The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1988

FEDERAL COORDINATOR FOR
METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA ·

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Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
Anthony J. Calio, Under Secretary

APRIL 1987
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PREFACE

These are exciting times in meteorology. Plans that have been developing over the last ten years are now being implemented. New observing and communicating systems are being acquired. New analysis and modeling techniques are being made operational. New service modes are being planned and tested. In times such as these, the annual Federal Plan takes on added interest.

This Federal Plan is the twenty-third in the series that has been published by the Office of the Federal Coordinator for Meteorological Services and Supporting Research. A special attempt has been made to focus this report on the many changes that are taking place in meteorological services and supporting research. Of course, as in the past, the report is prepared for the specific purpose of complying with the requirements of Section 304, Public Law 87-843. It is published to provide the Congress and the Executive Branch with a coordinated, overall plan for Government meteorological services and for those research and development programs that directly support and improve meteorological services. The Plan covers the programs of all agencies for FY 1987 and FY 1988.

Historically, the Federal Plan has provided a description of the various agency plans for improving these services. This feature will continue in this issue of the Plan. The first section has usually been devoted to a topic or program of special interest. This year the first section of the Plan is devoted to automated surface observing systems, a good example of interagency cooperation and coordination in meteorology.

The second section of this Plan highlights interagency cooperation that is essential to meet the needs for meteorological services. Section 3 contains a discussion of requested resources for FY 1988 as compared to planned resources for FY 1987. The emphasis is on changes in resources and the related changes in programs. All fiscal data are current as of the end of January 1987. Section 4 is a summary of the National Climate Program, and Section 5 describes the World Weather Program. Section 6 gives a brief description and plan for automated weather information systems; this is the first element of an intermediate range plan that will treat functional areas and systems. The appendices contain selected descriptions of agencies' weather activities and a list of acronyms.

The principal task of coordinating weather activities is accomplished by the interagency committees shown on the inside front cover. These committees and the organizations shown on the inside of the back cover conduct systematic, continuous reviews of basic and specialized meteorological requirements, services and supporting research according to guidelines set forth in the Office of Management and Budget Circular A-62.

R. L. Carnahan

Robert L. Carnahan
Federal Coordinator for
Meteorological Services and
Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES
AND SUPPORTING RESEARCH
FY 1988

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AUTOMATED SURFACE WEATHER OBSERVATIONS

Jon E. Parein*

Introduction

Surface weather observations are fundamental to all meteorological services. With the advent of new sensor and computer technology over the past decade, the feasibility of automating the nation's surface weather observations is becoming a reality. Successful automation of the surface weather observing function will provide more standardized observations that have consistent meaning from location to location. Moreover, automation permits 24-hour coverage at each location in an expanded network of stations at a lower overall cost.

These surface weather observations are used for forecasts and warnings and to support a wide range of aviation operations. Although designed originally to support aviation operations, these observations are readily accepted and used by meteorologists and others in various applications, such as hydrology, climatology, agriculture, and public service. Weather data and forecasts are also used for a wide range of planning and operating decisions by individuals, Government agencies, and many organizations involved in weather-sensitive activities.

Nation-wide deployment of automated surface weather observing systems is planned as a result of studies and coordination carried out under the Office of the Federal Coordinator for Meteorology (OFCM). Automating surface weather observations is a major component in the modernization of the Nation's weather services with a goal that goes beyond replicating the current manual method of observing surface weather phenomena. It is one of the developing weather technologies that will greatly increase the quality of weather services. The future will see significant changes in the way weather data are acquired, processed, and delivered to the user. Major new systems are planned to interface with, receive, and process data from all major meteorologic and hydrologic observing and guidance systems. These data will be integrated into new weather products that will greatly enhance the capabilities of field forecasters and air traffic controllers. In the sections that follow, the surface weather observing program will be described along with the technology that supports the automation of manual observations.

Background

From the earliest days of aviation, full regard has been taken for the importance of weather observations in assuring the safety and welfare of pilots and their passengers. As a consequence of aviation requirements, surface weather observations have been taken at airport locations for more than fifty years. Federal legislation enacted through the years has led to the present division of responsibilities in the Federal Government that supports this need.

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*This is an invited paper. Mr. Jon E. Parein is a meteorologist in the National Weather Service's Program Office for Automated Surface Observing Systems.

As the nation's primary civil meteorological agency, the Department of Commerce's National Weather Service (NWS) has the responsibility for observing, analyzing and forecasting weather conditions. As the agency responsible for safe operation of aircraft and efficient use of the nation's airspace system, the Department of Transportation's Federal Aviation Administration (FAA) has the role of establishing requirements for and disseminating aviation weather data to airspace users, and it also takes many of the surface weather observations. The Department of Defense has general requirements for aviation data and services that parallel those of civil aviation, as well as specialized requirements related to particular aircraft and flight operations and testing. The Air Weather Service (AWS) and Naval Oceanography Command (NOC) also take weather observations at Air Force air bases, Army airfields, and Navy air stations that support their aviation operations. In addition, the Army has need for observations to support weapons testing, flight operations, and chemical storage monitoring.

The NWS and FAA, along with the Air Force, Army and Navy, routinely take surface weather observations at approximately 1,000 locations across the country. Commercial airline companies take observations at more than 400 additional sites at airports where the Government does not provide these services. Data are rapidly exchanged among all users over Government and private circuits and directly support the various mission needs.

The Surface Weather Observation Today

A complete surface weather observation provides information on weather conditions at and near the earth's surface. In most cases, these observations are made and recorded at least hourly, with additional special observations taken when conditions change significantly. The meteorological parameters include cloud amount and height, precipitation type and amount, visibility, pressure, wind speed and direction, air and dew point temperatures, and present weather.

At present, surface weather observing methods are largely manual and labor intensive. With the help of sensors of varying sophistication, an observer personally views and records the indicated values. The observer must then calculate additional weather parameters, apply correction factors and convert data to proper units using previously observed values, published tables and formulas. The observer then codes the observation into the proper format and manually enters it into one or more communications systems.

Increasing Demand for Observations

Economic considerations in recent years have taken their toll on the nation's weather observation network. A number of weather observing operations have been closed or reduced in hours. There has been a reduction in the number of weather observers assigned to some stations, resulting in a decreased number of sites at which observations are made 24 hours a day. These are almost exclusively commercial airport locations. In addition, as the general aviation industry has grown, the demand for weather information has greatly increased at the smaller airports. These presently have limited or no weather observations.

There is a serious lack of sites from which observations are taken at least 16-hours a day. As a result, there are a number of areas in the U. S. in which the spatial density of observations is inadequate for aviation-specific forecasts. More than 1300 small general aviation airports with published instrument approach procedures have no weather observations available.

Joint Program Evolution

The NWS, FAA, and DOD have long recognized these deficiencies, but establishing, maintaining, and operating an adequate network with 24-hour-a-day manual coverage is prohibitively expensive. However, automation technology, which has been available since the 1960s, has improved in capability and cost-effectiveness. Thus, each of the agencies has been attracted to the possibility of replacing or at least reducing the human role in this labor intensive process while maintaining or improving the quality and utility of the observations.

In the late 1970's, DOC, DOT, and DOD participated in an OFCM project to determine the requirements and conduct a concept study for a Joint Automated Weather Observing System (JAWOS) to replace the Government's largely manual and obsolete weather observation system with state-of-the-art automation capabilities. The conclusion was that sufficient common requirements existed and that the three agencies should organize a collaborative development and acquisition effort.

The Joint Automated Weather Observing Program (JAWOP) was established under the direction of a JAWOP Council comprising policy level representatives of DOC, DOD, and DOT and chaired by the Federal Coordinator. Since 1979, the three agencies have been working together to define and conduct a joint program to automate surface observations. This joint program is the vehicle that ensures that essential agency requirements are met, technical aspects of the program are shared and coordinated, and opportunities for economies are recognized and seized. Joint activities have included algorithm and sensor development and evaluations, and more recently "joint" procurement.

System to Meet National Requirements

To meet the common requirements of NWS and FAA, NWS will procure, install, operate and maintain Automated Surface Observing Systems (ASOS) for both the FAA and the NWS. The FAA has requested NWS to acquire ASOS systems for at least 500 airports. These locations include about 300 airports with towers where manual observations are currently made by Flight Service Station and Air Traffic Control Tower personnel. The remainder of the systems procured for the FAA will be installed at nontowered airports with instrument approaches and no weather observations today. NWS is procuring 250 ASOS systems for use at locations where it manually observes the surface weather. The FY 1988 budget includes funds to initiate this program.

In addition, 500 automated weather observing systems are likely to be procured privately through the Airport Improvement Program or directly by the FAA. DOD is planning to automate surface weather observations at approximately 400 additional locations. By the mid-1990s, these actions should produce a network of up to 1600 locations in the United States with automated observing capability.

In general, the automated hourly and special observations will be distributed on national weather circuits. Minute-by-minute observations at the small nontowered airports will be radio broadcast direct to pilots.

Schedule

ASOS will be procured under a two-phase approach which will require competitive solicitations. The initial Request for Proposals (RFP) is scheduled for release in June 1987. Proposals from manufacturers are due in July 1987. After evaluations and negotiations, two or more awards will be made in early Calendar Year 1988 for the first-phase design and fabrication of four pre-production systems by each manufacturer.

In the second phase, the production phase, the successful first-phase vendors will compete for the second contract. This will cover the purchase of 36 limited-production systems and full-scale production of up to 1,000 systems. Phase 2 is anticipated to cover a five to six-year period of production and installation, with a possible 15-year maintenance contract which could begin during the first year of the system's operation. Selection of the one vendor to produce all production units is expected in late CY 1989, with the first systems available for installation early in 1990. Figure 1.1 depicts the production systems acquisition schedule.

National ASOS Network To Benefit the Nation's Weather Services

A primary benefit of the joint FAA/NWS ASOS program will be the significant improvement in overall national coverage. A large number of automated observing systems will be installed at airports currently without weather observations. The improved network coverage will contribute to improved aviation safety and better public forecasts and warnings by:

- o Operating full time, 24 hours a day (no more part-time stations);
- o Producing better (and standardized) observations of visibility and sky condition;
- o Providing a continuous weather watch and rapid alert of significant weather changes; and
- o Allowing for remote maintenance monitoring.

With the installation of automated systems, all locations for which aviation forecasts are made will have a full-time observing program. The deficiency brought about by lack of night observations along certain Transcribed Weather Broadcast (TWEB) routes (and even some inadequate day coverage) will be largely eliminated.

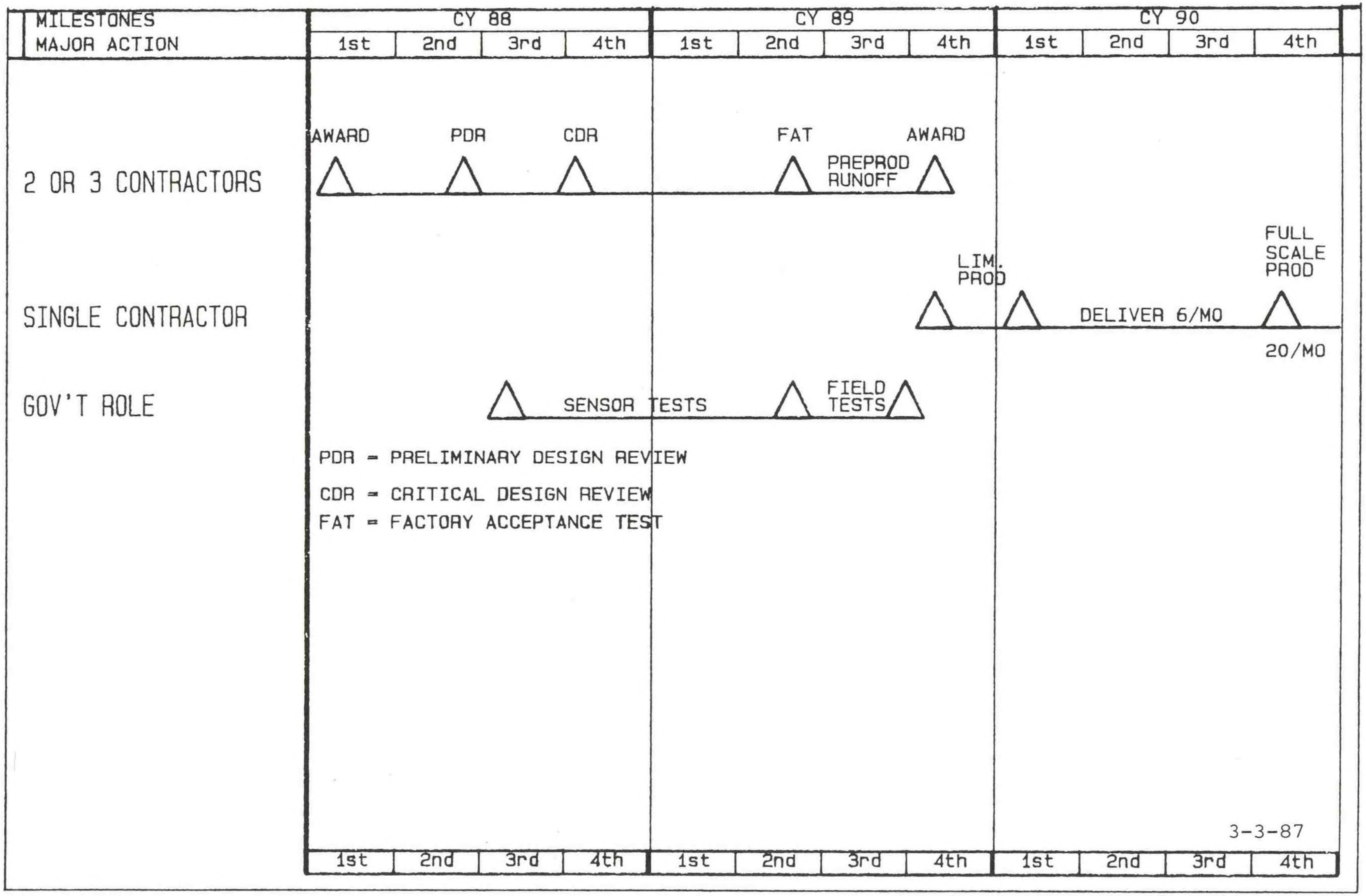

Figure 1.1 Schedule for Acquisition of Operational ASOS Units

System Description

ASOS will be a flexible and modular system capable of being deployed in various configurations and able to function with or without the attendance of an observer. The system is to operate continuously with high performance characteristics so that there is no disruption to routine aircraft or air traffic control operations. It will be capable of providing data in multiple reporting codes and interfacing with existing and future weather sensors in differing combinations, as well as with various communication systems. The block diagram in Figure 1.2 illustrates the ASOS concept.

ASOS is a sensor-intensive system. Figure 1.3 shows a typical configuration at a towered airport. An "average" ASOS consists of a set of sensors at centerfield, at least three near the runway touchdown area, and two or more (not shown) located at the Weather Service office or near the airport control tower. Weather data from these field sensors are routed to the acquisition control unit which performs all necessary control functions and transmits the weather observation to displays, printers, and weather communications circuits.

The sensor configuration varies depending upon the specific location. For some applications a lesser complement of sensors may be used. Conversely, multiple sensors of cloud height and visibility may be used at locations with unusual weather conditions or special operational requirements.

The ASOS will observe the following standard parameters:

- Cloud Amount and Height to 12,000 feet (selected remarks added);
- Visibility to ten miles (variable visibility remark may be added as needed);
- Present Weather including rain, snow, freezing rain, drizzle plus appropriate beginning and ending times (intensities will be reported for rain and snow);
- Obstructions to Vision - fog and haze;
- Temperature/Dew Point Temperature including maximum/minimum data and various other climatological parameters;
- Wind speed, direction, gusts, squalls, and a variable direction remark;
- Pressure including altimeter, sea-level pressure, density altitude, change and tendency and remarks such as rising/falling rapidly;
- Precipitation Accumulation including heavy precipitation reports as well as one, three, six, and 24 hour totals and water equivalent of frozen precipitation.

ASOS will be capable of receiving human input by means of an Operator Interface Device (OID). It will handle all the clerical tasks of local archiving, maintaining the observer's log and summaries, and formatting data in various codes for distribution over communications networks. The system stays continually on duty to detect and report significant weather changes as they occur, thus providing a continuous weather watch which is not now feasible at most Federal observing locations.

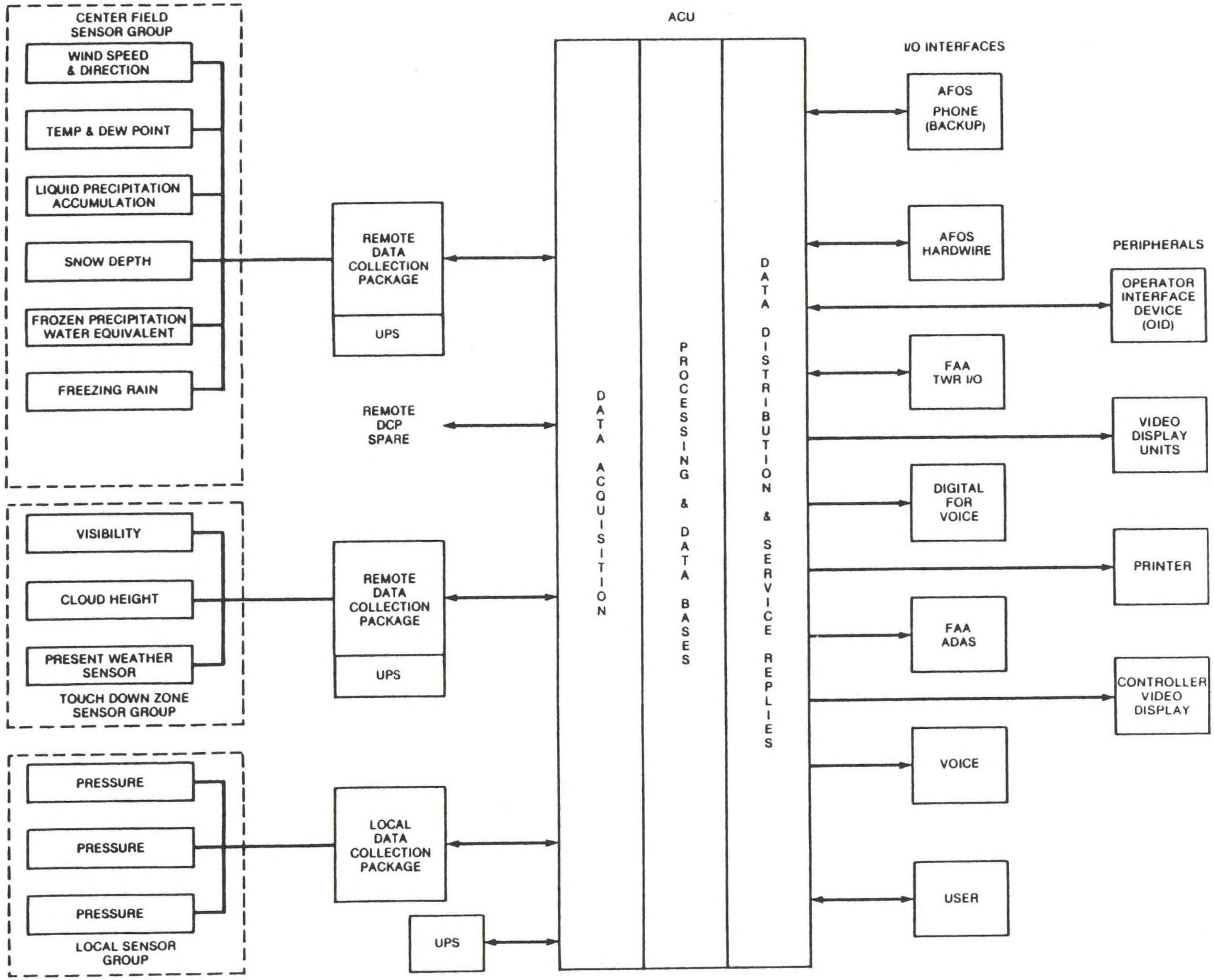

Figure 1.2 Typical System Block Diagram for ASOS

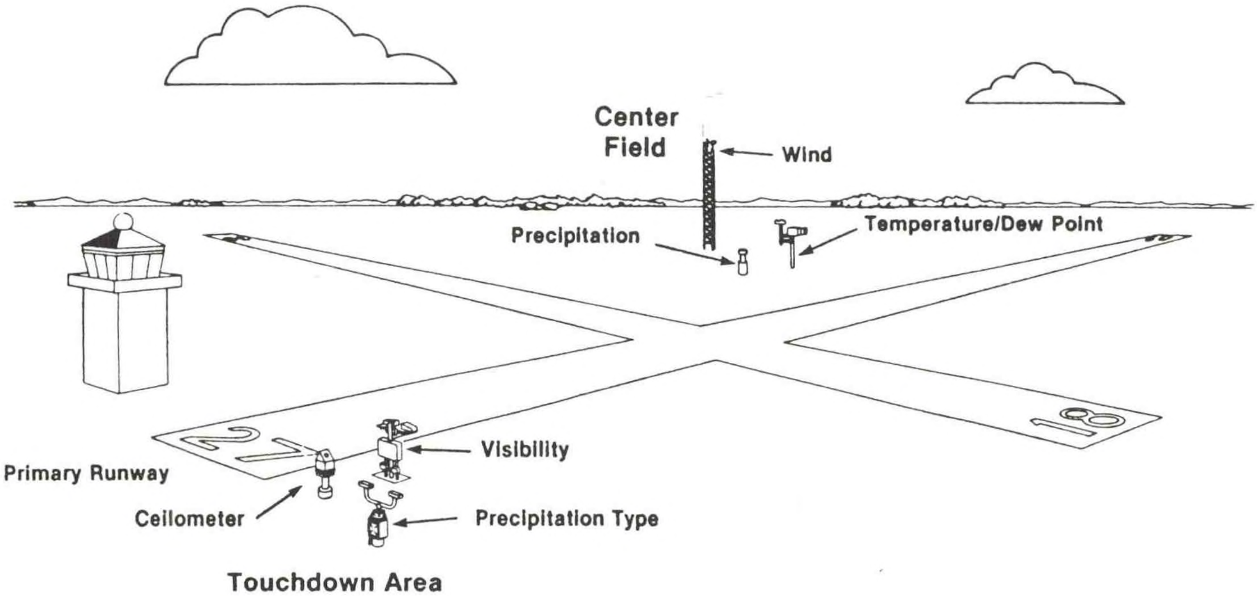

Figure 1.3 Typical Sensor Configuration at a Large Airport

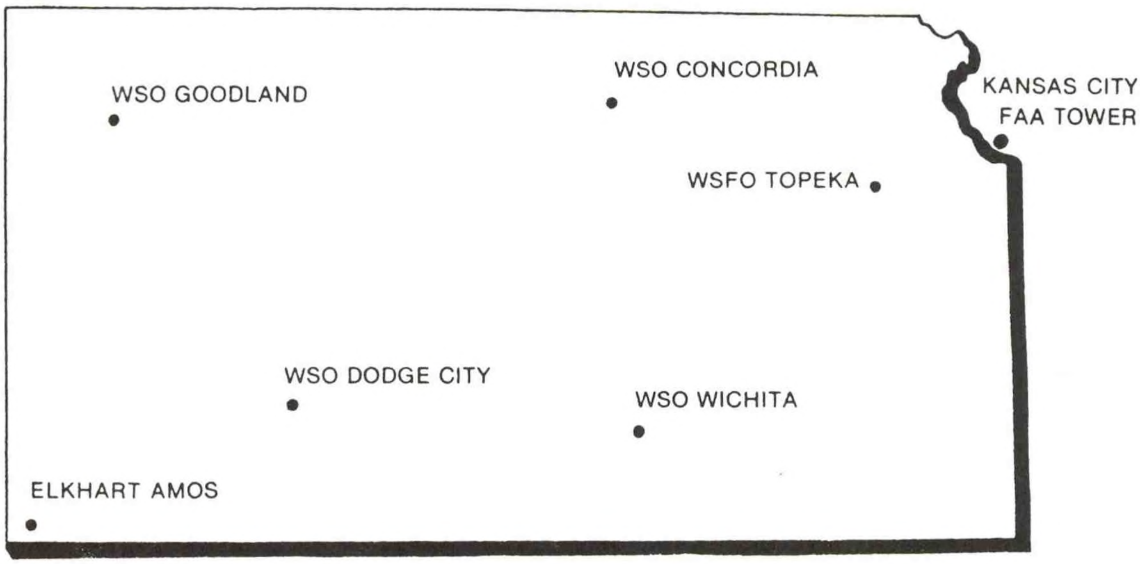

Figure 1.4 ASOS Observing Sites for the Kansas Pilot Project

Since ASOS will be providing critical weather information to support aviation operations, it will self-detect performance degradations in order to avoid reporting incorrect data. Continuous self-testing includes checking for a variety of electronic and sensor problems. Sensor problems will be detected by Government-furnished algorithms which compare the various sensor outputs for logical and meteorological consistency. As an additional level of diagnostic capability, maintenance technicians will use Built-In Test Equipment (BITE) to isolate failures to a replaceable unit. Technicians will be able to operate BITE by using the OID in the local office or by using OID functions via telephone from any location.

Early Development of the Automated Observation

The technology for automating surface weather observations has been under development by various federal agencies and sensor manufacturers for many years. The FAA Technical Center at Atlantic City Airport, Atlantic City, NJ, was responsible for early development of visibility sensor technology. The Air Force Geophysics Laboratory (AFGL) has also been active in the development of visibility sensors.

The NWS's Equipment Development Laboratory (EDL) did much of the design and development of the NWS's Automatic Metorological Observing System (AMOS) and Remote Automatic Meteorological Observing System (RAMOS). About 100 AMOS and RAMOS units are currently in operation throughout the U.S. and automatically observe the directly measured elements: temperature, dew point, wind, pressure and precipitation amount. About half of these systems are attended by an observer who adds information on the visual elements, including sky condition, visibility, and present weather.

EDL was also a prime developer of the joint FAA-NWS Aviation Automated Weather Observing System (AV-AWOS) experiment conducted in 1978. This test confirmed that the basic technology exists to automatically observe the more complex elements of sky cover and visibility [1].

The National Oceanic and Atmospheric Administration's Wave Propagation Laboratory (WPL) in Boulder, CO, was the early pioneer in developing a sensor to discriminate among different types of precipitation. Its successful development in present weather detection removed a critical gap in the array of sensors considered essential to successful automation of the surface weather observation.

The initial algorithms that translate sensor data into meaningful weather observations were developed by the NWS. These initial algorithms have been under continuous review and refinement by both the FAA and the NWS in order to improve the quality of the automated weather product.

Capability of the Automated Surface Weather Observation Today

Both the human observer and the ASOS unit produce an observation that gives the pilot crucial information necessary for safe operation of aircraft and gives the forecaster information required for forecasts. However, for certain elements the details of the observation differ in some respects. The human observer uses spatial averaging to describe sky condition, visibility and present weather identification. ASOS uses time averaging with the new sensors, such as the laser cloud height indicator, visibility sensor, and present weather identifier. The following describes the automated approach [2].

Sky Condition. In ASOS, a laser Cloud Height Indicator (CHI) is used to detect the presence of clouds. This sensor is a single-ended device unlike its predecessor, the Rotating Beam Ceilometer (RBC), which has a projector and a detector on a 400 to 1600 foot baseline. However, it is similar to the RBC in that it measures the height of clouds directly overhead. Because of the inherent, continuous motion of the atmosphere, the integration of cloud height measurements over a suitable time period produces an accurate automated observation of both cloud heights and amount.

With a sophisticated algorithm utilizing hierarchical clustering and a 30-minute sampling period, the determination of cloud cover is very successful. The most recent ten minutes of data are double-weighted to enhance the responsiveness and accuracy of the automated cloud report, which is particularly important during rapidly changing conditions. So, just as the observer now goes out and takes a spatial "snapshot" of the entire sky and then tries to convey this information to the user, the ASOS uses its memory over the last half-hour to achieve a similar result.

Visibility. Instruments for determining visibility directly measure the scattering or extinction coefficient of the atmosphere and a visibility report is derived [3]. There are many advantages to a sensor-derived visibility. The observer is often "site limited," generally confined to a weather office in a busy part of an airport complex with surrounding bright lights and often has poorly defined targets. At night, the observer must adapt to the dark and make a subjective "best guess" as to the airport visibility. Automated visibility observations will be more objective and standardized, continuous, and at night, more representative. These values will also have more consistency (i.e., convey the same meaning) from airport to airport.

Each airport will have a meteorological site survey conducted to determine the best location for the sensors. For aviation safety reasons, the runway touchdown area is the first choice. That's where the pilot needs the most current weather observation--especially during low visibility conditions. Initial experience suggests that about ten percent of the airports may require one or two additional sensors to provide "early warning" of changing visibility conditions in selected sectors of the airport. Today, the observer can only give the prevailing visibility and some general comment about differing visibility in other sectors. The early warning sensor will be physically located where most needed and report the actual visibility.

Present Weather. Sensors will be used in ASOS to continuously and automatically detect freezing rain, rain, snow, drizzle, and precipitation amount. In addition, ASOS will be able to accept lightning data from lightning detection networks and report the presence of a thunderstorm in the airport vicinity. The presence of selected obstructions to vision such as fog and haze will be inferred by an appropriate algorithm.

The most fundamental aspect of present weather detection is the discrimination between rain and snow. This achievement has followed a fifteen year development effort that led to the Light Emitting Diode Weather Identifier (LEDWI). This sensor has a transmitter and a receiver separated by one meter and mounted on a single pedestal. The transmitter consists of a modulated infrared light emitting diode expanded by two-inch optics. An in-beam receiver measures hydrometeor-induced scintillation. Extensive testing has shown that the LEDWI accurately detects snow 98 percent of the time and rain 95 percent of the time [4]. During the remaining two to five percent of the cases when the temperature is very near freezing and mixed precipitation (e.g., rain and snow) is occurring, the sensor then correctly reports precipitation of an undetermined state very nearly 100 percent of the time.

The ASOS will use an ice accretion detector to determine the onset and cessation of freezing rain. This sensor measures the accumulation of ice on a probe which vibrates at its natural resonant frequency. Changes in mass on the probe due to the ice accumulation produce a different frequency. After the initial accretion of 0.02 inches of ice, the sensor activates a de-icing cycle and then resumes its detection process.

<u>Demonstration Program Results</u>

There have been two major programs conducted to demonstrate the capability of modern automated surface weather observing systems, the first by the FAA and a following one by NWS.

<u>FAA Demonstration</u>. This program was conducted during 1983 to 1984 to gain technical and operational experience with automated surface weather observing equipment. Fourteen systems were procured to demonstrate the performance of commercially available technology, to provide the information necessary to refine a specification for a full-scale production program, and to support the development of a suitable procurement package and acquisition strategy. In addition, the demonstration program was designed to develop user experience and acceptance, and to obtain their feedback to improve the specification requirements and operational procedures for the production system.

The performance of these systems employing commercially available technology provided valuable experience with the automated weather observing concepts. The exposure to the aviation community developed strong support for automated weather observing systems and the benefits to be derived through their implementation. The demonstration program highlighted the need for specific improvements, and actions have been taken to solve problem areas identified during the demonstration.

<u>NWS Demonstration</u>. This program, the Kansas Pilot Project (KaPP), is an on-going effort involving prototype ASOSs installed at the six primary NWS observing locations in Kansas and the downtown Kansas City, Missouri, Municipal Airport (for FAA evaluation). See Figure 1.4. The sites, some operating with and some without augmentation by observers, were instrumented in mid-1985 and have been operating in parallel with the conventional manual observing operation. The KaPP is modeling future observing and forecasting operations as well

as evaluating the trade-off between levels of automation and the amount of human augmentation required to provide high quality surface weather information to forecasters, pilots, and other users.

After one year of operation, the KaPP proved to be a valuable "real world" test of the capability of automated observing technology [5]. The project is providing valuable experience with automated systems both in terms of the technology as well as the impact on future agency operations. The KaPP was especially useful in uncovering unanticipated sensor deficiencies and identifying operational changes that must be resolved in order to fully benefit from large-scale implementation of automated systems. The prototype systems will continue to operate in Kansas to foster user acceptance and develop operational procedures needed to transition in the future automated observing era.

In summary, the KaPP demonstrated that the prospects are excellent that technology will fully support the Federal automation program. The KaPP has served to increase the Government's knowledge of automated observing systems, reduced sensor development risks, and contributed to improved designs and plans for the future nationwide implementation of ASOS. With years of development as a foundation and promising technical developments at hand, the Federal Government's plans for improving weather services for aviation and the Nation can proceed with confidence.

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SECTION 2

FEDERAL COORDINATION AND PLANNING

In 1963, activities in meteorology gave rise to concern in Congress and the Executive Office of the President as to whether Federal meteorological activities were being coordinated adequately. This concern was given expression by the Congress in Section 304 of Public Law 87-843, the Appropriations Act for State, Justice, Commerce, and Related Agencies. Congress directed that the Bureau of the Budget prepare an annual horizontal budget for all meteorological programs in the Federal agencies.

The Bureau of the Budget (now Office of Management and Budget) issued a report entitled "Survey of Federal Meteorological Activities" (1963). It described each agency's program in some detail, particularly its operational services, and spelled out the relations between the programs of the various agencies. The report revealed close cooperation but little evidence of systematic coordination. As a result of this study and the concern of Congress, the Director of the Bureau of the Budget issued Circular A-62. The Circular provided the ground rules to be followed in the coordination process. It established a general philosophy for assignment and assessment of agency roles in the field of meteorology and set certain goals to be achieved by the coordination process. The Circular left the task of establishing the coordinating mechanism to the Department of Commerce (DOC), in concert with the other Federal agencies. In the field of meteorology, the Circular reaffirmed the concept of having a central agency, the Department of Commerce, responsible for providing common facilities and services and clarified the responsibilities of other agencies for providing specialized meteorological services.

The implementation of Circular A-62 by the Department of Commerce led to creation of the Office of the Federal Coordinator for Meteorological Services and Supporting Research within the National Oceanic and Atmospheric Administration (NOAA). The office operates with policy guidance from the Federal Committee for Meteorological Services and Supporting Research. The principal work in the coordination of meteorological activities and in the preparation and maintenance of Federal Plans is carried on by the staff of the Federal Coordinator with the advice and assistance of the Interdepartmental Committee for Meteorological Services and Supporting Research and several special purpose Program Councils. The organizational relationships are shown on the inside of the back cover.

MISSION AND STAFFING OF THE OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY (OFCM)

The mission of the OFCM is to promote coordination and cooperation among the Federal weather agencies so that the most and best weather information and user services are provided for the funds made available by the Government. To discharge its mission, the OFCM objectives are overlaid on the objectives of those agencies which provide the services and perform the research. The objectives are to:

- Review the set of Federal weather programs and total Federal requirements for weather services. This review may suggest additions or revisions to current or proposed programs; or identify opportunities for improved efficiencies, reliability, or cost avoidance through coordinated actions or integrated programs.

- Document agency programs and activities in a series of National plans and reports that enable agencies to revise or adjust their individual ongoing programs, and provide a means for communicating new ideas and approaches to the satisfaction of requirements.

- Perform analyses, summaries or evaluations of agency meteorological programs and plans that provide a factual basis for the Executive and Legislative branches to make appropriate decisions related to the allocation of funds.

- Provide a structure and program to promote continuity in the development and coordination of plans and procedures for interagency meteorological service operations and supporting research activities.

In 1979, a General Accounting Office (GAO) report, ("The Federal Weather Program Must Have Stronger Central Direction," LCS-80-10) recommended stronger centralized planning and direction for Federal weather activities. Pursuant to GAO's recommendation, the DOC increased the staff and provided other resources to the Office of the Federal Coordinator. Based on current staffing, there are 84 professional staff-months available within the OFCM. Approximately one-half of these resources is required for the direct support of the Committee structure and preparation of recurring plans (National Operations Plans and the annual Federal Plan). The remaining staff time is available for responding to special inquiries, investigations and studies. The Department of Transportation (DOT) and Department of Defense (DOD) each contribute approximately $250K per year to the operation of the OFCM. The DOD also provides two staff officers (one Air Force Colonel and one Navy Captain). DOT/FAA and DOC each provide one professional staff member. These four individuals act as Assistant Federal Coordinators for liaison to their respective agencies.

SPECIFIC COORDINATION OF MULTIAGENCY PROGRAMS

The Federal Committee for Meteorological Services and Supporting Research was established in 1964 with high-level agency representation to provide policy guidance to the Federal Coordinator and to resolve agency differences that arise during the coordination of meteorological activities and the preparation of Federal plans in general. The Committee is chaired by the Under Secretary of Commerce for Oceans and Atmosphere who is also the Administrator of the National Oceanic and Atmospheric Administration.

Thirteen Governmental agencies engaged in meteorological activities, or that have a need for meteorological services, are represented on the committee. These include the Departments of Commerce, Agriculture, Defense, Energy, Interior, State, and Transportation as well as the Environmental Protection Agency, Federal Emergency Management Agency, National Aeronautics and Space Administration, National Science Foundation, National Transportation Safety Board, and the U. S. Nuclear Regulatory Commission.

The Office of Management and Budget (OMB) and the Federal Committee provide guidance at the policy level to the Federal Coordinator. Guidance from the agencies is provided at the program management level by the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR). Under ICMSSR there are five standing committees for Basic Services, Systems Development, Aviation Services, Operational Environmental Satellites, and Space Environmental Forecasting.

Five Program Councils have been established within the OFCM to coordinate specific interagency cooperative programs. The five currently include Automated Weather Information Systems, Improved Weather Reconnaissance, Joint Automated Weather Observations, Aircraft Icing, and Next Generation Weather Radar. Each of the Councils is comprised of decision-level representatives of the agencies directly concerned with the specific program area.

During FY 1988, the major efforts of the interagency committees and the OFCM will be concentrated in the areas and tasks described in the remainder of this section.

Next Generation Weather Radar (NEXRAD)/Doppler Radar

The Departments of Commerce (DOC), Defense (DOD) and Transportation (DOT) stated a common need in the late 1970's for a radar system with improved capabilities for detecting and monitoring hazardous weather. In 1979 the three Departments established a Joint System Program Office (JSPO) within the National Oceanic and Atmospheric Administration to plan, define, acquire and deploy a "Next Generation Weather Radar" (NEXRAD) network. A Program Council with members from three Departments, and chaired by the Federal Coordinator, provides policy guidance and oversight.

The NEXRAD system combines solid state technology, advanced signal processing, and automation features with Doppler techniques to produce a moderately priced, highly reliable system meeting the common needs of the Departments of Commerce, Defense, and Transportation. These Departments all require information concerning the location, intensity, and movement of hazardous weather activity to meet their mission responsibilities. The Department of Commerce's National Weather Service also requires the same information to support effective management of water resources under non-hazardous conditions. Water resource management is rapidly increasing in visibility as a national problem, and the potential economic benefits from improved management made possible by modern radar techniques are very large.

The acquisition program is structured in four phases--system definition, validation, limited production, and full-scale production. During the system definition phase (February to November 1982), three contractor teams produced competitive system designs. Two contractors were selected for the follow-on validation phase.

During Part 1 (May 1983 through April 1984) and Part 2 (May 1984 through February 1985) of the Validation Phase, the two selected contractors produced subsystem specifications, demonstrated their data processing and system display design, and completed the integration of the system. The resulting prototype models of the NEXRAD system underwent extensive system level testing and initial operational test and evaluation. The NEXRAD Program Council extended the Validation Phase through June 30, 1987, to provide an opportunity for additional development and testing of the preproduction models before selection of a single production phase contractor.

During FY 1988, initial operational test and evaluation Part 2 will be performed using the upgraded preproduction model which will be located at the NEXRAD Operational Support Facility (OSF) in Norman, Oklahoma. The Precipitation Processing Subsystem will also be tested. The selected contractor will continue fabrication of early limited production units and will begin facilities preparation for the initial installations. Training personnel for the Operational Test and Evaluation and for software maintenance will also be completed in FY 1988.

Planned activities for FY 1988 include:

Start site design activities and facilities preparation for first 10 sites	1st quarter
Complete installation and checkout of the upgraded preproduction model	2nd quarter
Begin Initial Operational Test and Evaluation of the upgraded preproduction model	2nd quarter
Exercise option for Full Scale Production	4th quarter

Automated Surface Observations

The Departments of Commerce, Defense, and Transportation (DOC, DOD, DOT) maintain approximately 950 surface weather observing sites requiring an estimated 1,000 staff-years annually. Most surface observations are taken manually and consume a significant amount of staff time. In addition, sensor maintainability and reliability are presenting significant problems. A typical observing station now costs about $22,000 per year to maintain, and it is projected to increase about 10 percent per year because of the increasing difficulty of obtaining replacement parts. Consequently, selective replacement of obsolete sensors is now taking place just to retain the current capability.

Historically, each agency has independently developed a particular weather system capability in pursuit of its mission goals. In 1983, in order to coordinate these efforts and in response to OFCM's recommendation, the Joint Automated Weather Observing Program (JAWOP) was established. The JAWOP Council, chaired by the Federal Coordinator, provides policy and oversight for the three Departments' automated surface observation program development efforts.

In FY 1986, a Government-wide audit of the development of automated weather systems was performed by the President's Council on Integrity and Efficiency (PCIE). It was a joint effort of the Inspectors General from DOC, DOD, and DOT to determine if overlap and duplication existed in the devel-opment of automated weather systems. During this same period, the Departments took actions to greatly improve coordination and lessen duplication and overlap in the Federal weather community. Specifically, NWS and FAA sought convergence of their programs by closely examining system commonality and revalidating system requirements. This resulted in an agreement in 1987 by the JAWOP Council to use the NWS's Automated Surface Observing System (ASOS) at the FAA's towered airport locations.

The PCIE audit supported this action; it concluded that NWS and FAA could achieve substantial cost savings by consolidating development and acquisition actions. Subsequently, the Administrators of NOAA and FAA agreed that NOAA will procure, install, operate, and maintain the NWS's ASOS to meet both the towered and some of the nontowered requirements of the FAA. Immediate needs of the FAA will be satisfied by procuring 160 off-the-shelf Automated Weather Observing Systems (AWOS). The program to automate surface weather observations is fully discussed in Section 1.

The Working Group for Automated Surface Observations' Task Group for Surface Instrumentation Standards (TG/SIS) will continue to develop standards for automated observing systems algorithms and siting at airports.

In FY 1986, NWS completed the first year of operation of prototype ASOS as part of its demonstration phase. The demonstration involved six systems at operational NWS offices in the State of Kansas, as well as a system for FAA control tower evaluation. In addition, other systems were placed in different climates for further evaluation and development of key sensors and algorithms. The demonstration modeled the future observing operation and provided very useful information on system, sensor, and algorithm performance. The experience has supported sensor development as well. Overall, the demonstration showed ASOS to be viable for large-scale deployment. The prototype systems will continue to operate in Kansas to foster user acceptance and develop operational procedures needed to transition into the future automated observing era.

Advances in the development of key sensors continued in FY 1986. The NWS demonstration contributed to significant improvements in laser ceilometer technology, a critical component of automated observing efforts. These technical improvements were factored into the NWS's next generation laser ceilometer procurement. Production delivery has begun with field installation underway at primary NWS observing locations. The new ceilometer will be used as part of the ASOS sensor suite at NWS locations.

The FAA and NWS test of precipitation identification sensors and freezing rain sensors was conducted during the 1986-1987 winter season. This testing is part of a JAWOP plan to develop these sensors. These tests of precipitation identification sensors were conducted at both the Air Force Geophysics Laboratory's Weather Test Facility at Otis Air National Guard Base, Massachusetts, and the NWS's Systems Research and Development Center at Sterling, Virginia. Freezing rain sensors were tested at Worcester, Massachusetts, Municipal Airport, which has frequent icing events.

A JAWOP Visibility Plan will be developed in FY 1987 to coordinate visibility sensor development and testing within the Federal sector. A series of tests will determine the visibility sensor to be used for ASOS applications.

The Air Force activity in automated sensor development is principally the responsibility of the Air Force Geophysics Laboratory (AFGL). Sensor development, test, and evaluation are carried out by AFGL at Otis Air National Guard Base, MA. Efforts are concentrated on airfield weather parameters, for example, the automation of type and intensity of present weather, visibility, and lightning detection. AFGL is also investigating the use of an "all sky" camera to determine sector visibility and cloud cover. A further effort will be to determine the availability and utility of instruments and techniques for providing weather such as visibility and cloud height for AF tactical operations. Ongoing procurement and replacement of sensors include solid state temperature-humidity sensors, pressure sensors, and cloud height indicators. The Air Force has decided to use the NWS-developed Next Generation Ceilometer for replacement purposes.

The DOD's Department of the Navy is planning to automate the weather observing function at 87 Navy and Marine Corps facilities. It is currently evaluating all available options for accomplishing this goal. Options include the use of Navy's Shipboard Meteorological Oceanographic Observing System (SMOOS) and NWS's ASOS.

The U. S. Army's Atmospheric Sciences Laboratory (ASL) has developed and is testing the Surface Atmospheric Measurement System (SAMS) for automated collection and processing of surface weather parameters for supporting the Army's Research, Development, Test, and Evaluation sites. Standard measured parameters are solar radiation, air temperature, relative humidity, wind direction and speed, barometric pressure, soil temperature, delta T, and visibility at each Data Collection Platform (DCP). The central site, called the Acquisition Control Unit (ACU), directs the DCPs to acquire and transmit data, calculates a variety of derived parameters, and maintains a listing of the acquired data including reports and plots.

Planned activities for FY 1987 and FY 1988:

- The JAWOP Action Group will prepare a revised JAWOP Plan to reflect current Federal programs.
- The ASOS Request for Proposal for production systems for NWS and FAA will be released in Spring 1987. Production award is planned for early CY 1988.
- FAA will issue an invitation for competitive bids to procure 160 off-the-shelf AWOS systems.
- NWS, FAA, and DOD will jointly conduct an evaluation of various precipitation identification sensors.
- NWS and FAA will complete a joint lightning sensor evaluation.

- NWS, DOT's Transportation Systems Center, and DOD (AFGL), with support from FAA and Canada's Atmospheric Environment Service, will conduct an evaluation of visibility sensors in support of the ASOS production system acquisition.

- NWS will continue installation of Next Generation Ceilometers at its primary observing sites.

- The Task Group for Surface Instrumentation Standards will complete automated surface weather instrumentation standards related to siting and algorithms.

- NWS will continue to operate its Kansas demonstration project to foster user understanding and develop operational procedures needed to transition into the automated observing era.

- OFCM will revise the Federal Meteorological Handbook No. 1 to reflect automated observing procedures.

- USAF will continue selective replacement of aging sensors, including the purchase of new laser ceilometers by means of an add-on to the NWS procurement.

- The U.S. Army will complete installation of SAMS at all ten meteorological support team locations.

Automated Aircraft Reporting System

Automated aircraft reporting systems (AARS) have the potential to provide large amounts of accurate upper air data not currently available to numerical models, aviation forecast centers, or aircraft routing services. Flight level winds, temperatures, and turbulence observations can be taken every 120 km by wide-bodied passenger and military aircraft equipped with an AARS. These observations could be taken globally with a fleet of suitably equipped aircraft.

At present, several thousand automated upper-level wind and temperature reports are made from commercial aircraft each day over the United States; almost all of these data are proprietary and do not reach NMC or the global telecommunications system. These aircraft reports are relayed using an automated system that was developed by ARINC using a direct air-to-ground communications system installed in many domestic commercial aircraft. This system called ARINC Communications Addressing and Reporting System (ACARS), designed primarily to relay flight management data, was first used for automated wind and temperature reports on a group of 11 American Airlines B-747s. The ACARS is currently being used on about 60 B-747s, B-757s and B-767s. This system can be expanded to 260 additional aircraft with inertial navigation or inertial reference systems and to 390 aircraft with Omega very low frequency navigation systems. In 1987, American Airlines is equipping its aircraft with ACARS units to relay engine performance and meteorological data. This data will be sent to NMC and will result in a very large increase in automated aircraft meteorological reports--at no charge to the Government.

ACARS relay systems are much less expensive than aircraft-to-satellite data relay (ASDAR) systems, but, today, can only be used over land and adjacent coastal regions within line of sight of ACARS ground receiving stations. The potential use of satellite-relay for international applications is being explored.

The program to develop an operational aircraft to satellite data relay (ASDAR) was established in 1975. Early progress was made in refining the design and functions of the aircraft hardware and software. A consortium to oversee the procurement, monitoring, and maintenance of units to be deployed on aircraft was formally established in March 1983 under the auspices of the World Meteorological Organization (WMO). The consortium chose GEC McMichael, Ltd. to manufacture the ASDAR systems. Early in 1986, McMichael's parent company announced the closedown of McMichael, Ltd., putting the ASDAR operational development program in limbo. The consortium is negotiating a revised ASDAR contract with Marconi Defense Systems, Ltd. The contract calls for an initial buy of 13 units. The United States is to obtain one of the initial units. Follow-on options for an additional 29 units plus maintenance support are being negotiated.

Five prototype ASDAR units developed by NOAA and NASA for the First GARP Global Experiment are still being flown on Quantas Airlines aircraft. They continue to provide valuable data for our major processing centers. The FAA maintains the units through interdepartmental funding arrangements with DOC, DOD, and DOT.

The final report of the Aviation Weather Forecasting Task Force was issued in September 1986. The ten-member group placed highest priority on recommendations that FAA/NWS should take immediate steps to implement an automated aircraft reporting system consisting of 650 transport aircraft which would produce 30,000 cruise level and 30,000 climb and descent observations over the U. S. per day. The one-time approximate cost would be $2 million. The air-to-ground data links would be domestic ACARS, ASDAR, and/or International ACARS.

Implementing such an observing capability in combination with the present rawinsonde system, the vertical profiler, and satellite systems would produce a large improvement in the accuracy of meteorological wind analysis. This in turn will bring about more accurate numerical forecasts of winds, temperature, icing, and turbulence.

The Air Transport Association of America has strongly endorsed implementation of an automated aircraft weather data reporting system nationwide. In their judgment, this program will result in a significant improvement in both aviation forecasting and public forecasting as a result of a more comprehensive data base for analysis and forecasting. Because this program will provide a significant benefit to the general public as well as all aviation users, they believe it needs to be structured so that the expenses related to data collection and transmission are paid for by all beneficiaries, not just the airlines.

Planned activities for FY 1987 and FY 1988:

- NWS will support the WMO to contract for preproduction/production ASDAR units.

- NWS will coordinate with American Airlines on their provision of automated aircraft reports from B-767, DC-10, and B-727 aircraft.

- NWS will assist the FAA review of the FAA Task Force recommendations to implement a nationwide system of automated aircraft reporting systems.

Improved Weather Reconnaissance System (IWRS)

The United States Air Force (USAF) and the National Atmospheric and Oceanic Administration (NOAA) have a requirement to improve the quality and quantity of weather data obtained from weather reconnaissance aircraft. These data are needed to help improve the forecasts and warnings of tropical cyclones and East Coast winter storms. To provide improved data in support of the National Hurricane Center and the National Meteorological Center, the eight aircraft of the 53rd Weather Reconnaissance Squadron at Keesler Air Force Base, Mississippi, will be configured to use the Improved Weather Reconnaissance System now under development through contracts with the OFCM. NOAA contracted with Tracor Corporation to provide two pilot production models of the IWRS and the system documentation for use in procurement. Testing of the pilot systems has proceeded satisfactorily with many improvements identified during the period. The satellite communications subsystem was installed at Keesler Air Force Base, and at Tracor Aerospace in Austin, Texas. Testing of this subsystem is currently underway.

A joint Source Evaluation Board (SEB) has been formed to provide guidance to the procurement effort and to the technical and business committees. A total of eight systems will be procured to be installed on six of the weather reconnaissance aircraft and to provide ground spares at the main operating location and at the USAF depot at McClellan Air Force Base, California. The Request for Proposal (RFP) for the procurement of the IWRS was released early in 1987. Initial operating capability will be achieved during the first quarter of FY 1988.

Planned activities for FY 1987 and FY 1988:

o Release the RFP for eight IWRS	March 1987
o Select the contractor and award contract to produce the IWRS	September 1987
o Receive first production model to test	September 1988
o Initial operational capability (testing complete on first system)	November-December 1988
o Full operational capability (all systems installed)	February 1989

Automated Weather Information Systems (AWIS)

Automated Weather Information Systems (AWIS) is the generic term used within the Federal coordination mechanism to refer to the automated weather information systems of the various Federal agencies. The AWIS is being pursued to dramatically reduce labor intensive functions; to reduce the time required to collect, process and interpret weather data; to reduce the time to produce forecasts, warnings and special tailored products; and to expeditiously distribute these products to users. Major agency systems included in AWIS are the Department of Commerce's Advanced Weather Interactive Processing System for the 1990's (AWIPS), the Federal Aviation Administration's Central Weather Processor (CWP) and Flight Service Automated System (FSAS), the U.S. Air Force's Automated Weather Distribution System (AWDS) and Satellite Data Handling System (SDHS), and the U. S. Navy's Naval Environmental Display Station (NEDS) and associated Naval Environmental Data Network (NEDN), and the Tactical Environmental Shipboard System (TESS). Each of these systems involves interactive processing systems at their national centers as well as at their field offices. The systems include communications to collect and distribute raw data, information, and processed products. Excluded from AWIS are the observation subsystems and the super computers at the major centers.

Working under guidance from the Working Group for Automated Weather Information Systems, the Task Group for Communication Interfaces and Data Exchange (TG/CIDE) published, in early 1987, the first revision to the 1982 document entitled "Standard Formats for Weather Data Exchange Among Automated Weather Information Systems". In 1986, TG/CIDE produced another standards document entitled "Standard Telecommunication Procedures for Weather Data Exchange Among Automated Weather Information Systems." This latter standard is based upon the Federal Information Processing Standard 100 which is compatible with a similar document produced by the International Standards Organization. The thrust of the Working Group's effort is to adopt Federal, American and international standards and to develop standards, procedures and guidelines that are unique to weather information systems.

The AWIS Program Council, which consists of high level representatives from the Departments of Commerce, Defense and Transportation, was established during February of 1986 as part of the Federal coordination mechanism for meteorology. This was in response to a 1985 recommendation by the Inspectors General of these agencies. The Council decided to identify major items that need coordination in both the short and long term, to determine what redundancy among the systems can be eliminated, to determine what commonalities exist among the systems, and to produce a "Federal Plan for Automated Weather Information Systems". The AWIS Program Council agreed to use the existing Working Group for Automated Weather Information Systems to support the Council's agenda.

National Program for Space Environment Services and Supporting Research

The National Space Environment Forecast and Warning Program, provides for Federal agencies and public users real-time space environment data, forecasts of the time of terrestrial impact of significant solar output variations, and warnings of solar events threatening to human life or to effective and economic operation of modern technical systems. The common needs of the participating agencies has led to a program of shared resources and responsibilities that extend to observations and to operation of forecast centers which provide standard services to meet those needs.

Observations of solar activity with both optical and radio telescopes are provided by the Department of Defense (DOD). Solar and near-earth space environment observations are provided by complementary sensors on DOD and Department of Commerce (DOC) environmental satellites. DOD provides ionospheric and geomagnetic field data from terrestrial networks. Research data, also useful for the forecast and warning services, are obtained from other agencies and shared through real-time communication networks and jointly operated data bases. Research data from the National Science Foundation (NSF) experiments have been made available through these data sharing arrangements. Provision for real time access to data from National Aeronautics and Space Administration (NASA) satellites has been made for missions where the data are shown to have operational use and where logistical arrangements for data reception can be worked out. The Department of Energy (DOE) and the Department of Interior (DOI) make data available though similar arrangements. The Department of Transportation (DOT) operates radio systems that also provide information on the state of solar-terrestrial disturbances. Universities and private foundations engaged in solar-terrestrial research contribute to the pool of observations. Finally, real-time exchange of data with other countries through the International Ursigram and World Days Service fills gaps in the U. S. observing system. Most of the data gathered in this program are archived in data centers for use in future studies.

The complex of data gathered in the space environmental monitoring program needs to be reduced to a set of standardized indices and warnings and used to make forecasts of future levels of activity. A Space Environment Services Center to provide the forecasts and warnings and data bases to incorporate the observations is operated jointly by DOD and DOC to meet common needs. Some agencies, such as DOD, also operate dedicated centers to meet specific agency needs beyond those provided by the common service. Most of the data gathered in the operational portion of the space environment program are archived in the National Geophysical Data Center.

The role and responsibilities of agencies participating the the space environment program are detailed in the "National Plan for Space Environment Services and Supporting Research: 1983-1987". The plan is currently being updated and will be re-issued in 1987.

The Profiler System

Profiler is an automatic and unattended instrument that provides vertical profiles of winds and temperature in the troposphere, as well as integrated amounts of water vapor and cloud liquid along a zenith path. The nearly continuous observations, as well as the ability to provide soundings under nearly all weather conditions, makes the Profiler an attractive observational tool. The material presented here updates the lead article in the Federal Plan for Meteorological Services and Supporting Research, FY 1987, by detailing progress in both wind and thermodynamic Profiler research and applications.

The planned configuration of the wind Profiler demonstration network has 31 sites located in the central United States; the network is scheduled for completion by the end of 1989. The UNISYS Corporation of Great Neck, N.Y., was awarded the contract to build the 405 MHz wind Profiler radars for the network. One prototype, to be installed at Platteville, Colorado, in December 1987, will be extensively tested by NOAA for a year. The first production unit is due for network installation in December 1988. Thereafter, if the Government exercises its option, another Profiler will come off the production line every few weeks to complete the network by the end of 1989.

Wind Profiler Research. Tests were carried out to obtain a meaningful measure of Profiler precision and accuracy. The UHF (405 MHz) Profiler at Platteville, Colorado, was used because it has a phased-array antenna that provides five beam-pointing directions (east, north, south, west, and zenith). The analysis of about 8,000 data points taken at Platteville during February 1986 led to the following conclusions (Strauch, et al*):

- The precision of the hourly-averaged wind components is of order 1.2 meters per second.
- The precision of the new network radars should be better than 1 meter per second for altitudes less than 10 kilometers.
- The average vertical velocity is not always negligible for hourly averages; however, horizontal homogeneity of hourly averages can be assumed.
- Profilers may not operate properly during convective storms.

Thermodynamic Profiling. The six-channel microwave radiometer has continued to operate at Stapleton International Airport, Denver, Colorado, alongside the NWS radiosonde launch site. In addition, three dual-channel moisture-sensing radiometers have been operated at the Colorado wind Profiler sites of Fleming, Flagler, and Platteville. The Stapleton radiometer has shown rapid changes in low-altitude temperature structure during frontal passages. Radiometric profiler data (temperature and vapor/liquid moisture) was correlated with pilot reports of aircraft icing within a 50-mile radius of the profiler. As a consequence of the encouraging results, radiometric profilers are included in the National Plan to Improve Aircraft Icing (see below).

The vertical resolution of radiometrically derived temperature and humidity profiles is not adequate for all meteorological purposes. To improve the resolution of these profiles, several different approaches are being used:

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*Strauch, R. G. and A. S. Frisch, D. A. Merritt, K. P. Moren, B. L. Weber, and D. C. Welsh, 1987: The precision and accuracy of radar measurements, submitted to the Journal of Atmospheric and Oceanic Technology.

(1) Computer simulations are being conducted to determine an optimum and cost-effective set of frequencies for a next-generation thermodynamic sounder--the Mark II.

(2) A test channel, using state-of-the-art electronics, is being constructed and will be field tested with the current radiometer.

(3) Research in deriving temperature inversion heights and gradients from 405 MHz radar data is continuing.

(4) Modeling work* has shown that temperature structure in the middle and upper troposphere may be derived from an array of wind Profiler observations. Work is continuing on combining radar-derived winds and radiometric (both ground and satellite-based) data.

(5) A 90 GHz radiometer is being field tested with the steerable dual-channel unit. Theoretical studies have shown that use of this channel can improve humidity retrievals by about 30 percent. In addition, theoretical studies are being conducted to determine the feasibility of using millimeter radiometry to enhance water vapor retrievals.

Thus, prospects remain good for improving the vertical resolution of temperature and water vapor profiles. In addition to the basic improvements that will occur in instrumentation, the most promising approach seems to be the combining of wind, temperature, and moisture measurements interactively with dynamical forecast models. This will give dynamically consistent fields of data with temporal and spatial resolutions never before achieved.

PLANNING ACTIVITIES, COMMITTEE CHANGES, AND METEOROLOGICAL PUBLICATIONS

National Aircraft Icing Program

In late 1983, a subgroup of the Federal Committee for Meteorological Services and Supporting Research and other high-level officials in DOD, FAA, and NASA decided to promote greater coordination in aircraft icing by forming a National Aircraft Icing Program Council. The Council was established in 1984.

The Council has the responsibility for developing and maintaining a technology plan and for providing policy guidance for its execution. The Council's Working Group for Aircraft Icing prepared the initial National Aircraft Icing Technology Plan, which was published in 1986. The planned program has dual objectives: improving aircraft icing technologies for the current generation of aircraft and promoting advances in aircraft icing technology that will be needed by 1995 to meet national aeronautical goals for new generations of aircraft. This plan presents a comprehensive list of aircraft icing needs and objectives, and describes the efforts now underway and proposed in these areas of need. It is recognized that the scope, definitions, and priorities may change as the

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*Donall, E. G., and Y. H. Kuo, 1986. Retrieving Temperature and Geopotential Fields from an array of Wind Profiler observations. Preprint Volume, International Conference on Monsoon and Mesoscale Meteorology, November 4 - 7, 1986, Taipei, Republic of China. Sponsored by the American Meteorological Society and the Meteorological Society of China, pp. 218-223.

National Aircraft Icing Technology Plan is implemented, and updating the plan will be needed to reflect accomplishments and changes in agency missions and goals.

One section of the plan on "Detecting, Monitoring and Forecasting" is detailed in the National Plan to Improve Aircraft Icing Forecasts prepared by the Committee for Aviation Services' Ad Hoc Group on Aircraft Icing Forecasts. The NOAA Environmental Research Laboratories will provide the focus and leadership for an an interagency forecast improvement program which will utilize research aircraft and NOAA, NCAR, and FAA facilities in Eastern Colorado.

Federal Plans for Mutual Support and Cooperative Backup

Further advances in communications and automated information systems technology at the National Centers continue to facilitate cooperation among agencies. Additionally, the Federal Plan can now capitalize on modeling and processing capabilities available through arrangements with the meteorological center in the United Kingdom. The plan that was updated in March 1985 will be updated in 1987 and will reflect these new capabilities. Emphasis is being placed on mutual and cooperative support for the exchange of data, information, and products among agencies. As this mutual support improves, dedicated backup will be inherent in the system. Information system protocols and standards, including formats and communications interfaces will be stressed. This will also help to facilitate mutual support and backup for systems that are not located at the operational processing centers.

National Operations Plan for Drifting Data Buoys

The National Operations Plan for Drifting Data Buoys has been in use for a year. It has served as a guide for agencies that have data requirements in remote areas and for support of some field exercises and data gathering programs. The plan established initial areas of paramount interest as a starting effort. It has established a standard set of parameters to be measured as a minimum set of data to be collected for use in operational forecast and warning centers.

The Working Group for Drifting Data Buoys is conducting a thorough review of the plan in FY 1987 to evaluate changing requirements and modifications to the operational procedures. New procedures for quality control of the data being gathered from drifting buoys will be added when the French Service ARGOS and U. S. negotiations are completed. This will incorporate the use of the new Service ARGOS facility in Lanham, Maryland.

Committee and Working Group Changes

A schematic of the Federal Committee structure is found on the back inside cover of this Plan. In the last year, ICMSSR established:

o A Working Group for Monitoring the Stratosphere, chaired jointly by NOAA and NASA. This group is under the Committee for Basic Services (CBS) and is specifically charged with updating the National Plan for Stratospheric Ozone Monitoring and Early Detection of Changes, but is expected to review and coordinate all aspects of stratospheric monitoring.

- A Working Group for Meteorological Information Management. The group will coordinate the agencies' planning and management of meteorological data streams and prepare a real-time data management plan for the future consideration of the ICMSSR.

- An ad hoc group to provide liaison between NOAA and the other Federal agencies in regard to the data that can be obtained from the NOAAPORT facility.

- An ad hoc group under CBS to study: 1) the accuracies of estimates of positions, intensities, and windfields of tropical cyclones using satellite-based data; and 2) the accuracy of tropical forecasts that are made without the use of airborne reconnaissance data.

- A Working Group for Lightning Detection under CBS; this was formerly an ad hoc group.

Two working groups were abolished by ICMSSR--the Working Group for Automated Aircraft Reporting and the Working Group for Fire Weather Services. These groups were no longer essential to the coordinating efforts of ICMSSR.

Meteorological Publications of OFCM

The preparation of Federal plans is a major responsibility of the Federal Coordinator and requires extensive planning and coordination. Generally, Federal plans are prepared for each of the specialized meteorological services and for meteorological programs common to two or more agencies. In most cases, the preparation of Federal plans is facilitated by the existence of individual agency plans for the service or program involved. The Federal Coordinator compiles information from the involved agencies and proposes a unified plan for consideration. Current publications of the Federal Coordinator for Meteorology are given below:

Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research - Fiscal Year 1988	April 1987	FCM-P1-87
National Severe Local Storms Operations Plan	January 1986	FCM-P11-86
National Hurricane Operations Plan	May 1986	FCM-P12-86
National Winter Storms Operations Plan	October 1985	FCM-P13-85
Federal Plans for Mutual Support and Cooperative Backup Among Operational Processing Centers	March 1985	FCM-P14-85
The National Aircraft Icing Technology Plan	April 1986	FCM-P20-86
National Operations Plan for Drifting Data Buoys	May 1986	FCM-P19-86

National Plan to Improve Aircraft Icing Forecasts	July 1986	FCM-P21-87
National Plan for Space Environment Services and Supporting Research, 1983-1987	July 1983	FCM-P10-83
National Plan for Radiological Emergencies at Commercial Nuclear Power Plants	November 1982	FCM-P15-82
Guidance for Estimating Surface Winds Based on Sea State Observations from Aircraft and Sea State Catalog	May 1983	FCM-G1-83
Review of Aviation Weather Requirements and Services	December 1986	FCM-R10-86
Lightning Detection Study	November 1985	FCM-R8-85
Summary and Status of Automated Weather Information Systems	April 1984	FCM-R7-84
A Report on NEXRAD: National Airspace System Cost/Benefits	June 1983	FCM-R6-83
Review of Federal Research and Data Collection Programs for Improving Tropical Cyclone Forecasting	January 1983	FCM-R2-82
Standard Telecommunication Procedures for Weather Data Exchange Among Automated Weather Information Systems	February 1986	FCM-S3-86
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	December 1986	FCM-S2-86
Federal Standard Definitions for Meteorological Services and Supporting Research	November 1981	FCM-S1-81

SECTION 3

RESOURCE INFORMATION AND ANALYSES

The following tables summarize fiscal information of the Federal Government for the fiscal years 1987 and 1988. The funds shown are those used to provide meteorological services and supporting research which has as its immediate objective the improvement of these services. All fiscal data are current as of the end of January 1987 and are subject to later changes. These data do not have legislative approval and do not constitute a commitment by the U.S. Government.

AGENCY OBLIGATIONS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

The fiscal information in Table 3.1 is presented by agency for meteorological operations and supporting research and shows the planned funding level for FY 1987, the budget request for FY 1988, the percent change, and the individual agencies' percent of the total FY 1987 and FY 1988 Federal budget. The agencies total request for FY 1988 is $1,868 million as compared to planned expenditures of $1,621 million in FY 1987. This represents an increase of approximately 15 percent.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA program on Meteorological Services and Supporting Research will be continued with few major adjustments in basic programs. The funding request for operational programs is $12.08 million vs. the estimated FY 1987 expenditure of $6.55 million. Beginning in FY 1987, the Department of Agriculture (Soil Conservation Service) will implement a new five-year initiative to upgrade its snow telemetry data collection system at a projected cost of $5 million. In all, some 510 data collection sites in the system will be upgraded using state-of-the-art equipment. The Department Forest Service will also begin replacing manually operated weather stations with remote automatic weather stations; these stations are currently used for formulating strategies for forest fire control. An increase in equipment and site maintenance funds is also projected so as to improve the quality of weather data. A projected funding increase of $4 million in FY 1988 for USDA's Extension Service will be used to establish a nation-wide rural weather reporting network and support the placement of an agricultural meteorologist in each State.

The proposed funding of $8.82 million for the FY 1988 supporting research program is approximately the same level as the $8.66 million for FY 1987. Some reduction in observational activities is projected with a major reduction in the size of the rainfall network that has been used to monitor spatial and temporal patterns of rainfall on the Little Washita River Watershed in Central Oklahoma.

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 1988 total request of $482.2 million for meteorological programs is 1.1 percent higher than the FY 1987 available funds allocated for planned programs.

Changes in NOAA's operations and supporting research from FY 1987 to FY 1988 are given below where they are broken down by activities. Under Operations, Table 3.1 shows an increase of 3.4 percent in NOAA's request for FY 1988. This increase includes $57 million for satellite launching and ground systems. In FY 1988, NOAA plans to decrease staff and services at eight Weather Service Forecast Offices (WSFO) for a net decrease of $836 thousand and a reduction of 40 positions. NOAA also proposes to consolidate six of the National Weather Service (NWS) regions into four, resulting in a net decrease of $1.3 million and a reduction of 31 positions. These and other proposed decreases discussed below, were listed in the FY 1987 plan but were not approved by Congress. Overall, NOAA plans to reduce personnel engaged in meteorological operations by approximately 209 positions in FY 1988. Additional items that impact the budget activities are discussed below--Public Warning and Forecasts; Environmental Satellite, Data, and Information Services; Atmospheric and Hydrologic Research; as well as the program supporting activities.

- Public Warning and Forecasts. There will be a net increase of $17.3 million. Proposed decreases include $576 thousand for reduced numbers of meteorological technicians; $574 thousand for the elimination of contractual data buoy system engineering and tests; $1.4 million by eliminating agriculture weather services; $300 thousand by reducing fire weather services; $600 thousand by discontinuing maintenance of moored buoys surrounding Hawaii; $400 thousand by discontinuing expansion of backup emergency power for NOAA Weather Radio; $650 thousand in discontinuing maintenance and operation of the Colorado River Basin Flood Warning System; $3.0 million by discontinuing upgrade of Susquehanna River Basin Flood Warning System; $1.5 million by discontinuing expansion of the Integrated Flood Observing and Warning System (IFLOWS); and $4.2 million by eliminating the Ocean Product Center at NMC, the Ocean Applications Group at FNOC, Monterey, and reallocating resources with the Ocean Service Center Program to the National Centers.

  Increases in this subactivity include $14.0 million to continue development of Advanced Weather Interactive Processing Systems (AWIPS) and Automated Surface Observing Systems (ASOS), and $14.0 million for the Next Generation Weather Radar (NEXRAD) to continue limited production of NEXRAD units. Also included is an increase of $2.5 million for an integrated demonstration of new weather technologies (NEXRAD, AWIPS, ASOS) in an operational environment.

- Environmental Satellite, Data, and Information Services. Proposed funding for FY 1988 include increasing the polar satellite program by $54.0 million and the geostationary satellite program by $15.4 million to allow for continuation of procurements to provide the spacecraft and instrument fabrication, integration and testing, the launches, and the ground system. The FY 1988 budget request will maintain a system of polar orbiting satellites that obtain global data and a system of geostationary satellites that provide near continuous observations of the earth's western hemisphere.

TABLE 3.1 METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH COSTS, BY AGENCY
(Thousands of Dollars)

AGENCY	Operations FY87	Operations FY88	Operations %CHG	% of FY88 TOTAL	Supporting Research FY87	Supporting Research FY88	Supporting Research %CHG	% of FY88 TOTAL	Total FY87	Total FY88	Total %CHG	% of FY87 TOTAL	% of FY88 TOTAL
Agriculture	6550	12085	84.5	0.9	8661	8825	1.9	2.0	15211	20910	37.5	0.9	1.1
Commerce/NOAA	409251	423124	3.4	29.8	67845	59105	-12.9	13.2	477096	482229	1.1	29.4	25.8
Defense(Subtot)	531969	647584	21.7	45.7	137498	143791	4.6	32.0	669467	791375	18.2	41.3	42.4
Air Force	431119	510604	18.4	36.0	80219	81404	1.5	18.1	511338	592008	15.8	31.5	31.7
Army	1350	2867	112.4	0.2	29328	33021	12.6	7.3	30678	35888	17.0	1.9	1.9
Navy	99500	134113	34.8	9.5	27951	29366	5.1	6.5	127451	163479	28.3	7.9	8.8
Transp/CG	2227	2034	-8.7	0.1	0	0	0.0	0.0	2227	2034	-8.7	0.1	0.1
Transp/FAA	198529	329555	66.0	23.2	6770	18706	176.3	4.2	205299	348261	69.6	12.7	18.6
EPA	0	0	0.0	0.0	5800	5600	-3.4	1.2	5800	5600	-3.4	0.4	0.3
NASA	4933	3700	-25.0	0.3	240700	213100	-11.5	47.4	245633	216800	-11.7	15.2	11.6
NRC	235	235	0.0	0.0	363	265	-27.0	0.1	598	500	-16.4	0.0	0.0
TOTAL	1153694	1418317	22.9	100.0	467637	449392	-3.9	100.0	1621331	1867709	15.2	100.0	100.0
% of FY TOTAL	71.2	75.9			28.8	24.1			100.0	100.0			

- o Atmospheric and Hydrological Research. For FY 1988, there will be a reduction of $8.4 million in the Meteorological Research line item. Major components include decreases of $2.0 million in the Program for Regional Observing and Forecasting Services which develops computer and display workstations for forecasters and researchers, $1.25 million for mesoscale prediction research, $2.15 million for research into precipitation processes conducted under the joint State/Federal Weather Modification Program, and $3.0 million which was appropriated on a one-time basis in FY 1987 for a research computer to be installed in Oklahoma.

The FY 1988 request includes $30.0 million and 708 positions for aviation weather services that are to be funded from the "Airport and Airway Trust Fund" administered by the Federal Aviation Administration (FAA), an increase of $1.0 million from FY 1987. Starting in FY 1987, NOAA discontinued the transfer of funds to the Department of Defense for hurricane reconnaissance. The $10 million is being included in the DOD budget by the Congress.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 1988 is $791.4 million which is approximately 18 percent more than the total funding level for FY 1987. See discussion below.

U. S. Air Force

Operations. For FY 1988, the operations budget request is $510.6 million which is an increase of 18 per cent from the $431.1 million for FY 1987. Virtually all of this increase requests funding for multi-year procurement for the Defense Meteorological Satellite Program. The FY 1988 budget also contains funding for the Air Force's share of the tri-agency Next Generation Weather Radar (NEXRAD) program and initial procurement of the Automated Weather Distribution System (AWDS) for base weather stations worldwide supporting Air Force and Army combat operations. AWDS is an overall modernization of 1940s-1950s era weather stations. It will allow more rapid preparation of forecasts in severe weather situations, will disseminate data, and will alert operational units when weather conditions change or local warning criteria are expected to occur. AWDS will significantly enhance Air Force and Army flight safety and resource protection efforts.

The Department of Defense will maintain the 53rd Weather Reconnaissance Squadron based at Keesler AFB, Mississippi, to provide weather reconnaissance in FY 1988.

Supporting Research. For FY 1988, the budget request for supporting research is $81.4 million which is an increase of 1.5 percent over FY 1987. Changes from FY 1987 to FY 1988 in Air Force environmental research efforts occur in four major areas. Funding for the Satellite Data Handling/Support System (SDHS/SDSS) for the Air Force Global Weather Central declined slightly. The tri-agency Next Generation Weather Radar (NEXRAD) program funds and the Air Force's Battlefield Weather Observation and Forecast Program (BWOFS) funds increased. There was a slight reduction of funds programmed for the transition from research into operational use of analysis and forecast algorithms developed at the Air Force's Geophysics Laboratory (AFGL).

The FY 1988 budget request for supporting research in the Observations function has a net decrease. Decreases occurred as a result of the completion of research efforts for the major portion of the SDHS/SDSS project, termination of AFGL's Ground-Based Microwave Radio Propagation weather support, and the successful completion of the Weather Attenuation Experiment. There is a significant increase in research funding for engineering development efforts for BWOFS (both observation and prediction phases), and a modest increase for NEXRAD algorithm development (observation only). Funding for descriptive efforts increased chiefly in anticipation of the requirement for increased climatology for research on atmospheric interaction with reentry vehicles and additional analytical efforts in the satellite meteorology area (e.g., LIDAR sensors aboard future Defense Meteorological satellites). A similar magnitude increase occurred in the funding for AFGL's technology transfer efforts in the areas of cloud and vertical atmospheric analyses and upper atmospheric modeling efforts.

U. S. Army

Funding of meteorological programs by the Army is primarily for supporting research. In FY 1988, the budget request for supporting research is $33.0 million, which represents a 12.6 percent increase over FY 1987. This is the budget for Army-sponsored meteorological research, development, test and evaluation, and includes support to Army test and evaluation sites throughout the U.S. and Panama. The basic research program is structured to provide understanding of the physical principles governing atmospheric behavior, structure, and specific phenomena that affect Army operations and systems.

The FY 1988 requested funding for operational programs is $2.87 million which is increased from the $1.35 million in FY 1987. Much of the increase in the FY 1988 budget is attributable to equipment modifications and additions in support operations required by increased mission scope and complexity. Some is due to costs associated with a newly developed range test facility for testing self-contained munitions that after launch autonomously search for, acquire, select, and home on hostile targets. Nominal increases will occur in remote measurements, imaging and target research, and a new effort will begin dealing with boundary layer turbulence research.

U. S. Navy

In the operations area, the FY 1988 budget request is $134.1 million, an increase of about 35 percent from the $99.5 million in FY 1987. The operations programs are described in detail below. In the supporting research area, the FY 1988 budget request is $29.4 million, an increase of five percent from the $27.95 million in FY 1987. A description of the ongoing research programs is presented in Appendix A.

Observations. Most funding under this functional category is applied toward the Navy share for procurement of a microwave imager for the Defense Meteorological Satellite Program (DMSP), a joint USN/USAF project. This special sensor is tailored for operation aboard a DMSP spacecraft which will provide data concerning ocean surface wind speed, precipitation intensity, atmospheric water vapor, and polar ice conditions. Approximately $10.0 million of FY 1987 dollars, which will buy one sensor, was reprogrammed to FY 1988. This action was taken in order to procure two microwave imagers in FY 1988 to conform to the USAF procurement strategy for the DMSP satellite. Additional items increased under this category include an upgraded tactical environmental satellite receiver to replace aging and unsupportable equipment used to copy DMSP data, and the procurement of two additional Lightning Detection and Tracking Systems (LDATS) to upgrade our capability to observe and track lightning at shore facilities. Category decreases are a reduced number of planned upper air soundings by meteorological rockets and a slight decrease in planned contractor engineering support.

Analyses and Forecasts. The Satellite Processing Center Upgrade (SPCU) at Fleet Numerical Oceanography Center (FLENUMOCEANCEN) is designed to support Navy responsibilities under the Memorandum of Agreement with NESDIS/NOAA and AWS/USAF for the Shared Processing of meteorological/oceanographic satellite data. Follow-on phases of this upgrade to be initiated in FY 1988 will provide the hardware and software capability to assimilate and analyze the vast amounts of oceanographic data which will be available from foreign and domestic satellite systems planned for the early 1990's. Additionally, COMNAVOCEANCOM plans to procure upgrades for the Primary Environmental Processing System Upgrade and Expansion (PEPSUE) Information Systems (IS) at FLENUMOCEANCEN to provide improved and timelier support to operational fleet units. A capability is also included for the Joint Typhoon Warning Center (JTWC) at Naval Oceanography Command Center, Guam to develop automated procedures for predicting the formation and the track of tropical cyclones in the Pacific and Indian Oceans--this system will be called the Typhoon Information Processing System (TIPS). In FY 1988, the Tactical Environmental Support System (TESS), a system which provides afloat oceanographers ready access to environmental data upon which to base tactical forecasts, will be installed at approximately 70 sites. Funding for TESS in FY 1987 had included installation and training costs, equipment upgrades and interface costs not reflected in FY 1988.

Communications. The Consolidated Communication System (CCS) replacement at FLENUMOCEANCEN will upgrade obsolete, logistically unsupportable data communications hardware used to transmit environmental data and tailored tactical products to shore activities. CCS interfaces to several networks and ties FLENUMOCEANCEN to data sources worldwide, including USAF and NOAA. Communications equipment upgrades (to include satellite data acquisition) are part of the Aviation Support Display System (ASDS) which will be installed at CONUS oceanography detachments. ASDS will serve as a stand-alone interface to provide a downlink capability for GOES-TAP satellite data and potential interface with the planned NOAAPORT point to multi-point data distribution system. The system will also distribute tailored meteorological support products to customers such as aviation squadrons thereby improving the local dissemination of information critical to safety of flight.

Dissemination to Users. The principal item under this category is an upgrade to the capability to provide satellite imagery and data to both ashore and afloat units. Six AN/SMQ-11 sets will be purchased in addition to those previously programmed. Other category items include funding the ASDS system mentioned in the previous category to interface with external circuits and sources of environmental data, and meteorological and oceanographic sensors and equipment to replace antiquated and unsupportable versions in use within NAVOCEANCOM.

General Agency Support. Items listed under this category involve upgrading existing meteorological equipment--overhauls, rework and reinstallation--and providing training to Navy personnel concerning the observing and tactical usage of data. End strength increases in officer personnel are reflected as is an anticipated military pay raise in FY 1988. Military construction increases are to provide space for additional environmental equipment--observational and communications--expected in the next few years.

DEPARTMENT OF TRANSPORTATION (DOT)

Within DOT, the U. S. Coast Guard and the Federal Aviation Administration have reported on meteorological programs in FY 1987 and FY 1988.

U. S. Coast Guard (USCG)

All of USCG's funding for meteorological programs is for operations. In FY 1988, the funding level is $2.03 million as compared to $2.23 million in FY 1987. A breakdown of the FY 1988 operational costs is as follows:

- Observations Category -- $576 thousand
- Communications -- $288 thousand
- Dissemination to Users -- $70 thousand
- General Support -- $1.10 million.

Among the Coast Guard's activities is the collection and dissemination of meteorological information for the benefit of the marine community. The Coast Guard provides this information to NOAA's National Weather Service and provides use of facilities to the NOAA National Data Buoy Center.

Federal Aviation Administration (FAA)

Operations Programs. In FY 1988, proposed funding for the operational programs is $329.6 million, an increase of about 66 percent from the $198.6 million for FY 1987. Most of the changes are in the Observations category discussed below. The significant changes by functional categories are given below.

- Observations or Data Acquisition. Most meteorological data are acquired and collected by the NWS, FAA, DOD, air carriers, and contract observers. Included are surface observations, upper air soundings, and radar data. The FAA takes about 30 percent of the surface observations within the continental United States. The FAA also distributes Pilot Report (PIREP) information nation-wide and provides the majority of weather radar coverage in the Western United States. NWS provides both surface and upper air data at selected locations, while the National Environmental Satellite, Data, and Information Service (NESDIS) is the source of all available satellite weather information for civil use. The large increase in requested funding is for facilities and equipment costs associated with automated surface weather observations and two terminal Doppler radar programs (Terminal NEXRAD and Terminal Doppler Weather Radar).

- Communications. On the national level, meteorological data are transmitted on medium-speed Leased Service A, a low-speed teletypewriter network, and on a slow-speed facsimile system, aided by interphone communication links. The center of the Aviation Weather System's communications network is the Weather Message Switching Center located in Kansas City. This switching facility serves as the gateway for the flow of alphanumeric information between the various FAA facilities, NWS, and other users (e.g., DOD).

- Dissemination to Users. In today's system, nearly all weather information is presented to pilots through telephone or face-to-face briefings, commercially supplied briefings (usually via some type of computer terminal or telephone), or in the case of commercial operations, through their respective dispatch/operations offices. In FAA field facilities that provide weather services, textual and graphic weather products are received via computer terminal (Leased Service A), some teletype and line printer circuits, and the National Facsimile circuits. These products are sorted, posted and updated manually and are available for review by pilots who visit these facilities. General aviation pilots, for the most part, do not have direct access to the weather charts and products unless they subscribe to commercial weather services. This area also includes international preflight briefings and transcribed weather broadcasts.

Supporting Research. For supporting research, the requested funding in FY 1988 is $18.7, as compared with $6.77 million budgeted for FY 1987. This increase reflects the changing stages of various on-going programs and do not represent major program changes. The large increase in Dissemination is accounted for by a $10.5 million increase in the Central Weather Processor program. The program has reached the point where major expenditures for software and hardware are required to support delivery of a prototype system in FY 1989.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of EPA funding of meteorological programs is for supporting research. The requested funding level in FY 1988 is $5.6 million versus $5.8 million in FY 1987. EPA is continuing its development and validation of air quality models for pollutants. The research will focus on urban, regional, and complex terrain models and will be used to develop pollution control strategies.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Nearly all of NASA's funding is for supporting research. The requested funding for supporting research in FY 1988 is $213.3 million, a decrease of about 11.5 percent from FY 1987. The FY 1988 level reflects decreased funding for the Upper Atmosphere Research Satellite (UARS) and the NASA Scatterometer (NSCAT). The launch of UARS has been delayed from October 1989 to October 1991; NSCAT is also scheduled for launch in 1991. The requested funding for operations in FY 1988 is $3.7 million which is a decrease from $4.9 million in FY 1987.

NUCLEAR REGULATORY COMMISSION (NRC)

The total NRC budget request for meteorological activities is $500 thousand for FY 1988--$235 thousand for operations and $265 thousand for supporting research. This is a reduction from $598 thousand in FY 1987. The meteorological support program in NRC relates to the safe operation of nuclear facilities and the protection of the health and safety of the public and the environment. Obtaining current and relevant meteorological data on a real-time basis, for use in atmospheric dispersion models during emergencies, is also a prime consideration. The NRC budget in this area reflects these priorities. Budget reductions over the past several years have resulted in the deletion of the atmospheric dispersion field test program. This program was designed to obtain a data base and other information for use in validating real-time atmospheric dispersion models. Budget reductions for supporting research in FY 1988 ($265 thousand vs. $363 thousand in FY 1987) reflect the completion of certain tasks in the atmospheric dispersion model technical assistance and research program.

AGENCY OPERATIONAL COSTS BY FUNCTION

Table 3.2 shows how the agencies plan to obligate their funds for the five major operational functions involved in meteorological service operations. The funding levels in Table 3.2 for each agency were discussed above. Brief descriptions of the activities included in each of these major functions are provided below.

Observations. This function involves obtaining the data that underlie all weather forecasts and warnings. The observing function is divided into five program elements for planning and coordination: surface, upper air, weather reconnaissance, weather radar, and operational environmental satellite observing programs.

Analyses and Forecasts. This function involves centralized production of manual and computerized analyses of meteorological data as well as projections of the future states of the atmosphere and accompanying weather phenomena. This function is divided into three parts: analyses and forecasts on a global and hemispheric basis; products tailored for specific areas or user groups; and specific weather phenomena, such as hurricanes and severe thunderstorms.

Communications. This involves the communication system needed to move the large amounts of data and information from the observation sites to the processing centers and the communications system required to send forecast products to forecast offices or units.

Dissemination to Users. This function represents the final step in preparing and delivering weather service products to the users. The field offices of DOC and DOD and the flight service stations (FSS) of DOT are the principal program elements involved.

General Agency Support. This function involves the planning, training, maintenance, and management activities common to any large dispersed activity. The general support function is divided into internal support and planning, engineering and mission-related work, maintenance of equipment and facilities, training of personnel, and overall program management.

TABLE 3.2 AGENCY OPERATIONAL COSTS, BY FUNCTION
(Thousands of Dollars)

AGENCY	Observations FY87	Observations FY88	Analyses & Forecasts FY87	Analyses & Forecasts FY88	Communi-cations FY87	Communi-cations FY88	Dissem-ination FY87	Dissem-ination FY88	Gen'l Agency Support FY87	Gen'l Agency Support FY88	Total FY87	Total FY88	Total %CHG	% of FY88 TOTAL
Agriculture	4640	4800	300	2905	98	728	822	2822	690	830	6550	12085	84.5	0.9
Commerce/NOAA	126888	121199	199810	220015	6694	6660	29839	28801	46020	46449	409251	423124	3.4	29.8
Defense(Subtot)	222064	321263	91748	91875	55563	44951	72294	95584	90300	93911	531969	647584	21.7	45.7
Air Force	203489	279142	66093	66570	47065	33853	54175	70925	60297	60114	431119	510604	18.4	36.0
Army	1163	2617	0	0	0	0	0	0	187	250	1350	2867	112.4	0.2
Navy	17412	39504	25655	25305	8498	11098	18119	24659	29816	33547	99500	134113	34.8	9.5
Transp/CG	585	576	0	0	294	288	70	70	1278	1100	2227	2034	-8.7	0.1
Transp/FAA	90641	218352	0	0	34682	35319	42017	43192	31189	32692	198529	329555	66.0	23.2
EPA	--------- Not Applicable ---------													
NASA	995	530	989	1070	329	344	0	0	2620	1756	4933	3700	-25.0	0.3
NRC	0	0	235	235	0	0	0	0	0	0	235	235	0.0	0.0
TOTAL	445813	666720	293082	316100	97660	88290	145042	170469	172097	176738	1153694	1418317	22.9	100.0
% of FY TOTAL	38.6	47.0	25.4	22.3	8.5	6.2	12.6	12.0	14.9	12.5	100.0	100.0		

Table 3.2 shows that in FY 1988 the agencies will devote about 47 percent of their resources to observations as compared with 38.6 percent in FY 1987. The principal changes year-to-year are associated with cyclic variations in satellite procurements and with costs for new equipment such as automatic weather observing stations and weather radars. Approximately 22 percent is devoted to analyses and forecasts where the major year-to-year changes are the result of replacing the computers that are the keystone of the operations. Communications costs, comprising about 6 percent of the total program, are usually stable year-to-year, reflecting the long-term nature of communications systems planning, engineering and operation. The "dissemination to users" function is also usually stable from year-to-year at about 12 percent because the field office structures are not subject to large changes. General agency support, requiring approximately 13 percent, is subject to some significant year-to-year variations, especially in maintenance and training activities.

AGENCY SUPPORTING RESEARCH COSTS BY FUNCTION

Table 3.3 shows how the agencies plan to obligate their funds for supporting research in four functional areas: Observations, Description and Prediction, Dissemination, and Systems and Support.

The supporting research functions are defined roughly the same as those discussed previously for operational programs. About 70 percent of the research efforts is in the "observations" function and roughly 16 percent for "description and prediction." The research function of "systems and support" takes about 10 percent of the resources; it covers the development and engineering research work related to maintenance, training, and engineering operations. A relatively small amount, 4 percent, goes into supporting research for the dissemination function.

Supporting research programs characteristically are stable year-to-year unless a major project is initiated or terminated by one or more of the agencies.

METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH BY SERVICE

Table 3.4 summarizes how the agencies plan to obligate operational funds for basic and specialized meteorological services; Table 3.5 indicates the corresponding data for supporting research. Table 3.4 shows that "Basic" services require approximately 47 percent of the total operational costs while Aviation Services require about 41 percent. The remaining 12 percent is used to support the other specialized services. The definitions of specialized and basic services are provided below.

Specialized Services

Aviation Meteorological Services: Those services and facilities established to meet the requirements of general, commercial and military aviation. Civil programs are included that are directly related to services solely for civil and military programs in support of fixed and rotary wing aircraft and medium or long-range missile operations.

TABLE 3.3 AGENCY SUPPORTING RESEARCH COSTS, BY FUNCTION
(Thousands of Dollars)

AGENCY	Observations FY87	Observations FY88	Description & Prediction FY87	Description & Prediction FY88	Dissem-ination FY87	Dissem-ination FY88	Systems & Support FY87	Systems & Support FY88	Total FY87	Total FY88	Total %CHG	% of FY88 TOTAL
Agriculture	402	402	2052	2216	159	159	6048	6048	8661	8825	1.9	2.0
Commerce/NOAA	14914	14914	23511	16871	325	225	29095	27095	67845	59105	-12.9	13.2
Defense(Subtot)	104487	106769	18583	22868	5341	5507	9087	8647	137498	143791	4.6	32.0
Air Force	67805	66149	8346	11950	3180	3237	888	68	80219	81404	1.5	18.1
Army	20458	23671	4684	5683	1811	1905	2375	1762	29328	33021	12.6	7.3
Navy	16224	16949	5553	5235	350	365	5824	6817	27951	29366	5.1	6.5
Transp/CG	--------- Not Applicable ---------											
Transp/FAA	0	0	1181	886	1053	14691	4536	3129	6770	18706	176.3	4.2
EPA	0	0	5800	5600	0	0	0	0	5800	5600	-3.4	1.2
NASA	220400	192200	20300	20900	0	0	0	0	240700	213100	-11.5	47.4
NRC	0	0	363	265	0	0	0	0	363	265	-27.0	0.1
TOTAL	340203	314285	71790	69606	6878	20582	48766	44919	467637	449392	-3.9	100.0
% of FY TOTAL	72.7	69.9	15.4	15.5	1.5	4.6	10.4	10.0	100.0	100.0		

TABLE 3.4 AGENCY OPERATIONAL COSTS, BY SERVICE
(Thousands of Dollars)

AGENCY	Basic FY87	Basic FY88	Aviation FY87	Aviation FY88	Marine FY87	Marine FY88	Agriculture & Forestry FY87	Agriculture & Forestry FY88	General Military FY87	General Military FY88	Other FY87	Other FY88	Total FY87	Total FY88
Agriculture	0	0	0	0	0	0	7150	12085	0	0	0	0	6550	12085
Commerce/NOAA	360851	377616	30309	30309	15037	13863	3054	1336	0	0	0	0	409251	423124
Defense(Subtot)	173401	284613	226652	230094	28014	33781	0	0	52019	48531	51883	50565	531969	647584
Air Force	153580	238743	202061	201891	0	0	0	0	38088	32670	37390	37300	431119	510604
Army	0	0	0	0	0	0	0	0	1350	2051	0	816	1350	2867
Navy	19821	45870	24591	28203	28014	33781	0	0	12581	13810	14493	12449	99500	134113
Transp/CG	1514	1369	0	0	713	665	0	0	0	0	0	0	2227	2034
Transp/FAA	3427	3580	195102	325975	0	0	0	0	0	0	0	0	198529	329555
EPA	--------- Not Applicable ---------													
NASA	0	0	0	0	0	0	0	0	0	0	4933	3700	4933	3700
NRC	85	85	0	0	0	0	0	0	0	0	150	150	235	235
TOTAL	539278	667263	452063	586378	43764	48309	10204	13421	52019	48531	56966	54415	1153694	1418317
% of FY TOTAL	46.7	47.0	39.2	41.3	3.8	3.4	0.9	0.9	4.5	3.4	4.9	3.8	100.0	100.0

TABLE 3.5 AGENCY SUPPORTING RESEARCH COSTS, BY SERVICE
(Thousands of Dollars)

AGENCY	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88
Agriculture	0	0	0	0	0	0	8661	8825	0	0	0	0	8661	8825
Commerce/NOAA	61959	53426	5886	5679	0	0	0	0	0	0	0	0	67845	59105
Defense(Subtot)	0	0	0	0	27951	29366	0	0	109547	114425	0	0	137498	143791
Air Force	0	0	0	0	0	0	0	0	80219	81404	0	0	80219	81404
Army	0	0	0	0	0	0	0	0	29328	33021	0	0	29328	33021
Navy	0	0	0	0	27951	29366	0	0	0	0	0	0	27951	29366
Transp/CG	--------- Not Applicable ---------													
Transp/FAA	0	0	6770	18706	0	0	0	0	0	0	0	0	6770	18706
EPA	0	0	0	0	0	0	0	0	0	0	5800	5600	5800	5600
NASA	239200	211600	1500	1500	0	0	0	0	0	0	0	0	240700	213100
NRC	363	265	0	0	0	0	0	0	0	0	0	0	363	265
TOTAL	301522	265291	14156	25885	27951	29366	8661	8825	109547	114425	5800	5600	467637	449392
% of FY TOTAL	64.5	59.0	3.0	5.8	6.0	6.5	1.9	2.0	23.4	25.5	1.2	1.2	100.0	100.0

Marine Meteorological Services: Those services and facilities established to meet the requirements of Commerce and Defense on the high seas, coastal and inland waters, and for boating activities in coastal and inland waters. The civil programs which are directly related to services solely for marine uses and military programs supporting fleet, amphibious and sea-borne units (including carrier-based aviation and fleet missile systems) are included.

Agriculture and Forestry Meteorological Services: Those services and facilities established to meet the requirements of the agricultural industries and Federal, state and local agencies charged with the protection and maintenance of the Nation's forests. The agricultural, large-crop inventory program of the Department of Commerce is included.

General Military Meteorological Services: Those services and facilities established to meet the requirements of military user commands and their component elements. Programs and services which are part of Basic, Aviation, Marine, or Other Specialized Services are not included here.

Other Specialized Meteorological Services: Those services and facilities established to meet requirements of user agencies or groups not included in the preceding categories, such as support to civil and military programs involving space operations and support to Federal, state and local governmental agencies responsible for dealing with urban air pollution.

Basic Services

"Basic" services include the programs and activities that do not fall under one of the specialized services identified above. Basic services provide products that meet the common needs of all users and include the products needed by the general public in their every day activities and for the protection of lives and property.

AGENCY PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 3.6 shows how agency staff resources are distributed among the five functions involved in meteorological operations. Overall, agency staff resources for FY 1988 total 16,382--a decrease of 3.4 percent.

Observations. This function requires about 20 percent of the staff resources for weather operations. It is labor-intensive, particularly for around-the-clock observations required for forecasts, warnings and aircraft operations.

Analyses and Forecasts. This function consumes approximately 20 percent of the Federal staff resources for weather operations. This function, while requiring a substantial number of personnel, makes extensive use of computers and related automated processing systems to prepare a wide array of products employed by field offices to satisfy the needs of the public and specialized users of weather information. A significant portion of these staff resources are devoted to preparing and maintaining the computer programs necessary to produce new and more effective products.

TABLE 3.6 AGENCY PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS, BY FUNCTION
(Units are Full Time Equivalent Staff Years)

AGENCY	Observations		Analyses & Forecasts		Communi-cations		Dissem-ination		General Agency Supp		Total			% of FY88 TOTAL
	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	FY87	FY88	%CHG	
Agriculture *	72	72	14	14	5	5	9	9	9	11	109	111	1.8	0.7
Commerce/NOAA	1640	1544	1895	1808	72	71	567	542	353	353	4527	4318	-4.6	26.4
Defense(Subtot)	2381	1894	1416	1413	619	616	2382	2381	2572	2674	9370	8978	-4.2	54.8
Air Force	1963	1492	919	919	497	495	2154	2154	1723	1723	7256	6783	-6.5	41.4
Army	92	78	0	0	0	0	0	0	166	271	258	349	35.3	2.1
Navy	326	324	497	494	122	121	228	227	683	680	1856	1846	-0.5	11.3
Transp/CG *	32	32	0	0	16	16	4	4	32	32	84	84	0.0	0.5
**									15	15	15	15	0.0	0.1
Transp/FAA	356	359	0	0	661	662	1209	1210	618	642	2844	2873	1.0	17.5
EPA	--------- Not Applicable ---------													
NASA	--------- Not Applicable ---------													
NRC	0	0	0	0	0	0	0	0	3	3	3	3	0.0	0.0
TOTAL	4481	3901	3325	3235	1373	1370	4171	4146	3602	3730	16952	16382	-3.4	100.0
% of FY TOTAL	26.4	23.8	19.6	19.7	8.1	8.4	24.6	25.3	21.2	22.8	100	100		

* Figures are rounded to nearest whole number.
** Funded by other agencies.

Communications. This function requires about 8 percent of the staff resources. Communications has become less labor-intensive over the years as modern equipment came into use.

Dissemination. This function requires approximately 25 percent of all staff resources. This reflects the large number of field offices operated by the Departments of Commerce, Defense and Transportation, with many of these operating around-the-clock to serve the general public, military needs and the aviation industry.

General Agency Support. This function requires approximately 23 percent of all staff resources. This includes management, planning, training, maintenance, and specialized agency programs.

INTERAGENCY FUND TRANSFERS

Table 3.7 summarizes interagency fund transfers for FY 1987 to other agencies to pay for services that the receiving agencies can perform more efficiently and effectively. While specific amounts may vary from year-to-year, depending upon agency needs, the pattern shown in this table is essentially stable.

Department of Commerce (DOC). The Department of Transportation will be reimbursed $1,064,000 for facilities support.

Department of Defense (DOD). The Army will reimburse DOC $465,000 for expendables and coordination of supporting research; the Army will also reimburse DOE $425,000 for meteorological modeling. The Navy will reimburse DOC a total of $935,000 of which $897,000 is for basic analysis and forecasting and $38,000 is for the Mariners Weather Log. The Air Force will reimburse DOC a total of $1.237 million--for climate data ($667,000), NOAA's satellite relay to AFGWC ($263,000), ionospheric data ($280,000), and miscellaneous support items ($27,000).

Department of Transportation. The DOC will be reimbursed $9.05 million principally for meteorological support at Center Weather Service Units (located with most Air Route Traffic Control Centers), meteorological training support, and "AM Weather" broadcast over public television (PBS). DOC will be reimbursed an additional $550,000 for research and development related to Next Generation Weather Radar (NEXRAD) and prediction technology to support flight safety.

National Aeronautics and Space Administration. The Department of Defense will be reimbursed $635,000 and the Department of Commerce $744,000 principally for meteorological support to the space-shuttle operations.

Environmental Protection Agency. The DOC will be reimbursed $2.6 million for research related to air quality standards.

Department of Energy. To support the Weather Service Support Office at the Nevada Nuclear Test Site, $2.25 million is transferred to the Department of Commerce.

Nuclear Regulatory Commission. The Department of Energy will be reimbursed $358,000 for research on atmospheric dispersion models; NOAA will be reimbursed $20,000 for technical assistance.

Department of Agriculture. DOC will be reimbursed $30,000 to support the National Climate Program Office.

LOCATIONS BY OBSERVING TYPE

Table 3.8 indicates the number of locations or platforms at which the Federal agencies carry out (or supervise) the various types of weather observations. A list of acronyms for the various platforms is found in Appendix B.

TABLE 3.7

INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency		FY 1987 Funds (Thousand of Dollars Estimated or Planned)	
Transferred from:	Transferred to:	Operations	Supporting Research
Commerce	DOT	1,064	-
	NASA	115	
Defense: Army	DOC	-	465
Army	DOE	-	425
Navy	DOC	935	-
Air Force	DOC	1,237	-
Transportation	DOC/NOAA	9,050	550
NASA	DOD/USAF	635	-
	DOC	744	-
EPA	DOC	-	2,600
DOE	DOC	2,246	-
NRC	DOE	-	358
	DOC	-	20
USDA	DOC	-	30

TABLE 3.8
LOCATIONS BY TYPE OF OBSERVATION

Observation Type	Agency	FY 1987
Surface (Land)	Commerce (WSO, WSFO, WSMO)	237
	Commerce (WSCMO)	21
	Commerce (Marine Reporting/CG Station)	185
	Commerce (AMOS, RAMOS, AUTOB, DARDC)	132
	Commerce (Supplem. Av. Wea. Reportg Station)	402
	Defense (U.S.)	167
	Defense (Overseas)	87
	Transportation (Flight Service Station)	210
	Transportation (Limited Av.Wx. Rprtg Station)	146
	Transportation (FAA Contract Wea. Obs. Station)	19
	Transportation (USCG Coastal)	120
	NASA	2
Surface (Marine)	Commerce (Merchant Ship Coop Program)	1,600
	Commerce (SEAS-equipped ships)	90
	Commerce (Coastal-Marine Automated Network)	39
	Commerce (Moored Buoy)	35
	Commerce (Large Navigation Buoy)	8
	Defense (Ships w/met personnel)	33
	Defense (Ships w/o met personnel)*	110
	Transportation (Coast Guard Ships)	81
Upper Air (Balloon)	Commerce (U.S.)	97
	Commerce (Coop. foreign)	33
	Defense Fixed (U.S. & Overseas)	54
	Defense (Ships)	31
	Defense Mobile (U.S. & Overseas)	15
	NASA (U.S)	2
	Transportation (Coast Guard)**	10
Upper Air (Rocket)	NASA	1
	Defense	2
Weather Radar	Commerce (NWS)	128
	Commerce (At FAA Radars)	24
	Defense (U.S. & Overseas)	126
	Defense (Remote displays)	35
Weather Reconnaissance	Commerce (NOAA aircraft)	3
	Defense (USAF aircraft)	20

*Based on average monthly reporting.
**Inactive but available for use.

SECTION 4

NATIONAL CLIMATE PROGRAM

The National Climate Program (NCP) was established in 1978 by Public Law 95-367 to help "understand and respond to natural and man-induced climate processes and their implications." This interagency program of research and applications is managed by the National Climate Program Office (NCPO) for the Secretary of Commerce.

In 1986, the law was amended to provide several administrative changes (Public Law 99-272). An interagency Climate Program Policy Board is now responsible for coordinated planning and program review for the Program, review of all agency and department budget requests related to climate, submittal of a report to the Office of Management and Budget concerning such budgets, and consultation with users and producers of climate data, information and services. In addition the National Climate Program Office (NCPO) is to serve as the lead entity responsible for administering the program and is to be headed by a Director who represents the Board and is the spokesperson for the Program. The NCPO also serves as staff for the Board, reviews each agency budget request, coordinates interagency participation in international climate-related activities, and works with the National Academy of Sciences and other private, academic, State and local groups in preparing and implementing the 5-year plan and the Program. The amendments repealed the requirement for matching funds for grants, contracts or cooperative agreements under the intergovernmental climate programs.

Activities of the NCP are reported each year in an Annual Report to Congress, copies of which can be obtained from the National Climate Program Office, NOAA, 11400 Rockville Pike, Room No. 108, Rockville, MD 20852 [Tel: (301)443-8981].

Program Organization

The NCP is organized with three principal elements which closely parallel the World Climate Program. The goals of these elements are:

The Data and Services element is designed to create a knowledge base of up-to-date data and information for general use in describing and understanding climate and its variations. Over the next five years, the emphasis in this element will be on accurate, long-term monitoring of the climate including detection of ongoing climatic change, and making climate data and information more readily available through improved climate services.

The Research and Development element is designed to improve our basic understanding of climate, and our capacity to provide information about possible or likely changes and their causes. Over the next five years, this element will continue to emphasize national projects (coordinated with international efforts where possible) which advance the understanding of climate predictability on all time scales, and provide the foundation upon which informed decisions can be based regarding natural and man-induced climate anomalies.

The Impact Assessment and Response Strategies element addresses problems connected with the social-economic consequences of climate fluctuations, such as those affecting agriculture, forestry, water resources, and fisheries. This element is concerned with providing the information necessary for decisions aimed at reducing the negative effects of a changing or varying climate. Over the next five years, the activities within this element will aim to develop risk and impact assessment methodologies and products for decision making, primarily focused on the probable effects of increasing atmospheric carbon dioxide and trace gases, and organize federal responses to national priority issues in climate.

World Climate Research Program (WCRP) and Activities

The goals of the WCRP are to determine to what extent climate can be predicted and the extent of man's influence on climate. The primary approach for achieving these goals is based on the use of physical-mathematical models capable of simulating and eventually predicting climate changes over a wide range of space and time scales. The goals of the WCRP can be formulated in terms of three specific objectives or streams of climate research, each corresponding to different time scales. The first stream aims at establishing the physical basis for the prediction of weather anomalies on time scales of one to two months. The second stream aims at predicting the variations of the global climate over periods up to several years. Finally, the third stream aims at characterizing variations of climate over periods of several decades and assessing the potential response of climate to either natural or man-made influences, such as the increase in atmospheric concentration of carbon dioxide.

The WCRP builds directly upon the second major objective of the Global Atmospheric Research Program (GARP). In the early phases many activities were inseparable and equally essential for both programs. Development and testing of models that accurately simulate the annual seasonal cycle and preparation of data sets are examples of overlap activities. Some data collection efforts deployed during the First GARP Global Experiment (FGGE) still continue, e.g., tropical, Arctic and Southern Hemisphere buoys and automated aircraft reporting. Data sets for climate research that include after-the-fact compilations of specialized precipitation, ice and snow, solar and earth radiation, and oceanographic data are beng completed and made available.

Specific WCRP projects in which the National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and National Aeronautics and Space Administration (NASA) are the primary participants include the following:

International Satellite Cloud Climatology Project (ISCCP). Since July 1983, ISCCP has been gathering a five-year global data set from four of the five geostationary and the U.S. polar orbiting satellites. These data will be used to generate a global data set of cloud parameters in order to improve the parameterization of clouds in climate models and to improve our understanding of the earth's radiation budget and hydrologic cycle.

NOAA is responsible for collecting and conducting initial processing of data from U. S. meteorological satellites as well as providing an archive for all ISCCP products. Conventional meteorological data sets are also provided by NOAA. NASA is responsible for analyzing and generating the final global cloud products at the Goddard Institute for Space Studies in New York. In addition to operational data processing, NASA supports the research component of ISCCP called FIRE (First ISCCP Regional Experiment) that seeks to understand cirrus and stratus cloud processes in order to improve their representation in climate models.

Tropical Ocean and Global Atmosphere (TOGA) Program. The overall objectives of the program have been defined as:

- To gain a description of the tropical oceans and global atmosphere as a time dependent system, in order to determine the extent to which this system is predictable on time scales of months to years and to understand the mechanisms and processes underlying the predictability.
- To study the feasibility of modeling the coupled ocean-atmosphere system for the purpose of predicting its variations on time scales of months to years.
- To provide the scientific background for designing an observing and data transmission system for operational prediction.

TOGA activities began in January 1985 and are planned to continue for 10 years. In 1986, emphasis continued to be placed on monitoring data-sparse areas of the tropical and southern hemisphere oceans, primarily the Pacific and Indian, where drifting and moored buoys, coastal and island meteorological stations and sea level stations were deployed.

International Satellite Land Surface Climatology Project (ISLSCP). The major objective of the International Satellite Land-Surface Climatology Project is to develop methodologies for deriving quantitative information concerning land surface climatological variables from satellite observations of the radiation reflected and emitted by the Earth. The set of variables that may be so inferred includes: 1) radiation parameters, 2) surface temperature, 3) vegetation properties, and 4) soil moisture. Such quantitative information is required to:

- Monitor global scale changes of the land surface caused by climatic fluctuations or by the activities of man himself, by producing continuous, validated global data sets of the relevant physical variables;
- Further develop mathematical models designed to predict or simulate climate on various time scales, including methodologies for assimilating the satellite-derived variables into the models for initialization and validation; and
- Permit inclusion of land-surface climatological variables in diagnostic and empirical studies of climatic variations.

It is anticipated that the research program, together with preparation of an international operations implementation plan for producing validated land surface variables routinely from satellite observations, will take approximately five years.

World Ocean Circulation Experiment (WOCE). WOCE is being planned as an attempt to describe and understand the general circulation of the world ocean, with emphasis on the relation of the ocean to climate on a decadal time scale. It will primarily consist of a field program that is designed to gather the necessary data to extend modern theory and numerical models. It will be the first large-scale oceanographic study of its kind involving a coordinated program of satellite measurements, in situ observations, and oceanic and climate modeling.

In 1986, the U. S. participated in international scientific planning activities. A status report was published. Four phenomenological meetings were held which addressed problems of interbasin exchange and marginal sea outflows, the study of gyre interactions, deep ocean circulation and its relation to topography and oceanic heat flux. A high precision satellite altimeter mission, called TOPEX, and essential to WOCE, was approved as a new start within NASA. WOCE is expected to begin in 1990 as a 10-year program.

Funding and Agency Roles

The Climate Program has some overlap with the meteorological programs reported in other sections of this Plan, especially with regard to observations. Those activities that cannot be uniquely or exclusively identified as "climate" may also be reported in the other sections of this Plan. As a result, "climate" funding cannot be simply added to the "meteorological" programs for a grand total since some activities overlap.

The distribution of funding for climate research and services for FY 1986 through FY 1988 is shown in Table 4.1 for each agency. Table 4.2 gives more detail showing the base program divided into the major categories of the National Climate Program. Table 4.3 gives an approximate breakdown of the money within the National Climate Program which is spent on international activities. Analysis of the FY 1988 projections shows no significant change from the previous year, although there is internal restructuring with an increase in climate research and a decrease in products and services from FY 1986.

In each of the areas several agencies may play key roles even though one is designated as a lead. For example in the case of greenhouse gases, DOE has organized a national plan, which addresses fundamental uncertainties of the effects of greenhouse gases on the atmosphere, NOAA provides basic observational data (including the Radiatively Important Trace Species program), NSF and NASA contribute basic research in aspects of the carbon cycle, and EPA is undertaking assessment studies to evaluate the effects of climatic change on society. In 1985-1986 $25 million was expended annually on this topic. Funding in FY 1987 will increase by $7.16M through appropriations to EPA to begin research and assessment studies in the fields of stratospheric ozone depletion and climatic change due to greenhouse gases. EPA is required by Congress to submit two reports by 1988 on these topics: the first report will examine environmental consequences of climatic change, the second will examine policy options to stabilize and reduce emission of greenhouse gases.

In other areas, new proposals by Federal agencies are being made. NSF's proposed activities in global geosciences and NASA's proposed activities in Earth System Science are building the scientific underpinning for many aspects of the NCP. These initiatives are consistent with the goals and objectives of the NCP as defined by the National Plan.

* *

TABLE 4.1 NATIONAL CLIMATE PROGRAM BUDGETS BY AGENCY
(Millions of Dollars)

Agency	FY 1986 Actual	FY 1987 Estimated	FY 1988 Projected
Agriculture	15.4	15.4	15.4
Commerce [1]	33.0	30.1	32.3
Defense [2]	18.5	13.0	13.0
Energy [3]	13.3	14.6	14.9
EPA [4]	0.3	9.5	3.8
Interior	1.0	1.0	1.0
NASA [5]	18.3	18.9	18.9
NSF [6]	38.5	44.5	51.8
NCPO	1.9	2.1	1.1
Totals	140.2	149.1	152.2

[1] Figures do not include ship support to maintain climate activities nor funding for NCPO.

[2] The FY 1986 amount reflected one-time equipment upgrade at ETAC (Asheville, NC) and Global Weather Central (Offutt AFB, NE).

[3] CO_2-greenhouse research of which DOE is lead agency is approximately $1 million less than the total for FY 1986-1988.

[4] Increases reflect new Congressional initiative in greenhouse gas assessment studies.

[5] Funds include $5.5 million for direct research and $12.1 million for maintenance of observational systems.

[6] Includes ship support for academic fleet, but not logistics for polar research.

TABLE 4.2 CLIMATE PROGRAM BUDGETS BY MAJOR CATEGORY AND AGENCY
(Millions of Dollars)

Category	Agency	FY 1986 Actual	FY 1987 Estimated	FY 1988 Projected
Responding to Climate Impacts	USDA	12.9	12.9	12.9
	DOC	0.2	0.1	0.1
	DOD	-	-	-
	DOE	11.4	0.5	1.0
	EPA	0.3	9.5	3.8
	DOI	0.1	0.1	0.1
	NASA	-	-	-
	NSF	1.7	1.7	1.7
	TOTAL	26.6	24.8	19.6
Climate Research	USDA	-	-	-
	DOC	22.0	20.6	23.0
	DOD	2.1	2.0	2.0
	DOE	0.7	12.9	12.6
	EPA	-	-	-
	DOI	0.9	0.9	0.9
	NASA	17.6	18.1	18.1
	NSF	36.7	42.7	50.0
	TOTAL	80.0	97.2	106.6
Providing Climate Products	USDA	2.5	2.5	2.5
	DOC	10.8	9.4	9.2
	DOD	16.4	11.0	11.0
	DOE	1.2	1.2	1.3
	EPA	-	-	-
	DOI	-	-	-
	NASA	0.7	0.8	0.8
	NSF	0.1	0.1	0.1
	TOTAL	31.7	25.0	24.9

TABLE 4.3 U. S. CONTRIBUTION TO ACTIVITIES OF THE
WORLD CLIMATE RESEARCH PROGRAM
(Millions of Dollars)

	FY 1986 Actual	FY 1987 Approved	FY 1988 Requested
DOC	5.6	6.0	3.0
NASA	3.5	5.3	5.0
NSF	6.5	10.9	14.8
TOTAL	15.6	22.2	22.8

SECTION 5

WORLD WEATHER PROGRAM

The Department of Commerce (DOC) was designated by the President, following Senate Concurrent Resolution 67 (1968), to be the lead agency in coordinating the U. S. participation in the World Weather Program (WWP), including the Global Atmospheric Research Program (GARP). Previous to 1983, DOC published a separate report on WWP Plans. Beginning with the 1983 edition of the Federal Plan for Meteorological Services and Supporting Research, this section on the WWP has been included and has obviated the need for a separate report. Activities related to the World Climate Research Program are reported in Section 4. Included at the end of this section are bilateral and regional international cooperative activities not under the WWP. This section was prepared by the Working Group for World Weather Program (WG/WWP) of the Committee for Basic Services within the Federal coordination mechanism.

GOALS AND ORGANIZATION OF THE WORLD WEATHER PROGRAM

The goals of the World Weather Program (WWP) are to extend the time, accuracy, range, and scope of weather prediction and to understand the physical basis of climate and of climatic changes. The ability of the United States and other nations to use their existing scientific capability to understand the climate and to increase their weather predicting skills is limited by the lack of global weather data. Available weather data is barely adequate over 20 percent of the earth while the remaining 80 percent, mostly over the oceans, remains inadequately observed.

Development of the technology and the systems to obtain these observations, especially over the oceans, presents formidable problems. However, with the use of satellites, aircraft, ships, radar, anchored and drifting buoys, and balloons, a system can be developed that will be able to observe and collect comprehensive daily data about the atmosphere of the entire globe. This system is too complex to be implemented by a single nation. This has been clearly recognized by the leaders of many nations whose international cooperation in meteorology has been a tradition for more than a century. The continuing need for international cooperation prompted the President of the United States to propose to the United Nations (UN) in 1961 the establishment of an international effort in weather prediction. The United Nations responded by calling upon the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) to develop measures to improve weather forecasting capabilities and to advance knowledge of the basic physical forces that determine climate.

The WMO, with 152 members, is a specialized agency created by the UN to facilitate international cooperation in the fields of meteorology and hydrology. The WMO responded to the UN request with the concept of the World Weather Watch (WWW), an operational system to bring the global atmosphere under improved surveillance and to provide for the rapid collection and exchange of weather data as well as for the dissemination of weather products from centralized processing centers. WMO and the ICSU clearly recognized the need for intensified research concerned with the physical processes governing atmospheric motion and their formulation in mathematical models. To meet this need, the WMO and ICSU established the Global Atmospheric Research Program (GARP).

In addition to WWW and GARP, DOC through the National Oceanic and Atmospheric Administration (NOAA) is involved in two other major cooperative international programs. These are the Sahel Agrometeorological and Hydrological Program and the Bangladesh Disaster Alert/Agro-Climatic/Environmental Monitoring Project. Funds for NOAA's participation and support of these programs are provided by the Department of State (DOS) Agency for International Development (AID).

The responsibilities of U. S. Federal agencies in the WWP follow:

Department of Commerce: Represents the U. S. at WMO and ICSU and provides the focal point (NOAA) to coordinate our nation's efforts in these international programs, implements those service improvements in the existing international weather system for which the U. S. accepts responsibility, and develops new technology as related to its responsibilities.

Department of State: Maintains relations with developing nations and through the WMO assists developing nations in improving their national weather services; and develops appropriate multilateral and bilateral arrangements to further international participation.

National Science Foundation: Stimulates and supports basic research by nongovernment scientists on atmospheric and ocean circulations and modeling. It also promotes the education and training of atmospheric and ocean scientists at universities.

Department of Defense: Although the mission of the Department of Defense (DOD) weather services is basically internal, the nature of DOD's operations is global. As such, the observation, telecommunication and data processing programs of the military weather services provide significant indirect support to the WWW through DOD's interface with NOAA's National Weather Service (NWS). Information from the research and development activities of these services is exchanged routinely with other similar national agencies and is often presented at national forums.

Department of Transportation: Through the U. S. Coast Guard, provides personnel to support the NOAA's National Data Buoy Center (NDBC) in developing, operating and evaluating data buoy systems. Coast Guard cutters and aircraft provide operational support to deploy, service, and retrieve buoys built for test or operational purposes. The observation and telecommunication programs of the Department of Transportation (DOT) also provide significant indirect support to the World Weather Watch through DOT's interface with NOAA's National Weather Service.

National Aeronautics and Space Administration: Performs research and develops space technology required for an effective global weather system.

THE WORLD WEATHER WATCH

The World Weather Watch (WWW) is an integrated system which functions on three levels: global, regional and national. The WWW is divided into three operational elements that are closely linked and interdependent: Global Observing System (GOS), Global Data Processing System (GDPS), and Global Telecommunication System (GTS).

These elements are supported by the Monitoring and Operational Information Service which provides up-to-date information on the status of the WWW. Additionally, the WWW Implementation Support Activity arranges for the exchange of knowledge and methodology, and assists Members in the planning, design, establishment, and operation of WWW facilities and services.

Global Observing System (GOS)

The GOS is a coordinated system of methods, techniques, and facilities for making weather observation on a worldwide scale. It is a composite system containing surface-based and space-based (satellite) subsystems. The main elements of the surface-based subsystem are:

- Regional basic synoptic networks, manned and automatic, for both surface and upper-air observations.
- Fixed sea stations, composed of ocean weather stations, fixed and anchored platform stations, island and coastal stations.
- Mobile sea stations, including moving ships and drifting buoys.
- Aircraft Meteorological Stations, including automated aircraft reporting systems.

Other elements are:

Aeronautical Meteorological Stations	Solar Radiation Stations
Research and Special Purpose Vessels	Atmospheric Detection Stations
Climatological Stations	Meteorological Rocket Stations
Agricultural Meteorological Stations	Ozone Stations
Weather Radar Stations	Background Pollution Stations
Meteorological Reconnaissance Aircraft	Tide Gauge Stations

The space-based subsystem (satellite) has become increasingly important in supporting meteorological and hydrological predictions and warnings. The following types of satellites constitute the space-based subsystem:

a. Near-polar-orbiting satellites operated by the United States and the Soviet Union. Both countries plan to have operational satellites in orbit throughout the period 1987-90. At present, the system is composed of the Soviet's METEOR/Model 12 and the United States' NOAA/TIROS-N model satellites.

b. Geostationary satellites at fixed positions over the equator. Their longitude and operators are: 140°E (Japan), 74°E (India), 70°E (USSR), 0°E (European Space Agency), 75°W (USA), 135°W (USA). A new U. S. geostationary satellite (GOES-H) was successfully launched into orbit for final positioning over the equator at 75°W and is expected to become operational by April 1, 1987.

Each system is composed of one or more satellites and a ground segment. The satellites provide meteorological imagery; vertical temperature and humidity profiles; observational data collection; and dissemination of weather information. The ground segment is composed of receiving and processing stations for satellite signals and data from Data Collection Platforms (DCPs). The ground segment also provides information and products for further distribution by the Global Telecommunication System (GTS).

The WWW is a flexible system which can be adapted to changing technology and operational conditions. The latest technological and scientific developments in observations, data processing, and telecommunications have been under constant review with an eye towards improving the GOS, GDPS and GTS. WMO identified a specific effort entitled the Integrated Systems Study (ISS) as one of the major activities of the World Weather Watch. The basic purpose of the ISS was to develop plans which would ensure a more complete implementation of the WWW plan. Results or recommendations of the ISS have been completed and are being incorporated into the WWW Plan for the next four years. Thus, the study has provided a realistic long-term plan for use by WMO Members in developing their national programs for future improvements of the WWW.

During 1984, progress was made in identifying the specific technological improvements that are possible for the late 1980's and early 1990's. Most significant was the identification of the ASDAR (Aircraft to Satellite Data Relay), ASAP (Automated Shipboard Aerological System), and drifting buoy systems as important contributors to improving the GOS in that time frame. The concept of the Operational World Weather Watch Systems Evaluation (OWSE) has also been developed as a framework for regional implementation and evaluation plans have been developed and approved. The OWSE North Atlantic was started in January 1987 and is expected to continue through the end of 1988.

The U. S. has agreed to undertake the development of a plan and evaluation of the feasibility of satellite sounding improvement techniques through the use of baseline upper air rawinsonde, rocketsonde and ASAP observing systems. The intention is to evaluate the quality of soundings calibrated during direct satellite overflight. If a better satellite sounding develops from this technique, then a global system will be implemented operationally through the WMO. Results are expected by the end of 1988.

Global Data Processing System (GDPS)

The purpose of the GDPS is to make available all processed information required for both real-time and non-real time applications. The GDPS produces products and processed information, based on recent advances in atmospheric science, using powerful numerical computer methods. Members, employing suitable transmission techniques through the GTS, have real-time access to GDPS products which allow the Members to benefit from their participation in the WWW. Access to information in the non-real-time mode allow an exchange of delayed information for the Members to meet their requirements for observational and processed information.

The GDPS is organized as a three-level system. It consists of World Meteorological Centers (WMCs) and Regional Meteorological Centers (RMCs) at the global and regional levels, respectively, and the National Meteorologicial Centers (NMCs) which carry out GDPS functions at the national level. In general, real-time functions of the system involve preprocessing of data, analysis and prognosis, including derivation of appropriate meteorological parameters. The non-real-time functions include data collection and archival, quality control, storage and retrieval, as well as cataloging of observational data and processed information for operational and special applications, and for research.

WMCs are located in Melbourne, Moscow and Washington; they provide products used for general short, medium and long-range weather forecasts. Melbourne specializes in forecast products for the Southern Hemisphere.

The RMCs are located at Algiers, Algeria; Antananarivo, Malagasy; Beijing, People's Republic of China; Bracknell, England; Brasilia, Brazil; Buenos Aires, Argentina; Cairo, Egypt; Dakar, Senegal; Darwin, Australia; Jeddah, Saudi Arabia; Khabarovsk, USSR; Lagos, Nigeria; Melbourne, Australia; Miami, USA; Montreal, Canada; Moscow, USSR; Nairobi, Kenya; New Delhi, India; Norrkoping, Sweden; Novosibirsk, USSR; Offenbach, Germany; Rome, Italy; Tashkent, USSR; Tokyo, Japan; Tunis, Tunisia; and Wellington, New Zealand. These centers provide regional products used for short and medium-range forecasting of small, meso and large-scale meteorological systems by WMCs. Products of RMCs can be used by Members at the national level for further processing or interpretation to provide assistance or service to users. The European Center for Medium Range Weather Forecasting (ECMWF) also prepares daily forecasts for its members for the 4-10 day range, and a limited number of its short range products are also available to the WWW.

Implementation of the World Area Forecast System has also progressed during 1986. In this system, two centers (Washington and London) designated by the International Civil Aviation Organization (ICAO) as world area forecast centers (WAFC's) issue upper wind and temperature forecasts of up to global coverage to associated regional area forecast centers (RAFC's). This information is redistributed as required to users within each regional center's service area. The regional centers also prepare and similarly distribute forecasts of weather elements defined by ICAO as significant weather. Washington and London WAFC's have both been implemented since 1984. These centers, both also designated by ICAO as RAFC's, have also functioned as RAFC's since 1984. RAFC's associated with WAFC Washington include Brasilia, Buenos Aires, Tokyo, Wellington, Melbourne, and (possibly) New Delhi. Of the latter, RAFC's Wellington, Tokyo and Melbourne (along with Washington) are implemented; the others are expected to be implemented in 1987 or 1988. RAFC's associated with WAFC London include Paris, Frankfurt, Moscow, Nairobi, Cairo, Las Palmas, and Dakar. Of the latter, Paris and Frankfurt (along with London) are implemented; the others are expected to be implemented in 1987 or 1988.

Global Telecommunication System (GTS)

The GTS was established to provide communication services for the collection, exchange and distribution of observational data and processed information from the WMCs and RMCs operating within the GDPS of the WWW, to meet the needs of Members for operational and research purposes which involve real-time or quasi-real-time exchange of information. The GTS also supports other WMO programs, joint programs with other international organizations, and environmental programs as decided by the WMO Congress.

The GTS is organized on three levels:

a. The Main Telecommunication Network (MTN);

b. The Regional Meteorological Telecommunication Networks (RMTN);

c. The National Meteorological Telecommunication Networks (NMTN).

The GTS is supported by telecommunication functions of the WMCs, Regional Telecommunications Hubs (RTHs), RMCs, and NMCs.

The MTN links the WMCs at Melbourne, Moscow, and Washington with the RTHs at Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Nairobi, New Delhi, Offenbach, Paris, Prague, Sofia, Tokyo, and Jeddah. The MTN provides a communication facility between the WMCs and designated RTHs. It ensures the rapid and reliable exchange of observational data and processed information required by the Members. During 1985, further progress was made in upgrading the speed of some of the MTN.

The RMTNs consist of an integrated system of links which interconnects RTHs, NMCs, and RMCs to WMCs. The RMTNs provide for the collection of observational data and the selective distribution of meteorological information to Members.

In summary, the GTS enables the NMCs to receive and distribute observational data and meteorological information to meet the requirements of Members.

Planned WWW activities for FY 1987 include:

- Implementation of major improvements in automating RTH's (Brasilia, Buenos Aires, Beijing).
- Improvement of the capacity of MTN links by inclusion of graphics (Washington-Tokyo-Melbourne).
- Implementation of upgraded regional networks.
- Continued support for the aircraft to satellite data relay system which will provide important observational data from selected aircraft operating in the tropics and over data-sparse areas.
- Implementation of data collection platforms to enhance the collection of meteorological data from upper air and surface observing sites.
- Continued implementation of satellite direct readout stations that are compatible with polar orbiting satellites and the WEFAX (weather facsimile) component of the geostationary satellites.

Voluntary Co-operation Program (VCP)

From the beginning of WWW, it was clear that all countries need better weather observations and improved communication systems. To help remedy deficiencies and to fully implement the WWW, the WMO established a Voluntary Assistance Program (VAP) in 1967. The name of the program was changed to Voluntary Co-operation Program (VCP) in 1979.

The WMO-VCP Program helps the developing countries to implement the WWW program by providing equipment, services, and long and short-term study fellowships. Since the inception of the VCP, this program has provided short-term fellowships in electronics, communications, operation and maintenance of weather data collection systems, electrolytic hydrogen generators, tropical meteorology, and river flood forecasting to students from 43 countries. Long-term fellowships, through which the students receive baccalaureate or Masters degrees, have been completed by candidates from 38 countries. Highest priorities are given to those facilities needed to support the global aspects of WWW. The goal of VCP is to eliminate deficiencies in global observations and communications and to establish ground-readout stations within range of satellite Automatic Picture Transmission (APT) stations so that the countries may benefit more fully from satellite weather data.

The U. S. has contributed annually $1.5 million to VCP from 1969 through 1976, $2.0 million annually from 1977 to 1979, and $2.3 million annually from 1980 through 1984. In 1985, the U. S. contribution was reduced to $1.89 million. The expected contribution for 1986 and 1987 is $2.0 million. Other nations have contributed approximately $2.0 million annually. Contributions have been in three categories: equipment and services (80 percent), financial contributions (about 10 percent), education and training (about 10 percent).

In preparation for the First GARP Global Experiment (FGGE), conducted from December 1978 through November 1979, the United States, under the VCP, offered assistance to some developing countries of Africa, Asia, Southwest Pacific, and Central and South America. This offer of support included 15 wind finding radars for obtaining observations of upper-level winds, and 24 Automatic Picture Transmission (APT) Systems that permit direct readout of satellite weather data used in operational forecasting and severe weather warning.

To assist developing nations improve the quality and reliability of their weather observing and communications programs, the United States, through WMO-VCP, provides technicians to nations in Central and South America to assist in installation and maintenance of observing and telecommunications equipment. VCP also provides short-term training programs for foreign nationals at the National Weather Service's (NWS) training facility in Kansas City, and long-term fellowships for more advanced training in meteorology leading to the Bachelor of Science degree at U. S. universities.

Planned VCP activities for FY 1987 include:

- Replacement and/or implementation of 11 APT/WEFAX satellite receiving systems mainly throughout the Caribbean, Central and South America to enhance local warning capabilities.

- o Implementation and updating of surface and upper-air observational programs in the tropics, the Southern Hemisphere, and Africa as resources and priorities permit.

- o Continued support for the implementation of VCP projects in Latin America and the Caribbean areas in support of the hurricane and tropical storm programs.

GLOBAL ATMOSPHERIC RESEARCH PROGRAM (GARP)

The goals of GARP are: 1) to improve the time, range, and accuracy of weather forecasts for periods of one day to several weeks; and 2) to obtain a better understanding of the physical basis for climate. The goals are to be met by conducting regional and global experiments to acquire relevant data; to process and analyze those data; and to develop physical-mathematical models in order to understand the large-scale physical processes in the troposphere and stratosphere that control weather and climate. The second goal of GARP has been separately developed into a program called the World Climate Research Program (WCRP). U. S. activities related to the WCRP are contained in the National Climate Program described in Section 4.

Base Program

GARP is an international effort under the cognizance of the United Nations' WMO and the ICSU. As stated earlier, the Department of Commerce (DOC) was to be the lead agency in coordinating the U. S.' participation in the WWP, including GARP. Subsequently, the National Climate Program (NCP) Act of 1978, P.L. 95-367, assigned lead responsibilities to the DOC for the NCP (see Section 4) which includes national and international activities organized under the World Climate Research Program (WCRP). Like GARP, the lead agency for coordinating and implementing the U. S. participation in the WCRP is NOAA.

Within the GARP there have been two basic types of observational experiments: (1) regional experiments which acquire data necessary to understand smaller scales of motion and their impact on the large-scale global circulation, and (2) a global experiment called the First GARP Global Experiment (FGGE), to understand global motions and circulation which determine the changes in weather over periods longer than a few days. On January 1, 1980, a new agreement between the WMO and the ICSU was implemented which established a World Climate Research Program (WCRP) as part of the World Climate Program (WCP). This program will build directly upon FGGE through extensive use of the FGGE data set and through activities which are applicable to both FGGE and WCRP. FGGE is also referred to as the Global Weather Experiment (GWE).

The economic gains to be realized from successful long-range weather and climate predictions will be substantial. Some of the activities that will benefit are:

- o Agriculture: Increased production of food and fibers; avoidance of unnecessary reseeding; fertilizing and spraying operations; improved timing of hay, grain and fruit harvests.

- Construction: Efficient scheduling of the work force; protection of materials and equipment at construction sites.

- Water Management and Conservation: Advance warning and, where possible, avoidance of flood damage; better scheduling for navigation; irrigation and hydropower generation; better use of public and rural water supply; and improved agricultural and industrial planning.

- Public Utilities (Electric and Gas): Improved energy efficiency through more accurate prediction of demands; and more efficient methods of facility repair, maintenance and replacement, and switchover.

- Transportation: More efficient routing and scheduling of air, highway, and water traffic; and decreased spoilage of perishable commodities in transit at terminals.

- Public Interest: More adequate planning to protect health and property; and better scheduling of activities, including recreation and vacations.

GARP Projects and Activities

GARP Atlantic Tropical Experiment (GATE) -- This was a major regional experiment of the GARP. This program was undertaken to understand the effects of tropical weather systems on large-scale circulations and to improve numerical modeling and prediction methods. Many GATE research projects have been successfully completed with NOAA and National Science Foundation (NSF) funding.

First GARP Global Experiment (FGGE) -- Held in 1979, FGGE was a year-long international effort to observe the earth's atmosphere in greater detail than ever before. It is not likely that an observing program of this magnitude will be held again in the foreseeable future. With the FGGE data, it is possible to see how well existing global dynamic models of the earth's atmosphere simulate large-scale atmospheric conditions. This is a necessary step in addressing the problem of climatic change. The formal international observing period covered a complete annual cycle and included detailed observations within the summer and winter monsoon regions of Asia under a FGGE subprogram called the Monsoon Experiment (MONEX). The formal observing period was preceded by a buildup period during which the satellites of several nations and various specialized observing systems were launched and tested as were various data processing systems and models. FGGE is now in the research phase.

The four basic objectives of FGGE are: (1) to improve our understanding of atmospheric dynamics and the general circulation of the atmosphere, and hence improve our ability to model those mechanisms responsible for the circulation; (2) to determine the theoretical and practical limits of atmospheric predictability; (3) to design an optimal, affordable observing system for the future; and (4) to improve models of climate change by fully and accurately simulating the annual cycle as observed over FGGE's Operational Year.

Major FGGE data management and archiving activities have been completed, and a NOAA, NASA and NSF supported comprehensive research program based on FGGE data continues in FY 1987. NSF support will continue through FY 1988.

Table 5.1 Funding of World Weather Program*
(Millions of Dollars)

U. S. Agency	Program	FY 1986 Actual	FY 1987 Approved	FY 1988 Requested
DOC	GARP	2.20	2.20	2.20
NSF	GARP	3.60	2.70	1.80
DOS/AID	WWW/VCP	1.72	2.00**	2.00
	TOTAL	7.52	6.90	6.00

*These funds are for "direct" support only. They do not include funds for agency programs that indirectly support the World Weather Program.
**Funding requested.

* *

Alpine Experiment (ALPEX) -- The last field experiment for GARP was the Alpine Experiment (ALPEX), an element of the GARP mountain subprogram. The key scientific objectives of this experiment for the U. S. are to determine the large scale effects of mountains on the atmosphere, the formation and dissipation processes of mountain winds, and the physical processes involved with the formation of cyclones on the downwind side of the mountain ranges.

The field phase of ALPEX was completed in the Spring of 1982. The ALPEX final data set was completed in 1985. The research phase will be supported through FY 1988.

The funding of the World Weather Program by U. S. agencies is shown in Table 5.1. Planned GARP activities for FY 1987-88:

- o NSF will continue to support research using MONEX, FGGE and ALPEX field data.

- o NOAA will continue to support research using FGGE data.

BILATERAL AND REGIONAL INTERNATIONAL COOPERATIVE PROGRAMS

Bangladesh Disaster Alert/Agro-Climatic/Environmental Monitoring Program

After a particularly severe typhoon caused hundreds of thousands of fatalities in the mid-1970s, the U. S. Agency for International Development (AID), responding to an urgent request from the Bangladesh Government, established the Interim Cyclone Warning System in 1978. This system primarily uses data from weather satellites. NOAA and NASA provided installation of a ground station and training to operate and maintain the system. The Bangladesh Government was able, for the first time, to track typhoons in the Bay of Bengal and to issue timely warnings of storms hitting populated areas.

The project was so successful and well managed by the Bangladesh Government that AID decided to upgrade the Bangladesh handling of satellite information. NASA and NOAA were commissioned to install high-resolution picture receiving equipment and to train Bangladesh technicians to operate and maintain the equipment. This was handled under the Bangladesh Disaster Alert Project. The equipment enables Bangladesh technicians to track and forecast tropical disturbances as well as to improve river and coastal flood detection and forecasting. This project was completed in 1982.

As an outgrowth of the Disaster Alert Project, a very ambitious project was adopted by the Bangladesh Government, AID, NOAA and NASA--the Agro-Climatic/Environmental Monitoring Project (ACEMP) for Bangladesh. It consists of a highly sophisticated system of data processors, remote sensing data collection platforms (DCPs), and a research facility that will enable Bangladesh to become a main remote-sensing center in Southeast Asia. Data from LANDSAT and meteorological satellites as well as hydrological and meteorological data from DCPs now enables the Bangladesh Government to improve the management of its natural resources. This project permits the preparation of a land use map and aids the development of an in-country resource management information system. The project allows estimation of acreage in agricultural production and yields of principal crops; completion of a forest resource inventory; and detection of river siltation and flooding. Meteorological and hydrological uses include detecting and forecasting typhoons, river and coastal flooding, winter cyclones, and squall lines.

The entire U. S. funding of $5,426,000 for the Bangladesh project was provided by DOS/AID. In FY 1987, AID plans to provide an additional $184,500 for training of Bangladesh scientists.

Accomplishments of the Bangladesh project during FY 1986 were:

- Continued training of Bangladesh scientists and technicians.

- Working with the Government of Bangladesh, the ACEMP system became operational in FY 1986.

Sahel Agrometeorological and Hydrological Program (AGRHYMET)

Subsequent to the severe drought which began in 1969 in the Sudano-Sahelian area of West Africa, which reached catastrophic proportions in 1972 and 1973, six countries (Chad, Mali, Mauritania, Niger, Senegal, and Burkina Faso) established a Permanent Inter-State Committee for Drought Control in the Sahel. Gambia and Cape Verde joined the Committee in 1974. The Ministers of these countries requested assistance of international organizations specializing in the study of problems relating to drought, including certain meteorological problems. The UN responded by directing its agencies to organize the necessary assistance. For this purpose, a mission (1974) involving the United Nations Development Program (UNDP), the Food and Agriculture Organization, and the WMO, defined in detail the needs of the eight countries and prepared a "Program for the Strengthening of the Agrometeorological and Hydrological Services of the Sahelian Countries and for the Establishment of a Center for Training and Applications of Agrometeorology/Operational Hydrology."

The objectives of the Program are to contribute to the social and economic development of the Sahel by:

- o Monitoring continuously and adequately the meteorological and hydrological conditions by means of modern observing networks;
- o Improving the understanding of these conditions and their variations in order to forecast them;
- o Applying this monitoring and understanding to human activities, and more particularly to agriculture and livestock rearing, with a view to increasing and regulating the production of the resources.

The program was developed to span 15 years and was divided into three phases of approximately five years each.

Phase I (1976-1981). A regional training and data processing center was established in Niamey, Niger, during Phase I. Also during this period, the program identified and began to fulfill the requirements to strengthen and modernize the national meteorological services. This was accomplished so that a fully functioning regional agrometeorological and hydrological information network could be developed during Phase II. AID contributed $6.3 million to Phase I, while other donors such as the UNDP and certain European countries provided approximately $20.3 million. Political unrest has delayed the implementation of AGRHYMET in Chad.

Phase II (1982-1987). The goal of Phase II has been to make the total system operational and capable of providing information to farmers, herders, planners and other users. This will be accomplished by: 1) completing the agrometeorological and hydrological observing and reporting network throughout the Sahel; 2) implementing the data processing and analysis equipment in all the national services; and 3) training Sahelians in equipment technology, data processing, agrometeorology, hydrology, and administration.

AID's contribution to Phase II is expected to be $7.7 million while the other donors, including the member countries, are expected to contribute an additional $59.6 million.

Phase III (1987-1991). The goal of the AGRHYMET program in Phase III is to implement the capabilities attained in Phase II by generating meteorological and hydrological products and forecasts and distributing them to the users in a timely fashion. AID's projected contribution and NOAA's participation in Phase III is undetermined at this time.

South Pacific Severe Storm Detection and Warning Project - Fiji

NOAA/NWS has undertaken a project on behalf of AID to provide Fiji with satellite equipment to improve the timeliness and accuracy of typhoon and tropical storm forecasts and warnings. The equipment, which includes antennas, receivers, and a computer, will enable the Fijian Meteorological Service to receive both GMS and GOES imagery and serve other computational needs. This project was completed early in FY 1987.

SECTION 6

SUMMARY OF FUNCTIONAL PLAN FOR AWIS

This section in successive years will summarize and update the various plans and activities by functional area that are being coordinated under the auspices of the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM). This year, only one functional area is included. Other areas will be covered in subsequent years and updates will be included for those areas previously included.

Two functional areas which are now receiving much attention are the Automated Weather Information Systems (AWIS) and automated surface weather observations. Both are fundamental and essential to the provision of weather services, and each is a component of the national and worldwide observing, processing, and distribution system for meteorology. The lead article (Section 1) is dedicated to automated surface weather observations; related coordinating activities are covered in a subsection of Section 2.

AUTOMATED WEATHER INFORMATION SYSTEMS (AWIS)

The Federal AWIS includes those functions which begin at the interfaces between the various observing systems and end at the interfaces between the various dissemination systems, but exclude the major processors in the operational processing centers (OPC). The OPCs include NOAA's National Meteorological Center (NMC), the Air Force's Air Force Global Weather Central (AFGWC), and the Navy's Fleet Numerical Oceanography Center (FNOC). Figure 6.1 illustrates the AWIS boundaries while Figure 6.2 shows how the AWISs and OPCs are interconnected by communications.

Agreements have been reached among NOAA, the Air Force, and the Navy for the operational processing centers to provide shared processing, mutual support, and cooperative backup to ensure that national and international commitments are met in order to provide for the safety, security, and well being of people and property. These agreements were developed through the efforts of the Working Group for Operational Processing Centers (WG/OPC).

The supercomputers in the OPCs, which are not part of the AWIS, process vast amounts of data from satellite and from worldwide sources. Output from these systems form the basis for virtually all meteorological and oceanographic forecast and mission oriented products beyond a few hours. The AWISs on the other hand are being designed to take information from the OPCs and from local sources and produce products and services which are tailored to agency missions which extend a few hours into the future. Public watches and warnings and products for tactical military operations are examples.

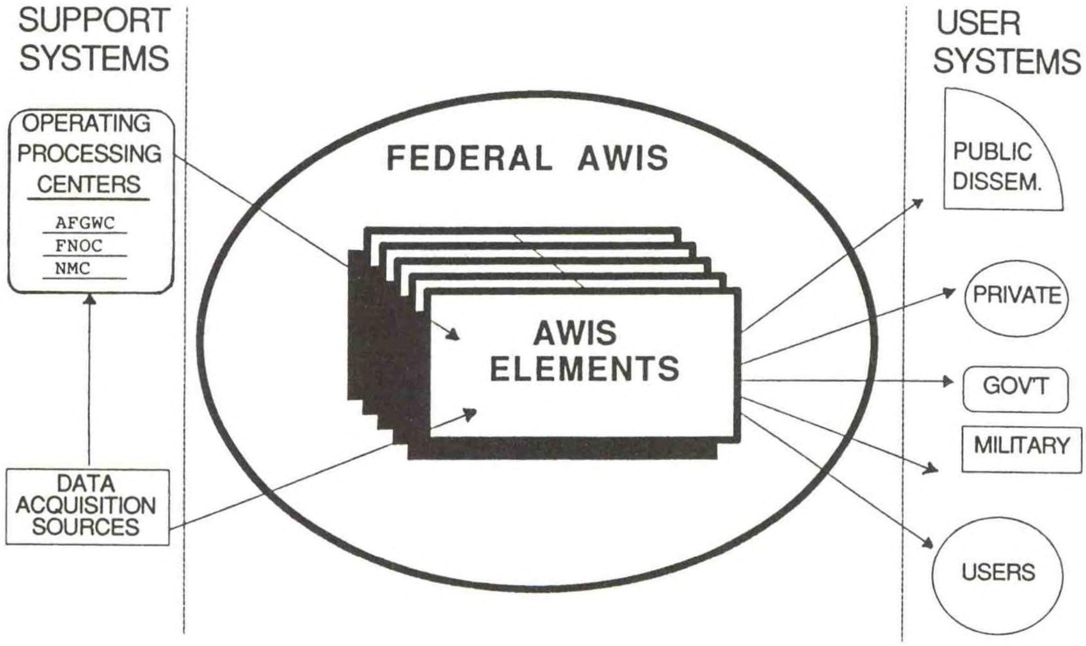


Figure 6.1. Boundaries of the Federal AWISs.

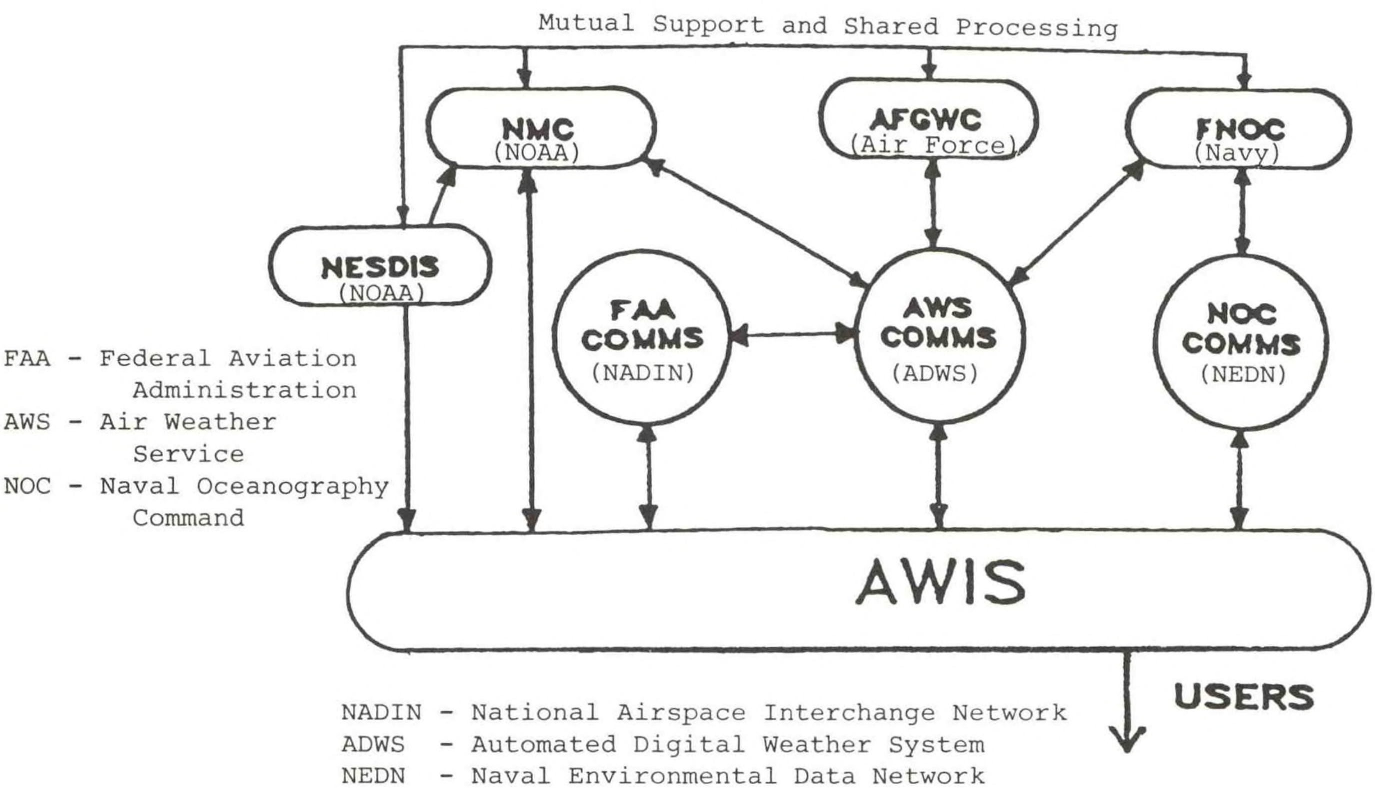


Figure 6.2. Communication Links Between the AWISs and the Operational Processing Centers (OPCs).

The AWISs are primarily interactive man-machine information and processing systems which allow people to manipulate data and information. They will be used primarily in field installations such as NOAA's Warning and Forecast Offices, USAF Air Bases, Army and Navy installations, and the Federal Aviation Administration's (FAA) Airways Control Facilities (ACF). Some AWISs will be located at military command levels as well as at the operational processing centers. Figure 6.3 shows the relationship among the departments and functional areas and gives the number of AWISs being procured by agency. The USAF number includes mobile systems required for tactical operations. The Navy's TESS (Tactical Environmental Support System) is not included because it is specially designed for shipboard installation and for use at sea and under combat conditions. Detailed descriptions and plans for these AWISs may be found in documentation in the respective agencies.

Statements of Need

New observing systems are coming on-line that will produce a substantial increase in volume of data that field personnel need to analyze and assimilate to produce mission tailored products. National centers will be producing new and improved products which are needed to support mesoscale work in the field and communication systems are being improved to deliver observations and products more rapidly to field personnel.

Field personnel cannot cope with this increase in volume of data and information in a timely manner to be responsive to users without the aid of computers and special software. Delays of minutes in producing warnings and forecast can be disastrous during tornado, flash flood, and wind shear conditions. The ability to assimilate nationally produced products with local data using expert systems tailored to the unique characteristics of the area and to the specific missions of the agencies involved is also needed to provide useful information to decision makers for planning resource protection. Without this ability, field personnel cannot increase lead time for users to take effective action that can help to reduce losses of assets and personnel. Additionally, these man-machine processing systems are needed for overall management of data in field operations. The following provide some detail beyond the general requirements just described.

AWIPS-90 (Advanced Weather Interactive Processing System for the 1990s). The National Weather Service requires this AWIS system primarily to provide general forecast and warning support to the U. S. Detailed warnings are provided for general dissemination for the public and more detailed warnings are provided in support of civil aviation and marine interests to meet domestic and international commitments.

SDHS-AWDS (Satellite Data Handling System and Automated Weather Distribution System). The U.S. Air Force's Air Weather Service requires this system to support a variety of real-time worldwide military activities. The systems are designed to meet very detailed and specific mission requirements which include tactical and strategic air and surface land operations for the Air Force and the Army. These operations include such detail as METWATCH for a single aircraft, missile and space shuttle operations, or an operational military unit. The AWDS system requirements also include pilot preflight and in-the-air briefings, flight clearance, NOTAMS (Notice to Airmen) and emergency response capabilities requiring mobile AWDS units.

	DOC/NWS	DOT/FAA	USAF/AWS	USN/NOC
ELEMENT	AWIPS	CWP	AWDS	NODDES
Operational Processing Centers	NMC	(NONE)	AFGWC via CFEP	FNOC
Install-ations	WFO	ACF	DoD Air Force Army	OCEAN CTRS. & STAFF HQTRS
Commun-ications	ACN	NADIN	ADWS	NEDN

CFEP - Communications Front End Processor
WFO - Warning and Forecast Office
ACF - Area Control Facility
ACN - AWIPS Communication Network
For other acronyms see Figure 6.2 or text

Figure 6.3 Relationships of AWISs by Functional Area

<u>NODDES/TESS</u> (Naval Oceanographic Data Distribution and Expansion System/Tactical Environmental Support System). The Navy requires these systems to support worldwide fleet operations. TESS is designed for shipboard use to meet stringent environmental and physical operational requirements of warships. Although meteorology is a key ingredient in TESS, oceanography and air-sea interaction are unique elements that the Navy requires of TESS to meet Navy tactical and strategic requirements. The NODDES is the land-based AWIS for the Navy to serve primarily Navy airfields.

<u>CWP</u> (Central Weather Processor). The Federal Aviation Administration requires this system to support real-time air traffic control. It provides National Airspace System (NAS) computers and air traffic control personnel severe weather information such as wind shear, icing, thunderstorm and lightning activity as well as general wind information for aircraft in flight. The CWP must also provide tailored information to provide effective and efficient management of air traffic flow nationwide to reduce the number of delays and to improve airspace use.

Current Status and Future Evolution

Each of the major AWISs is being developed within its own organization in order to meet unique mission requirements. The NWS and the FAA are working closely to ensure that their systems work effectively together. Coordination and cooperation is being effected through the Working Group for Automated Weather Information Systems (WG-AWIS) and under a high level AWIS Program Council which was established during 1986. Standards have been developed for data and information formats and for communication interfaces.

A draft Federal Plan for AWIS is now under development. It is a consolidated plan for the coordinated acquisition and operation of a functionally integrated Federal Automated Weather Information System (FAWIS). When completed, the FAWIS Plan will summarize and integrate agency plans for the acquisition and operation of FAWIS elements; will identify areas for interagency coordination, cooperation, and consolidation of activities in the acquisition and operation of FAWIS; and will assign organizational responsibilities and procedures to encourage and facilitate continued interagency coordination and cooperation. Figure 6.4 shows the Federal AWIS milestones.

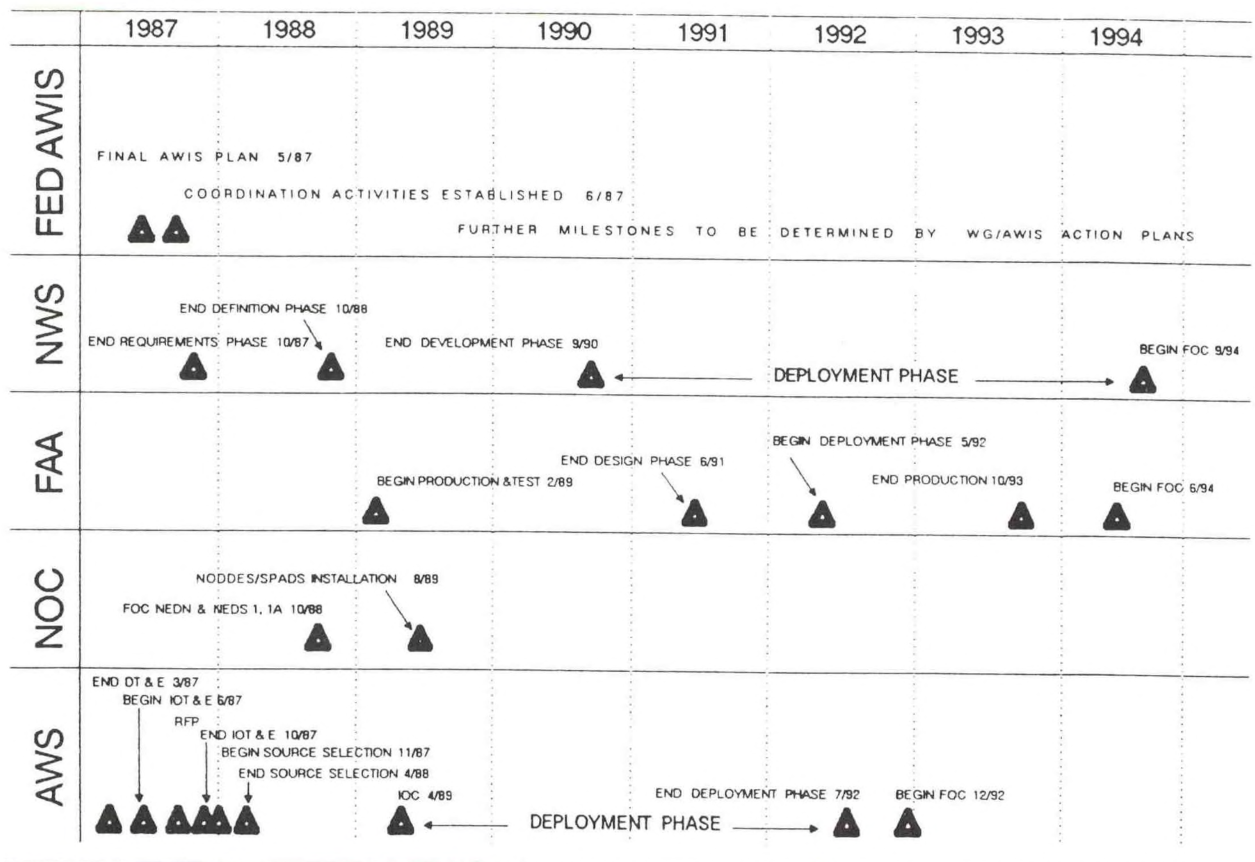


Figure 6.4 Federal AWIS Milestones

APPENDIX A

DEPARTMENT OF AGRICULTURE

Weather, through its effect on crop yields, is one of the most important factors influencing the Nation's total agricultural production. The Nation's food and fiber products which are critically important to our domestic and international economic situation, have taken on new dimensions in foreign affairs and national security. The recent shrinkage in export markets resulting from the substantial increase in global production of major commodities is having an adverse effect on the farm sector. The USDA conducts supporting research that focuses on understanding the interactions of weather and climate with plants and animals and assists the Department of Commerce in determining farmers' needs for weather information and in disseminating such information to them.

Historically, the Forest Service (FS) has collected meteorological data to assist the control of forest fires and the management of smoke from prescribed burning. However, other FS activities also need weather data to ensure sound management decisions. Therefore, a national weather program was established to coordinate all FS meteorological activities and to meet the increasing need for diverse weather information. The major objectives of the program are to: improve quality control of weather data, improve the design and operation of data collection networks, increase data recovery from the weather stations, and upgrade station maintenance. Meteorological data collected by manual weather stations and remote automated weather stations (RAWS) support research of weather effects on forestry management, forest fires, smoke management, visibility protection in Wilderness areas, and atmospheric deposition. A weather information management system and a library to archive all FS weather data is being considered.

The Soil Conservation Service (SCS) operates a network of 1400 manual snow courses and over 525 automated data collection sites in conjunction with a snow telemetry project (SNOTEL) for the western United States and Alaska. The primary objective of the project is to forecast streamflow for the coming spring runoff season. These measurements are made in cooperation with other federal, state and local agencies, power companies, irrigation companies, and the provincial Government of British Columbia.

Water supply forecasts help irrigators make the most effective use of available streamflow for achieving their agricultural production goals. Farmers who collectively irrigate more than 10 million acres of land in the western United States benefit from water supply forecasts. Other Federal agencies and private organizations also use water supply forecast information to help them carry out their missions. These forecasts also help the Federal Government in administering international water treaties.

Beginning in Fiscal Year 1987, SCS will implement a new 5-year initiative to upgrade the SNOTEL data collection system at a total cost of $5 million. This will include upgrading 510 data collection sites in the existing SNOTEL system with new state-of-the-art equipment. The data collection site upgrade will include replacement of snow pillows, transducers, damaged precipitation gages, antennas, towers, solar panels, batteries, temperature sensors, and deteriorated shelter houses.

Supporting Research

The mission of the USDA supporting research program is to develop and disseminate information and techniques to ensure an abundance of high-quality agricultural commodities and products while minimizing any adverse effects of agriculture on the environment.

The research efforts of the Agricultural Research Service (ARS) relate directly to the effects of climate on agricultural production and the natural resource base. They are directed toward developing technologies and systems for: 1) managing precipitation and solar energy for optimum crop production; 2) improving our understanding of water-plant-atmosphere interactions; 3) optimizing the use of energy, water, and agricultural chemicals; 4) reducing plant and livestock losses from pests and environmental stress; 5) developing improved techniques for irrigation and drainage; and 6) minimizing the adverse effects of climate and weather, including atmospheric contaminants, on agricultural production and the environment.

The Cooperative State Research Service (CSRS) coordinates research programs in the State agricultural experiment stations, the 1890 Land Grant institutions, and cooperating forestry schools. These institutions conduct a wide variety of research applicable to agriculture and forestry. Meteorological research in these institutions is practically all climatological. A large proportion of each State's program is consolidated into broad Regional Research Projects. Animals and plants are subjected to many climatic stresses and are therefore the focal point of much of this research.

Forest Service research includes efforts to: understand and control forest fire initiation by lightning; improve the translation of mid-range forecast elements to applicable forestry descriptions; incorporate drought information into fire management decision-making; and better describe how regional climatic variability affects the use of daily weather information by foresters.

Investigations by the National Agricultural Statistics Service (NASS) support domestic crop estimating programs for major commodities. Promising studies are underway to develop models relating weather parameters and associated variables to corn ear weight and wheat head weight. Results from previous efforts to develop models using weather variables to predict crop yield were disappointing. Evaluations of plant growth simulation models for short term forecasting have also had only limited success. Research will continue in this area with the expectation that the relationships between weather variables and crop yield will improve as better plant process models become available.

The NASS program to explore the use of satellite and weather data for assessing crop condition is continuing. A preliminary investigation of polar orbiting meteorological satellite data showed a strong relationship between crop condition and reflectance data as determined by the agreement between measured and forecast final corn and soybean yields. The crop condition assessment procedures, based on meteorological satellite data, are being automated and applications are being explored.

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

The National Oceanic and Atmospheric Administration (NOAA) is the principal meteorological agency of the Federal Government. By law, NOAA is responsible for reporting the weather of the United States and providing weather and flood warnings and forecasts to the general public, developing and furnishing applied weather services and recording the climate of the United States. This mission is carried out within NOAA by the National Weather Service (NWS), the National Environmental Satellite, Data and Information Service (NESDIS), the National Ocean Service (NOS), and the Office of Oceanic and Atmospheric Research (OAR).

NATIONAL WEATHER SERVICE

MISSION

The National Weather Service (NWS) has the principal responsibility for the plans and operations of the basic weather services and certain specific applied services. The basic mission of NWS is to help ensure the safety and welfare of the general public with respect to the effects of weather and to further the conduct of governmental and commercial activities which are affected by weather. In support of this mission, NWS:

- o Issues warnings and forecasts of weather, flood and ocean conditions.
- o Observes and reports the weather and the river and ocean conditions of the United States and its possessions.
- o Develops and operates national meteorological, hydrological, and oceanic service systems.
- o Performs applied meteorological and hydrological research.
- o Assists in developing community awareness and awareness materials for weather related natural disasters.
- o Participates in international meteorological activities, including the exchange, coding and monitoring of data and forecasts, and also including the installation and repair of meteorological equipment and systems overseas under the Voluntary Cooperation Program.

ENABLING LEGISLATION

The basic enabling legislation and authority for weather services are listed below:

- o Organic Act of 1890 created the U. S. Weather Bureau.

- o Enabling Act of 1919 allowed U. S. Weather Bureau to enter into cooperative agreements for providing agriculture weather services.

- o Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control.

- o Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for provision of weather observations and services to aviation.

- o OMB Circular A-62 established criteria for Federal coordination of meteorological services and supporting research.

SERVICES

NWS provides two broad types of services, (1) real-time operation-oriented services and (2) technical, advisory and other supporting services relating to meteorological and hydrological considerations.

The three principal real-time operational services are (1) the measurement and description of the meteorological and hydrological conditions that prevail; (2) the prediction of the future state of these conditions; and (3) the warnings of specific conditions that threaten life, property and the conduct of business.

To support the basic warning and forecast services, the weather observations include measurements of sky conditions, temperature, wind, wind gusts, precipitation, visibility, pressure, humidity, waves, tides, currents, ocean thermal features, river stages, and solar radiation, as well as descriptions of severe weather events such as tornadoes, hurricanes, thunderstorms, dust storms, blizzards, tsunamis, floods, and flash floods.

To support the applied services, additional measurements or observations are made where appropriate; e.g.,

- o Marine Weather: Coastal winds, waves, tides and currents, environmental hazards to navigation on the high seas, conditions for small craft operations, and ice and other factors affecting marine navigation.

- o Aviation Weather: Cloud ceilings and visibility, altimeter settings, and such significant enroute aviation hazards as aircraft icing and turbulence.

- o Agricultural Weather: Soil moisture and temperature, leaf wetness, sunshine and solar radiation, and evaporation. Although the Agricultural Weather Program will be terminated in FY 1988, several of these observations will be continued.

- o Fire Weather: Fuel moisture and local meteorological conditions affecting wildfire control.

The forecasting services involve the prediction of the future state of these same measurements for various time periods. The content of the forecasts is influenced by the interests and the requirements of the various groups of users. Forecasts are issued on a regular, recurring basis.

The warning services are keyed to the occurrence of specific events or conditions, critical to a broad or a specific set of interests. The familiar hurricane, tornado, flood, and winter storm warnings have broad impact on public and private operations. Other warnings involve critical interests to agriculture, forest protection, highways, inland waterways, and lakes; and to oceanic, marine, and aircraft operations. The warning services are provided at two levels of urgency, (1) the advice that conditions are favorable for the event or condition to occur and (2) the specific warning that it will occur or is occurring.

The additional advisory and supporting services of the NWS include:

- o Disaster awareness services.
- o U.S. interagency advice, coordination, and project management.
- o Assistance through the Voluntary Cooperation Program of the World Meteorological Organization (WMO).
- o International meteorological and hydrological advice and consultations.
- o NMC/Climate Analysis Center (CAC) provides current climate data, information, and analyses; makes monthly and seasonal temperature and precipitation forecasts; and monitors global and regional climate anomalies in support of agricultural, energy, and water resource users.

PRODUCTION AND DELIVERY OF SERVICES

The operational services of the NWS are provided by a tri-level field structure (Figure A.1). There are three national guidance centers, 52 Weather Service Forecast Offices (WSFO) and 13 River Forecast Centers (RFC) that have regional responsibilities for weather and hydrology services respectively and more than 280 facilities that provide local services.

National Centers

The National Meteorological Center (NMC) at Camp Springs, MD, provides large-scale regional, hemispheric, and global atmospheric forecasts based on the techniques of numerical weather prediction (objective methods), and develops associated forecast guidance (a blend of objective methods and subjective technique); these materials are delivered to domestic and to international users. The Center also provides analyses and forecasts of marine weather and oceanographic conditions. In addition, the Center provides monthly and seasonal outlooks, assessments of climatic conditions to users on a world-wide basis, and functions as a WMO World Meteorological Center.

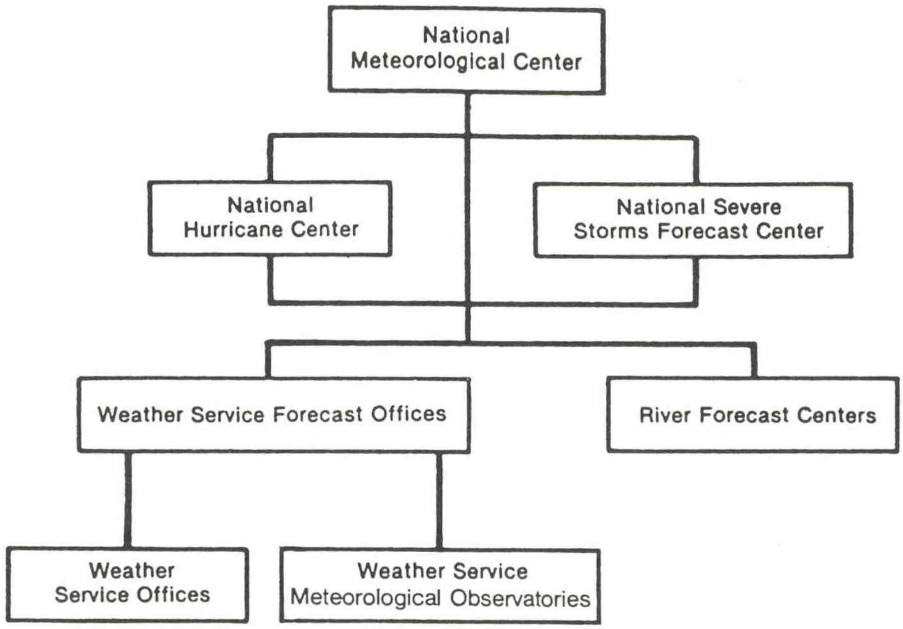


Figure A.1. NWS Field Structure for Technical Operations

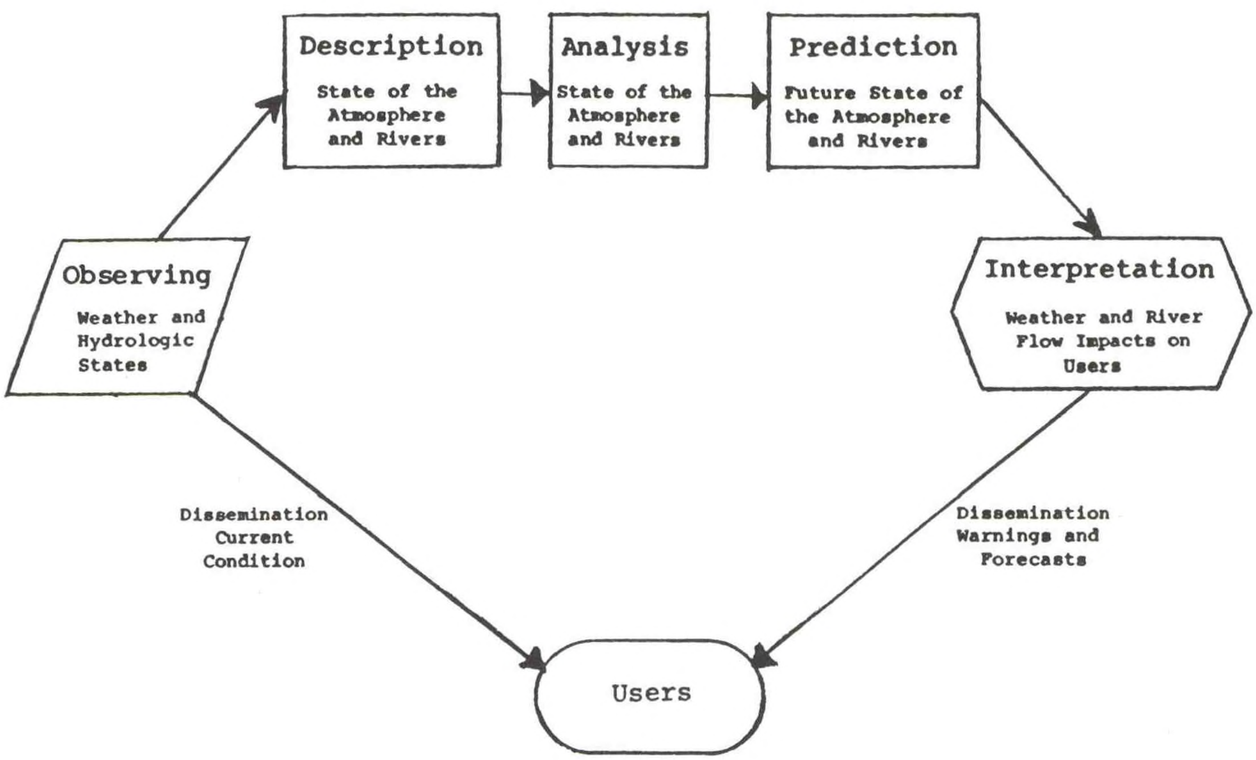


Figure A. 2. Weather Service Activities.

The National Hurricane Center (NHC) at Miami, FL, and two regional centers at San Francisco, CA, and at Honolulu, HI, prepare specialized forecasts, watches, warnings, and associated guidance for hurricanes and tropical storms.

The National Severe Storms Forecast Center (NSSFC) at Kansas City, MO, prepares specialized forecasts, watches, and guidance for tornadoes and severe thunderstorms. NSSFC's National Aviation Weather Advisory Unit provides aviation area forecasts as well as advisories to aircraft concerning potentially hazardous weather conditions on their route of flight.

Regional, Local, and Specialized Service Offices

Fifty-two WSFO's prepare and issue medium and small-scale forecasts, weather watches, and warnings; they also acquire meteorological data. There is essentially one WSFO per state.

The 231 local Weather Service Offices (WSO) issue small-scale forecasts and severe weather warnings; they also acquire and generate meteorological and hydrological data. There are 24 Weather Service Meteorological Observatories (WSMO), 25 Weather Service Contract Meteorological Observatories (WSCMO), and some 600 automated observing stations that acquire data.

Thirteen RFC's produce specialized river and flood level forecasts and guidance material. Each RFC covers a major national watershed or portion thereof involving several states. Fifty-two of the NWS meteorological field offices with designated hydrologic service area responsibility provide hydrologic services.

The 21 Center Weather Service Units and the Central Flow Weather Service Unit provide consultation and advice to air traffic controllers about weather conditions that may affect safe and efficient flight operations in the National Airspace System.

Four Ocean Service Units associated with WSFO's prepare regional marine weather and oceanographic products; they coordinate services with other coastal WSFO's.

Seven Satellite Field Services Stations associated with WSFO's and National Centers provide interpretive products and data distribution services to Federal and non-Federal users.

BASIC FUNCTIONS

The basic functions of the weather services consist of weather observing (data acquisition), warning and forecast preparation (analysis, prediction and interpretation), and dissemination.

The information flows from many individual sources to central facilities for analysis and the preparation of guidance, then, flows back out for increasing levels of interpretation and tailoring to specific locations and/or

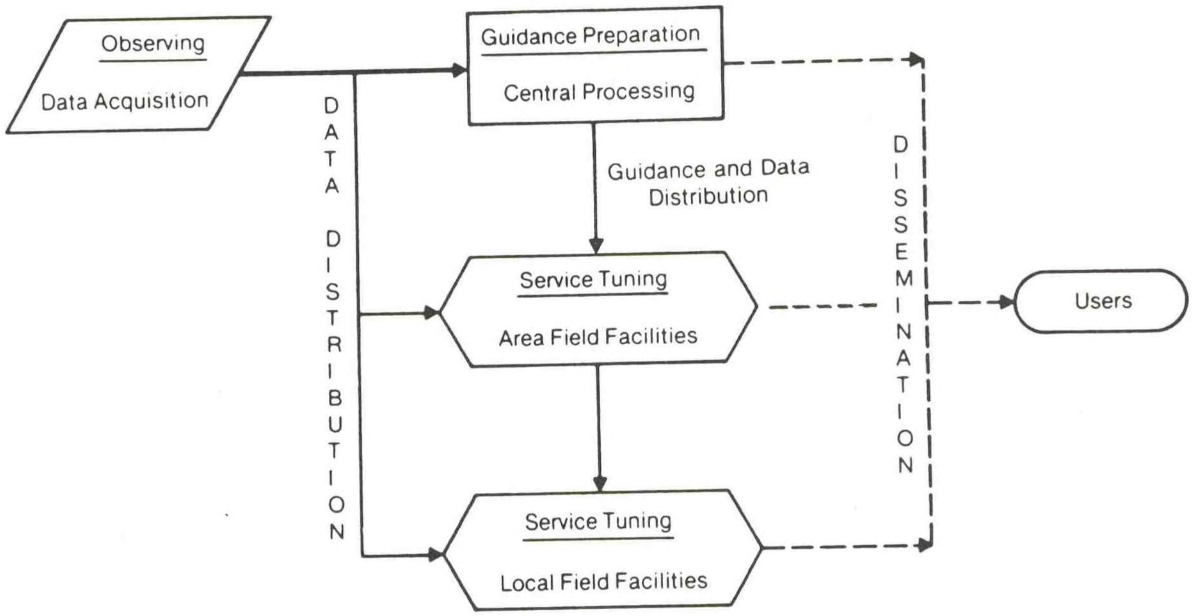


Figure A.3. Levels of Weather Service Functions.

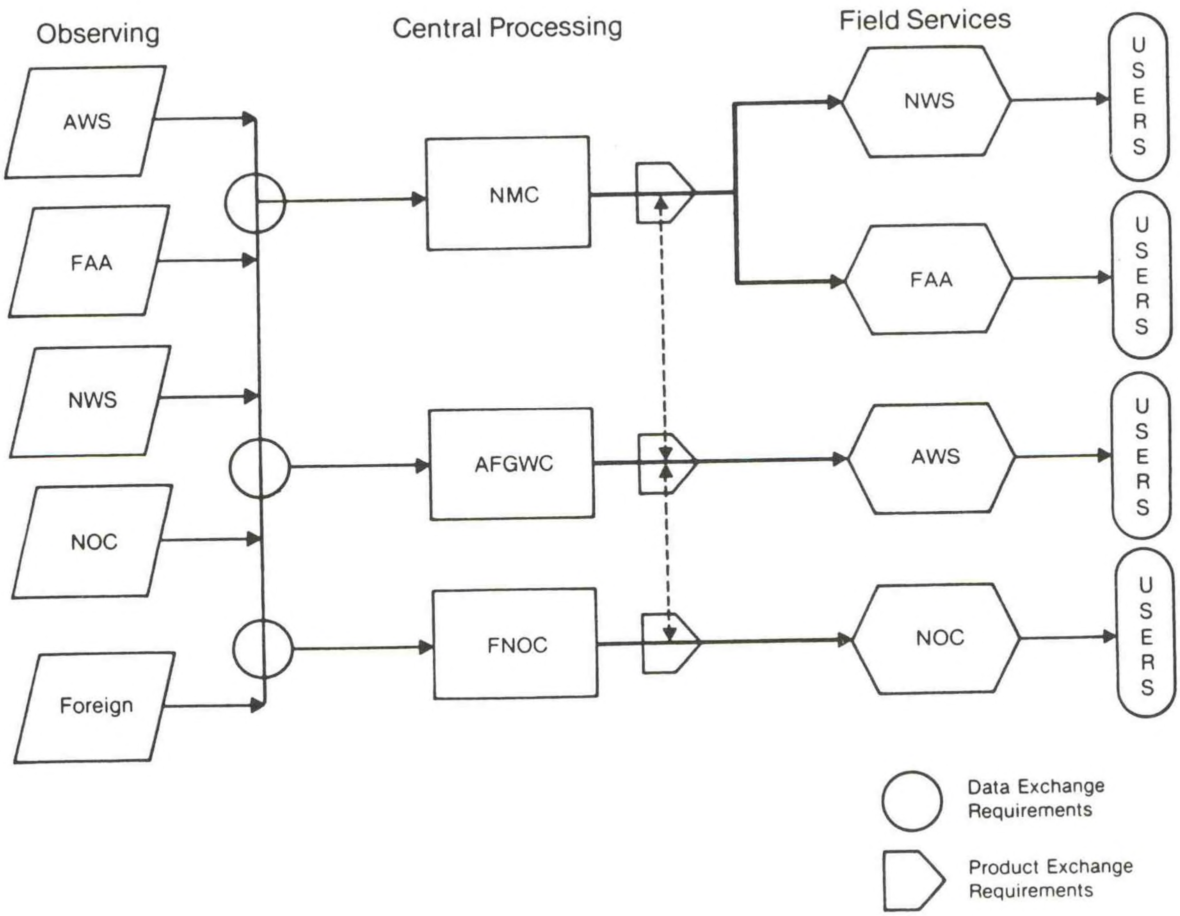


Figure A.4. Weather Service Interdependencies.

increasing levels of interpretation and tailoring to specific locations and/or applications (see Figure A.2). Figure A.3 illustrates the manner in which these functions are performed in the field operations structure.

The basic weather service relies on the cooperative efforts of several agencies of the U.S. Government and the weather services of foreign countries. Figure A.4 illustrates the key interdependencies of these agencies.

Data Acquisition

The production sequence begins with the acquisition of data on atmospheric, hydrological, and oceanographic conditions for the United States and large portions of the rest of the world. Most of the data are collected by the NWS, FAA, USCG, NESDIS, the Department of Defense, weather services of other nations, and cooperative observers (the latter including land, oil platform, and ship-borne cooperative observers). Some of these data come from the U.S. Army Corps of Engineers, the Soil Conservation Service, the Forest Service, the U.S. Geological Survey, the Bureau of Reclamation, and regional agencies such as the Tennessee Valley Authority and the Salt River Project.

There are more than 1,000 principal surface observation points nationwide, with about 400 sites providing 24-hour service. Schedules at other sites are predicated on established needs; e.g., flight schedules. Most NWS and FAA observations are manually acquired although NWS and FAA are in the process of installing automated meteorological observing systems at selected sites. Elements observed include cloud cover, temperature, dew point, wind speed and direction, atmospheric pressure, and precipitation type and amount. These principal sites are augmented by 11,000 land-based cooperative observers, who report daily temperature and precipitation amounts.

Many of these field stations also send balloon-borne meteorological instruments aloft to measure temperature, moisture, pressure, and wind to 29 km above the surface. A few rocket soundings reach 100 km. There are 126 observation sites within the United States and its territories, the Caribbean, Mexico, and Central and South America. Most sites take two upper-air soundings per day at the standard analysis times of 0000 GMT and 1200 GMT. These soundings are augmented by weather observations from aircraft in flight and from satellites.

Specifically designed NWS weather radars monitor the location, extent, intensity, and movement of such severe or hazardous weather conditions as hurricanes, tornadoes, severe thunderstorms, and intense winter snowstorms. Weather radars are also capable of quantitative estimates of rainfall amount over specific watersheds to aid the forecasting of river floods and flash floods. Over 120 weather radars are operated by NWS. These are augmented by about 90 weather radars operated by the Department of Defense. Of the NWS radars, 56 are staffed and operated continuously. NWS also makes weather observations from 24 FAA air traffic control radars in the mountainous regions of the west.

Polar-orbiting and geostationary environmental satellites collect large volumes of weather data in the visible, infrared, and microwave spectrums by radiometry. NESDIS operated weather satellites observe cloud cover, profile vertical temperature and humidity fields (soundings), measure sea surface temperature, portray sea and Great Lakes ice coverage, and provide data from which frost conditions, cloud tops, moisture (relative humidity) categories, and high altitude wind fields can be derived. They also collect and relay environmental data observed by remotely located sensing equipment.

Hydrologic data are collected at about 7,000 points nationwide. Measurements are made of river levels and precipitation amounts as input to prediction models that forecast river stages for over 3,000 points. About 15% of these data are obtained automatically through the GOES data distribution system and the Centralized Automatic Data Acquisition System. In addition, there are several hundred unofficial sources of river and rainfall data from communities and site-specific local networks.

NWS collects 90,000 to 95,000 marine surface weather observations monthly from cooperative weather observers aboard ships at sea worldwide. This program includes 49 countries that are recognized as contributers by the World Meteorological Organization (WMO). The U.S. Cooperative Ships Program is possibly the largest with over 1,600 ships in the program. There are 13 Port Meteorological Officers strategically located in U. S. ports to serve as liaison between NWS and the marine community. Thirty-five operational NOAA data buoys plus 12 other prototype or special purpose buoys provide hourly meteorological and sea state observations from critical nearshore and offshore locations. In addition, 39 automated stations in the Coastal Marine Automated Network (C-MAN) report weather conditions from selected coastal sites. These principal marine data programs are augmented by volunteer mariner reports relayed through cooperative private coastal radio stations.

Oceanographic data include "profiles" of deep ocean temperature and salinity which are based upon measurements made by U.S. Department of Defense, U. S. research vessels, and cooperating merchant marine ships. Sea-surface temperatures are observed and reported by NOAA data buoys and satellites, the U. S. Navy and American research vessels, as well as by ships-of-opportunity of many nations. Observations of tides, sea and swell are also observed and reported daily.

Forecast Preparation

The data are transmitted to all NWS organizations that have pertinent forecasting responsibilities. The organizations then process and analyze the data and use the results to prepare their respective outputs. These organizations include the WSFOs and the centers that have major responsibilities for preparing atmospheric, oceanographic, and/or climatic guidance. The WSFOs are responsible for issuing flash flood watches which are alerts to the possibility of short fused floods.

Preeminent among these organizations is the National Meteorological Center (NMC) which in many respects is the key to the NWS' analysis and forecast function. NMC has the responsibility for preparing coordinated large-scale forecasts over the entire globe and providing associated guidance for the United States and most of the remainder of the Northern Hemisphere, plus guidance for portions of the Southern Hemisphere. The Center produces a large number and variety of graphics and alphanumerics that describe both current and predicted conditions throughout these areas.

The current state of the atmosphere is depicted by 3- and 6-hourly pressure analyses at the surface, and 12-hourly analyses at selected levels above the surface. These products are produced by a mix of computerized numerical techniques (objective methods) and human interventions (subjective methods) and give the forecasters a generalized, three-dimensional picture of current weather conditions. In addition, analyses are prepared of oceanographic conditions for the Gulf of Mexico, the North American coastal areas, and portions of the North Atlantic and Pacific Oceans. Using these analyses, NMC then applies the techniques of numerical weather prediction to predict weather conditions for up to 10 days and dynamic oceanographic programs to predict marine phenomena in coastal and offshore waters.

NMC transmits these analyses and forecasts to NWS field offices throughout the Nation and to other users, both domestic and international, for the preparation of medium and small-scale forecasts. Thus, although NMC's products are primarily intended to guide public and private organizations in the preparation of medium and small-scale forecasts, virtually all of the Center's products become available to the public through NWS field offices. A few of the Center's products, however, are disseminated without change either directly by NMC or by other NWS facilities.

Medium and small-scale forecasting covers a less-than-national area, either a variable area determined by the current and future location of hurricanes, tornado systems or other specific phenomena or by a fixed area determined by river and stream drainage. Forecasts from NSSFC and NHC fall into the first category; those from the RFC's into the second. However, all share two common characteristics, (1) they forecast only specific meteorological/hydrological phenomena and (2) their products represent important guidance to the WSFO's even though the products typically go to some users without change.

The National Severe Storms Forecast Center (NSSFC) prepares and issues tornado and severe thunderstorm "watches", which are then disseminated to the public in the threatened areas. A watch is a public-oriented statement which indicates that meteorological conditions are favorable for the development of severe thunderstorms or tornadoes. The watch statement may include advice as to what precautions should be taken by the public to protect itself from these hazards. As opposed to a watch, a warning of severe thunderstorms or tornadoes must be issued by the NWS field facility having county warning responsibility when the event has been sighted or indicated by radar.

The National Hurricane Center (NHC) issues advisories, watches, and warnings describing the current and future location, intensity, and movement of hurricanes, other tropical storms, and associated coastal tides. These bulletins are considered final products and are issued either directly or through the WSFOs to the public and other interested groups without modification.

The River Forecast Centers (RFC) conduct analyses and prepare forecasts of river levels, stream flows, and flood stages to be expected in major national watersheds. They also provide runoff and snowmelt forecasts. RFC forecasts are normally disseminated to the public through the WSFOs without change. RFC's develop procedures for local flood warning systems used by over 1,000 communities to warn of impending floods, and provide WSFO's and WSO's with hydrologic guidance for use in preparing flash flood watches and warnings.

Building primarily upon the material provided by NMC, the 52 WSFO's prepare a large number of forecast products particularized in terms of area peculiarities and special user needs. These medium-scale forecasts often are issued directly to the public without further modification. A representative list of these products follows:

- State forecasts cover general weather conditions out to five days. Information includes expected amount of sunshine or cloudiness, precipitation, diurnal temperature variations and wind conditions.

- Zone forecasts are similar in content to state forecasts but are further restricted to an area generally comprising several counties or parishes and cover a period of two days.

- Recreational forecasts are similar to zone forecasts but are limited to public recreational areas, beaches, rivers and pleasure boating areas, skiing areas and so on.

- Aviation forecasts again represent a further subset of weather elements, so that the information applies to airport weather conditions and inflight weather.

- Marine forecasts focus on the coastal and offshore areas, the Great Lakes and high seas. They cover general weather conditions with specific emphasis on wind, wave, ice and coastal surf conditions.

- Fire weather forecasts provide the weather elements for use in fire management planning, forest and rangeland management activities, and wildfire control. These forecasts are often very localized, site-specific and time-specific in nature.

Small-scale forecasting involves the modification of medium-scale products so that they describe a specific locality, such as a city and its suburbs, an airport terminal, a national forest, a farming community, a local recreational area, and space launch and recovery areas. This process considers two different sets of variables: (1) topographic and climatological peculiarities, and (2) unique adaptation of the basic weather elements to make them site specific. Examples of the latter would include all weather and flood warnings.

Many small-scale public weather forecasts are made by meteorological technicians at the WSOs. These forecasts are frequently described as local adaptive forecasts; they are not original forecasts but rather an adaptation and localization of medium scale forecasts to meet local needs.

Communications and Dissemination

In addition to the above discipline-oriented functions, there are substantial functions required to support the interchange of data and products within the service, the dissemination of the services to users, and the management and maintenance of operations.

The internal NWS communications systems are in a transition stage. The use of most of the teletypewriter and facsimile circuits have been phased out, and the communication of both alphanumeric and graphic data is concentrated on the Automation of Field Operations and Services (AFOS) system. The AFOS consists of high-speed circuits (one for each NWS region) driven and interconnected by the Systems Monitoring and Coordination Center (SMCC). The AFOS became the primary communication system of the NWS in 1982. The implementation of the Remote Terminal to AFOS (RTA) in 1986 completed the NWS effort to replace FAA-controlled circuits used for internal NWS communications within the continental U.S.

External communications (i.e., communications to the non-NOAA users of weather information) involve a number of types of systems which are used to deliver weather services directly to the public, to private industry, and to other specialized groups via some intermediary organization. These include:

- Government-operated teletypewriter systems to commercial TV, cable television and radio stations; e.g., NOAA's Weather Wire Service.
- Direct radio broadcasts to the public through the NOAA Weather Radio system.
- Facsimile broadcasts to Government and non-Government users.
- Heavy-duty automatic telephone answering devices which are operated by telephone companies and which, directly, give the public weather information furnished by NWS stations.
- Direct NWS-to-the-public telephones, including automatic answering devices at NWS field offices and personalized services.
- Cooperative "Hotline" telephone answering services that provide users access to the latest hurricane advisories on a fee per call basis.
- Special interfaces to the communications systems of the agencies; e.g., FAA and Coast Guard networks, civil defense systems, and systems operated by private companies.

- A family of services for high volume data users accessed in Washington, D.C. Services include a Public Product Service channel, Domestic Data Service, International Data Service, and Numerical Product Service. The new services were first available in July 1983.

To a large extent, the success of the dissemination of services depends on the close cooperation among NWS, other government agencies and private enterprise. Dissemination to the general public is largely carried on by the news media. The NOAA Weather Wire Service, which is the chief interface to the media, is driven by the AFOS system.

TECHNICAL ASSISTANCE TO OTHER ORGANIZATIONS

Besides developing and issuing weather and hydrological reports, NWS provides a number of other services that essentially involve technical assistance, advice and consultation:

- Disaster preparedness assistance is designed to improve the response to forecasts and warnings by community officials and the public. It is carried out, within available resources, by WSO's and warning preparedness meteorologists assigned to WSFO's primarily in the eastern, midwestern and southern states. A Washington-based staff coordinates this program. The NWS effort is coordinated at all levels with the Federal Emergency Management Agency (FEMA) through a formal NOAA-FEMA Memorandum of Understanding.

- Technical hydrometeorological assistance is provided to Federal, state, and local agencies, and consulting engineers involved in water management. This involves the development of estimates of limiting rainfall amounts, probabilistic estimates of rainfall amounts and time and space distributions of rainfall associated with major storms.

- Support is provided to Regional Response Teams and on-scene coordinators during oil and hazardous substance spills in the form of spill trajectory forecasts and data on winds and seas in the spill area to assist clean-up operations.

- Marine outreach liaison is established with the marine community through state Sea Grant Marine Advisory Service programs.

- Comprehensive analyses of the meteorological factors associated with major historic storms are prepared for hurricane surge model development.

- NMC/CAC/Agricultural Weather Section serves as the NOAA component of the USDA/NOAA Joint Agricultural Weather Facility and provides advisory and information services in support of impact assessments of weather and climate on global agricultural production.

- The WSFO's and WSO's provide direct technical assistance to Federal, State, and local governmental agencies, educational institutions, and the news media, as well as to the general public on a local basis.

- Technical assistance is provided to communities in developing local self-help flash flood warning systems, nationwide.

- Technical assistance to Federal and State Forest and Land Management agencies is provided in the areas of training, observation, instrumentation, and site selection and in the evaluation of weather related developmental programs.

- The Voluntary Cooperation Program provides meteorological assistance to less developed countries.

- International meteorological and hydrologic advice, consultation, and assistance are available upon request.

- NWS supports the Department of Justice in weather-related litigation and provides certified weather records to the legal community.

- Climate services are offered by the Climate Analysis Center of NMC, WSFO's, WSO's, RFC's and AWSC's, in addition to that provided by the National Climatic Data Center of NESDIS.

APPLIED RESEARCH AND DEVELOPMENT

To ensure that the quality of NWS forecasts and services continues to improve and is in line with current state-of-the-art, applied research and development is being carried on in a number of areas within NWS.

Numerical Weather Prediction. The NMC conducts an ongoing program of research and development for improving day-to-day general forecasts, warning services, and medium-range forecasts (prediction out to 10 days) by placing the analysis and prediction system on a stronger scientific basis. The techniques numerical weather prediction, i.e., objective methods, design models that simulate atmospheric-oceanographic processes. These models are constantly improved as better techniques are developed for solving the underlying equations and as computer resources and advanced technology become available.

Forecast Techniques Development. In the design, development, test, and evaluation, the NMC focuses a significant amount of its research support on providing field forecasters with automated guidance on meteorologic (and by extension, hydrologic) events of immediate concern to the public and to users of specialized weather information, such as aviation, energy, and agriculture. Statistical techniques, as designed by the NWS' Office of Systems Development, are an integral part of this process.

Marine Products. The NMC conducts a program of research and development for oceanographic analysis and forecast guidance. The effort examines physical methods and numerical techniques appropriate to operational marine forecasting and develops numeric oceanographic models that produce the data sets required for the prediction of oceanic conditions along the North American coastal areas and offshore waters, and in the Gulf of Mexico.

Short-term Climate Fluctuations. Research and development are aimed toward improving the accuracy, extent, information content and lead time of seasonal outlooks. Diagnostic studies are being conducted of short-term regional and global climate fluctuations.

Hydrologic Research. Research efforts concentrate on improved hydrologic services by providing longer warning lead times for short-fused (flash flood) events; by making more accurate long-term forecasts of river flows for flood warnings and for water resources decision makers; and in support of these, through research in hydrometeorological data processing and analysis. Studies, augmented by research contracts, involve techniques for site specific small basin forecasts and area-wide flash flood risk assessments; integration of quantitative precipitation forecasts with runoff models; real time model updating; modeling snow melt processes; modeling complex river hydraulics including sedimentation and ice effects; dam break analyses; river flows through multiple reservoir systems; and extended streamflow prediction. Major work is underway to process, merge and quality control hydrometeorological data from multiple sources, especially concentrating on high resolution digital data from next generation radars.

Equipment Development. NWS conducts research to devise and develop new and improved techniques for measuring weather elements and provide new information systems to support the operations of the NWS National Centers and field offices. Meteorological instrumentation is being developed with a primary emphasis on automating the sensing and dissemination of the data. Integration of automatic sensing equipment with AFOS will allow for computer controlled collection and processing of observational data. Test and evaluation of weather equipment are conducted at Sterling, VA. This facility, which has the capability to simulate aspects of a typical weather station, conducts tests of equipment and procedures under a wide range of environmental and operational conditions. New buoy platforms and sensors for installation on existing platforms are developed and tested.

Specific Products. NWS also conducts ad hoc research and development to improve the quality and timeliness of forecasts and warnings issued to the public. Research and development are conducted in the Office of Systems Development, the Hydrologic Research Laboratory, the Regional Offices, the National Hurricane Center, the National Severe Storms Forecast Center, National Meteorological Center, River Forecast Centers, and many WSFOs to improve the forecasts of hurricanes, severe local storms, general weather, general flooding, flash floods, marine, and aviation weather conditions, using both dynamic and statistical techniques.

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

The National Environmental Satellite, Data and Information Service (NESDIS) manages U. S. Civil operational Earth-observing satellite systems, as well as global data bases for meteorology, oceanography, solid-earth geophysics, and solar-terrestrial sciences. From these sources it develops and provides environmental data and information products and services critical to the protection of life and property, the national economy, energy development and distribution, global food supplies, and the development and management of natural resources.

An agency of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), NESDIS was established December 1, 1982. It was formed by the merger of the former National Earth Satellite Service (NESS) and Environmental Data and Information Service (EDIS).

NESDIS currently operates polar-orbiting satellites that monitor daily weather and surface conditions over the globe. It also is responsible for operating two geostationary weather satellites that look, respectively, at the Atlantic Ocean and U. S. East and Gulf Coasts, and at the Pacific Ocean and West Coast. Currently there is only one operational satellite looking at the center of the U. S. and adjacent coastal waters.

The second major area of NESDIS responsibility is environmental data and information management and dissemination. NOAA gathers global data about the oceans, Earth, air, space, and Sun and their interactions to describe and predict the state of the physical environment. Many other agencies, organizations, and individuals, both domestic and foreign, collect similar data for particular uses and missions. Once the original collection purposes have been served, selected data flow to NESDIS data centers, which incorporate them into national environmental data bases that document the physical environment and its processes.

Environmental Satellite Services

SATELLITE OFFICES

The Office of Satellite Operations directs the operation of NOAA's environmental satellites and the acquisition of remotely sensed environmental data. It manages the Satellite Operations Control Center (SOCC) and Command and Data Acquisition (CDA) facilities that command and control, track, and acquire data from these Landsat satellites.

The Office of Satellite Data Processing and Distribution directs the operations of NESDIS central ground data processing facilities. It processes and distributes current weather satellite data and derived products to the National Weather Service and other domestic and foreign users. A system for the display and animation of satellite imagery from the GOES-TAP system is being installed in all National Weather Service Forecast Offices. The system, called the Satellite Weather Information System (SWIS), will automatically acquire, store, display, and animate GOES imagery and will superpose guidance products from the

National Meteorological Center with the imagery. Direct readout systems on NOAA's weather satellites enable users to receive, on relatively low-cost equipment, images and weather charts directly from the satellites.

National Weather Service's Satellite Field Services Stations (SFSSs) analyze, interpret, and distribute processed geostationary satellite products to regional National Weather Service offices and other Federal agencies. The products also are made available to private activities at their expense. SFSSs are located in Washington, D.C.; Miami, FL; Kansas City, MO; Honolulu, HI; San Francisco, CA; Anchorage, AK; and Slidell, LA. The Anchorage SFSS distributes data from both the polar-orbiting and geostationary systems. The San Francisco SFSS also has the capability of receiving data from the polar-orbiting satellite.

The Office of Research and Applications provides guidance and direction for NESDIS research and application activities. It coordinates the efforts of the Satellite Research Laboratory and Satellite Applications Laboratory. In addition, it assesses the requirements and goals of NESDIS research and applications programs, and evaluates their progress.

POLAR ORBITING SYSTEMS

The NOAA system of environmental polar-orbiting satellites replaced the ITOS system on July 15, 1979. TIROS N, the NASA prototype, was launched by the Atlas launch vehicle on October 13, 1978; and, NOAA 6, the first NOAA-funded operational satellite of this series, was launched on June 27, 1979. On February 27, 1981, TIROS N became inoperative when its power supply failed, causing complete loss of attitude control. On June 23, 1981, NOAA 7 was successfully launched, and it became operational August 24, 1981. On March 28, 1983, NOAA 8 was launched and became operational, replacing NOAA 6, on June 20, 1983. NOAA 8 failed on June 12, 1984. NOAA 9 was launched on December 12, 1984, and became fully operational on February 25, 1985. NOAA 6 was reinstated as marginal operational on July 2, 1984. NOAA-8 earth acquisition was recovered on May 10, 1985, and on July 1, 1985, replaced NOAA-6 as the operational descending spacecraft. Intermittent spacecraft clock problems again caused interruptions in service on September 7, 1985, and NOAA-6 was made operational on October 14, 1985. NOAA-10 was launched on September 17, and became fully operational in December 1986.

NOAA-funded satellites retain the NOAA name and are numbered consecutively beginning with the number immediately following that last used in the ITOS series. These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical models. They carry advanced instruments to provide improved temperature soundings and microwave channels to facilitate sounding retrieval in cloudy areas. They also provide advanced multichannel images and carry a data collection and platform location system. During the lifetime of the NOAA system, new instruments may be added or substituted for others. The first Advanced TIROS-N (ATN) satellite, NOAA 8, carries a search and rescue capability in addition to its standard instruments. NOAA 9 carries sensors to measure the earth's radiation budget and ozone.

NOAA spacecraft are five-sided, box-like structures that are 3.71 m long, 1.88 m in diameter, and 1,409 kg in weight, including expendables. NOAA 10 and 9 operate in near-polar, sun-synchronous orbits of 810 and 850 km, respectively, and provide environmental observations of the entire earth four times each day. NOAA 10 crosses the Equator in a southward direction at 0730 local time and NOAA 9 crosses the Equator in a northward direction at 1430 local time. NOAA 9 orbits at a somewhat higher altitude to avoid extended periods of readout conflict. The orbital period of the satellites is 101.58 minutes which produces 14.2 orbits per day.

The NOAA system satellites carry four primary instrument systems. The Advanced Very High Resolution Radiometer (AVHRR) provides data for real-time transmission to both Automatic Picture Transmission (APT) and High Resolution Picture Transmission (HRPT) users and for storage on the spacecraft tape recorders for later playback. Thus, the AVHRR instrument improves satellite services in stored and direct readout radiometer data for day and night cloud cover, sea-surface temperatures, and snow mapping. AVHRR readout is accomplished by the following:

- o Direct readout to ground stations of the APT class worldwide, at 4-km resolution, of the visible and infrared data. Panoramic distortion is removed.

- o Direct readout to ground stations of the HRPT class worldwide, at 1.1-km resolution, of all spectral channels.

- o Global onboard recording of 4-km resolution data from all spectral channels. Global area coverage for commanded readout for processing in the NOAA central computer facility at Suitland, MD.

- o Onboard recording of data from selected portions of each orbit at 1.1-km resolution of all spectral channels, with local area coverage for central processing and sea-surface temperature measurements.

The TIROS Operational Vertical Sounder (TOVS) system combines data from several complementary sounding instruments on the spacecraft. These instruments are the High Resolution Infrared Sounder (HRIS/2), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). The primary instrument providing tropospheric data, HRIS/2, is sensitive to energy from the visible to the carbon dioxide region of the infrared spectrum. This instrument is designed to provide data that permit calculation of temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere, and total ozone content. The SSU instrument, which is sensitive to energy in the carbon dioxide portion of the infrared spectrum, provides temperature information from the stratosphere. This instrument is provided by the Meteorological Office of the United Kingdom. The third instrument, the MSU, is sensitive to energy in the oxygen region of the microwave spectrum and will be used in conjunction with the two IR instruments. The microwave data permit computations to be made in the presence of clouds.

The Data Collection and Location System (DCLS) is provided by the Centre National d'Etudes Spatiales of Franceand is called the ARGOS DCLS. The ARGOS DCLS provides a means to locate and collect data from fixed and moving platforms. It provides two services not available in the geostationary meteorological satellite data collection system. First, it has the capability to determine platform location, using an inverse Doppler technique. Second, it is able to acquire data from any place in the world, but more particularly in the polar regions, beyond transmission range of the geostationary satellites.

The Space Environment Monitor (SEM) measures solar proton flux, alpha particle and electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitude. The three detectors included within this instrument are the Total Energy Detector, Medium Energy Proton and Electron Detector, and High Energy Proton and Alpha Detector. This instrument augments the measurements made by NOAA's geostationary satellites. The data from the SEM are processed at Suitland, MD, and transmitted over a dedicated data link to NOAA's Space Environment Laboratory at Boulder, CO, within one hour of the spacecraft readout. The NOAA system data, as well as the geostationary system data, are used to monitor the state of solar activity, which has a significant effect on terrestrial communications, electrical power distribution, and high-altitude aircraft flight.

In addition to the four primary instrument systems, NOAA 9 contains the Solar Backscatter Ultraviolet Radiometer and the Earth Radiation Budget Experiment. The Solar Backscatter Ultraviolet Radiometer (SBUV/2) is a nonscanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 micrometers to 400 micrometers. Data obtained from the instrument will be used to compute the amount and vertical distribution of ozone in the earth's atmosphere on the sunlit side of the earth.

The Earth Radiation Budget Experiment (ERBE) has two components. One is a nonscanner instrument with four earth viewing radiometers, two of which are wide angle (limb to limb of the Earth), while the other two are medium angle (10^{o} earth central angle). A fifth radiometer is a shuttered, sun-viewing monitor. The wide and medium angle radiometers each have a total channel (0.2 to 50 um), and a shortwave channel (0.2 to 5 um). The sun viewing radiometer measures the total solar spectrum (0.2 to 50 um). A second component of ERBE is a cross-track scanner instrument with three earth viewing radiometers having a 3^{o} by 4.5^{o} field-of-view. The spectral intervals of the radiometer are shortwave (0.2 to 5 um), longwave (5 to 50 um), and total (0.2 to 50 um).

NOAA 9 through I will carry the operational monitoring of atmospheric ozone, and NOAA 9 and G will contribute to experimental monitoring of the Earth's radiation budget. NOAA 8 and future polar satellites carry search and rescue (SAR) transponders, used to improve the detection and location of distress signals. This project is an international effort committed to global coverage for the search and rescue mission. The United States operates and maintains the SAR Mission Control Center and three ground stations. The ground stations receive Doppler signals directly from the satellite and process the information to provide the location of distress transmissions.

The ground system, required to receive large volumes of digital data from NOAA satellites, consists of two major subsystems--the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). The DACS includes components at the Wallops Island, VA, and Gilmore Creek, AK, Command and Data Acquisition (CDA) stations; the Satellite Operations Control Center (SOCC) at Suitland, MD.; and the Western European Station at Lannion, France. All the DPSS components are in the NOAA facility at Suitland.

DACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the DPSS processing and data handling facility. The delivery of NOAA system data from the CDAs to Suitland is accomplished by using the RCA American Communications, Inc., commercial satellite communications network. This system, which includes Earth Stations at Suitland, Wallops Island, and Gilmore Creek, delivers the data to SOCC. These data are immediately passed on to the DPSS subsystem for initial processing.

During three (occasionally four) sequential orbits, the spacecraft is out of range of both NOAA CDA stations. To eliminate the resultant time delay in the receipt of the high-priority sounding data during the "blind" period, a Western European readout station was established at Lannion, France. This station acquires stored sounding data and transmits it to the United States via the eastern GOES satellite located at 75°W.

The DPSS ingests the raw satellite data and preprocesses and stores them along with appended auxiliary information, such as Earth location and quality control parameters. Design of a new system to ingest and process the raw data was started in 1983. Initial installation of the new system took place in October 1984 with the final installation scheduled for December 1986.

GEOSTATIONARY SATELLITE PROGRAM

The geostationary satellite program began in 1966 as an operational experiment in which the imaging capability and weather broadcast system of the NASA Applications Technology Satellites 1 and 3 were used. This program became an operational reality following the launch of NASA's Synchronous Meteorological Satellites (SMS) 1 and 2 in 1974 and 1975. These satellites were the prototypes for NOAA's Geostationary Operational Environmental Satellites (GOES).

Since GOES 1 was launched on October 16, 1975, five more GOES satellites have been put into orbit. GOES 6, launched April 20, 1983, is the current operational geostationary satellite. GOES 5 failed prematurely on July 29, 1984, and since the next spacecraft will not be ready for launch until February 1987, the GOES 6 spacecraft alternates between a position of 98°W during the Atlantic hurricane season and 108°W during the winter storm season. The remaining satellites are providing limited operational support for data collection, weather facsimile services, and relay of data from the VISSR Atmospheric Sounder. The normal GOES System of two satellites consists of an Eastern (75°W) and Western (135°W) spacecraft, which provide repetitive viewing of the development and movement of destructive weather systems, such as thunderstorms, hurricanes and major midlatitude storms over much of North and South America and adjacent oceans.

The VISSR Atmospheric Sounder (VAS) is the principal instrument on the geostationary satellites starting with GOES 4. The VAS has both imaging and sounding capability. The VAS provides near-continuous cloud viewing with resolutions of 1, 2, 4 and 8 km in the visible wave lengths and 8 km and 16 km in the infrared wavelength. Full Earth disc pictures are available at 30-minute intervals throughout the day and night; partial disc pictures can be obtained at more frequent intervals to meet special requirements such as viewing development and movement of severe storms.

The concept of obtaining atmospheric soundings from geostationary satellites is being tested. GOES 6 is being used in an operational demonstration program to determine the capability of the VAS. Results have been excellent, and efforts are underway to develop a ground system to use the VAS data to improve NOAA's operational weather analysis and forecasting programs.The additional capabilities of the VAS are the multispectral imaging. The VAS has 12 infrared channels which are used to derive temperature and moisture profiles over selected areas. Sounding from a geostationary satellite affords several advantages over sounding from a polar-orbiting satellite. They are (1) constant surveillance, (2) constant viewing geometry, (3) better determination of temporal and spatial gradients, (4) easier comparison with radiosondes, and (5) synoptic large-area coverage.

The VAS demonstration program has resulted in a joint NOAA/NASA project called Centralized Storm Information System. Its future development and direction of operational meso-meteorological systems will be influenced by the outcome of the VAS experiment. The GOES also carry a Data Collection System which is used to collect and relay environmental data observed by a variety of remotely located platforms, such as river and tide gages, seismometers, buoys, ships, and automatic weather stations. These satellites re-broadcast imagery, meteorological analyses and other environmental data to remote locations using the weather facsimile (WEFAX) system. Also, data are collected for warnings of solar activity using the Space Environment Monitor. This instrument is similar to the SEM on board the NOAA series S/C and consists of a Magnetometer, a Solar X-Ray Telescope, and an energetic particle monitor.

Table A.1 shows the launch schedule for polar orbiting and geostationary satellites by NOAA.

SATELLITE COMMUNICATIONS SYSTEM (SATCOM)

The NESDIS Telecommunications System is a complex network of voice, teletype, and data grade transmissions sent via satellites, microwave, and terrestrial cable services.

A major component of the system is the Office of Satellite Operations which consists of the Satellite Operations Control Center (SOCC) and two Command and Data Acquisition Stations at Wallops, VA, and Gilmore Creek, AK. The Office of Satellite Operations is responsible for the operation and safety of NOAA polar and geostationary satellites and for providing satellite data to the Office of Data Services in Federal Building 4, Suitland, MD.

Another major component is the Central Data Distribution Facility (CDDF) at the World Weather Building in Camp Springs, MD. The CDDF is connected in turn with the Gilmore Creek CDA station, the seven Satellite Field Services Stations and with the NWS Weather Service Forecast Office at San Juan, PR. The Gilmore Creek CDA station also relays satellite data by land line and microwave circuits to the Anchorage SFSS and the NWS WSFOs at Anchorage and Fairbanks. The WSFO at Juneau, AK, receives satellite data from the Anchorage SFSS. By the end of FY 1983, SATCOM consisted of the following links:

TABLE A.1

PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM

Satellite Designator	Planned Launch Date*
NOAA H	CY 1987
NOAA D	CY 1988
NOAA I	CY 1990
NOAA J	CY 1991
NOAA K	CY 1992
NOAA L	CY 1993
NOAA M	CY 1995

Instruments for Advanced TIROS N Series

AVHRR	Advanced Very High Resolution Radiometer
SEM	Space Environment Monitor
SBUV	Solar Backscatter Ultraviolet Instrument (starting with NOAA F)
SAR	Search and Rescue Instrument (starting with NOAA E)
ERBI	Earth Radiation Budget Instrument (starting with NOAA F)
HIRS	High Resolution Infrared Radiation Sounder
SSU	Stratospheric Sounder Unit
MSU	Microwave Sounder Unit
DCS	ARGOS Data Collection System

GEOSTATIONARY SYSTEM

Satellite Designator	Planned Launch Date*
GOES H	CY 1987
GOES I	CY 1989
GOES J	CY 1990
GOES K	CY 1991
GOES L	CY 1994
GOES M	CY 1994

Instruments for GOES Series

SEM	Space Environment Monitor
DCS	Data Collection System
VAS	VISSR Atmospheric Sounder
SAR	Search and Rescue (starting with GOES I)

*Launch date depends on performance of prior spacecraft.

- The Wallops Island CDA station preprocesses and calibrates the "raw" GOES data. These data are retransmitted to the satellite which transponds the data to the Federal Office Building #4 (FOB4) facility at Suitland, MD.

- Two full-duplex circuits for delivery of stretched VAS data from FOB4 to the World Weather Building (WWB) at Camp Springs, MD (2.11 Mbps).

- Two full-duplex, voice-grade satellite and terrestrial data circuits connecting CDDF with the Anchorage SFSS and the Gilmore Creek CDA station for facsimile.

- Eighteen full-duplex circuits connect the computer facsimile outputs at the CDDF to the SFSSs. At the SFSSs, a total of about 250 "GOES-TAP" customer circuits relay the facsimile to nationwide locations. Several hundred other customers receive the facsimile over circuits that connect to the "GOES-TAP" customer circuits.

- Three full-duplex circuits from the Suitland FOB4 computer to the Wallops Island CDA station to transmit WEFAX information for GOES East, Central, and West Satellites.

- Two full-duplex, voice-grade circuits conditioned for digital transmission from the Wallops Island CDA station to WWB for relay of GOES Data Collection System (DCS) information.

- Additional digitally conditioned circuits, dedicated and dial-up, for delivery of DCS information from WWB to a multitude of users.

- A voice network connecting all SFSSs, CDDF, FOB4 and Wallops Island CDA.

- Two digitally conditioned voice-grade circuits between FOB4 and WWB for transmitting temperature sounding data used for interactive processing.

- Five voice-grade full-duplex circuits from Wallops Island CDA to WWB (two circuits), Kansas City SFSS (two circuits), and Miami SFSS (one circuit) for transmitting full disc east and west GOES IR data.

- One full duplex circuit for the transmission of facsimile data to Owings Mills, MD, for the "AM Weather" television program.

- Two C-2 conditioned circuits for the transmission of time code information from Goddard Space Flight Center to the CDDF and SOCC.

- Four full duplex circuits for the transmission of polar-orbiter facsimile from FOB4 to the CDDF and GOES data in the opposite direction.

- GMS WEFAX is transmitted to the CDDF on the duplex side of a circuit to the Honolulu SFSS.

- Meteosat WEFAX is downlinked at CDDF from an antenna located on the WWB.

- One 50-line multipoint voice coordination and monitoring network at Suitland for control and integration of launch activities.

- One 15-line multipoint voice coordination and monitoring network at Suitland for control and integration of launch activities.

- Two 100 WPM multipoint teletypewriter circuits connecting various elements of the satellite telecommunications network.

- Two 1.33 Mbps simplex satellite circuits for relay of NOAA system data from the two CDA stations to Suitland, MD, and to the RCA Ground Receiving Station at Offutt Air Force Base, Omaha, NE.

- Four alternate 9,600 Hz data/teletype and voice full duplex satellite and terrestrial circuits between the two CDA stations and Suitland, MD, to relay real-time NOAA system data, to transmit command and control functions to the NOAA spacecraft, and to provide alternate routing and backup for NOAA teletype and voice communications.

- Two full-duplex combination teletype and voice satellite and terrestrial circuits between the two CDA stations and Suitland, MD, for coordination of NOAA operations.

- Two simplex C-5 conditioned data facsimile circuits between the Wallops CDA station and Suitland, MD, for the relay of sectorized NOAA HRPT data.

- One simplex 48 kHz link from Wallops Island to Suitland shared with 36.2 kbps NOAA system Lannion (France) data to SOCC/DPSS and 43.7 kbps 4x4 IR GOES VAS data (4X4 mile resolution) to DPSS.

- One 9,600 bps full-duplex link between SOCC and NASCOM/GSFC for NOAA system launch support and spacecraft anomaly investigation.

- One 7,200 bps simplex link from NASCOM/GSFC to SOCC for NOAA system launch support and spacecraft anomaly data separation.

- Four voice circuits between NASCOM/GSFC and SOCC for NOAA and GOES launch operations and spacecraft anomalies; also, used for spacecraft backup support operations.

RESEARCH PROGRAM FOR FY 1988

Research and applications with environmental satellite data, in FY 1988 will be devoted to the improvement of and advanced technique development for quantitative and qualitative products and services that serve national and international programs in weather analysis and forecasting; climate diagnosis; and other programs for agriculture, fisheries management, energy; and other weather, land and environmental applications. The data from current NOAA operational satellites in polar and geosynchronous orbits, as well as research satellites operated by other nations and by NASA will be used to develop improved techniques and algorithms for the derivation of the global, three-dimensional structure of atmospheric temperature and moisture that is essential for numerical weather analysis and forecasting.

The study and application of the near continuous stream of data available from the visible and infrared imagery, and the multispectral imagery and soundings from the geostationary environmental satellites, will help to understand the life cycle of severe storms and the morphology end evolution of the mesoscale meteorological systems within which they form. The cooperative program of NOAA's Prototype Regional Observing and Forecasting System (PROFS) will continue to study the use of satellite data as a a tool for operational forecasting centers to apply to the problems of short term warnings of severe thunderstorms, tornadoes, and hurricanes.

Climate analysis, diagnosis, and monitoring performed at the National Meteorological Center's Climate Analysis Center rely upon satellite observations of the earth-atmosphere budget of incoming and outgoing radiation. Knowledge of the "radiation budget" of the earth-atmosphere system is essential for renewed national and international research efforts for assessing global changes in the Earth's environment and its climate. Research with satellite data is particularly useful in understanding the effects of clouds as regulators of incoming and outgoing radiation.

Research will continue towards the improvement of the derivation of sea surface temperature for climate diagnosis and other applications. The availability of multispectral data from passive microwave sensors on the Defense meteorological satellites and the continued improvement of infrared techniques will further this work. The data from NASA's Coastal Zone Color Scanner will continue to be studied for relating the biological interpretation of the color spectra to NOAA's fisheries' responsibilities.

Applications oriented research efforts are greatly assisted by the use of interactive data processing and display systems which permit the rapid presentation and manipulation of multiple sources of data. Applications research will continue in improving techniques to estimate the amounts and global distributions of atmospheric aerosols, the effects of aerosols on climate, and on other satellite measurements. Methods for estimating precipitation from satellite data is important for flash flood forecasts on the local scale, and precipitation is important to the understanding of the effects of latent heat release on the global scale for use in numerical weather forecasts and numerical climate modeling. Other parameters such as solar insolation reaching the ground and parameters important to the study of geology, geography, and hydrology, are the subject of continuing research using satellite data from multiple national and international sources.

The expertise resident with the scientists at NESDIS will be called upon to provide scientific advice on future sensors and information processing systems as next-generation environmental satellites are proposed for development.

Environmental Data Bases

NATIONAL CLIMATIC DATA CENTER

The National Climatic Data Center (NCDC) holds the baseline climatic data for the United States and is the largest climatic data center in the world. Receiving more than 300 million observations annually from a global network of meteorological and climatological stations, plus a continual stream of data from NOAA's environmental satellites, NCDC processes, publishes, and studies these data to assess climatic trends, changes, and variabilities. This information is then used by Government, industry, and private interests in decision making, resource management, and long-term planning. Each year, more than 135,000 requesters and subscribers are provided over two million copies of climatological bulletins, copies of original records, satellite photographs, and thousands of magnetic tapes containing digital data and information.

The NCDC interacts with other NOAA components and many Federal agencies. These interactions serve to reduce duplication of effort, plan up-front for potential retrospective data uses, prevent data formatting pitfalls, recommend unique data sources for problem solving, suggest new approaches to the study of environmental concerns, and coordinate special applied studies.

Other interactions include the study, analyses, and publication of information on climate change and varability in cooperation with DOE carbon dioxide research; application of climatological data in air and water pollution studies for EPA; drought indices and crop growth measurement with Department of Agriculture; analysis of the marine environment and publication of marine atlases with DOD; work to provide ground truth information to verify NASA satellite sensor measurements; and studies on the impact of population shift in relation to energy consumption for DOE and OMB. These examples indicate the variety and types of interagency efforts undertaken by the NCDC. They should not be construed as being all-inclusive, nor should it be assumed that the Center's involvement is limited to these particular areas.

For FY 1988, the NCDC expects to continue the basic programs and coordination of efforts with other agencies. Planned activities include:

- o Development of Volume I, National Climate Information System;
- o Establish Climate Computer (CLICOM) in developing countries;
- o Work with NWS to ensure data management for NEXRAD, PROFILER, ASOS, etc.;
- o Participate in organization of an International Workshop on Climate Indices;
- o Install GOES data handling on GOES Archive and Retrieval System;
- o In conjunction with NWS, ensure integrity of data from new on-site observing or processing systems such as the Automatic Radio Theodolite, Microcomputer Aided Paperless Surface Observation, and the max/min thermometer.

NATIONAL OCEANOGRAPHIC DATA CENTER

The National Oceanographic Data Center (NODC) supports climatic services and research through its ocean data management and data service activities. The NODC is engaged in providing data management, for example, to major climate-related studies such as the Tropical Ocean and Global Atmosphere (TOGA) program. In addition the NODC provides data products and services individually to researchers and members of the operational marine community (e.g., the Navy, Coast Guard, shipping industry, fishermen). Although the NODC has traditionally served as a facility for retrospective, in situ data, the requirements of many projects and users for faster ocean data access has necessitated that NODC begin to handle certain types of near-real-time data, as well as ocean satellite data. To meet the new demands being placed on it, the NODC is upgrading its technological capabilities.

Data Management

A principal goal of the TOGA program is better understanding of ocean-atmosphere dynamics in the tropical Pacific (Figure A.5). The NODC provides data management for TOGA through an innovative, cooperative venture with the Scripps Institution of Oceanography (SIO). In FY 1987 the NODC and Scripps established a Joint Environmental Data Analysis (JEDA) Center for TOGA subsurface thermal data from the tropical Pacific. NODC acquires, tracks, and provides initial quality control for these data; Scripps provides further quality control by generating analytical TOGA data products (Figure A.6). By FY 1988 this TOGA data management system will be well along in meeting its goals of: (1) speeding data acquistion and processing, (2) making data available more frequently (monthly), and (3) improving data/data product quality by engaging the expertise of the scientific community (here represented by Scripps) in this task. At the end of 1986 NODC's TOGA Pacific data base held 20,287 temperature profile observations.

NODC continues to maintain close contact and participate in planning for other global climate programs such as the World Ocean Circulation Experiment (WOCE) and the Global Ocean Flux Study (GOFS). NODC anticipates providing WOCE with data management support analogous to its TOGA effort; NODC's future role in GOFS remains to be defined. In FY 1987 NODC will wrap up its data management activities for the SEQUAL (Seasonal Response of the Equatorial Atlantic) program, which was a prelude to TOGA. By 1988 the NODC expects to establish joint data management centers with other institutions for other types of data (e.g., sea level data) crucial to the new global ocean programs.

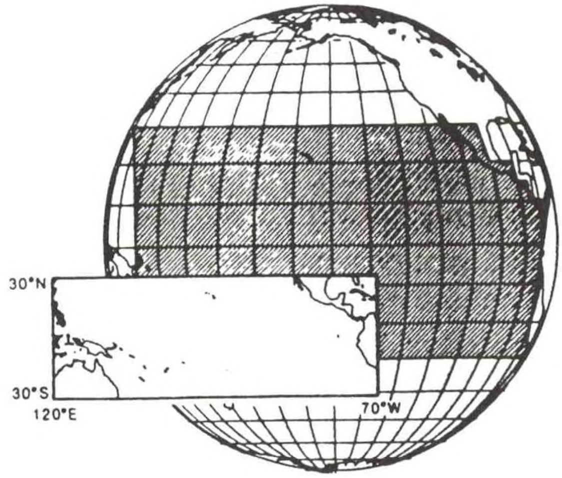
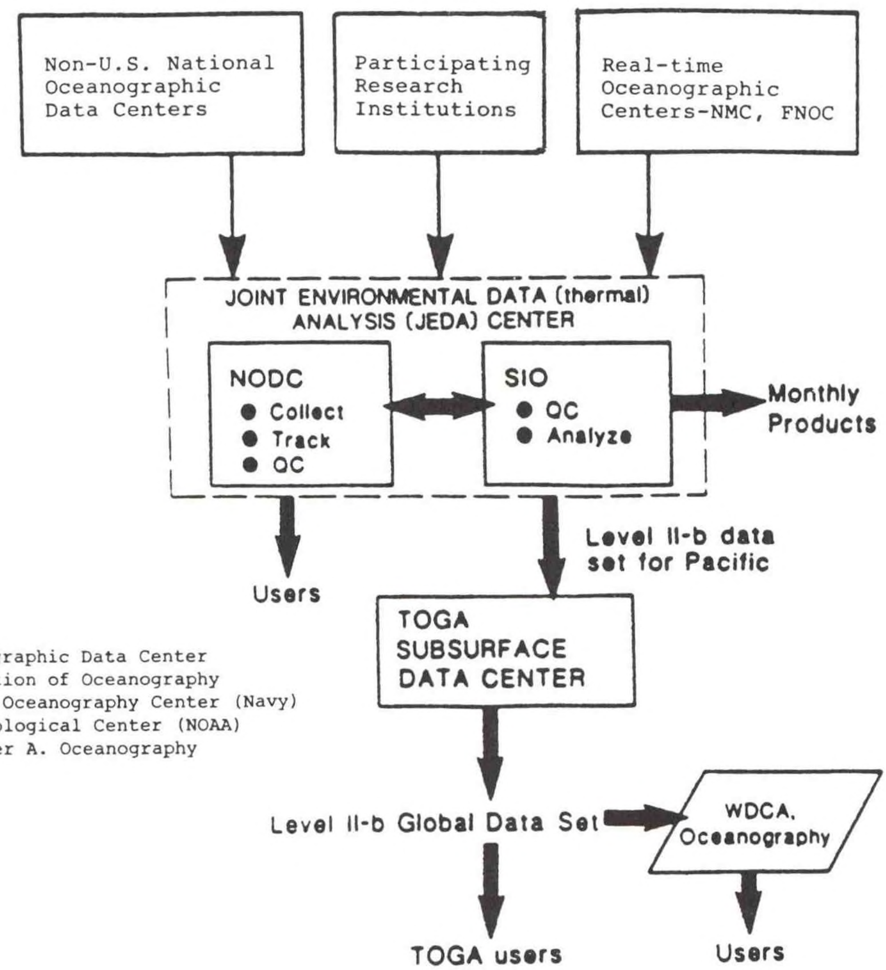


Figure A.5 TOGA Pacific Area



NODC - National Oceanographic Data Center
SIO - Scripps Institution of Oceanography
FNOC - Fleet Numerical Oceanography Center (Navy)
NMC - National Meteorological Center (NOAA)
WDCA - World Data Center A. Oceanography

Figure A.6 TOGA Pacific Data Flow

Ocean-sensing satellites and their prodigious data-gathering ability are making possible the new era of global geosciences. In FY 1987 the NODC began assuming increased responsibility for archiving and disseminating ocean satellite data by initiating distribution of wind/wave data from the U.S. Navy Geodetic Satellite (Geosat). This trend will accelerate in FY 1988.

Data Services

NODC's archival data holdings are a major resource for climate researchers. To help meet its commitment to users, the NODC has made special efforts to increase its holdings in the relatively data-sparse tropical ocean, particularly the tropical Pacific. For example, over 19,000 expendable bathythermograph (XBT) temperature profiles were obtained from Australia. In January 1987, NODC's global ocean data holdings included over 735,000 oceanographic stations and over 1.6 million bathythermograph temperature profiles.

In 1986 the the NODC provided data products/services to nearly 4,700 customers. As the NODC augments its suite of near-real-time and ocean satellite data products, this number is expected to grow by at least six percent each year.

One of NODC's principal products for the operational marine community is the "Mariners Weather Log". Produced with support from the U.S. Navy and the National Weather Service, this quarterly publication provides retrospective reports on marine weather in the North Atlantic and Pacific Oceans, as well as global tropical cyclone tracks. Under a new editor since mid-1986, the Log is being revamped to be more useful to the marine community and to ensure the continuing support of cooperative observers at sea in global ocean data collection efforts.

Technology Enhancements

To meet the needs of global climate programs, the NODC, other NOAA elements, and other agencies and institutions are cooperating to develop improved data management/data access systems. The NODC is workly closely with NASA, for example, to test and evaluate the Global Online Data (GOLD) catalog, the data inventory component of the NASA Ocean Data System (NODS). In FY 1987 the NODC will be connected to the NASA Space Physics Analysis Network (SPAN), a telecommunications system used to link major oceanographic data archival and research facilities.

The NODC is also involved in planning for NOAAPORT, a system for distributing NOAA's near-real-time data to operational users. If implemented, NOAAPORT would replace currently-used telephone circuits with satellite communications in the early 1990's.

These kinds of upgrades would result in a distributed system linking data bases at many locations in and out of NOAA. Improved access to ocean data bases and implementation of a data catalog system--in cooperation with other agencies --would provide a resource for studies of global change.

NATIONAL GEOPHYSICAL DATA CENTER

The National Geophysical Data Center (NGDC) carries out a number of programs which provide data for research in Meteorology and Climatology. These include historical data bases of volcanic activity; digital topographic data for global and regional circulation modelling; an extensive file of ocean bottom samples and ocean drilling data; specialized data sets from the CLIMAP project which interpreted climatic conditions and geographic features from marine sediments for glacial and interglacial intervals; a variety of data on solar variability, solar flares and upper atmosphere phenomena, which are used in the study of relationships between solar variability and climate; a data inventory and coordination role for climate data derived from ice-cores; a collection of historical photographs of glaciers; a DOE-sponsored program to investigate Southern Hemisphere CO_2 data in relation to variations in atmospheric circulation and sea ice conditions; temperature and pressure data from satellite-queried buoys placed on the central Arctic pack ice; and an extensive collection of mosaic imagery from the Defense Meteorological Satellite Program (DMSP) satellites, which is used for studies of snow and ice cover.

Additional activities include the acquisition of data from the DMSP satellites and the Solar Electro-optical Observing Network (SEON); management of data from the DOD/NOAA sea ice chart digitizing programs; provision of Marginal Ice Zone Experiment data management services; and development of a computer-based Cryospheric Data Management System for data acquired by the DMSP Special Sensor Microwave Imagery. NGDC plans to continue and expand the services outlined above in FY 1988.

ASSESSMENT AND INFORMATION SERVICES CENTER

The Assessment and Information Services Center (AISC) performs analysis of weather/climate events and the effects on all aspects of human activities. The Center has three primary thrusts: techniques development, library and information services, and automated systems. AISC promotes the development of the U.S. economy and the effective management of oceanic, atmospheric, and terrestrial resources by: 1) developing analyses of global and regional environmental impacts on human activities and; 2) providing access to environmental datasets and published information through the NOAA Libraries and the National Environmental Data Referral System.

The Center provides a bridge between research scientists and managers of natural resources who use and interpret environmental data and information. Upon request, the Center develops, adapts, and tests models and techniques for analysis of environmental impacts on human activities and resources. The tailoring of quantitative models and techniques to meet specific user requirements often requires presentation of information for various scenarios in a geographic information format. Baseline information and modelled scenarios are useful resources, for environmental impact assessment, management planning, and determination of "at risk" populations, mitigation strategies and policies.

AISC produces a series of products based on analysis of historical, current, and forecast environmental data and relates these data to variations in economic factors and other parameters. The principal products and services are described below.

Climate Impact Publication. "Climate Impact Assessment, United States" is a monthly publication that evaluates the effects of unusual meteorological events on energy use, food production, human comfort, transportation, and other weather-sensitive economic categories.

In FY 1988, AISC will develop models for systematic estimations of weather impacts on transportation, retail sales, and mortality. Specifically, these models will relate weather to business activity, consumer and wholesale prices, and weather-related deaths, such as, during heat wave and cold spell. Studies on the effects of weather on other human activities, such as, transportation, construction, and employee absenteeism, will also be conducted.

Energy Publication. A monthly publication on U.S. energy use, "Climate Impact Assessment, United States, Energy," contains weather-related cost estimates for residential consumption of heating fuels in the cold season and electricity in the warm season. The publication provides population-weighted energy use information for selected cities in the United States, the 48 conterminous States, nine Census regions, and the country as a whole on a weekly, monthly, and seasonal basis. During the heating season issues also include an international heating oil section with a weather/energy consumption indicator for seven foreign countries.

In FY 1988, the Center will continue to improve this product by breaking down the cost estimates by type of fuel and to derive forecasting procedures for fuel costs during the entire season.

Marine Resources. AISC produces studies for understanding and monitoring of processes, conditions, and changes in the marine environment. Local and regional analysis address areas of seafood resources, transportation, recreation and tourism, and coastal and estuarine development. Marine studies encompass gathering the data, performing analysis, and producing a synthesis and coherent report of all the information. The Center's marine reports provide an important extension service to the states, academia, and the private sectors. AISC serves as the clearinghouse of the information included in the reports. It is a unique function that was never done before and has helped various organizations--Federal, states, and the private sectors.

In marine resources analysis, the Center develops and performs multi-diciplinary studies of regional, national, and global ocean-climate interactions with living marine resources and human activities. The Center performs these tasks using various approaches including time series analysis numercial modelling and statistical analysis. Reports are produced regularly and special studies are performed for unusual events, such as, hurricanes, floods, and other large scale perturbations.

Meteorological analyses related to marine resources will continue in FY 1988 in the following areas:

1) Chesapeake Bay and Adjoining Shelf. AISC has been producing marine environmental assessment for Chesapeake Bay since 1981. Quarterly reports and a comprehensive annual summary have been published each year. The analyses continue to expand in scope and coverage including physical conditions in the Bay

and fishery, recreation, and economic impacts of weather/climate events. The Chesapeake Research Consortium has been given responsibility for producing these assessments and reports. In FY 1988, AISC will continue a study for the Bay region including dynamical modeling, larval transport, satellite monitoring of sediment loading and bloom concentrations, and economic impact modeling. AISC is working with other NOAA Line Organizations, the Environmental Protection Agency, the U.S. Army Corps of Engineers, and those state agencies with interests in the Bay.

2) Gulf of Mexico. AISC has published annual summaries for the Gulf of Mexico for four years, 1982-1985. The annual summary is a comprehensive analysis of impacts of weather/climate, with discussion of weather, hydrology, and oceanography, and summaries of fishery, recreation, and transportation activities. In FY 1988, AISC will produce one more annual summary for 1986 with extensive efforts to transfer the analysis to the private sectors.

3) San Francisco Bay. AISC has produced the Annual Summary for the San Francisco Bay marine environmental assessment 1985 as part of the continuing expansion of operational assessment efforts. This study is similar to the Chesapeake Bay in terms of local emphasis but different from the Gulf of Mexico due to concentrated areal coverage. This first analysis includes information on weather, oceanography, fisheries, recreation, transportation, and pollution. The assessment focuses on the effects of environmental events (weather, oceanography) on economic sectors of marine activity and provides a multi-disciplinary view of San Francisco Bay highlighting its multiple uses. Relationships between study variables are presented where possible. Where it is difficult to establish clear relationships, data from scientific and economic areas are presented to further display the multiple use of the Bay system. In FY 1988, AISC will continue to produce the annual summary for San Francisco Bay with the accompanying efforts to look for a private group that will produce the operational analysis.

4) Southeastern United States. Interest and concern for the coastal regions of the United States have been growing during the last several years. Changes and developments in the coastal areas are causing land use conflicts. AISC has long recognized this situation and has initiated a study for the Southeastern United States from Florida to the Carolinas. The analysis is similar to the Gulf of Mexico. In FY 1988, AISC will continue to produce the annual summary for 1987.

National Environmental Data Referral Service. AISC has established a National Environmental Data Referral Service (NEDRES). This service includes a computerized database that is accessible on a major information retrieval system from any location served by commercial data communication networks. Published catalogs and a network of cooperating organizations provide up-to-date information about the existence, characteristics, and availability of environmental data. Part of the NEDRES program will be a National Climate Information Clearinghouse which will provide a national inventory of climatological data. An inventory of climatic data holdings in the North Central States is complete. In FY 1988, the climatic data holdings inventory for the Western States will be completed. This will complete the inventory of climatic data in the 48 contiguous States.

Library Services. AISC operates NOAA's main library system. The Library is one of the major libraries in the world. It includes one of the largest collections of U. S. and foreign climatological data publications. Upon receipt of the publications, bibliographic records which identify and describe the publications are prepared and shared in a common service data base with hundreds of other Federal, public, and academic libraries. The publications are available for use in the library or can be borrowed. Additionally, on-line computer searches for references to published literature in all areas of environmental science are available through the NOAA Library.

NATIONAL OCEAN SERVICE

The National Ocean Service (NOS) develops, implements, and manages programs in physical, biological, chemical, and geological oceanography required to support the ocean services program; and establishes a scientific information base on which to support development of a national policy for oceans and their users. NOS coordinates efforts of the various oceanic activities pursued by the National Weather Service and the National Environmental Satellite, Data, and Information Service. The following selected NOS activities provide products and services that support meteorological, climatic, and environmental programs.

The Office of Ocean Services manages the NOAA Ocean Services Program through which NOAA modernizes and enhances ocean services and products by improving ocean data collection, analysis and distribution capabilities; the Office also develops cooperative efforts with state and local governments, other Federal agencies, and the private sector. It establishes requirements for marine data and evaluates and quality controls marine data sets, products, and services that are collected/distributed.

The Ocean Observations Division manages real-time marine data collection programs (e.g., Shipboard Environmental (Data) Acquisition Systems--SEAS) to augment the capability for real-time data collection over broad ocean areas using a variety of sensor platforms (e.g., SEAS, drifting buoys, moored buoys, etc.). To increase understanding of large-scale ocean processes and their effect on the atmosphere, the Ocean Observations Division participates with other NOAA (e.g., Tropical Ocean and Global Atmosphere program), U. S. Government, and international data collection programs. It also provides operational support and long-term policy guidance for these programs.

The Ocean Products Division provides operational marine forecast and analysis guidance material in support of NOS and NWS field offices and private industry. It develops operational numerical prediction model output products and improves methods of data analysis. Output products may include analyses of: marine weather and boundary layer phenomena; waves and wave dynamics; and ocean thermal structure and dynamics.

The Ocean Applications Group enlists the substantial resources of the U.S. Navy's Fleet Numerical Oceanography Center (FNOC) in Monterey, California, to conduct a program of activities in support of product development at the Ocean Products Division. It provides a vehicle to ensure maximum cross utilization of ocean data, analyses, and predictions to provide services to civilian users and to assist the U.S. Navy in serving military users.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

Environmental Research Laboratories

Environmental Research Laboratories (ERL) R&D programs support NOAA space and meteorological services, and are oriented toward providing understandings and developing techniques and technologies to form the basis for future improvements in the nation's weather services. These important functions encompass the missions of several ERL laboratories.

Special emphasis is placed on improving severe weather forecasts and warnings. Severe weather is any major natural hazard such as flash floods, strong winds, thunderstorms (including tornadoes and hail), and heavy snowstorms. ERL laboratories will continue to conduct both in-house and cooperative research with other NOAA components, joint institutes, and universities.

OBSERVATION TECHNOLOGY

ERL's Wave Propagation Laboratory (WPL) led an FY 1986 effort to procure from industry 30 ground-based wind Profilers. Prototype Profilers were installed during FY 1987. Data will be evaluated beginning in FY 1988; they will be archived and used for research purposes as well. The temperature and humidity Profiler at Denver, Colorado, continued to operate in FY 1987. Additional radar wind studies will be undertaken to improve the accuracy and height resolution of temperature and humidity profiles. Ground-based Profiler data will be compared with GOES satellite profiles to improve overall sounding accuracy.

ERL will continue to operate a network of five automatic tropospheric wind profiling radars and total water (i.e., vapor and precipitation) measuring radiometers in eastern Colorado during FY 1988. This research effort will significantly contribute to development and test of methods for effective use of continuous profile data to improve NWS short-range, local forecasting. The data will be used in real time by the Denver National Weather Service Forecast Office and ERL's Program for Regional Observing and Forecasting Services, as well as for research by the Weather Research Program.

The technology of infrared Doppler lidar will be advanced by continuing studies of wavelength and geographical dependence of backscattered energy in the 9-10.6 micrometers band with a high power (2 joules/pulse) infrared Doppler lidar.

SEVERE WEATHER RESEARCH

The National Severe Storms Laboratory (NSSL) in Norman, OK, focuses its research to understand and forecast severe convective storms and their associated weather hazards such as hail, high winds, heavy rain, lightning, and turbulence. The parameters of storm development and intensification are identified by incorporating observations from dual Doppler and conventional weather radars, the tallest meteorologically instrumented tower in the United States, an automated surface network, remote-sensing wind Profilers, instrumented aircraft, and facilities for mapping and characterizing lightning in storms and strikes to ground.

Further development of unique lightning and electrical field sensors will be translated into improved identification and warning of lightning hazards, both to aviation and to the general public, in cooperation with the National Weather Service. NSSL will continue studies relating storm electricity paremeters to the dynamics and precipitation structure of severe storms, and determining interactions between electrical processes and storm microphysics as an aid in identifying storm types and predicting changes in storm characteristics. Immediate technology transfer will be effected by close association with the Oklahoma National Weather Service Forecast Office.

In FY 1988, ERL's Environmental Sciences Group/Weather Research Program (WRP) will continue to transfer knowledge of convective weather systems and associated heavy rainfall to NWS through courses at its training center; through visits and interactions with NWS centers, regional headquarters, and field forecast offices; and through cooperative projects.

Environmental Sciences Group Program for Regional Observing and Forecasting Service (PROFS) is working toward improvements in the effectiveness of short-range locally specific weather services. The improvements are achieved through a program of applied forecasting research and development which draws upon the improved understanding of the natural processes of storm development as determined by the research community and integrates these advances with emerging technologies, advanced observational systems (such as NEXRAD, VAS, and the Profiler), and conventional data and capabilities. These quasi-operational systems are realized in specific configurations of the highly flexible PROFS Exploratory Development Facility, with extensions into the Denver WSFO in FY 1987 and Denver FAA ARTCC. The advanced capabilities will be evaluated for forecast improvement and effect on operations, as precursor to the NWS forecaster work-station of the 1990s.

PROFS will continue its emphasis on data application from the GOES VISSR Atmospheric Sounder (VAS), Doppler radar, and the Profiler as inputs to its quantitative mesoscale analysis and prediction model, thus expanding service improvement efforts to include nonsevere as well as severe weather.

With the support and cooperation of the Federal Aviation Administration, the National Weather Service, the Air Weather Service (USAF), and the National Aeronautics and Space Administration, NSSL and the Environmental Sciences Group/PROFS will continue to develop real-time radar data displays and algorithms.

MESOMETEOROLOGY AND PRECIPITATION FORECASTING AND WARNING

The Environmental Sciences Group/WRP develops techniques to improve short-term forecasts of significant weather events. Through detailed case studies and regional climatologies, WRP scientists have developed diagnostic tools and aids to operational forecasting of severe thunderstorms, lightning, flash floods, and mesoscale convective storm complexes, and for monitoring rainfall from satellite digital infrared data. Activities under way include studies of the precipitation structure of mesoscale convective systems, studies of the interactions between mesoconvective systems and their environment, use of satellites to infer storm development and rainfall, studies of severe storm forecasting procedures, and improving parameterization of deep convection within 3-dimensional mesoscale models via a 2-dimensional model. A significant effort is under way to study data from the NOAA P-3 aircraft, Profilers, Doppler radar, and microphysical data in the vicinity of convective mesosystems, gathered during the Oklahoma-Kansas PRE-STORM project.

WRP will continue an effort begun in FY 1987 to develop enhancements to the NWS operational LFM numerical model. The goal is to provide a continuing stream of improvements in the numerical guidance provided twice daily to weather forecasters.

HURRICANE RESEARCH

The Hurricane Research Division (HRD) of ERL's Atlantic Oceanographic and Meteorological Laboratory performs research to improve hurricane forecasts and warnings. HRD's hurricane field program uses highly instrumented NOAA P-3 research aircraft to acquire unique data which are analyzed to describe and understand the dynamics and energetics of the hurricane's inner intense core. HRD develops numerical hurricane models using these and other sophisticated data.

During FY 1987, HRD placed highest priority on gathering synoptic-scale Omega Dropwindsonde (ODW) data for use in research to improve hurricane track prediction. This will be continued in FY 1988 to obtain an adequate volume of ODW data and to support NWS real-time forecasting and to develop a next generation objective analysis scheme.

The Hurricane Research Division will continue to analyze data acquired in FY 1986 and FY 1987. These analyses are directed toward studies of hurricane dynamics and microphysics, motion and internal dynamics, and atmospheric and oceanic boundary layer dynamics.

NUMERICAL MODELING

The ERL Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton, NJ, conducts long-lead-time research to understand the predictability of weather on both large and small scales and carries out experimental applications of this understanding to NOAA missions. Three main areas of weather research are covered by the GFDL program--Experimental Prediction, Hurricane Dynamics, and Mesoscale Dynamics.

Experimental Prediction research will be carried out with the National Meteorological Center to determine the predictability of the global atmospheric circulation on extended time scales. The research plans include the following:

- Develop more accurate and efficient atmospheric and oceanic Global Circulation Models (GCM's) suitable for monthly and seasonal forecasts.
- Identify important external forcing mechanisms for the forecast range of several weeks to several months; accurately specify initial states of the atmosphere, oceans, soil, and snow-ice.

- o Investigate the influence of additional internal processes such as orographic effect, cloud-radiation interaction, and cumulus convection upon atmospheric variability on the seasonal time scale.

- o Study the mechanisms of various atmospheric phenomena such as blocking, orographic cyclogenesis, equatorial ocean-atmosphere interaction, tropical circulations, and teleconnections.

Hurricane Dynamics models the genesis, development and decay of tropical storms including small-scale features within hurricane systems, using multi-nested models of the storm system and its environment. The group's plans include the following:

- o Improve understanding of the genesis, development, and decay of tropical depressions by investigating the thermo-hydrodynamical processes using numerical simulation models.

- o Study small-scale features of hurricane systems, such as the collective role of deep convection, the exchange of physical quantities at the lower boundary, and the formation of organized spiral bands.

- o Investigate the capability of numerical models in the prediction of hurricane movement and intensity.

- o Develop next generation operational hurricane prediction model.

Mesoscale Dynamics determines the practical limits of mesoscale predictability and simulates mesoscale phenomena and their interaction with larger and smaller scales. The group's plans include the following:

- o Produce accurate numerical simulations of mesoscale processes in order to understand the role of synoptic scale parameters in the generation and evolution of mesoscale processes. Develop 4-D data assimilation techniques.

- o Understand the dynamics of mesoscale phenomena and their interaction with larger and smaller scales.

- o Determine practical limits of mesoscale predictability by means of sensitivity studies on numerical simulations of mesoscale phenomena.

SPACE ENVIRONMENT SERVICES

The National Oceanic and Atmospheric Administration and the USAF Air Weather Service jointly operate the National Space Environment Services Center in the Space Environment Laboratory (SEL) in Boulder. The Center provides forecasts, alerts, indices, and summaries of disturbances occurring on the sun, in space, in the geomagnetic environment, and in the upper atmosphere. The services are used by the DOD, DOT, DOC, DOI, DOE, NASA, NSF, commercial users, and the research community: (1) to optimize the operation of technical systems that are adversely affected by disturbances in the space environment, and (2) to carry out research in the solar-terrestrial environment. Examples of the adverse effects include loss or reduced efficiency of communications systems, radiation hazards to personnel and systems in space and on high altitude aircraft, degradation of surveillance and monitoring systems for defense, errors in navigation systems, and perturbations of satellite orbits.

The Center serves as the International World Warning Agency for the solar-terrestrial environment. It collects international data in real time, provides Ursigram and World Days Service, and meets additional specific needs of other Government agencies. The Center distributes data to other countries and issues a consensus set of daily forecasts for international use.

The Center operates with observations received from agencies that make their data available in real time and, in return, receive the services to meet their own needs. Agencies making major contributions of data include DOD, NASA, DOC, NSF, DOE and DOI. The Space Environment Laboratory (SEL) cooperates directly with NOAA/NESDIS to receive solar x-ray, particle, in situ magnetic field, and plasma data from the Space Environment Monitors on GOES and polar-orbiting NOAA satellites.

Data are collected, stored, and displayed for analysis; products are distributed through the Space Environment Laboratory Data Acquisition and display System (SELDADS). The upgraded SELDADS II system, with greatly increased data capacity and analysis and display capabilities, became fully operational in FY 1986.

Services are distributed via teletype and digital data links (primarily operated by other agencies), via the SELDADS, by radio broadcast (WWV), by mail, by recorded telephone messages available to commercial dial-up users, and by low-cost commercial satellite broadcast service.

DEPARTMENT OF DEFENSE

The Department of Defense (DOD) operates a military environmental service system to provide specialized worldwide meteorological and oceanographic prediction services in support of military forces. This service directly supports all phases of military operations, from strategic planning to tactical operations. The U.S. Navy's Naval Oceanography Command and the U.S. Air Force's Air Weather Service are the primary military performing agencies. The Army and Marine Corps each have a small generic weather support capability, but depend upon the primary weather services for most support. The military weather services contribute to the national and international weather observing capability by making conventional observations on land and at sea where there is no other conventional weather observing capability and where the observations are most needed to meet military requirements. In addition, DOD maintains special observing capabilities such as the Defense Meteorological Satellite Program and aerial weather reconnaissance to meet unique military requirements. The reconnaissance program also serves national needs for data from tropical and coastal winter storms. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES ARMY

U.S. ARMY METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

The U.S. Army meteorological research program is, by necessity, very broad, covering such topics as: 1) microscale models of chemical transport and diffusion in complex terrain, 2) theoretical studies of the atmospheric interaction with high-energy laser beams, 3) advanced remote sensing techniques, 4) artificial intelligence techniques for meteorological applications, 5) sound/noise propagation through complex atmospheres, 6) meteorological techniques for near surface observation of target area, and 7) atmospheric effects on electro-optical propagation, to name a few. The following are some of the higher priority efforts.

The highest priority work in basic research is remote sensing. An important effort in this area is the remote determination of temperature, humidity, and wind characteristics to an altitude of 10 kilometers or more. This work will lead ultimately to the replacement of existing balloon-borne upper-air measurement systems which are noted for their intensive need for both manpower and logistical support. Another primary effort involves research on the application of ultraviolet LIDAR for remotely measuring not only temperature and humidity but also detecting airborne biological agents. This sensor offers the promise of providing a capability of describing and mapping contaminated areas using the UV LIDAR mounted on both aircraft and ground vehicles. Second to the lab's focus on remote sensing is that research dedicated to the development of highly advanced transport and diffusion models for use at chemical depots, in war-gaming activities, and ultimately on the battlefield for tactical applications.

The highest priority work in exploratory development is the Integrated Meteorological System (IMETS). IMETS will automatically sense, collect, process, and transform weather data into Tactical Weather Intelligence (TWI) products which assist the commander in making combat decisions. Mathematical, physical and empirical models, terrain coupled meteorology, and the latest techniques in display and artificial intelligence technologies are being exploited to derive the TWI products. Numerous software applications have already been officially fielded for use in the Army's MICROFIX system and include applications for the intelligence, aviation, chemical, and operations elements of Army divisions. In addition to MICROFIX, TWI software has been inserted into the Staff Planning and Decision Support (SPADS) and the Target Analysis and Planning (TAP) systems. Feedback from units in Germany, Korea, and CONUS has been extremely positive and a strong desire expressed for more product development.

TECHNICAL ACCOMPLISHMENTS IN FY 1986

In March 1986, the U.S. Army Atmospheric Sciences Laboratory (ASL) conducted a demonstration of TWI concepts with the 17th Field Artillery Brigade in Germany during a regularly scheduled Army Training and Evaluation Program (ARTEP). This demonstration included the use of TWI software implemented on the AN/UYK-71, MICROFIX computer and the utilization of near real-time meteorological data collected by experimental prototypes of a tactical (vehicular mounted) meteorological sensor package. A combination of near real-time meteorological data and TWI software allowed the 17th Field Artillery Brigade to realistically incorporate weather data and weather effects into its ARTEP exercise. This significantly improved the chemical hazard estimation and prediction portion of the Brigade's exercise. The exercise showed that meteorological sensors, taking near real-time measurements and feeding TWI software, can provide to battlefield commanders those decision aids which significantly improve the commander's ability to maximize combat effectiveness.

In early 1986, ASL designed and developed a collection of prototype Meteorological Sensor Packages (MSP) which, with no moving parts, measures wind speed, wind direction, ambient temperature, barometric pressure, relative humidity, and magnetic north. These sensors are designed for tactical use and can be operated in the stand-alone mode or mounted on tactical vehicles such as the M113 armored personnel carrier and highly mobile multi-wheeled vehicle. ASL installed telescopically mounted MSP aboard the Nuclear, Biological, and Chemical (NBC) Reconnaissance System (NBCRS) being configured by the Chemical Research Development and Engineering Center (CRDEC) using an M113. The MSP measurements are remotely displayed within the NBCRS in order that meteorological effects can be applied to the problem of predicting the drift and dispersion of the toxic elements. The MSP performed successfully during the Phase I concept evaluation program (CEP) conducted during FY 1986. Phase II was conducted by the Armor and Engineer Board at the Armor School, Fort Campbell, KY, where the MSP again performed flawlessly. The final phase of the CEP was a three month exercise near Bamberg, Germany, with the system being operated and maintained by troops in the field. For the first time, the MSP will allow the Army access to real-time weather data forward of the division Tactical Operation Center.

The Laboratory has developed a large number of significant TWI applications. This software package consists of meteorological data analysis, NBC and smoke applications, probability of casualties under Mission Oriented Protective

Posture (MOPP), and target acquisition models for the majority of U.S. and Threat EO systems. ASL provided these to the U.S. Army Forces Command (FORSCOM) for incorporation into the latest released software version 2.1 of MICROFIX. The U.S. Army Military Academy (as agent for FORSCOM) also installed the TWI software packages in the topographic work station of MICROFIX, which was distributed during July 1986 to all tactical Corps and Division terrain analysts sections. This marks the first time that weather intelligence decision aids have been placed in the hands of U.S. Army forces for tactical application.

A live fire evaluation of the ASL concept for using FIREFINDER radars to remotely measure winds for an artillery MET message was conducted in April 1986 at Grafenwoehr, West Germany. This evaluation was conducted by the 17th Field Artillery Brigade, with elements of the 1st Armor Division and the 3rd Infantry Division. It consisted of two phases. Phase I compared the effects of correcting simulated artillery fire for ballistic winds using two methods of computing the artillery MET message. The first method used the ASL developed methodology of measuring atmospheric winds using the backscattered energy from an AN/TMQ-37 radar and deriving a vertical density profile from surface based measurements. The second method used the standard technique of calculating the MET massage from the data obtained from a balloon-borne radiosonde. The Phase II comparisons used data measuring the impacts of live rounds fired using each MET message to determine which correction method caused the rounds to fall closer to the intended target. The comparison was conducted with both 155 mm and 8 inch howitzer batteries firing at ranges up to 11 km. The main finding from this comparison was that the met message derived from the radar through software techniques was at least as accurate as that derived using current balloon-borne radiosonde measurement techniques. This result has significant implications for reducing the extensive manpower and equipment requirements for the Field Artillery. With Fort Sill's concurrence, ASL has begun the modification of AN/TPQ-36 software which will permit a stand-alone MET message to be generated using the radar's embedded computer and to be transmitted to TACFIRE over existing communications links. This software will be provided to the Artillery Board for evaluation using an AN/TPQ-36 as a surrogate for the proposed FIREFINDER II.

A target acquisition model has been developed which provides the battlefield commander with a valuable tool for assessing the environmental effects on U.S. and Threat electro-optical sensor performance. Weather has a dramatic effect on weapons systems capabilities through reduction of detection and recognition ranges; but with the knowledge of atmospheric effects, weapon systems resources may be better utilized. The target acquisition model for TWI treats thermal imaging devices, silicon TVs, direct view optics, and laser and guidance devices which are in current deployment by U.S. and Warsaw Pact countries. The model outputs effective acquisition and recognition ranges for three probability levels and is operational on a briefcase-type portable computer. The model has become an integral part of the IMETS and has been demonstrated as a valuable tool during the 17th Field Artillery Brigade exercises. The target acquisition model has been incorporated into the Brigade Planner, which is a system being developed at the TRADOC Analysis Center (TRAC) for computer-assisted tactical planning by brigade commanders. The model continues to be updated through incorporation of sensor performance models for the most recently fielded systems and by improving its ability to cope with more realistic battlefield scenarios.

ASL provided automation software, meteorological data analyses, and predictive models to the Defense Nuclear Agency (DNA) to complete the initial software version of the Automated NBC Information System (ANBACIS). This system, which automates many of the manual calculation procedures used by chemical officers, is a joint effort of ASL, DNA, the Army Development and Employment Agency (ADEA), the 9th Infantry Division, and the U.S. Army Chemical School. The ASL programs comprise over 70% of the current ANBACIS software. For the first time, the chemical officer will have an automated means of rapidly and accurately predicting the movement and concentration of NBC agents on the battlefield.

A model has been developed which predicts the level of solar and lunar illumination under realistic weather conditions (clear, cloudy, partly cloudy, precipitation). It provides a capability to predict illumination levels for the operation of image intensifier devices. Field data obtained by the ASL meteorological teams at various CONUS locations have been used to validate the model predictions.

Although the Multiple Launch Rocket System (MLRS) was designed to minimize the effects of cross winds during the burn phase of the rocket's flight (up to an altitude of about 300 meters), uncertainty in these winds is the largest contributing source of inaccuracy for the rocket. ASL investigations have shown that significant improvements in effectiveness can be achieved if the launch wind error can be reduced. ASL has evaluated several techniques for measuring these winds, ranging in complexity from an anemometer on a telescoping mast to a sophisticated remote sensing device known as a Laser Doppler Velocimeter (LDV). This evaluation was performed with actual launch data taken at White Sands Missile Range in non-tactical launcher locations. In order to investigate the effects of complex terrain, wind profiles were taken with a mobile LDV positioned behind buildings, along tree lines, etc., and then compared with wind profiles extrapolated from a single point sensor mounted at 5 meters above the ground. This movement technique was used to simulate the complex terrain of tactical launch sites. These data have been analyzed and have been provided to the project manager and the manufacturer to aid in determining the most cost effective wind sensing system to use with the MLRS.

An extensive data base of meteorological measurements was collected between June 1985 and May 1986 in Northern California. These data will be used to test and validate ASL's family of numerical atmospheric models, the Hierarchy. This set of models is so named since each of the inner scale sets of code are dependent on the outer scale model for its initial and boundary conditions. The Hierarchy provides a spatial resolution ranging from 200 km down to 100 m, thus providing the meteorology which encompasses the total range of atmospheric processes bearing on tactical operations. The field experiment was accomplished with the combined efforts and resources of ASL, CRDEC and the U.S. Forest Service. A unique data base, never before obtained anywhere in the world, was collected using measurements taken over widely varying terrain features, land use and meteorological conditions. Some two billion data points have been collected to characterize both diurnal (24-hour) and seasonal differences to test the modeling system's precision and generality. Coupled with rigorous analysis procedures, the data base will permit further refinement of the models in order to prepare a significantly improved means of predicting atmospheric effects by the tactical Army. The Army's present capability is limited to defining the meteorology over flat, open terrain. Thus the Army will now have a significantly improved capability for supporting chemical warfare/ chemical biological defense, smoke operations and other activities dependent on atmospheric transport/diffusion processes. The Army's wargaming models will be significantly improved and the Army will have the means to more realistically evaluate the effects of variable terrain and land use upon the meteorology of the battlefield.

Measurements of aerosol-induced laser breakdown thresholds have been made for wavelengths characteristic of the free electron laser. The presence of particles in the laser beam reduces the threshold for breakdown by factors of ten to several thousand below that for clean air, depending on wavelength and particle size. Thresholds are most dependent on wavelength, and are reduced most for the near-ultraviolet and least for the near-infrared. Once laser breakdown thresholds are exceeded, a plasma quickly forms, absorbing and eventually blocking further radiation from the laser source. ASL's finding that breakdown thresholds are reduced more for shorter wavelengths is new and unexplained by classical breakdown theories. The measurements can be qualitatively explained by considering: 1) the effect of enhancement or internal electromagnetic fields within irradiated particles, and 2) the increasing importance of (quantum) multiphoton absorption processes at short wavelengths. Results suggest there is an optimum wavelength "window" for the propagation of high intensity or high energy laser beams through aerosol-laden atmospheres.

Scientists at ASL are assessing the feasibility of fielding a UV LIDAR device for remotely sensing certain meteorological parameters, the detection and identification of biological agents, and the discrimination of many battlefield targets. The sensor uses laser-induced fluorescence to detect and identify targets based on unique temporal and spectral fluorescent signatures. A catalog of fluorescent signatures of mycotoxins, lubricants, and paints has been compiled to define target specificity. The ultraviolet LIDAR has been used to investigate the effects of the atmosphere and background clutter on signature detection. This remote sensor will have an important impact as a stand-off detector of biological agents and as a target acquisition and recognition sensor which could operate in foliage and camouflaged environments. With the ability to detect the presence and temperature of airborne water droplets, a remote sensor of this type could warn aviators of a potential icing hazard prior to entry of such regions.

In the U.S. Army Training and Doctrine Command (TRADOC), the technical data upon which major decisions are often made are derived from war game simulations. Prior to ASL involvement, the effects of obscurants on systems performance in such simulations were treated only in a cursory manner, if treated at all. At the request of the TRADOC community, research projects were conducted at the ASL with the objective of developing new and innovative methods for including the effects of obscurants such as smoke and dust into the overall hierarchy of TRAC war game simulation models. Consequently, the modeling hierarchy, ranging from the detailed CARMONETTE and CASTFOREM Mainframe models to the (near) real-time JANUS simulation, have been significantly improved in terms of realistic battlefield effects. Many important results predicted by these models have been used in high level briefings to the U.S. Army Vice Chief of Staff to answer questions raised during the Comprehensive Smoke Study. Further, the JANUS war game simulation system which incorporates the ASL smoke and dust models is being distributed to the TRADOC schools for use in the education and training of soldiers.

Army weather problems are resolved by first determining atmospheric effects on systems and operations, then devising methods to mitigate these effects through 1) designing material to be more nearly "all-weather", 2) including battlefield weather in wargaming models, 3) devising near-real time corrections for Army systems such as artillery fire, and 4) measuring atmospheric parameters on the battlefield and using this network of data to give "tactical decision aids" to the commander so that weather is an integral part of the battle plan.

DEPARTMENT OF THE NAVY

OVERVIEW

Within the U.S. Navy, meteorological and oceanographic support is provided by the Naval Oceanographic and Meteorological Support System (NOMSS). The NOMSS is a collective title which includes environmental personnel and resources assigned to various naval shore and afloat staffs, U.S. Marine Corps aviation weather units, test stations and ranges, shipboard weather offices, and activities of the Naval Oceanography Command (NAVOCEANCOM). In addition, personnel and resources from the naval research, development, logistic, and training components are included within the NOMSS. Naval systems commands, laboratories, research facilities, and training commands constitute these various components.

Primary support for the NOMSS is provided by activities and detachments assigned to the NAVOCEANCOM. Shore field activities within the NAVOCEANCOM having, inter alia, meteorological responsibilities include a primary numerical processing center, three regional Naval Oceanography Centers, two Naval Oceanography Command Centers, eight Naval Oceanography Command Facilities, over 50 Naval Oceanography Detachments, two Naval Oceanography Command components, and the Naval Oceanographic Office (NAVOCEANO).

The Fleet Numerical Oceanography Center (FLENUMOCEANCEN) Monterey, CA, operates the master computer center of the NOMSS and functions as the hub of the Naval Environmental Data Network (NEDN). The NEDN is designed for product distribution among the major NAVOCEANCOM activities. Through linkage with DOD and NOAA environmental satellite systems and U.S. Air Force and NOAA data distribution centers, FLENUMOCEANCEN acquires global coverage of environmental data. From these data, basic and applied numerical (computer) products are generated for distribution via the NEDN and other communications systems for use by other NOMSS activities in producing specific support products and services.

The three regional Naval Oceanography Centers--the Naval Western Oceanography Center (NAVWESTOCEANCEN) at Pearl Harbor, HI; the Naval Eastern Oceanography Center (NAVEASTOCEANCEN) at Norfolk, VA; and the Naval Polar Oceanography Center (NAVPOLAROCEANCEN) at Suitland, MD--are assigned broad geographical areas of responsibility for oceanographic and meteorological fleet support services and related matters. NAVWESTOCEANCEN is responsible for the Pacific and Indian Ocean areas; NAVEASTOCEANCEN for the Atlantic and Mediterranean Sea areas; and NAVPOLAROCEANCEN for the Arctic and Antarctic areas. They utilize basic and applied numerical products from the FLENUMOCEANCEN to provide environmental broadcasts and tailored support in response to specific requests from the operating forces. NAVPOLAROCEANCEN also supports and operates a Navy-

NOAA Joint Ice Center which provides analyses and forecasts of sea ice conditions to civilian interests, as well as to DOD.

The two Naval Oceanography Command Centers (NAVOCEANCOMCENs) are located at Rota, Spain, and on the island of Guam. NAVOCEANCOMCEN Guam assists NAVWESTOCEANCEN with provision of environmental services in the Western Pacific and the Indian Ocean areas. NAVOCEANCOMCEN Rota assists NAVEASTOCEANCEN in the Mediterranean Sea area. Both of these centers provide fleet environmental broadcasts and tailored support in a manner similar to the regional centers. NAVOCEANCOMCEN Guam has an additional responsibility for operation of the "Joint Typhoon Warning Center" (with the Air Weather Service of the U.S. Air Force), providing tropical warnings to U.S. interests and DOD activities in the Western Pacific and Indian Oceans.

Seven Naval Oceanography Command Facilities (NAVOCEANCOMFACs) at Brunswick, ME, Jacksonville, FL, San Diego, CA, Yokosuka, JA, Cubi Point, RP, Keflavik, IC, and Bermuda provide limited area, local and aviation environmental forecast services. Five of these activities command assigned detachments. Primary forecast guidance is utilized by all facilities; the overseas facilities augment this guidance with data from local sources. The eighth facility, NAVOCEANCOMFAC in Bay St. Louis, MS, is responsible for Naval Reserve matters of the NAVOCEANCOM, and the management of programs concerning NAVOCEANCOM training, meteorological and oceanographic equipment, and NAVOCEANCOM publications and forms.

There are approximately 50 Naval Oceanography Command Detachments (NAVOCEANCOMDETs). Although primarily located at Naval Air Stations, an increasing number are being located at Naval Stations to provide services to sea-going units. Each is established under an Officer-in-Charge or Chief Petty Officer-in-Charge who reports to a designated shore/field activity. The majority of these detachments are oriented to provide direct environmental support, including aviation and oceanographic services, within their local areas. Detachments within the contiguous states utilize the basic and applied numerical products from both the National Meteorological Center and the FLENUMOCEANCEN to provide meteorological and oceanographic services. Overseas detachments utilize foreign and Air Weather Service (ASW) products, as available, in addition to FLENUMOCEANCEN numerical products. Three of the detachments are oriented to provide specific technical support to the NOMSS; such functions include coordination of the Navy's climatological program at the National Climatic Data Center and liaison and coordination at AWS support centers for the inter-service exchange of data and products.

NAVOCEANO operations are directed primarily to oceanography and Mapping, Charting and Geodesy (MC&G) matters. However, climatology is included in many of their publications and an appropriate atmospheric as well as oceanographic data base is maintained for this purpose.

Environmental units permanently assigned to 39 aviation capable U.S. Navy ships further augment the NOMSS. These units, staffed with environmental personnel and equipped in accordance with their designated support functions, are integral to the command to which they are assigned. Smaller units of environmental personnel, termed Mobile Environmental Teams (METs), are temporarily assigned to Navy ships upon request to meet short-term support requirements.

These METs, available from five NAVOCEANCOM activities (Rota; Norfolk; San Diego; Yokosuka; Cubi Pt.,) are outfitted with their own portable gear. Navy ships without dedicated units also contribute to the NOMSS by providing vital meteorological and oceanographic observations, often times from data-sparse oceanic areas. Technical guidance is provided by NAVOCEANCOM.

U.S. Marine Corps (USMC) garrison aviation weather units are staffed with trained meteorological personnel. They function and are supported in a manner similar to Naval Oceanography Command Detachments but under USMC management. These weather units are integral to Marine Corps aviation activities and provide support to assigned activities and tenant organizations thereof, which include nine major air stations in the contiguous United States, one in Hawaii, and two in Japan.

The Fleet Marine Force (FMF) aviation units, also staffed with trained meteorologists are indigenous to each of the twelve Marine Air Groups (MAG). They operate and maintain meteorological mobile facilities (METMF) to provide environmental support during tactical operations. The units are task organized to respond to the Commander's requirements according to the mission, functioning independently as required. While in garrison, the weather personnel and METMF equipment augment and support the host activity's weather unit.

PROGRAM DESCRIPTION

Toward meeting the mission of the Naval Oceanographic and Meteorological Support System (NOMSS), the Navy's meteorological support programs are designed to satisfy validated fleet requirements. The Navy's meteorological programs include surface and upper atmospheric observations, flight forecasting services, tailored forecast (WEAX) and optimum track ship routing (OTSR) for naval vessels, local and operating area forecasts, tropical cyclone warnings, local severe weather forecasts, high seas and winds forecasts, manual and numerically-derived analyses and prognoses, statistical and climatological studies, and a wide range of mission specific and tactical support products to the operating forces of the U.S. Navy.

The FY 1988 budget includes programs that address a total of 32 validated requirements, including 14 from the U.S. Atlantic Fleet, 13 from the U.S. Pacific Fleet, and 2 from the Naval Forces, Europe. Efforts are focused in three broad areas: shipboard tactical environmental support; upgrades to the Fleet Numerical Oceanography Center (FLENUMOCEANCEN), other Naval Oceanography Command (NAVOCEANCOM) centers, and their data distribution networks; and, enhanced capabilities at NAVOCEANCOM shore-based aviation support activities.

Efforts in the FY 1988 program are highlighted by:

1. Tactical Environmental Support System (TESS). TESS is a modular, computer-based support system designed to provide Navy decision-makers with meteorological/oceanographic assessments and forecasts and to integrate air/ocean data with sensor/weapon platform parameters to assess system performance. TESS will function as the operational, resident air/ocean master data base. Data sources will include in-situ sensors, meteorological and oceanographic satellites, U.S. and foreign radio weather broadcasts and data fields prepared ashore, principally at the Fleet Numerical Oceanography Center.

The acquisition strategy for TESS is to build upon an interim capability based on the Navy-Standard Desktop Tactical-Support Computer. This interim capability is being implemented as a non-research and development effort and will be completed during FY 1988. A total inventory of over seventy units is planned with installations keyed to major fleet combatants and selected shore activities with significant command and control responsibilities.

2. Satellite Processing Center Upgrade (SPCU). Under a Memorandum of Agreement (MOA) on the Shared Processing of Satellite Data (1984), the concept of centers of expertise (COE) was established to describe the areas of primary emphasis of each of the three participants to the MOA. In this context, the National Environmental Satellite, Data and Information Service (NESDIS) was designated the COE for atmospheric soundings, FLENUMOCEANCEN COE for sea surface measurements, and the Air Force Global Weather Center for cloud imagery. To satisfy Navy responsibilities under this MOA, a significant upgrade to FLENUMOCEANCEN's satellite processing capabilities and supporting communications is underway. Two phases are planned under this Satellite Processing Center Upgrade. The first phase (IOC October 1987) provides processing capability to support the initial implementation of the Shared Processing of Satellite Data MOA. An additional phase of SPCU beginning in FY 1988 will provide the satellite processing capabilities required by FLENUMOCEANCEN in the early 1990s. In addition to supporting shared processing, the SPCU will provide global satellite data for analysis and prediction models, imagery for product quality control, and supplementary imagery for regional oceanography centers to support areas outside local satellite-data coverage. Additional efforts to upgrade data processing within FLENUMOCEANCEN, and distribution from FLENUMOCEANCEN to other Naval Oceanography (NAVOCEANCOM) centers, will facilitate the tailoring of overall product support and data dissemination.

3. Satellite Data Receiver/Recorder, AN/SMQ-11. The AN/SMQ-11 has been developed as the next generation satellite receiving-recording system for use aboard major afloat combatants and ashore. It will replace a variety of existing Navy satellite reception systems. The SMQ-11 is composed of a planar array antenna system and two equipment cabinets for data processing. It has the capability to process encrypted transmissions from the Defense Meteorological Satellite Program (DMSP) as well as imagery from national civil satellite systems (TIROS, GOES). Satellite information from this system will be provided to the Tactical Environmental Support System (TESS) for additional processing and applications. Additional planning is underway to exploit data from satellite systems (foreign and domestic) projected for the early 1990's. Production of the AN/SMQ-11 commenced in FY 1987. Delivery and installation of initial units is planned for FY 1988. A total inventory of 72 units are programmed.

4. Lightning Position and Tracking Systems (LPATS). The LPATS detects lightning cloud-to-ground (CG) strokes over a large area with a high degree of precision, accuracy and reliability. In the past, late detection and reporting of the existence of lightning has presented a particular threat to personnel working in exposed areas. On the other hand, unnecessary false alarms have seriously impacted work schedules. Aircraft and in-port ship refueling, weapons handling and fuel storage are highly dependent on early detection of the threat of lightning as they require significant lead times to insure that proper safety precautions can be effective. The LPATS networks employ a new generation of

technology providing enhanced detection efficiency and flexibility over existing systems. Network data communications employs satellite links, replacing more costly land lines used previously. A total of 18 LPATS networks are programmed with installations concentrated along the eastern and Gulf coast of the U.S. Installation commenced in FY 1987 and will be completed in the spring of 1988.

5. Atmospheric Modeling. The primary goal of this effort is to improve fleet readiness and safety of ships and aircraft, and to enhance weapon system performance through the application of new numerical modeling technology. Weather prediction problems contain three elements: observation, forecasting, and product utilization. Improvements in product utilization are primarily being addressed within the Tactical Environmental Support System (TESS) program, previously described. Several efforts are underway to enhance the quantity, quality, and optimum utilization of observational data. Procurement of a portable, mini-rawinsonde (MRS) system, begun in FY 1987, will continue during FY 1988. MRS consists of a surface receiver/processor and lightweight balloon-borne expendable sensor package capable of measurements of pressure, temperature, humidity, and wind speed and direction. The Shipboard Meteorological and Oceanographic Observing System (SMOOS) and Automated Observing System (AOS) programs are developing shipboard and shore-based systems for improving the timeliness, quality, and reliability of meteorological and oceanographic measurements. These modular, flexible and user friendly systems will utilize proven, off-the-shelf technological components and equipments where possible. Furthermore, efforts are underway to optimize the utility of satellite data in Navy numerical modeling. In addition to data assimilation, the Air/Ocean Prediction (AOP) program plans further evaluation and optimization in FY 1988 of the Navy's Global Atmospheric Prediction System (NOGAPS) Spectral Model and Advanced Tropical Cyclone Model (ATCM). Both were initially implemented during FY 1987.

C. Summary. The impact of these programs on fleet readiness and operational capabilities is significant. By the end of FY 1988, a logical framework will be in place to ensure that a survivable, responsive and layered network can provide shore-based and in-situ support to the operating forces of the U.S. Navy.

UNITED STATES AIR FORCE

METEOROLOGICAL SERVICES

The Air Weather Service (AWS) of the Military Airlift Command (MIC) is tasked by Air Force Regulation (AFR) 23-31 to provide or arrange for staff and operational weather services to active and reserve United States Air Force (USAF) and Army units, designated unified or specified commands, and other agencies as directed by the Chief of Staff, USAF. The primary AWS mission is to support Air Force and Army combat operations in wartime. During peacetime, AWS prepares for this role by practicing special wartime support procedures and by providing or arranging daily weather support to its military customers. AFR 23-31 also defines certain related environmental and scientific support requirements to other DOD and U.S. Government agencies, foreign governments, or individuals. Collection, processing, and dissemination of atmospheric and space environmental data and weather modification are intrinsic to such support.

The Office of Management and Budget Circular A-62, 13 November 1963, divides meteorological services into two types--basic and specialized. Although involved in both services, AWS is more heavily oriented toward specialized services. The general functions involved in providing meteorological services include:

- o Observing weather conditions.
- o Communicating meteorological data and information.
- o Preparing analyses and forecasts.
- o Issuing and disseminating forecasts and warnings.
- o Providing specialized support.

Observations

Meteorological observations are frequently classified as surface, upper air, radar, or satellite observations. Observation and sensing of the space environment is discussed under Space Environmental Forecasting Program below.

Surface observations are taken by AWS personnel in support of military operations and analysis and forecasting. Observations at both Air Force and Army locations (fixed and tactical) are manually prepared with some atmospheric elements being sensed by instruments and some directly by the observer. These observations are made available to local users and are also collected by the Automated Weather Network (AWN) for transmission to the Air Force Global Weather Central (AFGWC) and to other military and civil locations throughout the world. In FY 1985, there are 111 AWS surface observing locations or facilities in the continental United States (CONUS) and 68 overseas.

Upper air observations provide the major input for numerical analysis and forecasting. Most of this information is obtained from U.S. civil and foreign sources, as well as rawinsonde (fixed and mobile) and rocketsonde facilities operated by AWS. Additional upper air information from data-void areas is obtained from USAF weather reconnaissance aircraft and in-flight pilot reports from both military and civil aircraft.

The Air Force performs aerial weather reconnaissance in support of U.S. military and national requirements. Essential weather observations are obtained by weather reconnaissance aircraft from tropical cyclones, along tactical deployment routes, from in-flight refueling areas. In addition, these aircraft provide supplemental vertical soundings over data-sparse ocean areas. Thirteen WC-130 aircraft are provided by MAC's 23rd Air Force (23AF) and seven by the Air Force Reserve (AFRES). Aerial reconnaissance weather officers and enlisted dropsonde operators are Provided by AWS and the AFRES for the 23AF and AFRES aircraft respectively.

Weather radar is a principal source of information for making short-term warnings of severe weather. AWS operates 73 fixed weather radar sets (24 at overseas locations) and six tactical weather radar sets. Two of the CONUS sets are a part of the U.S. basic weather radar network; eleven are used in a backup capacity. Also, eleven of the AWS weather radars are used to support the National Hurricane Operations Plan. The tactical weather radar sets are used to support contingency operations.

The meteorological satellite system provides a large volume of cloud, upper air and space environmental data for strategic and tactical support. The Defense Meteorological Satellite Program (DMSP) is a DOD operational satellite system managed by the Air Force to support worldwide military requirements. The DMSP was designed and developed under a total system concept to provide the specialized meteorological data required by DOD. Sensors, communications, and ground processing facilities were developed to provide maximum responsiveness to the military decision-maker. DMSP satellites are normally placed in an approximately 830-km, sun-synchronous polar orbit with a period of 101 minutes. On-board sensors provide to the AFGWC visual and infrared (IR) images of the entire globe, temperature soundings, auroral electron counts, and other specialized environmental data. DMSP also supplies direct, real-time readout of regional cloud-cover information (visual and IR) to selected military terminals located around the world.

The present DMSP spacecraft series (Block 5D) uses an Operational Line-scan System (OLS). The OLS is a digital system designed to format and store visual and IR data. The visual sensors detect the brightness of reflected solar illumination from 0.4 to 1.1 micrometers. The IR sensors measure emitted radiation in the 8 to 13 micrometer spectral band. Beginning with the fourth Block 5D series spacecraft, the infrared spectral window was narrowed to 10.5 to 12.5 micrometers to reduce the amount of absorption by ozone and water vapor. The visual sensors were selected to optimize distinction among clouds, ground, and water. Electronic circuitry converts the sensed infrared energy directly into equivalent blackbody temperature, making temperature the displayed parameter. Visual and IR imagery are obtained at near-constant cross-track resolutions of 0.5 km (fine data) and 2.8 km (smooth data). The Block 5D satellite incorporates selective redundancy and other reliability improvements to achieve longer operational life. It uses both stellar and inertial references, together with on-board processors, to maintain stability and pointing accuracy and is significantly better than earlier DMSP satellites.

The DMSP communications and ground processing systems are designed to produce usable products within five minutes after the data stream ends. The central processing facility at the AFGWC is linked to the DMSP command readout facilities via a real-time satellite link. High-quality imagery is displayed for manual use and can be input directly into the AFGWC computers. There, it is converted into cloud parameters and collated with conventional meteorological data to produce a comprehensive three-dimensional numerical cloud analysis. The Air Force system for direct local readout of DMSP data is composed of fixed and transportable terminals. The transportable terminals are self-contained units, capable of being airlifted within a matter of hours for worldwide deployment.

Communications

The utility of observations of meteorological elements depends on an effective communications network. The USAF global weather communications system provides for the collection of alphanumeric meteorological data, delivers these data to weather centrals and forecast facilities, and distributes centrally-produced products to the user. The Air Force Communications Command (AFCC) system consists of conventional weather teletype networks; high-speed automated digital facilities; long-haul, point-to-point teletype data circuits; facsimile networks; and radio and teletype intercept facilities.

The Automated Weather Network (AWN) is the backbone of military weather communications. High-speed computers interconnected with 2400-4800 baud circuitry are used to deliver foreign and domestic weather data to designated users. Data-intercept sites in key overseas areas obtain foreign weather broadcasts for AWN delivery to the AFGWC. The AWN also delivers these data to the Navy's Fleet Numerical Oceanography Center and to NOAA's National Meteorological Center. Overseas collection and dissemination teletype networks are driven by the AWN Automatic Digital Weather Switch (ADWS) computers at Hickam AFB, HI, and RAF Croughton, UK. The CONUS ADWS at Carswell AFB, TX, drives the CONUS Meteorological Data System (COMEDS) and special teletype systems within the CONUS, an integral part of the weather collection and dissemination function. COMEDS serves as the prime communications system for the collection and dissemination of military Notice to Airmen (NOTAM) message traffic to all DOD CONUS users.

The Weather Facsimile Switching Center (WFSC) at Offutt AFB, NE, is the hub of the facsimile system, providing graphic data to worldwide military users. WFSC drives the separate networks serving the CONUS, Europe and the Pacific, using computers to store and forward required products.

Data requirements of AWS units worldwide are met through a combination of routine delivery and an Automatic Response-to-Query (ARQ) system to satisfy their needs for mission-essential, non-routine weather data.

In addition to communications responsibilities, AFCC maintains the AWS meteorological equipment. The command also maintains the Air Force DMSP facilities and operates the tactical equipment. Organizational maintenance is funded through the host base while intermediate maintenance is funded by AFCC.

Preparation of Analyses and Forecasts

The primary center for providing weather analyses and forecasts for Air Force and Army operations is the AFGWC at Offutt AFB, NE. The AFGWC employs over 700 scientists and technicians (military and civilian) and uses eight computer systems. The computer-based operation of AFGWC uses a "build-and-apply" concept. Worldwide weather data are relayed to AFGWC via the AWN and blended with civil and military meteorological satellite data to construct a real-time, integrated environmental data base. Scientific computer programs further digest the data to construct models of the atmosphere and to forecast its future behavior. Final tailoring of the data is accomplished for application to the specific problem of the decision-maker. A significant improvement in the interaction between forecaster and machine is currently underway with the achievement on 28 May 1986, of Full Operational Capability (FOC) of the Satellite Data Handling System (SDHS) at AFGWC; SDHS consists of 35 interactive workstations capable of high-speed interaction with satellite and conventional meteorological data to prepare forecasts and other environmental products. Operational transition to SDHS is currently underway, with expected completion in December 1988. This transition will achieve the result of automating virtually all tasks currently performed manually within AFGWC. The Federal Plan for Mutual Support and Cooperative Backup Among Operational Processing Centers designates AFGWC as backup for the NWS's facsimile network, NMC's computational center for aviation wind forecasts, and NWS's National Severe Storms Forecast Center.

In support of tactical military operations, AWS operates centralized units consisting of AFGWC, USAF Environmental Technical Applications Center (USAFETAC), fixed theater Forecast Units (FUs), deployed Tactical Forecast Units (TFUs), and fixed Weather Support Units (WSUs). Normally weather support is a mix of centrally and locally produced meteorological products. AFGWC is generally responsible for forecaster aids (analyses and prognoses) and other operational support products which are for general purpose use by meteorologists who apply the information to specific areas or missions. Theater Forecast Units are specifically named units, e.g., the Korean Forecast Unit designated to provide forecast services and products from a fixed location for a specific geographical area, tactical operation, or exercise. A Tactical Forecast Unit provides the same services as a theater FU; however, it is activated and deployed to support a specific contingency, activity, or exercise which is not or cannot be supported by theater FUs. FU/TFU forecasts may be direct applications of AFGWC or theater FU products or may be refined based on information available locally at the FU/TFU. AFGWC directly supports deployed weather teams whenever the theater FU doesn't have support responsibilities, a TFU is not established, or during the period when the deployed TFU is not yet operational.

Dissemination of Forecasts and Warnings

The Air Force and Army require worldwide meteorological services to support specific operational and planning activities. Military users require meteorological information directed to the needs of weapon systems being developed or used; command and control systems; Army firing units; research, development and evaluation; training and deployment of military forces; and contingency operations.

AWS contributes to the unique global needs of military aviation and makes its information available to civil aviation.AWS provides pre-mission briefings, air/ground radio services, tailored observations, forecasts, and warnings for unique military requirements.

An aspect of special emphasis in military weather support is the need to provide adequate decision-assistance to commanders and resource managers. To fulfill this requirement, designated AWS personnel serve as part of the working staff of supported Air Force and Army units. In this capacity, AWS identifies all weather sensitive areas of the supported operation, monitors the weather service provided in these areas, and provides expert advice when weather threatens to restrict training or combat operations. This AWS effort helps ensure that Air Force and Army units are able to fulfill their missions in spite of adverse weather, and it results in efficient use of weather resources by gearing them to mission essential support needs.

Deployed weather teams are the basic units supporting customers in a tactical theater. These teams provide surface and upper air observations often by using tactical weather observing equipment, staff weather officer services, and forecasting support. The Tactical Weather System, Tactical Weather Radar (AN/TPS-68), and tactical meteorological satellite direct readout terminals provide the means to acquire vital meteorological data within a theater. A high frequency radio broadcast system that will transmit alphanumeric and facsimile products to the theater weather support force is planned. This system will consist of a number of regional broadcast stations. Initial operation began at Clark AFB, PI, in 1985.

Specialized Support

The USAF Environmental Technical Applications Center (USAFETAC), Scott AFB, IL, provides environmental data and specialized studies to support the USAF, U.S. Army, and other Government agencies. Typical support satisfies requirements for assessments of natural environmental effects on military plans, weapon systems, facilities, and intelligence activities. USAFETAC collects environmental data from its parent organization (AFGWC), then sorts, checks, stores and employs these data to produce tailored products. USAFETAC also operates a facility collocated with the National Climatic Center in Asheville, NC, that exchanges data and shares some facilities with that civil agency. USAFETAC typically collects, quality assures and applies worldwide surface and upper air observations; a three-dimensional cloud analyses extracted from meteorological satellite imagery (Realtime Nephanalysis);a global analysis of snow cover; solar, geomagnetic and space observations and indices; and many other specialized environmental data sets.

In addition to the specialized support provided by USAFETAC, the AWS supports an array of specialized requirements of the Air Force and Army. Some of these are described below.

AWS integrates Army weather support into its overall support concept. AWS personnel are trained and oriented on applicable Army organizations, concepts of operations, and weather sensitivities of Army operations and equipment. AWS support units are aligned and integrated with the Army intelligence organization. Support products are in a form which is directly usable and understandable by Army personnel and are integrated into Army communications systems. Mobile and fixed meteorological equipment for use in Army support is programmed by AWS. In a tactical environment, direct forecast support is normally provided down to corps, divisions, separate brigades, regiments, and groups. Observer support is normally provided at these levels and at brigade levels within the division.

AWS provides meteorological support to the nation's space and missile programs. This includes a wide range of weather observing services at the Air Force Eastern Space and Missile Center and the Kennedy Space Center. AWS also provides the forecasting service for NASA's unmanned launches at the Kennedy Center. Recently, AWS established a staff weather office in the Headquarters, U. S. Space Command.

AWS provides specialized meteorological services for the Air Force Western Space and Missile Center at Vandenberg AFB, CA, and the Pacific Missile Range which includes Pt. Mugu and San Nicholas Island, CA, and Barking Sands, HI. AWS also supports the White Sands Missile Range, NM, the Kwajalein Missile Range, and other DOD research and test facilities.

The Air Force and the Navy operate the Joint Typhoon Warning Center on Guam under the Naval Oceanography Command Center, Guam. The Center provides tropical cyclone warning services to DOD units and other US subscribers in the area west of 180° to the east coast of Africa in both hemispheres.

The Air Force and NOAA operate the Joint USAF/NOAA Space Environment Services Center at Boulder, CO. The Center provides space environmental data to AFGWC, other U.S. Government agencies, and non-Government agencies such as universities.

Through the AFGWC, AWS directly supports DOD Special Strategic Programs, the National Command Authority, the National Military Command System, and the National Security Agency. Tailored environmental support products are disseminated to these customers worldwide.

Planned Enhancements

USAF and Army operational requirements for environmental support are the basis for all AWS actions to improve existing or acquire new capabilities. AWS assesses these requirements and attempts to satisfy them through either hardware acquisitions or technique development.

AWS plans to modernize its base-level weather support systems. This includes an Automated Weather Distribution System (AWDS) and the Next Generation Weather Radar (NEXRAD). Both of these systems have funds budgeted for their R&D phase.

The AWDS will automate the handling of weather data by incorporating the latest state-of-the-art data processing, communications, and display technologies. The data-handling function will maximize forecaster capability. A modular design will permit AWDS to be operated in a fixed or mobile environment and minimize staffing requirements. Initial installation is planned for mid-1989 with completion of overseas and tactical installations by 1992. AWDS will be able to receive information from the National Weather Service through the AFGWC via the AFOS at the AFGWC.

AWS plans to significantly enhance its tactical warfare weather support capability through employment of the Battlefield Weather Observation and Forecast System (BWOFS). BWOFS involves the development of two capabilities: one, called Tactical Decision Aids (TDA), to provide weather support for electro-optical (E-O) target acquisition, weapons guidance, and reconnaissance systems, and the other, the Pre-Strike Surveillance/Reconnaissance System (PRESSURS), to acquire weather observations in uncontrolled or enemy controlled areas of the battlefield. TDA and automated algorithms are scheduled for fielding in tactical C2 computers by 1989; and, PRESSURS is scheduled for initial operation in 1993.

NEXRAD is being procured under the auspices of the NEXRAD Joint System Program Office. NEXRAD will be an automated, digitized, S-band Doppler system that will be jointly developed, procured, operated, and maintained by the DOD, NOAA, and FAA within the CONUS and by the USAF overseas. The system will be designed to incorporate the latest technological advances in Doppler radar, data processing, communications, and display. The CONUS NEXRAD network will satisfy weather radar requirements in support of the general public, the military, and the entire spectrum of the aviation community. Installation of the NEXRAD is planned between 1989 and 1994.

Weather Reconnaissance is scheduled to have the Improved Weather Reconnaissance System (IWRS) operational in 1989. The IWRS prototype began test flights in 1985. The system, which will incorporate the new USAF inertial navigation system (INS) for improved positioning is being built as a joint NOAA and USAF project. IWRS will provide an automated data gathering capability, improved flight level wind determination, a windsounding capability, and satellite data relay from the reconnaissance aircraft. This greatly improved reconnaissance package will be capable of gathering and transmitting vastly increased quantities of data for use in computer prediction models.

In the area of atmospheric pressure measurement, the USAF has converted from wide-bore, mercurial barometers to dead-weight piston gauges used as regional primary pressure standards. Digital barometer and altimeter setting indicators are being delivered by the manufacturer and several have been installed. The unit is solid state, easily transportable, highly accurate, and mercury free. This will eliminate base weather station mercurial barometers and their associated health hazard due to mercury contamination. Funds have also been approved to procure replacement temperature/dewpoint equipment, wind measuring equipment (low level, fixed, and tactical), tactical meteorological sets and to upgrade cloud-height measuring equipment. Installation of the temperature/dew point equipment began in March 1987 and will continue through the end of 1989. Contracts were awarded in FY 1985 to acquire transportable cloud-height measuring equipment and to replace and expand the existing equipment for the worldwide ionosonde network. Delivery of equipment begins in July 1987. A contract for a replacement for the radio wind sounding receiver was awarded and delivery began in May 1986.

A program of Preplanned Product Improvements (P^3I) to the Satellite Data Handling System (SDHS) is currently underway at AFGWC, with scheduled completion by late FY 1989. This program will improve the reliability of the SDHS and add new capability such as the AWDS Product Driver to the Baseline SDHS.

The analysis and forecast preparation capability of the AFGWC has been enhanced by the implementation of the Advanced Weather Analysis and Prediction System (AWAPS). The AWAPS program hardware consists of a supercomputer for processing numerical models and two database computers to supply data to the supercomputer and to store and handle the increased resolution products from the supercomputer. The two Sperry 1100/70 database computers became operational in late 1984. The Cray X-MP supercomputer became operational during early 1985. Two new software models were implemented by the AWAPS. AWAPS software consists of the AFGWC developed High Resolution Analysis System (HIRAS), the Global Spectral Model (GSM) and the Relocatable Window Model. The latter two models were developed under contract by the National Meteorological Center (NMC). The three models will provide a significant increase in the accuracy and resolution of analyses and forecasts at the AFGWC. In January 1988, the Relocatable Window Model (RWM) will be implemented, joining the HIRAS and GSM models that became operational in 1985-1986.

In addition, the AFGWC will replace its three 10-year old Sperry/Univac 1110 computers with Sperry 1100/91 computers in early 1987. The new computers provide an increased capacity to process meteorological satellite data and meet increased classified customer requirements for environmental products.

An advanced solar polar prediction model will be implemented by AFGWC by the beginning of FY 1988. The new model has a number of significant improvements over the earlier versions of the model, which have been used for the past decade. The new version includes forecasts for "heavy ions" (atomic nuclei heavier than hydrogen), as well as improved algorithms for solar proton arrival time, magnitude, and time-intensity profiles. In addition, the new model can make predictions in 14 different energy ranges: 10 have been selected for satellite anomaly forecasting; two for predicting radiation dose expected for an astronaut inside or outside a polar-orbiting shuttle; and two channels to predict the amount of polar cap, high-frequency radio wave absorption.

SPACE ENVIRONMENTAL FORECASTING PROGRAM

Many DOD systems operate in, or are affected by,conditions above 50 kilometers. The ionosphere, near-space, and deep-space are collectively referred to as the space environment. The AWS provides basic and specialized support to military electromagnetic communications, surveillance, and warning systems which operate in this environment. AWS provides environmental forecasting and specialized services in the major technical areas of: (1) forecasting and specification of ionospheric variability, (2) state of the magnetosphere, (3) forecasting and specification of solar flare and solar particle events, and (4) providing geomagnetic and solar indices to users for determining upper atmospheric density variability. The hub of the AWS space environmental forecasting program is the AFGWC Space Environmental Support Branch which provides the only operational space environmental support within the DOD. The AWS is now planning to move the space environmental support functions and manpower positions to Falcon AFS, CO, where they will be established as the Space Forecast Center.

Data Sources

USAF operates and funds for a variety of ground-based and space-based solar-geophysical sensors. The Solar Observing Optical Network (SOON) is comprised of AN/FMQ-7 solar optical telescopes located in Puerto Rico, New Mexico, Hawaii, Australia, and Italy. The Radio Solar Telescope Network (RSTN) is comprised of four AN/FRR-95 solar radio telescopes; a prototype in Massachusetts; and three others in Hawaii, Australia, and Italy.

USAF operates, or funds for the operation of, numerous other geophysical sensors as shown in the following table:

Sensor	Purpose	Locations
Polarimeters	Measure total electron content of ionosphere	Six, N. Hemisphere
Ionosondes	Measure ionospheric electron density profiles	Eight, N. Hemisphere
Magnetometers	Measure changes in geomagnetic field	Six, mid-high latitude

Defense Meteorological Satellite Program	Measure precipitating electron flux, ion flux, ion density, electron/ion temperature, and provide optical auroral pictures	Polar orbit
DOD Spacecraft	Measure high energy and low energy electron/protons	Geostationary orbit
Solar X-ray Imager (Programmed for FY 1991 on NOAA GOES-Next)	Locate position of solar flares, measure solar X-rays	Geostationary orbit

Data Provided

Space environmental support encompasses the present state and forecasts of the sun, the interplanetary medium, the near-earth space environment, and the ionosphere.

Solar Flares: The SOON (AN/FMQ-7) was specifically designed to provide consistent, rapid flare observations and data for reliable, short-term forecasting of solar flares and their effects. Currently, the actual work on exploitation of SOON data by applying advanced modeling techniques is being accomplished by the Air Force Geophysics Laboratory, Hanscom AFB, MA, and NOAA's Space Environment Laboratory (SEL) located at Boulder, CO.

USAF has four AWS people assigned to the SEL in Boulder. Real-time support has included the production of forecasts and the installation of a computer-to-computer data link system between the SEL at Boulder and the AFGWC at Offutt AFB. This system provides proton and X-ray flux measured by NOAA/GOES satellites; hourly summaries of proton, X-ray, electron, and geomagnetic data; and 90-minute summaries of geomagnetic field variations taken from the Boulder magnetometer. Other real-time support from SEL has been furnished using dedicated communications to relay measurements and assist in the development of joint USAF/NOAA products.

Geomagnetic Index: AFGWC monitors variation of the Earth's magnetic field through the use of ground base magnetometers. Data from these sensors are processed at AFGWC to develop a geomagnetic index which is transmitted to users for real-time use in density models. Recently, AFGWC has expanded its magnetospheric monitoring by using real-time low energy particle data from operational DOD geostationary spacecraft as well as magnetospheric observations from the GOES satellites.

Ionospheric Variability: AFGWC forecasters monitor the state of the ionosphere, the sun, and the magnetosphere and provide notifications and forecasts of ionospheric irregularities. Short term forecasts for high frequency communications systems can be provided in real time as can specification and forecasts of electron density profiles and total electron content. Large-scale fields of parameters, such as the critical frequency of the F2 layer, are also available. The primary long-range forecast requirements are for HF radio propagation.

AFGWC uses the ITS-78 and Ionospheric Conductivity and Electron Density (ICED) programs to provide this support. The program has been modified for direct interface to the Automatic Digital Network both for receiving requests and for transmitting its output to worldwide military users.

Event Notification: Since the state-of-the-art in accurately forecasting solar and geophysical events is limited, AWS has concentrated on providing rapid notification to system operators of actual solar events which could degrade the performance of their systems. Rapid event notification is provided for decision assistance to all levels within the military chain of command. Typical types of notification include: solar events which cause disruption to high frequency communications on sunlit paths; solar radio bursts which may cause disruptions to communications systems and/or interference to radar systems; solar proton events which can produce radiation hazards to both personnel in space and spacecraft; ionospheric disturbances which can cause degradation to HF and satellite communications systems; and magnetospheric disturbances which affect the orbital parameters of low altitude satellites. The Proton Prediction System model upgrades will enhance AWS forecasts of solar proton events. AFGWC notifications of these events are usually provided within minutes of detection of a disturbance and are specifically tailored for each system operator.

SUPPORTING RESEARCH

The overall objective of the Air Force meteorological research program is the development of techniques and equipment for observing and predicting meteorological conditions that affect military systems and operations. Requirements for research and technology in meteorology are expressed in Air Force Technology Planning Objectives, Research Objectives, Technology Needs, Statements of Operational Needs, and Development Goals. In addition, the Air Weather Service provides guidance in the form of documented geophysical requirements and research objectives. The Air Force Geophysics Laboratory (AFGL) at Hanscom AFB, MA, has the mission responsibility within the Air Force to conduct both in-house and contractual basic research, exploratory development and advanced development in the environmental sciences, including meteorology.

Its meteorology program in the area of exploratory development places emphasis on moisture and cloud numerical weather prediction, ground-based and satellite remote sensing, climatological studies, boundary layer meteorology, cloud physics, and battlefield weather observation and forecasting. Research and development for the Defense Meteorological Satellite Program is also conducted, primarily under contract.

In the area of moisture and cloud forecasting, research is being pursued on global and mesoscales. The short-range (0-6 hr) advection model was upgraded with satellite input and is in the process of being upgraded with radar input. Research with a mesoscale cloud model is focussing on improved boundary conditions and accounting for local forcing. Global model cloud forecast errors were diagnosed, compared to AFGWC operational cloud forecasts and new moisture-to-cloud algorithms are being developed. New physical parameterization schemes for cumulus convection, boundary layer processes and radiation (including input from satellite sensors) have been developed and are being tested on the global model. The initial regional model was completed and will undergo testing and modification. The cloud scale model was tested in preparation for sensitivity studies. This model defines cloud development/dissipation effects. Forecaster effectiveness in an automated operational environment, such as the Automated Weather Distribution System (AWDS), will be evaluated using AFGL's Automated Interactive Meteorological System (AIMS). Also, an evaluation of the contribution of continuous wind measurements from a vertically pointing VHF radar to the numerical modeling and realtime monitoring of developing mesoscale weather systems is underway. Finally, an assessment of the utility of Artificial Intelligence/Expert Systems in short-range weather forecasting is being pursued. Support will remain the same in this area unless additional funding becomes available in later years. The long range goal of this effort is to transfer a revised Numerical Weather Prediction (NWP) model to AFGWC by FY 1989/1990.

In the ground-based remote sensing area, automated Doppler weather radar-based techniques are being developed for the detection of hurricane characteristics and severity, 4-D cloud and precipitation predictions, and hail size estimation. There is an urgent need to incorporate these techniques into the joint DOD, DOC, and DOT Next Generation Weather Radar (NEXRAD), presently undergoing development. Coherent polarization diversity weather radar techniques to derive hydrometer characteristics, such as particle size distribution, orientation, and thermodynamic phase, will be tested. Also, instrumentation for combined weather radar and satellite imagery processing will be utilized for the automated estimation of cloud motion and for integrating these motions to map cloud and precipitation systems in three dimensions. Doppler weather radar techniques will be developed for the detection and assessment of clear air convection and convergence for the timely identification and forecast of regions conducive to thunderstorm initiation. This research directly supports the development of the Next Generation Weather Radar (NEXRAD) and is expected to remain constant.

In support of satellite meteorological requirements, improved inversion algorithms will be developed to compute more accurate vertical temperature and water vapor profiles from satellite-measured radiance data at far-infrared and microwave wavelengths. A versatile cloud-truth data field will be established. This data field is essential for the future evaluation of cloud algorithms using satellite observations. The use of microwave imagery information for mapping meteorological parameters such as rain rate, ocean surface wind speed, and soil moisture will be evaluated. Also, techniques will be developed for incorporating microwave imagery data into the cloud analysis programs at the AF Global Weather Central. A moderate increase in support for this research is planned to develop the new analytical methods in satellite meteorology with the ultimate goal of more accurately depicting cloud characteristics (i.e., cloud heights, cloud thickness, phase (ice/water) and rain areas).

In climatological techniques development, weather simulation models are being developed to replicate numerically typical weather sequences for operational applications. Research in modeling clouds and visibility is being expanded to include additional atmospheric elements, specifically to include a mesoscale environmental simulation package to provide a realistic sequence of weather events at any specific location. This model will allow environmental factors to be considered in the design stage of weapon systems and for application to war games. Research into the specification of the probability for simultaneous cloud-free viewing from multiple sites under various cloud conditions is ongoing. The following climatological studies will be completed: rainrate duration modelling, analysis of high resolution cloud photographs taken from orbit used to quantify the distribution of cloud sizes, of clear intervals and of the variation in apparent cloud cover as view angle changes. An increase in support for climatological studies is planned. These efforts will likely be applied to a problem now under investigation regarding reentry vehicles.

In boundary layer meteorology, work will continue on developing toxic chemical dispersion models for various scenarios. The toxic chemical dispersion model for smooth terrain and uniform wind fields (AFTOX) is now being reviewed by the Air Weather Service which is considering this model as a replacement to their current dispersion model. A heavy gas dispersion model is being developed under contract and will be available by August 1987. A user's manual for the terrain-induced surface wind flow model developed in FY 1986 will be written. Additional improvements and testing of the model over the next two years are anticipated. A complex terrain dispersion model, which is a combination of AFTOX and the wind flow model, will undergo further development and testing. The updated terrain dispersion model will be delivered to the AWS in FY 1989/1990. A small decrease in support has caused a delay in the delivery of the model.

The major thrust of the cloud physics program will emphasize the development of computerized mathematical models for forecasting the microphysical structure of clouds and cloud systems, given macroscopic statements about the nature of the atmosphere. Also, the extremely high frequency (EHF) data reduction and interpretation from the Division's Weather Attenuation Program will continue and the microphysics of the cloud model will be tested against available data sets. The Weather Attenuation Program includes the simultaneous measurements of EHF attenuation and detailed microphysics of the clouds, rain and snow in the melting layer. The support in this research will change from meteorology observation to prediction with the long-term goal to develop the prediction capability for electro-optical attenuation, airframe icing, and missile targeting.

The battlefield weather program will emphasize the development of low-cost expendable instrumentation for measuring humidity, transmission at visible and infrared wavelengths, and the macroscopic characteristics of clouds and cloud systems (cloud cover amount, cloud tops and bases). A system capable of collecting weather information in battle areas not under friendly control will be fabricated and demonstrated at a test range. Operational Tactical Decision Aids (TDAs) will be developed for CO_2 laser and millimeter-wave precision guided munitions and target acquisition systems as required. TDAs for infrared, TV low-light-level and 1.06 um laser systems will be upgraded to include new targets, backgrounds, and systems, such as Night Vision Goggles used by our Special Operations Forces.

DEPARTMENT OF ENERGY

The Department of Energy (DOE) supports meteorological services at nine of its laboratories and at the Nevada Test Site. Services include climatological summaries, general weather forecasts, and items specifically in support of laboratory operations such as environmental monitoring, atmospheric sciences research, and hazardous material release assessments. The National Weather Service Nuclear Support Office at the Nuclear Test Site provides continuing meteorological services required by the safety and technical programs associated with all forms of nuclear and non-nuclear experiments conducted at the test site and other locations.

DEPARTMENT OF INTERIOR

A principal meteorological activity of the Department of Interior (DOI) is the weather modification research program called Project Skywater, administered by the Bureau of Reclamation, dedicated to augmenting water resources in demonstration of a practical precipitation management technology. Other Bureau of Reclamation activities including water scheduling, flood hydrology, irrigation project management, and reservoir operations, as well as projects related to the development of wind and solar energy resources, also require the collection and use of meteorological data. Currently, Reclamation operates approximately 400 hydrometeorological data collection platforms (DCPs) and collects near real-time data through two GOES direct readout ground stations (DRGS) in Denver, CO, and Boise, ID.

The Water Resources Division of the Geological Survey collects precipitation, stream flow, and other climatological data for a number of projects concerning rainfall/runoff and hydrologic processes. Currently, the Geological Survey collects hydrometeorological data from approximately 1,800 GOES DCPs through four DRGS. Precipitation and dryfall atmospheric deposition samples are collected in a number of studies for the determination of atmospheric contribution to the chemical constituent loads to runoff, and for defining the effect of atmospheric deposition on water quality and the aquatic environment. The Geological Survey provides lead agency coordination for the atmospheric deposition monitoring program of the Interagency Task Force on Acid Precipitation.

The Geological Survey is continuing a joint research program with NASA to map snowpack water equivalent using satellite passive microwave techniques. Comparison of data collected by the Department of Agriculture's Soil Conservation Service Snow Telemetry (SNOTEL) sites, by Survey field teams, and through instrumentation by other agencies is being made to test the feasibility of making near real-time assessments of snowpack from space.

The Bureau of Land Management in DOI collects meteorological data from a system of remote automatic weather stations and operates a lightning detection system, containing wideband direction-finders that respond primarily to cloud-to-ground lightning, in its fire and resource management programs. This effort is fully integrated with the U.S. Forest Service fire weather system. The Bureau of Land Management operates approximately 200 fire-weather DCPs and collects data from its own and another 200 Forest Service DCPs through a DRGS base at Boise, ID.

The Minerals Management Service Environmental Studies Program gathers offshore environmental data in support of its mineral leasing responsibilities. Currently, the Service supports approximately 20 data buoys which transmit via NOAA satellites.

The National Park Service monitors air quality in several national parks and monuments. Approximately 20 GOES DCPs are used to collect these data.

DEPARTMENT OF STATE

The Department of State interests in meteorology are general but touch a number of areas. They involve the international aspects of food and feeding the world, disaster warnings and assistance, long-range concern with the socio-economic effects of climate change, World Meteorological Organization activities, international meteorological programs, and concern with some programs which start as operating programs but develop international interest and concern such as the possibility of seeding of storms in the Pacific.

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

RESPONSIBILITIES FOR AVIATION WEATHER

The Federal Aviation Administration (FAA) is responsible for the safety and separation of aircraft and the efficiency of flight operations. The adequacy of aviation weather information contributes significantly toward fulfilling these responsibilities. FAA makes recommendations to the U.S. Department of Commerce on civil aviation meteorological services, provides specialized equipment at certain airfields, observes and reports the weather at about 360 airports, distributes weather data over civil communications systems, and provides the principal means for disseminating weather information to pilots.

Weather information for pilots is made available through Flight Service Stations, recorded messages broadcast over navigational aids, special weather broadcasts, and telephone answering systems. Air Route Traffic Control Centers have weather service units manned by National Weather Service (NWS) meteorologists to assure that vital weather information is available to controllers and pilots.

FAA maintains a continuing research program to improve aviation weather service to the users of the National Airspace System. FAA also engages in engineering efforts to improve weather observations and communications related to aviation.

The Aviation Weather Program is aimed at progressively improving the timeliness and accuracy of weather information provided to aircrews and to the Air Traffic Control (ATC) system to reduce the number of weather related accidents and incidents and to increase both system capacity and fuel savings by reducing weather related delays. Facets of the program are conducted in close cooperation with the National Weather Service (NWS). Wherever practical, the objectives of this program are accomplished by enhancing existing and planned air traffic control and flight service station system components and facilities for the collection, processing, and dissemination of significant weather information.

PROGRAMS FOR AVIATION WEATHER

En Route Weather Radar Program

This program supports the definition, development and implementation of the next generation weather radar (NEXRAD) for en route applications. NEXRAD will provide accurate aviation-oriented products concerning reflectivity, wind velocity, and turbulence indicators based on software algorithms which take full advantage of the improved detection of these weather phenomena.

Radar weather presentations available from today's systems provide limited data for air traffic control (ATC). Improved weather data will increase aviation safety and fuel efficiency. In addition to the benefits to be gained in today's system, future automated ATC functions and improved traffic-flow management require reliable and accurate weather data so that projected maximum fuel savings and manpower productivity gains based on these improvements can be realized.

Implementation costs associated with NEXRAD are being funded jointly by the Department of Commerce, the Department of Defense, and the FAA. The program is being managed by a Joint Special Projects Office within the Department of Commerce, and is being developed and acquired under the auspices of the NEXRAD Program Council within the Office of the Federal Coordinator.

NEXRAD implementation in the field is scheduled to begin in 1989 and be completed in 1995. The number of NEXRAD units to be acquired is being determined by the participating agencies.

FAA is emphasizing the development of future algorithms that take advantage of the improved detection of precipitation, wind velocity, and turbulence, and provide new or improved aviation-oriented products.

To improve hazardous weather detection, reduce flight delays, and improve flight planning services, the joint NEXRAD program provides several aviation weather products related to wind, wind shear, turbulence, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones-tornadoes. In FY 1988, research activity will concentrate on the development of icing, wind shear, and other aviation-related algorithms.

Terminal Next Generation Weather Radar (NEXRAD)

Initially, the FAA is diverting 17 of its non-network NEXRAD units to major airports where they will provide interim wind shear detection support until replaced by the Terminal Doppler Weather Radar (TDWR). These initial units will be identical to the NEXRAD hardware, but will utilize a different software package. Implementation of these units is scheduled for the 1990-1992 time frame. When replaced by the TDWR, the units will be relocated to their originally intended locations (principally in Alaska, Hawaii, and the Caribbean) where they will provide NEXRAD-type coverage for the National Airspace System.

Terminal Doppler Weather Radar (TDWR)

This program consists of the procurement and installation of a new terminal weather radar based on Doppler techniques. The TDWR will be optimized to detect microbursts and wind shear. In addition, it will produce weather products such as precipitation areas and intensity, wind, turbulence, thunderstorm location, and storm movement.

Microbursts are weather phenomenon that consist of an intense downdraft that may occur in clear air or in precipitation, and are particularly dangerous to aircraft that are landing or departing. The TDWR scanning strategy will be optimized for microburst/wind shear detection. The radar will be located on or near the airport operating areas.

Trade studies that examined alternative designs, frequency comparisons, and other design considerations have been completed by the NEXRAD development contractors. These studies contributed to the specification of the TDWR. Algorithms are being developed by the Government. Data collected with the FAA transportable Doppler weather support facility (at Memphis, TN, Huntsville, AL, and Denver, CO) provided the primary basis for development and validation of the algorithms. This facility was used to evaluate the operational aspects of TDWR and will continue to support the evaluation of enhancements to the present algorithms and the development of new algorithms.

A competitive contract will be awarded late in FY 1988 for turnkey TDWR installations at sites specified by FAA. Field implementation will occur in the 1992 to 1996 timeframe.

Related FAA activities will provide algorithm enhancements to improve the detection and identification of dangerous wind shear and other hazards in the terminal/airport environment.

In FY 1988, research will continue on the enhancement of the microburst detection algorithm to provide an indication of where these phenomena are forming. This will provide advance warning of wind shear conditions. Also, work will be done on algorithms that will predict where thunderstorms will form.

Low Level Wind Shear Alert System (LLWAS)

LLWAS, also, provides pilots with information on hazardous wind conditions that create unsafe conditions for aircraft landings or departures. It is an ongoing program which, when completed, will provide 110 enhanced systems. The basic capability, completed at all 110 sites in 1987, consists of a wind sensor located at center field and five sensors near the periphery of the airport. A computer processes the sensor information and displays wind shear conditions to air traffic controllers for relay to pilots.

LLWAS was initially conceived to be an interim system to be replaced when a better system matured. However, it now appears that the enhanced system may become an integral part of the terminal weather detection capability. Also, a combination of LLWAS/TDWR may result in a more effective capability, and will provide redundancy at high-threat/high-traffic airports.

Both near and long-term modifications lead to the implementation of the enhanced LLWAS. Near-term modifications consist of improving the algorithms associated with the 6-sensor basic capability systems, correcting sensor siting (including height), incorporating data recorders, and updating the computers. Field implementation of these modifications will be completed in FY 1988.

The long-term modifications include expanding the existing systems to 11 sensors, developing improved algorithms for the 11-sensor system, and designing new information/alert displays. These improvements will increase the system's wind shear detection capability, reduce false alarms and enhance maintenance features. They will be implemented in the field starting in FY 1988 and will be completed in 1992.

FAA is conducting studies to improve LLWAS performance with respect to increased detection probability, reduced false alarms, and improved interpretability, and to develop pilot and controller procedures based on the characteristics of the identified hazard.

LLWAS algorithms are being developed by NCAR to improve wind shear detection at airports that will enable controllers to make recommendations to pilots on runway usage and possible waveoffs (termination of the approach) necessitated by the hazard. In addition, displays are being developed that will enable a controller to quickly evaluate the hazard and recommend actions. Operational procedures will be developed for rapid and appropriate actions by the controller and the pilot in response to a dangerous wind shear event.

In the future, LLWAS and TDWR will work in conjunction to provide wind shear detection and alarm. Studies will be conducted on how these systems can be combined into an integrated capability based on a single wind shear display for the air traffic controller, and on how integrated wind shear information can best be communicated to the pilot. Also, studies will be conducted to evaluate other sensors for the airport approach and departure corridors. These sensors are intended to provide wind shear detection out to three miles from the touchdown zone.

Automated Surface Weather Observing Program

This includes the activities of the FAA in acquiring automated surface weather observing systems; acquiring related data acquisition systems; and development, test, and evaluation of weather sensors.

AWOS/ASOS Acquisition. Automated surface weather observations will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, barometric pressure, cloud height, visibility, precipitation type, occurrence and accumulation) through the use of automated sensors. It will process these data, and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

The FAA has a need to implement as soon as possible Automated Weather Observing Systems (AWOS) at 160 airports to provide the basic aviation weather products directly to pilots approaching the airport. The majority of these systems would be installed at various nontowered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that currently do not have a local weather reporting capability. Some of these systems will be used to support an Air Traffic operational evaluation at former flight service locations that currently employ contract weather observers.

The FAA plans to acquire these systems via a competitive invitation for bid based upon the specification established to qualify candidates AWOS systems for procurement by state and local governments. These systems--which are built to the standards of quality necessary to ensure the safety of flight operations--are believed to be available off-the-shelf as a commercial product. The FAA has asked NOAA to procure, install, operate, and maintain ASOS systems at the remaining airports where FAA personnel take observations and at nontowered airports with instrument approaches.

Automated Weather Observing Systems (AWOS) for Non-Federal Applications. The majority of airports within the National Airspace System (NAS) do not have a local weather reporting capability. For example, operations for commercial operators under instrument flight rules are restricted at over 1,300 airports because of the unavailability of weather observations.

Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using dollar resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement, as well as the funding for the regular maintenance necessary to maintain the system. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance.

During 1986, the FAA completed the specification document that establishes the criteria necessary to provide confidence in the quality of the meteorological data provided to the aviation community by the AWOS. These criteria establish: (1) the data and documentation to be provided by the manufacturer to establish that the equipment provides the quality information required by the aviation community; (2) the verification that the equipment is correctly installed and operating properly, and that the owner has the resources to maintain the system in proper operating condition; and (3) the requirement for aperiodic visits to the operating AWOS by the FAA or other technical representatives to verify that the system continues to operate correctly.

This non-Federal AWOS is available in three versions. An AWOS I system contains sensors to measure wind data (speed and direction), ambient and dewpoint temperature, altimeter setting, and density altitude. An AWOS II contains the AWOS I sensors plus a visibility sensor, and an AWOS III adds a cloud height sensor to an AWOS II. Most important, all versions are required to have the capability to broadcast a minute-by-minute update of the current weather to the pilot by radio, using a computer generated voice output from the AWOS. This AWOS may have the capability that enables the pilot (or other user) to call the AWOS on a telephone and obtain the current weather observation during his pre-flight activities. In addition, the observation may be transmitted to the data bank within the national weather network.

The AWOS I and AWOS II systems, manufactured by two companies, have been certified for use in the NAS (and therefore qualify under the AIP). Certification of an AWOS III for these manufacturers is dependent upon qualification of a laser cloud height indicator for unattended operation, an action that should be completed by June 1, 1987. About five other manufacturers are in various stages of completing their applications to obtain approval for their AWOS systems.

AWOS/ASOS Data Acquisition System (ADAS). ADAS will function primarily as a message concentrator collecting weather messages from AWOS and ASOS automated surface observation equipment located at controlled and non-controlled airports within each air traffic control center's area of responsibility. It will distribute minute-by-minute AWOS/ASOS data within the center in which it is installed, and provide for national distribution of AWOS hourly and special observations through FAA's Weather Message Switching Center Replacement (WMSCR) facilities. This will make weather observation data available to pilots and air traffic controllers on a timely basis within the "local" area, and provide necessary distribution of the data to NWS, and other users.

The acquisition of ADAS will be accomplished via prototype and production. Field implementation will start in 1991 and be completed in 1993.

Weather Sensor Development, Test and Evaluation. This activity (1) evaluates new systems and techniques for the measurement of surface weather parameters, (2) tests the capabilities of improved weather sensors, and (3) supports research studies on weather conditions that are hazardous to flight operations.

Because of the importance of reliable, complete and timely surface observations to aviation safety, and the need to reduce the cost of obtaining these observations, the FAA supports advanced weather sensor development activities. The work is conducted primarily by the NWS and the National Oceanic and Atmospheric Administration's (NOAA) Environmental Research Laboratory. Sensor technologies being investigated include: 1) laser and infrared forward scatter and back scatter meters for visibility; 2) cloud height indicators for measurements above 5,000 feet; 3) laser-based detectors that can discriminate between hydrometers (rain, freezing rain, hail, snow, etc.) and lithometeors (dust, smoke, haze, etc.) and can measure any associated precipitation rates; 4) lightning detection systems; and 5) evolving technologies for the detection and measurement of icing and clear air turbulence. Algorithms which utilize the measurements of several different types of sensors will be investigated to identify existing weather conditions.

In FY 1988, work will be conducted to refine precipitation-discrimination sensors. Lightning detection network data will be integrated into the automated surface observation systems to provide advisories on lightning activity in the vicinity of the airport directly to the pilot via an appropriate communications outlet.

Flight Service Station Automation System (FSAS)

This program will improve user access to weather and Notice to Airmen (NOTAM) information, simplify flight plan filing, and provide a flight service station automation system that will meet the projected increases in demand for flight services without proportional increases in staff. Automation is being developed and implemented in two stages: 1) FSAS Model 1 (limited automation), and 2) FSAS Model 2 (full automation). Consideration is being given to increasing the processing capability of the Model 1 system over that presently planned to support the consolidation of additional existing Flight Service Stations into Automated Flight Service Stations.

The first Model 1 system was commissioned in 1986, and the last system in FY 1987. Three stages of development are planned for Model 2. They provide increased system capacity, improved flight service specialist aids, and the capability to retrieve additional meteorological products for pilot briefings. All Model 1 systems will be converted to Model 2s.

The capability for direct user access terminals to improve pilot access to weather information and flight plan filing, and the capability for stand-alone specialist weather graphics will be leased or purchased from commercial vendors. Through 1988, 37 automated flight service stations will be commissioned. All 61 will be commissioned by 1992.

Weather Message Switching Center Replacement (WMSCR)

WMSCR replaces the weather message switching center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, MO, with state-of-the-art technology. It will perform all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of Notices to Airmen (NOTAM). It will rely on FAA's National Airspace Data Interchange Network (NADIN) for a majority of its communications support. The system will accommodate graphic data and function as the sole FAA gateway to the National Meteorological Center and, therefore, will be the source of NWS products for the National Airspace System.

To provide for geographic redundancy, the system will have nodes in the NADIN buildings in Atlanta, GA, and Salt Lake City, UT. Each node will support approximately one-half of the United States and continuously exchange information with the other to ensure that both have identical national data bases. In the event of a nodal failure, the surviving one will assume responsibility for the entire network. The implementation of WMSCR will allow the closing of NATCOM.

The production contract will be awarded in FY 1988, and the system will be implemented in the field in 1991.

Weather Communications Processor (WCP)

WCP will implement data link services to aircraft utilizing the discreetly addressed data link capability of the FAA's Mode S surveillance system. It will receive downlink requests for weather products from aircraft, formulate replies and return them to the pilot via the data link. This will improve air-ground communications services by expanding the pilot's ability to access desired weather information while operating on the airport surface or in flight. It will also reduce the workload of flight service specialists and air traffic controllers who currently provide the only means of such access.

Initially, the data link services to be implemented will be those for which automated data bases currently exist, or are planned to be operational in the near term. These include alphanumeric products such as SIGMET, AIRMET, surface observations, terminal forecasts, winds aloft, pilot reports and alphanumeric radar summary information.

The contract award for system development will be made in FY 1988. Field implementation of these initial products and services will begin in 1990 and will be completed in 1992.

Central Weather Processor (CWP)

CWP will improve the dissemination of weather information throughout the National Airspace System to pilots, air traffic controllers, flight service specialists, traffic management specialists, and NWS meteorologists assigned to weather service units in the air traffic control centers and the central flow control facility. It will provide specialized automated tools to these meteorologists which will greatly enhance their ability to summarize hazardous weather information and ensure that the latest and best information is disseminated to all users. CWP will also provide for a near-real-time, area mosaic of weather radars (NEXRAD) for subsequent distribution to controller displays. These improvements are necessary to reduce the high percentage of accidents and delays directly related to weather.

Detailed design of the prototype system will be completed in FY 1988. Test and evaluation of the prototype will be completed in 1991. A production contract award will be made in 1992. Field implementation will be initiated in 1994 and completed in 1995.

Requirements for the CWP and other specialized elements of the planned National Automated Weather Information System (AWIS) are being integrated under the auspices of the AWIS Program Council within the Office of the Federal Coordinator. The intent of this activity is to avoid unnecessary duplication of development effort and to assure the effective interconnection of the AWIS elements and the sharing of information and products in the operational phase.

Weather Processing

A new FAA project supports the development of the Central Weather Processor through the definition and design of new interfaces and products associated with the operation of the CWP.

The Working Group/AWIS, under direction of the Program Council within the Office of the Federal Coordinator, has developed a National Plan which integrates requirements, development, and implementation activities associated with AWIS programs and projects of the Department of Commerce, the Department of Defense and the Department of Transportation. Under this plan, the departments are cooperating in the review, clarification, and allocation of requirements to the various specialized elements of the planned National AWIS. New interface requirements are being defined and plans for product sharing are being developed. Subjects being addressed include the use of FAA-generated NEXRAD mosaics by the planned NWS Warning and Forecast Offices (WFO), and the communication of these mosaic products via the planned NOAAPORT satellite system for use by FAA flight service facilities.

This project translates these new interface requirements into verified interface designs and product specifications which, when they are approved for implementation, will be included in the CWP program.

Development also will be accomplished to support the utilization by CWP of new sensors/products such as GOES-NEXT, lightning detection networks, and the planned vertical Profiler network. In addition, new interfaces with elements of the NAS will be developed to support the CWP weather information dissemination function. Included is an interface with the Traffic Management Processor to support the weather-information requirements of the Central Flow Control Facility, which is responsible for national flow control between the major air traffic hubs. Also, an interface with the CWP will be developed to provide NEXRAD mosaics for communication to the pilot, and receive Pilot Weather Reports from aircraft in flight.

Centralized Weather Information Processing

This is a new project to develop an integrated weather data base for generating route-oriented alphanumeric and graphic products that are consistent and machine readable.

Activities include the identification of weather-information sources appropriate for a centralized data base, development of a suitable structure for this data base, specification of machine-readable output products, and development of a rigorous set of algorithms for the generation of these products.

Airborne Wind Shear Detection and Avoidance

This project will develop requirements for airborne wind shear devices that provide the flight crew with the ability to reliably detect hazardous wind shear along the intended flight path, with sufficient time to avoid it.

In 1987, the FAA and NASA entered into a 5-year Memorandum of Agreement through which NASA will provide unique national resources for the study, analysis and verification of requirements for "forward-looking" sensors such as Doppler radar and Doppler lidar. These resources include NASA's Aircraft Landing Dynamics Facility to evaluate the full-scale effects of heavy rain, aircraft simulation capabilities, the ability to perform four-dimensional microscale atmospheric modeling, and instrumented flight-test facilities. The two agencies will develop the functional and performance requirements for airborne wind shear detection and avoidance, and will transfer the results of this effort to manufacturers to accelerate their development and certification programs.

In FY 1988, the focus of the effort will be on full-scale simulation tests of candidate system configurations of sensors, flight controls and cockpit displays that were established in the initial year of activity.

UNITED STATES COAST GUARD

Among the U. S. Coast Guard's activities is the collection and dissemination of meteorological information for the benefit of the marine community. In pursuit of this aim, the Coast Guard provides use of information and facilities to the National Oceanic and Atmospheric Administration (NOAA), specifically the National Weather Service (NWS) and the National Data Buoy Center (NDBC).

Coast Guard seagoing cutters submit weather observations to the National Weather Service and the U. S. Navy. Certain coastal stations submit weather observations to the National Weather Service. Additionally, NWS sensors on Coast Guard Large Navigational Buoys automatically transmit data to NWS centers. These data are utilized by the NWS in formulating its forecast products. NWS weather forecasts are disseminated in part by the Coast Guard through radio broadcasts to both the commercial and private vessels. Certain shore stations maintain visual displays authorized by the NWS to provide weather warnings to boaters.

U. S. Coast Guard Marine Science Technicians receive basic training in meteorology as part of their general scientific background.

The Coast Guard supplies a staff of up to 15 personnel to the NDBC (costs reimbursed by NDBC at its facility in Mississippi) to provide technical expertise in the operation and management of the project. In addition, the Coast Guard makes available vessel, shore and aircraft support for stationing, monitoring and maintaining buoys.

Meteorological activities are coordinated by the Ice Operations Division of the Office of Operations in Coast Guard Headquarters. Field management of meteorological activities is a collateral function of the Coast Guard area and district staffs.

No Coast Guard unit is dedicated solely to meteorology; all facilities perform a variety of missions. No capital investments in meteorological facilities are planned or contemplated.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for working with state and local government agencies to ensure adequate air quality meteorological support programs. Applied research and meteorological support to EPA is provided by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC. Such meteorological support to the Office of Air and Radiation, the EPA Regional Offices, and other EPA components include: review of the meteorological aspects of environmental impact statements, state implementation plans, development and application of air quality dispersion models, and preparation of dispersion studies and evaluations.

EPA applied research is in such areas as: air quality dispersion model development; the evaluation, development and application of air pollution climatology; determination and description of pollutant effects on atmospheric parameters; and determination of meteorological effects on air quality. Dispersion models for inert and reactive pollutants are under development and evaluation on all temporal and spatial scales; e.g., urban, mesoscale, and regional. Particular emphasis is being given to the development of a dispersion model for use in complex terrain and particulate and photochemical air quality dispersion models on several scales utilizing data collected during earlier field programs. The data obtained from field programs initiated earlier will be used to develop and evaluate models in the FY 1988-89 period. Examination of the relationship between meteorology and air quality continues with emphasis on ozone, sulfates, acid deposition, particulate matter, and toxic air pollutants.

FEDERAL EMERGENCY MANAGEMENT AGENCY

The Federal Emergency Management Agency (FEMA) was established in 1979, to merge closely allied Federal programs involved with preparedness, mitigation, response, and recovery to national emergencies ranging from natural and man-made hazards to nuclear attack. FEMA replaced five former agencies, consolidating into a single organization a dozen different Federal emergency-related activities, including such functions as community awareness for meteorological emergencies and coordination of all emergency warnings.

One example of a FEMA activity that is directly related to meteorology is the hurricane preparedness program which funds local vulnerability and evacuation studies. Additional meteorologically related programs, within the Office of Natural and Technological Hazards, deal with flooding, dam safety, atmospheric releases of hazardous and radiological materials, and other meteorological hazards. Although FEMA has only one full-time meteorologist, the agency has called upon the Department of Commerce and other agencies for support during times of emergencies.

Within FEMA, the Office of Research serves as principal point of contact for technological studies and coordination. No specifically meteorological studies are funded in FY 1988, but a close watch is kept on selected programs of other agencies, including the Department of Defense.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

OPERATIONS

The National Aeronautics and Space Administration (NASA) has initiated plans for acquiring improved weather information during launch and landing of the space shuttle. These plans will augment the current capability with better communication, integrated data management systems and displays, and improved forecasting. Dense, integrated, and automated networks of data gathering stations/systems are being established within an approximate 100-mile radius of Kennedy Space Center, Florida (KSC). and eventually Vandenberg Air Force Base, California, to aid in making more precise short-term forecasts. These forecasts will not only assist in launch and landing decisions, but will help in planning pre-launch operations. As NASA gains additional confidence in its ability to observe and predict the weather, it should be possible to set more precise launch and landing criteria with extra assurance and safety.

NASA plans to install a wind profiling radar (wind Profiler) for use as a supplement to the usual atmospheric measurements performed during the shuttle launch and landing sequence at KSC. The primary objective of the wind profiler will be to monitor the wind profile variations over KSC. NASA intends to use the wind profiler to compile a climatology of tropospheric and lower stratospheric mean winds and their variability over KSC and also to monitor wind persistence during launch and landing sequences. The use of profiler data as input into pre-launch loads simulations will also be analyzed.

NASA plans to install additional Meteorological Interactive Data Display Systems (MIDDS) at Johnson Space Center and to enhance the existing system at KSC. These systems quickly and conveniently bring all of the observational data together. The major objective of these systems is to provide a means of integrating all the observational data and assisting the meteorologist in forecasting through integrated data base management and display. The presentation and interpretation of weather data will reduce the time required to evaluate weather situations and increase the forecaster's confidence in forecasts for launch and landing of the space shuttle as well as in identifying the requirements for operational redundancy and safety.

The MIDDS allows remote and local access to a wide range of data from satellites and conventional observations, time-lapse displays of imagery data, overlaid graphics, and current and past meteorological data. Multicolor composites of conventional and satellite weather data, radar, etc., can also be generated.

It is expected that these improvements will strengthen and enhance the information provided to the ground-based decision makers and astronaut observers to insure that NASA achieves the best operational posture for the space shuttle launches and landings.

SUPPORTING RESEARCH

The National Aeronautics and Space Administration (NASA) Atmospheric Sciences Research Program conducts research using space technology to improve our understanding of atmospheric behavior on scales ranging from the mesoscale to the planetary scale and from periods of hours to decades. NASA's role in this endeavor is based upon the unique perspective of the earth's atmosphere and surface provided by space platforms. Satellite sensors can and do provide not only global coverage, but obtain repetitive observations of limited areas more cost-effectively than by any other means. Space observations can and do provide information essential to advancing our knowledge of atmospheric processes.

The NASA program includes the following major components:

- Development of space-borne observing systems and supporting ground-based systems to observe the state of the atmosphere, and important atmospheric and surface parameters such as temperature, albedo, clouds, etc.

- Development of algorithms and inversion techniques to derive useful atmospheric parameters from remote observations.

- Development of data processing and data assimilation techniques to address the problems peculiar to the use of satellite data in atmospheric analyses and modeling.

- Analysis of satellite data to improve our understanding of atmospheric processes on temporal and spatial scales consistent with satellite observing capabilities.

- Development of models to exploit the spatial densities and temporal frequencies inherent in satellite data to initialize and verify models and assess their value.

- Development of parameterization schemes which serve as the basis for the use of space observations in atmospheric models of all scales.

- Assessment of the performance of satellite sensors through numerical experiments which compare model output with and without satellite data.

In studying mesoscale phenomena, NASA uses geosynchronous satellite data (especially NASA-developed temperature soundings), aircraft instrumentation (e.g., Doppler lidar wind measurements), and ground-based techniques in addition to conventional observations to obtain data that will improve our understanding of the processes involved in the generation propagation and decay of severe weather phenomena. Models are being developed to use the quantitative information provided by these remote sensors.

NASA has been assigned lead responsibility for the National Climate Program principal thrust in solar and earth radiation. The earth's radiation budget, which is the central element of this research, describes the energy balance which exists between the sun, earth, and space. It is the geographical and temporal imbalance in this key relationship which governs the state and changes of regional climate. Earth radiation budget data acquired by Nimbus research satellites, beginning in 1976, are currently being processed and merged into a global climate data set, and are being augmented with data from the Earth Radiation Budget Experiment (ERBE) since 1984. Monitoring of the solar irradiance is also being accomplished by sensors aboard Nimbus-7 and the Solar Maximum Mission (SMM). The total solar irradiance (often referred to as the solar constant) is the basic source of energy for driving the climate system. Climate model studies have shown that persistent variability in this quantity could have a major impact on climate.

As part of its climate research activity, NASA is participating in the World Meteorological Organization-sponsored International Satellite Cloud Climatology Project (ISCCP) which began in July 1983. Both geosynchronous and low orbiting satellites are collecting a five-year data set for analysis and use in earth radiation budget studies. The cloud climatology, when developed, will be the most complete ever assembled. In addition, NASA has participated in the development of a plan for a field experiment to gather information needed to interpret the ISCCP data in detail. The regional experiment, the First ISCCP Regional Experiment (FIRE) was carried out in 1986. In support of FIRE, NASA has established a national project office at the Langley Research Center. NASA continues to supply NOAA with the TIROS-N and GOES series spacecraft (funded by NOAA) for operational meteorological deployment.

The data set gathered during the GARP Global Weather Experiment continues to serve as the basis for analyses under NASA research proposals. Emphasis is placed on observations obtained from space with the interpretation and application of these data to the development of advanced techniques for modeling and prediction. Nearly one hundred investigations, by both NASA scientists and those from the external scientific community, involve the analysis, diagnosis, modeling, and evaluation studies using these data.

NASA continues to support research and development activities to improve our remote sensing capabilities for possible future deployment on satellites. Studies involve remote sensing of atmospheric temperature, pressure, moisture, and winds using passive and active techniques. Successful flights of remote sensing instruments on several aircraft have been made using sensors to study the dynamics and radiative properties of cloud tops, and the fluxes of heat, moisture, and momentum between the ocean and the atmosphere.

Development of the Upper Atmosphere Research Satellite (UARS) is progressing. The UARS will address the coupling of chemical, radiative, and dynamic processes in the stratosphere and the mesosphere. NASA's Scatterometer (NSCAT) will measure surface wind velocity over the oceans with high accuracy. NSCAT continues in development and is expected to be flown on the "N-ROSS" (U.S. Navy satellite).

NUCLEAR REGULATORY COMMISSION

The Nuclear Regulatory Commission (NRC) licenses and regulates all nuclear facilities subject to the Atomic Energy Act of 1954, as amended. The licensing and operation of nuclear facilities require identification and evaluation of meteorological conditions that can affect the safe operation of the facility and that provide input to the assessment of the radiological impacts of any airborne releases from the facility.

Within the NRC, the Offices of Nuclear Reactor Regulation and Nuclear Material Safety and Safeguards review facility siting, design, construction, and operation. These reviews include consideration of meteorological factors. The Office of Inspection and Enforcement and the Regional Offices assure that commitments by NRC applicants, permittees and licensees are carried out, and conduct NRC response to nuclear facility emergencies. The Office of Nuclear Regulatory Research develops regulations, guides, criteria, and other standards relating to the protection of public health and safety and the environment in the licensing of nuclear facilities. This Office also develops and conducts confirmatory research programs in support of activities of the other offices and in support of rule-making and standards activities.

There are several meteorological areas in which the NRC will have an interest during FY 1988 and beyond and may involve the cooperative efforts of all of the NRC offices. Paleoclimatic reconstruction and climatic change models for high-level radioactive waste repositories will continue to be evaluated, and meteorological criteria for siting low-level radioactive waste repositories are being developed. Upgrading of the meteorological capabilities of the NRC and the operators of nuclear facilities to cope with emergencies involving unplanned airborne releases of radioactive material from the facility is expected to continue. Updated guidance on meteorological measurement programs and high wind and tornadoes is being developed. The NRC is also concerned with the dispersion of toxic and explosive nonradioactive substances and their potential effects on the safe operation of nuclear facilities.

APPENDIX B

SELECTED ACRONYMS AND ABBREVIATIONS

AARS	Automated Aircraft Reporting System
ADAS	AWOS/ASOS Data Acquisition System
ADDS	Atmospheric Distributed Data System
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGL	Air Force Geophysical Laboratory
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services
AFRES	Air Force Reserve
AFS	Air Force Station
AHOS	Automated Hydrologic Observing System
AI	Artificial Intelligence
AID	Agency for International Development
AISC	Assessment and Information Services Center
AMOS	Automatic Meteorological Observing System
AMR	Aircraft Microwave Refractometer
APT	Automatic Picture Transmission
ARGOS	French Data Collection System
ARINC	Aeronautical Radio, Incorporated
ARTCC	Air Route Traffic Control Center
ASDAR	Aircraft to Satellite Data Relay
ASOS	Automated Surface Observing System
ATC	Air Traffic Control
AUTOB	Automatic Meteorological Observing System
AVHRR	Advanced Very High Resolution Radiometer
AWDS	Automated Weather Distribution System
AWIPS	Advanced Weather Interactive Processing Systems
AWIS	Automated Weather Information Systems
AWOS	Automated Weather Observing System
AWN	Automated Weather Network
AWS	Air Weather Service
AWSC	Agricultural Weather Service Center
CAC	Climate Analysis Center
CAS	Committee for Aviation Services
CAT	Clear Air Turbulence
CBS	Committee for Basic Services
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CDDF	Central Data Distribution Facility
CEAS	Center for Environmental Assessment Services
COES	Committee for Operational Environmental Satellites
COMEDS	Continental U.S. Meteorological Data System
COMNAVOCEANCOM	Commander Naval Oceanography Command
CONUS	Continental United States
CSD	Committee for Systems Development

CSEF	Committee for Space Environment Forecasting
CWSU	Center Weather Service Unit (FAA)
DACS	Data Acquisition and Control Subsystem
DARDC	Device for Automatic Remote Data Collection
DCPLS	Data Collection and Platform Location System
DCS	Data Collection System
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOS	Department of State
DOT	Department of Transportation
DPSS	Data Processing and Services Subsystem
EPA	Environmental Protection Agency
ERBE	Earth Radiation Budget Experiment
ERBSS	Earth Radiation Budget Satellite System
ERL	Environmental Research Laboratories
ESSC	Environmental Studies Service Center
FAA	Federal Aviation Administration
FCMSSR	Federal Committee for Meteorological Services and Supporting Research
FEMA	Federal Emergency Management Agency
FGGE	First GARP Global Experiment
FLENUMOCEANCEN	Fleet Numerical Oceanography Center
FNOC	Fleet Numerical Oceanography Center
FSAS	Flight Service Automation System
FSS	Flight Service Station
FY	Fiscal Year
GAO	General Accounting Office
GARP	Global Atmospheric Research Program
GDPS	Global Data Processing System
GMT	Greenwich Mean Time
GOES	Geostationary Operational Environmental Satellite
GOS	Global Observing System
GSFC	Goddard Space Flight Center
GTS	Global Telecommunications System
GWE	Global Weather Experiment
HRIS/2	Modified High Resolution Infrared Sounder
HRPT	High Resolution Picture Transmission
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
ICSU	International Council of Scientific Unions
IR	Infrared
ITOS	Improved TIROS Operational Satellite
IWRS	Improved Weather Reconnaissance Systems

JAWOP	Joint Automated Weather Observation Program
JAWS	Joint Airport Weather Studies
JSPO	Joint System Program Office (NEXRAD)
LLWAS	Low Level Wind Shear Alert System
M	Million
MAC	Military Airlift Command
McIDAS	Man-computer Interactive Data Access System
MMS	Meteorological Measuring System
MOS	Model Output Statistics
MSU	Microwave Sounding Unit
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communication Center
NAVEASTOCEANCEN	Naval Oceanography Center, Norfolk, VA
NAVOCEANCOMCEN	Naval Oceanography Command Center
NAVOCEANCOMDET	Naval Oceanography Command Detachment
NAVOCEANCOMFAC	Naval Oceanography Command Facility
NAVOCEANO	Naval Oceanographic Office
NAVPOLAROCEANCEN	Naval Polar Ooceanography Center, Suitland, MD
NAVWESTOCEANCEN	Naval Western Oceanography Center, Pearl Harbor, HI
NAWAS	National Warning System
NBC	Nuclear, Biological, and Chemical
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCP	National Climate Program
NCPO	National Climate Program Office
NDBO	NOAA Data Buoy Office
NDC	National Distribution Circuit
NEDN	Naval Environmental Data Network
NEDRES	National Environmental Data Referral Service
NEDS	Naval Environmental Display Station
NESDIS	National Environmental Satellite, Data, and Information Service
NEXRAD	Next Generation Weather Radar
NHC	National Hurricane Center
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOMSS	Naval Oceanographic and Meteorological Support System
NOTAM	Notice to Airmen
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
NTSB	National Transportation Safety Board
NWR	NOAA Weather Radio
NWS	National Weather Service
OFCM	Office of the Federal Coordinator for Meteorology
OMB	Office of Management and Budget

PATWAS	Pilot Automatic Telephone Weather Service
PROFS	Prototype Regional Observing and Forecasting Service
RAMOS	Remote Automatic Observing System
R&D	Research and Development
RD/T&E	Research and Development, Test and Evaluation
RFC	River Forecast Center
ROMS	Remote Ocean Surface Measuring System
SATCOM	Satellite Communications System
SBUV	Solar Backscatter Ultraviolet Instrument
SDHS	Satellite Data Handling System
SEL	Space Environment Laboratory
SEM	Space Environment Monitor
SFSS	Satellite Field Services Station
SIO	Scripps Institution of Oceanography
SMCC	Systems Monitoring and Coordination Center
SOCC	Satellite Operations Control Center
SSU	Stratospheric Sounding Unit
STIWG	Satellite Telemetry Interagency Working Group
TDWR	Terminal Doppler Weather Radar
TESS	Tactical Environmental Support System
TIROS	Television Infrared Observation Satellite
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS N Operational Vertical Sounder
TWEB	Transcribed Weather Broadcast
UN	United Nations
USAF	United States Air Force
USAFETAC	USAF Environmental Technical Applications Center
USCG	United States Coast Guard
USDA	U.S. Department of Agriculture
USN	U.S. Navy
VAS	VISSR Atmospheric Sounder (GOES D and subsequent spacecraft)
VHF	Very High Frequency
VHRR	Very High Resolution Radiometer
VISSR	Visible and Infrared Spin Scan Radiometer
VRS	Voice Response System
VTPR	Vertical Temperature Profile Radiometer
WCRP	World Climate Research Program
WEFAX	Weather Facsimile
WMC	World Meteorological Center(s)
WMO	World Meteorological Organization
WSCMO	Weather Service Contract Meteorological Office
WSFO	Weather Service Forecast Office
WSMO	Weather Service Meteorological Office
WSO	Weather Service Office
WWP	World Weather Program
WWW	World Weather Watch

FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (FCMSSR)

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (ICMSSR)

- Working Group for Operational Processing Centers
- Working Group for Meteorological Information Management
- Working Group for Automated Weather Information Systems
- Ad Hoc Group for NOAAPORT Liaison

STANDING COMMITTEES

- AVIATION SERVICES
- OPERATIONAL ENVIRONMENTAL SATELLITES
- SPACE ENVIRONMENT FORECASTING
- SYSTEMS DEVELOPMENT
  - o Working Group for Automated Surface Observations
  - o Working Group for Atmospheric Transport and Diffusion
  - o Working Group for Profiler Systems

BASIC SERVICES

Working Groups

- o Cooperative Backup Among Operational Processing Centers
- o Dissemination of NMC Products
- o Drifting Data Buoys
- o Hurricane and Winter Storms Operations
- o Lightning Detection Systems
- o Marine Environmental Prediction
- o Meteorological Codes
- o Metric Implementation
- o Monitoring the Stratosphere
- o Radar Meteorological Observations
- o Satellite Telemetry Interagency
- o Severe Local Storms Operations
- o Surface Observations
- o Upper Air Observations
- o World Weather Program

PROGRAM COUNCILS

- AUTOMATED WEATHER INFORMATION SYSTEMS
- JOINT AUTOMATED WEATHER OBSERVATIONS
- NATIONAL AIRCRAFT ICING
- NEXT GENERATION WEATHER RADAR
- IMPROVED WEATHER RECONNAISSANCE SYSTEM

March 31, 1987