Australia, Algeria, Thailand, Costa Rica, Venezuela, Mali, Mexico, and Ghana. Sources of funding have been the governments of Australia, Algeria, and Mexico, and Economic" and 'Social Commission for Asia and the Pacific of the United Nations (ESCAP), U.S. Information Agency (USIA), and U.S. Agency for International Development (USAID).

Twenty percent of the dollar value of Landsat data produced in FY 75 at the EROS Data Center was for foreign users, and this level is expected to continue. To date, 127 foreign countries have procured Landsat data from the EROS Data Center. In addition a significant part of the Landsat data production for U.S. industry is for oil and mineral exploration by U.S. companies overseas.

Question 8. Which, if any, countries would be willing to participate in, and share in the cost of, an operational Landsat program?

Answer 8. We have had many contacts with foreign countries that are interested in participating in the Landsat program Any agreements are negotiated by NASA. NASA can provide the most complete answer at this time. We are aware of the agreements for two stations in Canada and the stations and plans for stations in Brazil, Italy, Iran, Zaire, and Chile. The agreements that NASA is signing with these countries provide for sharing the cost of follow-on Landsat systems. We are also aware of interest in building ground stations by Upper Volta, Norway, Australia, India, Japan, Indonesia, and Saudi Arabia.

Chairman HUMPHREY. We have one additional witness from the agencies, Dr. Hill, who is project manager of LACIE, Department of Agriculture. We will proceed with you now, and then Dr. Park.

STATEMENT OF DR. HOWARD HILL, PROJECT MANAGER, LACIE, U.S. DEPARTMENT OF AGRICULTURE

Dr. HILL. Mr. chairman, I welcome the opportunity to report to the Technology Assessment Board on the application of advanced technologies by the Department of Agriculture. Providing current and reliable food, agricultural, and nutrition information is a first concern for the 'Department of Agriculture. There are many users of this information. They include the general public, Federal and State agencies and the Congress, and international organizations and foreign governments.

The Department's primary interest in advanced technology is as a user of its services. As advanced technologies make more systems available, we are striving to put them to use to accomplish the Department% objectives. The remote sensing user requirements task force created in 1973, has specific responsibilities to help the Department to meet its future needs for remote sensed information.

The task force was directed to catalog the Department% requirements of earth resources data, determine those requirements that would return maximum benefits, and develop a coordinated plan for acquiring processin$_{g)}$ analyzing, and distributing data to meet those requirerments.

Last year the task force completed its cataloging of the Department% remote sensing information requirements. More than 2,000 items of information were identified as being potentially collectable by remote sensing techniques that would be useful in carrying out the Department% program.

The next step was to analyze these requirements in terms of priority of need and available technology. Those requirements which Show near-term promise of satisfaction and maximum net benefits will receive first consideration for being filled.

The task force will next study the cost-effectiveness of applications which are identified as being technically feasible to implement, and having a potential for significant benefits. Finally, a plan for research, development, and implementation will be submitted to the Secretary.

Now" I would like to summarize for you the analytic and communication technology already being used experimentally and operationally by USDA agencies with primary concern for preparing and reporting information on food, agriculture, and nutrition.

The Large Area Crop Inventory Experiment—LACIE—is an excellent example of USDA's continuing efforts to exploit advances in technology in improving its food and agriculture information systems in that it integrates a number of technologies into a comprehensive system.

The LACIE is an experiment to test the technical feasibility and cost effectiveness of utilizing data from an Earth resources satellite along with meteorological, climatological and historical data to predict production of a major agricultural crop. The experiment is being carried out jointly by the .National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, and the U.S. Department of Agriculture. USDA is participating in this experiment primarily as a prospective user of an operational crop-reporting and forecasting system. Wheat was selected as the test crop.

Within USDA, six agencies are participating in LACIE under Foreign Agricultural Service—FAS—leadersl~ip.

L.ACIE is being carried out in three phases. Phase 1, carried out in 1975, tested acreage estimating capabilities in selected wheat producing areas of the United States. Wheat yield models were developed and tested during this phase. Phases 2 and 3 will test LACIE capabilities to estimate wheat area, yield, and production in the United States and other wheat-producing regions. Phase 2 began in October 195 and will continue through this year. Monthly crop forecasts will be prepared during the growing season. Associated research and development and tests of new techniques for crop identification measurement and yield estimation will be conducted throughout the experiment.

It is important to stress that LACIE is an experiment, and recommendations for future program. use will be based on the outcome of evaluations that are made as the experiment proceeds.

USDA has lead responsibility for evaluating crop estimates in relation to USDA requirements, for analyzing costs and benefits of an improved crop forecasting capability, and for designing a user system for post-LACIE implementation. We foresee application of LACIE-proven techniques by analyst teams that use readily available hardware and software.

Design of the user system was started recently with the target of completing design and testing in time to implement LACIE at the end of the present schedule, if experimental results support that course of action. Because of its position as the eventual user agency of an operational system, USDA has broad responsibility for defining output requirements and for integrating this output, as appropriate, with ongoing programs.

Although LACIE now is limited to wheat, it is expected that programs and techniques developed during the experiment can be applied to the estimation of other agricultural crops and land use. If successful and if found to be cost effective, a crop-forecasting system utilizing the earlier mentioned technologies would provide better and

more timely crop estimates as inputs to the Department's international crop information collection and reporting system.

The Department has several longstanding programs for collecting and distributing information on food, agriculture, and nutrition. Each of these programs uses advanced technology where appropriate, in carrying out that function. The FAS relies heavily on its Agriculturalattache reporting system for information about the supply and demand for agricultural products in countries around the world.

As the volume of information about foreign production, imports, exports, consumption, and stocks has grown, FAS has made greater use of computer services to store and retrieve this information as well as for analysis. The FAS plans to use advanced technology through interactive computer terminals in its commodity divisions, thus enabling their analysts to have more current information when it is needed and facilitate statistical analysis and econometric modeling.

FAS also hopes to be able to employ advanced techniques associated with intercontinental message switching and data transmission to improve attache information collection and reporting. The actual use of these technologies. however, will depend upon the outcome of a future cost-benefit analysis and the avdiability of funds for such a project.

Since the launch of Landsat 1 in 1972, the Statistical Reporting Service-SRS--has studied its potential use for collecting agricultural information. Work to date has been mainly to identify crops and estimate crop acreage from Landsat imagery.

The approach used by SRS is described at greater length in my full report, but their work so far shows measurable results using both Landsat and aerial photography. Potential applications include using remote sensed information to supplement or verify existing ground survey procedures.

Timely economic information on the agricultural sector has taken on greater value to decisionmakers as U.S. agriculture moves away from controls and comes more directly under the influence of domestic and foreign economic conditions.

More realistic models of the agricultural economy are being developed by the Economic Research Service applying computer technology which permits analysis of the complex interrelationships within agriculture, and between agriculture and the domestic and world economies. The models are discussed at greater length in the full report but basically consist of shorti-term commodity-forecast models and long-term economic-projections models.

In summary, we produce information on food, agriculture, and nutrition at many points in the Department of Agriculture. Advanced technology is being used in the production of this information where it is feasible to do so, as evidenced by greater efficiency or expanded capability to carry out the function.

Advanced technology offers many opportunities for improving service to information users. Increasingly, utilization of technology requires integrated application of two or more kinds of technologies. The LACIE is an example of this trend. Meeting the LACIE objective of accurate and timely crop reports on a worldwide basis will reeqire, the integration of satellite, computer, and communications technology. Some of the same technology is being tested for application to domestic crop reporting in con-junction with conventional survey methods.

The objective in both instances is to improve the Department's capability for producing accurate and timely crop reports, and to do so in a cost-effective manner.

Computer and communication technologies also are being more widely used by the Department. More realistic models of the agricultural economy are possible by applying computer technology to such uses as short- and long-term economic forecasts, and evaluation of alternative future conditions that might occur. These analyses would not be possible without the support of computerized data bases and models.

These technology applications, and other information activities that rely on more conventional method, are employed for the purpose of responding more effectively to pertinent questions about our food and fiber production and distribution system, and for helping to anticipate future problems bearing on the system's performance.

Thank you.

Chairman HuMPHREY. Thank you.

[The prepared statement of Dr. Hill follows:]

STATEMENT OF DR. HOWARD L. HILL, LACIE PROJECT MANAGER, FOREIGN AGRICULTURAL SERVICE, U'. S. DEPARTMENT OF AGRICULTURE

Mr. Chairman, I welcome the opportunity to expand *our* remarks regarding the recommendations presented in "Food, Agriculture, and Nutrition Information Systems: Assessments and Recommendations." In particular, you have requested that we respond with a detailed description of the relevant activities of our agency that deal with the application of advanced technologies.

The preparation and distribution of current and reliable food, agricultural, and nutrition information continues to be a first concern for the Department of Agriculture. Although increased crop production has, to a certain extent, alleviated the tight supply situation of a year ago, the needs of the future are clear: increased food production in this country and overseas, especially in the developing world. Reliable information on present agricultural production and markets is essential for measuring progress toward this goal, and for planning and decision-making for future production and distribution, foreign trade and transportation.

The Department's primary interest in advanced technology is as a user of its services. Advanced technology, such as computers and modern research equipment, is routinely used by the Department in its research and action programs. As advanced technologies make more systems available, we *are* striving to put them to use to accomplish the Department's objectives in these areas.

REMOTE SENSING USER REQUIREMENTS TASK FORCE

In mid-1973, *as* part of the Department's continuing efforts to apply advances in technology to improving the information available to decision makers both within and outside the Federal government, the Secretary created a Remote Sensing User Requirements Task Force with representatives from 8 Department agencies which use remote sensing (R/S) in carrying out their programs. Representatives from several other Department agencies and NASA were also appointed to the Task Force to provide technical assistance in such areas as benefit assessment, information systems requirements, integration with research programs, and technical hardware capabilities.

The Task Force was directed to catalog the Department's requirements of earth resources data, determine those requirements that would return maximum benefits, and develop a coordinated plan for acquiring, processing, analyzing, and distributing data to meet those requirements. The coordinated plan will evaluate the potential for incorporating R/S-acquired data into ongoing programs and information systems, and will provide information on benefits and costs, resource requirements, technology capabilities, and other information needed by the Department on how to make effective use of R/S technology to obtain needed information.

The Task Force has now completed its cataloging of the Department's remote sensing information requirements. More than 2000 items of information were identified as being potentially collectable by remote sensing techniques that would be useful in carrying out the Department's program. Included were such diverse

items as information on timber species, wildlife migration, volume of sediment in waterways, soil features, world agricultural crop production, and others. These requirements were entered in an automated data base which allows the Task Force to identify commonality of requirements among USDA agencies and to provide management with information on data essential to decision making.

A Task Force implementation analysis team made up of specialists from the USDA, NASA, Department of the Interior, and Universities has analyzed these requirements in terms of priority of need and available technology. Requirements were grouped according to technological status (research, development, operational). Those requirements which show near-term promise of satisfaction and maximum net benefits will receive first consideration for being filled.

The Task Force will next study the cost effectiveness of applications which are identified as being technically feasible to implement, and having a potential for significant benefits. Finally, an integrated research, development, and implementation plan will be submitted to the Secretary.

The remainder of this report will focus on remote sensing, analytic and communication technology already being used experimentally or operationally by USDA agencies with primary concern for the preparation and reporting of information on food, agriculture, and nutrition. The use of advanced technologies gives a clear picture of the important. role we attach to these programs.

DEPARTMENT USES OF ADVANCED TECHNOLOGY

LACIE Program

In recent years, shortages of agricultural commodities have been serious in some countries and have become a concern to all. Uncertainty about crop prospects has impacted on livestock production, commodity prices, consumer prices, trading patterns, and trade balances. One outcome of these developments is a sharp increase of interest in crop forecasting and in exchanging information about crop production conditions.

Emerging technology holds promise of providing the means to quicker, more accurate assessment of crop production prospects, particularly for foreign countries. In particular, prospects appear strong for assessing crop conditions via remote sensing of crop growing areas and through analysis of weather and climatic factors affecting crop growth. TheLarge Area Crop Inventory Experiment (LACIE) is an excellent example of USDA'S continuing efforts to exploit advances in technology in improving its food and agriculture information systems in that it integrates a number of technologies *into* a comprehensive system.

The Large Area Crop Inventory Experiment (LACIE) is an experiment to test the technical feasibility and cost effectiveness of utilizing data from an earth resources satellite along with meteorological. and climatological and historical data to predict production of a major agricultural crop. The experiment is being carried out jointly by the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Agriculture (USDA). Each agency brings its unique capabilities to this project and seeks, in turn, to fulfill some part of its overall mission responsibilities. USDA is participating in this experiment primarily as a prospective user of an operational crop reporting and forecasting system. Wheat, a food crop of major importance, has been selected as the test crop for LACIE.

Within USDA, LACIE is a multi-agency effort. Six agencies are participating, and have contributed professional staff with specialized skills to the experiment. The Foreign Agricultural Service (FAS) has been designated as the lead agency; other participating agencies are Agricultural Research Service (ARS), Agricultural Stabilization and Conservation Service (ASCS), Economic Research Service (ERS), Soil Conservation Service (SCS), and Statistical "Reporting Service (SRS).

LACIE will be carried out in three phases. Phase 1. carried out in 1975, tested acreage estimating capabilities in selected wheat producing areas of the United States. Wheat yield models were developed during this phase. Phases 2 and 3 will test LACIE capabilities to estimaite wheat area, yield, and production in the United States and other wheat producing regions. Phase 2 began in October1975 and Phase 3 begins October 1976. Monthly crop forecasts will be prepared during the growing season. Associated research and development and tests of new techniques for crop Identification measurement and yield estimation will be conducted throughout the experiment. The project is being monitored by the participating agencies; however, USDA has lead responsibility for evaluating crop estimates in relation to USDA requirements and for analyzing costs and benefits of an

improved crop forecasting capability. Because of its position as the eventual user agency of an operational system, USDA has broad responsibility for defining output requirements and for integrating this output, as appropriate, with ongoing programs.

It is important to stress that LACIE is an experiment, and recommendations for future program use will be based on the outcome of evaluations that are made as the experiment proceeds.

USDA also has lead responsibility for designing a user system for post-LACIE implementation. We foresee application of LACIE-proven techniques by analyst teams that use readily available hardware and software. Design of the user system was started recently with the target of completing design and testing in time to implement LACIE at the end of the present schedule, if experimental results support that course of action.

Although LACIE now is limited to wheat, it is expected that programs and techniques developed during the experiment can be applied to the estimation of other agricultural crops and land use. If successful and if found to be cost-effective, a crop forecasting system utilizing the earlier mentioned technologies would provide better and more timely crop estimates as inputs to the Department's international crop information collection and reporting system.

Quicker and better information *on* world crops could: (1) help the United States and other countries to manage better agricultural production and to minimize fluctuations in price and trade volumes; (2) provide earlier warnings of crop shortages due to adverse weather; (3) provide timely indications of crop diseases and insect infestations which could affect world food supplies; and (4) provide improved production and supply information to international organizations such as the Food and Agriculture Organization for use in carrying out their responsibilities.

If a decision is made to make LACIE operational, the requirement of a system with a capability to provide routine repetitive international crop forecasts would require a continuing flow of earth resources and meteorological data which are available to the user within a short time after acquisition, and are repeated at frequent intervals throughout the growing system, and are suitable for computer processing and analysis. Of course, a decision to implement a crop forecasting system at the end Of LACIE is also contingent on a determination that the information generated is sufficiently accurate, timely and cost-effective to warrant an investment in such a system.

LACIE is a large and technically complex undertaking, involving close cooperation between two Departments (Agriculture and commerce) and one independent agency (NASA) : and several agencies within each of the Departments. The present experimental approach should, in time, be replaced by a user system capable Of applying current technology and the advanced technology now planned for the 1980's. Thus LACIE is providing an environment both for testing technology-including future technology relevant to crop identification and yield forecasting—and for determining how best to utilize modern analytic capabilities in carrying out an information function.

Foreign Agricultural Service

The backbone of the Foreign Agricultural Service information system is its Agricultural Attache Reporting System, which relies on attaches stationed in 63 posts around the world reporting on 82 countries. ***In*** the current world environment of short food stocks and production shortfalls, the intelligence collected by this network is vital. In many cases, it is the only source of information about the supply and demand for agricultural products in foreign countries around the world.

It is necessary to aggregate, process, and summarize to a great extent the high volume of detailed information concerning foreign production, imports, exports, consumption and stocks to get a meaningful picture of existing world stocks of food and feed grains and the potential demand for U.S. agricultural products. The Foreign Agricultural Service utilizes a computer system for storage and retrieval of this information as well as for statistical analysis and simple modeling to support its Foreign Commodity operation.

The Foreign Agricultural Service plans to make future use of advanced technology where it is both cost effective and funded. Plans include making FAS computerized information systems more readily accessible to economists and commodity analysts through interactive computer terminals in commodity divisions. This will allow FAS economists to have more current information when it is needed and facilitate statistical analysis and econometric modeling.

FAS also hopes to be able to employ advanced techniques associated with intercontinental message switching and data transmission to improve attache information collection and reporting. The actual use of these technologies, however, will depend upon the outcome of a future cost benefit analysis and the availability of funds for such a project.

Statistical Reporting Service

Since the launch of LANDSAT 1 (ERTS 1) in 1972, the Statistical Reporting Service has conducted a continuing research program to investigate the potential use of this imagery as a tool for Collecting agricultural information. The primary thrust of the work to date has been in the area of crop identification and the development of methods to estimate crop acreages from LANDSAT imagery. Key components of this system under study are: (1) design and development of a flexible automated computerized data handling system for data conversion, calibration, interpretation, pattern recognition and statistical analysis: (2) development of a multi-stage sampling design that will utilize LANDSAT data, ground observations and related data in the estimation Process; (3) analyzing data acquired considering accuracy, data acquisition cost, coverage and availability, for optimizing number and size of ground sample segments; (4) evaluation of alternative land use and crop classification systems using LANDSAT data for improving current SRS sampling frames; and (5) comparisons of crop identification and classification results from high altitude aircraft photography and LANDSAT to determine potential improvements in classification that could occur with better resolution satellite imagery.

Research results show that LANDSAT classification accuracy for crops is closely related to field size, field shape and diversity of crops produced. Accuracy ranges from about 90 percent for Southwest Kansas with 4 crops down to 40 percent for Central Idaho with 12 crops. Classification accuracy was improved, ranging to about 80 percent for 15 crops in Idaho, when higher resolution aerial photography was used. However, operational problems related to handling large volumes of data in such a system must be resolved before it can be tested for a large area.

Computer software has been developed that can match and retrieve LANDSAT data and corresponding ground truth sample data and estimates. This system allows LANDSAT information to be correlated with ground truth data obtained from routine field surveys.

The correlation (R) of LANDSAT data and SRS ground truth data for identical areas ranges from .5 up to .8. We believe that the LANDSAT data can be used to improve existing acreage estimates. Further study will be conducted to test this theory for other areas of the country and to develop cost estimates for the potential improvements using LANDSAT and other survey procedures.

LANDSAT data will be processed on the ILLIAC IV Computer (a parallel processing system using 64 computers linked together and a separate computer serving as the Central Processing Unit). This computer can process over 7,000.000 pixels (data points) in about 12 minutes. A digitizer that generates a system Of coordinates is used to extract sample segment data from LANDSAT frames (tapes) for correcting classification errors, using ground truth acquired by personal enumeration of sample segments.

Problems that must be resolved 'before this technology can be put into any operational system include: (1) earlier availability of LANDSAT tapes, (2) improvements in the ability to extend crop signatures between LANDSAT frames, and (3) refinements in specified crop signatures that will improve . classification and measurement accuracy.

The use of photography for making orchard tree and fruit counts also is being researched. A computer model uses digitized information from aerial and ground photographs. Results show that fruit trees as well as mature oranges, apples and peaches can be successfully counted from data obtained from photographs. The tree counts can be used in sample surveys to estimate tree populations while the automated fruit counting system can be used in a multi-stage sampling design to more precisely estimate the number of fruits per tree.

Economic Research Service

The Economic Research Service provides economic information on the agricultural sector to public and private decision makers. The task has become more difficult as U.S. agriculture moves away from controls and comes more directly under the influence of domestic and foreign economic conditions. ERS has recognized the need to apply advanced techniques to problems of data man-

agement and it recently centralized its automatic data processing services into one unit, consisting of a data storage system linked to a generalized analytical package for estimating relations, making variable transformations, plotting data, and conducting statistical analyses. This technology will aid analysts by reducing the time required to conduct an analysis while increasing the amount of data which can be analyzed. Quality and timeliness of the analyses will be improved and other agricultural analysts will be able to more quickly retrieve data from the system. Ultimately, this will benefit the decision maker through improved information on which to base decisions,

Agricultural Modeling System

More realistic models of the agricultural economy can be developed by application of computer technology which permits analysis of the complex interrelationships within agriculture, and between agriculture and the domestic and world economies. To assist in analyzing these interdependencies, ERS is developing a cross-commodity modeling system of the agricultural sector.

It is composed of commodity subsector models linked through common variables to form a modeling system. Thus, when facts change which influence one commodity subsector the impact this has on other related commodities can be measured.

Currently, this modeling system is composed of individual models for beef, pork, dairy, chickens, eggs, turkeys, corn, oats, barley, grain sorghum, soybeans, and wheat.

The livestock and grain models have been linked and the others are in the process of being linked. In addition, models for cotton, tobacco, and selected fruits and vegetables are being developed and will subsequently be linked.

Such a modeling system will make available an analytical capability previously not available and allow ERS analyses to reflect more of the total impact of various changes on agriculture.

Economic ***Projection Program***

The ERS is developing a man-machine simulation of the domestic and world food and agricultural systems of which the principal computerized components include:

(1) The National Interregional Agricultural Projections system (NIRAP), which is the core projections capability and point of coordination for all ERS food and agricultural projections. This system contains basic supply-demand relationships in domestic food and agriculture.

(2) The world Grains, Oilseeds and Livestock (GOL) trade model which projects major world trade relationships in food and agriculture. This model can be run independently or in concert with the NIRAP system.

(3) A linear programming model of interregional transportation of farm commodities and interregional adjustments in farm production given specified environmental constraints. This model can be run independently or in concert with the NIRAP system.

(4) A rural economic development simulation model developed to analyze impacts of different national growth policies on employment and income in rural America. This model currently operates independently from the NIRAP system.

The program functions in two annual cycles, development and analysis. Feedback from previous analysis cycles provides the basis for changing existing models or developing new ones.

This information is used to operate component models of the NIRAP system from which are generated preliminary projections and analysis of alternative futures, which are reviewed and revised as needed prior to their actual use to answer futuristic questions in food and agriculture.

SUMMARY

Information on food, agriculture, and nutrition is produced at many points in the Department of Agriculture. Advanced technology is being used in the production of this information where it is feasible to do so, as evidenced by greater efficiency or expanded capability to carry out the function.

This report concentrates on Department information activities which utilize or experiment with advanced technology for collecting, analyzing, and distributing information on food, agriculture, and nutrition. The information thus developed is widely used by the general public, by public agencies for policy and program decision making, and for analyses of agricultural and resources issues

6s-s77—76—20

faced by the Congress. Information produced by the Department also is used by international organizations and foreign governments. The kinds of information and the principal users are discussed at greater length in reports provided earlier to the Technology Assessment Board.

Advanced technology *offers* many opportunities for improving' service to information users. Increasingly, utilization of technology requires integrated application of two or more kinds of technology. The Large Area Crop Inventory Experiment (LACIE) is an example of this 'trend. Meeting the LACIE objective of accurate and timely crop reports on a worldwide basis will require the integration of satellite, computer, and communications technology in a cost-effective manner. Some of the same technology is being tested for application to domestic crop reporting in conjunction with conventional survey methods. The objective in both instances is to improve the Department's capability for producing accurate and timely crop reports, and to do so in a cost-effective manner.

The potential for using remotely sensed information in fulfilling the Department's responsibilities is being systematically assessed by the Department's Remote Sensing User Requirements Task Force. A large number of such uses have been identified. The uses vary in their importance. Practical considerations such as funding, supporting technology requirements, staff expertise, and technical attributes of the collection system, require that priorities be set among the uses to be met.

Computer and communication technologies also are being more widely used by the Department. More realistic models of the agricultural economy are possible by applying computer technology to such uses as short and long-term economic forecasts, and evaluation of alternative future conditions that might occur. These analyses would not be possible without the support of computerized data bases and models.

Communication technology plays a large role in the information function as the need for timely analysis and reporting on a worldwide basis becomes generally accepted. As the potential of the technology is more thoroughly studied additional applications are expected.

These technology applications, and other information activities that rely on more conventional methods, are employed for the purpose of responding more effectively to pertinent questions about our food and fiber production and distribution system, and for helping to anticipate future problems beating on the system's performance.

[The following questions were submitted by Senator Humphrey to Dr. Hill and his answers thereto:]

Question 1. What specific programs of the various agencies of USDA could be operated more efficiently if remote sensing data were available on a continuing basis?

Answer 1. Since the Department is a long-time user of aircraft data, we assume that your question refers to remotely sensed data from space. The Department's Remote Sensing User Requirements Task Force is currently examining the Department's needs for remotely sensed data in the carrying out of its responsibilities. The Task force assignment is approximately 50 percent complete. Until the Task Force has completed its assignment and has issued its final report, we cannot fully answer this question.

However, we believe that a prime beneficiary of the continued availability of remotely sensed would be the Department's food and agricultural information systems. The frequent "looks" at major crops around the world should permit more timely assessments of major crop area, condition, yield, and expected production as inputs to the Foreign Agricultural Service's crop forecasts. This improved information in turn could permit more rational decisions by the Department's program managers.

The Large Area Crop Inventory Experiment (LACIE) experience should also help to answer this question.

Question 2. What major improvements in agency programs are anticipated, if and when such data are available on a continuing basis?

Answer 2. The input of remotely sensed data from space to the Department's international crop forecasting system should provide both Federal and non-Federal users with more timely and accurate international crop production forecasts. Also, we are optimistic that use of remotely sensed data will provide earlier indications of insect infestations, crop diseases, or weather phenomena, which could adversely impact world crop production. It is also anticipated that remote

sensing data could be used to supplement the Department's domestic crop reporting system. We should be able to amplify our response to this question when the Remote Sensing Task Force Report is available.

Question 3. What new or special problems would USDA expect to have to deal with to utilize such data?

Answer 3. In an operational use of remote sensing data, some potential problems can be assumed. These include: (1) precise registration of the' remotely sensed data to geographic coordinates (ground location), (2) timely delivery of the remotely sensed data to the user, and (3) problems associated with the rapid processing and analysis of the extremely large amounts of data contained in Landsat type scenes.

Upon completion of LACIE, we should be able to provide a more complete answer.

Qucstion 4. What, if any, institutional obstacles would need to be overcome if such data were available on a continuous basis?

Answer 4. In general, it would seem that several institutional issues would include: requirements on existing USDA organizations in order to integrate include: requirements on existing USDA organizations in order to integrate remotely sensed data into existing information systems; location and management of remote sensing preprocessing, processing and analysis hardware and personnel; organizational and management consideration involved in interfacing special purpose equipment with the Department's general purpose computers; and budget allocation to support the remote sensing activities.

Question 5. How would satellite data integrate with the current traditional data system ? (i.e. Displace, compliment, or supplement) Which data series would be most affected?

Answer 5. We are able to make some statements about the probable integration of information from an operational LACIE type system. We foresee opportunities to both complement and supplement USDA's crop production information system. Present non U.. S. crop production data series would be affected by the introduction of crop data that are collected on a timely basis, and are more accurate than present data. However, we do not foresee that these data could be produced entirely from I,ANDSAT information-there would still be dependence on existing data sources and on meteorological data.

Question 6. Has USDA, as a result of the first year of the LACIE experiment, been able to pinpoint additional research needs to increase the utility of this technology for USDA's usage requirements?

Answer 6. Technology areas that need to be strengthened were identified in the first phases of LACIE, and are intended in the evaluation report of Phase I which is expected to be appraised and released in the near future. The evaluation was carried out and reported by a LACIE team made up of staff from USDA, NOAA, and NASA. USDA resources available to LACIE will be applied to the solution of these technology problems wherever possible during the remainder of LACIE : in addition, fundamental problems requiring longer term research attention will be identified as LACIE continues. There is already a NASA-funded research program that supports LACIE, and we expect also to identify problems that fall within the area of USDA research concern.

Question 7. Could you provide OTA with a copy of the report of the Remote Sensing Use and Requirements Task Force?

Qiestion 7. It is expected that the Task Force will complete its task and issue its final report about the first of 1977. Copies will be forwarded to the OTA upon publication.

Question 8.. Could you provide OTA with a copy of the first years LACIE study ?

Answer 8. The LACIE Phase I Evaluation Report, mentioned above, is currently being reviewed for approval. Upon approval and publication, we will forward copies to the OTA.

Question 9. Are USDA's cost effective studies taking into account the international elements?

Answer 9. Yes. In evaluating the cost effectiveness of LACIE, among other elements, we plan to address the question of the value of improved international crop production information to decision makers—both within and outside the Federal Government, consumers, and producers. At this time however, there are no plans to appraise the value of improved information to non-U.S. Governments and/or organizations.

Question 10. Your paper deals with several other technologies used in information systems. OTA would appreciate knowing:

(a) Which models are being used or drawn upon by USDA for policy making purposes ? How would YOU suggest the Congress use these models?

(b) What fire the strengths and weaknesses of the principal modeling tools used by USDA?

(c) How much is being spent on modeling by USDA? What would be the effects of increase in the order of two-three times?

(d) Does the private sector make better use of modeling techniques than the U.S. Government ? How?

Answer 10. Testimony before the Office of Technology Assessment by Howard L.. Hill on F'ebruary 4, 1976, provided some brief overview of economic modeling activity in the Department of Agriculture. Nest of this activity is in the Economic Research Service (ERS) and is an integral part of their capability . to provide current forecast, and long range projections information on food and agriculture. None oil the information provided regularly by ERS depends solely on economic models but these tools are increasingly important in the work of this Agency.

Quentin M. West, ERS Administrator, testified before the Office of Technology . Assessment on September 25, 1975. His testimony provided an overview of what ERS has been doing in the past three years to Improve their analytical capability including modeling, improve output of information and improve the flow of data to use in analysis.

Most of the models used in USDA for helping to provide information to policy makers are developed internally by Department staff or in cooperation with economists at land grant universities. The primary model of the general economy being used by the Economic Research Service is the one developed by Wharton Econometric Forecasting Associates. The ERS long range projections activity relies primarily on the National Interregional Agricultural Projections (NIRAP) System and various university models. These models concentrate on different subject matter, different levels of detail and aggregation and different time periods from the next year to the next 20-30 years. The models attempt to capture the underlying structure and economic relationships of agriculture, such as the interrelationships between commodity sectors and between general economic activity and agriculture.

Economic models in the Department use the various modeling tools available. These include econometrics, statistical analysis, simulation, input-output, and mathematical programing. These tools have different strengths and weaknesses and are therefore applicable under different circumstances. In all modeling efforts, the foundation has to be a well-trained and informed staff and availability of data that allows appropriate use of the modeling tools. Understanding the economic issues and problems, making sound assumptions for significant factors not included in the models, such as informed opinions of industry contacts, and objective and clear interpretation of results from the modeling efforts require the well-trained and capable staff.

Some of the principal weaknesses of current modeling efforts include the need for more quarterly models, incorporation of some data on such important factors as weather, and improvement of models on agriculture in foreign countries.

About 15 percent of ERS budget is associated with the development and use of models. Having a significant increase in funds available for formal modeling work should have high benefits since a great deal of modeling work remains to be done.

Private industry uses basically the same modeling techniques as USDA. In fact, most of the models developed and used by USDA must be more comprehensive than those found in industry. The one area that private industry has been ahead of USDA is in using current computer technology ***to*** manage the volumes of data needed in economic analysis. ERS is currently making necessary improvements in this area and developing more powerful automated data management and analysis capabilities. This change was covered in Quentin West's testimony of September 25,1975.

Chairman HUMPHREY. Gentlemen, we thought it would be beneficial to have someone outside of the Government also make a presentation, We will next hear from Dr. Archibald Park of the Earth Satellite Corp.