The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1994

OFCM
OFFICE OF THE FEDERAL COORDINATOR FOR METEOROLOGY

FCM P1-1993

U.S. DEPARTMENT OF COMMERCE/National Oceanic and Atmospheric Administration

THE FEDERAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (FCMSSR)

DR. D. JAMES BAKER, Chairman
Department of Commerce

VACANT
Department of Agriculture

CAPT BRADLEY SMITH, USN
Department of Defense

DR. ARISTIDES PATRINOS
Department of Energy

DR. DEBRA KNOPMAN
Department of the Interior

VACANT
Department of State

MR. E. T. HARRIS
Department of Transportation

DR. JEFFREY PAYNE
Office of Management and Budget

MR. RICHARD W. KRIMM
Federal Emergency Management Agency

VACANT
National Aeronautics and Space Administration

DR. ROBERT W. CORELL
National Science Foundation

MR. WILLIAM G. LAYNOR
National Transportation Safety Board

DR. THEMIS P. SPEIS
U.S. Nuclear Regulatory Commission

MR. H. MATTHEW BILLS
Environmental Protection Agency

MR. JULIAN M. WRIGHT, JR.
Federal Coordinator

MR. JAMES B. HARRISON, Executive Secretary
Office of the Federal Coordinator for
Meteorological Services and Supporting Research

THE INTERDEPARTMENTAL COMMITTEE FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (ICMSSR)

MR. JULIAN M. WRIGHT, JR., Chairman
Federal Coordinator

DR. NORTON D. STROMMEN
Department of Agriculture

MR. ROBERT C. LANDIS
Department of Commerce

CAPT BRADLEY SMITH, USN
Department of Defense

DR. HARRY MOSES
Department of Energy

MR. LEWIS T. MOORE
Department of the Interior

MR. JEFFREY MACLURE
Department of State

MR. RICHARD HEUWINKEL
Federal Aviation Administration
Department of Transportation

MR. FRANCIS SCHIERMEIER
Environmental Protection Agency

MR. RICHARD W. KRIMM
Federal Emergency Management Agency

DR. SHELBY TILFORD
National Aeronautics and Space Administration

DR. RICHARD S. GREENFIELD
National Science Foundation

MR. JAMES SKEEN
National Transportation Safety Board

MR. ROBERT A. KORNASIEWICZ
U.S. Nuclear Regulatory Commission

DR. JEFFREY PAYNE
Office of Management and Budget

MR. JAMES B. HARRISON, Executive Secretary
Office of the Federal Coordinator for
Meteorological Services and Supporting Research

The Federal Plan for Meteorological Services and Supporting Research

FISCAL YEAR 1994

FEDERAL COORDINATOR
FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

6010 Executive Boulevard, Suite 900
Rockville, Maryland 20852

FCM P1-1993
MAY 1993
WASHINGTON, D.C.

PREFACE

This Federal Plan, the 29th in the series that began in 1965, continues the tradition of summarizing the meteorological services and supporting research activities of all agencies of the Federal Government. As in the past, the Plan provides 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 meteorological programs of all agencies for FY 1993 and FY 1994.

The first section of the Plan provides an overview and general summary of the entire document. Essential budget information is provided in graphic formats which summarize the significant aspects of the budget tables included in Section 3. Section 2 highlights interagency cooperation that is essential to meet the needs for meteorological services. Section 3 contains a discussion of resources requested in the President's budget for FY 1994 as compared to planned resources for FY 1993. The emphasis is on changes in resources and the related changes in programs. Fiscal data are current as of the end of February 1993. Section 4 provides a review article on "Training and Professional Development in the Modernized Weather Services". The appendices contain descriptions of agencies' weather activities, a description of the World Weather Program, and a list of acronyms.

This Plan does not include information on basic research in the atmospheric sciences. By long-standing agreement, the more fundamental research activities have been coordinated and reported by the Subcommittee on Atmospheric Research (SAR) of the Committee on Earth and Environmental Sciences under the Federal Coordinating Council for Science, Engineering and Technology. A SAR report for FY 1987-1990 was published in 1992. The SAR report is retrospective and serves a very different purpose from that of this Federal Plan, but there are similarities. Representatives of the Office of the Federal Coordinator for Meteorology and the SAR have coordinated approaches to these two reports; however, the distinctions between "supporting" research and "basic" research are sometimes debatable. Some duplications, some omissions, and some double reporting of funding are therefore possible, in spite of efforts to minimize these occurrences.

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 and continuous reviews of requirements for basic and specialized meteorological services and for supporting research according to guidelines set forth in the Office of Management and Budget Circular A-62.

Julian M. Wright, Jr.
Federal Coordinator for Meteorological
Services and Supporting Research

THE FEDERAL PLAN FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH, FISCAL YEAR 1994

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1

EXECUTIVE SUMMARY

The President's Budget for FY 1994 requests $2.473 billion for meteorological services and supporting research. This is a 17.9 percent increase over funds appropriated for FY 1993. As in previous years, about 91 percent of the total is requested for three Departments -- Commerce, Defense, and Transportation. The increased funding is primarily associated with the transition to the modernized weather services -- new observing, forecasting, and satellite systems. Major programs initiated in previous years continue to be funded and the groundwork for new programs is being coordinated within the infrastructure of the Office of the Federal Coordinator for Meteorology (OFCM) by the various program councils, committees, and working groups. Budget support for Federal meteorological activities reflects the cooperative efforts and the substantial progress of meteorological science and technology in recent years. This level of support is needed to fully exploit advancements in both observing systems and forecasting procedures during this decade.

Major Programs of DOC, DOD and DOT

The Federal Government continues support for major weather observation, data integration, and communications programs in the budget requests for FY 1994.

The Next Generation Weather Radar (NEXRAD) Program is supported by the Departments of Commerce (DOC), Defense (DOD) and Transportation (DOT). The NEXRAD Program Council, chaired by the Federal Coordinator, continues to provide policy guidance and oversight for the procurement, installation, and operation of the WSR-88D Doppler radars. All ten limited production systems have been accepted by the Government. In FY 1993, a total of 35 systems will be delivered, and 46 systems are scheduled for delivery in FY 1994. The radar is exceeding all performance expectations with markedly higher quality and quantities of storm and wind data that allow more timely and accurate warnings of severe weather.

The automated surface weather observation program is under the policy guidance of an interagency program council chaired by the Federal Coordinator. This program is progressing on schedule -- a contract was awarded by the Department of Commerce in February 1991 for up to 1,700 units to be installed during the next 5 years. More than 190 units have been accepted, and 17 are commissioned.

The automated weather information systems are under development or are being installed by several agencies. These systems facilitate data collection, processing, and interpretation that result in more timely and improved weather forecasts. An additional feature is the rapid distribution of information and products to users. The Air Force has installed and accepted more than 112 of their new systems which markedly modernize their base weather station operations; a total of 164 systems will be installed. A program council, a committee, and several working groups within the OFCM structure provide coordination for various aspects of the agencies' programs. Funding for the DOC, DOT, and DOD programs is in the FY 1994 budget request.

Other Agency Programs

The Department of Agriculture will continue its weather-related activities for FY 1994 at essentially the same level of funding ($27.62 million) as FY 1993. These include observations taken by the Forest Service and research on the interactions of climate with plant and animal production. The Department of the Interior request is $870,000. The Environmental Protection Agency requests $8.1 million which is the same as for FY 1993.

The National Aeronautics and Space Administration budget request of $176.98 million is virtually all for supporting research, as in previous years. This will include support for meteorology-related activities within the Earth Observing System (EOS), Earth Probes, and for the Upper Atmosphere Research Satellite (UARS). The Nuclear Regulatory Commission (NRC) request of $360,000 is for weather-

related activities that emphasize public safety and health in connection with the operation of nuclear facilities. A detailed summary of each agency's meteorological program is given in the Appendices.

Training and professional development programs of the agencies are described in Section 4. These programs are being implemented to take full advantage of the new systems described above.

Federal Coordination Activities

A National Aviation Weather Program Council, established in 1989, provided policy guidance for preparation of the ***National Aviation Weather Program Plan***. The Plan was published in September 1992, and incorporates the cooperative efforts of six agencies. It addresses the full suite of requirements for Aviation Weather products and services. The Plan identifies requirements that can be met by current capabilities, and by the projected capabilities of currently funded programs. The Plan focuses on the requirements that will necessitate special efforts around the year 2000 and beyond.

In February 1993, the Office of the Federal Coordinator for Meteorology hosted the 47th Interdepartmental Hurricane Conference (IHC) in Miami, Florida. Representatives from DOC, DOD, and DOT reviewed the 1992 hurricane season and operations in the Atlantic, East and West Pacific, and Indian Ocean. As a result of the storms that made landfall, Hurricane Andrew and Iniki and Typhoon Omar, IHC attendance was nearly 140 people. The representatives proposed IHC action items and changes to the ***National Hurricane Operations Plan*** (NHOP) and the ***National Plan for Tropical Cyclone Research*** (NPTCR). Changes that were agreed upon have been incorporated into the plans; the 1993 NHOP was published in April and the changes to the NPTCR were disseminated in March 1993.

The newly established Working Group for Post-Storm Data Acquisition has been very active. Their objective is to prepare an interagency plan to obtain scientific and engineering data following hurricanes, tornadoes, tsunamis, and lake storms. These data are highly perishable, and a coordinated rapid response is required immediately following a storm.

The acquisition and use of lightning data by the Federal agencies has been an area of considerable interest and concern in recent years. An experimental nationwide network proved the value of these data for operations in many agencies. A Request for Proposals for lightning data was issued by the National Weather Service (NWS), and a contract was awarded in August 1992. The lightning data are now considered operational and are routinely distributed to NWS field offices.

A group established to inventory agencies' mobile meteorological equipment published the ***Federal Directory of Mobile Meteorological Equipment and Capabilities*** in March 1993. The directory will assist agencies in planning and carrying out a response to various meteorological emergencies and to reduce duplication of effort in developing new equipment and capabilities.

A substantially revised and expanded ***Directory of Atmospheric Transport and Diffusion Models, Equipment, and Projects*** has been completed and will be distributed in mid-1993. This directory will assist agencies in planning for, and responding to, emergencies involving the release of hazardous substances into the atmosphere.

Ten Federal Meteorological Handbooks (FMH) are prepared and updated under the guidance of the various OFCM committees and working groups. Revisions have been completed and published for the ***Surface Synoptic Codes*** (FMH-2), ***Meteorological Rocket Observations*** (FMH-10), and ***Doppler Radar*** (FMH-11) which consists of four volumes. Drafts of ***Surface Observations*** (FMH-1) and ***Upper Air Observations*** (FMH-3) are being reviewed.

Resources

The FY 1994 resources requested for Federal meteorological operations and supporting research are $2.473 billion, representing a 17.9 percent increase from the $2.097 billion in FY 1993. Of the total, about $2.119 billion will be for operations and $354 million for supporting research. The FY 1994 budget, by agency, is shown in Table 1.1.

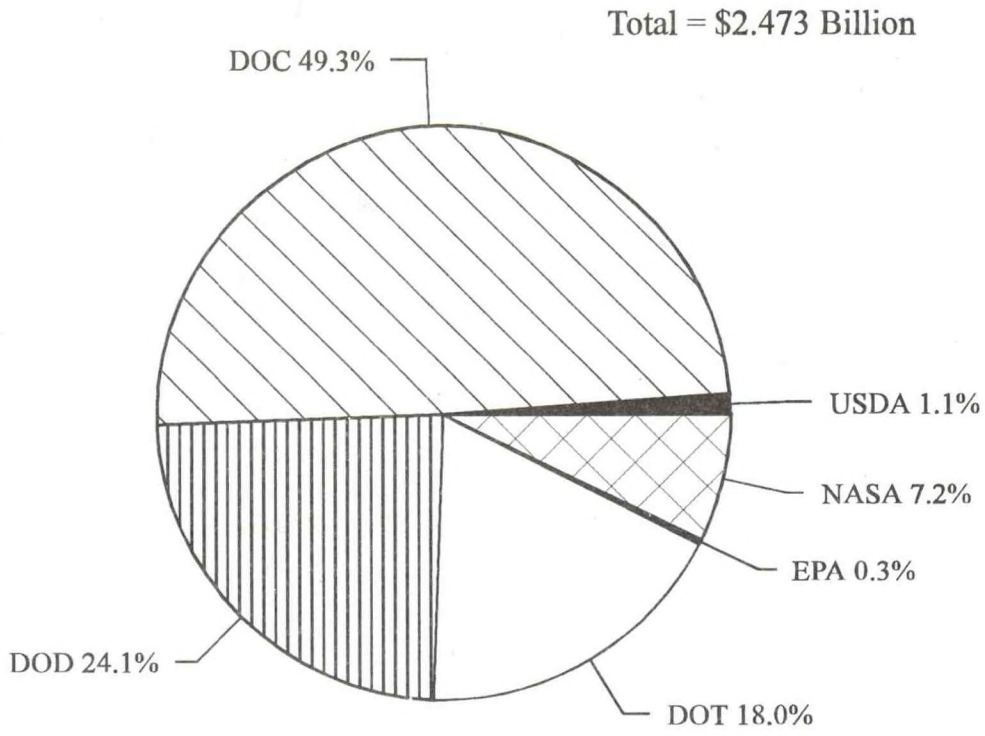


Figure 1.1 Agency Percent of Total Federal Budget for Meteorological Operations and Supporting Research, FY 1994

Table 1.1. Federal Budget for Meteorological Operations and Supporting Research, FY 1994 (in thousands of dollars)

Agency	Operations	% of TOTAL	Supporting Research	% of TOTAL	TOTAL	% of TOTAL
Agriculture	$12,160	0.6	$15,462	4.4	27,622	1.1
Commerce	1,172,759	55.3	46,857	13.2	1,219,616	49.3
Defense	511,476	24.1	84,006	23.7	595,482	24.1
Interior	870	0.0	0	0.0	870	0.0
Transportation	413,294	19.5	30,660	8.7	443,954	18.0
EPA	0	0.0	8,100	2.3	8,100	0.3
NASA	7,982	0.4	169,000	47.7	176,982	7.2
Nuclear Reg. Comm.	360	0.0	0	0.0	360	0.0
TOTAL	2,118,901	100.0	354,085	100.0	2,472,986	100.0

Figure 1.1 shows each agency's proportion of the total FY 1994 proposed Federal spending for meteorological operations and supporting research. Each agency's proportion of the proposed Federal spending for meteorological operations is shown in Figure 1.2; as in previous years, the Departments of Commerce, Defense, and Transportation account for approximately 99 percent of the Federal budget for meteorological operations. Each agency's proportion of the proposed Federal spending for supporting research is shown in Figure 1.3.

The agencies expect that 16,849 personnel (full-time-equivalent) will be employed in Federal meteorological operations in FY 1994; this is an increase of 2.0 percent over the 16,515 personnel employed in FY 1993.

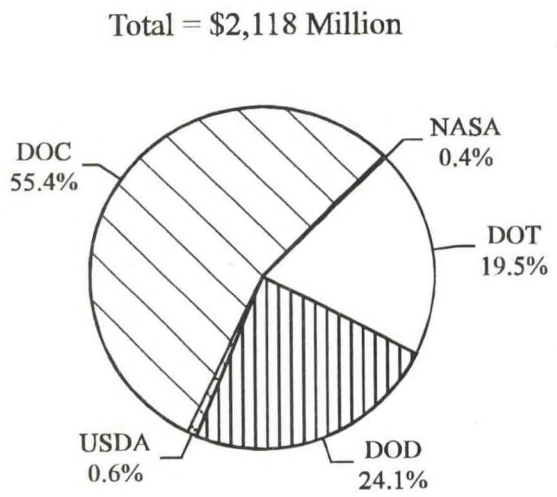


Figure 1.2 Agency Percent of Federal Budget for Meteorological Operations, FY 1994

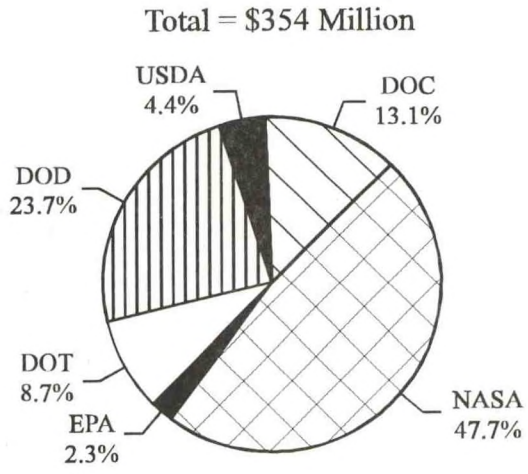


Figure 1.3 Agency Percent of Federal Budget for Supporting Research, FY 1994

SECTION 2

FEDERAL COORDINATION AND PLANNING

In 1963, activities in meteorology gave rise to concern in Congress and the Executive Office of the President about the adequacy of coordination of Federal meteorological activities. 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 the 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 relationship 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. The Circular reaffirmed the concept of having a central agency, the Department of Commerce, responsible for providing common meteorological facilities and services and clarified the responsibilities of other agencies for providing meteorological services specific to their own needs.

The implementation of Circular A-62 by the Department of Commerce led to creation of the Office of the Federal Coordinator for Meteorology (OFCM). 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 done by the staff of the Federal Coordinator with the advice and assistance of the Interdepartmental Committee for Meteorological Services and Supporting Research, several program councils, committees, and working groups. The organizational relationships are shown on the inside of the back cover of this document.

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 those Federal agencies having weather-related activities so that the most effective and best possible weather information and user services are provided for the funds made available by the Government. To discharge its mission, the OFCM objectives are meshed with the objectives of those agencies which provide the services and perform the research. The objectives are to:

- 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 fulfill requirements;
- 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;
- 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;
- Review Federal weather programs and Federal requirements for meteorological services and supporting research. This review may suggest additions or revisions to current or proposed programs or identify opportunities for improved efficiency, reliability, or cost avoidance through coordinated actions or integrated programs.

In 1979, a General Accounting Office (GAO) report, "The Federal Weather Program Must Have Stronger Central Direction," LCD-80-10, recommended stronger centralized planning and direction for Federal weather activities. Pursuant to GAO's recommendation, the DOC increased the permanent professional staff from one to seven and assigned an additional professional as Department representative; DOC also provides administrative support to the OFCM. DOC provides approximately one-half of the office operating budget. The Department of Defense (DOD) currently provides two staff officers (one Air Force Colonel and one Navy Lieutenant Commander) and contributes approximately one-fourth of the OFCM annual operating budget. DOT/FAA provides one professional staff member and also contributes approximately one-fourth of the OFCM annual operating budget. The four regularly assigned agency representatives are designated Assistant Federal Coordinators for liaison to their respective agencies. Based on the current staffing plan, there are ten professionals and five full time administrative support personnel 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 required for responding to special inquiries, investigations, and studies.

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 that engage 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. In addition, the Office of Management and Budget is represented.

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 six standing committees: Basic Services, Operational Processing Centers, Automated Weather Information Systems, Aviation Services, Operational Environmental Satellites, and Space Environment Forecasting.

Six Program Councils are established within the OFCM structure to coordinate specific interagency cooperative programs. These are: Joint Automated Weather Observations, Automated Weather Information Systems, Aircraft Icing, Aviation Weather, Next Generation Weather Radar, and Improved Weather Reconnaissance. Each of the Councils is comprised of decision-level representatives of the agencies directly concerned with the specific program area; the Federal Coordinator serves as chairperson for all the Councils.

Next Generation Weather Radar (NEXRAD)

Delivery of the Weather Surveillance Radar (WSR-88D) is proceeding. The WSR-88D is a computerized Doppler weather radar developed to meet the needs of the Departments of Commerce, Defense, and Transportation for improved ability to detect and maintain surveillance of hazardous weather. This need was defined by the three Departments, through an OFCM-sponsored study, in the late 1970's. It led, in 1979, to the establishment of a Joint System Program Office to develop and procure the new Doppler radar under policy guidance and oversight of a Tri-Agency NEXRAD Program Council chaired by the Federal Coordinator.

The WSR-88D system's advanced technology provides automated Doppler signal processing, computerized processing of data by sophisticated meteorological software algorithms, state-of-the-art ergonomically designed operator workstations, and a high-capacity, processor-driven communications capability. The system is modular in design, upgradeable, has a long life-cycle expectancy, and its advanced weather radar products meet the needs of the three Departments for accurate information on the location, severity, and movement of hazardous weather.

The Department of Commerce's National Weather Service (NWS) uses the WSR-88D for more than forecasts and warnings of severe weather. NWS also uses the WSR-88D rainfall analysis capability to improve its river stage and flood forecasts and to provide data to the Nation in support of effective management of water resources. This advance in water resources management reaches beyond flood control to impact areas such as river navigation, drinking water supplies, pollution management, and water-based recreation -- all with beneficial economic consequences. The Department of Defense uses NEXRAD data to support military operations and protect defense assets on a worldwide basis. The Department of Transportation's Federal Aviation Administration uses the data to improve flight safety and to manage traffic more efficiently within the National Airspace System.

The NEXRAD program procurement followed the competitive bidding procedures established in Office of Management and Budget Circular A-109. The acquisition progressed through the System Definition Phase and Validation Phase design and development efforts, to selection of a system contractor and award of Limited Production and Full Scale Production contracts. Unisys was awarded a Limited Production contract for 10 NEXRAD units in December of 1987. In 1989, the WSR-88D prototype unit was given a rigorous independent examination during Initial Operational Test and Evaluation Part 2. The WSR-88D proved that it could significantly improve the timeliness and accuracy of forecasts of severe weather occurrences. Paramax (a newly formed subsidiary of Unisys) was awarded the Full Scale Production option in January 1990 for 165 additional Doppler radars. The current program requirement is for a total of 159 radar systems to be procured and fielded at 113 NWS sites in the contiguous forty-eight states, 31 DOD sites in the U.S. and overseas, and 13 FAA systems in Alaska, Hawaii, and the Carribbean.

Ten WSR-88Ds near Oklahoma City, Oklahoma; Sterling, Virginia; Melbourne, Florida; Northwest Florida (Eglin AFB); Frederick, Oklahoma (Altus AFB); St. Louis, Missouri; Dodge City, Kansas; Goodland, Kansas; Wichita, Kansas; and Houston/Galveston, Texas, have been accepted by the Government, and are available for use prior to system commissioning. With the program now in full scale production, the Government accepts two to four new systems a month. Final delivery of the last system is scheduled for early 1996. In FY 1993, a total of 35 systems will be delivered, and 46 systems are scheduled for delivery in FY 1994. Major developments in hardware and software capabilities are underway for product improvement. Current broad-scale activities in support of deployment include depot repair facility preparations, implementation of system support capability, establishment of spare parts inventory, and preparations for system commissioning.

The Operational Support Facility (OSF), established in 1988 at Norman, Oklahoma, began providing 24-hour-a-day operational support to WSR-88D field units. The OSF manages the WSR-88D operator training program for all agencies, and is completing preparations for the management and coordination of the life-cycle system support program for the NEXRAD system. The DOD maintenance training facility at Keesler AFB, Mississippi, is in operation, and the transition of DOD operator training to Keesler AFB is currently programmed for 1994.

Archiving of the NEXRAD Level III data, which are advanced weather radar products, was begun in 1992 by DOC/NOAA at the National Climatic Data Center (NCDC). Plans are now being formulated to address archiving the higher resolution data (Level II) from which the products are generated.

Automated Surface Weather Observations

Historically, each agency has independently developed an operational weather system capability in pursuit of its mission; supporting research was frequently carried out jointly. In 1983, in order to coordinate these efforts and in response to an OFCM

recommendation, the Joint Automated Weather Observation Program (JAWOP) was established by the Departments of Commerce, Defense, and Transportation/FAA. The JAWOP Council, chaired by the Federal Coordinator, provides policy and oversight for the three Departments' automated surface observation program development efforts.

In 1986, NWS and FAA sought convergence of their automated surface weather observation programs by closely examining system commonality and revalidating system requirements. This resulted in an agreement in 1986 by the JAWOP Council to use the NWS Automated Surface Observing System (ASOS) at the FAA's towered airport locations. The Administrators of NOAA and FAA agreed that NOAA will procure, install, operate, and maintain the ASOS to meet FAA requirements for both the towered and most of the non-towered airports. Towered airports are the large airports that have a control tower and FAA personnel to control aircraft traffic. Non-towered airports are those smaller airports with no control tower or regular observers for weather conditions. The NWS and FAA application of ASOS will make this system the primary Federal surface observing system. Immediate needs of the FAA for limited weather observations at small non-towered airports will be satisfied by 200 off-the-shelf automated weather observing systems (AWOS) as an interim capability system until the fielding of ASOS, which is now underway, is completed.

The ASOS development concluded with preproduction systems qualified through field tests conducted at the Tulsa International Airport (involving the Weather Service Office and the Airport Traffic Control Tower), and the NWS Sterling Research and Development Center. The results of these field tests, as well as the overall ASOS test program, were reviewed by an independent interagency Test Review Board (TRB). The Board found sound system performance and recommended proceeding to the production phase. In February 1991, the ASOS production and implementation contract was awarded to AAI Corporation for as many as 1700 units over the next 5 years. Production was initiated, and the early systems were fielded in the central United States during the summer of 1991. The TRB met again in August 1991 and recommended continuation of the production phase. At its March 1992 meeting, the TRB concluded that the risks of proceeding with full system acceptance and commissioning during the summer of 1992 were small and manageable. Commissioning of NWS-sponsored ASOS units began in late summer of 1992 and will provide the official weather observation for associated airports. More than 190 units have been accepted and 17 units have been commissioned as of April 1993.

An earlier 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 next generation laser ceilometer procurement. Production delivery has been completed at primary NWS observing locations. The new ceilometer will be used as part of the ASOS sensor suite at most locations. Both the Air Force and FAA have decided to use the NWS-developed Next Generation Ceilometer for replacement purposes. The Air Force has acquired 287 ceilometers and the FAA has acquired 115 ceilometers through the NWS. The Air Force is also considering use of the NWS-developed ASOS for certain Air Force applications.

The Navy is planning to replace obsolete equipment with ASOS at Navy and Marine Corps air stations. The Navy does not plan to use ASOS as a fully automated station except at remote sites, such as bombing ranges, where surface observations are not presently taken due to manpower limitations. The Navy requires 86 ASOS units (85 operational and one R&D) at 70 continental U.S. sites and 15 overseas sites. The R&D unit was installed in the Spring of 1992 at the Naval Electronics Engineering Center, Charleston, SC. In order to satisfy the requirement for automated shipboard observations, the Navy is developing the Shipboard Meteorological and Oceanographic Observing System (SMOOS).

Air Force activity in automated meteorological sensors is focused on the combat environment. The Tactical Weather Observing System (TWOS), the observing component of the Air Force's Combat Weather System (CWS) program, consists of four ground-based meteorological sensing capabilities: an airfield observing sensor suite, an upper air measurement system, hand-held sensors, and an expendable tactical observing sensor suite. The primary emphasis is for Commercial Off-the-Shelf

(COTS) acquisition; new sensor development has been deferred until late in program acquisition.

The U.S. Army Research Laboratory (ARL) has developed and installed the Surface Automated Meteorological 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, humidity, wind speed and direction, barometric pressure, and soil temperature at each data collection package (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 1994 include:

- Continue with ASOS full scale production, fielding as many as 15 or more systems per month;
- Continue commissioning of ASOS units;
- NWS, FAA, and DOD (under the auspices of the JAWOP) will continue with selected future sensor enhancement, development, and testing;
- OFCM will continue coordination of drafts of the ***Federal Meteorological Handbook No. 1 - Surface Observations*** to reflect automated observing procedures;
- USAF and FAA will continue selective replacement of aging sensors by means of an add-on to the NWS procurement;
- USN will continue replacement of the AN/GMQ-29 semi-automated observing systems ashore with ASOS during the FY 1993-1996 timeframe;
- USN's technical evaluation of the Shipboard Meteorological and Oceanographic Observing System was completed in 1992 and production is expected to begin during FY 1993.

Automated Weather Information Systems

Automated Weather Information Systems (AWIS) are required by a number of Federal agencies. The AWIS are being procured to reduce labor intensive functions; to reduce the time required to process and interpret weather data; to reduce the time to produce forecasts, warnings and special tailored products; and to distribute these products to users expeditiously. Major agency systems classified as AWISs are the Department of Commerce's Advanced Weather Interactive Processing System (AWIPS), the Federal Aviation Administration's Central Weather Processor (CWP), the U.S. Air Force's Automated Weather Distribution System (AWDS), and the Naval Oceanographic Data Distribution and Expansion System (NODDES). The systems include communications to collect and distribute raw data, information, and processed products. Excluded from AWIS are the observation subsystems and the supercomputers at the major centers. The U.S. Air Force has more than 112 of the AWDS installed in military weather stations located in the continental U.S and Canada; a total of 164 AWDS will be installed.

The AWIS Program Council, which consists of high-level representatives from the Departments of Commerce, Defense, and Transportation, was established during February 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 needed coordination in both the short and long term; determine if there was redundancy among the systems and, if so, whether it should be eliminated; determine what commonalities existed among the systems; and produce a ***Federal Plan for the Coordination of AWIS Programs***.

In order to further its agenda, the AWIS Program Council uses the Committee for Automated Weather Information Systems (CAWIS) and its Working Group for Communications Interfaces and Data Exchange (WG/CIDE), Working Group for AWIS Meteorological Applications (WG/AMA), and Working Group for NOAAPORT Liaison (WG/NPL). CAWIS published the ***Federal Plan for the Coordination of AWIS Programs*** in May 1988. WG/CIDE publishes standards documents relating to formats and telecommunications procedures. Its most recent ***Standard Formats for Weather Data Exchange Among Automated Weather Information Systems*** was published in May 1990. Its most recent ***Standard Telecommunication Procedures for Weather Data Exchange*** was published in October 1991. 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, where necessary, to develop standards, procedures, and guidelines that are unique to weather information systems. In addition, WG/CIDE designed the Interdepartmental Meteorological Data Exchange System (IMDES). The most recent progress report on the implementation of IMDES was published in July 1991.

WG/AMA is preparing an inventory of meteorological applications programs and techniques and provides a forum for coordination of developments in new or improved meteorological applications. WG/NPL provides an interdepartmental forum for the discussion of plans regarding the implementation of NOAAPORT. NOAAPORT is the name given to the service for distributing meteorological data and products to AWIPS and other environmental data systems beginning in the NWS modernization era.

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 agreed to promote greater coordination in aircraft icing detection and to form a National Aircraft Icing Program Council. The Council was established in 1984.

The Council is responsible 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***, published in 1986. The planned program has dual objectives: 1) improving aircraft icing detection technologies for the current generation of aircraft, and 2) promoting advances in aircraft icing detection 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 research needs and objectives, describes the efforts now underway, and proposes the areas of need. It recognizes that the scope, definitions, and priorities may change as the ***National Aircraft Icing Technology Plan*** is implemented and as the need arises to reflect accomplishments and changes in agency missions and goals.

One section of the technology plan, "Detecting, Monitoring, and Forecasting" is addressed in detail in the ***National Plan to Improve Aircraft Icing Forecasts***, prepared by an ad hoc group for the Committee for Aviation Services, and published in 1986.

In 1989, the FAA established a 6-year funding schedule, beginning in FY 1990, to achieve the goals set forth in the icing forecasting plan. In FY 1990, funding was provided by the FAA to the National Center for Atmospheric Research (NCAR) to develop and conduct an extensive icing research program. Two objectives of this program are to develop and evaluate an icing severity index and an operational icing forecast for aviation. A third objective is to evaluate sensors appropriate for the detection of icing conditions. NCAR will conduct field data collection exercises during four successive winters: two in the Denver area and two in the central U.S. This effort commenced in January 1990 with a combined ground-based and airborne data collection in the Colorado area. The program is being monitored by the National Aircraft Icing Program Council.

An extension of the program is investigating the use of Doppler radar observations of snowfall location and movement in conjunction with wind and temperature data to provide estimates of icing on the ground at air terminals. This part of the program may provide short-term forecasts for the onset, duration, and severity of snow showers and the icing severity on the ground.

National Aviation Weather Program

A program council was formed in late 1989 and a supporting Joint Action Group (JAG) in 1990 to address aviation weather issues and provide guidance in the preparation of a national aviation weather program plan. The membership consists of the Departments of Agriculture, Commerce, Defense, Transportation, NASA, and the National Transportation Safety Board. The Program Council, assisted by the JAG, has produced the ***National Aviation Weather Program Plan***, (FCM-P27-1992). It was published in September 1992 and distributed widely to the Federal agencies and among the aviation weather-user communities.

The JAG worked closely with users of aviation weather data and services; users from the Federal sector, private meteorologists, the air carriers, and

general aviation. The users assisted in developing a list of user needs which were matched against the current capability of the providing agencies, and the future capability of agency programs that are currently planned and funded. There remained 39 unmet needs that fit into 7 categories. The categories that still need improvement are:

- Surface and terminal observations;
- Surface and terminal forecasts;
- Upper air and enroute reports;
- Upper air and enroute forecasts;
- Automation;
- Information access and dissemination;
- User education.

The users determined that User Education was the highest priority category to keep them abreast of the modernizations of the National Weather Service and the National Airspace System by FAA. The JAG will develop interagency action plans to address the remaining needs.

Improved Weather Reconnaissance System (IWRS)

The Improved Weather Reconnaissance Program Council (IWRPC) was formed to manage the acquisition of the IWRS equipment which was to be installed on the Air Force's WC-130 weather reconnaissance aircraft. The Department of Defense, through the Air Force Reserve (AFRES), has a Congressional mandate to provide aircraft weather reconnaissance in support of National Weather Service requirements. With the successful completion of the program, the IWRPC continues to meet at least once a year to evaluate the operational effectiveness of the IWRS and to evaluate/approve proposals for IWRS improvements and upgrades. The IWRPC met on February 27, 1993, in conjunction with the 47th Interdepartmental Hurricane Conference, and discussed two key issues: the development of the lightweight Omega digital dropwindsonde (LOD2) and the WC-130 upgrade. The LOD2, which was developed under contract by the National Center for Atmospheric Research (NCAR), has passed final acceptance testing, and the Air Force has begun the acquisition process. While there are a sufficient number of the old dropwindsondes to support weather reconnaissance operations through FY 1994, the IWRPC will continue to closely monitor the acquisition of the LOD2. AFRES briefed a proposal to upgrade six late model C-130 aircraft to WC-130 status with the installation of the IWRS equipment at a cost of approximately $600,000. This upgrade would effectively extend the life of the WC-130 fleet and significantly enhance flight safety. The council agreed to fund the AFRES project from IWRS program funds. The NCAR LOD2 contract was also financed with IWRS funds. Both projects are on track.

PLANNING, COMMITTEE ACTIVITIES, AND PUBLICATIONS

Meteorological Information Management

The development of new, higher-resolution atmospheric observational systems, the operational deployment of large-scale graphic and alphanumeric communications and display systems, and the transition from traditional paper and film displays for graphical and satellite imagery to automated digital displays, mean that a virtual explosion of meteorological information is occurring and will continue for the foreseeable future. The tremendous volume and complexity of new information threatens to overwhelm present-day archival systems and lead to confusion and serious inefficiencies in the application of retrospective data to scientific and operational needs.

At the same time, the explosion of data is coupled to a growing demand for retrospective meteorological data to support research initiatives, such as analysis of global change, and operational uses such as military planning and environmental and engineering studies. These factors have led to a proliferation of retrospective databases and the real possibility of significant duplication of effort and development of incompatible databases by Federal agencies, other producers, and users.

Recognition of this growing problem led ICMSSR to establish the Working Group for Meteorological Information Management. The aims of this Group are to review current agency plans and requirements, develop guidelines for new data systems, develop a national reference system for retrospective databases, and devise a coordination mechanism to ensure, (1) that user needs are considered, and (2) that duplication of effort is eliminated to the extent possible. In 1991, the Working Group published the ***Federal Plan for***

Meteorological Information Management. The document outlines Federal agency requirements for retrospective meteorological data, recommends interagency data management and coordination actions, and describes a proposed national reference system for federally owned, retrospective, meteorological databases. The Working Group is continuing to implement appropriate portions of the plan.

Federal Meteorological Handbooks

At the direction of the ICMSSR, the OFCM has undertaken a revitalization of the Federal Meteorological Handbooks (FMH) using the existing interdepartmental coordination infrastructure of committees and working groups. The FMH series includes observing and reporting practices for surface, upper air, radar, and meteorological rocket observations. The titles of eleven existing handbooks are: ***Surface Observations***, ***Surface Synoptic Codes***, ***Radiosonde Observations***, ***Radiosonde Code***, ***Winds-Aloft Observations***, ***Upper Wind Code***, ***Weather Radar Observations***, ***Manual on Barometry***, ***Aviation Weather Observations***, ***Meteorological Rocket Observations***, and ***Doppler Radar Meteorological Observations***. The OFCM is reevaluating the status of the FMH series and revising each handbook, as required, to:

- highlight the responsibility for preparation and maintenance;
- develop a mechanism to ensure that the FMHs remain current and complete;
- assure the merging of information from new or automated technology;
- meet requirements for utility of the primary users;
- reinforce the status of each handbook as the Federal standard for observing and reporting the meteorological phenomena and parameters by which the atmosphere is usually described.

Many OFCM working groups of the Committee for Basic Services are participating in this task. To date, revisions were completed for the ***Surface Synoptic Codes*** (FMH-2) and ***Meteorological Rocket Observations*** (FMH-10) handbooks. Additionally, the four-part ***Doppler Radar Meteorological Observations*** (FMH-11) was completed and published. These parts are: Part A - ***System Concepts, Responsibilities, and Procedures***, Part B - ***Doppler Radar Theory and Meteorology***, Part C - ***WSR-88D Products and Algorithms of Doppler Radar Meteorological Observations***, and Part D - ***WSR-88D Unit Description and Operational Analysis***. Federal agencies are also reviewing and preparing comments to preliminary drafts of ***Surface Observations*** (FMH-1) and ***Upper Air Observations*** (FMH-3).

New versions of all handbooks are available to private-sector users through the Customer Services at the National Climatic Data Center, Asheville, NC. Federal agencies may request copies from the OFCM.

Working Group for Meteorological Codes

The use of meteorological codes is of fundamental importance for the collection, exchange, and distribution of meteorological information. The Working Group for Meteorological Codes (WG/MC) is the principal means, within the OFCM, for coordinating the employment of these codes by concerned Federal agencies.

A major issue addressed by the WG/MC during 1992 was the implementation of WMO's METAR, SPECI, and TAF codes. Plans call for the NWS to develop software to convert surface aviation observations to METAR observations for approximately 250 airports. These airports primarily serve as ports-of-entry for foreign and domestic air carriers. The projected implementation date is July 1993. In addition, terminal forecasts for approximately 80 airports will convert to the new TAF code.

Satellite Telemetry

The Satellite Telemetry Interagency Working Group (STIWG) is co-chartered by the Federal Coordinator for Meteorological Services and Supporting Research and the Chief, Office of Water Data Coordination. The STIWG reports to the Coordinators through the Committee for Basic Services and the Hydrology Subcommittee in the respective coordinating infrastructures. The STIWG is comprised of representatives of agencies which collect data from remote Data Collection Platforms (DCP) through the GOES Data Collection System (DCS). Some of the agencies participating in STIWG activities are: Bureau of Land Management, Bureau of Reclamation, National Weather Service, National Ocean Service, U.S. Army Corps of Engineers, U.S. Geological Survey, Environmental Protection Agency, U.S. Forest Service,

National Data Buoy Center, Nuclear Regulatory Commission, and others. The National Environmental Satellite, Data, and Information Service (NESDIS), as the GOES DCS operator, meets with the STIWG for coordination of users' needs, system procedures and status, policy, funding, and troubleshooting.

DCPs owned by the user agencies sense and collect a variety of types of data at remotely located positions. Among those types of data are rainfall, stream flow, water levels in lakes and reservoirs, seismic stress and vibration, wind direction and speed, atmospheric pressure, soil moisture; air, soil and sea surface temperatures; relative humidity, etc. The DCPs must meet performance specifications established by NESDIS and are two general types: self-timed or random reporting. Some DCPs have both capabilities. The collected data is transmitted to the GOES where it is rebroadcast for reception at the Command and Data Acquisition (CDA) site at Wallops Island, VA, or at Direct Readout Ground Stations (DRGS) at agency sites.

A major concern of the STIWG and NESDIS has been the growing numbers of DCPs and the possibility of system saturation. NESDIS, in response to this growing concern, has taken steps to increase the efficiency of bandwidth use in the satellite and to increase the throughput at the ground processing system at the CDA. The members of STIWG have participated in the upgrade process by operating their DCPs in the shortest time slots reasonable, and by conducting studies and funding certain projects to reach the maximum capability. STIWG funds have provided additional demodulators at the CDA to use more channels from the GOES transponder and complement the NESDIS upgrade to the ground processing system, DCS Automated Processing System (DAPS).

As agencies added more DCPs and their data stream increased, some had difficulty acquiring their data in a timely manner. The DAPS provided sufficient processing but call-in methods to the database were costly and inadequate. STIWG launched another cooperative project for moving data in a more efficient way. They funded, and NESDIS manages, a contract for a channel on a domestic communications satellite (DOMSAT) which rebroadcasts the stream of processed data from the DAPS. Agencies can receive theirs or all the data stream on a Domsat Read Only Terminal which is relatively inexpensive compared to the DRGS.

The STIWG funded a number of studies recently to evaluate the impact on the DCS if DCPs transmitted at higher baud rates than the 100 bps rates currently in use. The studies showed promises of great bandwidth savings at higher baud rates for self-timed DCPs and at lower baud rates for random reporting under a new philosophy for sharing the available bandwidth and time. Currently NESDIS, with STIWG contributions, is developing the prototype and specifications for 300 and 1200 baud rate transmitters for DCPs and the demodulators for the DAPS.

The STIWG meets about four times a year to evaluate the status of the GOES DCS system, explore operational problems, and coordinate future projects to be undertaken to increase system efficiency.

Post-Storm Data Acquistion

A new working group for post-storm data acquisition was established by the Interdepartmental Committee for Meteorological Services and Supporting Research to prepare an interagency plan for scientific and engineering data acquisition, especially highly perishable data, after coastal storms, tornadoes, tsunamis, and lake storms. The organizational meeting was held on September 30, 1992, and one of the key outcomes was the requirement for a fund to support the group's objectives and activities. A project was established that will be supported with funds from individual agencies.

At the January 1993 meeting, the group conducted an in-depth review of each agency's requirements and capabilities to acquire and archive data, and developed a draft outline for the interagency plan. Active participants are from the U.S. Army Corps of Engineers, National Weather Service, Federal Emergency Management Agency, U.S. Geological Survey, NOAA Coastal Oceans Program, and the U.S. Department of Agriculture's Soil Conservation Service. The goal is to complete the Federal plan in 1994.

National Program for Lightning Detection Systems

In 1983, the Office of the Inspector General, Department of Commerce, issued a management audit report that indicated the significance of the threat of lightning to life and property, and the need to improve

severe weather forecasting. It stated that a number of agencies were active in programs directed toward lightning detection and encouraged the Department of Commerce (NOAA) to determine the action necessary to improve the Nation's lightning detection program.

The Department of Commerce member of the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) requested that the Office of the Federal Coordinator for Meteorology (OFCM) undertake a study to document the Federal agencies' interest in lightning detection, and existing and planned programs of the agencies. The study, completed in early 1985, revealed that extensive systems exist for the detection and tracking of cloud-to-ground lightning. These systems are organized in networks operated by various Federal agencies, universities, and private industry.

In December 1984, ICMSSR agreed to the need for a "National Plan for Lightning Detection Systems." The National Plan should make maximum interagency use of existing systems and coordinate the ongoing lightning programs of the Federal agencies. Preceding the plan, however, a study of the status of the various agency, university, and industry lightning programs was conducted. The study revealed agencies were operating with different levels of experience in lightning detection and at different stages in formulating operational requirements. A report entitled ***The Status of National Programs for Lightning Detection Systems***, published in 1986, identified issues and problems that needed to be resolved in developing a national plan for lightning detection systems. A field testing program evaluating available lightning detection systems was conducted by the National Severe Storms Laboratory (NSSL). A report by NSSL, ***An Evaluation of Two Lightning Ground Strike Locating Systems***, was published in 1988.

The Working Group for Lightning Detection Systems (WG/LDS) determined that development in several areas had not progressed sufficiently to prepare a final national plan. To further the many efforts in progress, including an interagency experiment in using national lightning data, a ***Preliminary National Plan for Lightning Detection Systems*** was published by the OFCM in 1988 to provide a framework for further development. The interagency experiment in using composite national lightning data was successfully concluded in March 1991. The agencies were able to learn a great deal about the performance of lightning detection systems and the uses of the data.

The Working Group has compiled agency requirements for lightning detection and developed a set of standards for lightning detection systems. These documents formed the foundation for a National Weather Service procurement of operational lightning data from a commercial source and a Request for Proposal was issued in February 1991. Proposals were received and evaluated. Contract award took place in August 1992. The data are used routinely in NWS field operations. Meanwhile, various agencies continue to make use of lightning data to meet their requirements.

Profiler Systems

NOAA formally initiated research in the early 1980's to explore the development of ground-based systems that would supplement, and in some instances provide an alternative to, the radiosondes used over the past 50 years to obtain upper-air meteorological data. The concept of profilers involves combining remote sensors to monitor upper-air winds, temperature, and moisture continuously and automatically.

Wind Profilers. NOAA began installation of its wind profiler demonstration network (WPDN) in 1990 and completed the installation in early 1992. WPDN wind profilers form a network of 32 nearly identical unattended radar sites. Each site is configured with a wind profiling Doppler radar, an optional surface meteorological package, equipment shelter, and local signal and data processing capability. Each site has a communications link to the Profiler Control Center -- a monitoring, data processing, and command and control facility located in NOAA's Forecast Systems Laboratory in Boulder, Colorado. WPDN data are collected and distributed in near-real-time to NWS, other agencies, and institutions to assess the impact of profiler technology on NWS operations and to support research on a wide range of atmospheric problems. This assessment is designed to determine the potential value of a national network and to aid the decision-making process of implementing such a network.

Thermodynamic Profiling. Types of temperature and moisture profilers include Radio Acoustic Sounding System (RASS), the correlation radiometer (CORRAD),

the High-resolution Interferometric Sounder (HIS), and the Raman and Differential Absorption Lidar (DIAL). Temperature sounding comparisons between radiosondes, RASS, and the microwave radiometer have been conducted with encouraging results. HIS experiments have shown promise but more work is needed. By operating a thermodynamic profiler in conjunction with a wind profiler, wind, temperature, and moisture profiles can be obtained simultaneously and independently.

Interdepartmental Hurricane Conference

In February 1993, the Office of the Federal Coordinator for Meteorology hosted the 47th Interdepartmental Hurricane Conference (IHC) in Miami, Florida. On the first day, the research community's presentations covered on-going research, experiments, and performance of numerical models. During the rest of the conference, representatives from DOC, DOD, and DOT reviewed the 1992 hurricane season and operations in the Atlantic, East and West Pacific, and Indian Ocean. As a result of the storms that made landfall, Hurricanes Andrew and Iniki and Typhoon Omar, IHC attendance was nearly 140 people. The representatives proposed IHC action items and changes to the ***National Hurricane Operations Plan*** (NHOP) and the ***National Plan for Tropical Cyclone Research*** (NPTCR). Changes that were agreed upon have been incorporated into the plans; the 1993 NHOP was published in April and the changes to the NPTCR were disseminated in March 1993. One of the most discussed agenda items was the need for WSR-88D tropical cyclone algorithms. Three other groups met in conjunction with the 47th IHC: Improved Weather Reconnaissance Program Council (IWRPC); Ad Hoc Group for Tropical Cyclone Research (AHG/TCR); and National Weather Service Advisory Committee on Unmanned Aerial Vehicles (Hurricanes). In addition, FAA, USAF Reserve, OFCM staff, and NOAA Corps Aircraft Operations representatives met and discussed weather reconnaissance issues and volcanic ash fallout problems.

Weather Reconnaissance Program

The Air Force Reserve's 815th Weather Squadron (815 WS) provides weather reconnaissance in support of tropical cyclone and winter storm forecasting operations. The 815 WS, part of the 403rd Airlift Wing, Keesler Air Force Base, Mississippi, operates 12 WC-130 aircraft that are configured with the Improved Weather Reconnaissance System, a fully automated, high-density data gathering system. These data are vital to the forecasts and warnings produced by the National Hurricane Center, the Central Pacific Hurricane Center, and the National Meteorological Center. The Office of NOAA Corps Aircraft Operations has two fully instrumented WP-3D aircraft to augment the 815 WS when necessary and to support the research requirements of the National Hurricane Center and the Hurricane Research Division of the Office of Oceanic and Atmospheric Research. In addition to the activities addressed in the IWRS section (page 2-7), the OFCM is currently serving as the contracting officer's technical representative for the procurement of a prototype stepped frequency microwave radiometer, which will provide improved surface wind speeds around tropical storms and hurricanes, to be flown on NOAA's WP-3D.

No-GOES Contingency Plan

Problems with the development of the new GOES-I satellite instruments have delayed the launch to early 1994. NOAA continues to refine its No-GOES Contingency Plan in the event that an interruption occurs in GOES-7 imaging operations, prior to a GOES-I launch.

The Plan was distributed to agency representatives on the Committee for Operational Environmental Satellites and to other offices having a broad operational interest. To date, four national tests have been conducted by NOAA, with the fifth test scheduled for October 1993. These operational tests have served as a mechanism to further improve products and communications procedures to ensure the timeliness, quality, and utility of the No-GOES imagery. The goal of these No-GOES tests is to demonstrate the NOAA product generation and distribution system to supply imagery from non-GOES sources, and to evaluate the utility of the current No-GOES product suite. After each test, feedback from the user community assists NOAA in establishing an optimum suite of No-GOES products.

Enhancements have been made to provide additional capabilities to access, process, distribute, and display non-GOES satellite data. Specifically, observations from NOAA and Department of Defense (DOD) polar orbiting satellites and from the

EUMETSAT/European Space Agency's Meteosat-3 satellite are being enhanced to present these data in the most useful format for the operational meteorological users. Enhancements include the addition of U.S. state boundaries on Meteosat-3 imagery, institution of operational Meteosat-3 products on GOES-Tap via the new GOES Sectorizer System (GSS), new enhanced polar acquisition stations at selected NWS offices, higher resolution NOAA polar satellite composites, and various processing/communications upgrades. As additional systems, capabilities, and products are established, they will be incorporated and evaluated in subsequent tests.

Hydrometeorology

A relatively new working group has been addressing areas for mutual cooperation and coordination in hydrometeorology. One of its first tasks has been the development of a handbook for automated flood warning systems, a task still in progress. The group also recommended the workshop held in late 1991 that was sponsored jointly by OFCM and the Department of the Interior's Office of Water Data Coordination. The workshop addressed three particular items:

- the archiving of the NEXRAD precipitation data;
- the rain gage networks to calibrate the Doppler radars;
- the dissemination of information to users of radar data.

A report summarizing the results of the workshop was issued in January 1992, and the complete proceedings were published in September 1992.

Atmospheric Transport and Diffusion

The Working Group for Atmospheric Transport and Diffusion (WG/ATD) published the ***Directory of Atmospheric Transport and Diffusion Models, Equipment, and Projects*** in March 1991. During the past year, the WG/ATD has been updating the directory. A new directory will be published in 1993.

Space Environment Services and Supporting Research

The National Space Environment Forecast and Warning Program provides 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 human life or effective and economic operation of modern technical systems. The common needs of the participating agencies have led to a program of shared resources and responsibilities that extend to observations and to operation of forecast centers that provide standard services to meet those needs.

Observations of solar activity with 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)/NOAA environmental satellites. DOD provides ionospheric data from terrestrial networks. Research data, also useful for the forecast and warning services, are obtained from other agencies and shared through real-time communications networks and jointly operated databases. Research data from experiments sponsored by the National Science Foundation (NSF) was made available through these data sharing arrangements. Provision for real-time access to data from National Aeronautics and Space Administration 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 Departments of Energy (DOE) and Interior (DOI) make space-based and ground-based data available through similar arrangements. The Department of Transportation (DOT) operates radio navigation 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. A Japanese satellite equipped with a special U.S. sensor provides X-ray imaging of the Sun. Most of the data gathered in this program are archived in data centers for use in future studies.

The data gathered in the space environmental monitoring program need 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 databases to the agencies is operated jointly by DOD and DOC/NOAA in Boulder, CO to meet common needs. Some agencies, such as DOD's Air Force Space Forecast Center (AFSFC) at Falcon

Air Force Base, CO, 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 in the space environment program are detailed in the ***National Plan for Space Environment Services and Supporting Research, 1993-1997*** (FCM-P10-1993), which was prepared by the OFCM Committee for Space Environment Forecasting and published in 1993.

Monitoring the Stratosphere

There is considerable public concern and political debate about the possible man-made effects and influences on the ozone layer. Similarly, there are concerns about possible changes in the Earth's global climate. To measure these effects and changes, if any, long-term monitoring of the ozone and other stratospheric trace gases and temperatures is necessary. The data obtained from this stratospheric monitoring are used to support long-term global studies that can be regarded as "basic" research. However, the stratospheric monitoring is an operational activity that is an extension of atmospheric monitoring for weather and climate. As a result, it is included in this Plan.

In 1982, OFCM published ***The National Plan for Stratospheric Ozone Monitoring and Early Detection of Change, 1981-1986***. The plan developed a program of transition from a reliance on a ground-based network to a combined satellite and ground-based program providing global coverage of ozone and temperature.

The more recent ***National Plan for Stratospheric Monitoring, 1988-1997*** (FCM-P17-89) published in 1989 builds on the previous effort and, in particular, stresses that the problem is not simply one of detecting ozone change. The complex interactions of chemistry, radiation, and dynamics require that meteorological parameters and many chemical species be monitored. Moreover, experience has shown that monitoring, per se, is not a simple engineering problem of taking observations at a station. The stratospheric changes being sought are relatively small, thus monitoring should be considered as a combination of theory, laboratory measurements, field measurements, and interpretation. Sections in the plan give detailed attention to monitoring ozone, meteorology (temperature and winds), solar irradiance, source gases, and trace gases. The agencies' programs and plans for monitoring are described.

From the viewpoint of sensors and sensor platforms the great majority of considerations are progressing in a satisfactory manner. Operational measurement programs for the source gases and the satellite measurements of ozone and temperature continue. In addition, the international Network for Detection of Stratospheric Change (NDSC) is being developed and operations began during 1992. Also, the Upper Atmosphere Research Satellite (UARS) was launched in September 1991. With current assessment of an extended lifetime of the satellite (one cryogen cooled instrument will have a scheduled lifetime of about 20 months), UARS will play an important role in evaluation of other monitoring products.

In addition, NOAA/NESDIS has established plans to incorporate high-altitude microwave channels (sensing above 40 km) as part of the next-generation satellite system. The lack of this information was identified in the National Plan as a major deficiency of the monitoring program. Unfortunately, these high-altitude channels can not be included until the late 1990's. Fortunately, the DOD is planning to include a somewhat different version of the high-altitude microwave channels on their operational SSM/I satellite beginning in about 1996. These data would fill the gap in coverage and the Working Group for Monitoring the Stratosphere has recommended that these data be included within the NOAA operational temperature processing system.

Mobile Meteorological Equipment.

In 1991, OFCM sponsored a report entitled ***Federal Meteorological Requirements 2000*** (FCM-R13-1990) that was a review of the meteorological requirements of the agencies of the Federal Government through the decade of the 1990s and leading up to the year 2000. The report recommended areas where continued and increased interagency coordination is warranted, thus providing opportunities for further action by OFCM. One of those areas for near-term OFCM involvement was in the area of "Mobile Meteorological Equipment." The viewpoint was that DOD's tactical equipment should be given increased visibility to possibly satisfy other Federal agency needs.

With the approval of the ICMSSR, an ad hoc group was formed to address this issue. The group's efforts culminated in the March 1993 publication of the ***Federal Directory of Mobile Meteorological Equipment and Capabilities***. Future activities of the group will include the updating and expansion of the directory.

Committee and Working Group Changes

A schematic of the Federal Committee structure for meteorological coordination is found on the back inside cover of this Plan. In the past year, ICMSSR established the Ad Hoc Group for Volcanic Ash under the Committee for Aviation Services. In recent years, several major volcanic eruptions have occurred and have spewed volcanic ash over large areas and high into the stratosphere. The volcanic ash represents a serious hazard to aircraft engines and impacts agricultural and environmental systems. The Ad Hoc Group for Volcanic Ash will be the principal focal point for preparing a, "National Plan for Volcanic Ash Reporting and Warning." The Plan will include the requirements and the duties of the Federal agencies with regard to volcanic ash information. The Plan will include:

- procedures for reporting volcanic events;
- the systems to collect volcanic information;
- descriptors of ash plumes;
- systems to forecast ash plume movement;
- forecast products;
- dissemination systems for forecasts and warnings.

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 listed in Table 2.1. In general, single copies are available upon request to OFCM.

RELATED FEDERAL METEOROLOGICAL COORDINATION

The focus of OFCM and of this report is on Federal operational meteorological programs and directly supporting research. While not specifically a part of OFCM activities, brief descriptions are given below of Federal coordination activities that relate to other aspects of meteorology.

Subcommittee for Atmospheric Research

The Subcommittee for Atmospheric Research (SAR) was originally known as the Interdepartmental Committee for Atmospheric Sciences (ICAS). It was established in 1959 by the Federal Council for Science and Technology (FCST) and was the principal mechanism for coordination of research in atmospheric sciences within the Federal Government until 1977. At that time, FCST and its subordinate organizations were abolished and replaced by the Federal Coordinating Council for Science, Engineering and Technology (FCCSET). SAR succeeded ICAS and became a Subcommittee of the FCCSET Committee on Atmosphere and Oceans (CAO). In 1987, the CAO was disestablished and replaced by the Committee on Earth Sciences (CES) which became the Committee on Earth and Environmental Sciences (CEES) in 1990. The SAR is now a subcommittee of the CEES.

The primary goal of SAR is to improve the planning and coordination of atmospheric research activities among the agencies involved. Agencies represented on SAR are the U.S. Departments of Agriculture, Commerce, Defense (Army, Navy, Air Force), Energy, Interior, State, and Transportation. The Environmental Protection Agency, National Aeronautics and Space Administration, and National Science Foundation are also represented. Observers from several other agencies such as the Office of the Federal Coordinator for Meteorology, the Office of Science and Technology Policy, the Office of Management and Budget, and the National Academy of Sciences/National Research Council complete the SAR.

SAR publishes a biennial report of the ***National Atmospheric Sciences Program*** that is distributed widely. The latest report published in 1992 highlights 1987-1990 activities and budgets.

World Weather Program

Some Federal agencies participate in international activities relating to meteorological services and data exchange. These activities are carried out under the World Weather Program of the World Meteorological Organization which is a specialized agency of the United Nations. The World Weather Program is described in Appendix E.

Table 2.1 Current Publications of OFCM

Publication Title	Date	Number
Federal Plan for Meteorological Services and Supporting Research, Fiscal Year 1994	May 1993	FCM-P1-1993
National Plan for Space Environment Services and Supporting Research: 1993-1997	August 1993 (Expected)	FCM-P10-1993
National Severe Local Storms Operations Plan	September 1990	FCM-P11-1990
National Hurricane Operations Plan	April 1993	FCM-P12-1993
National Winter Storms Operations Plan	October 1992	FCM-P13-1992
Federal Plans for Mutual Support and Cooperative Backup Among Operational Processing Centers	March 1985	FCM-P14-1985
National Plan for Stratospheric Monitoring, 1988-1997	July 1989	FCM-P17-1989
National Aircraft Icing Technology Plan	April 1986	FCM-P20-1986
Preliminary National Plan for Lightning Detection Systems	June 1988	FCM-P22-1988
Federal Plan for the Coordination of Automated Weather Information System Programs	May 1988	FCM-P23-1988
Federal Plan for Meteorological Information Management	July 1991	FCM-P24-1991
National Plan for Tropical Cyclone Research Change 1 (update inserts)	July 1992 March 1993	FCM-P25-1992
National Aviation Weather Program Plan	September 1992	FCM-P27-1992
Federal Meteorological Handbook No. 1 - Surface Observations	April 1988	FCM-H1-1988
Federal Meteorological Handbook No. 2 - Surface Synoptic Codes Surface Synoptic Code Tables (Update)	December 1988 July 1990	FCM-H2-1988 FCM-T1-1990
Federal Meteorological Handbook No. 10 - Rocketsonde Observations	December 1988	FCM-H10-1988
Federal Meteorological Handbook No. 11 - Doppler Radar Meteorological Observations		
Part A - System Concepts, Responsibilities and Procedures	June 1991	FCM-H11A-1991
Part B - Doppler Radar Theory and Meteorology	June 1990	FCM-H11B-1990
Part C - WSR-88D Products and Algorithms	February 1991	FCM-H11C-1991
Part D - WSR-88D Unit Description and Operational Analysis	April 1992	FCM-H11D-1992
Directory of Atmospheric Transport and Diffusion Models, Equipment, and Projects	April 1993	FCM-I3-1993
Federal Directory of Mobile Meteorological Equipment and Capabilities	March 1993	FCM-I5-1993
Tropical Cyclone Studies Tropical Cyclone Studies Supplement	December 1988 August 1989	FCM-R11-1988 FCM-R11-1988 S
Interdepartmental Meteorological Data Exchange System Report, IMDES	July 1991	FCM-R12-1991
Federal Meteorological Requirements 2000	October 1990	FCM-R13-1990
Standard Formats for Weather Data Exchange Among Automated Weather Information Systems	May 1990	FCM-S2-1990
Standard Telecommunication Procedures for Weather Data Exchange	October 1991	FCM-S3-1991
Federal Standard for Siting Meteorological Sensors at Airports	May 1987	FCM-S4-1987
47th Interdepartmental Hurricane Conference (Minutes)	February 1993	None

SECTION 3

RESOURCE INFORMATION AND AGENCY PROGRAM UPDATES

Budget requests for meteorological services and supporting research total $2.473 billion for FY 1994. This is an increase of 17.9 percent from the $2.097 billion appropriated for FY 1993. Of the total, the Department of Commerce budget represents 49.3 percent, Department of Defense represents 24.1 percent, and Department of Transportation represents 18.0 percent, with the remaining 8.6 percent for other agencies.

The tables in this section summarize fiscal information of the Federal Government for the fiscal years 1993 and 1994. The funds shown are those used to provide meteorological services and associated supporting research that has as its immediate objective the improvement of these services. Fiscal data are current as of the end of February 1993 and are subject to later changes. The data for FY 1994 do not have legislative approval and do not constitute a commitment by the U.S. Government. The budget data are prepared in compliance with Section 304 of Public Law 87-843, in which Congress directed that an annual horizontal budget for meteorological programs in the Federal agencies be prepared.

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 (appropriated) funding level for FY 1993, the budget request for FY 1994, the percent change, and the individual agencies' percent of the total Federal funding for FY 1993 and FY 1994.

DEPARTMENT OF AGRICULTURE (USDA)

The USDA budget request for FY 1994 is $27.62 million -- essentially the same as the planned funding level for FY 1993. The FY 1994 request for meteorological operations ($12.16 million) permits USDA to assist the Department of Commerce in determining farmers' needs for weather information and in disseminating such information to them. Major USDA activities related to weather observations include the need to complete incremental modernization of the snow telemetry (SNOTEL) system operated by the Soil Conservation Service and the replacement of manual fire rating stations with remote automated weather stations (RAWS) by the Forest Service. The SNOTEL and RAWS networks provide cooperative data for NOAA's river forecast activities, the irrigation water supply estimates, and Bureau of Land Management operations. The Digital Weather Image Processing System (DWIPS) has enhanced global monitoring of crop conditions by the Joint Agricultural Weather Facility.

The supporting research component of the USDA request for FY 1994 ($15.46 million) focuses on understanding the interactions of weather and climate with plant and animal production and water resources management. The goal of supporting research is to develop and disseminate information and techniques to ensure an abundance of high-quality agricultural commodities and products while minimizing adverse effects of agriculture on the environment. The research budget does not include the coordinated ultraviolet band work with the Environmental Protection Agency (EPA). The Forest Service program, initiated in 1988, supports a research program for a long-term monitoring network to assess potential effects of global climate change and variability on forest health and productivity. Work continues in forestry ecological systems modeling. In FY 1994, Agriculture Research Service will continue hydrologic work on a regional scale. The special grant for the North Dakota Agricultural Weather program ($400,000) is included in the FY 1994 budget.

DEPARTMENT OF COMMERCE (DOC)

All reported DOC meteorological activities are within the National Oceanic and Atmospheric Administration (NOAA). The NOAA FY 1994 total congressional request of $1,219 million for meteorological programs is 33 percent more than the FY 1993 appropriated funds. Changes in NOAA's operations and supporting research for FY 1994 are presented below, subdivided by activities.

Weather Services. Increases for FY 1994 include 270 positions and $52.5 million for the NWS transition to a modernized weather service (MARDI). This

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

AGENCY	Operations FY93	Operations FY94	Operations %CHG	% of FY94 TOTAL	Supporting Research FY93	Supporting Research FY94	Supporting Research %CHG	% of FY94 TOTAL	Total FY93	Total FY94	Total %CHG	% of FY93 TOTAL	% of FY94 TOTAL
Agriculture	11673	12160	4.2	0.6	15946	15462	-3.0	4.4	27619	27622	0.0	1.3	1.1
Commerce/NOAA	869740	1172759	34.8	55.4	47343	46857	-1.0	13.2	917083	1219616	33.0	43.7	49.3
Defense(Subtot)	523205	511476	-2.2	24.1	69435	84006	21.0	23.7	592640	595482	0.5	28.3	24.1
Air Force	334312	320441	-4.2	15.1	11100	13900	25.2	3.9	345412	334341	-3.2	16.5	13.5
DMSP*	49055	51290	4.6	2.4	21938	31953	45.7	9.0	70993	83243	17.3	3.4	3.4
Navy	92459	92826	0.4	4.4	9965	10260	3.0	2.9	102424	103086	0.7	4.9	4.2
Army	47379	46919	-1.0	2.2	26432	27893	5.5	7.9	73811	74812	1.4	3.5	3.0
Interior/BLM	870	870	0.0	0.0	0	0	0.0	0.0	870	870	0.0	0.0	0.0
Transportation/CG	4742	4742	0.0	0.2	0	0	0.0	0.0	4742	4742	0.0	0.2	0.2
Transportation/FAA	349433	408552	16.9	19.3	33663	30660	-8.9	8.7	383096	439212	14.7	18.3	17.8
EPA	0	0	0.0	0.0	8100	8100	0.0	2.3	8100	8100	0.0	0.4	0.3
NASA	7354	7982	8.5	0.4	155000	169000	9.0	47.7	162354	176982	9.0	7.7	7.2
NRC	360	360	0.0	0.0	0	0	0.0	0.0	360	360	0.0	0.0	0.0
TOTAL	1767377	2118901	19.9	100.0	329487	354085	7.5	100.0	2096864	2472986	17.9	100.0	100.0
% of FY TOTAL	84	86			16	14			100	100			

*DMSP is the Defense Meteorological Satellite Program that supports all DOD components and other government agencies. It is primarily funded and managed by the Air Force.

increase will fund the staffing required to operate the new NEXRAD units, prepare for the multi-site operational demonstration, provide required training on the new technologies, and prepare for the nationwide NWS modernization. Recent delays in the transition to modernized operations make it critical now to expedite the field staffing transition; complete scheduled Weather Forecast Office/River Forecast Center relocations; continue with NOAA Weather Radio Console Replacement and other system developments; and begin the certification process as required by Public Law 102-567.

An increase of 24 FTE and $38.9 million funds the DOC share of the tri-agency NEXRAD program, including the hardware production contract, logistical support for system deliveries in FY 1995 and 1996, and depot and logistics supply support for fielded radar systems. A $400,000 increase for the ASOS program will allow the full-scale production and installation phase of ASOS to continue. An increase of 40 FTE and $29.3 million will support continued AWIPS/NOAAPORT development phase activities that were initiated in December 1992, pre-MARD preparation and risk reduction activities, equipping a limited number of sites, and Operational Test and Evaluation activities to be conducted in FY 1994. And finally, NOAA proposes an increase of $6 million for the NOAA Central Computer Facility. The requested funding level will be used to fully implement the Class VII system (installed in FY 1993), continue the existing Cray YMP 8/32 computer system, and maintain both systems.

Proposed FY 1994 decreases include the following: (1) $190,000 by canceling contract observers at Stampede Pass, Washington; Sexton, Oregon; and Blue Canyon, California, (2) $240,000 for the American Samoa Weather Service Office and (3) $518,000 to reduce the level of engineering development and redesign at the National Data Buoy Center.

Environmental Satellite, Data, and Information Services. Proposed funding for FY 1994 includes an increase in the polar-orbiting satellite program of $8.2 million and an increase in the geostationary satellite program of $64.7 million. These changes will allow for continuation of procurements to provide the spacecraft and instruments, launch services, and ground systems necessary to assure continuity of environmental satellite coverage. The FY 1994 budget request will maintain a system of polar-orbiting satellites that obtains global data and a system of geostationary satellites that provides near continuous observations of the Earth's western hemisphere.

Funding of $10.3 million is included for the continuation of the Earth System Data and Information Management (ESDIM) Program. This program is a NOAA-wide effort to save critical environmental data from being lost and to improve access to these data.

Funds are also included to provide basic mission services including maintenance and operation of satellite ground facilities; provision of satellite-derived products; conduct of research to improve the use of satellite data; and the archiving and dissemination of climatic, oceanographic and geophysical data.

Weather Research. Requested funding for FY 1994 of this activity, which includes Solar Environmental Research, is $34.99 million -- a decrease of about 1.9 percent from FY 1993. Critical increases are requested for base programs in weather research and space-environment forecasts. An increase of $357,000 is requested to improve solar forecast data handling and processing capabilities. Total decreases of about $1.0 million are proposed. Federal funding for the cooperative five-state Weather Modification Research Program is proposed for termination. This Program supports studies of the physical mechanisms of cloud and precipitation formation. Finally, funding for the new Southeastern U.S. storm research program is also proposed for termination.

DEPARTMENT OF DEFENSE (DOD)

The DOD total budget request for FY 1994 is $595.5 million which is 0.5 percent more than the total funding level for FY 1993. Details are given below.

U.S. Air Force

U.S. Air Force resources for meteorological support fall under two distinct categories: general operations and Defense Meteorological Satellite Program (DMSP) operations.

General Operations. The operations portion of the budget request for FY 1994 is $320.4 million. Air

Force funding represents a large portion of environmental support to the DOD. These funds will pay for weather and space environmental support to the USAF (both active and reserve components), the U.S. Army, seven unified commands, and other agencies as directed by the Chief of Staff of the Air Force. More than 4000 people conduct these activities at over 250 worldwide locations; these people include active military, Air Force reservists, Air National Guard weather flight personnel, weather communications and computer specialists, and civilians. These funds pay the salaries of these people and the day-to-day operations and maintenance costs for the support they provide.

The $320.4 million also includes weather communications. The Automated Weather Network (AWN) communications hub (to be located at Tinker AFB, OK by FY 1994) processes over 250,000 weather messages per day to and from nearly 10,000 worldwide weather stations over Air Force long-haul circuitry and approximately 1400 leased circuits.

The FY 1994 request includes $47 million for procurement of Air Force standard weather systems needed to sustain and improve on current environmental support capabilities. Funding for procurement of the Automated Weather Distribution System (AWDS) is complete, and acquisition of pre-planned product improvements (P3I) for AWDS is underway. AWDS P3I retrofits AWDS systems with enhancements that were either beyond the scope of the original program or beyond the state of the art. Improvements will include communications connectivity to other DOD systems and ingest of GOES satellite data. Procurement funding of the AF portion of the tri-agency NEXRAD [Weather Surveillance Radar, 1988D (WSR-88D)] continues in FY 1994. Other procurement funding goes to upgrading the Satellite Data Handling System at Air Force Global Weather Central (AFGWC).

General Supporting Research. The FY 1994 budget request for Air Force supporting research is $13.9 million. The Air Force continues R&D efforts in the radio telescope portion of the Solar Electro-optical Observing Network (SEON) and the AWDS P3I area.

This program includes R & D efforts for the Combat Weather System (CWS) in support of USAF and Army combat operations, and combines initial efforts in tactical weather observing and forecasting systems with further refinement of Electro-Optical Tactical Decision Aids (EOTDA).

DMSP Operations. DMSP is the primary DOD environmental satellite program. Though funding for DMSP comes from the Air Force, the system is the major source of space-borne meteorological data for the military services and other high-priority DOD programs. Through the shared processing network, the DOD provides environmental data from DMSP sensors to the National Weather Service via the network hub at NESDIS.

The operations portion of the budget request is $51.3 million. The major portion of this funding is for on-orbit operations, tactical terminal procurement, and satellite sensor integration. Also included in the DMSP line is funding for 370 military and civilian personnel associated with the operation of, and to a much smaller extent, the procurement of the DMSP system. The funds also pay operations costs for two dedicated command and control facilities.

DMSP Supporting Research. The FY 1994 budget request for DMSP research and development is $31.9 million. These funds are for initial development of the next generation satellite system (DMSP Block 6), which is scheduled to replace the Block 5D-3 production spacecraft in 2005. Block 6 spacecraft will offer improved avionics and will exploit advanced hardware and software technologies to produce a more reliable, longer-lived spacecraft with greater mission capability. The remaining funds are for continued calibration and validation efforts for new and modified sensors, development of a new smaller tactical terminal, and modification of data application algorithms.

U.S. Navy

The U.S. Navy FY 1994 funding request for meteorological programs is $103.09 million. The request includes $92.83 million for operational programs and $10.26 million for supporting research.

Operations Support. Operations support for the Navy and Marine Corps includes the day-to-day provision of meteorological products and services, as it does for other agencies. Navy also provides specific and unique services; such as, acoustic propagation

models and products, environmentally-sensitive tactical decision aids, and global ice analysis and forecast products, to all services. Communications costs are significant for an organization with global responsibilities, and the uniqueness of forces at sea drives requirements for specific products and communications capabilities. Primary program changes for FY 1994 include increased funding for the Cooperative Program for Operational Meteorology, Education and Training (COMET) and increased large-scale computer operational funding to cover a full year of the Primary Oceanographic Prediction System (POPS) operations.

Systems Acquisition. Major systems undergoing procurement in FY 1993 and FY 1994 include:

- Tactical Environmental Support System (TESS(3))
- Primary Oceanographic Prediction System (POPS)
- SMQ-11 Environmental Satellite Receiver/Recorder
- Automated Surface Observing System (ASOS)
- Shipboard Meteorological and Oceanographic Observation System (SMOOS)
- NEXRAD Principal User Processors (PUP)

Research and Development. This research is generally not system-specific, but may have applications to one or more meteorological, oceanographic or tactical systems. Navy's tabulation of these data includes R&D funding for exploratory development initiatives.

The U.S. Navy's advanced development, under sponsorship of the Oceanographer of the Navy, transitions work started under exploratory development to the operational Navy systems. Work in this area includes upgrades to the Navy's numerical forecasting capability; improvements in communications, including data compression techniques; and development/ improvement of models to better predict meteorological parameters in littoral regions as well as the impact these parameters have on sensors and weapon system performance.

U.S. Army

The U.S. Army is requesting $46.9 million for meteorological operations and $27.9 million in supporting Research and Development in FY 1994. Operations show only a slight decrease from FY 1993 funding. However, it includes the Space and Strategic Defense Command funding of about $4.5 million for weather support at two test facilities for the first time. Although the actual cost of salaries and equipment for artillery meteorological crews continues to increase, the decrease in the number of Army divisions causes a slight decrease in the total cost for operations. Likewise, the cost associated with the USAF weather teams supporting Army units decreased as the number of locations were drawn down.

Acquisition cost associated with the Field Artillery Meteorological Measuring System (MMS) and the Integrated Meteorological System (IMETS) remain on track in FY 1994 with $11.1 million being programmed for MMS and $5.6 million for IMETS. Within U.S. Army Europe and Forces Command, costs are associated with maintaining software and hardware for existing tactical weather systems and adding a few interim systems for aviation support until IMETS is fielded.

Within the Training and Doctrine command, the U.S. Army Aviation Center will have $0.44 million increased costs associated with the installation of NEXRAD, distribution of weather information within the flying units, and installation of automated weather observing systems at limited use locations not fully manned by Air Force weather observers.

Army Materiel Command (AMC) funding of $8.9 million in FY 1994 for Test and Evaluation Command (TECOM) Meteorological (Met) Teams was a decrease of 9 percent from FY 1993. The FY 1994 budget provides for only the basic operations of 11 Met Teams supporting 14 Army Research, Development, Test and Evaluation (RDTE) ranges and sites. TECOM Met Teams provide atmospheric data collection, analyses, consultation, warning and forecast services for Army and DOD RDTE efforts. No new meteorological initiatives were begun in FY 1993 nor submitted for FY 1994 because of funding constraints.

In Research and Development, Army Research Laboratory, Battlefield Directorate (formerly ASL) showed modest increases in basic and applied research, while Army Research Office, Communication and Electronic Command and the Research Institute of Environmental Medicine were about the same in FY 1993 and FY 1994.

TABLE 3.2 AGENCY OPERATIONAL COSTS, BY BUDGET CATEGORY

(Thousands of Dollars)

AGENCY	Operations Support		Systems Acquisition		Special Programs		Total			%of FY94 TOTAL
	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	%CHG	
Agriculture	11087	11552	0	0	586	608	11673	12160	4.2	0.6
Commerce/NOAA	464598	565659	400553	602511	4589	4589	869740	1172759	34.8	55.4
Defense(Subtot)	421571	413192	100509	97189	1125	1095	523205	511476	-2.2	24.1
Air Force	275736	270951	58576	49490	0	0	334312	320441	-4.2	15.1
DMSP*	32300	27700	16755	23590	0	0	49055	51290	4.6	2.4
Navy	87561	88747	4898	4079	0	0	92459	92826	0.4	4.4
Army	25974	25794	20280	20030	1125	1095	47379	46919	-1.0	2.2
Interior	870	870	0	0	0	0	870	870	0.0	0.0
Transportation/CG	4742	4742	0	0	0	0	4742	4742	0.0	0.2
Transportation/FAA	255929	281971	91318	124266	2186	2315	349433	408552	16.9	19.3
EPA	--------- Not Applicable ---------									
NASA	5896	5942	792	1130	666	910	7354	7982	8.5	0.4
NRC	360	360	0	0	0	0	360	360	0.0	0.0
TOTAL	1165053	1284288	593172	825096	9152	9517	1767377	2118901	19.9	100.0
% of FY TOTAL	66	61	34	39	1	0	100	100		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD components and other government agencies. It is primarily funded and managed by the Air Force.

DEPARTMENT OF THE INTERIOR (DOI)

The DOI funding request of $870,000 for FY 1994 is for meteorological operations within the Bureau of Land Management (BLM). In 1987, the funding and implementation for the Bureau-wide Initial Attack Management System (IAMS) and the Remote Automated Weather Station (RAWS) programs were re-emphasized and the program was completed in 1992. This emphasis increased the operational and maintenance (O&M) funding required and the procurement funding needed to complete the total system. Annual increases in program costs are attributed to the increased requirements of personnel, travel, and operations to cover the added stations and network expansion to full implementation. After full implementation is reached, procurement costs will be reduced to systems life cycle change-out and O&M costs will normally plateau.

DEPARTMENT OF TRANSPORTATION (DOT)

The meteorological programs for the U.S. Coast Guard and the Federal Aviation Administration for FY 1993 and FY 1994 are described below.

U.S. Coast Guard (USCG)

All of USCG's funding for meteorological programs is for operations support. In FY 1994, the requested funding level is $4.74 million which is the same as the planned budget for FY 1993. There has been no basic change in the meteorological services provided by the Coast Guard. 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 coastal and marine weather observations to NOAA's National Weather Service and provides use of buoy tender facilities to the National Data Buoy Center.

Federal Aviation Administration (FAA)

Total FAA funding for aviation weather in FY 1993 is $383.1 million for both operations and supporting research. The FAA's proposed FY 1994 total budget for aviation weather is $439.2 million. The increase in the budget is principally in Operations which will rise from $349.4 million to $408.6 million. Funding for Supporting Research will decrease about 8.9 percent to $30.7 million.

The FAA involvement in meteorological programs is principally concerned with aviation weather. The FAA role is limited to the observation and dissemination of aviation weather information and to very short range automated warnings and forecasts. FAA's aviation weather programs are directed to improve the timeliness and accuracy of weather information to the aviation user. The FAA also supports research in those areas that involve improvements to the observation, data dissemination, and forecasting of aviation weather; the end user of the resulting products include pilots, dispatchers, and air traffic controllers.

The FY 1994 increases are in Operations Support and Systems Acquisition (see Table 3.2) as FAA continues to increase its support to monitor and disseminate aviation weather to pilots, dispatchers, and controllers. Individual system acquisition and operational programs with increases greater than $2 million are listed below:

Program	Increase ($millions)
Operations Support:	
Flight Service Stations Operations	3.2
Contract Aviation Weather Observations	3.3
Maintenance of Meteorological Equipment	10.6
Leased Telecommunication Lines	2.0
ASOS Maintenance	4.8
Systems Acquisition:	
Next Generation Weather Radar	$38.6
Automated Surface Observing System	10.2
Flight Service Station Automation	4.8

Partially offsetting these increases in FY 1994 are decreases in Systems Acquisition programs of $14.2 million for the Terminal Doppler Weather Radar (TDWR), $3.9 million for AWOS, and $2.1 million for the Realtime Weather Processor.

Funding for supporting research programs decreases from $33.6 million in FY 1993 to $30.7 million in FY 1994. The decreases occur in development programs for airborne meteorological sensors and the Aviation Gridded Forecast System. Decreases occur in research programs for short range

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

AGENCY	Research & Development		Systems Development		Special Programs		Total			%of FY94 TOTAL
	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	%CHG	
Agriculture	15946	15462	0	0	0	0	15946	15462	-3.0	4.4
Commerce/NOAA	36134	38102	4220	4405	6989	4350	47343	46857	-1.0	13.2
Defense(Subtot)	63685	78606	5750	5400	0	0	69435	84006	21.0	23.7
Air Force	6100	9400	5000	4500	0	0	11100	13900	25.2	3.9
DMSP*	21938	31953	0	0	0	0	21938	31953	45.7	9.0
Navy	9965	10260	0	0	0	0	9965	10260	3.0	2.9
Army	25682	26993	750	900	0	0	26432	27893	5.5	7.9
Interior	--------- Not Applicable ---------									
Transportation/CG	--------- Not Applicable ---------									
Transportation/FAA	5321	2089	28342	28571	0	0	33663	30660	-8.9	8.7
EPA	8100	8100	0	0	0	0	8100	8100	0.0	2.3
NASA	100300	111600	54700	57400	0	0	155000	169000	9.0	47.7
NRC	0	0	0	0	0	0	0	0	0.0	0.0
TOTAL	229486	253959	93012	95776	6989	4350	329487	354085	7.5	100.0
% of FY TOTAL	70	72	28	27	2	1	100	100		

*DMSP is the Defense Meteorological Satellite Program that supports all DOD components and other government agencies. It is primarily funded and managed by the Air Force.

forecasting and for icing analyses and forecasting. The decreases are partially offset by a significant increase in the Aviation Weather Product Generator. The FAA is continuing its airborne windshear research programs and is supporting the development of Aeronautical Data Link Communications. The definition of supporting research used in this Plan generally incorporates a broader spectrum of activities than is covered by FAA's research and development programs.

The number of personnel (full-time-equivalent, FTE) expected to be engaged in FAA's FY 1994 operational aviation weather program is 3759; this is a 5.7 percent increase over the FY 1993 level. The increase is primarily related to increases in required meteorological equipment maintenance.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

All of EPA funding of meteorological programs is for supporting research. The anticipated funding level in FY 1994 is $8.10 million, remaining essentially the same as the FY 1993 level established under the 1990 Clean Air Act Amendments.

Although funding for modeling research into visibility degradation and acid aerosol dispersion will diminish, it will be replaced by a Congressional appropriation for field studies and modeling of accidental releases of toxic and/or hazardous materials. Another Congressional appropriation providing for performance of the Southern Oxidant Study continues during FY 1994.

The EPA is continuing its development and validation of air quality dispersion models for pollutants on all temporal and spatial scales as mandated by the Clean Air Act. The research will focus on indoor, urban, mesoscale and regional models which will be used to develop pollution control and exposure assessment strategies. Increased emphasis will be placed on meteorological research into regional ozone transport, global climate change, toxic chemical dispersion, and acid aerosol formation, while research into acid deposition model development and evaluation continues. Increased efficiency of computation and interpretation of results are being made possible by means of high performance computing and scientific visualization techniques.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

Virtually all of NASA's funding in meteorology is for supporting research. The requested funding for FY 1994 is $169.0 million, an increase of nearly 9 percent from the revised FY 1993 level. The FY 1994 level reflects increased funding for all of the supporting research and analysis programs and for the meteorology share of the Earth Observing System (EOS) instruments, science, and information systems. This meteorology share is estimated to be approximately 10 percent of the total EOS funding.

During FY 1994, NASA will complete Critical Design Reviews for all instruments on the first (i.e., AM-1) EOS platform while preliminary design activities will continue on the instruments planned for the second (PM-1) platform. Also, during FY 1994 the EOS Data Information System (EOSDIS) is required to accomplish its first major milestone: completion of the Version 0 prototype information system for operational use by the Earth science research community. Version 0 will provide Earth science researchers with a comprehensive, interdisciplinary "Earth science view" of existing and near-term, pre-EOS NASA Mission to Planet Earth data. The EOS instrument and science funding have increased from a revised FY 1993 level of $263.8 million to an estimated $322.7 million for FY 1994, while these levels are respectively $130.7 million and $182.7 million for EOSDIS. The remainder of the NASA funding consisting of the meteorology share of Earth probes, mission operations and data analysis, interdisciplinary research, process studies, and modeling and data analysis is estimated to increase by 3 percent in FY 1994 from the revised FY 1993 levels.

NUCLEAR REGULATORY COMMISSION (NRC)

The NRC requested funding is for meteorological operations. The FY 1994 request of $360,000 is essentially unchanged from the FY 1993 request.

The NRC meteorological support program is focused solely on obtaining and analyzing meteorological data and information for atmospheric transport and dispersion models used in dose projections, plume pathway characterizations and concentration estimates related to the safe operation of nuclear facilities and the protection of public health and

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

	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
AGENCY	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94
Agriculture	0	0	0	0	0	0	11673	12160	0	0	0	0	11673	12160
Commerce/NOAA	803342	1105934	35596	36672	25806	27031	2316	0	0	0	2680	3122	869740	1172759
Defense(Subtot)	16113	16271	361729	349215	26828	25816	0	0	113653	115279	4882	4895	523205	511476
Air Force	0	0	334312	320441	0	0	0	0	0	0	0	0	334312	320441
DMSP*	0	0	0	0	0	0	0	0	49055	51290	0	0	49055	51290
Navy	15965	15781	27417	28774	26828	25816	0	0	17367	17560	4882	4895	92459	92826
Army	148	490	0	0	0	0	0	0	47231	46429	0	0	47379	46919
Interior/BLM	0	0	0	0	0	0	0	0	0	0	870	870	870	870
Transportation/CG	3792	3792	0	0	950	950	0	0	0	0	0	0	4742	4742
Transportation/FAA	0	0	349433	408552	0	0	0	0	0	0	0	0	349433	408552
EPA	--------- Not Applicable ---------													
NASA	0	0	0	0	0	0	0	0	0	0	7354	7982	7354	7982
NRC	60	60	0	0	0	0	0	0	0	0	300	300	360	360
TOTAL	823307	1126057	746758	794439	53584	53797	13989	12160	113653	115279	16086	17169	1767377	2118901
% of FY TOTAL	47	53	42	37	3	3	1	1	6	5	1	1	100	100

*DMSP is the Defense Meteorological Satellite Program that supports all DOD components and other government agencies. It is primarily funded and managed by the Air Force.

safety and the environment. Obtaining current, accurate, and relevant meteorological information on a real-time basis for use during emergencies is the primary consideration. The NRC budget in this area reflects this priority.

AGENCY FUNDING BY BUDGET CATEGORY

Table 3.2 (page 3-6) shows how the agencies plan to obligate their funds for meteorological operations broken down by budget category. The funding levels for each agency were discussed above. Table 3.3 shows how the agencies plan to obligate their funds for meteorological supporting research according to the budget categories.

In earlier years, the agencies' operational budgets were subdivided into "functional" categories--Observations, Analyses and Forecasts, Communications, Dissemination, and Management Support. Advancing technology and increasing integration of components have blurred the meaning of these functions and have made identification more difficult. The new categories were chosen to align more closely with agency budgets. As a result, the new categories are referred to as "budget categories." The two major new categories are "Operations Support" and "Systems Acquisition." To a large degree, these correspond to non-hardware costs (Operations Support) and hardware costs (Systems Acquisition). For agency convenience in identifying small components that do not fit into the above two major categories, a third category, is added, "Special Programs." Programs that provide support to several Government agencies such as the Air Force's Defense Meteorological Satellite Program are listed on a separate line. The agencies' supporting research budgets are subdivided along similar lines -- Research and Development (non-hardware), Systems Development (hardware), and again Special Programs for small items that do not easily fit into the first two categories.

AGENCY FUNDING BY SERVICE CATEGORY

Table 3.4 summarizes how the agencies plan to obligate operational funds for basic and specialized meteorological services; Table 3.5 shows a similiar breakout for supporting research funds. Table 3.4 shows that "basic" services require approximately 53 percent of the total operational costs while aviation services require about 37 percent. The remaining 10 percent is used to support the other specialized services. The definitions of specialized and basic services are provided below.

Basic Services

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

Specialized Meteorological Services

Aviation Services. Those services and facilities established to meet the requirements of general, commercial, and military aviation.

Marine Services. Those services and facilities established to meet the requirements of Commerce, Defense, and Transportation 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 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.

General Military 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 Services. Those services and facilities established to meet meteorological

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

	Basic		Aviation		Marine		Agriculture & Forestry		General Military		Other		Total	
AGENCY	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94	FY93	FY94
Agriculture	0	0	0	0	0	0	15946	15462	0	0	0	0	15946	15462
Commerce/NOAA	45718	45232	1625	1625	0	0	0	0	0	0	0	0	47343	46857
Defense(Subtot)	1466	1466	11100	13900	9965	10260	0	0	46904	58380	0	0	69435	84006
Air Force	0	0	11100	13900	0	0	0	0	0	0	0	0	11100	13900
DMSP*	0	0	0	0	0	0	0	0	21938	31953	0	0	21938	31953
Navy	0	0	0	0	9965	10260	0	0	0	0	0	0	9965	10260
Army	1466	1466	0	0	0	0	0	0	24966	26427	0	0	26432	27893
Interior/BLM						---	Not Applicable		---					
Transportation/CG						---	Not Applicable		---					
Transportation/FAA	0	0	33663	30660	0	0	0	0	0	0	0	0	33663	30660
EPA	0		0	0	0	0	0	0	0	0	8100	8100	8100	8100
NASA	0	0	0	0	0	0	0	0	0	0	155000	169000	155000	169000
NRC	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	47184	46698	46388	46185	9965	10260	15946	15462	46904	58380	163100	177100	329487	354085
% of FY TOTAL	14	13	14	13	3	3	5	4	14	16	50	50	100	100

*DMSP is the Defense Meteorological Satellite Program that supports all DOD components and other government agencies. It is primarily funded and managed by the Air Force.

requirements that cannot be classified under one of the preceding categories, such as, space operations, urban air pollution, global climate change, and water management.

PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS

Table 3.6 shows agency staff resources in meteorological operations. Overall, agency staff resources requested for FY 1994 total 16,849, which is an increase of 2.0 percent from FY 1993.

INTERAGENCY FUND TRANSFERS

Table 3.7 summarizes FY 1993 funds transferred from one agency to another agency to pay for services that the second agency 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 and reflects a significant level of interagency cooperation.

Department of Commerce (DOC). The National Science Foundation will be reimbursed $1.3 million for atmospheric modeling; the USCG $1.075 million for support to the National Data Buoy Center; and NASA $250.9 million for procurement and launch of satellites, and $1.34 million for atmospheric modeling and support at Wallops Island.

****

TABLE 3.6 PERSONNEL ENGAGED IN METEOROLOGICAL OPERATIONS
(Units are Full Time Equivalent Staff Years)*

AGENCY	FY93	FY94	%CHG	% of FY94 TOTAL
Agriculture	98	98	0.0	0.6
Commerce/NOAA	4912	5197	5.8	30.8
Reimbursed**	616	616	0.0	3.7
Defense(Subtotal)	7185	7031	-2.1	41.7
Air Force	4824	4673	-3.1	27.7
DMSP*	355	370	4.2	2.2
Navy	1576	1531	-2.9	9.1
Army	430	457	6.3	2.7
Interior/BLM	16	16	0.0	0.1
Reimbursed**	4	4	0.0	0.0
Transportation/CG	127	127	0.0	0.8
Transportation/FAA	3556	3759	5.7	22.3
EPA	0	0	0.0	0.0
NASA	0	0	0.0	0.0
NRC	1	1	0.0	0.0
TOTAL	16515	16849	2.0	100.0

* Numbers of personnel are rounded to nearest whole number.
** "Reimbursed" are personnel funded by other agencies.

Department of Defense (DOD). The Air Force will reimburse DOC a total of $2.085 million for NEXRAD support and shared processing communications; DOI (U.S. Geological Survey), $215,000 for magnetometer data; and NASA, $200,000 to improve the Meteorological Imagery Data and Analysis System (MIDAS). The Navy will reimburse DOC $825,000 for climatological analysis and forecasting; $43,000 for training in satellite applications and forecasting; and $3.033 million for procurement of Automated Surface Observing Systems (ASOS). The Army reimbursements include: DOC $630,000 for operations to maintain precipitation reporting stations, and $171,000 for supporting research relating to LIDAR development, horizontal path profilers, wind profiler, radio acoustic sounder, and radar support; DOI/USGS $400,000 to monitor and operate limited observing sites; the Army will also reimburse NASA $104,000, the NSF $38,000, and the National Laboratories $345,000 for supporting research.

Department of Transportation (DOT). The FAA will reimburse DOC/NOAA a total of about $17.0 million for operations -- $7.29 million for meteorological support at Center Weather Service Units (located with most Air Route Traffic Control Centers and the National Aviation Weather Unit in Kansas City); $8.06 million for contract weather observations; $529,000 for world-area forecasts; $270,000 for meteorological studies; $100,000 for "AM Weather" broadcast; and $719,000 for meteorological instructors at the FAA academy. FAA will reimburse DOC/NOAA approximately $22.2 million for supporting research. FAA will also reimburse NOAA $28.5 million in FY 1993 and $78.0 million in FY 1994 for procurement of NEXRAD radars and automated surface observing systems. The National Science Foundation will be provided $2.634 million for work on short-range weather forecasting, airborne sensors, and related work. The NASA will be reimbursed $3.295 million for supporting research on airborne windshear technology and training.

National Aeronautics and Space Administration (NASA). The Air Force will be reimbursed $1.752 million for observations and forecasts and $275,000 for data acquisition; NOAA/NWS will be reimbursed $1.25 million principally for meteorological support to the space shuttle operations; NOAA/NDBC $100,000 for operation of data buoys; and NOAA/NCC $130,000 for climatological data.

Environmental Protection Agency (EPA). NOAA's Air Resources Laboratory will be reimbursed $4.2 million for development, evaluation, and application of air quality dispersion models; provision of meteorological expertise and guidance for EPA policy development activities.

Department of Energy (DOE). The NOAA/NWS will be reimbursed $2.246 million to support the NWS Nuclear Support Office at the Nevada Nuclear Test Site.

Nuclear Regulatory Commission (NRC). NOAA's Air Resources Laboratory will be reimbursed $35,000 for technical assistance, and DOE $150,000 for technical assistance.

Department of Agriculture (USDA). NSF/SAR will be reimbursed $30,000 to support studies by the National Academy of Sciences.

LOCATIONS BY TYPE OF OBSERVATION

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. Both the type and the number of platforms change little from year to year.

TABLE 3.7 INTERAGENCY FUND TRANSFERS FOR METEOROLOGICAL OPERATIONS AND SUPPORTING RESEARCH

Agency Funds Transferred from:	Agency Funds Transferred to:	FY 1993 Funds ($K) Estimated or Planned Operations	Supporting Research
Commerce/NOAA	NSF	$1,300	
	DOT/USCG	1,075	
	NASA/Wallops	1,340	
	NASA(Procurement)	250,902	
Defense/Air Force	DOC	2,085	
	DOI/USGS	215	
	NASA	200	
Defense/Navy	DOC/NOAA/NCDC	825	
	DOC/NESDIS	43	
	DOC/NOAA (Procurement)	3,033	
Defense/Army	DOC/NOAA	630	171
	DOI/USGS	400	
	NASA		104
	NSF		38
	National Laboratories		345
Transportation/FAA	DOC/NOAA	16,974	22,200
	DOC/NOAA(Procurement)	28,526	
	NSF		2,634
	NASA		3,295
NASA	DOD/USAF	1,752	
	DOD/USAF	275	
	DOC/NOAA/NWS	1,250	
	DOC/NOAA/NDBC	100	
	DOC/NOAA/NCC	130	
EPA	DOC/NOAA/ARL		4,200
DOE	DOC/NOAA/NWS	2,246	
NRC	DOC/NOAA/ARL	35	
	DOE	150	
USDA	NSF/SAR/NAS		30

TABLE 3.8 LOCATIONS BY TYPE OF OBSERVATION

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 1993)
Surface, land	
Commerce (WSFO, WSO, WSMO)	233
Commerce (WSCMO)	28
Commerce (AMOS, RAMOS, AUTOB, DARDC)	145
Commerce (Supplem. Aviation Wea. Reporting Station)	418
Defense (U.S.)	167
Defense (Overseas)	89
Transportation (Flight Service Station)	95
Transportation (Limited Aviation Wea. Reporting Sttn)	160
Transportation (FAA Contract Wea. Obs. Station)	116
Transportation (Automated Wea. Obs. Station)	175
Transportation (USCG Coastal)	124
Interior	214
Agriculture	840
NASA	2
Surface, marine	
Commerce (Merchant Ship Coop Program)	1,500
Commerce (Merch Ship Coop - Foreign Assisted)	314
Commerce (SEAS-equipped ships)	120
Commerce (Coastal-Marine Automated Network)	52
Commerce (Buoys -- 120 moored, 70 drifting)	190
Commerce (Large Navigation Buoys)	9
Commerce (Water Level Gages)	189
Defense (Ships with met personnel)	34
Defense (Ships without met personnel; based on record archivals during CY 1992)	309
Transportation (USCG Ships)	76
NASA	2
Upper air, rocket	
NASA	1
Defense	2

TYPE OF OBSERVATION/AGENCY	No. of Locations (FY 1993)
Upper air, balloon	
Commerce (U.S.)	98
Commerce (Foreign, cooperative)	33
Defense Fixed (U.S. & Overseas)	54
Defense Mobile (U.S. & Overseas)	79
Defense (Ships)	33
NASA (U.S.)	1
Weather radar	
Commerce (NWS)	129
Commerce (at FAA Sites)	27
Defense (U.S. & Overseas)	109
Defense (Remote displays)	36
Transportation	2
Transportation (Remote displays)	131
NASA	1
Weather reconnaissance (No. of aircraft)	
Commerce (NOAA)	2
Defense (USAFRES)	12
Geostationary meteorological satellites (No. operating)	
Commerce (planned configuration of 2)	1
Polar meteorological satellites (No. operating)	
Commerce (planned configuration of 2)	2
Defense (planned configuration of 2; 1 satellite is only partly operational)	3

SECTION 4

TRAINING AND PROFESSIONAL DEVELOPMENT IN THE MODERNIZED WEATHER SERVICES*

The weather services that operate within the Federal arena are in the midst of an exciting and challenging modernization that will revolutionize the way weather warnings and forecasts are provided. This article describes the meteorological training and education programs being implemented, as well as continuing basic training programs that will enable meteorological personnel to fully exploit the capabilities of the new systems and the expanding information provided by these systems.

NEED FOR NEW EDUCATION AND TRAINING PROGRAMS

The modernization of the weather services is being underscored by the arrival of new observing technologies, the attendant increase in the quality and quantity of meteorological data collected, the manner in which these data are assimilated into operations, and the speed with which vital information is disseminated to the public and specialized users. These changes call for new and expanded programs to educate and train the personnel who use, operate, and maintain these systems.

New technologies will provide field forecasters with an unparalleled set of observational and forecast data. For example, the Next Generation Weather Radar [Weather Surveillance Radar 1988 Doppler (WSR-88D)] enables forecasters, for the first time, to "see" atmospheric motions that can greatly affect local weather. New automated surface observing systems (ASOS) provide weather observations with unprecedented temporal and spatial resolution. The launching of the first (GOES-I) in a series of Geostationary Operational Environmental Satellites in the spring of 1994 will increase the temporal and spatial resolution of satellite images, and enhance remote sensing of atmospheric variables. Finally, Advanced Weather Interactive Processing Systems (AWIPS) will enable forecasters to assimilate these and other data into their daily forecast and warning routines with greatly increased flexibility, efficiency, and ease.

These new systems will greatly expand the amount of information to be processed and interpreted. This will require operational forecasters/meteorologists to obtain a high level of proficiency and education. Under the National Weather Service (NWS) modernization, many of the staff positions will be upgraded and the number of highly qualified meteorologists will increase substantially. Special attention and specific programs are needed to hire, train, and educate qualified forecasters/meteorologists who must have (1) a clear understanding of the new technological systems, (2) a thorough understanding of the relationship between hydrology, meteorology, and oceanography, and (3) an understanding of the latest theories and techniques in mesoscale meteorology and hydrology. The goal of this strategy is to enable forecasters to prepare enhanced warnings for smaller areas and to improve the overall skill in short-term forecasting.

Frequent reference will be made to *training* and *professional development* (T & PD). While they are referred to jointly, there is an important distinction. *Training* generally tends to be a one-time effort following the installation of a new technology, or the hiring or promotion of an individual. *Professional development* relates to the long-term or career path of an employee, and refers to the process by which personnel develop broad knowledge or high level skills - scientific, technical, or managerial - that can be applied to operational situations. Professional development should continue throughout an employee's career.

---

*Material relating to National Weather Service training programs and to the COMET program was provided by Mr. Eli Jacks, a meteorologist working under the guidance of Mr. LeRoy Spayd, Program Leader for Training and Professional Development in the Office of Meteorology, National Weather Service. Material relating to training programs of the Department of Defense and the Federal Aviation Administration was provided by agency representatives. The satellite training section was prepared by Mr. H. Michael Mogil, Office of Research and Applications/National Environmental Satellite, Data, and Information Service. The Office of the Federal Coordinator assumes responsibility for overall review and editing.

JOINT AGENCY TRAINING CENTERS

DOPPLER RADAR OPERATIONAL SUPPORT FACILITY (OSF)

The Operational Support Facility (OSF) in Norman, Oklahoma was initially established to train over 2000 meteorologists and hydrologists to use and interpret the information generated by the new WSR-88D Doppler radar systems. The OSF was created under a tri-agency agreement (DOC, DOD, and FAA). OSF classroom and laboratory facilities will be shared by the NWS, DOD, and FAA personnel through early March 1994, at which time the NWS will use the facility to conduct and manage NWS-exclusive training.

A 4-week course, WSR-88D Operations Training, covers operation of all applicable WSR-88D equipment and the interpretation of radar-generated products for weather forecasts and warnings. Prior to attending the course, NWS attendees are required to successfully complete a series of prerequisite training modules consisting of videotapes, workbooks, and printed material. There are currently three such modules available. In addition, a post-course proficiency checklist has been designed by the OSF to be administered upon the student's return to his/her duty station. In NWS, the pre- and post-course material is to be supervised by the designated specialist or by the Meteorologist/Hydrologist-in-Charge.

The OSF is increasing its training capacity to 72 students for each 5-week period during the summer of 1993. This increase is necessitated by the planned pace of WSR-88D installations, the increased number of staff that must be proficient with the WSR-88D as compared with the older radars, and the current requirement that all staff must be completely trained when the WSR-88D is commissioned.

COOPERATIVE PROGRAM FOR OPERATIONAL METEOROLOGY, EDUCATION AND TRAINING (COMET)

COMET is a cooperative endeavor with the National Weather Service (NWS) as primary sponsor, Department of Defense as a contributing partner, and along with the National Environmental Satellite, Data, and Information Service (NESDIS) and the Environmental Research Laboratories (ERL) as contributing co-sponsors. COMET is administered by the University Corporation for Atmospheric Research (UCAR) at Boulder, Colorado. UCAR is a consortium of 61 institutions in the U.S. and Canada with doctoral programs in the atmospheric or related sciences. Through the contributions of each member and primary support from the National Science Foundation, UCAR oversees a wide range of programs and facilities that serve its members and the world scientific community alike.

COMET's mandate is to facilitate the development and administration of training/education courses and materials, to expedite the organization and exchange of data to be used for applied research, and to serve as a general catalyst to bring the operational and research components of the atmospheric sciences closer together.

COMET Residence Program

This program was established in collaboration with NWS and was designed to meet specific needs of NWS as the primary sponsor of COMET. The program provides a university-style atmosphere and is located in a research center with classroom and laboratory facilities. One advantage of the COMET Residence Program is that, because it has no fixed faculty, experts for each element can be drawn from the entire field of cooperating universities, research laboratories, or weather operations. Residence courses are held at the COMET facility in Boulder, CO.

COMET's premier residence course is the COMET Mesoscale Analysis and Prediction (COMAP) Course. This is an in-depth, 8-week course on advanced meteorological theory, diagnostic and prognostic techniques, and applied research techniques utilizing the latest scientific and technological methods. The course emphasizes mesoscale phenomena at the college post-graduate level and is taught in an environment that simulates a Weather Forecast Office (WFO); it is especially designed for the new Science and Operations Officer (SOO) positions at the WFOs.

Instructor teams consist of a university professor and an individual with operational forecasting experience who share responsibility for conducting the course. The selected operational person is relieved of

normal duties to prepare for and present the course. The first COMAP class was held in the fall of 1991, and the second was held in the spring of 1993; the maximum seating capacity is 18 students. Two COMAP classes per year are scheduled for 1994-1997; this will provide the initial 116 SOOs required for the modernization program.

COMET's second major residence course is the Hydrometeorology Course, which was developed in conjunction with the NWS Office of Hydrology. This 3-week, undergraduate-level course contains material primarily for hydrologic specialists, hydrologic forecasters, hydrometeorological analysis and support forecasters, and service hydrologists. The NWS provides a full-time hydrometeorologist to assist in the development and teaching of the course. The course content includes advanced mesoscale theory with a special focus on hydrological forecasting. Emphasis is placed on recognizing attributes of various storm systems from the patterns or signatures that are presented by the new technologies. The first two classes were held in 1993.

The COMET Residence Program also offers special courses in mesoscale meteorology for NWS managers, University faculty, and DOD personnel.

COMET On-Site Computer-Based Learning (CBL)

COMET is developing and distributing Computer-Based Learning (CBL) modules to NWS field offices and DOD installations to facilitate local training and professional development (T & PD). The NWS and DOD are co-sponsors of this program, which is also referred to as "The Distance Learning Program." These highly interactive lessons are stored on videodisc and feature material developed by subject matter experts on a host of meteorological and hydrometeorological topics. The videodiscs are played on specially designed Professional Development Workstations (PDWs). The PDW is a 386-based personal computer with a videodisc player, CD-ROM reader, and special video cards installed. Each CBL module takes 3 to 8 hours to complete and is focused on a single subject taught at the undergraduate level. All modules consist of multiple lessons of 20 to 40 minutes each and employ branching and interactive multimedia techniques. Forecasters are expected to review modules during quiet periods while on duty. Progress on the modules by individual forecasters is monitored by the staff member designated to serve as the instructor, although grades or scores are not assigned.

The PDWs and the first four CBL modules, *Doppler Radar Interpretation*, *Boundary Detection and Convection Initiation*, *Heavy Precipitation and Flash Flooding*, and *The Forecast Process* have been distributed to NWS National and Regional Headquarters Offices, National Meteorological and Training Centers, and field forecast offices. They are also being distributed to DOD installations. Three to four additional modules per year will be created and distributed through the late 1990s, yielding an extensive library of computer-based lessons (see Table 1). Prioritized CBL production is negotiated each year among the contributing co-sponsors (NWS, Air Weather Service, and Naval Oceanography Command). Compared to resident courses, the use of CBLs is a cost-effective means of accomplishing T & PD for approximately 8,000 personnel from the program sponsors by the year 2000.

COMET CBL modules are designed for all forecast personnel including meteorologists, hydrometeorologists, hydrologists, and oceanographers. In addition, CBLs are offered for sale to the private sector and university community by UCAR. To ensure applicability and usefulness, each module is evaluated by an appointed team of operational forecasters as an integral part of the operational process. In addition to the modules listed in Table 1, a third CBL team is being established, funded solely by the NWS, to provide NWS-unique CBLs required for the modernization program. Personnel on this third team will produce CBLs for the Special Service areas, such as Agricultural Meteorology, Fire Weather Forecasting, and Hydrometeorology modules.

To further complement the COMET work co-sponsored by the Air Weather Service (AWS) and the Naval Oceanography Command, the Weather Training Development Facility (Detachment 5, Headquarters Air Weather Service) at Keesler AFB, Mississippi, was established on July 1, 1992. The mission of Detachment 5 is to produce quality and timely CBL modules (using interactive videodisc, i.e., IVD) which satisfy Air Force-unique training requirements and to

serve as the AWS focal point for fielded IVD training workstations, courseware interoperability, and courseware distribution. The composition of the 12-person unit is specifically tailored to perform its unique mission. The two officer positions include an advanced weather officer (Major) as commander and an education and training officer (Captain). The ten enlisted positions include a weather superintendent (Senior Master Sergeant), three other enlisted weather forecasters, two communications computer systems programmers, two graphics technicians, a visual information production documentation specialist, and an information management specialist.

The unit's first year will be devoted to in-house training, developing unit procedures, and establishing and coordinating any necessary agreements with various agencies and points of contact. By July 1993, Detachment 5 will begin developing a series of CBL modules on meteorological satellite (METSAT) interpretation. AWS has the lead among the Federal agencies for METSAT module development. Future module development will be prioritized from the training needs identified by AWS and the major Air Force and Army command staff weather officers.

COMET Outreach Program

The objective of the COMET Outreach Program is to increase opportunities for mesoscale and synoptic-scale education and research, and improve local forecasts by fostering professional interactions between NWS forecasters and university faculty and students. Cooperative activities include:

- Activities to improve the use of new observing systems or the understanding of local mesoscale forecasting problems.
- Activities to assist operational forecasters in enhancing their educational backgrounds and staying abreast of research developments.
- Activities to assist the university research community in staying abreast of operational problems and needs.
- Activities to create case studies or new data analysis techniques with application to teaching, research, or operational forecasting.

Two types of outreach programs are in place:

Partners Program: A cooperative effort between an individual NWS forecaster and a researcher or professor focused on the study of a particular forecast problem. This type of program is generally of limited duration, uses locally available data, and leads to the preparation of a joint paper and/or adoption of a new forecast technique.

Cooperative Program: A broad cooperative activity between a university department and a NWS office or center. Activities may include forecast applications research, involvement of university faculty and graduate students in NWS professional development activities, or the use of NWS data and personnel in university educational activities. Programs of this type may be related to specific short-term objectives; however, they are more likely to involve the establishment or expansion of long-term relationships between a university department and a NWS office.

Outreach initiatives between forecasters and researchers are submitted as joint proposals from the NWS and universities or research laboratories to COMET. As part of the agreement, written final reports of the findings are documented by the cooperators and are broadly disseminated by COMET. Interest in the COMET Outreach Program is rapidly expanding within the academic community, and benefits to both the NWS and the academic community should continue to increase. A Request for Proposal was released April 15, 1993 with proposals due at COMET on October 1, 1993.

NOAA/NESDIS SATELLITE TRAINING PROGRAM

The Satellite Applications Laboratory (SAL), part of the Office of Research and Applications, NOAA/NESDIS, continued to expand its training and technology transfer programs during the past year. Merging applications research with training has significantly broadened SAL's ability to deliver needed information to its customers around the world and to tailor its applications development efforts.

Table 1: Planned COMET Computer-Based Learning Modules with Schedule

Year(CY) Released	Module #	Title	Instructional Hours
1991	1	Workshop on Doppler Radar Interpretation	10-12
	2	Boundary Detection and Convective Initiation	8-10
1992	3	Heavy Precipitation and Flash Flooding	8-10
1993	4	Forecast Process	2-4
	1.1	Workshop on Doppler Radar Interpretation (Reference Section)	3-8
	5	Numerical Weather Prediction	4-6
	6	Marine Meteorology I: Wind and Waves	8-10
1994	7	Extratropical Cyclones I: Initiation of Cyclogenesis	4-6
	8	Marine Meteorology II: Structural Icing and Visibility	4-6
	9	Extratropical Cyclones II	4-6
	NWS 1	Hydrology for Meteorologists	4-6
	10	Thunderstorm Structure	4-6
1995	11	Detection of Severe Convection	4-6
	12	Forecasting of Severe Convection	4-6
	NWS 2	Fire Weather	4-6
	GOES 1	GOES-I, I: System/Capabilities	4-6
	13	Forecasting Fog and Stratus	4-6
	14	Convective Hazards to Aviation	4-6
1996	15	Tropical Meteorology I	4-6
	NWS 3	Agricultural Weather	4-6
	GOES 2	GOES-I, II: Advanced Imagery Techniques	4-6
	16	Extratropical Cyclones III	4-6
	17	Tropical Meteorology II	4-6
1997	18	Forecasting Aircraft Icing	4-6
	NWS 4	TBA	4-6
	19	Forecasting Turbulence and Atmospheric Wave Motion	4-6
	20	Polar Meteorology	4-6
1998	21	Forecasting High Winds	4-6
	NWS 5	TBA	4-6
	GOES 3	Advanced Sounding Techniques	4-6
	22	Forecasting Mainstream Flooding	4-6
	23	Instrumentation	4-6
	Revision 1	Module Revision #	4-6

Scientist-trainers from SAL conducted over 40 customized courses (one to six days) and workshops for nearly 1,000 meteorologists, oceanographers, weather broadcasters, and high school teachers in the past year. The National Weather Service (NWS), the United States Navy, and the United States Air Force were the primary recipients of this training. NOAA's National Climatic Data Center also received initial satellite training tailored to its efforts at providing satellite data sets to customers outside the NWS.

Workshops and sessions in longer-term courses addressed general satellite imagery interpretation, as well as new applications involving water vapor imagery, aviation and marine topics, flash flood forecasting, microwave data, and oceanography topics related to NOAA's new COASTWATCH system. The use of scientists to serve as trainers enhances two-way communication and allows scientists to see firsthand how their research is being used. Research on mid-latitude ocean cyclogenesis resulted from discussions at an inter-agency training course.

SAL scientist-trainers also provided extensive technical expertise to COMET for development of training modules on heavy rainfall, convective initiation, and extra-tropical cyclone development. They also contributed to development of a two-volume training workbook on satellite applications to tropical meteorology and a technical report on a new technique for using satellite imagery to assess central pressures in mid-latitude oceanic storms. Both of these were reprinted by DOD and shared with their operating sites around the world. The NWS has distributed the tropical workbook to member nations of the World Meteorological Organization.

SAL provided satellite imagery and related data sets in support of NWS and DOD applied research efforts. This included long-term projects as well as shorter-term post-mortem events. More than 12,000 images and 50 video tapes were provided to almost 100 customers in the past 12 months.

NESDIS published approximately 200 reports, memoranda, and journal reprints in 1992. To enhance transfer of information, most were shared with universities and research centers (Government and private) around the world. Several of the publications were also used for training.

Training materials currently being developed address tropical cyclone recurvature, polar lows, ice and sea surface temperature analysis, atmospheric aerosols, and further assessments into mid-latitude ocean cyclogenesis. Additional applications work is planned for the new GOES satellites scheduled to be launched in FY 1994 and for blending various data sets (satellite, Doppler radar, lightning, profiler) into a more complete atmospheric analysis. These research and development efforts will provide new information for future training activities. Training material focused at the high school level is also being developed.

AGENCY WEATHER TRAINING PROGRAMS

NWS WEATHER TRAINING AND STAFF RESTRUCTURING

As part of the Modernization and Associated Restructuring (MAR), NWS has placed a major emphasis on upgrading the quality of meteorological science practiced at NWS field offices. The steps to accomplish this include: developing an extensive plan for training and professional development (T & PD), designating a science leader at each field office, and creating opportunities for collaboration with universities and other research institutions. To create such opportunities, NWS sponsored COMET -- a new entity described earlier -- and plans to collocate as many Weather Forecast Offices as possible with universities.

In March 1992, the NWS issued the Integrated Training & Professional Development Plan which addresses all of the T & PD requirements for the MAR. The NWS Offices of Meteorology and Hydrology, in conjunction with the Heads of Training Centers and the NWS Director's Task Group on Training, are responsible for planning adequate resources and for coordinating these T & PD activities.

A new position will be established at all future NWS Weather Forecast Offices (WFO) and River Forecast Centers (RFC) to oversee the T & PD effort locally, as well as to enhance the quality of science performed on-station. At WFOs, this position will be called the Science and Operations Officer (SOO), at

RFCs the new position will be called the Development and Operations Hydrologist (DOH). There will be 31 SOOs and 6 DOHs on board by the end of FY 1993, and plans call for an additional 42 SOO and 7 DOH positions to be filled by the end of FY 1994.

As the senior scientific advisor and technical leader at the WFO, the SOO will be the local manager for all on-site T & PD, local research, and techniques development. The DOH will serve a somewhat similar function at the RFC, along with a responsibility to oversee the operational support for the high levels of on-site data assimilation and hydrologic forecast technologies employed at those centers. SOOs and DOHs will develop methods to exchange, share, and transfer science and technology while working with universities, research organizations, and other NWS offices. SOOs and DOHs will take specialized courses to qualify them to provide on-site T & PD for the office staff. They will also oversee the effectiveness of on-site professional development programs such as workshops, seminars, and computer-based modules.

NWS Training Center (NWSTC)

Since 1955, courses offered by NWSTC (located in Kansas City, MO) comprised a significant part of NWS training and professional development efforts. Under MAR, NWSTC will continue to play a vital role in courses relating to hydrometeorology, organization, management, engineering, and equipment maintenance. The NWSTC provides a number of carefully designed, job-centered training programs for employees of the NWS and, on occasion, for those from other Federal agencies and foreign governments that cooperate with the United States in international atmospheric programs.

The NWSTC is made up of two divisions: the Hydrometeorology and Management Division, and the Engineering Division. Courses offered by the Hydrometeorology and Management Division generally provide organizational/procedural orientation for new employees and managers, while courses in the Engineering Division generally provide training for maintenance personnel. The courses are currently being revised, as appropriate, to reflect changes brought about by the MAR.

The Hydrometeorology and Management Division currently provides NWS employees with eight residence courses and 15 remote training modules. Specific modules are required for most courses and must be successfully completed prior to residence training. Present courses include the Flash Flood Forecasting Course, the Forecasters' Development Course (FDC), the Weather Service Operations Course, a Management and Supervision Course, two radar courses, and a Writing and Broadcast Seminar.

The FDC will continue the important work of preparing Meteorological Interns for their role in the modernized NWS. The current NWS Operations and Station Management and Supervision courses will evolve into a course for Hydrometeorological Technicians (HMT) and MAR managers, respectively. The Flash Flood Forecasting Course will evolve into a WFO Operational Hydrometeorological Forecasting (WOHF) Course and will refocus its objectives and concentrate more on hydrology for meteorologists than on flash floods alone. The Basic Operational Hydrology (BOH) Course will train all new hydrologic interns in basic hydrometeorology. The contractor-led training will be conducted at the NWSTC for Advanced Weather Interactive Processing System (AWIPS) and Automated Surface Observing System (ASOS). Other new courses will be offered for HMTs, SOOs, DOHs, Warning Coordination Meteorologists, and NWS managers.

The Engineering Division offers over 25 residence and correspondence courses on as many subjects, and provides virtually all the equipment training NWS electronics technicians (ETs) require. This training includes instruction on new equipment as well as on current operational equipment. The Engineering Division is deeply involved in maintenance courses for the WSR-88D. The 6-week residence course is designed to teach maintenance and repair down to the locally replaceable-unit level. Each WSR-88D technician is scheduled to receive training prior to the installation of their respective WSR-88D. The Division also offers ASOS maintenance training courses. As other new equipment is accepted for operational use, courses will be developed to provide NWS field maintenance personnel with the skills needed to keep data flowing and communications open.

Finally, the Remote Training Module program will continue to provide background and prerequisite material for NWSTC courses. These modules will

assist in keeping the overall course costs to a minimum as well as provide a source of reference material for future use.

On-Site Training Administered by SOOs and DOHs

The on-site approach is especially desirable when a requirement dictates that a large number of employees must receive T & PD during a short period of time. The NWS is currently involved in developing an expanded on-site T & PD program that emphasizes self-paced learning under the direction and tutelage of the SOO or DOH, and using materials developed by a variety of sources. SOOs and DOHs will be responsible for administering COMET CBL modules and WSR-88D pre- and post-course modules to forecasters on-station. In addition, SOOs and DOHs will lead other local T & PD efforts such as training hydrometeorological technicians on the use of the WSR-88D unit that controls the functionality of the WSR-88D.

SOOs and DOHs will also serve as research mentors for projects carried out by forecasters. These studies may take the form of COMET-supported Outreach projects but may also be confined to NWS-internal activities. Finally, SOOs and DOHs will be responsible for planning seminars and workshops by subject matter experts at their local office or at a central location.

On-Site Training for New Technologies

AWIPS operations training will be done entirely on-site starting in 1996. Every meteorologist and hydrologist available at installation will be trained by the AWIPS contractor. In addition, a system CBL module will be provided for review and practice. AWIPS will be able to run the training CBL while being used operationally, except when in the Alert or Warning mode.

ASOS users will train on-site using the *ASOS User's Guide*. Initially, at ASOS-equipped sites, on-site contractor training will be provided to those ETs and HMTs who are required to use the ASOS Operator Interface Device. The NWS ASOS Program Office and Office of Systems Operations will develop self-paced study guides and workbooks for on-site training and the NWSTC will offer a course for ASOS National Administrators.

GOES-I user training is still being developed, but will likely consist of CBL modules that will be produced by the third CBL team and a special GOES-I residence training course for SOOs. This training would be carried out by NESDIS and NWS subject-matter experts at COMET.

On-Site Library

In order to facilitate the enhancement of scientific research on-station, the NWS is establishing requirements for a standard on-station library for all field offices. Contents of this library will include professional journals, internal technical publications, basic textbooks, and an historical archive of hydrometeorological data on CD-ROM. Creation of these CD-ROMs is being coordinated with the NESDIS National Climatic Data Center in Asheville, NC.

University Assignment Program (UAP)

The UAP will continue during the NWS modernization. This program was established to allow forecasters the opportunity to take job-related coursework that would enhance their performance on the job or qualify them for other positions within the organization. UAP opportunities generally allow employees to receive their full-time salary and benefits while studying full- or part-time. UAP opportunities are advertised each year and selections are made competitively.

As part of the field office restructuring, there will be an increased need for hydrometeorologists with college degrees at new WFOs and RFCs. In response to this need, the NWS has worked with San Jose State University (California) to establish a course for meteorological technicians that provides the synoptic and dynamic meteorology credits required to qualify for meteorologist positions in the modernized NWS.

COMBINED MILITARY SERVICES WEATHER TRAINING

The training of enlisted weather observers, forecasters, and the Navy's aerographer's mates has long been a joint venture between the Air Force, Navy, and Marine Corps, with the Air Force as the lead organization. The year 1993 will see the transfer of the military weather schoolhouse from Chanute AFB, IL to Keesler AFB, MS. Keesler AFB is the home of the largest technical training center in the Air Force's Air

Education and Training Command (AETC), and its new, modern $6.3 million weather training facility was completed in April 1993. To prevent any training shortfalls, AETC carefully phased the move of military weather training from Chanute to Keesler.

The full complement of instructors will include 90 active duty and civilian Air Force personnel and 72 active duty and civilian Navy personnel. In addition to the basic observing and forecasting courses, 19 supplemental courses will be taught; these will range from tropical weather analysis and forecasting to environmental support for electro-optical systems and satellite imagery interpretation. Also included are the Navy and Marine Corps courses for meteorological equipment training. The first supplemental courses taught at Keesler began in January 1993.

The average daily count of Air Force, Navy, Marine Corps, Coast Guard, and occasionally international students will reach 400 by July 1993.

AIR FORCE OFFICER WEATHER TRAINING

For the officer force, the Air Force looks to civilian institutions and, in the future, will look to the Air Force Academy as the principal sources for qualified undergraduate meteorologists. In the past, the Air Force sent a selected number of commissioned officers to be trained in meteorology at civilian institutions under the Air Force Institute of Technology's (AFIT) Basic Meteorology Program. This program has been discontinued, and now the Air Force relies on the Reserve Officer Training Corps (ROTC), Officer Training School, and Air Force Academy programs to fulfill requirements for approximately 60 officer meteorologists per year. The Airman Education and Commissioning Program (AECP) is another source of officer meteorologists. Under this program, talented enlisted personnel who have completed 2 years of college credit are selected to attend a civilian institution to complete his/her undergraduate degree and become an Air Force commissioned officer. This is a highly competitive program that produces a limited number of meteorologists. The Air Force Academy program, which will produce 3-10 graduates per year, and AECP are the key undergraduate meterology programs funded by the Air Force.

To fulfill its requirements for advanced degrees, the Air Force again relies on civilian colleges and universities. Under the AFIT program, highly qualified officers are competitively selected to attend civilian institutions to complete masters and Ph. D. programs in meteorology or related sciences. In FY93, the Air Force had AFIT quotas for 3 Ph. D.'s and 38 masters in meteorology and a single masters requirement each in computer science and space operations. The total--43 advanced degrees.

AIR NATIONAL GUARD WEATHER TRAINING

In 1993, the Air National Guard (ANG) established the Weather Readiness Training Center (WRTC) at Camp Blanding Training Site, FL. The WRTC mission is to provide basic and intermediate level training to non-prior service ANG Weather Flight (WF) personnel throughout the country. Staffed by three full-time instructors and a cadre of visiting part-time instructors, training will employ a hands-on approach and focus on the performance of meteorological and climatological support in a tactical environment. Within a 42-day period, instruction will feature enhancement of technical skills, wartime survival/readiness, and a variety of other tactical duties and responsibilities not covered during formal training at Keesler.

The principal WRTC training goal is to standardize follow-on training, both technical and tactical, and enhance unit readiness by enabling WF personnel to return to their units qualified and trained to fill wartime taskings. The ANG Weather Program which consists of 34 Weather Flights provides over 60 percent of the Air Force's meteorological support to the U.S. Army. The WF's provide operational forecasts and support to Army Brigades, Divisions, Corps, Echelons above Corps, Continental U.S. Armies and Special Forces. These Army units consist of National Guard, Reserves, as well as Active Duty components.

NAVY WEATHER TRAINING

U.S. Navy Post-Graduate Study

The Naval Postgraduate School (NPS) at Monterey, CA, offers a Masters of Science in Meteorology and Physical Oceanography to mid-grade officers. Oceanography officers are expected to complete a masters degree program to be competitive for advancement. The NPS program lasts 2 years, provides an in-depth study in both fields, and

culminates with a thesis in one of the fields. Exceptional officers can continue on in a Ph. D. program in either meteorology or oceanography at NPS or at a civilian university, such as, the University of Washington or the Massachusetts Institute of Technology. These education programs are fully paid for by the Navy but require the officer to commit to a specified length on active duty.

Naval Oceanographic Office (NAVOCEANO) Courses and Training

Composite Warfare Oceanographic Support Module (CWOSM). CWOSM incorporates the Command's only full-spectrum journeyman level meteorological and oceanographic (METOC) support curriculum. The course, targeted at operational forecasters, chief petty officers and oceanography officers, covers METOC services to all warfare areas except anti-submarine warfare (ASW). Commander, Naval Oceanography Command is currently reviewing the addition of ASW. CWOSM is taught at the Fleet ASW Training Centers in San Diego, CA and Norfolk, VA. The CWOSM coordinator office establishes and maintains a standard approved curriculum with corresponding instructor and student course material. CWOSM training material packages are distributed upon request. They may be used for local instruction, but do not replace attendance at the full CWOSM course. Approximately 225 students attend resident and exportable CWOSM courses annually.

Tactical Oceanography Workshop (TOW). Since the late 1980's, the TOW program has provided exportable training on the air/ocean environment's impact on ASW. The first half of the two-day workshop consists of lectures tailored to the receiving activity's needs. Topics may include bathythermograph interpretation, sonar equation, ocean variability and acoustic/non-acoustic and shallow water ASW. On the second day, a table-top warfare game reinforces concepts covered in lectures. In 1991, NAVOCEANO transferred responsibility for TOW management and presentation to the fleet ASW training centers. Components at these two activities provide these workshops to U.S. military units worldwide. Approximately 1,000 students attend TOW training each year.

Professional/Technical Course Development. After a training need or requirement for a specified air/ocean area is identified, the METOC Training Department, in conjunction with the Chief of Naval Education and Training (CNET), develops non-resident training courses. If necessary, text material is developed locally along with an associated course. Staff members or claimancy experts who participate in course validation conduct an initial peer review and provide feedback to the technical writer. From this feedback, the course is refined and sent to CNET for management and distribution. The Operational Oceanography course was developed under this arrangement in FY 1991. A basic meteorology course is under development for distribution in FY 1993.

Instructional Methodology. New instructional media, specifically computer-based learning and CD-ROM, will meet future training needs of modern aerographer's mates. The training support staff is developing CD-ROM as a storage medium for future training aids. The first CD-ROM publications will be WSR-88D tutorials developed by the Operational Support Facility in Norman, Oklahoma. With the advent of CANOES, the Computer-Assisted Naval Oceanography Education System, students will learn in an interactive multimedia environment incorporating still photographs, animation, audio, and full-motion video. Approximately 21 meteorology/oceanography interactive modules are planned through 1997.

Basic Oceanography Accession Training (BOAT). NAVOCEANO's BOAT school prepares new oceanography officers for their first tour in the community by providing them with the fundamentals of operational forecasting and warfare support. The intensive 11-week course covers topics in meteorology and oceanography, along with mapping, charting and geodesy. The target audience is officers (O-1 through O-3) who have not yet attended postgraduate school.

Inter-Agency Liaison. Under a memorandum of agreement between the National Oceanic and Atmospheric Administration/National Environmental Satellite Data, and Information Service (NOAA/NESDIS) and the Naval Oceanography Command, NESDIS provides satellite interpretation training to NAVOCEANOCOM. Four training sessions of 20 to 30 students per session are planned each year through FY 1996.

APPENDIX A

DEPARTMENT OF COMMERCE WEATHER PROGRAMS

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, 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 Office of Oceanic and Atmospheric Research (OAR); the National Ocean Service (NOS); and the Office of NOAA Corps Operations (NC).

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 primary 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:

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

ENABLING LEGISLATION

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

- Organic Act of 1890 created the U.S. Weather Bureau in the Department of Agriculture;
- Enabling Act of 1919 allowed the U.S. Weather Bureau to enter into cooperative agreements for providing agriculture weather services;
- Flood Control Act of 1938 authorized the establishment, operation, and maintenance of the Hydroclimatic Network by the Weather Bureau for Flood Control; on July 1, 1940, the Weather Bureau was transferred from the Department of Agriculture to the Department of Commerce;
- Federal Aviation Act of 1958 outlined duties of the Secretary of Commerce for provision of weather observations and services to aviation;
- Reorganization Plan 2 of 1965 placed the "National Weather Service" (NWS) in the newly created Environmental Science Services Administration (ESSA);
- Reorganization Plan 4 of 1970 made the NWS a part of the newly created National Oceanic and Atmospheric Administration (NOAA).

SERVICES

NOAA provides around-the-clock weather and flood warning and forecast services to the public for the protection of life and property and to meet the needs of all segments of the economy. Weather services are provided by a nationwide network of offices that collect

data, prepare state and local warnings and forecasts, and disseminate information to the population both directly and indirectly through the mass media. Data, analyses, forecasts, and outlooks used by field forecasters to prepare local forecasts are centrally processed by the National Meteorological Center (NMC). The NWS core mission also depends on the study, development, and testing of new methods for improving basic warning and forecast capabilities through research.

Local Warnings and Forecasts

Local weather services are provided through a national network of 52 Weather Service Forecast Offices (WSFOs), 222 more localized Weather Service Offices (WSOs) and 13 River Forecast Centers (RFCs).

Weather Warnings and Forecasts. Both WSFOs and WSOs issue local warnings of severe weather such as hurricanes, tornadoes, severe thunderstorms, flash floods, and extreme winter weather. WSFOs prepare forecasts for zones which are comprised of typically one or more counties that experience similar weather. Each WSFO has forecast responsibility for several zones which, together, comprise an area the size of an average state. WSFOs issue zone forecasts 4 times daily for a period out to 48 hours and a generalized statewide forecast twice daily, including an extended 5-day forecast on a daily basis. WSFOs also provide the main field forecast support for the marine and aviation programs as well as guidance for the fire weather program.

All counties in the United States are assigned to specific WSOs or WSFOs for warning purposes. These offices issue and distribute local warnings of severe weather for their assigned counties. WSOs adapt generalized weather forecasts to local areas and issue severe weather and flash flood warnings.

In preparing local warnings and forecasts, WSFOs use forecast guidance prepared by the National Meteorological Center (NMC) that is based on worldwide meteorological observations. The National Severe Storms Forecast Center (NSSFC) and the National Hurricane Center (NHC) also provide central support for the local warning program.

Weather Service Meteorological Observatories (WSMOs) are additional sources of data for surface observations, upper air observations, and/or radar data. These observations are also used in the NMC data base for generating guidance products used by field forecasters.

River and Flood Warnings and Forecasts. RFCs prepare guidance used by WSFOs, and WSOs to issue flash flood watches, warnings, and river forecasts. RFCs provide forecasts of river stage and flow and related products and services for use by water resources managers and other users. Most WSFOs and WSOs support the RFCs by collecting and relaying hydrologic data. NMC provides central support to RFCs by forecasting the movement of large storms that are causing significant precipitation.

Marine Weather Services. Using weather analyses and forecast guidance provided by NMC, marine weather forecasters at coastal and Great Lakes WSFOs issue wind, wave, weather, and ice warnings, forecasts, and other information for the population living and working along the sea coast, off-shore, on the Great Lakes, and on the high seas. Principal products include small craft advisories, gale, storm, tropical cyclone, and storm surge warnings; coastal, off-shore, and high seas forecasts; sea and swell forecasts; sea and lake advisories; and special weather forecasts to aid in the containment and clean up of oil spills and other hazardous substances in the marine environment. In support of Marine Weather Services, the NWS operates the National Data Buoy Center (NDBC). This Center provides real-time operations, data acquisition and data processing, and distribution of meteorological and oceanographic data from moored and drifting buoys and automated observing stations at selected coastal locations. The NDBC also provides systems integration, deployment, maintenance and repair, and redeployment of data buoys and coastal stations. The NWS, through its Port Meteorological Officer Program, also coordinates and manages data acquisition from cooperative merchant ships under the international Voluntary Observing Ship program sponsored by the World Meteorological Organization.

Agricultural Weather Services. NWS provides the Nation with generalized agricultural weather services, including observations, and forecasts that improve agricultural efficiency, conserve energy, and protect the environment. At the direction of Congress, NWS issues warnings of low temperatures injurious to winter

and spring crops, particularly in citrus and deciduous fruit-growing areas as well as specialized forecasts similiar to those available from the private sector.

Fire Weather Services. Designated NWS offices provide weather warning, forecast, and advisory services to Federal, state, and local wildland management agencies to support wildfire control and suppression activities. Localized weather forecasts are issued, as required, during a fire. NWS offices also provide site-specific forecasts and advisories to Federal natural resource agencies for prescribed burning and smoke management, insect and disease control, planting and cultivating new growth, preservation of watersheds, and promotion of wildlife habitat and recreational facilities.

Tsunami Warnings. Tsunami watches and warnings for Pacific Ocean areas and Alaska are prepared and issued by the Tsunami Warning Center at Ewa Beach, Hawaii, and the regional center at Palmer, Alaska. NWS collects and analyzes observational data from an international network of seismological observatories and sea level observing stations which operate on a cooperative basis. The centers use the data to prepare watches and warnings covering all U.S. territories and states bordering on the Pacific Ocean and disseminate them to WSFOs, Federal and state disaster agencies, military organizations, private broadcast media, and other facilities that furnish warning information to the public.

Central Forecast Guidance

Over the last several decades, NOAA has made major improvements in forecasting synoptic-scale (large-scale, slowly evolving) weather.

General Weather Guidance. The National Meteorological Center (NMC) provides centralized processing of data, analyses, forecasts, and outlooks required by field forecasters as a basis for local forecasting. The Center, using numerical forecasting techniques run on large computers, provides the NWS, other Government agencies, private industry, and foreign users with forecast guidance covering periods out to 10 days. When needed, the NMC provides guidance in tracking hurricanes (to 72 hours) and in forecasting the movement of large storms that cause significant precipitation.

In the course of its 24-hour-per-day, year-round operation, NMC receives approximately 50,000 surface observation reports daily from land stations, 3,000 reports from ships, 4,100 upper air observations, and 3,000-4,000 reports from aircraft. Weather satellites provide cloud imagery, atmospheric temperature soundings, and sea-surface temperatures. Ocean buoys provide additional information on sea temperatures, ocean currents, and air-sea interactions. These data are processed, catalogued, used in the various forecast guidance model runs, and distributed widely to field offices, other Government agencies, private subscribers, and overseas users.

NOAA will continue to incorporate improvements in general weather guidance by:

- Implementing second generation Regional Analysis and Forecast Systems (RAFS) models with higher resolution and improved physics to forecast severe thunderstorms, heavy rain, and snow more accurately;
- Implementing second generation hurricane models to predict the development and movement of hurricanes more accurately;
- Continuing improvements in 1 to 2 day and 3 to 10 day forecasts as much as possible pending the availability of increased computer capacity to handle state-of-the-art physics, increasing resolution, and analysis.

Severe Storm Guidance. The National Severe Storms Forecast Center (NSSFC), Kansas City, MO, prepares and releases messages of expected severe local storms, including tornadoes. These messages, called Tornado or Severe Thunderstorm Watches, include information for public use and aviation services. NSSFC meteorologists continuously monitor weather developments and issue watches when needed. NOAA will continue to develop systems application programs designed to streamline use of the satellite and numerical weather prediction data by forecasters to improve severe storm guidance.

Hurricane Guidance. Two Hurricane Forecast Centers forecast the path and intensity of hurricanes, other tropical disturbances, and associated sea conditions. These two centers are the National Hurricane Center (NHC) in Miami, FL, and the Central Pacific Hurricane Center (CPHC) in Honolulu,

HI. A portion of NHC's responsibility for public warnings rests with the Hurricane Warning Office at San Juan, PR. NMC provides forecast guidance on the track and intensity of hurricanes based on numerical models.

Special hurricane forecasting staff at NHC base their predictions, advisories, and warnings on subjective and objective methods. The hurricane forecasting functions at the NHC and CPHC are integrated with the regular forecasting functions of the Weather Service Forecast Offices where these Centers are located. NOAA will continue to improve hurricane guidance through development of techniques and programs that maximize use of satellite data and through implementation and calibration of storm surge models.

Climate Guidance. The Climate Analysis Center prepares monthly and seasonal (90-day) outlooks and collects and analyzes data to depict current anomalies of climate. To improve the accuracy of climate outlooks, the Center develops predictive techniques, performs diagnostic studies of large-scale climate anomalies, and conducts stratospheric research. NOAA will continue to incorporate improvements into long-range climate guidance.

Atmospheric and Hydrological Research

NWS conducts applied research, building upon the more basic research conducted by NOAA laboratories and the academic community. Applied meteorological and hydrological research is integral to providing more timely and accurate weather and flood warning and forecast services to the U.S. public.

Meteorological Research. NWS will conduct meteorological research to develop, test, evaluate, and improve numerical models and analysis/forecast techniques used in weather and climate prediction including:

- Techniques for predicting mesoscale phenomena (e.g., heavy precipitation, tornadoes, and severe thunderstorms). These techniques will be developed and improved to use digital data from new observing systems such as NEXRAD (Next Generation Weather Radar) with doppler capability, and GOES-NEXT (geostationary satellites with higher resolution);
- Models to improve hurricane tracking, hurricane probability estimates, and tropical analyses;
- Storm surge models to assist in developing hurricane evacuation plans for additional coastal basins.

Hydrological Research. NWS will develop improved hydrologic and hydrometeorological models and procedures in support of the national flood forecasting and water resources forecasting programs including:

- Improvements to the Extended Streamflow Prediction model and its complementary models in the National Weather Service River Forecast System;
- Specialized flood and flash flood forecasting procedures using linked hydrological and meteorological models;
- Algorithms to combine NEXRAD precipitation estimates with data from satellites and other ground-based observation systems.

MODERNIZATION

A Strategic Plan for the Modernization and Associated Restructuring of the National Weather Service was submitted to Congress in 1989. Implementation of the plan will optimize efficiency and effectiveness of the mesoscale warning and forecast program and will include an operational demonstration and evaluation program as required by Public Law 102-567 to refine operational procedures and resolve implementation issues best addressed through actual field experience. Continued improvements in larger scale, centrally prepared weather guidance products for day 2 and beyond through advanced forecasting models and the requested increased computer processing capability are essential to successful implementation of mesoscale forecasting in NWS field operation, where field forecasters will concentrate on the small-scale, short-lived processes that occur in the zero to 36 hour time-scale.

The National Implementation Plan, will provide, on a regular basis, a planning framework and general strategies for accomplishing the transition, as well as advanced notification of when implementation activities are scheduled to occur at each site. The interrelationships of all of the activities--facilities

preparation, staffing augmentation, training, commissioning of systems, and realigning operations and services--have begun so that the demonstration can begin in 1995. In addition to preparations for the demonstration, nationwide planning and implementation have begun; facilities construction is on-going; training for field personnel is being conducted with necessary backup personnel to cover operational shifts; software development continues; new communications are being established; and all NWS offices have developed and are updating detailed site plans for the transition. The NWS modernization effort is a complex mix of internal NWS activities and multiple contractor efforts. Internal activities provide land, facilities, software, training, staffing, and new operational procedures.

Modernization and Associated Restructuring. The NWS has begun this process of change prompted by two factors: the need to apply advances in hydrometeorological science and technology to operational forecasting, and the need to replace obsolete and increasingly unreliable equipment.

These factors offer the opportunity to improve severe weather warnings, flood warnings, and forecasts through the acquisition of the following new technologically advanced systems:

- Automated Surface Observation System (ASOS) to reduce time-consuming manual observations, provide continuous weather watch, and permit increased productivity of staff;
- Next Generation Weather Radar (NEXRAD) with Doppler capability and sophisticated software to provide nationwide coverage for timely and accurate detection of severe weather and floods;
- Advanced Weather Interactive Processing System (AWIPS) to enable local forecasters to integrate, process, and transmit high-volume radar, satellite, upper air, surface observation data and guidance information;
- Class VII computer power at the NOAA Central Computer facility to accommodate advanced numerical weather prediction models and increased data to improve accuracy of forecast guidance.

These systems upgrades, coupled with observations from planned, advanced geostationary and polar-orbiting satellites and newly developed mesoscale forecasting techniques, will greatly improve the timeliness and accuracy of severe weather and flood warnings to the U.S. public. Improved capability to detect and predict the small-scale, short-lived (mesoscale) phenomena which cause the most destructive weather events will increase warning lead times for severe thunderstorms, tornadoes, high winds, and flash floods, as well as reduce false warnings.

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

The National Environmental Satellite, Data and Information Service (NESDIS) manages U.S. civil operational environmental satellite systems, as well as global databases for meteorology, oceanography, solid-earth geophysics, and solar-terrestrial sciences. From these sources it develops and distributes 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 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 Environmental Satellite Service (NESS) and Environmental Data and Information Service (EDIS).

NESDIS operates two polar-orbiting satellites in sun-synchronous orbits with equatorial crossing times in the early morning (circa 7:30 a.m. LST) and early afternoon (circa 1:40 p.m. LST). These satellites collect global data four times per day that provide atmospheric and surface measurements in support of short-term weather forecasting and longer term global climate change research. An agreement in principle with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) gives EUMETSAT the morning segment of the polar environmental mission, with U.S.-provided payload instruments and sensors, beginning early in the next decade.

NESDIS is also responsible for operating two geostationary environmental satellites: one that monitors the Atlantic Ocean, U.S. East and Gulf Coasts, and the U.S. Midwest and one that monitors the Pacific Ocean and West Coast. However, on January 21, 1989, the Western satellite, GOES-6, failed. The Eastern satellite, GOES-7, was moved to a centralized location on February 21, 1989. Its location was adjusted between 108°W and 98°W to provide maximum coverage during the Pacific and Atlantic storm seasons. On April 23, 1992, GOES-7 was maneuvered to 112°W following an agreement between the United States and the European meteorological satellite organization (EUMETSAT), for the movement of a European geostationary satellite, Meteosat-3, to position of 50°W to cover the Americas and the Atlantic Ocean. This permitted the movement of GOES 7 to its new position to enhance coverage of the Pacific Ocean. Meteosat-3 was then moved to 75°W on February 19, 1993, after ground equipment was installed at the Wallops, Virginia, Command and Data Acquisition (CDA) Station. This new ground station allows Wallops to relay spacecraft commands and data from a European ground station. Meteosat-3 can be moved as far as 115°W, if GOES-7 fails, to provide U.S. coverage before the launch of the next U.S. geostationary satellite.

Environmental Satellite Service

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 Stations (CDA) which command and control, track, and acquire data from these environmental 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 has been installed in all Weather Service Forecast Offices (WSFO). The system, called the Microcomputer Satellite Weather Information System (Micro-SWIS), automatically acquires, stores, displays, and animates GOES and other satellite imagery, and superimposes guidance products from the National Meteorological Center with the imagery. WEFAX (Weather Facsimile) 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 Distribution Facilites (SFDFs) distribute processed geostationary satellite products to regional National Weather Service offices and other Federal agencies. The products also are made available to private groups at their expense. SFDFs are located in Washington, DC; Miami, FL; Kansas City, MO; Honolulu, HI; San Francisco, CA; and Anchorage, AK. The Anchorage, Washington, and San Francisco SFDFs distribute data from both the polar-orbiting and geostationary systems. The San Francisco and Anchorage SFDFs also have the capability of receiving data broadcast directly from the polar orbiting satellites via the HRPT system (see "Polar Orbiting Systems" below.)

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. These laboratories conduct studies on the use of satellite data to monitor environmental characteristics and change and develop algorithms to analyze these data for applications to operational weather prediction. Further, the Office of Research and Applications participates in the development of new spacecraft and sensors for future systems. It also carries out a vigorous program to calibrate and validate satellite data to ensure its quality for long term studies. Staff from these laboratories also conduct a strong technology transfer program through scientific presentations, technical reports, and training workshops at domestic and international sites.

POLAR ORBITING SYSTEMS

These satellites increase the accuracy of weather forecasting by providing quantitative data required for improved numerical weather forecast models. Currently, the primary operational spacecraft are NOAA-11 and NOAA-12. NOAA-13 was launched August 9, 1993, and will replace NOAA-11 as the primary afternoon spacecraft after checkout. NOAA-9 and NOAA-10 also provide data from operational

sensors. They carry advanced instruments to provide temperature soundings and microwave channels to facilitate sounding retrieval in cloudy areas. They also provide multi-channel images and carry a data collection and platform location system, and a satellite-aided search and rescue (SAR) subsystem. SAR transponders are 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 systems. The ground stations receive Doppler signals directly from the satellite and process the information to provide the location of distress transmissions. During the lifetime of the NOAA system, new instruments may be added or substituted for others. NOAA-9 carries sensors to measure the Earth's radiation budget and ozone. The projected launch schedule and associated instruments for polar-orbiting satellites are shown in Table A.1.

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-13, NOAA-12, NOAA-11, NOAA-10 and NOAA-9 operate in near-polar, sun-synchronous orbits and provide environmental observations of the entire Earth four times each day. NOAA-13 crosses the Equator in a northbound direction at 1339 local standard time; NOAA-l2 crosses the Equator in a southward direction at 0731 local standard time; NOAA-11 crosses the equator in a northward direction at 1600 local standard time; NOAA-10 crosses the Equator in a southward direction at 0628 local standard time; and NOAA-9 crosses the Equator in a southward direction at 0817 local standard time. The orbital period of the satellites ranges from 101.23 to 102.2 minutes which produces approximately 14.2 orbits per day.

The NOAA series 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. The AVHRR instrument provides stored and direct readout radiometer data for day and night cloud cover, sea surface temperatures, and snow and ice mapping. AVHRR readout is accomplished by the following:

- Direct readout to ground stations of the APT class worldwide, at 4-km resolution, of the visible and infrared data; panoramic distortion is removed;
- Direct readout to ground stations of the HRPT class worldwide, at 1.1-km resolution, of all spectral channels;
- Global onboard recording of 4-km resolution data from all spectral channels; global area coverage (GAC) for commanded readout for processing in the NOAA central computer facility at Suitland, MD;
- Onboard recording of data from selected portions of each orbit at 1.1-km resolution of all spectral channels, with local area coverage (LAC) 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 (HIRS/2), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). The primary instrument providing tropospheric data, HIRS/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 is used in conjunction with the two IR instruments. The microwave data permit computations to be made in the presence of clouds.

The Data Collection System (DCS) is provided by the Centre National d'Etudes Spatiales of France and is called the ARGOS DCS. The ARGOS DCS 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, electron flux density, and energy spectrum and total particulate energy distribution at spacecraft altitude. The two sensors included within this instrument are the Total Energy Detector (TED) and the Medium Energy Proton and Electron Detector (MEPED), in addition to a common data processing unit. 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. Space environment data from the NOAA satellites, as well as the geostationary 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, the "afternoon" NOAA series spacecraft carry the Solar Backscatter Ultraviolet Radiometer. The Solar Backscatter Ultraviolet Radiometer (SBUV/2) is a non-scanning (fixed nadir viewing) spectrometer designed to measure scene radiance and solar spectral irradiance from 160 nanometers to 400 nanometers. Data obtained from the instrument are used to compute the amount and vertical distribution of ozone in the Earth's atmosphere on the sunlit side of the Earth.

The ground system required to receive large volumes of digital data from NOAA satellites consists of two major subsystems -- the Polar Acquisition and Control Subsystem (PACS) and the Central Environmental Satellite Computer System (CEMSCS). The PACS includes components at the Wallops, VA, and Fairbanks, AK, Command and Data Acquisition (CDA) stations, and the Satellite Operations Control Center (SOCC) at Suitland, MD. All the CEMSCS components are in the NOAA facility at Suitland.

PACS is used to command and control the spacecraft, monitor its health via housekeeping telemetry, and retrieve and transmit the spacecraft environmental data to the CEMSCS processing and data handling facility. The delivery of NOAA system data from the CDAs to Suitland is accomplished by using the General Electric American Communications, Inc. commercial satellite communications network. This system, which includes Earth stations at Suitland, Wallops and Fairbanks, delivers the data to SOCC. These data are immediately passed on to the CEMSCS for processing. The CEMSCS ingests the raw satellite data and preprocesses and stores them along with appended auxiliary information, such as Earth location and quality control parameters.

GEOSTATIONARY SATELLITE PROGRAM

GOES-7, launched in February 26, 1987, is currently positioned at 112°W. The next launch of a geostationary satellite, GOES-I, is currently scheduled for mid-1994. NOAA currently plans to locate one spacecraft at 75°W and another at 135°W. If still operational, Meteosat-3's future movement and location depends upon the functionality of GOES-7. Following the launch of Meteosat-6, planned for November 1993, Meteosat-5 will replace Meteosat-3 at 75°W. Meteosat-3 will be moved to standby at 50°W. If EUMETSAT resources allow, NOAA will be furnished with a back-up geostationary satellite in a one-GOES scenario. This will assure optimum and extensive coverage of the development and movement of significant weather systems, such as thunderstorms, hurricanes and major mid-latitude storms over much of North and South America and adjacent oceans. The projected launch schedule and associated instruments for geostationary satellites are shown in Table A.1.

The VISSR Atmospheric Sounder (VAS) is the principal instrument on GOES-7, the current operational GOES. The VAS has both imaging and sounding capability. The VAS provides near-continuous cloud viewing with nominal resolutions of 1 km in the visible wavelengths and 8 km in the infrared wavelength. Full Earth disc pictures are available at regular 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 exploited by GOES-7 as is the capability of the VAS to provide multi-spectral 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 comparisons with radiosondes, and (5) synoptic large-area coverage. Starting with GOES-I in 1994, the systems will be capable of simultaneous imaging and soundings.

The GOES also carry a Data Collection System (DCS) 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. GOES satellites rebroadcast imagery, meteorological analyses, and other environmental data to remote locations using the weather facsimile (WEFAX) system. 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 of polar-orbiting spacecraft and consists of a Magnetometer, a Solar X-Ray Telescope, and an energetic particle monitor. A system similar technically to the DCS, but used for a different purpose, is the Search and Rescue Satellite Aided Tracking (SARSAT) transponder. The SARSAT transponder on GOES-7 is capable of providing an early alert that a ship or airplane is in distress. While the present system is incapable of providing location of the distress signal, it provides advance warning to the SARSAT Mission Operations Control Center which then begins preparations to act when the location signal is received from the NOAA polar satellite SARSAT transponder/processor. The transponder on GOES-7 is considered pre-operational, but beginning with GOES-I the transponder will be operational.

In calendar year 1991, NESDIS began sending a limited set of remapped GOES image data products to the first two National Weather Service modernization "risk reduction" sites. Weather Service Forecast Offices at Norman, Oklahoma, and Denver, Colorado, were equipped with work stations to capture satellite images and other NOAA data, emulating modernized Weather Service capabilities. This dedicated-line transmission of remapped GOES data will be upgraded to a point-to-multipoint broadcast service with the initial deployment of AWIPS. After acceptance, this service to be used to distribute other NOAA environmental data and satellite products to various users.

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 (CDA) Stations at Wallops, VA, and Fairbanks, 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 Satellite Data Processing and Distribution in Suitland, MD.

Another major component is the Environmental Satellite Distribution/Interactive Processing Center (ESD/IPC) in Camp Springs, MD. The ESD/IPC is connected in turn with the Fairbanks CDA station, and the six SFDFs. The Fairbanks CDA station also transmits satellite data to the Anchorage SFDF and the NWS WSFOs at Fairbanks and Juneau.

SUPPORTING RESEARCH PROGRAM

The requirements and goals addressed by NESDIS supporting research in FY 1994 include:

- NOAA's role in the national effort on the study of climate and global change (as detailed in the interagency report of the Committee on Earth and Environmental Sciences);
- The modernization effort of the National Weather Service (per P.L.100-685);
- The improvement of the monitoring of the global ocean and the management of resources in the coastal zones;
- The management of data that will be needed to support the above;
- The evaluation, validation, and implementation of new products and services from GOES-I; these will support the NWS modernization;
- The continuation of products and services from the polar orbiting satellite system.

Research and the development of applications of environmental satellite data are devoted to the improvement and development of improved techniques for quantitative and qualitative products and services. These serve national and international programs in weather analysis and forecasting; climate diagnosis; programs for agriculture, fisheries, coastal zone management, energy; and other weather, land and environmental applications. The data from current NOAA operational satellites in both polar and geostationary orbits, and research satellites operated by other nations and by NASA and DOD are used to develop improved techniques and algorithms for the definition of the global, three-dimensional structure of the atmosphere (winds, temperature and moisture structure) that is essential for numerical weather analysis and forecasting.

The geostationary environmental satellites provide nearly continuous imagery and multi-spectral data in the visible and infrared (window and water vapor wavelengths) for study and applications. These studies lead to the understanding of the genesis and life cycles of severe storms (from thunderstorms to hurricanes and winter snow storms) and the morphology and evolution of the mesoscale systems (small time and space scales) in which they form. This research leads to the direct application of data from GOES-I; analysis of the data also leads to applications with the other modernization tools that include NEXRAD, Profilers (wind and temperature), ASOS, and AWIPS.

****

TABLE A.1 PROJECTED SATELLITE LAUNCH SCHEDULE

POLAR-ORBITING SYSTEM		GEOSTATIONARY SYSTEM	
Satellite Designator	Planned Launch Date*	Satellite Designator	Planned Launch Date*
NOAA J	CY 1994	GOES I	CY 1994
NOAA K	CY 1996	GOES J	CY 1995
NOAA L	CY 1997	GOES K	CY 1999
NOAA M	CY 1999	GOES L	CY 2000
		GOES M	CY 2004

Instruments for Advanced TIROS N Series

AVHRR	Advanced Very High Resolution Radiometer
SEM	Space Environment Monitor
SBUV	Solar Backscatter Ultraviolet Radiometer
HIRS	High Resolution Infrared Sounder
SSU	Stratospheric Sounding Unit (NOAA I,J only)
MSU	Microwave Sounding Unit (NOAA I,J only)
SAR	Search and Rescue System
DCS	ARGOS Data Collection System
EHIC	Energetic Heavy Ion Composition Experiment (NOAA-I)
MAXIE	Magnetospheric Atmosphere X-Ray Imaging Experiment (NOAA-I)
RAIDS	Remote Atmospheric and Ionospheric Detection System (NOAA-J)
AMSU-A	Advanced Microwave Sounding Unit-A (NOAA K,L,M only)
AMSU-B	Advanced Microwave Sounding Unit-B (NOAA K,L,M only)

Instruments for GOES Series

Imager
Sounder
SEMSpace Environment Monitor
SXISolar X-Ray Imager (GOES L or M)
SARSearch and Rescue
DCSData Collection System

*Launch date depends on performance of prior spacecraft.

Improvement in the methods for estimating precipitation from satellite data is critical for flash floods on the local scale. On the global scale, before making landfall, a satellite derived rainfall potential is attained for tropical systems and disseminated, both foreign and domestically. Other measurements from satellites requiring continued study and improvements are solar insolation and the "vegetation-index", a measure of biomass concentration. In addition, cloud motion winds are an essential source of data input to the National Meteorological Center's numerical forecast models.

Climate analysis, diagnosis and monitoring performed by the National Meteorological Center's Climate Analysis Center depend upon global satellite observations of the incoming and outgoing radiation. Knowledge of this "heat" or "radiation-budget" of the earth-atmosphere system is essential to the national and international research on the Earth's climate and environment. Research with satellite data is the key to understanding the effects of clouds as regulators of incoming and outgoing radiation that may lead to long term net warming of the globe. Applications research continues to improve estimates of the global distribution of atmospheric aerosols, their effect on climate, and on other satellite measurements. Satellites provide the only global measurement of ozone. Monitoring its distribution and concentration is critical to understanding the fate of this important atmospheric compound.

Monitoring sea surface temperature with satellites will continue to be a focus of research for climate diagnosis and other applications. The passive microwave and other multispectral data from DOD's meteorological satellites and international satellites contribute to improvements in the measurement of this important parameter. Research and development on the use of satellite data in coastal marine areas continues. This includes algorithms for estimating temperature, turbidity, and productivity for bays and estuaries. These satellite observations combined with aircraft and in-situ oceanic data contribute to development of dynamic models of coastal processes.

Improvement in the methods for estimating precipitation from satellite data is important for forecasting flash floods on the local scale, and, on the global scale, important to the understanding of the effects of the release of latent heat of condensation in both numerical weather forecasts and in numerical climate models. Other measurements from satellites requiring continued study and improvements are solar insolation, the "vegetation-index" of biomass concentration, and winds derived from cloud motions. These contribute to understanding the hydrologic and biogeochemical cycles.

The scientists at NESDIS continue to provide expertise and advice for the specification of sensors, processing systems and technical requirements for the development of future satellite systems.

Environmental Data Bases

NATIONAL CLIMATIC DATA CENTER

The National Climatic Data Center has the principal responsibility to manage the national climatological data program, including data and information services. To meet this responsibility, the Center:

- Performs all data management functions regarding retrospective meteorological data, including data from in-situ and remote sensing sources (satellites, radars, etc.). Such functions include data acquisition, archiving, retrieval, indexing, quality assessments, evaluation, synthesis, dissemination, and publication of data collected by global and national observation networks or systems that have enduring value to the Nation and are sufficient to describe the climate;
- As a designated agency Federal Records Center, operates the Center for NOAA for processing, storage, and servicing of retrospective meteorological records;
- Prepares and provides special products and services to users as required as a basis for regulatory standards and policy decisions;
- Maintains national and global databases for analyses of long-term climate trends and for monitoring global change;
- Provides facilities, data processing support, data exchange, and expertise, as required, to meet U.S. commitments to foreign nations, international organizations, and to the World Meteorological Organization's programs. In this capacity, NCDC operates the World Data Center-A for

Meteorology under the auspices of the International Council of Scientific Unions.

The modernization of observing networks with the use of new technology and the increased concern on global climate change throughout the world have increased the challenge of managing climate data and serving the research community. To meet this challenge, NCDC will be focusing on the development and implementation of new data processing systems for data from new observing equipment and new satellite systems; and to prepare and structure baseline data sets to meet the national and global needs for monitoring climate change.

Climate Data Management

The management of retrospective meteorological data for climate purposes has become increasingly complex as new automated and remote sensing high volume observing systems replace traditional manual systems. First, these new systems have necessitated a change in the concept of processing data for the climate database. New automated observing systems have made it possible to effectively quality control data for random errors on site, leaving the more complex quality control to identify systematic errors and biases to the NCDC. Second, the data from the new systems (both in-situ and satellite) must be integrated with the historical data, and third, the requirements for accurate homogeneous long series data sets on a national, regional and global scale are placing an additional demand on data management and user services that may require the reprocessing of entire long-series databases.

In FY 1994, the NCDC plans to:

- Continue technology upgrade (i.e., computers, on-line storage and access, communication, etc.) to meet the data management and services through the 1990's;
- Implement new processing systems to account for the changed concept in processing data from automated systems and to accept new data streams;
- Study the characteristics of data collected with automated systems versus manually observed data and continue the development of techniques to treat data to form homogeneous long series databases;
- Working with the World Meteorological Organization, participate in the preparation of a high priority global data set to monitor climate change;
- Prepare climate perspectives studies to place contemporary climate into historical perspective;
- Reanalyze and/or reprocess long-series data sets and produce global/regional baseline data sets;
- Enhance the operation of the World Data Center to concentrate on the collection and exchange of international historic climate data needed to complete long series data sets;
- Participate in NOAA data management programs as required to support global change;
- Develop CD-ROM based systems to describe the climate of the United States and to present data and information from around the world.

Climate Services

The demand for the basic climatic data and information services has been increasing annually. The recent concern for climate change has placed an increased need to readily identify the availability of databases and to service large volumes of data. NOAA has implemented a NOAA Master Directory and will be expanding the capabilities of this directory that will help users access data. The NCDC plans to develop an interface between the NCDC data inventory system and the NOAA directory to provide more information to users. An automated system that allows users to browse (review) and to order available data products, and to provide cost accounting, has been partially implemented. On-line access to databases will continue to expand in FY 1994.

NATIONAL OCEANOGRAPHIC DATA CENTER

The National Oceanographic Data Center (NODC) supports climatic services and research through its data management and data services activities. The NODC provides data management for major climate-related studies such as the Tropical Ocean-Global Atmosphere (TOGA) program, the World Ocean Circulation Experiment (WOCE), and the Joint Global Ocean Flux Study (JGOFS). The NODC also provides data products and services individually to researchers as well as to members of the operational marine community (e.g., the Navy, Coast Guard, shipping industry).

Data Management

The NODC is working closely with the academic community to provide data management for global change research programs. Three joint centers have been established with university groups to focus on different aspects of data management for global change:

- Joint Environmental Data Analysis (JEDA) Center with the Scripps Institution of Oceanography, University of California at San Diego;
- Joint Archive for Sea Level (JASL) with the University of Hawaii;
- Joint Center for Research in the Management of Ocean Data (JCRMOD) with the University of Delaware.

The JEDA Center is providing management of subsurface thermal data in support of TOGA. This activity is now part of a larger, global effort called the Global Temperature-Salinity Pilot Project (GTSPP). A cooperative international project, the GTSPP was initiated to improve the quality, volume, and accessibility of global temperature and salinity data. While the JEDA Center at Scripps continues its focus on the Pacific Ocean, the Commonwealth Scientific and Industrial Organization of Australia is providing management and quality control for Indian Ocean data, and NOAA's Atlantic Oceanographic and Meteorological Laboratory in Miami is providing management and quality control for data from the Atlantic Ocean. The NODC receives both near-real-time and delayed-mode temperature-salinity data and merges them into a continuously managed global database. As of August 1993, the GTSPP database contained a total of nearly 202,000 temperature profiles, including 112,000 from the Pacific Ocean, 70,000 from the Atlantic Ocean, and 20,000 from the Indian Ocean.

Through the creation of the Joint Archive for Sea Level, the NODC is assisting researchers at the University of Hawaii in the acquisition, processing, quality assurance, archiving, and dissemination of sea level data from a network of island-based and coastal tide gages. The network consists of stations in the Pacific Ocean Sea Level Network originally established as part of the North Pacific Experiment (NORPAX), which began in 1974, as well as stations operated by many national and foreign agencies. As of July 1993, the sea-level data archive at the NODC contained hourly, daily, and monthly sea level values totaling 2,650 station-years from 137 stations in the Pacific Ocean, 47 stations in the Atlantic Ocean, and 55 stations in the Indian Ocean.

An initial project of JCRMOD was the establishment and operation of a data information unit (DIU) in support of WOCE. An online information system called Oceanic provides WOCE program information to principal investigators and other researchers. Using the successful WOCE DIU as a model, a DIU is being created for the TOGA Coupled Ocean-Atmosphere Response Experiment (COARE). In addition to an oceanographic component TOGA/COARE also includes atmospheric and ocean-atmosphere interface components and will thus extend the types of data to be tracked beyond those for WOCE. An information system for TOGA/COARE analogous to Oceanic is also operational.

To promote efforts to locate and preserve older, historical ocean data, the NODC has organized the Global Oceanographic Data Archaeology and Rescue (GODAR) Project. In support of this project the NODC in October 1992 published the *NODC Inventory of Physical Oceanographic Profiles: Global Distributions by Year for All Countries*. This publication is the first in a planned series of data inventory publications that provide data distribution plots and summaries of the NODC's data holdings. This information will help the worldwide oceanographic community to identify data not yet included in the NODC's digital data archives. At the 17th IOC Assembly in March 1993, the GODAR project was endorsed by the Intergovernmental Oceanographic Commission (IOC), and the U.S. NODC/WDC-A, Oceanography, was designated as the project leader. The success of initial GODAR activities has already resulted in the submission to the NODC of an additional 960,000 temperature-salinity profiles from nine countries.

NODC's ocean climate research group will publish the results of several major studies in 1993 and 1994. Several scientific papers will describe decadal-scale variability of the North Atlantic Ocean as determined from the analysis of historical data, in particular, time-series data from Ocean Weather Stations "C" and "5." A multivolume ocean atlas that will provide objective

analyses of major ocean parameters is in the final phases of preparation. This atlas will extend and update the earlier work published in the *Climatological Atlas of the World Ocean* (NOAA Professional Paper 13, 1982).

Data Services

During FY 1992, the NODC fulfilled a total of 11,035 user requests and disseminated a total of over 200 gigabytes of digital data to customers. CD-ROM continues to be an increasingly important medium on which to disseminate large ocean data sets. By the end of FY 1993, the NODC will have released about 30 individual discs holding several major ocean data sets and other ocean data products. Among the recent CD-ROM data sets are altimeter data from Geosat Geodetic Mission for ocean areas south of 30°S, (2 discs), oceanographic station profile time series (1 disc), and NOAA marine environmental buoy (wind/wave) data. A projected series of 14 CD-ROMs are to be completed early in FY 1994.

The NODC has management responsibility for the NOAA Library and Information Network (NLIN) consisting of:

- the NOAA Central Library in Silver Spring, MD;
- regional libraries at major NOAA facilities in Miami, FL, and Seattle, WA;
- more than 30 field libraries and information centers at other NOAA locations throughout the United States.

The NOAA Central Library will move to the new NOAA building complex in Silver Spring, MD in June 1993. The new and expanded facility will enable the library to offer improved information services to users including climate and global change researchers. At the Silver Spring location, which is immediately adjacent to the Silver Spring station on the Washington, D.C., Metrorail Red Line, the information resources of the NOAA Central Library will be more easily available to both NOAA personnel and other users.

Technology Enhancements

To support its CD-ROM production efforts, the NODC has a CD-ROM mastering workstation that includes a CD-ROM recorder. The NODC uses the discs (one-offs) produced with this device to test and evaluate prototype CD-ROMs before they are sent to commercial plants for mass replication. Writable CD-ROMs containing data selected from NODC's archive databases are also provided to individual customers as an alternative to receiving data on magnetic media.

Early in FY 1994, the NODC will complete the conversion of its computer system from an older configuration based on a cluster of DEC VAX computers to a modern client-server architecture based on advanced UNIX workstations. A relational data management system will be used to manage the NODC's data holdings. An upgraded Ethernet local area network (LAN) will link the distributed computing resources at NODC's headquarters offices. Silicon Graphics workstations will function as servers to support NODC database operations, user services, and data communications. Peripheral devices include magnetic tape drives (9-track, 8mm, IBM 3480 cartridge), an optical disk drive, and an optical "Jukebox" that provides over 300 gigabytes of mass storage. The Ethernet LAN will operate with the TCP/IP protocol and support about 90 nodes, including both high speed workstations and PC-class computers.

NATIONAL GEOPHYSICAL DATA CENTER

Program Description

The National Geophysical Data Center (NGDC) carries out a number of programs which provide data for research in meteorology and climatology. Of particular interest is NGDC's program to assemble global information on paleoclimate and cooperate in research projects to employ the combined global paleoclimate database for climate model verification and climate change studies. Support for this program from the NOAA Climate and Global Change Program (CGCP) is continuing.

NGDC has actively sought and acquired many paleoclimate databases derived from tree-rings, pollen and macrofossils, lake and bog sediments, marine sediments, ice cores, and other geological and biological sources. Digital data sets have been enhanced with custom display and search capabilities. These research tools are currently being distributed to the paleoclimate community. Objectives of the program are to cooperate with researchers from NOAA, other agencies, and academia to describe the global patterns of decade to millenial scale climate

change; to identify and understand the causes of this climate change; improve the ability of separating man-induced climate change from the natural variability, and to validate the models that are being used to predict global climate change the next several centuries.

Long-term, global records of solar variability archived at NGDC are the principal databases available to support research into the impact of changing solar energy output affecting Earth and changing climate or other global systems. Older ways of observing solar activity continue to be used today and their results are archived at NGDC. They provide continuity between the past and modern observations using new technology deployed on the Earth and in space. They offer a means to calibrate new observations and, by proxy, extend them back into the past. Drawings and counts of sunspots from visual observations exist since the early 17th century, and show the persistence of the well-known 11-year solar cycle. These have been used since the mid-19th century to produce the sunspot number index of solar activity. Efforts to correlate these numbers with weather and climatic conditions have intrigued scientists at least since the beginning of the 19th century (almost 50 years before 11 year sunspot cycle was discovered). From early in the 20th century, systematic telescopic observations were made of solar flares in visible light and other wavelengths. NGDC holds Space Environment Monitor data from NOAA geostationary satellites since the early 1970s, including X-ray flare records made above the shield of Earth's atmosphere. For the past 11 years, satellites have carried instruments above the atmosphere and recorded significant changes in the total solar irradiance, the "solar constant," the total luminosity of the Sun. These data may be studied at NGDC, combined with complementary geomagnetic and ionospheric databases and with records about auroral occurences. They already are made available to the research community in publications and on magnetic tapes, floppy diskettes, and Compact Disc-Read Only Memory (CD-ROM) media for computer analysis.

NGDC, through its contract data center, the National Snow and Ice Data Center (NSIDC) maintains several cryosphere-related data sets of interest to meteorology and climatology. These include a collection of historical photographs of glaciers; temperature, pressure, and position data from satellite-queried drifting buoys placed on the central Arctic pack ice; and data from the DOD-NOAA sea ice chart digitizing programs. NSIDC provides data management services for the Second Greenland Ice Sheet Program (GISP II) and the National Science Foundation-funded Arctic System Science Ocean-Atmosphere-Ice Interaction (ARCSS) research programs. In addition, NSIDC has developed gridded sea ice products (sea ice concentration and multi-year ice fraction) based upon passive microwave data collected by the Scanning Multi-channel Microwave Radiometer on Nimbus 7 and the DMSP Special Sensor Microwave Imager. The passive microwave data sets are being distributed on CD-ROMs. Under NOAA ESDIM funding, NSIDC is acquiring snow cover, glacier, and sea ice records from former Soviet Union scientists and institutes.

NGDC is integrating multi-thematic global and continental data for intercomparison and analysis related to studies of global change. Various elements of this program include: (a) Global Ecosystems Database, an integrated multi-disciplinary environmental CD-ROM database structured for Geographic Information Systems and designed to support global characterization and modelling research; (b) Africa Global Change Database, initially constructed as a pilot database for the IGBP (predecessor to the Global Ecosystems Database), and now an educational product being made available to the teaching and research communities; (c) regional integrated databases for China, North America and South America. Additions to the Ecosystems database are released annually. The 1992 release included global data sets of topography; AVHRR derived monthly vegetation indices; vegetation, ecosystems, and land-cover classifications; methane emissions; soil classes and properties; long-term average monthly temperature; precipitation; cloudiness; and geographic boundaries. The 1993 release will add new global and regional data sets and model-derived outputs. In addition to integrated database products distributed on CD-ROM, NGDC also maintains and improves individual disciplinary data sets related to this mission, including: Generalized Monthly Global Vegetation Index, Experimental Calibrated bi-weekly Global Vegetation Index, Tateishi Monthly Global Vegetation Index and derived land-cover class, Olson World Ecosystems, Varlyguln/Basllevitch above-ground phytomass, CZCS marine pytoplankton pigment

concentrations, global and continental topography, global geographic boundaries, numerous geophysical data sets, and an operational archive of DMSP satellite meteorological data. In support of these databases, graphic browse and visualization software is being developed. These databases and the associated supportive access software will play an important role in the NOAA CGCP.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

Environmental Research Laboratories

Environmental Research Laboratories (ERL) R&D programs support NOAA meteorological and space services and are oriented toward providing, understanding, and developing techniques and technologies to form the basis for 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 and hurricane forecasts and warnings. Severe weather includes any major natural hazard such as flash floods, strong winds, thunderstorms (including tornadoes, lightning and hail), heavy snowstorms, extreme cold or drought. ERL laboratories will continue to conduct both inhouse and cooperative research with other NOAA components, joint institutes, and universities.

Observing Technology

The Wave Propagation Laboratory (WPL) develops and experimentally evaluates new atmospheric remote sensing concepts and systems. WPL also improves the Nation's atmospheric research and forecasting and warning services through the transfer of remote sensing technology.

As an outcome of WPL research, ERL's Forecast Systems Laboratory is operating 29 wind profiling Doppler radars that make up the Wind Profiler Demonstration Network. This network, located in the central United States, is providing hourly winds aloft data to weather forecasters and is helping improve weather forecasts and warnings. The operation of this network will continue in FY 1994.

During FY 1994, WPL will continue development of atmospheric profiling systems to remotely and continuously measure vertical profiles of wind speed and direction, temperature, and humidity. Specific efforts include the development and integration of the radio-acoustic sounding system (RASS) into wind profilers to augment their capability with temperature profiles and, continuing development of techniques that can integrate the data from ground-based and satellite-borne profiling systems for more effective use of this data in forecasts.

WPL will also continue development of Lidars and infrared Doppler multifrequency radars as research tools to improve our knowledge of atmospheric winds, turbulence, and moisture processes. Development of dual-polarization Doppler and multifrequency radars and passive radiometers will also be undertaken to study convective storms and their precursors, including in-cloud and entrainment processes.

Severe Weather Analysis and Forecasting 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 Doppler weather radar, satellites, remote-sensing wind profilers, instrumented aircraft, and lightning location networks. NSSL provides significant technical and scientific support, including research and development, for the NOAA/USAF/FAA NEXRAD program.

In FY 1994, NSSL will continue to develop techniques, in cooperation with the National Weather Service, to identify and warn of weather hazards to aviation and the general public. Immediate technology transfer will be effected by close association with the National Weather Service Forecast Office in Norman, OK.

Also, ERL will continue to transfer knowledge of Doppler radar applications, convective weather systems and heavy rainfall events; much of the transfer is through courses at the NWS training center. Visits and

interactions with NWS centers, regional headquarters, and forecast offices continue and FSL and NSSL are participating directly in new training programs such as the Cooperative program for Operational Meteorology, Education and Training (COMET) in Boulder and the NEXRAD Operational Support Facility in Norman.

Improvement of short-range (1-12 hour) forecasting will be accomplished by the development and evaluation of new local data system technologies and techniques, many of which can be incorporated into operational weather forecasting in the near term. The Program for Regional Observing and Forecasting Services (PROFS) provides a tested prototype to evaluate workstations for laboratory and forecast office environments. Specifically, PROFS has and will continue to develop capabilities to allow the forecaster to integrate, view, and manipulate observations from current and planned meteorological sensing systems using computer-assisted data display and synthesis techniques. By maintaining state-of-the-art capability for use in research and development of operational techniques, it has provided a mechanism to evaluate weather service requirements for the Advanced Weather Interactive Processing System (AWIPS).

PROFS will continue its emphasis on data application from the GOES VISSR Atmospheric Sounder (VAS), Doppler radar, Aeronautical Radio Incorporated (ARINC) Communications Addressing and Reporting System (ACARS), and the WPDN as inputs to its quantitative mesoscale analysis and prediction model, thus expanding service improvement efforts to include nonsevere as well as severe weather, to assist NWS modernization and restructuring, and to upgrade National Meteorological Center operations.

Mesometeorology and Precipitation Forecasting and Warning Research

NSSL and FSL develop techniques to improve short-term forecasts of significant weather events. Through detailed case studies and regional climatologies, ERL scientists have developed diagnostic tools and aids for operationally forecasting thunderstorms, lightning, flash floods, and large mesoscale convective storms complexes. Activities underway include studies of the precipitation structure of mesoscale convective systems, of interactions between mesoconvective systems and the larger environment, of satellites to infer storm development and rainfall, and of winter storm forecasting procedures.

Hurricane Analysis and Prediction Research

The Hurricane Research Division (HRD) of the Atlantic Oceanographic and Meteorological Laboratory performs research to improve operational 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.

More specifically, HRD is engaged in a research strategy that consists of three areas: increasing data density in tropical cyclones and their surrounding environments, understanding storm dynamics and energetics, and improving forecast models. These elements are crucial for improved tropical cyclone track and intensity forecasts which will save lives and money.

In addition to the HRD research, the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton, NJ, 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.

Numerical Analysis and Prediction Modeling

GFDL 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. Two main areas of weather research are covered by the GFDL program -- Experimental Prediction and Mesoscale Dynamics. Experimental prediction research is carried out with the National Meteorological Center to determine the predictability of global atmospheric circulation on extended time scales. Mesoscale dynamics research seeks to understand the practical limits of mesoscale predictability and the interaction of mesoscale phenomena with the larger and smaller scales.

The Wave Propagation Laboratory, through cooperative agreements with the National Center for Atmospheric Research, continues to apply four-dimensional data assimilation modeling techniques to

simulate Profiler Network observations. Results have demonstrated the importance of co-locating RASS temperature capabilities with wind profilers and will provide information for determining the necessary density of an operational wind profiler network.

ARL's Atmospheric Sciences Modeling Division (Research Triangle Park, NC) conducts intramural and extramural research programs to develop predictive models on local, regional, and global scales for assessing changes in air quality and air pollutant exposures, as affected by changes in ecosystem management and regulatory decisions. The Division provides technical guidance on applying and evaluating air quality simulation models that are used to assess, develop, or revise air pollution control strategies for attainment/maintenance of ambient air quality standards.

Air Quality Research

The Air Resources Laboratory (ARL) carries out research on processes that affect the quality of the atmosphere, primarily in the contexts of air pollution, deposition, and emergency preparedness. Various field divisions of ARL focus on specific issues related to the development of predictive models. The Atmospheric Turbulence and Diffusion Division (Oak Ridge, TN) carries out an integrated program of theoretical and experimental research on atmospheric turbulence and diffusion in the lower atmosphere. This includes dispersion and planetary boundary layer studies in non-stationary and non-homogeneous conditions, air-surface exchanges of properties and trace gases (especially over and within vegetation canopies), and emergency preparedness efforts.

ARL's Field Research Division (Idaho Falls, ID) conducts research on the transport, dispersion and removal of those materials in the atmosphere usually regarded as pollutants. Progress toward this goal is sought by studies of the mean and turbulent atmospheric flow characteristics on all scales of motion and by studies of the history of a wide variety of tracers accidentally or purposefully introduced into the atmosphere.

The Aeronomy Laboratory conducts research on air quality as part of its tropospheric chemistry program. The primary focus for air quality is on understanding the processes of surface ozone formation in rural regions and the contribution of natural hydrocarbons to these processes. This work is accomplished through field experiments, laboratory work, and numerical modeling studies.

The Wave Propagation Laboratory uses its remote sensor capabilities (e.g., wind profilers and lidars) to understand the interaction of meteorological processes in air quality.

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, CO. 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 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 communication systems, radiation hazards to personnel and systems on high altitude aircraft and in space, degradation of surveillance and monitoring systems for defense, errors in navigation systems, perturbations of satellite orbits, and disruptions in power distribution networks.

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 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 the polar-orbiting NOAA satellites.

Data are collected, stored, and displayed for analysis and products are distributed through the Space Environment Laboratory Data Acquisition and Display System (SELDADS II). 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.

NATIONAL OCEAN SERVICE

The National Ocean Service (NOS) develops, implements, and manages programs in physical, biological, chemical, and geological oceanography and establishes a scientific information base on which to support development of national policy for the oceans and their users. NOS efforts are coordinated with marine programs administered by other components of NOAA. Products and services provided by NOS encompass the full range of NOAA marine activities. Operational ocean observing activities administered by NOS include: Voluntary Observing Ship (VOS) programs; moored/drifting buoy programs; and water level programs.

Voluntary Observing Ship (VOS) Program. NOS operates a global VOS Program that provides real-time meteorological and oceanographic data from selected vessels. Data are collected with the Shipboard Environmental data Acquisition System (SEAS), which transmits the information to NOAA via the GOES system. The information is then disseminated nationally and internationally using existing data networks. Presently there are over 120 vessels in the program, which record and transmit surface meteorological information four times per day at synoptic hours. Of these vessels, about 80 also are equipped to collect expendable bathythermograph (XBT) data.

TOGA Southern Hemisphere Drifting Buoy (SHDB) Program. In support of the Tropical Ocean and Global Atmospheric (TOGA) Program, NOS maintains a network of thirty meteorological drifting buoys in the Southern Hemisphere. The buoys measure sea level atmospheric pressure, air temperature, and sea water temperature. Observations are obtained through the ARGOS data collection and platform location system on-board the NOAA polar orbiting satellites.

TOGA-Tropical Atmosphere Ocean (TAO) Moored Array. NOS is a partner with OAR in the implementation of the TOGA-TAO moored buoy array. TOGA-TAO is a basin-wide array of moored ATLAS buoys in the tropical Pacific deployed in support of TOGA that report surface wind, air temperature, sea surface temperature, ten subsurface temperatures to a maximum depth of 500m and two subsurface pressures in real-time via the ARGOS system. There will be 53 buoys deployed by the beginning of FY 1994. The array is operated by the TOGA-TAO Project Office located at NOAA's Pacific Marine Environmental Laboratory in Seattle, WA where NOS has responsibility for management of project operations and logistics. While the principle objective of the project is to support the research objectives of TOGA, the real-time availability of the data makes it extremely valuable to the national operational meteorological centers.

Arctic Drifting Buoy Program. The U.S. Interagency Arctic Buoy Program (USIABP) was established in 1992 to provide the management structure and coordination necessary to maintain a baseline network of drifting buoys. Buoys within the array provide sufficient spatial resolution to define surface synoptic scale atmospheric pressure, air temperature, and sea ice drift fields. Emphasis has been placed on the accurate measurement of ambient air temperature. Data are used in real-time for operational weather and ice forecasting and for research in the Global Climate Change Program. The USIABP is a collaborative program that draws operating funds and services from the collective contributions of eight Government agencies and/or programs. The organizations include: NOAA's NOS, Office of Oceanic and Atmospheric Research, and Office of Global Programs; the Office of Naval Research; the Naval Oceanographic Office (NAVOCEANO); the National Aeronautics and Space Administration, and the National Science Foundation. By the end of FY 1993, the USIABP will have a network of 40 buoys. The USIABP buoy network is expected to grow to approximately 50 buoys by the end of FY 1994.

National Water Level Observation Network (NWLON). NOS operates and maintains the NWLON for the collection of water level data, as well as other oceanographic and meteorological data. The NWLON consists of 189 stations located in U.S. coastal areas and the Great Lakes. Through its strategic locations and data dissemination capabilities, NWLON supports a number of NOAA and other Federal Programs, such as: the NOS Tide Prediction Program; NWS Tsunami Warning System and storm surge warning/forecast activities; Climate and Global Change Program; and the U.S. Army Corps of Engineers lake level regulation, dredging operations, and coastal construction efforts.

Physical Oceanographic Real-Time System (PORTS). PORTS is a data acquisition and dissemination system which integrates a number of important meteorological and oceanographic parameters, including currents, water levels, and marine winds. The first operations PORTS system was deployed in Tampa Bay during 1991 and is maintained by the Mote Marine Laboratory under a cooperative agreement with NOS. Traditional NOAA tide and current prediction tables provide only the astronomical tides and currents and do not always meet the needs of users who must also consider the non-tidal effects of river flow, winds and other meteorological forces. PORTS measures and integrates these important data and provides a data dissemination system that includes telephone voice response, as well as modem access.

NOS also provides operational marine analyses and forecast guidance material, as required by NOAA's mission responsibilities. Analyses, interactive guidance products, and numerical model output are produced at, and disseminated from two National Centers -- the NOAA Ocean Products Center (Camp Springs, MD) which provides marine weather and physical oceanographic products, and the Navy/NOAA Joint Ice Center (Suitland, MD) which provides analyses/forecasts of hazardous ice conditions for the Great Lakes and Polar regions.

OFFICE OF NOAA CORPS OPERATIONS
AIRCRAFT OPERATIONS CENTER

The Aircraft Operations Center (AOC) supports several NOAA missions, in particular, it operates a fleet of aircraft which are used to support NOAA's research and development programs to improve weather, marine, and climate services. It also provides weather reconnaissance support to NOAA programs, other Federal agencies and international programs approved by the Aircraft Allocation Council. Light aircraft provide aerial photography for nautical and aeronautical charting and living marine resources surveys.

AOC was established in October 1983 to consolidate the management of all aircraft used by NOAA. Fourteen aircraft located throughout the United States are managed by AOC located at MacDill Air Force Base in Tampa, Florida.

NOAA's atmospheric and oceanographic research and reconnaissance operations are supported by two fully instrumented WP-3D aircraft which carry state-of-the-art environmental research equipment. The aircraft research and navigation systems provide detailed spatial and temporal observations of a wide range of atmospheric and oceanic parameters. AOC develops and calibrates specialized instruments, integrates user-supplied instruments into the automated systems, and processes and analyzes data sets obtained from various field programs.

AOC aircraft provide high density/accuracy hurricane data to the National Hurricane Center in near real-time. Storm data are transmitted via the aircraft satellite data link to upgrade forecasting models of hurricane track/intensity. The AOC aircraft have primary responsibility for reconnaissance of tropical storms and hurricanes over foreign airspace that may be restricted for U.S. military flights. AOC augments USAF operational aircraft reconnaissance with high-density, high-accuracy data when storms are within 24 hours of landfall of the continental United States and whenever DOC needs exceed DOD resources. AOC also provides a quick response capability for investigation of storm activity east of 80°W longitude from August 1 through September 30 each year.

APPENDIX B

DEPARTMENT OF DEFENSE WEATHER PROGRAMS

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 system directly supports all phases of military operations, from strategic planning to tactical operations. While the Army and Marine Corps each have a small specialized weather support capability, the Navy's Naval Oceanography Command and the Air Force Weather support system are the primary sources of military weather 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 are no other conventional weather observing capabilities 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 to meet unique military requirements. Observational data are sent by military communications networks to military and civil facilities in the United States and overseas.

UNITED STATES AIR FORCE

METEOROLOGICAL SERVICES

The functional manager for Air Force meteorological services is the Director of Weather (HQ USAF/XOW), within the HQ USAF, Deputy Chief of Staff for Plans and Operations. HQ USAF/XOW oversees the development and implementation of weather support concepts, doctrine, policies, plans, and programs to ensure effective weather support for the Air Force, Army, and other agencies as directed by the Chief of Staff, USAF. The AF also provides support to DOD joint operations as directed by the Joint Chiefs of Staff under the Unified Action Armed Forces (JCS Publication 0-2). Another role of HQ USAF/XOW is to interface with other Military Departments, Federal Agencies, and international organizations concerning coordination, cooperation, standardization, and interoperability of weather services.

Air Weather Service (AWS) is a field operating agency reporting to HQ USAF/XOW. AWS provides centralized weather and space environmental support to designated users through three centralized support organizations: Air Force Global Weather Central (AFGWC), USAF Environmental Technical Applications Center (USAFETAC), and Air Force Space Forecast Center (AFSFC). Additionally, AWS transitions technology to operational capabilities; manages Air Force-wide weather systems; and provides standardization, interoperability, and effectiveness evaluation of the Air Force weather support system.

Of the two types of meteorological services, basic and specialized, the Air Force is more oriented to specialized services, supporting military aviation, combat air and ground operations, and space operations. The general functions involved in providing meteorological services include:

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

Observations

Meteorological observations are frequently classified as surface, upper air, radar, or satellite observations. Observation and sensing of the space environment are discussed in the Space Environmental Services section.

Surface observations are taken by Air Force 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 AFGWC and to other military and civil locations throughout the world. There are 162 Air Force operated surface observing locations or facilities in the continental United States (CONUS) and overseas.

Upper air observations provide a major input for numerical analysis and forecasting. Most of this information comes from U.S. and foreign rawinsonde sources and military and civilian satellite-derived data. Additional upper air information from data-void areas is obtained from in-flight pilot reports from both military and civil aircraft.

Weather radar is a principal source of information for making short-term warnings of severe weather. The Air Force operates 87 fixed weather radar sets (20 at overseas locations) and 5 tactical weather radar sets. Two of the CONUS sets are a part of the U.S. basic weather radar network; nine are used in a backup capacity. Also, 15 of the Air Force weather radars are used to support the National Hurricane Operations Plan. The tactical weather radar sets are used to support contingency operations. The Air Force will operate 30 WSR-88D (NEXRAD) radars when the system installation is completed in FY 1996, and have access terminals at 148 Air Force bases and Army posts.

The Air Force manages the Defense Meteorological Satellite Program (DMSP), which provides a large volume of cloud, upper air, and space environmental data and is the most important single source of global weather data used for combat support. On-board sensors provide AFGWC and the Navy's Fleet Numerical Oceanography Center (FNOC) with visible, infrared, and microwave imagery of the entire globe; temperature and moisture sounding data; auroral electron counts; and other specialized space environment data. DMSP also supplies direct, real-time readout of regional cloud and mission sensor data to selected land-based and ship-borne terminals located worldwide.

The present DMSP satellite series (Block 5D-2) uses an Operational Linescan System (OLS). Beginning with the fourth (Block 5D-1) series satellite 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 visible detectors were selected to optimize distinction among clouds, ground, and water. It uses both stellar and inertial references, together with on-board processors, to maintain stability and pointing accuracy. The DMSP also flies a microwave temperature sounder (SSM/T) which provides vertical temperature and height profiles of the atmosphere. Satellite F-8, launched in June 1987, carried the first microwave imager (SSM/I) providing new capabilities to observe rainfall, ocean surface wind speed, cloud and soil moisture, ice conditions, and other environmental data.

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 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 Air Force-operated Automated Weather Network (AWN) is the backbone of military weather communications. High-speed computers interconnected with 2400 baud to 56 kilobaud circuitry deliver foreign and domestic weather data to designated users. Weather intercept sites in key overseas areas obtain World Meteorological Organization weather broadcasts for AWN delivery to AFGWC. The AWN also delivers these data to FLENUMOCEANCEN and to NOAA's National Meteorological Center.

Overseas collection and dissemination networks deliver data to, and exchange data with, the AWN Automatic Digital Weather Switch (ADWS) at Hickam AFB, HI, and RAF Croughton, UK. In the continental US (CONUS), the AWN at Tinker AFB, OK drives the Automated Weather Distribution System (AWDS), the CONUS Meteorological Data System (COMEDS), and other special teletype systems, and provides direct support to AWDS in the collection and dissemination of weather information. These circuits also collect and disseminate military Notice to Airman (NOTAM) message traffic to all DOD CONUS users.

The Communications Front-End Processor (CFEP) at Offutt AFB, NE, is the hub of all communications at AFGWC. It drives dedicated circuits, the AWN, and the weather chart facsimile system, which provides graphic data to worldwide military users. CFEP also drives separate graphics networks serving the CONUS,

Alaska, Europe, Central America, and the Pacific, using computers to store and forward required products.

Preparation of Analyses and Forecasts

The primary center for providing weather analyses and forecasts for Air Force and Army operations is AFGWC at Offutt AFB, NE. AFGWC uses mainframe production computers, a super computer (CRAY XMP), a cluster of two super minicomputers for computer flight plan generation, and an interactive graphics and imagery system. 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 database. 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. The interaction between forecaster and machine is accomplished with the Satellite Data Handling System (SDHS). SDHS consists of 35 interactive workstations capable of high-speed interaction with satellite and conventional meteorological data to prepare forecasts and other environmental products. SDHS provides man-machine interactive computer support to virtually all forecasting and analysis tasks formerly performed manually within AFGWC. The Federal Plan for Mutual Support and Cooperative Backup Among Operational Processing Centers designates AFGWC as backup for the NWS facsimile network, the NWS Automation of Field Operations and Service's (AFOS) products, and the NWS National Severe Storms Forecast Center.

In support of combat operations, the Air Force weather support system operates centralized units consisting of AFGWC, USAFETAC, AFSFC, fixed theater Forecast Units (FU), deployed Joint Meteorological/Oceanographic (METOC) Forecast Units (JMFU), and fixed Weather Support Units (WSU). 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 for general purpose use by meteorologists who apply the information to specific areas or missions. Theater FUs 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 JMFU provides the same services as a theater FU; however, it is deployed to support a specific combat operation or exercise which is not or cannot be supported by theater FU. AFGWC will directly support deployed weather teams whenever the theater FU lacks support capabilities, a JMFU is not established, or during the period when the deployed JMFU 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.

The Air Force weather support system contributes to the unique global needs of military aviation and makes its information available to civil aviation. Air Force personnel provide flight weather briefings, air/ground radio services, and tailored observations, forecasts, watches, and warnings to support 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 Air Force weather personnel serve as part of the working staff of operational Air Force and Army units. In this capacity, Air Force 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 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 combat 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, tactical meteorological satellite direct readout terminals, and tactical communications terminals provide the means to acquire vital meteorological data within a theater. A high frequency radio broadcast system is used to transmit alphanumeric and facsimile products to the theater weather support force. This system consists of regional broadcast stations at Anderson AFB, Guam; Elmendorf AFB, AK; Elkhorn, NE; Homestead AFB, FL; and Croughton, England.

Specialized Support

The USAF Environmental Technical Applications Center (USAFETAC), Scott AFB, IL, provides environmental data and specialized studies to support the Air Force, 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 AFGWC and then sorts, checks, stores and employs these data to produce tailored products. USAFETAC also operates a facility collocated with the National Climatic Data 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 (Real-time 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 Air Force supports an array of specialized requirements of the Air Force and Army. Some of these are described below.

The Air Force integrates Army weather support into its overall support concept. The Army trains and educates Air Force personnel about Army organizations, concepts of operations, and the weather sensitivities of Army operations and equipment. Air Force 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 the Air Force. In a tactical environment, direct forecast support is normally provided down to corps, divisions, separate brigades, regiments, echelon-above-corps, aviation brigades, armored cavalry regiments, ranger regiments, and special forces groups (as well as subordinate battalions deployed at forward operating bases). Observer support is provided to all levels identified above.

The Air Force 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. The Air Force also provides launch forecasting service for NASA's manned and unmanned launches and for commercial launches from the Kennedy Space Center.

The Air Force 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. The Air Force 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 degrees 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, products, services, and solar forecasts to a wide variety of customers.

The Air Force also 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.

Air National Guard

There are two distinct functions within the Air National Guard (ANG) weather program. The

traditional ANG weather program consists of 34 weather flights, ranging in size from 13 to 25 personnel. The flights provide support to US Army units, mostly those of the Army National Guard (ARNG). The flights meet monthly to train for their wartime missions. The ANG is also responsible for peacetime weather support to its flying units. Civil Service employees of the ANG provide weather support at six National Guard Bureau (NGB) locations, and additionally, there is contractor-provided weather support at six ANG locations.

Planned Enhancements

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

The Air Force is modernizing 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 programmed for their R&D and acquisition phases. Installation of both systems is in progress.

The AWDS automates 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 permits AWDS to be operated in a fixed or mobile environment with minimal staffing requirements. AWDS receives information from the National Weather Service via the AFOS through AFGWC and will eventually receive data via the IMEDS circuits once the AFOS circuit is deactivated (late 1990's).

To enhance AWDS in base weather stations and to expand forecasting capabilities, the AWDS Pre-Planned Product Improvement (P3I) will provide the following:

- interoperability with other command, control, communication, computer, and information (C4I) systems;
- a remote briefing capability, an intra-AWDS product preparation capability;
- multiple software improvements;
- improved meteorological satellite ingest capability.

The Concept for Weather Support to Air Force Theater Operations 1995-2005 (CONOPS), dated 5 May 92, describes the means to produce and apply environmental information in support of the employment of military assets. The Combat Weather System, (CWS), described in the Operational Requirements Document for Combat Weather System, dated 30 Oct 92, describes the approach to implement the CONOPS by supporting military forces from initial deployment through sustained theater operations.

The goal of the CWS is to interface highly capable automated weather observing and forecasting systems with combat planning and execution systems. The CWS will enhance the effectiveness of combat operations by improving the capability of deployed weather forces to produce comprehensive and timely weather decision products for battlefield commanders and aircrews. The observing components of the CWS will provide accurate automated observations and quickly distribute these data to weather forecast systems and operational customers. In turn, the forecasting portion of the CWS will rapidly integrate these observations while quickly generating tailored forecasts for distribution. Operational users will receive timely products via the automated theater battle management C4I systems.

The NEXRAD radar, WSR-88D, is being procured under the auspices of the NEXRAD Joint System Program Office. The WSR-88D is an automated, digitized, S-band Doppler system that was jointly developed and procured. It will be operated and maintained by DOD, NOAA, and FAA within the CONUS and by the Air Force and Navy overseas. The system incorporates 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. Installations of the WSR-88D are in progress and are expected to be completed by 1996.

The Centralized Data Management System (CDMS) transition is a related series of distinct acquisition, development, and integration efforts to transition AFGWC from a multiple copy database environment to a centralized database environment.

Under the CDMS transition, AFGWC replaced two computers with one computer for both unclassified and classified production as well as backup and development capacity. This acquisition also provided a centralized database computer which will be integrated with improved software from the AFGWC hardware/software systems and will transition to the centralized database environment under planned programmed steps with major AFGWC hardware upgrades and related software modernization efforts. CDMS transition reached initial operational capability in 1992 with operational support to the Global Applications Database. Final operational capability is currently scheduled for FY 2000 in conjunction with the AFGWC Satellite Data Handling System replacement.

The latest model developed under AFGWC's Advanced Weather Analysis and Prediction System (AWAPS) is the Relocatable Window Model (RWM), a regional relocatable analysis and forecast model suite designed for military applications. The model will provide non-cloud parameters to the CWS.

The Advanced Computer Flight Plan (ACFP) System will replace a leased optimized computer flight plan system and the existing Air Force-owned flight simulation model. The ACFP system will be Government-owned and will satisfy requirements beyond the capabilities of current systems with enhanced flight planning and optimization features and increased responsiveness to customer needs.

By 1999, plans call for USAFETAC to upgrade and replace computers to handle new databases and increase data processing and storage capabilities. Also, meteorological data simulation is receiving increasing emphasis. Simulation capabilities are expected to expand to include time-phased multi-dimensional models, climate spreading techniques, and tunable models to support research, development, and testing of operational concepts.

Advances in meteorological observing and data processing technology must eventually be transitioned back to the fixed bases. The Fixed Weather Observing System (FWOS) will upgrade existing sensors and develop new sensors to meet requirements for airfield meteorological sensing in the year 2000 and beyond. State-of-the-art processors will be used to consolidate sensor inputs, format observations, and disseminate them to operational customers. New and evolving requirements for support to customer C4I systems will be satisfied by the Base Meteorological Center System (BMCS). This system will take advantage of advances in atmospheric modeling, artificial intelligence, database processing, and data visualization to help Air Force Weather Technicians monitor, manipulate, and transmit environmental databases to operational customer C4I systems.

The MARK IVB Direct Readout program will procure seven satellite receiver terminals to replace the aging MARK IIAs, IIIs, and IVs. In addition to providing high resolution satellite imagery from polar and geosynchronous weather satellites, the MARK IVB terminals will be able to accept and use data from the DMSP microwave imager and sounders and the TIROS microwave sounding units A and B. The MARK IVB will produce both uniform gridded data fields and traditional meteorological products.

The Small Tactical Terminal (STT) program will procure small, lightweight, ruggedized, modularized, interoperable first-in satellite receive terminals that will receive data transmitted by geostationary and polar orbiting (Automatic Picture Transmission) meteorological satellites. Full rate production is scheduled to begin in FY 1995.

In January 1988, the Air Force awarded four competitive concept study contracts for Block 6, the follow-on to the Block 5D-2/5D-3 satellites. In July 1992, two contractors were selected to proceed with the risk reduction phase. The objectives include lowering DMSP system life cycle cost and assessing cost effective options for increased survivability, interoperability, and remote sensing capability. The Navy (oceanography) and Army (tactical support) are participating in the Block 6 studies. Initial operational capability for the DMSP follow-on system is planned for FY 2005.

SPACE ENVIRONMENTAL SERVICES

Many DOD systems operate in, or are affected by, conditions above 50 kilometers. The space environment includes the thermosphere, ionosphere, and magnetosphere, as well as the regions that influence them such as the heliosphere (solar) and interplanetary space. The AWS provides basic and

specialized space environmental support to military electromagnetic communications, surveillance, and warning systems which operate in this environment. AWS provides space environment forecasting and specialized services for:

- ionospheric conditions;
- energetic particle fluxes at geostationary orbits;
- solar flare and solar particle events;
- upper atmospheric density variations by providing geomagnetic and solar indices;
- detailed post-analysis studies of operational system problems to determine if the space environment was a contributing factor.

The effects of the space environment on DOD systems are many and varied. The magnetosphere affects satellite operations through such phenomena as Single Event Upsets (SEUs) and spacecraft charging. Manned spaceflights are vulnerable to intense radiation from large solar flares. Ionospheric conditions have a profound effect on the propagation of radio waves and radar signals, leading to communications blackouts and erroneous radar returns. Variations in the neutral atmosphere affect satellites orbiting at relatively low altitudes.

The focal point for AWS space environment support is the AFSFC. AWS also participates with NOAA in the joint operation of the Space Environment Services Center (SESC) in Boulder, CO. Under existing agreements, SESC and AFSFC provide limited back-up for each other during contingencies.

Data Sources (See Table B-1)

Solar Data. AFSFC operates a network of solar optical and radio telescopes. Solar Electro-Optical Network (SEON) observatories are located at Sagamore Hill, MA; Ramey, Puerto Rico; Holloman AFB, NM; Palehua, HI; San Vito, Italy; and Learmonth, Australia.

AFSFC receives real-time solar X-ray and energetic particle data from the Geostationary Operational Environmental Satellites (GOES). DOD geostationary satellites provide additional energetic particle data.

Ionospheric Data. A world-wide (primarily northern hemisphere) network of ionosondes and polarimeters provides ionospheric data. AWS is currently deploying the automated Digital Ionospheric Sounding System (DISS) to replace older instruments and provide improved ionospheric coverage. Of the 19 proposed DISS sites, 13 are operational.

Geomagnetic Index. AFSFC monitors variations of the geomagnetic field using ground-based magnetometers, computes a real-time geomagnetic index, and transmits the derived index to users for use in density models.

Magnetospheric Data. AFSFC has a limited in-situ magnetospheric monitoring capability by using real-time high energy particle data from operational DOD geostationary spacecraft and GOES.

AFSFC Warning and Forecast Services

In near real time, AFSFC provides operators advance warning of conditions that could degrade performance of their systems. Notifications include:

- solar X-ray events which can disrupt high frequency (HF) communications on sunlit paths;
- solar radio bursts which can disrupt communication systems and interfere with radar systems;
- solar proton events which can produce radiation hazards to spacecraft;
- ionospheric disturbances which can degrade HF and satellite communication systems;
- geomagnetic disturbances which can affect the orbital parameters of low altitude satellites or cause spacecraft charging in high Earth orbits.

Future Improvements in AFSFC Support

The AFSFC is enhancing its ability to observe the space environment, analyze data, and model the near-Earth environment.

Transionospheric Sensing System (TISS). The TISS is a planned replacement for the current polarimeter network. The TISS, using signals from Global Positioning System (GPS) satellites, will measure total electron content and ionospheric scintillation. The initial purchase and deployment of five TISS units is in progress.

SEON Upgrade. The SEON upgrade will improve the capabilities of the SEON observatories in two phases. Phase I, which upgrades obsolete and insupportable equipment to maintain current capability is in progress. Phase II will include advanced

engineering development and procurement of a vector magnetograph and a solar radio burst locator when operational.

Solar X-Ray Imager. A Solar X-Ray Imager (SXI) will be flown on the GOES Next series of satellites. The SXI will monitor solar emissions in the extreme ultraviolet (EUV) and X-ray portions of the solar spectrum. These data will be down linked to the SESC and transmitted to AFSFC in real time.

Space Environmental Technology Transition (SETT) Models. The SETT program transitions state-of-the-art space environmental models to operational use at AFSFC. These models will specify and forecast the space environment from the Sun to the Earth's upper atmosphere. The transition of the SETT models to the AFSFC will be complete by 1999. Follow-on model development will focus on improving model accuracies and will replace surrogate parameters (as model inputs) with direct measurements wherever possible.

a. Magnetospheric Models. The Magnetospheric Specification Model (MSM) provides specification of magnetospheric particle fluxes at geostationary altitudes and precipitating particle fluxes in the auroral zone. An upgrade to this model, the Magnetospheric Specification and Forecast Model (MSFM), is under development and will provide 1 hour forecast capability and increase the MSM coverage area.

b. Ionospheric Models. The Parameterized Real-Time Ionospheric Specification Model (PRISM) specifies global electron density. Model output is updated using data from DMSP space environmental sensors and other real-time data sources. A second ionospheric model, the Ionospheric Forecast Model (IFM) is still under development and will be based on a model developed by Utah State University. When completed in 1995, the IFM will provide a short term (1-3 hours) ionospheric forecasting capability.

****

Table B.1 Geophysical Sensors of Space Environment

Sensor	Purpose	Locations
Polarimeter	Measure total electron content of the ionosphere	6 sites; N. hemisphere
DISS	Measure electron density in the lower ionosphere	13 sites; N. hemisphere, plus older analog ionosondes
TISS	Measure total ionospheric electron content and scintillation	5 sites; N. hemisphere
Magnetometer	Measure changes in the geomagnetic field	7 sites; mid to high latitude; N. hemisphere
Riometer	Measures absorption of HF radio signals in the high latitude ionosphere	Greenland & Alaska
DMSP	Measure in-situ precipitating electron flux, ion flux, ion density, electron and ion temperature, and optical aurora	Polar orbits
Neutron Monitor	Measure solar and galactic cosmic ray fluxes	Greenland
DOD Spacecraft	Measure energetic electron and ion fluxes within the magnetosphere	Geostationary orbits
GOES	Measure energetic electron and ion fluxes within the magnetosphere; solar X-ray fluxes	Geostationary orbits
SEON	24-hour monitoring of solar optical and radio emissions at selected wavelengths	Ramey, Puerto Rico; Holloman, NM; Palehua, HI; San Vito, Italy; Learmonth, Australia; Sagamore Hill, MA

c. Neutral Atmosphere Model. The Vector Spherical Harmonic Model (VSH), under development by the University of Michigan and scheduled for completion in 1998, will specify global neutral particle densities, winds, and temperatures from 90 to 1500 km in the atmosphere.

d. Integrated Space Environmental Models (ISEM). Now in the planning stages, these models will include the Interplanetary Shock Propagation Model (ISP) to propagate discontinuities in the solar wind from the Sun to the Earth's upper atmosphere. This will provide a 1-3 day warning of geomagnetic storms resulting from solar flares. A coupling model and executive system will be developed to integrate the models into a single system sharing input and output data.

Solar Wind Interplanetary Measurements (SWIM). SWIM is an Air Force Phillips Laboratory experiment scheduled to fly on NASA's WIND research satellite in 1993 and will provide 2 hours of real-time interplanetary solar wind data to AFSFC each day. Additionally, there will be two campaigns a year during which real-time data will be provided 8 hours a day. The expected life of SWIM/WIND is 5 to 7 years.

SUPPORTING RESEARCH

The objective of the Air Force meteorological research program is to provide a new detailed knowledge of the atmosphere; how it works, how it limits system performance, and how it can be used to the advantage of the Air Force as a force multiplier on the battlefield. Improved measurement and prediction techniques together with early evaluation of weather effects on new systems moves the Air Force closer to achieving the goal of all-weather operations. Requirements for research and technology in meteorology are expressed in Air Force Technology Planning Objectives, Mission Area Analyses, and Mission Need Statements.

The Phillips Laboratory, Geophysics Directorate (PL/GP) at Hanscom AFB, MA, is responsible for in-house and contractual basic research, exploratory development, and advanced technology development in the environmental sciences. Its exploratory development program in meteorology emphasizes moisture and cloud numerical weather prediction, satellite remote sensing, climatological studies, and battlefield weather observing and forecasting.

Weather Prediction

The focus of the numerical weather prediction program will shift from global to theater-scale weather prediction. Research efforts will be directed to the assimilation of vertical distributions of temperature, water vapor, and winds that can be measured globally from polar-orbiting and geostationary weather satellites. The objective is to determine the extent to which these data can enhance theater-scale forecast accuracy for worldwide Air Force combat operations. The advanced development of forecast models and techniques occurs in the Combat Weather Support Program.

More work is planned to evaluate how continuous wind measurements from a vertically pointing very high frequency (VHF) radar will contribute to numerical modeling and real-time monitoring of developing mesoscale weather systems.

Artificial intelligence applications involving expert systems and neural networks will yield an advanced fog prediction system and a regional forecast model to be tailored for tactical weather support.

The Advanced Meteorological Processing System (AMPS) will provide techniques and models to enhance base weather station support by incorporating "expert system" techniques and numeric-based approaches. New procedures will be used to process and combine weather radar and satellite imagery to automatically estimate cloud motions. These motions can then be integrated to allow mapping cloud and precipitation systems in three dimensions.

The development and refinement of algorithms to reduce false alarms and increase warning lead times for hazardous weather at air bases covered by WSR-88D radar will continue. The weather radar measurement program has been terminated. Another program will define atmospheric conditions that produce lightning triggered by the buildup of electric fields around a launch vehicle during liftoff.

Satellite Remote Sensing

To support satellite meteorological requirements, a major effort is directed toward determining temperature and water vapor vertical profiles and horizontal fields from satellites. Research efforts include assessments of active satellite sensors, such as satellite-borne lidars and radars, to determine the

profiles of wind and other weather variables with very high vertical resolution for initialization and assimilation into weather prediction models.

Techniques will be developed to incorporate microwave imagery data into the cloud analysis programs at AFGWC. The present level of support will continue for this research to develop new analytical methods in satellite meteorology. The ultimate goal is to more accurately depict cloud characteristics; i.e., cloud height, cloud thickness, phase, and rain areas. The design of satellite sensors in terms of wavelength, resolution, and bandwidth and the calibration of deployed satellite measurements systems, such as the DMSP SSM/T-2 water vapor sounder, will continue primarily in support of DMSP. Research on passive microwave as an unobtrusive imaging system for use in cloudy or smoky environments is ongoing.

Characterization of cloudiness on the operational theater scale, based on direct readout of satellite weather data, is being implemented in support of tactical operations. A package of satellite cloud analysis algorithms, called TACNEPH, will be implemented in the Mark IVB DMSP ground terminal and the more portable small satellite tactical terminals.

The PL/GP AF Interactive Meteorological System (AIMS) is used to support research in satellite meteorology and, in particular, the developmental and evaluation of high resolution cloud analysis techniques to support tactical operations in the field and worldwide classified projects.

Climatology Studies

Support of Environmental Requirements Cloud Analysis and Archive (SERCAA) will provide a new global cloud analysis algorithm for use in determining the radiative and hydrological effects of clouds on climate and global change. SERCAA can provide the next-generation real-time cloud analysis model; it may replace the present real-time nephanalysis (RTNEPH) in use at AFGWC. An archive of these quality cloud products is planned which will be useful in environmental monitoring and climate change research.

In climatological technique 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 a mesoscale environmental simulation package to provide a realistic sequence of weather events at any given 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 specifying the probability of simultaneous cloud-free viewing from multiple sites under various cloud conditions is ongoing. Simulation of time evolution of 3-D scenes of weather elements will initially concentrate on cloud scenes. Whole-sky imagery data and concomitant satellite imagery will provide the basis for developing algorithms for ground-based and overhead viewing scenarios. Weather simulation computer models for conceptual design and studies and analysis applications will continue.

Two new programs initiated in FY 1993 require more understanding of atmospheric effects on laser propagation. In one of these programs, the effects of atmospheric phenomena near the tropopause on laser propagation is the key issue. Modeling and measurement focus on more complete understanding of turbulence, aerosols, and cirrus clouds on such propagation. In the second of these programs, investigations are underway to evaluate the ability to measure winds with a Doppler radar in support of weapon targeting (the so-called ballistic wind problem). Actual measurements are being conducted together with supporting meteorological observations and analyses.

The environment for hypersonic vehicles will be specified. This effort has applications to vehicles operating at hypersonic speeds, such as the National Aerospace Plane (NASP) and hypervelocity vehicles, including reentry vehicles. The surface material of both hypersonic vehicles and reentry vehicles is eroded by cloud and dust particulate in the atmosphere with resulting serious degradation in performance. Climatologies and simulations of natural and man-made clouds and dust for representative conditions and locations will be developed.

The Cloud Information Reference Library and Archive (CIRLA), sponsored by the Air Force, is a computer-based on-line data system enabling researchers to rapidly locate, assess, and contact organizations with relevant cloud and cloud-related information. CIRLA incorporates academic,

Government, and industrial sources of data and supports increasing emphasis on transfer of information to the civilian scientific and engineering communities.

Atmospheric Density

The objective of the atmospheric density work is to develop very accurate methods to measure and predict density of the neutral atmosphere in the altitude range of 9 to 1500 kilometers. Current density models do not achieve the levels of accuracy required by the Air Force, so new measurements of density will be made using recently developed, well calibrated, and highly accurate instruments. These new measurements will be the basis for an upper atmospheric global circulation model that incorporates current physical understanding of the processes that drive the upper atmosphere. Models will be used to calculate accurate trajectories of satellites, reentry vehicles, and space debris.

Battlefield Weather Observing and Forecasting

The battlefield weather program improves electro-optical tactical decision aids (EOTDA) (which are used on microcomputers in base weather stations) so they can be used on host command and control computer systems using an AFGWC-provided database. This automated forecasting aid is used to predict acquisition and lock-on ranges for precision guided weapons used by the Air Force and the Army.

The Tactical Weather Observation System (TWOS) program is selecting and testing meteorological sensors and techniques suitable for use in an automated tactical mode. Shortfalls in the automation of weather observations are primarily identification of clouds, measuring visibility, and determining present weather.

The Air Combat Targeting/Electro-optical Scene Simulation (ACT/EOSS) effort in the Weather Impact Decision Aids (WIDA) program is in progress. It will incorporate global terrain and features, target structure, meteorological, and operational planning data in target contrast and EO sensor performance models. These will reside on battle planning systems and provide commanders and air-crews complete in-theater environmental situational awareness.

A new program, initiated to investigate the capability of millimeter wavelength imaging to detect tactical ground targets in the presence of clouds and weather, will result in a new class of Weather Impact Decision Aids.

UNITED STATES NAVY

OVERVIEW/ORGANIZATION

Within the U.S. Navy, meteorological support services are provided globally to units based ashore and at sea. U.S. Navy meteorological personnel and resources are assigned to 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. Personnel and resources from the naval research, development, logistic, and training components are also included. Naval Systems Commands, laboratories, research facilities, and training commands constitute various additional support components.

Primary support is provided by activities and detachments assigned to the Naval Oceanography Command. Shore field activities within the Naval Oceanography Command include a primary numerical processing center, the Naval Oceanographic Office, three regional Naval Oceanography Centers, two Naval Oceanography Command Centers, six Naval Oceanography Command Facilities, 44 Naval Oceanography Command Detachments, and two Naval Oceanography Command components.

The Fleet Numerical Oceanography Center (FNOC), Monterey, CA, operates the master computer center and functions as the hub of the Naval Environmental Data Network, which is designed for product distribution among the major Naval Oceanography Command activities and ashore Navy command centers. The functional operation of the Naval Environmental Data Network is planned for replacement by the Defense Data Network during FY 1994. Through linkage with the DOD environmental satellite systems and Air Force and NOAA data distribution centers, FNOC acquires global coverage of environmental data. A joint agreement exists between the Air Force, Navy, and NOAA to share processing tasks and environmental product lines of mutual interest from DMSP and NOAA TIROS satellites. From these data, basic and applied numerical

products are generated for distribution via communications systems for use by other activities in producing specific support products and services. The Naval Oceanographic Office, Stennis Space Center, MS is the Navy's primary NOAA TIROS data processing facility.

The three regional Naval Oceanography Centers provide broad geographical fleet support services within their areas of responsibility. The Naval Western Oceanography Center, Pearl Harbor, HI is responsible for the Pacific and Indian Ocean and the Red Sea areas; the Naval Eastern Oceanography Center, Norfolk, VA for the Atlantic and Mediterranean Sea areas; and, the Naval Polar Oceanography Center for the Arctic and Antarctic areas. These centers use numerical products from the FNOC to provide environmental broadcasts and tailored support in response to specific requests from the operating forces of the Department of Defense and allied countries.

The Naval Oceanography Command Center, Rota, Spain assists the Naval Eastern Oceanography Center by providing environmental broadcasts and tailored support to DOD forces in the Mediterranean and the Black Sea area. The Naval Oceanography Command Center, Guam, similarly assists the Naval Western Oceanography Center in the Western Pacific, Indian Ocean, and the Red Sea areas. Additionally the Naval Oceanography Command Center, Guam operates the Joint Typhoon Warning Center with the U.S. Air Force to provide tropical cyclone warnings to DOD and U.S. interests in the Western Pacific and Indian Oceans.

The six Naval Oceanography Command Facilities at Brunswick, ME; Jacksonville, FL; San Diego, CA; Yokosuka, Japan; Keflavik, Iceland; and Bermuda provide limited area, local and aviation environmental forecast services, as well as direct support for aircraft, ship, and submarine staffs. Four of these activities command detachments. Meteorological forecast guidance from the regional oceanography centers and Fleet Numerical Oceanography Center is used by all facilities. The facilities located overseas augment this guidance with data from local sources.

There are 44 Naval Oceanography Command Detachments located worldwide. Although primarily situated at Naval Air Stations, several are located at Naval Stations in support of sea-going units. Each detachment is established under an Officer or Chief Petty Officer-in-Charge, who reports to one of the Naval Oceangraphy regional/command centers or facilities. These detachments provide areal and aviation meteorological and oceanographic forecasting and warning services to DOD and allied units within their local and functional areas of responsibility. Detachments within the contiguous states use the basic and applied meteorological numerical products from both the Fleet Numerical Oceanography Center and the National Meteorological Center in providing support services. Overseas detachments additionally use U.S. Air Force and foreign products as available, in addition to Fleet Numerical Oceanography Center numerical products. Two detachments are oriented to provide specific technical support in coordinating the Navy's climatological program at the National Climatic Data Center, Asheville, NC; and circuit management with the USAF Automated Weather Network (AWN) at Tinker AFB, OK.

Meteorological/oceanographic (METOC) units are permanently assigned to 34 aviation-capable U.S. Navy ships. These units, staffed with officer and enlisted personnel, and equipped in accordance with their designated support functions, are integral to the command to which they are assigned. Smaller units, termed Mobile Environmental Teams (MET), are temporarily assigned to Navy ships and DOD or allied units upon request to meet short-term operational requirements. These METs, available from six Naval Oceanography Command activities (Rota, Norfolk, San Diego, Jacksonville, Yokosuka, and Pearl Harbor) are outfitted with their own portable equipment. Navy ships without dedicated units also contribute by providing vital meteorological and oceanographic observations, frequently from data-sparse oceanic areas. Technical guidance is provided by the Naval Oceanography Command.

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

The Fleet Marine Force aviation units, also staffed with USMC meteorological personnel, are indigenous to each of the twelve Marine Wing Support Squadrons. They operate and maintain meteorological mobile facilities 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 equipment augment and support the host activity's weather unit.

PROGRAM DESCRIPTION

The Navy's meteorological Operational Support programs are designed to satisfy validated fleet requirements. They include surface and upper atmospheric observations programs, flight forecasting services, Optimum Path Aircraft Routing System (OPARS), tailored forecasts, Optimum Track Ship Routing (OTSR) for naval and naval contract vessels, local and operating area forecasts, tropical cyclone warnings, local severe weather forecasts, high seas and wind warnings/forecasts, manual and numerically-derived analyses and prognoses, microcomputer-based product dissemination and display capabilities, statistical and climatological studies, and a wide range of mission-specific and tactical support services provided to the operating forces of the U.S. Navy.

The FY 1994 budget includes programs that address a total of 89 validated requirements. Efforts are focused in three broad areas: shipboard tactical environmental support; upgrades to Fleet Numerical Oceanography Center, Naval Oceanographic Office and other Naval Oceanography Command centers and associated data distribution networks; and enhanced capabilities at Naval Oceanography Command shore-based aviation support activities. Efforts in the FY 1994 program address both the Systems Acquisition and Operations Support categories. They are highlighted below.

Tactical Environmental Support System (TESS). TESS is a modular, computer-based support system designed to provide Navy decision-makers with meteorological and oceanographic assessments and forecasts. This system allows integration of air/ocean data with sensor/weapon platform parameters to assess the environmental impact on specific system performance. Initial operational deployment began during FY 1992. TESS functions as the operational, resident air/ocean database. Data sources include in-situ sensors, environmental satellites, U.S. and foreign radio weather broadcasts, and data fields prepared principally at the Fleet Numerical Oceanography Center and regional oceanography centers ashore. This system's applications and capabilities extend well beyond those of an automated weather information system because of the extensive oceanographic and acoustic analysis and prediction capabilities; as well as databases containing tactical sensor and weapon system parameters for use in tactical decision aids hosted in the system.

Acquisition strategy for TESS is built upon an interim capability based on the Navy Standard Desktop Tactical Support Computer. This interim capability known as TESS 1 and TESS 2, was implemented as a non-research and development effort, and was completed during FY 1989. A total interim inventory of over 70 units will exist with installations on major fleet combatants and selected shore activities with significant command and control responsibilities. The follow-on system, TESS(3), will rehost the existing TESS capabilities, while providing significant new enhancements, increased processing power, more flexible operator interface, and broader communications connectivity.

Primary Oceanographic Prediction System (POPS). Existing computer systems at the FNOC have reached their limits in computational speed, memory, and processing architecture. Further improvements in atmospheric modeling requires computational capabilities that exceed those of the current computer systems. Emergent requirements were documented, validated, and funded beginning in FY 1990. Replacement of the existing Class VI machine at the FNOC began with the installation of a Class VII supercomputer in FY 1992. This computer, scheduled to become operational in FY 1993, will significantly upgrade the ability to run Navy operational and developmental meteorological models.

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 at selected sites ashore. This system is replacing a variety of existing Navy satellite receivers. The SMQ-11 is composed of a dual-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 can be provided to the Tactical Environmental Support System, TESS(3) for additional processing and applications. Additional planning is underway to exploit data from other satellite systems (foreign and domestic) projected for the late 1990's. Production of the AN/SMQ-11 commenced in FY 1987 and is planned to be completed in FY 1995. A total inventory of 74 units is programmed.

Atmospheric Modeling. The primary goal of this effort is to improve fleet readiness and safety of ships and aircraft, and to enhance weapons system performance with improved weather forecasts through the application of new numerical modeling technology. Significant efforts are underway to optimize the use of satellite data in Navy numerical modeling. Continued upgrades to the Navy Operational Global/Regional Atmospheric Prediction System (NOGAPS/NORAPS) spectral models are planned, incorporating asynoptic and remotely-sensed data in the operational model initialization process. The relocatable, high-resolution (40 km) NORAPS model is now used routinely for operational contingency support.

Sensor Development. Several efforts are underway to enhance the quantity, quality, and optimum utilization of observational data.

Mini-Rawinsonde. Procurement of a portable mini-rawinsonde system began in FY 1988, and was completed in FY 1992. The system 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.

Shipboard Meteorological and Oceanographic Observing Sensor (SMOOS). The SMOOS is a suite of sensors that automatically measures shipboard meteorological and oceanographic parameters and provides output directly to TESS (3) for archival and application. SMOOS sensors and associated hardware will be fielded for shipboard versions of TESS (3) only. This sensor has been merged with TESS (3) development efforts.

Automated Surface Observing System (ASOS). The ASOS is designed to support Aviation operations and weather forecast activities. ASOS systems are scheduled for acquisition and installation at Navy and Marine Corps aviation forecasting sites worldwide during FY 1993 through 1996 timeframe, and are replacing several obsolescent sensors. ASOS will provide continuous minute-by-minute observations to assist meteorological technicians in assimilating field parameters and improve the efficiency of surface aviation observations.

Next Generation Weather Radar (NEXRAD). Principle User Processing Stations (PUPS) associated with NEXRAD will provide significant improvements in radar analysis of meteorological features and severe weather over the United States. Navy is participating in the NEXRAD program, and will draw upon NEXRAD radars for coverage over Navy forecast areas. In some cases, Navy property was made available for the installation of the radar. NEXRAD PUPS will be installed during FY 1993 and 1994 to display imagery from NEXRAD systems covering operational areas. NEXRAD will not totally replace other meteorological radars for Navy, because a number of locations overseas will not be covered by the NEXRAD system.

Supplementary Weather Radar. The Navy has established a Mission Needs Statement for procurement of a Supplementary Weather Radar. These systems will provide radar coverage at selected sites not scheduled to receive a NEXRAD PUP, and will replace the obsolete AN/FPS-106 weather radar now in use.

Memorandum of Agreement (MOA)

Navy and NOAA now operate under a new umbrella MOA, signed in 1993, that will incorporate all previous agreements as annexes. Significant weather/equipment related aspects include:

- Cooperative relationships between FNOC and NMC;
- Navy/NOAA operational imagery signal agreements;
- NOC/NWS agreement on provision of Navy meteorological services to Micronesia;
- Navy/NOAA Joint Ice Center operations;
- Navy/NOAA/AWS agreement on shared processing of satellite data;
- Navy/NOAA agreement on the procurement, installation, maintenance, and operation of ASOS.

MOAs exist between the Department of Commerce, Department of Transportation, and the Department of Defense concerning production and operation of the NEXRAD system. One MOA (June 1989) addresses allocation of program costs in the production phase of NEXRAD. A second MOA (September 1990) addresses interagency operations of the WSR-88D weather surveillance Doppler radar.

Summary. The impact of these programs on fleet readiness and operational capabilities is significant. By the end of FY 1994, a logical framework will be in place to ensure that a survivable, responsive, and layered network can provide on-scene as well as shore-based support to the operating forces of the U.S. Navy.

UNITED STATES ARMY

OVERVIEW

Army Operational Support

The U.S. Army provides three kinds of direct weather support to the Army mission. These are direct reception of weather satellite data at deployed locations, upper air observations for artillery fire support missions, and limited surface weather observations to support Army weapons systems. The Air Force provides other operational weather services in combat, contingencies, and peacetime training under Law and according to an Army-Air Force agreement. The Army also provides operational weather support to Army Research Development, Test and Evaluation (RDTE) ranges and sites through the Test and Evaluation Command (TECOM) Meteorological Teams (Met Teams) and U.S. Army Space and Strategic Defense Command (SSDC) contractors. TECOM operational support is described as part of the Army Materiel Command in the RDTE section. SSDC provided weather support to the High Energy Laser System Test Facility, White Sands Missile Range in FY 1993 and to Kwajalein Atoll range through a Meteorological Environmental Test Support contractor.

Army provides the tactical equipment and communications equipment to Air Force Weather Teams (WETMs) for tactical operations. Army Major Commands (MACOM) have purchased off-the-shelf items to provide interim Army tactical equipment until the Integrated Meteorological System (IMETS) is fully fielded. IMETS is an automated system that receives, integrates, and processes weather data from several sources including forecast centrals, tactical surface and upper air observing sites, and military and civilian weather satellites. It will provide digital displays of near real-time weather observations and forecasts to other Army tactical users to help develop tactical decision aids (TDA). TDAs will help determine the impact of adverse weather on Army operations and weapons. IMETS will be mounted in a standard shelter on a highly mobile, multipurpose wheeled vehicle (HMMWV). The IMETS Product Manager is under the direction of the Program Executive Officer for Command and Control Systems (PEO, CCS). Communications and Electronics Command (CECOM) Army Research Laboratory provide appropriate technical assistance to the IMETS Product Manager. The Army will start fielding IMETS in FY 1994.

Interim systems presently providing operational support include the U.S. Army Europe Automated Weather System (UAWS) and the Forces Command (FORSCOM) GOLDWING System. Both delivered key weather support to deployed forces in the Persian Gulf. Army WETMs used GOLDWING in Somalia in FY 1993. UAWS is a tactical, secure radio system, mounted in a 5-ton truck with shelter that receives and transmits weather information and downlinks civil weather satellite imagery. GOLDWING performs similar functions, but is lightweight and transportable in boxes by two men. Both systems employ a small tactical receiver and antenna system to directly receive civil weather satellite imagery. GOLDWING and UAWS are now planned to be continued in conjunction with IMETS at locations where funding constraints do not allow IMETS to be fielded. UAWS and GOLDWING will continue to be upgraded and used in tactical exercises and contingencies by Air Force WETMs and Air National Guard Weather Flights supporting Army active and reserve forces. IMETS will link to UAWS and GOLDWING over HF radio until UAWS and GOLDWING are completely replaced by IMETS.

Army Artillery Meteorological Crews are assigned to artillery units at division level, to Field Artillery Brigades, and to Separate Brigades with a direct support Artillery Battallion. Army soldiers regularly take tactical upper air observations to support artillery units during tactical training exercises, at permanent Army artillery ranges, or during the full range of

combat missions. Artillery Meteorological Crews also take limited surface observations at tactical locations on an "as needed" basis to support artillery operational requirements.

Artillery Meteorological Crews use the Meteorological Data System (MDS), the AN/TMQ-31, to take upper air observations during tactical operations. It is a mobile upper air sounding system on a 5-ton truck and trailer. The MDS sends upper air data to the Field Artillery Tactical Data System for use in adjusting artillery fire, to the Air Force WETMs, and to the Chemical Officer for use in smoke, nuclear, biological, and chemical (NBC) defense operations. In order to meet mobility requirements, the Army will continue to develop the Meteorological Measuring System (MMS), AN/TMQ-38, as a non-developmental item (NDI) during FY 1994 and 1995 with fielding scheduled for FY 1996. The MMS will be deployable on a small vehicle and reduce the size of the Artillery Meteorological Crews. MDS will be refurbished and issued to the reserve force as it is replaced by the MMS. The MMS program is managed by the Program Manager for Electronic Warfare/Reconnaissance, Surveillance, and Target Acquisition (EW/RSTA), Fort Monmouth, NJ. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK developed the requirement documents and is the combat developer for artillery meteorological equipment.

Army Intelligence personnel in the forward combat areas take aperiodic, limited, surface weather observations at the brigade and battalion command posts. They use a Belt Weather Kit (BWK) except in Eighth U.S. Army, Korea, where they use the AN/TMQ-34.

Headquarters, Department of the Army, Office of the Deputy Chief of Staff for Intelligence (ODCSINT) is responsible for Army weather support policy encompassing both tactical operations and peacetime training support. Office of the Deputy Chief of Staff for Operations is responsible for validating and prioritizing weather support requirements and programs to meet Army requirements.

Army Operational Support Provided by the Air Force

The Air Force provides tactical and fixed-installation weather support to the Army. This support includes tactical forecasting and observing support during field exercises, contingencies, and wartime; and peacetime weather support services at Army airfield weather stations. Although peacetime Air Force WETM support is primarily for aviation training from Army airfields, WETM also support Army maneuver, artillery, intelligence, and other staff elements during exercises and training. The Army and Air Force share responsibility for fixed and tactical support equipment. The Air Force installs, operates, and maintains standard meteorological and observing equipment at Army airfields. The Air Force provides the personnel, tactical observing and other tactical meteorological equipment in the field, while the Army provides and maintains the tactical communications, field equipment, and vehicles to support the Air Force WETMs deployed in tactical exercises, contingencies, or combat.

U.S. Army Space and Strategic Defense Command (SSDC)

SSDC provides operational support to test facilities. The U.S. Army Kwajalein Atoll (USAKA) Meteorological Test Support (METS) contractor performs meteorological functions in support of missile operations and for synoptic purposes including surface, upper air, and meteorological satellite observations, and the preparation of daily and special weather forecasts for the Kwajalein Range.

The High Energy Laser System Test Facility (HELSTF) had weather support provided through a combination of Civil Service and contract scientists, meteorologists, and technicians. They provide weather forecasting, toxic corridor advisories, propagation advisories, real-time displays, observations, custom measurements, and test reporting. The Army identified HELSTF as a potential facility to be closed in FY 1994.

Army Corps of Engineers Civil Operational Activities

The Corps of Engineers (COE) operates a network of about 8000 gages of which 2200 are land-based limited meteorological observing gages. The remainder are hydrologic in nature. The meteorological observing sites measure precipitation and other data in the United States to provide information for regulating COE dams and other water projects used for flood control, navigation, hydroelectric power, irrigation, water supply, water quality, and recreation. The COE transfers funds to NWS to collect and maintain precipitation information from 1573 of these sites.

Similarly, COE transfers funds to the Geological Survey to collect and maintain precipitation information from 423 of these sites. The remainder are maintained by the COE. Data from many of these sites are automatically telemetered using satellite microwave, land lines, radio, etc. to provide for real-time use of data. Although the COE finances the network, data are made available to all other Federal agencies.

Training and Doctrine Command Programs

The Training and Doctrine Command (TRADOC) manages and develops training programs, writes both Army and joint weather support doctrine, and establishes the weather requirements documents for Army tactical weather support equipment. The U.S. Army Field Artillery School (USAFAS), Fort Sill, OK, is the proponent for upper air meteorological support. The U.S. Army Intelligence Center (USAIC), Fort Huachuca, AZ, is the proponent and user representative for tactical weather support in wartime, contingencies, and peacetime tactical training. The Engineer School, Fort Leonard Wood, MO coordinates weather support requirements in Terrain Analysis and Topographic Engineering. TRADOC schools coordinate their requirements for weather support with the Combined Arms Center, Deputy Commanding General for Combat Developments (CAC, DCGCD), Fort Leavenworth, KS prior to submission to Headquarters (HQ) TRADOC for approval. HQ TRADOC manages TRADOC weather policy.

TRADOC Centers and Schools develop the requirements documents for weather equipment, write the concepts and manuals describing the operational doctrine for weather support procedures, write and teach weather training courses for Army personnel, and provide orientation training on Army procedures to the Air Force WETM personnel assigned to Army units.

USAFAS and USAIC write concepts to describe new organization, training, equipment, or doctrine needed to eliminate known deficiencies. They work in concert with the Communications and Electronics Command (CECOM), the Materiel Developer, to acquire new weather support equipment. The Aviation Center, Chemical School, and Engineer School also incorporate weather support procedures into training programs in their mission areas. The Engineer School develops evaluation procedures considering the effects of weather conditions into terrain analysis, mobility and counter-mobility doctrine, training, and planning. The U.S. Army Aviation Center (USAAVNC) has unique operational requirements for weather support at Fort Rucker, AL and to remote training locations that are beyond Air Force direct support. Therefore, USAAVNC maintains additional Army observing and communications equipment in conjunction with the Air Force weather support at the Army airfield at Fort Rucker.

USAFAS trains all Field Artillery Meteorological Crew members with a staff of approximately 40 military and civilian instructors. USAFAS also has the role of developing requirements documents for new upper air observing systems and writing operational support concepts, doctrine, and procedures to be taught in the classroom and executed in the field.

USAIC, Fort Huachuca is the functional proponent for tactical Army weather support. It is responsible for writing tactical weather support doctrine, identifying deficiencies and baseline requirements, providing weather support training to intelligence and Air Force personnel, and establishing requirements documents for weather support equipment, except in the artillery support area. USAIC developed the Army operations familiarization training course for Air Force personnel. Two courses are scheduled for FY 1994.

The Combined Arms Center, Commanding General for Combat Developments (CAC, CGCD) is responsible for integrating weather support across branch and functional areas. The CAC, DCGCD also exercises oversight to the combat developments process as it applies to remedying weather-related deficiencies and improving weather support across functional areas.

HQ, TRADOC is the approval authority for joint weather doctrine, weather hardware requirements and weather support policy.

WEATHER SUPPORT FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION (RDTE)

Under Army-Air Force agreement, the Army has responsibility for weather support for research, development, test, and evaluation (RDTE) to support Army ground combat missions. The Corps of Engineers (COE) and the Army Materiel Command (AMC) are the major contributors to weather research. The Medical Research and Development Command does research related to soldiers performance in the

range of weather conditions expected to be encountered in all theaters of operations.

Corps of Engineers (COE)

The COE is responsible for reviewing all emerging Army systems for environmental effects as stated in Army Regulation 70-1. The COE also manages the Airland Battlefield Environment (ALBE) Program. Tactical Decision Aids (TDA) are developed for this program by three COE laboratories: Topographic Engineering Center (TEC), Cold Regions Research and Engineering Laboratory (CRREL), Waterways Experiment Station (WES) and one Army Materiel Command (AMC) laboratory: Army Research Laboratory (ARL) Battlefield Environment (BE) Directorate. ALBE TDAs interpret the impact of weather and terrain conditions on Army systems and operations. They are based on weather and terrain limitations, known as critical values. Critical values are determined from design criteria, operational testing, or other evaluations of Army capabilities in adverse weather. The ALBE software will be transitioned to the terrain and weather support systems such as the Integrated Meteorological System (IMETS), the Digital Topographic Support System (DTSS), and the Army Tactical Command and Control System (ATCCS).

Topographic Engineer Center (TEC). The COE Topographic Engineer Center, Fort Belvoir, VA provides environmental support to Army research and development programs and coordinates the development of TDA relating to environmental effects on combat systems and operations. This includes the development of environmental effects databases and models that are relevant to the military plans, operations, and material acquistion communities. TEC is also responsible for developing intergrated software modules that are designed to be exploited in the synthetic environment arena. TEC also contributes to the development of policies and procedures for the consideration of realistic natural environmental conditions in the materiel acquisition process. TEC also produces climatology based studies on the effects of the environment on Army operations to support specific requests.

Cold Regions Research and Engineering Laboratory (CRREL). Under the military portion of its civil and military support mission, the CRREL, Hanover, NH provides weather support to Army research and development of weapon systems and combat missions in winter environments. CRREL develops databases and models, predicting infrared and millimeter wave (MMW) weapon system performance and the capability of technology to enhance military operations in cold environments. Under a recent Memorandum of Understanding (MOU), the U.S. Army Test and Evaluation Command (TECOM) provides operational observing, weather instrumentation, and forecasting services for CRREL's RDTE efforts through a Met Team located at CRREL.

Army Materiel Command (AMC)

AMC is responsible for the design, development, test, and evaluation of equipment to satisfy requirements for meteorological support equipment. AMC provides climatological support to RDTE projects, involving electro-optics and obscurants. It is also responsible for determining weather effects critical threshold values and environmental sensitivities of battlefield systems. AMC has several subcommands and elements carrying out weather research and development responsibilities.

Test and Evaluation Command (TECOM). TECOM is a subcommand of AMC providing operational support to 14 ranges and test sites with 11 Meteorological (Met) Teams. Under responsibilities established in Army Regulation 115-10/Air Force Regulation 105-3, the TECOM Atmospheric Sciences Division (ASD), White Sands Missile Range, NM provides weather support and atmospheric characterization to Army RDTE. ASD is programmed to move to HQ TECOM, Aberdeen Proving Grounds, MD in FY 1994.

TECOM will continue only basic meteorological support at 14 Army RDTE ranges and sites. Meteorological instrumentation will continue to be acquired, not through direct funding, but rather through Army technical development resources or through funding from RDTE projects for test specific or unique requirements.

Army Research Laboratory (ARL) Battlefield Environment (BE) Directorate (formerly Atmospheric Sciences Laboratory). The Army war fighting concept, AirLand Operations, is influenced by the natural environment. Weather and other atmospheric effects play a critical role in any contemporary battlefield scenario, as demonstrated in the Persian Gulf War. Today's battlefield commander, whether deploying an electro-optically guided weapon system or defending

against airborne chemical agents, must effectively anticipate these environmental factors in order to be successful. The goal of BE research and development is to give the battlefield commander the atmospheric advantage, turning potentially adverse atmospheric phenomena into force multipliers.

As leaders in boundary layer modeling and simulations, BE researchers use advanced computational techniques to develop meso/microscale meteorological models to describe and predict wind, relative humidity, temperature, and turbulence profiles over complex terrain, including the target (forward) area. State-of-the-art transport and diffusion models are being developed and tested to predict the behavior of atmospheric aerosols, obscurants, NBC agents, and dense gases. Other simulation efforts are investigating image propagation, information transfer, and cloud physics. In addition, realistic weather and battle-induced atmospheric conditions models are being incorporated into Army simulations to enhance the ability to describe real-world effects on battle outcomes.

BE has a wide-ranging role in supporting Army weather support missions. Theory and models are being developed for scientific analysis of the impact of the atmosphere on combat operations, equipment, and personnel. Models and computer codes are used to describe the realistic battlefield atmospheres. Research is performed on the fundamental physical processes related to the propagation of energy through battlefield atmospheres contaminated by natural and combat-induced obscurants. BE will continue to maintain and update a library of multi-disiplinary codes for describing atmospheric effects on operations relying on the propagation of electromagnetic or acoustic energy. Extensive field experiments are conducted to validate friendly and threat system performance in realistic environments and to conduct validation of meteorological models.

Advances have been made in weather data acquisition and processing technology for battlefield use. BE scientists investigated theories and techniques for remote detection of aerosols and profile measurements of the wind, temperature, relative humidity, and turbulence using passive, low-signature methods. They continued to develop remote, passive/low signature sensing techniques for use in an automated tactical atmospheric profiler, as well as the capability to collect data from atmospheric satellites sounders and imager data over target areas. New data fusion assimilation techniques are being developed to describe meteorological conditions over the battlefield area.

BE continues to develop technologies to exploit and mitigate environmental effects on the battlefield. Research efforts included computer models and TDA for lessening the multiple effects of adverse weather, smoke, dust, and low-light levels on Army systems. Other modeling efforts sought to improve the use of smoke, camouflage, concealment, deception, and low-observables technology. Computer display techniques are developed for visualizing battlefield environments, acoustic and electromagnetic models, noise abatement forecasts, and enhanced artillery meteorological messages to improve long-range artillery and smart weapons.

In support of the war on drugs, researchers developed a dual-band infrared/ultraviolet lidar system to detect and identify clandestine drug activities. A joint program with the U.S. Department of Agriculture is planned to develop a new surface energy balance model.

BE's unique instrumentation and data analysis capabilities over White Sands Missile Range, NM will be used to support the calibration and ground truth validation of multi-agency satellite sensors.

BE will continue to provide highly specialized support in the form of sophisticated instrumentation for smoke and obscurant testing, atmospheric characterization for electro-optical (EO) systems testing, and other unique meteorological measurement capabilities tailored to the needs of the DOD RDTE community. Instrumentation includes:

a. Simultaneous Multispectral Absolute Radiometer Transmissometer (SMART). Measures transmission of visible or infrared radiation through an environment degraded by obscurants.

b. Mobile Imaging Spectroscopy Laboratory (MISL). Characterizes the changes in propagation of images as a function of atmospheric conditions in near-real-time for weapon system comparison testing.

c. Multispectral Imagery Data Analysis System (MIDAS)/Atmospheric Transmittance Large Area System (ATLAS). Measures smoke cloud growth and

movement, and estimates transmittance through smoke clouds.

d. Transportable Atmospheric Characterization System (TACS). Provides an array of particles spectrometers, scintillometers, infrared temperature sensors, path integrated humidity sensors, and standard meteorological sensors.

e. Research Visible and Infrared Transmissometer (REVIRT) and the Multiple Path Transmissometer/Radiometer (MPTR) both measure the percentage of relative transmission of visible and infrared radiation through obscurants.

f. Mobile Atmospheric Spectrometer (MAS). Measures spectral transmittance using high resolution Fourier transform spectrometer techniques.

g. Atmospheric Turbulence Measurement and Observation System (ATMOS). Measures the transverse coherence length, the isoplanatic angle, and determines the phase structure function for characterizing high energy laser and imaging environments.

h. Fluorescent Target Detection System (FTDS). Uses ultraviolet laser-induced fluorescence to detect ground-based military materials and chemical substances.

i. Meteorological Optical Measurement System (MOMS) and the Mobile Atmospheric Sensing System (MASS). Supports directed energy programs and instrumentation development.

j. Wind and Turbulence Profiling Radar Facility (WTPRF). Uses acoustic and radar to detail temperature, wind and turbulence profiles up to 20km to support DOD system test bed measurements.

Army Research Office (ARO). The Army Research Office (ARO), Research Triangle Park, NC manages the Army's extramural basic research program in the atmospheric sciences. These programs are concerned with atmospheric dynamics at small scales, propagation of electromagnetic radiation through natural and induced obscurants, and boundary layer atmospheric physics.

The basic research program is conducted in two funding lines: the individual investigator program and the University Research Initiative (URI). In both programs, the focus of the research is on the atmospheric processes and effects in the atmospheric boundary layer where the Army operates. Objectives of the research are to develop, from first principles, the physical basis for understanding the boundary layer processes, thereby leading to better understanding of atmospheric effects on soldiers, material, and weapon systems. The research examines dispersion of battlefield materials, the effects of heterogeneous terrain features on air flow, and the development of natural obscurations. An essential element of the research is the development of instrumentation to measure the volumetric fields of wind velocity, temperature, and moisture in the boundary layer to resolve turbulence time scales. One URI center will concentrate on boundary layer processes, especially near the ground. The second center is developing remote sensing of boundary layer wind fields at time and space scales of atmospheric dispersion.

Missile Command (MICOM). The MICOM Research, Development and Engineering Center (RDEC), Chemical and Material Sciences Group, Redstone Arsenal, AL develops climatological models and reports about atmospheric criteria to support specific design efforts. Missile design climatology is used to establish satisfactory criteria for weapon systems and program development efforts.

Communications and Electronics Command (CECOM). The CECOM Intelligence and Electronic Warfare (IEW) Directorate, Fort Monmouth, NJ is conducting research and development on the Meteorological Measuring System (MMS), and the Target Area Met Sensor System (TAMSS) for the Program Executive Office, IEW and the Integrated Meteorological System (IMETS) for PEO Command and Control Systems (CCS).

The MMS research is on a light version of the Meteorological Data System (MDS), upper air sounder. MMS is being designed to collect, process and disseminate upper air meteorological data to field artillery and target acquistion users. It will meet Army light assault requirements to deploy on roll-on, roll-off ships.

The TAMSS research is part of the Field Artillery's (FA) Met Improvement Plan. This program includes a suite of sensors and systems contributing to the acquisition of weather data in the target area during deep operations. This suite will include parallel development of sensors and equipment in both the Intelligence and FA areas. The FA portion of this

program will include the development of a Global Positioning System (GPS) sonde, radiometric and interferometric profilers and dropsondes. TAMSS is in early development and will be fielded after the end of the decade.

The IMETS research supports the development of a tactical meteorological collection, analysis, forecasting, display and dissemination system. It will be capable of receiving observational information from surface, upper air and weather satellites, and compile them into a comprehensive database. It will be capable of merging two or more data displays to form composites over various terrain backgrounds, and process TDAs designed to meet operational requirements. It will employ standard Army Tactical Command and Control hardware and Air Force Tactical Automated Weather Distribution System software. IEW Directorate will support IMETS through initial fielding in FY 1994 and further development.

Medical Research and Development Command

U.S. Army Research Institute of Environmental Medicine (USARIEM). The USARIEM, Natick, MA conducts research on the effects of temperature, altitude, work, and nutrition on the health and performance of individual soldiers or combat crews operating Army systems.

Applied research efforts in thermal physiology and biophysical modeling are directed toward improving soldier performance and minimizing health risks in climate extremes. The sensitivity of the soldier to weather parameters, (primarily ambient air temperature, dew point temperature, wind speed, and solar radiation) defines an operational envelope for unimpaired human performance. The goals of applied research are to develop methods to assess and extend the boundaries of the envelope in an operational setting. On-going research efforts include:

a. Laboratory and field studies, using soldier subjects to support validation requirements for thermal strain predictive models.

b. Laboratory and field studies, using soldier subjects, to quantify psychological and task performance decrements associated with weather extremes.

c. Laboratory and field studies to provide technical testing support to the U.S. Army Medical Materiel Development Activity (USAMMDA) for development of a pocket-sized electronic heat stress monitor for use at the small unit level.

d. Laboratory and field studies to support evaluation of satellite remote sensing and Geographic Information System (GIS) technology for heat stress/heat injury assessment.

APPENDIX C

DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

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 advisories and information to pilots.

Weather information for pilots is made available through Flight Service Stations (FSS), recorded messages broadcast over navigational aids, special weather broadcasts, telephone answering systems, and by the Direct User Access Terminal (DUAT) system provided by private vendors. 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 (NAS). 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, dispatchers and 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. Wherever practical, the objectives of this program are accomplished by enhancing existing and planned air traffic control operations and procedures by providing improved aviation weather information services. Facets of the program are conducted in close cooperation with the NWS.

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 enroute applications. NEXRAD will provide accurate aviation- oriented products concerning reflectivity, wind velocity, and hazardous storms.

Improved weather data from NEXRAD provided to ATC through the Real-time Weather Processor (RWP) 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 Federal Aviation Administration. The program is being managed 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 began in 1990 and is expected to be completed by 1996. The number of NEXRAD units to be acquired is being determined by the participating agencies. FAA is emphasizing the development of algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms, and that 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, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones-tornadoes.

Terminal Doppler Weather Radar (TDWR)

This program consists of the procurement and installation of a new terminal weather radar based on Doppler techniques. TDWR units will be located to optimize the detection of microbursts and wind shear at selected high activity airports. In addition, it will have the capability to identify areas of precipitation, and thunderstorm location. TDWR's will be integrated with the existing Low Level Wind Shear Alert System (LLWAS) at many airports.

Microbursts are weather phenomenon that consist of an intense down draft with strong surface outflows. They 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.

Algorithms for the automatic detection of microbursts, wind shear, and gust fronts are further being refined and tested by the FAA. Data collected with FAA's transportable Doppler weather radar facility (at Memphis, TN; Huntsville, AL; Denver, CO; Kansas City, MO, and Orlando, FL) 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 enhancement and development of wind shear algorithms at Orlando and Denver.

A contract was awarded in November 1988 for 47 turnkey TDWR installations at sites specified by FAA, of which 45 are operational units and two are support units for training and testing. Field implementation will occur in the 1992 to 1994 time frame. The alphanumeric display and the situation displays will be located in the tower cab and the Terminal Radar Approach Control (TRACON). The displays have been tested operationally in 1988, 1989, 1990, 1991, and 1992, at Denver Stapleton, Kansas City, and Orlando International Airports. In 1992, the production displays were utilized at Orlando.

In FY 1992, a TDWR software upgrade package was initiated. This package will integrate TDWR and LLWAS, and will implement changes identified during the operational demonstrations.

Other Weather Radar Programs

The present Air Route Surveillance Radars provide weather data for the Air Route Traffic Control Centers (ARTCC) out to 200 nautical miles. A new Air Route Surveillance Radars (ARSR-4) will provide the ARTCC's with accurate multiple weather levels out to 200 nautical miles. This will be the first en route radar with the ability to accurately report targets in weather. The ARSR-4 will be used to provide weather information until NEXRAD is operational in the Rocky Mountain area. Even after NEXRAD is in place, ARSR-4 will provide supplemental weather information for some areas.

The ARSR-4 is a joint Federal Aviation Administration/United States Air Force (FAA/USAF) funded project. Forty joint FAA/USAF radar sites will receive the new ARSR-4 radar during the 1992-1994 period.

Airport Surveillance Radar-9 (ASR-9) Weather Modular Enhancement

The Weather Modular Enhancement will be an add-on modification to the existing ASR-9 radars and will provide air traffic controllers information on low level wind shear associated with microbursts in the vicinity of the ASR-9 radars. Presently, the ASR-9 weather data that are available consist of the six levels as defined by the National Weather Service. In addition, gust front detection capability will be provided.

New Generation Runway Visual Range (RVR)

The runway visual range program provides for a new generation RVR sub-element of the NAS. The RVR provides runway visual range information to controllers and users in support of precision landing and takeoff operations. The new generation RVR incorporates state-of-the-art sensor technology and imbedded remote maintenance monitoring. New generation RVRs will be procured for all new qualifying locations and will replace many existing RVRs in the NAS inventory.

The RVR provides for near real-time measurement of visibility condition along a runway (up to three points along the runway can be measured - touchdown, midpoint and rollout) and reports these visibility

conditions to air traffic controllers and other users. The system automatically collects and formats data from three sensors: a visibility sensor, using forward scatter meters replacing the transmissometers currently in use; a runway light intensity monitor of both runway edges and center line lights; and an ambient light sensor controlling computer calculations using a day or night algorithm. The data processing unit calculates RVR products and distributes the products to controllers and other users.

A total of 529 RVR visibility sensors will be deployed at 264 airport locations begining late CY 1993. Enhancements are planned to interface with the Tower Control Computer Complex (TCCC) and the NWS's Automated Surface Observation System (ASOS) by 1996.

Low Level Wind Shear Alert System (LLWAS)

LLWAS provides pilots with information on hazardous windshear conditions that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The basic system 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.

The LLWAS-Network Expansion (LLWAS-NE) is the first step in the FAA's efforts to upgrade National Airspace Systems' capability to detect windshear. Earlier, six-sensor LLWASs have provided adequate protection for microbursts; however, testing at Denver Stapleton Airport and recently at Orlando International Airport have resulted in the development of two more sophisticated windshear detection systems. One of these systems is the LLWAS-NE. The LLWAS-NE will include expanding the network of sensors, improved sensor siting, and runway-oriented alerts.

The airports scheduled for LLWAS-NE installation in late 1992 and early 1993 are: Orlando, Washington National, Chicago O'Hare, Atlanta, Dallas-Ft. Worth, Tampa, St. Louis, and the new Denver Airport. Long-term modifications of LLWAS will lead to the implementation of an enhanced LLWAS.

The improvement phase referred to as LLWAS-3 will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new information/alert displays which enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. Initially, 83 airports were identified to receive LLWAS-3. Funding for LLWAS-3 is programmed to begin in 1992. LLWAS-3 is scheduled to be fully deployed by 2001.

In the future, LLWAS-3 and TDWR will work in conjunction providing a synchronous alarm of wind shear to the air traffic. Studies have been conducted on how these systems can be integrated into a single wind shear display for the air traffic controller. Development of a system is underway that will integrate the information from these two systems into a single wind shear display for the air traffic controller. Investigation is also underway on how integrated wind shear information can best be communicated or displayed 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

The FAA is acquiring automated surface weather observing systems; acquiring related data acquisition systems; and development, test, and evaluation of weather sensors in cooperation with the National Weather Service.

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 deployed Automated Weather Observing Systems (AWOS) at 200 airports to provide the basic aviation weather products directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to

enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that currently do not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations, and are available off-the-shelf as a commercial product.

The FAA has negotiated with NOAA to procure, install, operate, and maintain Automated Surface Observing Systems (ASOS) at the remaining airports where the FAA provides observations and at additional non-towered airports without current weather reporting capabilities. A production contract was awarded in February 1991. The FAA will be sponsoring, as part of a reimbursable agreement with NOAA, 537 systems with an option for 228 additional systems. The first FAA-sponsored system was installed in August 1991 and will continue to be installed into 1995.

Automated Weather Observing Systems (AWOS) for Non-Federal Applications. 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 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. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on Non-Federal Automated Weather Observing Systems.

There are currently five versions of the non-Federal AWOS. An AWOS-A provides only altimeter readings. The AWOS I system contains sensors to measure wind speed and direction, ambient and dew point temperature, altimeter setting, and density altitude. The AWOS II contains the AWOS I sensors plus a visibility sensor, and an AWOS III adds a cloud height sensor to an AWOS II. An AWOS IV will include AWOS III plus the option for precipitation identification, thunderstorm detection and/or runway surface condition. 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. AWOS III also enables the pilot (or other user) to call the AWOS on a telephone and obtain the current weather observation during his preflight activities. In addition, the observation may be transmitted to the database within the national weather network.

By the begining of FY 1994, there will be more than 275 non-Federal AWOSs. Some of these are capable of reporting through a geostationary communications satellite and many more will reach that capability during the year. These observations will be entered into the national network for use in support of the National Airspace System and the national weather system.

AWOS/ASOS Data Acquisition System (ADAS). ADAS will function primarily as a message concentrator collecting weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each air traffic control center's area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to RWP and DLP (via NADIN) within the center in which it is installed. It will also distribute AWOS data to the National Airspace Date Interchange Network (NADIN) which will forward the data to WMSCR for further distribution. This DLP via Mode S makes weather data available to pilots and air traffic controllers on a timely basis within the "local" area and other users. Field implementation of ADAS is planned to start in 1993 and be completed in 1995.

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 for 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. Technologies being investigated include sensors for: (1) improved visibility detection; 2)

current type and amount of precipitation; 3) lightning detection systems; 4) runway surface conditions; and 5) sensors that can detect freezing rain.

Flight Service Automation System (FSAS)

This program will improve user access to weather and Notice to Airmen (NOTAM) information, simplify flight plan filing, and provide a FSAS that will meet the projected increases in demand for flight services without proportional increases in staff. Automation is being implemented through installation of a Model 1 Full Capacity (M1FC) system at each of 61 Automated Flight Service Stations.

The first Model 1 System was commissioned in 1986; it was not until August 1991 that the full capacity was achieved. As of April 1993, all Model 1 Systems had been replaced by M1FC, which were operating in 50 Automated Flight Service Stations (AFSS) and 14 Flight Service Data Processing Systems (FSDPSs). All 61 AFSSs will be commissioned by June 1994, and all 21 FSDPSs will be installed by September 1994. M1FC will provide sufficient hardware and software to drive all of the terminals in the 61 AFSSs.

The Direct User Access Terminal (DUAT) system has been operational since February 1990. Pilot users are able to access Weather and NOTAMs and file their IFR and/or VFR flight plans from their home or office personal computer through DUATS.

Graphics Weather Display Systems (GWDS) in the AFSSs consist of a variety of different vendor systems. These systems will be maintained as interim systems until replaced by a standardized graphics functionality.

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 primary FAA gateway to the National Meteorological Center (NMC) and, therefore, will be the principle source of NWS products for the National Airspace System (NAS).

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 databases. 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 system is expected to be operational by mid 1994.

Aeronautical Data Link Program (ADLP)

The ADLP will implement the Data Link Processor (DLP) to support weather services for aircraft utilizing the discreetly addressed data link capability of the FAA's Mode Surveillance system. It will receive down link 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 databases 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. Installation of this system is scheduled to begin in 1991 and is continuing as programmed. The ADLP will be enhanced in 1996 to support additional weather (including wind shear advisories) and ATC tower applications (including digital ATIS) and to provide expanded data link communications functions in support of ATC data link services.

National Airspace Data Interchange Network (NADIN)

The NADIN II Packet Switched Network is being implemented to serve as the primary interfacility data

communications resource for a large community of NAS computer subsystems. The network design incorporates state-of-the-art packet switching technology into a highly connected backbone network in order to provide extremely high data flow capacity and efficiency to the network users. NADIN II will consist of operational switching nodes at each Area Control Facility and two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City and Atlanta. It will interface directly to such systems as the WMSCR, Real-Time Weather Processor (RWP), Meteorological Weather Processor (MWP), ADLP, AWOS/ASOS Data Acquisition System (ADAS), Traffic Management System (TMS), Consolidated NOTAM System (CNS), and Area Control Computer Complex (ACCC), and may be used as the intrafacility communications system between these (collocated) users during transition to end-state.

Central Weather Processor (CWP)

CWP will improve the dissemination of weather information throughout the National Airspace System (NAS), 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 to 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 radar information (NEXRAD) for subsequent distribution to controller displays. These improvements are necessary to help reduce the high percentage of accidents and delays directly related to weather.

The CWP is composed of two elements. The first is a commercially-available Meteorological Weather Processor (MWP) which will be procured through a series of 5-year leases. This will provide current meteorological data for the preparation of short-term aviation forecasts and severe weather advisories by the NWS meteorologists assigned to the FAA centers. The second element is a Real-time Weather Processor (RWP) which will automatically create unique NEXRAD-based mosaic products. The RWP will send these products, along with other time-critical weather information to controllers through the Advanced Automation System (AAS) and to pilots via the enhanced Weather Communications Processor and Mode S data link.

The deployment of MWP was completed in 1992. The MWP leased in the second 5-year period will interface with the RWP which should become operational in 1998. The MWP will also interface with NWS offices to permit a rapid flow of weather information to and from each FAA center. Future leases of the MWP will consider the possibility of utilizing services available from AWIPS-90 (Advanced Weather Interactive Processing System) sponsored by the National Weather Service.

Requirements for the CWP and other agencies' automated weather information systems are being coordinated through the Committee for Automated Weather Information Systems (CAWIS) working under the auspices of the AWIS Program Council. The intent of this activity is to avoid unnecessary duplication of development effort and to assure the sharing of information and products in the operational phase.

Weather Processing

The Committee for Automated Weather Information Systems, under the direction of the Program Council within the Office of the Federal Coordinator, developed a National Plan which integrates requirements, development and implementation activities associated with AWIS programs and projects of the Departments of Commerce, Defense, and 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. 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 DLP to provide NEXRAD mosaics for communication to the pilot and receive Pilot Weather Reports from aircraft in flight.

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.

Centralized Weather Information Processing

This project will develop an integrated weather database 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 database, development of a suitable structure for this database, 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 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 1989, the effort focused on full-scale simulation tests of candidate system configurations of sensors, flight controls and cockpit displays. FY 1990 was the first opportunity to perform flight tests of candidate airborne wind shear detection and avoidance concepts based upon the previous year's analysis and experiments.

It is projected that in FY 1992 airborne remote detection technology and onboard processing of ground-based data will be developed, evaluated and flight tested.

Improved Aircraft Icing Forecasts

This initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as recommended in the, "National Plan to Improve Aircraft Icing Forecasts." This Plan was jointly developed under the aegis of the Federal Coordinator for Meteorological Services and Supporting Research by the Department of Transportation, Department of Defense, Department of Commerce, National Aeronautics and Space Administration, and the National Science Foundation to provide the National Weather Service with an improved aircraft icing forecast capability. The objectives of this program for FY 1992 are to develop an icing severity index, develop icing guidance models, and to develop a better comprehension of synoptic and mesoscale conditions leading to icing. The end result of this effort will be improved icing forecasting capability, to be operational in 1996. Pilots will be provided with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

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 commercial and private vessels.

In 1989 the International Ice Patrol, a Coast Guard

unit, began air-deploying satellite-tracked drifting buoys equipped with barometric sensors in the northwest Atlantic. These data are available to all users through GTS.

U.S. Coast Guard Marine Science Technicians receive basic training in meteorology as a major part of the training for their specialty.

The Coast Guard supplies a staff of up to 15 personnel to the NDBC (costs reimbursed by NOAA 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 Navigation Safety and Waterway Services at Coast Guard Headquarters. The Coast Guard NDBC operation is managed at the Coast Guard Headquarters by the Short Range Aids to Navigation Division of the Office of Navigation Safety and Waterway Services. Field management of meteorological activities is a collateral function of the Coast Guard area staffs.

The U.S. Coast Guard operates or provides support for Omega and LORAN-C radionavigation stations in the U.S. and in some overseas locations in accordance with the Federal Radionavigation Plan and bilateral agreements with other nations. In addition to providing signals for aviation and maritime navigation systems, the Omega and LORAN-C systems and other electronic navigation systems (e.g., Global Positioning System) provide signals for the operation of radiosondes and dropsondes that are essential to the meteorological observation network in the U.S. as well as for the international weather community.

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.

APPENDIX D

WEATHER PROGRAMS OF OTHER AGENCIES

DEPARTMENT OF AGRICULTURE

Weather is the most important factor influencing the Nation's variability in crop yields and related production. The Nation's food and fiber products are a critical resource impacting our domestic and international economic position and have taken on new dimensions in foreign affairs and national security. The recent expansion in export markets has reduced stocks and benefitted our farm sectors as global consumption of total grains has exceeded production in two of the last three years. The U.S. Department of Agriculture (USDA) conducts supporting research that focuses on understanding the interactions of weather and climate with plants, animals, forests and forest ecological systems and assists the Department of Commerce in determining farmers' needs for the weather information and in disseminating such information to them.

The World Agricultural Outlook Board (WAOB), in cooperation with the National Weather Service's Climate Analysis Center monitors the daily weather patterns around the world. The WAOB agricultural meteorologists convert the weather data into information to assess crop development and yield potential for all major commodity crops in major producing areas of the world. Special weekly briefings are provided to the Secretary of Agriculture and the economics and commodity analysts of USDA. The Senate and House Agricultural Committees also requested periodic briefings on crop relating drought effects in 1988 and 1989.

Historically, the Forest Service (FS) has collected meteorological data to assist in 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 establish 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 are being developed in cooperation with the Regional Climate Centers of the National Climate Program. The Forest Service monitoring network will provide essential data for use in Global Change work.

The Forest Service currently operates more than 300 RAWS, mostly in the western United States. Air temperature, relative humidity, soil moisture, wind direction, speed, and precipitation are transmitted via GOES telemetry. These data are received via a direct readout ground site in Boise, ID, operated by the Bureau of Land Management. The main use of the data is in the calculation of the fire danger rating for the Forest Service and cooperating agencies. These data are also used by other resource managers such as road engineers, wildlife biologists, and hydrologists who monitor precipitation, silviculturalists who are attempting to maximize tree planting opportunities, ecologists, and soil specialists and fisheries biologists monitoring the effects of runoff. The main secondary user of these RAWS data is NOAA National Weather Service for fire weather forecasting and flood warnings.

The Soil Conservation Service (SCS) operates a network of 1400 manual snow courses and over 550 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 FY 1987, SCS implemented a new 5-year initiative to upgrade the SNOTEL data collection system at a total cost of $5 million. This effort continues and includes upgrading 510 data collection sites in the existing SNOTEL system with new state-of-the-art equipment and adding about 40 additional sites. The data collection site upgrade will include replacement of snow pillows, transducers, damaged precipitation gages, antennas, towers, solar panels, battery 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 commodities and products while minimizing any adverse effects of agriculture in 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 atmospheric production and the environment.

The Cooperative State Research Service (CSRS) coordinates research programs in the state agricultural experiment stations, the 1890 Land Grant Distributions, and cooperating forestry schools. These institutions conduct a wide variety for research applicable to agriculture and forestry. Meteorological research in these institutions is practically all climatological. A 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. Work begun in FY 1990 to evaluate plant response to changes in levels of ultraviolet radiation as part of the Global Change research program will be significantly expanded through the CSRS competitive grants program in FY 1994. The work is coordinated with EPA's ultraviolet radiation program and will support assessment efforts to develop related national policy on environment.

Forest Service research includes efforts to: understand and control forest fire initiation by lightning; improve the translation of mid-range forecast elements to describe forestry conditions, incorporate drought information into fine management decision-making and better describe how regional climatic variability affects the use of daily weather information by foresters. The FS long term monitoring network will provide critical data for use in the Global Change research work.

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 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 conditions is continuing. A preliminary investigation of polar orbiting meteorological satellite data showed a good relationship between crop condition and reflectance data as determined by the agreement between measured and forecast final corn and soybean yields. The crop conditions assessment procedures, based on meteorological satellite data, are being automated and near real-time applications are being explored.

DEPARTMENT OF THE INTERIOR

Specific financial data for the Department of the Interior's (DOI) Atmospheric Science Research Programs are reported through the Subcommittee for Atmospheric Research; however, operational program budgets are reported in the Federal Plan. The narrative below describes the full range of meteorological activity in the Interior Department.

The Bureau of Reclamation activities requiring the collection and use of meteorological data include water scheduling, flood hydrology, irrigation project management, and reservoir operations, as well as projects related to the development of wind and solar energy resources. Multi-agency work is also proceeding in projecting potential effects of climate change on western water resources and Bureau operations. Bureau of Reclamation's weather modification research program has not been funded since 1989 except for reimbursable work.

Currently, Reclamation's HYDROMET system collects data from approximately 400 hydrometeorological data collection platforms (DCPs) which transmit data in the "real-time" through the NOAA's Geostationary Operational Environmental Satellite (GOES) to the Bureau's Direct Readout Ground Stations (DRGS) in Boise, Idaho. AGRIMET is a subset of 36 HYDROMET DCPs dedicated to analysis of crop water use and water conservation. Data collected and products created in Boise are immediately transferred to other Bureau, Federal and state offices.

The Geological Survey's Water Resources Division collects precipitation, streamflow, and other climatological data for a number of projects concerning rainfall/runoff, water quality and hydrologic processes. Currently, the Geological Survey collects hydrometeorological data from approximately 3,500 GOES DCPs through six DRGS units. In September 1992, the Survey awarded a contract to procure direct readout terminals (DROTs) to receive domestic satellite (DOMSAT) retransmission of all data collected on NOAA's GOES data collection system. These compact DROT systems are proving to be much more efficient and economical data sources than the conventional DRGS receivers.

The 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 assessments of snowpack from space.

The Survey also researches past climate change, regional hydrology, the carbon cycle, coastal erosion, volcanic activity, and glaciology. It collects precipitation and dryfall atmospheric deposition samples in a number of studies for 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 Bureau of Land Management's (BLM) Initial Attack Management System (IAMS) provides real-time data access and modeling for the fire management organization. The system enables rapid evaluation, assessment, and decision making capabilities for the BLM's wildfire responsibilities. The principal inputs are Remote Automatic Weather Station (RAWS) meteorological data, Automatic Lightning Detection System (ALDS) information, vegetation, slope, elevation, and terrain data, These real-time data sources are coupled to advanced fire modeling capabilities to facilitate the BLM's fire and resource management objectives.

The BLM's RAWS Program collects meteorological data from a network of stations located throughout twelve western states including Alaska. This network is comprised of three classes of systems placed at strategic remote locations. All data are recovered via the GOES system by the BLM's DRGS located at the Boise Interagency Fire Center (BIFC) in Boise, Idaho. The Bureau presently owns 359 systems with about 300 of these being fielded. The network is planned to ultimately reach 359 fielded systems. Completion of the network as planned is based on acquiring the personnel to implement and maintain the total number of planned systems.

The BLM's RAWS Support Facility at BIFC provides a full range of management, maintenance, data, and support services for the BLM and numerous

other Government agencies. This work is performed under long-term interagency agreements with those agencies having similar equipment and requirements.

The BLM's Automatic Lightning Detection System (ALDS) covers the eleven western states and Alaska. The western U.S. ALDS is comprised of 36 direction finders (DF) providing high detection efficiency coverage of cloud-to-ground activity for 95 percent of the western United States. The system provides data via a satellite telecommunications system for the BLM's IAMS. Data are also supplied to the National Weather Service, State University of New York (SUNY), New Mexico Institute of Mining and Technology, and several Department of Defense installations. The Alaska ALDS is comprised of nine DFs providing the required coverage for Alaska Fire Service's needs.

In addition to the meteorological monitoring BLM conducts primarily to support fire management activities, the BLM also conducts site-specific climate monitoring at over 200 locations on the Public Lands in the eleven western states and Alaska. The operation of these sites ranges from seasonal to annual measurements of precipitation. temperature, soil moisture and other meteorological parameters necessary to assess local climatic influences. These data are primarily used for natural resources management and planning at the local level.

In 1991, the BLM Global Change Research Program established five monitoring sites in BLM wilderness and wilderness study arm to establish baseline conditions for assessment of long term ecosystem trends. A total of 20 sites are planned to be established over the initial 5-year period. A standardized monitoring platform will be operated at these sites to include measurements of climate and atmospheric chemistry.

The Minerals Management Service's Environmental Studies Program gathers offshore environmental data in support of mineral leasing responsibilities. Currently, the Service supports eight data buoys which transmit via NOAA satellites from off the Pacific Coast. Wind data are used in the Service's Oil Spill Risk Analysis Model to predict effects of potential spills.

The National Park Service (NPS) monitors air quality and visibility in several national parks and monuments. Gaseous pollutants data are collected on continuous and integrated (24-hour) bases. Surface meteorological data are collected and analyzed for hourly averages. Precipitation chemistry is determined on week-long integrated rainfall samples. Twenty-four average particle concentrations (mass, elemental analyses, some chemical constituent analyses) are measured twice weekly. Atmospheric light extinction is measured continuously and satellite-telemetered to a central location for analyses.

The NPS also conducts and contracts research to develop and test air quality models to assess long-range transport, chemical transformation, and deposition of air pollutants. These models are used to estimate source contributions and to identify source regions responsible for observed pollutant loadings.

The Bureau of Indian Affairs collects atmospheric data to evaluate potentially irrigable Indian Trust lands in the Southwest. The Bureau also shares fire weather data with other Federal agencies while participating in fire weather forecasting at the Boise Interagency Fire Center.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Operations

The National Aeronautics and Space Administration (NASA) Headquarters Weather Support Office, through its Weather Working Group, has continued to improve NASA's weather support capabilities for both manned and unmanned launch vehicles. 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 landing. Improved weather information begins with improved observing systems and includes efforts to provide better communications, integrated data management systems and displays, an automated network of observing

stations/systems, and improved forecasting techniques and methods.

The elements comprising the operations program are intended to provide the specialized meteorological data that are needed for the support of both manned and unmanned launch vehicles. Mesoscale weather events have a strong impact on shuttle ground processing operations, launch, and landing operations. The long range goal of the program is to provide support that uses the latest technological developments. The Applied Meteorology Unit, collocated with the AF Cape Canavaral Forecast Facility, provides a facility in which recent technological development can be verified and older technology may be reexamined and improved for the purpose of transitioning useful procedures, techniques, and models into the operational forecasting arena. Applications likely to provide near-term benefits to launch and landing operations, and to ground processing are given rigorous attention.

The goal of the Advanced Development Program has been to develop techniques and systems that aid in prediction and avoidance of the weather impacts associated with mesoscale weather phenomena in a subtropical coastal environment. Summer thunderstorms are frequent in this environment; many hazardous ground and launch operations are carried out during shuttle processing that are especially endangered by mesoscale weather events such as thunderstroms. The project addresses predicting the development of convective clouds, the extend of threat of lightning associated with thunderstorms and electrified clouds, and the initiation of lightning. Attention is being given to improved prediction models.

NASA has upgraded weather observing capabilities at the shuttle landing and alternate landing sites. This includes completion of the Meteorological Interactive Data Display System (MIDDS) that facilitates the transfer of meteorological data and reduces the time required to evaluate weather situations and increase the forecaster's confidence in their recommendations for launches, landings, and operations of both manned and unmanned space vehicles. This technology also provides for operational redundancy and increases safety.

Supporting Research

NASA sponsored research and analysis activities in these areas are devoted to advancing the understanding of the basic physical processes by which the atmospheric system absorbs, transforms, stores, transports, and releases energy and water, and studying the relationships between wind stress, ocean circulation and ocean surface topography. These activities are carried out under the auspices of the Atmospheric Dynamics, Radiation and Hydrologic process research program.

NASA goals in these research areas include the development of an improved understanding of:

- the internal and boundry forcing processes that maintain the atmospheric circulation.
- fundamental processes involved in the generation, maintenance, propagation, and decay of mesoscale atmospheric phenomenon.
- radiative exchange processes within the sun-earth atmosphere system and to develop improved parameterizations for earth system models.
- the physical processes that govern the hydrological cycle and its impact on atmosphere and oceans.

The approach includes development of ground, airborne, and space-based remote sensing techniques; field experiments to obtain comprehensive data sets; and advanced process modeling.

To address the processes responsible for cloud-radiation interaction and feedback, the First International Satellite Cloud Climatology Project (ISCCP) Regional Experiment (FIRE) was established in the mid-1980s as a U.S. multi-agency program with NASA as lead agency. FIRE has concentrated on two important cloud types with regard to climate impact: cirrus clouds that cause a warming effect and marine stratocumulus clouds that cause a cooling effect. The intensive field observations relating to cirrus were conducted in late 1991 from Kansas, while those relating to the marine stratocumulus were carried out in mid-1992 in the vicinity of the Azores and Madeira Islands in the North Atlantic Ocean.

The Earth Radiation Budget Experiment (ERBE) has provided the first solid observational evidence that clouds cause a slight net cooling of the planet, but we do not know even the sign of the cloud-radiation feedback under changed climatic conditions.

In early 1992 NASA participated in the multi-agency STORM-Fronts Experiment Systems Test (STORM-FEST). Primary science objectives of STORM-FEST are concerned with the study of structure and evolution of wintertime fronts and associated mesoscale precipitation features in the central U.S., and the dynamical and physical processes that govern these structures.

Intense planning is ongoing for NASA participation in the international Tropical Ocean Global Atmosphere (TOGA) Couple Ocean-Atmoshpere Response Experiment (COARE) in the western tropical Pacific Ocean during 1992 to 1993, with a comprehensive field campaign in early 1993. The NASA component of TOGA/COARE, while contributing directly to COARE objectives, will emphasize scientific objectives associated with the Tropical Rainfall Measuring Mission (TRMM) and NASA's dynamics and radiation programs. The highest priority is for observations related to TRMM science, i.e., tropical ocean precipitation climatology, vertical structure of precipitation, convection processes, water budget estimates and all aspects of the water cycle over the COARE experimental region. Cloud and radiation objectives are closely associated with the tropical cirrus FIRE objectives.

Planning for the international Global Energy and Water Cycle Experiment (GEWEX) is also ongoing. The first phase of the GEWEX initiative -- the Continental-Scale Experiment over the Mississippi Basin -- is slated to take place during the 1993-94 time period. GEWEX will observe and model the global hydrological cycle, in order to predict variations of global and regional hydrologic processes and water resources, and their response to environmental change.

In the near term, NASA plans to accelerate the study of the possibility for sea-level rise due to global warming with the launch of the TOPEX/POSEIDON satellite mission in August 1992. The technical goal of this important mission is to precisely measure the topography of the global oceans for 3 to 5 years. The primary science objective is to improve our understanding of the role of ocean processes in global change. Specifically, sea-level rise estimates will be calculated. TOPEX/POSEIDON data will be combined with surface measurements to improve numerical models of ocean circulation and develop coupled ocean-atmosphere circulation models.

The NASA Scatterometer (NSCAT) is scheduled for launch on the Japanese Advanced Earth Observing Satellite (ADEOS) in 1996. NSCAT will contribute systematic high-resolution wind observations over the ocean. These data are critical in understanding fundamental processes in which the oceans and atmosphere play a role in moderating the Earth's climate. NSCAT and TOPES/POSEIDON will be key contributors to the World Ocean Circulation Experiment (WOCE) and the TOGA programs, both componenets of the World Climate Research Program.

TRMM is being developed jointly by the U.S. and Japan to measure tropical rainfall and its variation from space. Given the tremendous uncertainty that exists regarding the quantity and distribution of precipitation in the tropics, and the importance of understanding the hydrologic cycle of this region, a minimum of 3 years of climatologically significant observations of rainfall are planned. TRMM will be placed in a low-inclination orbit for frequent time-varied observations of low-latitude regions and is scheduled for launch in 1997.

The Upper Atmosphere Research Satellite (UARS) launched in September 1991 continues to provide valuable data for studying the coupling of chemical, radiative, and dynamic processes in the stratosphere.

Development of the Earth Observing System (EOS) is continuing. The primary objective of the EOS is to document global climate change and to observe regional-to-global scale processes. Utilizing several satellites, EOS will document global climate change over a fifteen-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. The first EOS platform is scheduled for launch in 1998.

ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for working with state, local, and other Federal Government agencies to ensure adequate air quality meteorological programs to support regulatory applications. Applied research and meteorological support is furnished primarily by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, through an interagency agreement with the National Oceanic and Atmospheric Administration (NOAA) which provides approximately 60 research meteorologists to the EPA. Meteorological support to the EPA Office of Air and Radiation, the EPA Regional Offices, and to state and local agencies includes: review of the meteorological aspects of environmental impact statements, state implementation plans, and variance requests; development and application of air quality dispersion models for pollution control and exposure assessment strategies; and prepa-ration of dispersion studies and model evaluations. Meteorological expertise and guidance are also provided for the air quality standard, modeling guideline, and policy development activities of the EPA.

In light of recent changes to the Clean Air Act, air quality models and the manner in which they are used are expected to evolve considerably over the next few years. In the area of acid deposition, the evaluation of nitrogen and oxidant chemistry in addition to sulfur chemistry will elucidate the role of model formulation, radiative transfer, and vertical exchange in the air quality model predictions, along with development of a better understanding of model predictions relative to control strategy assessment. Further development and evaluation of existing air quality models will take place to accommodate the inter-pollutant effects resulting from the variety of control programs that are now or will be in place. These inter-pollutant effects include trade-offs between oxidant, ozone, sulfur oxides, nitrogen oxides, and volatile organic compound controls as well as developing predictable methods of forecasting impacts on visibility and acid aerosol effects.

With respect to inhalable particulate model development, dispersion grid models will be enhanced to accurately predict aerosol growth from precursors over regional transport distances. To assist in the evaluation of the contribution of various sources to regional air quality, inert tracer and tagged species numerical models are being developed. These models will introduce separate calculations for inert or reactive chemical species emitted from a particular source or region. The calculations will proceed to simulate transport and transformation to a receptor point, where the contribution of the particular source could be isolated. With respect to oxidant air quality modeling, the role of biogenic volatile organic compounds, rural nitrogen oxides, and vertical transport will be elucidated along with the development of a better understanding of the fundamental aspects of the ozone nonattainment problem such as differences in urban and rural photochemical production and their interaction through transport.

Atmospheric research in the areas of climate and climate change include the chemistry of the global troposphere that effects the distribution and fate of reactive greenhouse gases, and regional climate studies addressing the interaction of climate with the biosphere. The climatology program involves both analytical and statistical climatology as well as regional scale climate model development. Climate change issues and their feedbacks with the biosphere will be stressed.

In addition to these three major areas, dispersion models for inert, reactive, and toxic pollutants are under development and evaluation on all temporal and spatial scales, e.g., indoor, urban, mesoscale, and regional. Other efforts include the construction and application of air pollution climatologies; determination and description of pollutant effects on atmospheric parameters; and determination of meteorological effects on air quality. Measurement data obtained during field programs and from wind tunnel and water channel/towing tank experiments will be used to continue development and evaluation of these models in the FY 1993-94 period. EPA participation in the interagency High Performance Computing and Communications (HPCC) Program is enabling increased efficiency in air quality meteorological modeling, with the subsequent transfer of these achieved efficiencies to the user community.

The EPA is also an active participant in the U.S. Weather Research Program mainly by providing research-in-kind in the area of meteorological simulation modeling on local, meso, and regional spatial scales of pollutants from fossil fuel power plants, vehicle exhausts, and other emissions sources.

The detailed understanding and modeling of the mesoscale circulations that control the atmospheric dispersal of these pollutants will also be applied to coping with accidental releases of toxic or radioactive materials.

DEPARTMENT OF STATE

The Department of State is assuming a much more active role in international climate/meteorological policy making as a result of growing public concern with possible substantial warming of the global atmosphere due to the "greenhouse gas effect." The Assistant Secretary of State for Oceans, International Environmental and Scientific Affairs, chairs the U.S. Delegation to the Intergovernmental Panel on Climate Change (IPCC) which held its first meeting at Geneva in November 1988. The purpose of the IPCC is to serve as a government forum to call for scientific examination and assessment of future global climate change due to atmospheric warming from the greenhouse effect. It is anticipated that the IPCC will draw upon scientific assessment support from the World Meteorological Organization (WMO), the United Nations Environmental Program (UNEP), the International Council of Scientific Unions (ICSU) and their various international climate assessment programs.

The Department of State is also active on the Committee on Earth and Environmental Sciences (CEES) of the Federal Coordinating Committee on Science, Engineering and Technology (FCCSET). The CEES was established in 1987 by the President's Science Advisor to coordinate all domestic programs dealing with global change, including global climate change assessments. The CEES is the chief Federal interface with the National Research Council's global change program which is a part of the ICSU's emerging International Geosphere/ Biosphere Program (IGBP). IGBP is charged with assessing and analyzing Earth systems science and changes in the Earth systems as a whole. Through the CEES, the State Department is able to help shape and define U.S. international science policies regarding global change, including global climate change.

These new responsibilities are in addition to, but do not replace, traditional Department responsibilities set forth in earlier annual Federal Plans, i.e., international aspects of global food policies, disaster warnings and assistance, WMO 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 Pacific storms.

Finally, the Department is monitoring and implementing international actions to enforce the provisions of the 1985 Vienna Convention on the Preservation of the Ozone and the subsequent Montreal Convention Protocols on enforcement of chloroflourocarbon (CFC) reduction. All of the above activities -- especially IPCC, IGBP and CEES responsibilities, and the ozone monitoring and implementation actions -- will be continued for many years.

NUCLEAR REGULATORY COMMISSION

The U.S. 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 these nuclear facilities require the identification of meteorological and climatological 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, reviews of facility siting, design, construction and operation are conducted by the Office of Nuclear Reactor Regulation and the Office of Nuclear Material Safety and Safeguards. These reviews include consideration of meteorological factors. The NRC Office for Analysis and Evaluation of Operational Data and the NRC Regional Offices asssure that commitments by NRC applicants, permittees and licensees are carried out, and also conduct NRC responses to nuclear facility emergencies. The Office of Nuclear Regulatory Research develops regulations, guides, criteria, and other standards related to the protection of public health and safety and the environment in the licensing and operation 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.

The two primary meteorological areas in which the NRC will have an interest during FY 1994 and beyond are (1) improvements in the meteorological capabilities of the NRC and the operators of nuclear facilities to cope with emergencies involving unplanned releases of radioactive material and (2) paleo-climatic reconstruction and long-term climate change models for

applications in the assesment of geologic high-level radioactive waste repositories. The NRC also maintains an interest in the transport and dispersion of hazardous non-radioactive materials and their potential effects on the safe operation of nuclear facilities.

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 Nevada 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.

FEDERAL EMERGENCY MANAGEMENT AGENCY

Under direction of the President, the mission of the Federal Emergency Management Agency (FEMA) is to plan for and coordinate the protection of the civilian population and resources of the Nation, and to include planning for the continuity of constitutional government in time of emergency. FEMA replaced five former agencies, integrating a number of emergency activities which include development of community awareness for meteorological emergencies and coordination of all emergency warnings to the public.

FEMA's principal involvement with meteorology results from the coordinating role of FEMA in support of preparedness for national security emergencies, and for carrying out statutory disaster relief responsibilities involved with the extremes of meteorologically-related phenomena. These responsibilities have been listed in Executive Order 12656 which forms the basis for FEMAs continuing relationship with the Executive line agencies.

In carrying out its role, FEMA works with all of the agencies to assure that the delivery of meteorological and climatological-related information is conducted in keeping with established preparedness goals and objectives. As administrator of the National Flood Insurance Program, FEMA publishes a system of Flood Insurance Rate Maps (FIRM) which serve as the official demarcation for flood insurance risk. Recently, FEMA was given responsibility by the 100th Congress for coordinating the preparation of a national coastal erosion and flood plain database.

FEMA's priority interests with the Office of the Federal Coordinator are in promoting standards and procedures which will enhance the ability of the Nation to mitigate and recover from national security emergencies, and to coordinate its statutory responsibilities by enhancing integrated services under off-standard conditions. These interests extend to national standards for geographic information systems used for delivery of meteorological services by other agencies. For meteorologically-related matters, the National Preparedness Directorate is the principal contact point within FEMA. Developments involving flooding and erosion impacts are coordinated within the Insurance Administration offices of FEMA.

APPENDIX E

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). 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, a section on the WWP has been included and has obviated the need for a separate report. Included at the end of this Appendix are bilateral and regional international cooperative activities not under the WWP. While not exhaustive, most Government programs are included. This Appendix was prepared by the Working Group for World Weather Program of the Committee for Basic Services within the Federal meteorological coordination mechanism.

GOALS AND ORGANIZATION OF THE WORLD WEATHER PROGRAM

The goals of the 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 are barely adequate over 20 percent of the Earth while the remaining 80 percent, mostly over the oceans, remain 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 167 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.

More recently the WMO, through its commission structure, is working towards the design and implementation of improved observations for a Global Climate Observing System (GCOS) through enhancements to the Global Observing System (GOS) and other appropriate measures. These efforts are expected to yield an enhanced GOS for both operational and research purposes; they are part of the effort to strengthen WMO's commitment to improve understanding of climate and related environmental matters, as articulated by the Second World Climate Conference in 1990 and repeated at the United Nations Conference on the Environment and Development (UNCED).

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

Department of Commerce (DOC): Represents the U. S. at WMO 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 (DOS): 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 (NSF): Stimulates and supports basic research by non-Government 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 (DOD): 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 (DOT): Through the U. S. Coast Guard, provides personnel to support 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 WWW through DOT's interaction with NOAA's National Weather Service.

National Aeronautics and Space Administration (NASA): 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 essential elements that are closely linked and interdependent: Global Observing System (GOS), Global Data Processing System (GDPS), and Global Telecommunication System (GTS).

These elements are coordinated and closely integrated through three WWW support functions. The Data Management function coordinates, monitors, and manages the flow of data and products within the WWW system to assure their quality and timely delivery. It also includes the definition and use of code forms for data exchange. The Systems Support Activity provides guidance, technical and scientific information, and training to those involved in the planning, development, and operation of WWW components. The Implementation Coordination function assures the timely completion of the WWW implementation and effective support and maintenance of the WWW system.

Global Observing System (GOS)

The GOS is a coordinated system of methods, techniques, and facilities for making weather observations 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
Research and Special Purpose Vessels
Climatological Stations
Agricultural Meteorological Stations
Weather Radar Stations
Meteorological Reconnaissance Aircraft
Solar Radiation Stations
Atmospheric Detection Stations
Meteorological Rocket Stations
Ozone Stations
Background Pollution Stations
Tide Gage Stations
Wind Profilers

The space-based (satellite) subsystem provides vital support for meteorological and hydrological predictions and warnings. The use of satellites enables the routine collection of environmental observations from even the

most remote locales. Two categories of satellites are used: those in near-polar orbits and those in geostationary orbits.

Satellites in near-polar orbits provide global coverage twice a day (in daylight and darkness) by circling from pole to pole as Earth rotates beneath. They usually orbit at altitudes under 1000 km. They are equipped with instruments to collect precise radiance measurements for numerical analysis and prediction applications, as well as instruments/systems for other applications. Typical products derived from their primary instruments are: atmospheric temperature and water vapor soundings; sea surface temperatures; radiation fluxes; cloud cover information; and ice/snow extent. Additionally, they are used to monitor, among others, ozone, volcanic eruptions, global vegetation greenness, and the distribution of energetic particles in the upper atmosphere. Systems aboard these satellites may include those to collect and relay data from both fixed and drifting in-situ platforms and to provide the detection and tracking of signals from emergency transmitters used in Search and Rescue programs.

Presently, operational meteorological satellites in polar orbits are operated by the Commonwealth of Independent States (the Meteor-3 series) and the United States (the NOAA series). NOAA currently launches satellites, alternately, into afternoon and morning orbits on a planning schedule of 15 1/2 months between launches. China has been operating a polar orbiter, FY1B, since September 3, 1990. This experimental satellite has been working intermittently since August 1991. The current operational NOAA polar orbiting satellites are NOAA-11 (launched in an afternoon orbit in September 1988) and NOAA-12 (launched in a morning orbit in May 1991). NOAA-9 (launched in December 1984) and NOAA-10 (launched in September 1986), although not in full service, continue to provide ozone and radiation budget measurements. NOAA-I (which will become NOAA-13 when operational) is currently scheduled for launch in an afternoon orbit no earlier than June 1993.

Operational geostationary meteorological satellites provide the repetitive, day and night observations of the Earth-disk in their fields of view that are needed to provide a "continuous weather watch." From their geostationary altitude (36,000 km) over the Equator, and with orbital speed matched to Earth's rotation rate, each remains fixed above its assigned equatorial subpoint on Earth. They monitor the Earth scene below in the visible and the infrared bands and, by providing observations of an area every few minutes, are well-suited to tracking the progress of mesoscale and/or short-lived environmental events. In addition to imagery, products derived from geostationary satellite data include surface temperature fields and atmospheric winds (from cloud displacements over time). Some geostationary weather satellites are equipped to provide atmospheric temperature and water vapor soundings, image atmospheric water vapor distributions and transport, and monitor solar particle flux, (including solar x-rays), at the spacecraft. Systems for collecting and relaying data from automatic sensor platforms are included in the payload, a Search and Rescue Satellite-Aided Tracking capability may be aboard, and communications functions are provided to support users. Data from these satellites are proving increasingly important in climatic monitoring and research.

Presently, operational geostationary weather satellites are operated by Japan, India, EUMETSAT (Europe), and the United States. Japan's Geostationary Meteorological Satellite (GMS) is positioned at 140°E; India's Indian National Satellite (INSAT) is at 74°E; and EUMETSAT's METEOSAT is at 0°. EUMETSAT is currently operating a second METEOSAT at 50° W providing supplementary Atlantic data coverage. The United States normally operates two Geostationary Operational Environmental Satellites (GOES); one at 75°W, the other at 135°W. An earlier launch failure resulted in GOES-7 (launched in February 1987) becoming the sole operational GOES when GOES-6 failed in 1989. GOES-7 is now positioned at 112°W. NOAA plans to launch the next satellite in this series (GOES-I, to become GOES-8 when operational) in 1994.

Faced with an aging, single GOES, the United States has developed two plans to ensure data continuity in both the short and long term. First, should GOES-7 fail prior to the launch of GOES-I, NOAA has developed and successfully tested a No-GOES Contingency Plan. This plan, which is ready for implementation if and when needed, utilizes a combination of data from the U.S. Polar Orbiting Environmental Satellite (POES) system, the DOD DMSP, and the European METEOSAT series of satellites. These various data types are acquired by NOAA and disseminated to the normal recipients of

GOES-7 data. Second, NOAA has entered into agreement with the European Space Agency (ESA) and EUMETSAT for the "loan" of the METEOSAT-3 spacecraft, which has been moved to a position at 75°W longitude. The Europeans will continue to operate this satellite through a "bent-pipe" communications link from Darmstadt, Germany to Wallops Island, Virginia, to the satellite. A long-term, mutual back-up agreement is under negotiation.

Both the NOAA and the GOES series of U.S. satellites broadcast their data directly to any properly equipped ground station within line of sight. Reception of these broadcasts is unrestricted and does not require any pre-notification. The United States, through NOAA, develops information and products from these data for further distribution over the Global Telecommunications 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 are under constant review with an eye towards improving the GOS, GDPS and GTS.

Over the last few years, several systems intended to improve the operation of the GOS have undergone development and deployment. Among these systems is the family of automated aircraft reporting systems (AMDAR), which includes the Aircraft to Satellite Data Relay (ASDAR) system and the Aircraft Communications Addressing and Reporting System (ACARS). All ASDAR certification and flight tests have been virtually completed. Eight systems have been installed on British Airways aircraft. Two systems are on Continental Airlines, and one is on KLM. Two additional installations have been completed -- one is aboard a Saudia Airlines aircraft, and the other is aboard a Lufthansa aircraft. These two installations are waiting for certification acceptance at the national level. The remaining three systems are awaiting selection of aircraft for installation.

All operational ASDAR platforms were withdrawn from operation over the time frame of late June to early July 1992 because of a potential overheating problem. The units were returned to the factory for installation of a thermal shutdown switch. A delay in the delivery of a particular component needed to accomplish this modification led to a delay in returning the units to service. The actual return of units to the field began towards the end of 1992.

Agreement was also reached to purchase an additional eight operational ASDAR systems. Of these eight systems, two systems will be used as spares to replace units removed from service for maintenance. Of the remaining six systems, two have been purchased by Switzerland, one by the Netherlands, and three by the United Kingdom. Delivery of these additional eight systems is expected in late 1993.

A cooperative effort among Aeronautical Radio Inc (ARINC), NWS and the FAA began operating to provide thousands of automated meteorological reports from ACARS equipped aircraft flying over the U.S. The ARINC Meteorological Data Collection and Reporting System collects, organizes and disseminates automated position/weather reports to the NWS. The standardized weather data is being sent to the NWS in the Binary Universal Format Representation (BUFR) code. Between 10,000 and 20,000 reports a day in varied formats and internal codes are received by ARINC and the quantity is expected to increase to 150,000 (mostly automated ACARS) reports by the mid to late 1990's.

Large quantities of weather reports, particularly over oceanic and other data sparse areas, will be realized via satellite communication and navigation systems. This source of data was the primary subject by the U.S. and other members of the International Civil Aviation Organization (ICAO) and the WMO's Automatic Air Reporting study group. The group developed amendments to the ICAO Technical Regulations and made substantial progress toward standardizing meteorlogical down-link codes (automatic binary, automatic character, manual routine, and special air-reports).

In addition to these aircraft-based systems, others are also being deployed to improve the GOS. The Automated Shipboard Aerological Program (ASAP) has, for example, about 12 systems reporting regularly. During the same period there has also been deployment of substantial numbers of drifting buoys. A number of nations including the U.S. are implementing test networks or single sites of ground based Doppler radars called wind profilers to provide nearly continuous soundings of wind. During the past year there were approximately 88 systems in use world-wide. A

demonstration network of 29 wind profilers is being operated principally in the central part of the U.S. to assess the utility of the data in operational and research meteorological analysis and prediction. A report is being prepared on the results of the multi-year meteorological and engineering assessment. The data has been made available on the GTS to those countries requesting it.

The concept of the Operational World Weather Watch Systems Evaluation (OWSE) has also been developed as a framework for regional implementation. The OWSE-Africa, which was created to evaluate the very extensive use of a geostationary meteorological satellite (operated by the European operational satellite consortium, EUMETSAT) to improve telecommunications and data availability in Africa, has been completed. It was designed to implement and test the data collection system for receipt of meteorological observations from various countries in Africa. Thus far, approximately 100 data collection platforms have been installed in Kenya, Ethiopia, Ghana, Sudan, Nigeria, Sierra Leone, Zaire, Egypt, Madagascar, St. Helena, Guinea, and Cape Verde. Evaluations have been carried out to gage the improvement of observations, and preliminary results show that when systems are operating, high receipt rates are achieved. Results indicate that high receipt rates may be achieved for data originating in Africa, but infrastructure and maintenance issues remain for full operational deployment to be successful.

Efforts are underway to design and implement a Global Climate Observing System (GCOS) building upon the WWW, Global Atmospheric Watch (GAW), Integrated Global Ocean Services System (IGOSS), and other existing systems to further knowledge and understanding of climate and the prediction of climate and climate change. Initial efforts are focused upon establishing planning groups to address needs and requirements for data over the atmosphere, ocean, and land surfaces. Links to existing organizational structures are being established and a high priority has been set on making observational enhancements.

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 have real-time access through the GTS to GDPS products which allow all countries to benefit from their participation in the WWW.

The GDPS is organized as a three-level system. It consists of World Meteorological Centers (WMCs), Regional/Specialized Meteorological Centers (RSMCs) together with National Meteorological Centers (NMCs) which carry out GDPS functions at the national level. In general, real-time functions of the system involve preprocessing of data including real time quality control, analysis and prognosis, including derivation of appropriate meteorological parameters. The non-real-time functions include data collection and archival, additional 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 on a global scale. Melbourne specializes in forecast products for the Southern Hemisphere.

The RSMCs 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, CIS; Lagos, Nigeria; Melbourne, Australia; Miami, USA; Montreal, Canada; Moscow, CIS; Nairobi, Kenya; New Delhi, India; Novosibirsk, CIS; Offenbach, Germany; Rome, Italy; Tashkent, CIS; Tokyo, Japan; Tunis, Tunisia; Washington, USA, and Wellington, New Zealand. The European Center for Medium Range Forecasting is also an RSMC. These centers provide regional products used for short and medium-range forecasting of small, meso-, and large-scale meteorological systems by WMCs. Products of RSMCs can be used by members at the national level for further processing or interpretation to provide assistance or service to users.

In the World Area Forecast System (WAFS), two centers (Washington and London) are designated by the ICAO as World Area Forecast Centers (WAFCs). They issue upper wind and temperature forecasts with global coverage to associated Regional Area Forecast Centers (RAFCs). The regional centers also prepare

and distribute forecasts of weather elements defined by ICAO as significant weather.

In the planned implementation of the final phase, the two world centers would prepare and issue computer-based wind and temperature forecasts as they now do. In addition, those centers will automate all of the significant weather elements. While some of these elements are now prepared automatically, others may begin to be realized in the near future through forecaster initiated graphic interaction.

The dissemination of aeronautical information via global satellite broadcast is expected to begin in early 1994. The U.S. will provide the links to two of the three satellites specified in the system.

Global Telecommunication System (GTS)

The GTS provides communication services for the collection, exchange and distribution of observational data and processed information among the WMCs, RSMCs and NMCs 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:

- The Main Telecommunication Network (MTN);
- The Regional Meteorological Telecommunication Networks (RMTN);
- The National Meteorological Telecommunication Networks (NMTN).

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

The MTN links the WMCs at Melbourne, Moscow, and Washington with the RTHs at Algiers, Beijing, Bracknell, Brasilia, Buenos Aires, Cairo, Dakar, Jeddah, Maracay, Nairobi, New Delhi, Norrkoping, Offenbach, Prague, Rome, Sofia, Tokyo, Toulouse and Wellington. It ensures the rapid and reliable exchange of observational data and processed information required by the Members.

The RMTNs consist of an integrated system of links which interconnects RTHs, NMCs, and RSMCs 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 1993 include:

- Improvement of the capacity of MTN links and inclusion of graphics (e.g., Washington-Brasilia, Washington-Buenos Aires);
- Implementation of upgraded regional networks;
- Continued implementation of satellite serviced 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 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, the U.S. 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 more than 50 countries. Long-term fellowships, through which the students receive baccalaureate or advanced degrees, have been completed by candidates from over 48 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 for Automatic Picture Transmission (APT) reception so that the countries may benefit more fully from weather satellite services.

The U.S. has contributed annually from $1.5 million to $2.3 million to VCP since 1969. Other nations contribute a total of approximately $2.0 million annually and this continues to increase. Contributions are in three categories; equipment and services (80 percent), financial contributions (about 10 percent), education and training (about 10 percent).

The Department of State (DOS) provides funding for VCP projects with NOAA administering and carrying out programs designed to aid meteorological/hydrological and climate projects in recipient countries. In FY 1992, DOS funding for WWW/VCP programs was $2.00 million. In FY 1993, $2.25 million was approved and in FY 1994, $2.30 million has been requested.

The Climate Computing (CLICOM) project of the WMO's World Climate Program has become a major and very successful WMO project in which the U.S. has played a leading role. Each CLICOM unit consists of a small network of 1 to 6 personal computers, peripherals and resident data management software which together provides developing countries with the capability to digitize and better use their climatological data. The resulting climate information can be used for better management of each country's agricultural, hydrologic and other natural resources. It is also important in determining the potential impact of the changing global climate. The U.S. VCP has provided major funding for the original development of the data management software and also funded hardware and training for installation of CLICOM in countries in Africa, Central and South America. The system has been installed in 100 countries with funding coming from France, Finland, the United Kingdom, the United States and the United Nations Development Program. Fifteen instructors have been trained and nearly 150 systems are in use.

Planned VCP activities for FY 1993 include:

- Continued support for data collection and telecommunications capabilities in Africa;
- Implementation and updating of surface and upper-air observational programs in the tropics, the Southern Hemisphere, and Africa as resources and priorities permit;
- Support for first year operating costs and equipment for WAFS/RA-IV WWW satellite communications;
- Provision of user terminals for WAFS/RA-IV WWW communications to several Caribbean nations;
- Continued support for the implementation of VCP projects in Latin America and the Caribbean areas in support of the hurricane and tropical storm programs;
- Installation and training on the CLICOM climate data management system for countries in Africa, Central and South America, Asia, and Eastern Europe; and maintenance of the software for the WMO.

BILATERAL AND REGIONAL INTERNATIONAL COOPERATIVE PROGRAMS

United States - Peoples Republic of China (PRC) Protocol in Atmospheric Sciences

This US - PRC Protocol has provided a broad diversity of both research and operational activities over more than a decade. Program areas include monsoon studies, techniques for forecasting torrential rains, climate studies, mesoscale meteorology, Tropical Ocean Global Atmosphere (TOGA) research, satellite meteorology, and the training and participation program.

Over the past year, collaborative efforts with visiting PRC experts took place in the areas of tree-ring collection and analysis and in paleoclimatic research. A Climate Dynamics Workshop was held in Washington D.C., with eight PRC scientists attending. Two U.S. heavy-rain experts lectured throughout China to assist the PRC in developing its PC-based technology. Within the mesoscale meteorology program, two PRC scientists participated in the one-month WSR-88D Doppler radar training course, while one U.S. expert lectured in China on mesoscale modeling. The Third Joint Mesoscale Meteorology Workshop was held in August 1992, in the PRC, with 12 U.S. scientists participating. In the area of satellite meteorology, a senior PRC scientist is working in the

U.S. on incorporating PRC data sets into the existing records at the U.S. National Climate Data Center. Several U.S. experts on geostationary image navigation, ground system data processing techniques, and satellite monitoring of mesoscale systems lectured in China. In atmospheric chemistry, both U.S. and PRC scientists jointly conducted intensive ground-based observations at Lin An station in support of the GTE/PEM-WEST flight made in October 1991.

Four Chinese scientists attended a workshop on atmospheric chemistry modeling in the spring 1992. Within the Tropical Ocean and Global Atmosphere (TOGA) program, a PRC scientist is spending a year in the U.S. on coupled ocean-atmosphere modeling and El-Nino Southern Oscillation (ENSO) prediction. The Training and Participation Program hosted five Chinese trainees in the fields of hurricane operations and modeling, weather service management, advanced weather interactive processing systems, and fire weather forecasting. Six additional Chinese will be studying advanced weather interactive processing workstation development beginning in the spring of 1993.

APPENDIX F

SELECTED ACRONYMS AND ABBREVIATIONS

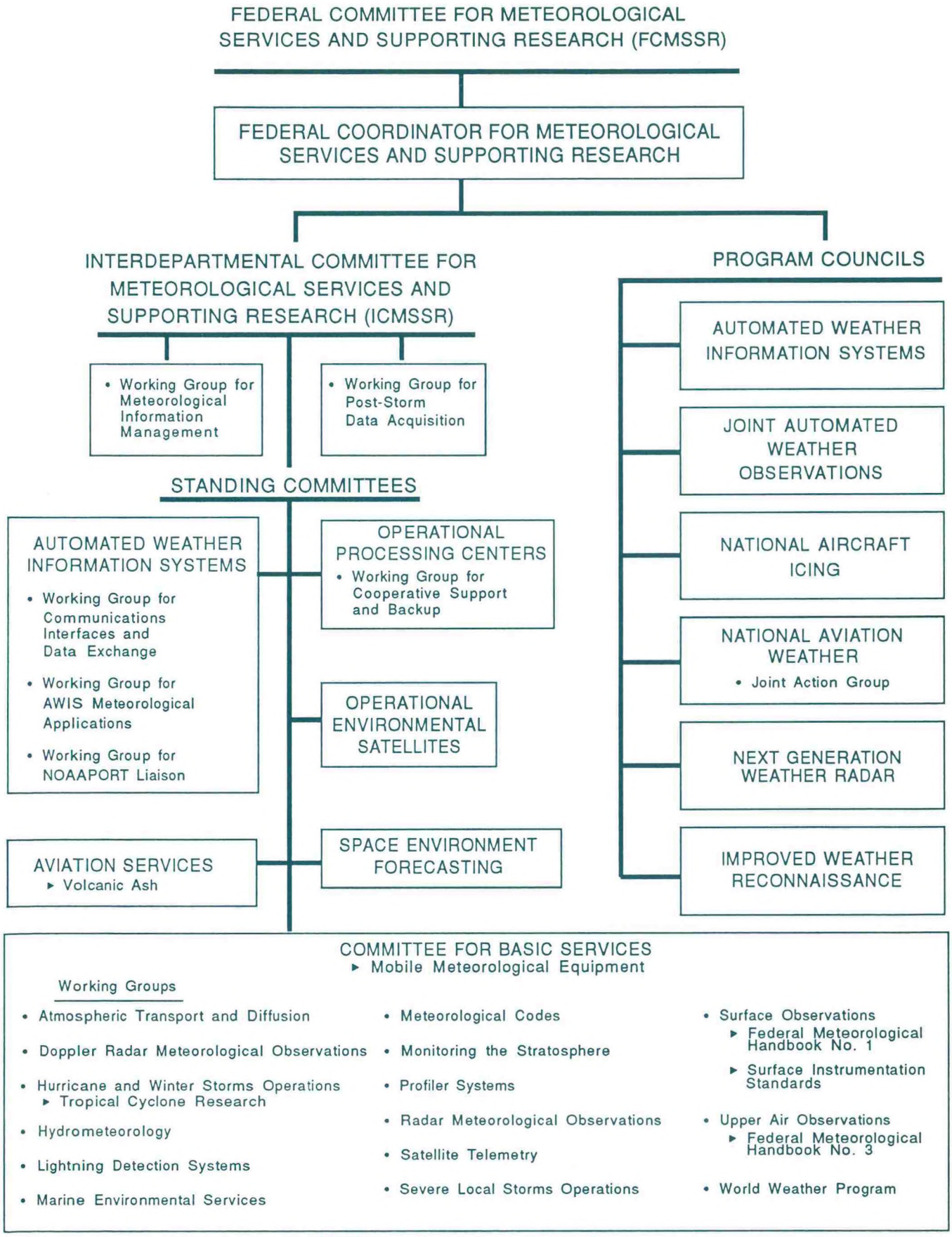
ADAS	AWOS/ASOS Data Acquisition System (FAA)
ADLP	Aeronautical Data Link Program (FAA)
AF	Air Force (USAF)
AFB	Air Force Base
AFCC	Air Force Communications Command
AFGWC	Air Force Global Weather Central
AFOS	Automation of Field Operations and Services (NOAA/NWS)
AFRES	Air Force Reserve
AFS	Air Force Station
AFSFC	Air Force Space Forecast Center
AFSS	Automated Flight Service Station (FAA)
AI	Artificial Intelligence
AIP	Airport Improvement Program (FAA)
ALBE	AirLand Battlefield Environment (Army)
AOC	Aircraft Operations Center (NOAA)
AMR	Aircraft Microwave Refractometer
ARGOS	French Satellite Data Collection System
ARSR	Air Route Surveillance Radar (FAA)
ARTCC	Air Route Traffic Control Center (FAA)
ASL	Atmospheric Sciences Laboratory (Army)
ASOS	Automated Surface Observing System (NOAA)
ASR	Airport Surveillance Radar (FAA)
ATC	Air Traffic Control (FAA)
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
AWDS	Automated Weather Distribution System (USAF)
AWIPS	Advanced Weather Interactive Processing Systems (NOAA)
AWIS	Automated Weather Information Systems
AWOS	Automated Weather Observing System (FAA)
AWN	Automated Weather Network
AWS	Air Weather Service (USAF)
CAC	Climate Analysis Center (NOAA/NWS)
CAS	Committee for Aviation Services (OFCM)
CAT	Clear Air Turbulence
CAWIS	Committee for Automated Weather Information Systems (OFCM)
CBL	Computer-Based Learning
CBS	Committee for Basic Services (OFCM)
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CECOM	Communications and Electronics Command (Army)
COES	Committee for Operational Environmental Satellites (OFCM)
COMET	Cooperative Program for Operational Meteorology, Education and Training
CONUS	Continental United States
CSEF	Committee for Space Environment Forecasting (OFCM)
CWP	Central Weather Processor (FAA)
CWSU	Center Weather Service Unit (FAA)
DACS	Data Acquisition and Control Subsystem (NOAA/NESDIS)

DCPLS	Data Collection and Platform Location System (NOAA/NESDIS)
DCS	Data Collection System (NOAA/NESDIS)
DDN	Defense Data Network (DOD)
DIFAS	Digital Ice Forecasting and Analysis System (USN)
DLP	Data Link Processor (FAA)
DMSP	Defense Meteorological Satellite Program (DOD)
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 (NOAA/NESDIS)
DUAT	Direct User Access Terminal (FAA)
EO	Electro-Optical
EOSAEL	Electro-Optical Systems Atmospheric Effects Library
EPA	Environmental Protection Agency
ERBE	Earth Radiation Budget Experiment (NOAA/NESDIS)
ERL	Environmental Research Laboratories (NOAA)
FAA	Federal Aviation Administration
FCMSSR	Federal Committee for Meteorological Services and Supporting Research
FEMA	Federal Emergency Management Agency
FNOC	Fleet Numerical Oceanography Center (USN)
FSAS	Flight Service Automation System (FAA)
FY	Fiscal Year
GARP	Global Atmospheric Research Program
GDPS	Global Data Processing System (WWP)
GOES	Geostationary Operational Environmental Satellite (NOAA)
GOS	Global Observing System (WWP)
GSFC	Goddard Space Flight Center (NASA)
GTS	Global Telecommunications System (WWP)
GWDS	Graphics Weather Displays Systems (FAA)
HIRS/2	Modified High-resolution Infrared Sounder (NOAA)
HRPT	High Resolution Picture Transmission (NOAA)
ICMSSR	Interdepartmental Committee for Meteorological Services and Supporting Research
ICSU	International Council of Scientific Unions
IMETS	Integrated Meteorological System (Army)
IR	Infrared
ITOS	Improved TIROS Operational Satellite (NOAA)
IWRS	Improved Weather Reconnaissance Systems
JAWOP	Joint Automated Weather Observation Program
JTWC	Joint Typhoon Warning Center (USAF/USN)
LLWAS	Low Level Wind Shear Alert System (FAA)

M	Million
McIDAS	Man-computer Interactive Data Access System
MET	Mobile Environmental Teams (USN)
METOC	Meteorological/Oceanographic (USN/USAF)
MMS	Meteorological Measuring System (Army)
MOA	Memorandum of Agreement
MSU	Microwave Sounding Unit
MWP	Meteorological Weather Processor (FAA)
NADIN	National Airspace Data Interchange Network (FAA)
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NBC	Nuclear, Biological, and Chemical
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center (NOAA)
NDBC	National Data Buoy Center (NOAA)
NEDN	Naval Environmental Data Network (USN)
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NEXRAD	Next Generation Weather Radar Program (WSR-88D)
NGDC	National Geophysical Data Center (NOAA)
NHC	National Hurricane Center (NOAA)
NMC	National Meteorological Center (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NOC	Naval Oceanography Command (USN)
NODC	National Oceanographic Data Center (NOAA)
NODDES	Naval Oceanographic Data Distribution and Expansion System (USN)
NOGAPS	Navy Operational Global Atmospheric Prediction System
NOMSS	Naval Oceanographic and Meteorological Support System (USN)
NORAPS	Navy Operational Regional Atmospheric Prediction System
NOTAM	Notice to Airmen
NRC	Nuclear Regulatory Commission
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center (NOAA)
NSSL	National Severe Storms Laboratory (NOAA)
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
OPARS	Optimum Path Aircraft Routing System (USN)
PATWAS	Pilot Automatic Telephone Weather Service (FAA)
PL/GP	Phillips Laboratory, Geophysics Directorate (DOD/AFSC)
POPS	Primary Oceanographic Prediction System (USN)
PROFS	Program for Regional Observing and Forecasting Service (NOAA/ERL)
PUP	Principal User Processor (NEXRAD)
R&D	Research and Development
RD/T&E	Research and Development, Test and Evaluation
RFC	River Forecast Center (NOAA/NWS)

RVR	Runway Visual Range (FAA)
RWP	Real-time Weather Processor (FAA)
SATCOM	Satellite Communications System (NOAA)
SBUV	Solar Backscatter Ultraviolet Instrument (NOAA)
SDHS	Satellite Data Handling System (DOD/USAF)
SEM	Space Environment Monitor (NOAA)
SFDF	Satellite Field Distribution Facility (NOAA/NWS)
SMOOS	Shipboard Meteorological and Oceanographic Observing Sensor (USN)
SOCC	Satellite Operations Control Center (NOAA/NESDIS)
SSU	Stratospheric Sounding Unit (NOAA)
STIWG	Satellite Telemetry Interagency Working Group (OFCM)
SWIS	Satellite Weather Information System (NOAA/NWS)
T & PD	Training and Professional Development
TDWR	Terminal Doppler Weather Radar
TDA	Tactical Decision Aid
TESS	Tactical Environmental Support System (USN)
TIROS	Television Infrared Observation Satellite (NOAA)
TOGA	Tropical Ocean and Global Atmosphere
TOVS	TIROS N Operational Vertical Sounder (NOAA)
TRADOC	Training and Doctrine Command (Army)
UAV	Unmanned Aerial Vehicles (Army)
UN	United Nations
USAF	U.S. Air Force
USAFETAC	USAF Environmental Technical Applications Center
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USN	U.S. Navy
UTC	Universal Coordinated Time (US usage)
VAS	VISSR Atmospheric Sounder
VHF	Very High Frequency
VHRR	Very High Resolution Radiometer
VISSR	Visible and Infrared Spin Scan Radiometer
VRS	Voice Response System
WEFAX	Weather Facsimile
WMC	World Meteorological Center(s)
WMO	World Meteorological Organization
WMSCR	Weather Message Switching Center Replacement (FAA)
WRP	Weather Research Program (NOAA)
WSCMO	Weather Service Contract Meteorological Office (NOAA/NWS)
WSFO	Weather Service Forecast Office (NOAA/NWS)
WSMO	Weather Service Meteorological Office (NOAA/NWS)
WSO	Weather Service Office (NOAA/NWS)
WSR-88D	Weather Surveillance Radar (NEXRAD)
WWP	World Weather Program
WWW	World Weather Watch

☆ U.S. GOVERNMENT PRINTING OFFICE: 1993— 341-834/ 83089



MAY 1993

LEGEND:
- • Designates a Working Group
- ▸ Designates an Ad Hoc Group or a Task Group