format.

Inability of Landsat-D to provide full geographic coverage. The proposed Landsat- D, with its dependence on the tracking and data relay satellite system (TDRSS) will not provide timely (24-hour) coverage for India, Pakistan, and a major portion of the U.S.S.R. spring wheat region. These areas are critical to FAS. USDA repeatedly requested installation of wide-band tape recorders on Landsat-D and D' to ensure full geographic coverage. However, the tape recorders are not included in the planned system configuration.

Strong probability of a lengthy Landsat MSS data gap between the end of Landsat-3 and the operational readiness of Landsat-D (this has already occurred). FAS **and USDA were unable to alter NASA's schedule, which seemed to be dictated** more by a preoccupation with technical problems with the Thematic Mapper than by the pressing need of users for continuity of MSS data.

The uncertainty about MSS data continuity required the diversion of analytical resources to development of techniques to use NOAA's environmental satellites as an alternative data source.

Lack of rapid turnaround R&D assistance in developing, testing, and implementing techniques to processs and analyze environmental satellite data. This slowness seemed to stem from the R&D community's perception that its role was to carry out basic and long-term research as opposed to applied research to solve pressing problems.

Internal:
- establishing system credibility with FAS commodity analysts and others.

issues outstanding:
- delays in delivery of Landsat data;
- probability of an extended break in Landsat data continuity;
- lack of timely data for India, Pakistan, and part of Soviet Union through the 1980's; and
- lack of R&D support to resolve near-term operational problems.

Improvement in Information

For the past 2 years, the project has been analyzing space-acquired meteorological data and providing condition assessments to FAS commodity analysts. These reports are not used by the agency as "stand alone" reports, but are used as additional input in formulating the agency's country-by-country production and demand forecasts. Because the reports have only been available for 2 years and because they are integrated into multisource reports, it is impossible at this time to quantify improvements to the FAS information system. However, qualitative improvements through enhancements to the FAS analytical process are evident. Examples of services that improve the analysis **and** increase confidence are as follows:
- early warnings of situations that may affect agricultural commodity production and assessments of probable impact;
- continuous monitoring of conditions in foreign high-risk/high-priority regions throughout the entire crop production cycle, and issuance of periodic assessment reports; and
- confirmation (or denial) of reported situations affecting foreign crops.

Availability to analysts and embassy attaches of information in gridded data base relative to:
- moisture available to plants at planting time and throughout the growth cycle and deviation from baseline years;
- crop growth stage at any specified time, and deviations from baseline;
- daily temperature/precipitation, and deviations;
- soils/climate information for areas of interest; and
- agricultural acreage, yield and production statistics at subcountry/province level.

Landsat and Successor Systems Requirements

Ground Data Handling.-This function is the cornerstone of any operational use of data acquired from space. The FAS technical requirements relative to this function were first stated in the Department's user requirements document, which was developed during LACIE and subsequently reaffirmed in informal correspondence between **USDA and NASA/NOAA. Additionally, the requirements were also documented as input to the recent Integrated Remote Sensing Systems Study (IRS[3]), These requirements are as follows:**

Data Delivery

Data delivery requirements in support of **FAS operations are as follows:**
- **HDDT** in Product ("P") format with radiometric and geometric corrections applied. Nearest neighbor resampling is preferred.;
- delivery systems should not introduce data errors over and above those inherent in the collector; and
- pass-to-pass registration of frame data is a minimum requirement. Header data for registration to a given cartographic base is also considered a requirement.

Data Timeliness

Timeliness of data is a critical technical requirement for FAS. The quantification of this requirement is specified below:

Ž All data collected by the 4-band MSS are to be made available for processing by FAS within 48 hours after acquisition by the satellite.

All special FAS requests to activate the collector over areas routinely scheduled for coverge must be scheduled within 24 hours after receipt of the request.

Data retransmission required because of errors or omissions must occur within a 12-hour period regardless of error source.

Data Continuity

The requirement for data continuity has two discrete elements: day-by-day processing and delivery to the user; and data coverage comparability between space platforms, with no gap in time between operational readiness of successive collection platforms. Each of these FAS requirements is summarized as follows:

Day-by-Day Data Receipt (reliability)
- total daily data collection must be processed and delivered to FAS within the timeliness criterion; and
- data backlogs cannot be tolerated within the scheduled operations and resource base of FAS.

Data Gap

The data gap potential is the most worrisome situation a user of satellite data can face. In this context FAS has initiated and supported the following requirements:

- A space platform with fully operational MSS to be in orbit at all times;
- the 4-band MSS with on-board wide-band tape recorders to be continuously operated through the 1980's;
- a single satellite (collector) operational with a backup available for launch to assure data continuity; and
- total world coverage capability with *no* "black holes," or data gaps due to other priorities as are expected to occur with Landsat-D and TDRSS.

Experience during the past 2 years of operation have reinforced these technical requirements. Current FAS analytical capabilities are facing serious degradation because the minimum requirements defined in this section have not been satisfied, and apparently will not be satisfied during the Landsat-D system lifetime.

Personnel Impact

No FAS functions or positions will be eliminated as a result of the current system. However, automation and the integration of new data sources into the analytical and decisionmaking process will relieve senior analysts to concentrate on additional tasks that have been levied upon commodity programs by Congress and the executive branch without a compensating increase in personnel.

International Impact

It is not possible at this time accurately to determine the dollar value that changes in the system will have on the dollar value of U.S. exports, world prices, U.S. competitive position and economic policy. However, over the next 4 to 6 years, given a "free market" environment, the real value to the United States of current foreign crop information will increase dramatically. The magnitude of this value will depend in a large measure upon the U.S. policy concerning export of space-related technology to nations who compete for U.S. foreign markets. A policy of open and equal access to agricultural data collected by U.S. space platform and related technology could tend to reduce the U.S. competitive advantage in the world market and perhaps "stagnate" our level of exports. It could also permit other nations to compete in markets that have been traditionally dominated by the United States. This situation may not be acceptable given the need for expanded U.S. markets to offset the increasing dollar flow for oil imports. This is a national policy question that FAS and USDA cannot resolve. However, national policy on the international availability of U.S. space technology and/or data collected from space will have a significant impact on the value to the United States of improved agricultural information.

International Cooperation

The current system and the preceding R&D have stimulated interest in bilateral cooperation in the exchange of technology. The following will serve as an example:

In early 1977, the President of Mexico received an in-depth briefing by FAS of LACIE results and USDA application of remote-sensing technology. This briefing led to agreements in principle between the Secretary of Agriculture and the Mexican Minister of Agriculture later to exchange mutually beneficial technology. FAS and Mexican technical managers developed a plan for an exchange of technical staff between the Ministry of Agriculture and FAS (CCAD).

NASA's International Affairs office was represented at all meetings in Washington and Mexico City. One problem encountered in these planning sessions was NASA's insistence that Mexico purchase a ground receiving station even though all areas of interest to the Mexican Government were routinely collected to meet U.S. data requirements and processed through NASA's Goddard Space Flight Center. This problem could have been resolved, but factors external to USDA and NASA halted further communications toward negotiations of a working bilateral agreement.

Given the increasing awareness of the need for closer ties between the United States and Mexico, it would seem to be in the U.S. interest to reopen negotiations that would lead to a bilateral agreement regarding agricultural applications of space technology.