NATIONAL WEATHER SERVICE

Office of Meteorology

NWS PROGRAM SURVEY

The 1990's -
A Decade of Change

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U.S. DEPARTMENT OF COMMERCE
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1.0 INTRODUCTION

The National Weather Service (NWS) has begun a far-reaching modernization which will be completed during the 1990s. NWS products and services, indeed the NWS itself, will change profoundly as technology enables improvements in observations, interactive processing and telecommunications. The key to the efficient NWS use of advances in these fields will be the use of computer technology. The revolution in mini and microcomputers has already enabled NWS to speed up its preparation of warnings and forecasts and to disseminate them more quickly, to the benefit of a growing community of increasingly sophisticated users.

This report describes the uses of technology in the operations of the NWS. It has been compiled by the NWS Office of Meteorology with the assistance of many segments of the NWS. Like its predecessors, it will quickly become out of date in the sense of specific dates and schedules. Yet, this report should be a valuable source of general information on NWS operations and programs.

The information contained in this report is current as of mid 1990. The mention of a specific company or commercial product does not constitute or imply endorsement by the NWS.

1.1 Previous Versions of this Report

National Weather Service, 1981. "Technology Assessment for the 1980's and Projections for the 1990's." Office of Meteorology, Silver Spring, MD, May 1981. 21pp.

National Weather Service, 1986. "NWS Program Survey: An Inventory of Technological Advances." Office of Meteorology, Silver Spring, MD, May 1986. 42pp.

National Weather Service, 1988. "NWS Program Survey: Continuing Advances in Technology." Office of Meteorology, Silver Spring, MD, June 1988. 44pp.

2.0 ATMOSPHERIC OBSERVATIONS

Measurements of meteorological and hydrological parameters, such as temperature, moisture, pressure, wind, and rainfall, are the basis for production of NWS warnings and forecasts, as well as the cornerstone of climatology. The NWS will continue to support programs that provide weather observations, both nationwide and worldwide. In keeping with cost-conscious trends in government, the NWS will seek to increase the automation of its observational functions.

2.1 Surface Observations

The NWS surface observation program involves more than 1,200 people and annually consumes over 300 staff years. Automating the observations procedure as much as possible offers a greater opportunity to use personnel more efficiently while taking advantage of advances in technology. This is critical since NWS will require more observational data in the coming years as it seeks to focus on subsynoptic scale weather systems, which often may not be adequately detected by current observational networks.

2.1.1 Hydrologic Observing Networks

NWS hydrologists have used observational data from a variety of sources over the years, including: cooperative weather observers from the NWS and the Department of Agriculture; river gauging sites of the NWS, U.S. Geological Survey (USGS), and the Corps of Engineers (COE); surface aviation reports from NWS, Federal Aviation Administration (FAA) and Department of Defense (DOD); and the Automatic Hydrologic Observing Systems (AHOS), in which some 1100 stations report river and rainfall observations via land line or satellite. Recently, automated hydrometeorological observing systems (LFWS; section 2.1.2) owned and operated by local, state and other Federal Government agencies have provided data to NWS field sites. While the ever-increasing amounts of data have been quite useful to NWS, there have been several areas of concern; the data have been in different formats; data bases have been located in widely dispersed sites; and the functions of the instrument sensors often have not included the provision of data exclusively for hydrometeorological purposes. The NWS, in its attempts to modernize and streamline its operations, is involved in a number of efforts to address these concerns.

The NWS and the COE have been the primary developers of the Standard Hydrometeorological Exchange Format (SHEF), a standard data coding and exchange method for providing a flexible means of distributing data and information among the many agencies that use hydrometeorological data. The unique SHEF format has also alleviated the problem of varied data formats from the many sources of hydrometeorological data used by the NWS.

One of the vital components of the current hydrometeorological observing systems continues to be cooperative observer networks (Section 2.1.3). Despite their importance, the cooperative networks have had several major deficiencies. For example, some observers only report when rainfall in the last 24 hours ending at 7:00 a.m. exceeds 0.5 inches. Another deficiency is that the reports are telephoned in to a service hydrologist or a hydrologic technician at a Weather Service Forecast Office (WSFO), a process that is time-consuming, error-prone, and not cost-effective. Some of the inefficiency from the data collection procedure has been removed by a data collection system in which the observers enter their data via touch-tone telephone, a memory telephone or a computer, into a minicomputer. Other automation efforts are being led by federal and state agencies which operate hydrologic observing networks, two of which are the COE and USGS. Many of these agencies' gauges report hourly data through the GOES Data Collection Systems (DCS) to ground stations operated by various state and federal agencies. To improve the timeliness of automated reports, a program is under way to make observational data available through emergency channels from the satellite, which will include event or criterion generated reports in near real-time.

Automated NWS hydrometeorological stations such as AHOS have, until recently, been designed to provide data only at six-hourly intervals (synoptic times) because NWS hydrological and meteorological operations have historically been focused upon the use of observations taken at those times. As a result of these time requirements, communications problems often developed, in part because of the volume of data flowing to NWS River Forecast Centers (RFC) at synoptic times. So much data were transmitted to the RFCs that several hours were needed to receive and process the data. Recent developments in NWS hydrometeorological sensors and in communications methods are leading to the establishment of networks of event-based, self-reporting sensors and communications channels. These systems ease the communications loads at RFCs because only new information is sent from the gauges. The required synoptic six-hourly data for forecast model input can be interpolated with sufficient resolution from the event-generated observations. An added benefit of these systems is that the current site status is always known, within small time increments.

The current network of NWS and FAA synoptic and basic weather observing stations is another major source of hydrometeorological information. Synoptic data are included in the basic observation every three hours. The Automated Surface Observing System (ASOS), section 2.1.5, will enable increasing amounts of automated observational data to be disseminated every hour via AFOS. When fully implemented, the ASOS network will approximately triple the size of the current basic observational network. The expansion of the basic observational network will provide additional data for hydrologic forecast models, and this will lead to improvements in short and long term river forecasts. In addition, ASOS criteria-based and hourly routine precipitation reports in SHEF will be available to NWS field offices to support the flood forecast and warning program and to adjust precipitation estimates from radar respectively.

2.1.2 Local Flood Warning Systems (LFWS)

There are over 20,000 communities and recreational areas identified by the Federal Emergency Management Agency (FEMA) as flood prone. The NWS hydrometeorological services provide 3,100 communities with site specific flood forecasts and warnings. These communities are, in general, located along the Nation's larger rivers. The NWS provides forecast and warning service to the remaining communities via its flash flood watch and warning programs.

While relying on NWS watch/warning information, communities (usually in cooperation with the NWS) can reduce the flood risk by establishing a Local Flood Warning System (LFWS). Timely collection of detailed information on local rainfall and/or stream levels allows more accurate and reliable predictions of floods for small watersheds by either the NWS or some local agency. Predictions of floods locally, either by a NWS office in the area or by a community agency, reduces problems with communications and usually enables more frequent updating of predictions. About 1000 LFWSs were operating as of early 1990.

LFWSs of various types and levels of sophistication exists to meet community needs. The basic parts of a LFWS are:

(1) The warning system, consisting of the equipment, people, and procedures for recognizing an impending flood and disseminating warnings;

(2) A prepared plan of action to be taken before and during the flood;

(3) Arrangements for maintenance and updating of equipment and plans.

The NWS, as its resources permit, provides technical and forecast assistance to communities that seek to establish LFWSs. LFWSs are generally classified as manual self-help, or automated LFWSs. Systems which primarily rely on radio reporting hydrometeorological sensors and which use small computers to analyze data and run forecast procedures are classified as automated systems.

2.1.2.1 Manual Self-help LFWSs

To date most LFWSs are of this type. They consist of a local data collection system, a community flood coordinator, a simple-to-use flood forecast procedure, a communications network, and an emergency action plan. The data sensors may range from rain and river gauges read by volunteers to automatic rainfall and stream gauges in remote or sparsely settled areas. Such an LFWS may be as elementary as a single gauging site for a small basin and serving a single town. The main characteristic of the systems is that virtually all of the warning and forecast procedures are done by community volunteers.

2.1.2.2 Automated LFWSs

Recent technological advances and decreasing costs in computerized systems have sparked a steady growth in automated LFWSs. Two of the more prominent systems are ALERT and IFLOWS which are described below.

Automated Local Evaluation in Real Time (ALERT): The ALERT system was developed by the California-Nevada RFC in Sacramento, CA, and consists of automated event-reporting river and precipitation gauges, automated data-collection and processing equipment, a hydrologic model, hydrometeorological analysis, and software for processing, communications and display. The precipitation gauges are modular, self-contained units. A tipping bucket mechanism causes transmission of a radio signal containing the station identifier and an accumulated precipitation value when 1 millimeter of precipitation is detected. The river gauge transmits preselected incremental changes in river elevation, using the same electronics as in the precipitation gauge. Both gauges are powered by self-contained batteries. Data collection and processing hardware consist of a radio receiver to collect event-reported radio signals, and a dedicated microcomputer system. Radio transmissions from the gauge locations to the local agency are line-of-sight. The data collection systems operate continuously in a fully automatic mode, receiving data and processing information for display, including precipitation maps, to the user. A streamflow simulation model can provide updated streamflow forecasts every twelve minutes.

Integrated Flood Observing and Warning Systems (IFLOWS): The NWS, in cooperation with the Appalachia Regional Commission, the Tennessee Valley Authority, and the States of Kentucky, Virginia, Pennsylvania, West Virginia, North Carolina, and Tennessee, has implemented a prototype IFLOWS. This system combines event-reporting sensors, data and voice communications, and minicomputer technology to each county in a 180-county region covering the states noted. Data, forecasts, and warning products are distributed to state and county authorities responsible for the provision of emergency services to people in flood-threatened areas. NWS offices are directly linked to IFLOWS. The sensors trigger the transmission of radio signals that include the station identifiers and values of the monitored parameters. The sensors and transmitter are battery-powered. Radio transmissions for the sensors are line-of-sight to receivers which relay the information via microwave radio to the dedicated central processing minicomputer. The counties and communities can receive warnings, forecasts, and data over this same communications system. IFLOWS operates continuously to monitor local conditions for the counties and communities and for NWS offices in the IFLOWS region.

2.1.3 NWS Cooperative Observer Networks

Approximately 11,500 cooperative observers record daily temperature and precipitation data and mail their records to the National Climatic Data Center (NCDC) each month. NCDC archives and publishes these data monthly in "Climatological Data" and "Hourly Precipitation Data." Over 5,000 of these observers, in the hydrological part of the network, also report precipitation and/or river level data in real time to NWS offices by phone. Some report daily; others only when certain criteria are met. In addition, some of these observers serve as severe weather spotters when severe weather threatens or is observed.

Many real time reports are sent by voice telephone, often at times when NWS personnel are the busiest, preparing flash flood or severe weather watches and warnings. Recording, encoding, and transmitting these reports is time-consuming and labor-intensive. As a result, in the early 1980s the NWS Central Region developed a method by which observers report directly to computers via Touch-Tone telephones. This system, called Remote Observation System Automation (ROSA), now formats and sends an average of 8,000 weekly observations to NWS field offices via the Automation of Field Operations and Services (AFOS) communication system. Beginning in the mid-1980s the Southern Region instituted a similar program known as the Automated Tone Dial Data Collection System (ATDDCS). Installation of the ROSA system began in the Western and Eastern Region in 1990.

2.1.4 Snow Survey Using Passive Sensors

A current operational NWS program uses aircraft-borne sensors to measure terrestrial gamma radiation, which is attenuated by water mass in snow and by soil moisture in the upper 20 cm. This program operates over 1,078 flight lines, covering 16 states between Maine and Montana, as well as 5 Canadian provinces, during the fall and winter. The area scanned covers river basins outside the operational field area subject to snowmelt flood problems. Snow water equivalent and soil moisture data are available to the public, and the program is coordinated among several U.S. and Canadian agencies.

2.1.5 Automation of Surface Observations Program (ASOP)

Several automated observing systems have seen fairly widespread though limited use in the NWS for a number of years. AHOS (Section 2.1.1) is one, and another is a series of Automatic Meteorological Observing Stations (AMOS) sites, which provide hourly observations of temperature, pressure, and wind, primarily for surface aviation observations. Other parameters necessary for aviation interests, such as ceiling, visibility, occurrence and type of precipitation, and remarks, must be added manually to AMOS reports. About 50 AMOS sites and 50 Remote AMOS (RAMOS) sites are operational.

Recent advances in sensor and microprocessor technology have made it possible to more fully automate the surface observation. To seize the opportunity presented by these advances, the NWS has established the Automation of Surface Observations Program (ASOP). Its goal is to implement Automated Surface Observation System (ASOS) at all NWS primary observing stations.

The NWS has assumed the lead role in the purchase of up to 1,700 ASOS units which will be deployed by the NWS, the FAA and the U.S. Navy. To meet the common requirements of these agencies, the NWS will design, procure, install, operate, and maintain ASOS for both the NWS and the FAA, and provide a level of logistics support to the Navy as well.

ASOS is a key element in the NWS plan for modernization and field restructuring. It will help the NWS to meet increasing demands for airport weather observations without adding staff. The NWS plans to implement ASOS at about 250 of its primary observing stations, which are mostly WSO and WSFO locations.

As part of its National Air Space modernization, the FAA has a firm requirement for at least 592 ASOSs and a potential requirement for an additional 204 systems. Two operational applications are planned:

- A non-towered or small-airport application -- the intent of this program is to provide ASOS at small, general-aviation airports that have approved instrument approaches but are currently without weather observations. The FAA has identified an urgent need for ASOS at 233 such airports; installation at another 204 small airports is possible.

- A towered or large-airport application -- the intent of the towered program is to provide weather observations for 359 airports at which air traffic control facilities or Flight Service Stations (FSS) currently take weather observations.

NWS and FAA installations are scheduled to begin in 1991 at sites for the Modernization and Restructuring Demonstration (MARD) in the Central Region and to be completed nationwide by 1994. The implementation schedule calls for the initial 233 FAA small airport systems to be in service by late 1992.

A primary benefit of the consolidated federal ASOS program will be the significant improvement in overall national coverage; this in turn will contribute to improved aviation safety and to better public warnings and forecasts by providing observations 24 hours a day, producing better and standardized observations of visibility and sky condition, providing a continuous weather watch and rapid alert of significant weather changes, and allowing for remote maintenance monitoring.

ASOS will automate the observing process, including measurement of weather elements, data processing, display, communication, and archiving functions. It will provide accurate weather information for weather forecasters, pilots, air traffic personnel, and others. ASOS will be a flexible and modular system capable of being displayed in a variety of configurations and operated with or without the attendance of an observer. Unattended, it will automatically collect, process, ensure the quality of, format, display, archive, and transmit the weather elements required for a surface weather observation. ASOS will also accept inputs from human observers who may override or add information to the automatically generated observation.

The NWS, the FAA, and components of the DOD have interdependent observing programs which need to be coordinated. The Joint Automated Weather Observing Program (JAWOP) was established to coordinate observing policy, sensor development and implementation planning among the agencies. Coordination of JAWOP efforts is done by the JAWOP Council, which is chaired by the Federal Coordinator for Meteorology. The Council addresses policy level program scope, agency requirements, resource commitments, and agency support to the joint program. It provides oversight and policy guidance to assure that the interests of each department are addressed. A JAWOP Action Group has been established to implement the guidance and direction set by the Council.

The NWS and FAA are developing plans for 1) comprehensive quality control of ASOS observations, 2) adding limited additional information by human observers to ASOS observations at limited locations, 3) using remote sensing information to complement ASOS observations and 4) using information from other surface observing networks to supplement ASOS.

2.1.6 In-Situ Coastal and Marine Observations

Synoptic-scale weather forecasting requires observational data from all regions of the globe. However, it has historically been difficult to receive weather information from the 72 percent of the planet covered by the oceans. With the assistance of automation, cooperative programs, and satellites, steps are being taken to fill these "silent areas" so that weather forecasting on a worldwide basis may be more accurate. In this section, several programs conducted or assisted by the NWS, are described in which efforts are made to provide improved weather observations over the oceans.

2.1.6.1 Ship Observations

Until the 1970s, commercial ships were virtually the only source of weather observations on the high seas. While ship reports are still an important element of marine weather analysis and forecasting, their weather and oceanographic observations have come to play a large role in environmental monitoring and climatology. In addition, ship data provide ground truth for observational programs that depend on automated or satellite sensors. The NWS will continue to require ship reports for all its marine warning and forecast programs.

The international Voluntary Observing Ship (VOS) program, using the general structure and the observational codes recommended by the World Meteorological Organization (WMO), counts more than 7,400 participating ships from 54 countries; the U.S. is the largest free-world participator. Worldwide, the VOS produces over 120,000 surface synoptic observations each month. VOS vessels report the standard meteorological parameters; some also record oceanographic parameters such as subsurface temperature, oxygen content, salinity, and ocean-current data, using a variety of conventional and experimental devices. The ship reports are communicated to collection centers, and ultimately to the National Meteorological Center (NMC), by a wide spectrum of methods ranging from ancient to modern. Although future emphasis will be on technological improvements to communication, it is not unreasonable to expect this wide variety of communications modes to continue. These modes include; Morse code; voice transmissions on radio, including observations in synoptic code and unformatted, plain-language MArine REPort (MAREP); Simplex Teletype Over Radio (SITOR); the Shipboard Environmental Data Acquisition System (SEAS), which prompts the observer, prepares meteorological and bathymetric information, and sends these data by GOES satellite; and the INternational MARitime SATellite program (INMARSAT).

2.1.6.2 Deep Ocean Moored Buoys (DOMB)

A system of 40 DOMBs reports wind speed and direction, maximum wind gust, air pressure and temperature, sea-surface temperature, and wave spectra. These buoys are moored in areas seaward of the continental shelf in the Atlantic and Pacific Oceans and the Gulf of Mexico. Eight more DOMBs operate in the Great Lakes. This system began with the experimental buoy program of the early 1970s in combination with other existing and planned marine data systems. It represents a sizable contribution to the NWS warning and forecast services within the U.S. 200-mile economic zone. DOMB observations are part of the database of the WMO's world climate programs. The real beneficiaries of moored buoy data are the recipients of the more accurate coastal, Great Lakes, or oceanic warnings and forecasts that are the result of data buoy reports. Those who benefit most from the improved marine forecasts are marine transportation groups, fishermen, the boating public, and other individuals engaged in varied offshore engineering activities. Also, the importance of ground truth for observational programs that depend on automated or satellite sensors, and the need for subsurface oceanic data, will probably necessitate a continued program of DOMBs, particularly to complement ship and satellite data.

2.1.6.3 Coastal Marine Automation Network (C-MAN)

The NWS uses marine reports from 172 U.S. Coast Guard manned or fully automated stations. The data flow through a high-speed collection network to the NWS, which disseminates the reports via AFOS. The Coast Guard, which has provided weather observations to the NWS for decades, allows the NWS to install automated observing systems at its sites. The NWS and the NOAA Data Buoy Center (NDBC) began development of the C-MAN program in 1981. The intent was to instal sensors, payloads, and satellite communications equipment, similar to the instrumentation on ocean buoys, at about 100 coastal headland stations and 8 Large Navigational Buoys (LNB, former lightships). The existing C-MAN network consists of 9 LNB's and 40 fixed stations. The 40 fixed stations consist of 9 USCG offshore platforms, 19 USCG lighthouses, 8 beach areas, and four exposed fishing piers.

Automation of additional sites will depend on the outcome of future budget initiatives.

With assistance from the U.S. Navy, the U.S. Department of the Interior, and the NWS Pacific Region, the NDBC is installing a network of stations on islands in the Western Pacific. Three stations have thus far been installed. A network of 20 stations is expected to be operational by 1992.

2.1.6.4 Drifting Buoys

Expendable drifting buoys can provide reliable, inexpensive measurements of wind speed and direction, air pressure and air temperature. They also can provide sea surface and subsurface temperature, hydrostatic pressure to a depth of 600 meters, and ocean-current data. All data are transmitted via the NOAA polar orbiting satellite system. Drifting buoys are ideal for collecting data from ocean areas not regularly transited by ships and not covered by a moored-buoy network. Drifting buoys have proven their utility during several research and forecasting activities beginning with the First GARP Global Experiment (FGGE) in the late 1970's, as well as operational deployments in the subtropical Atlantic and Pacific Oceans for the Tropical Ocean Global Atmosphere (TOGA) Experiment. A grid network of 40 operating drifting buoys has been maintained in the remote oceans of the Southern Hemisphere since 1984 and is expected to be maintained for the duration of TOGA, through 1994. The NDBC also maintains an inventory of drifting buoys for emergency use/rapid response situations such as hurricanes and oil spills.

A drifting buoy is designed to report data for one to two years via polar-orbiting satellites. Drifting buoys figure prominently in the future NWS marine observational network because of their reliability and cost.

2.1.6.5 Wave Measurement Systems

Nondirectional wave measurement systems have been standard equipment on NDBC moored buoys for several years. Some buoys, supported by the Coastal Engineering Research Center of the Corps of Engineers, provide directional wave data from the Great Lakes and U.S. coastal waters. The NDBC operated five such buoys in FY 1989. This network will grow to ten in FY 1990, with the prospect of further growth to possibly 20 stations by 1992. Data reported by these buoys are quite useful to NWS Forecast Offices with coastal marine responsibilities. To enhance usefulness, the NDBC is publishing in FY 1990 a Users Guide explaining to meteorologists some of the ways in which the directional wave data may be used.

In recent years, the NDBC has improved the reliability, cost effectiveness, and accuracy of its wave measurement systems. In FY 1990, tests that demonstrate the effectiveness of a new, lower-cost method for measuring directional wave data have been completed. This advance in technology promises to lower the operating costs for buoys of the sizes now used. Furthermore, the smaller sensors required by this new system will allow smaller and less expensive buoys, measuring directional wave data only, to be constructed. This advance will ultimately increase the geographical coverage for directional wave measurements, while maintaining lower network costs.

2.1.7 Surface based Lightning Detection Systems

Radar and satellite observations can indicate areas of probable thunderstorm activity. But beyond the likelihood that a thunderstorm is occurring somewhere, no information is available from these sources concerning the amount of electrical activity in a thunderstorm. Surface airways observers attempt to describe the degree of electrical activity when a thunderstorm is near the observing site. This information is useful to interests in the immediate area of the observation at the time. In recent years, NWS has made a concerted effort to determine the areal extent, distribution, frequency, and intensity of electrical activity in thunderstorms, and to attempt to evaluate the utility of this information in the NWS mission.

NWS efforts at lightning location methods date from the early 1960s, using radio devices to locate static electricity discharged by lightning strokes (sferics). Since 1977, the U.S. Bureau of Land Management (BLM) has operated an Automatic Lightning Detection System (ALDS) in the western United States. The ALDS was installed for BLM and other land management agencies to detect lightning-caused wildfires; but NWS has been able to obtain the lightning stroke data on an experimental basis for its forecast operations. The ALDS network consists of 12 position analyzers and about 30 direction finders, with an effective range of 400 km. Virtually the entire western U.S. is covered by this network. The direction finders observe the direction of the lightning stroke and the magnitude of its electromagnetic signal. They perform waveform matching to determine if a stroke was a cloud-to-ground or cloud-to-cloud stroke. The lightning stroke's location is computed by triangulation using the received direction and magnitude from two direction finders. Real-time data (every half hour) and accumulated data (every 24 hours) are sent from the Boise Interagency Fire Center in Boise, ID, to NWS Western Region (WR) Headquarters in Salt Lake City, UT. The processed data are then sent to the WR AFOS loop. Data consist of mapped stroke location and intensity; the intensity is available in both digital and contoured forms. These data have, since 1983, been distributed to all WR WSFOs and WSOs. Additionally, they may be accessed throughout the AFOS network.

The ALDS data have been useful to the NWS in a number of ways. In the WR, continuous areal radar coverage is not available because of the mountains; ALDS has enabled forecasters to locate areas of thunderstorms in these areas. ALDS has helped forecasters to distinguish thunderstorms from non-thunderstorm clouds and to detect thunderstorms embedded within dense cloud masses. Ongoing research studies are attempting to relate lightning frequency to rainfall rate.

A network similar to the BLM network has been established in the eastern U.S. What began as a small research network in the Northeast U.S. has now expanded to a large-scale quasi-operational network covering most of the U.S. east of the Rockies. The direction finders in the network are controlled by a computer at the State University of New York at Albany (SUNYA).

A major step was taken by Federal agencies in 1987 to establish an experimental national network in cooperation with SUNYA. The experiment centers around a proposal by SUNYA to collect and merge data from their network along with data from the BLM and National Severe Storm Laboratory (NSSL) networks. Agencies access data at the agencies' cost for evaluation purposes during the course of the three-year effort which was recently extended into 1991.

Results to date have convinced the NWS of the value of lightning data, and plans are being made to acquire operational data by 1991 through a competitive procurement. Meanwhile, the NWS has access to privately developed networks of lightning detection systems. Networks of lightning detection sensors also operate in Alaska and Canada, as well as other countries. Smaller networks operate in Colorado, Texas, Florida and other locations.

2.2 Upper-Air Observations

The rawinsonde network is the foundation of NWS upper-air analyses and forecasts. Observations from automatic remote sensors -- profilers and satellites -- will be increasingly useful with time.

2.2.1 Conventional Atmospheric Soundings

Upper-air observations over land, obtained by balloon-borne radiosondes having temperature, pressure, and relative humidity sensors, remain the foundation of NWS basic meteorological analyses and numerical weather prediction. This network of 114 units, which dates from the 1940s and 1950s, provides the ground truth for other types of sounders such as profilers and satellite sensors. Its importance will be undiminished, but in the interest of reducing errors and cost, the network will become increasingly automated.

The Automatic Radio Theodolite (ART) program is designed to upgrade and automate current upper-air tracking systems. It has replaced outdated subassemblies with solid-state modules and other equipment to allow automatic operation. Full automation has resulted from computer software that recognizes the meteorological data transmitted by a time-commutated radiosonde. ART hardware has been installed at 89 upper-air stations, and ART software is operational at 82 sites. In FY 1990, all upper air stations except Wallops Island, VA replaced their minicomputer with micro ART.

2.2.2 Atmospheric Profilers

NOAA's Environmental Research Laboratories (ERL) have since the late 1970's, investigated the use of ground-based sensing techniques to determine vertical variations of temperature, moisture and wind. Their research has led to the development of surface-based upward pointing sounders known as profilers. The two types are the thermodynamic and wind profilers. A recent development is the addition to the wind profiler of a radio-acoustic sounding system (RASS) which produces measurements of temperature in the lower levels of the atmosphere.

RASS produces detailed profiles of virtual temperature above wind profiler sites every few minutes to within about one degree Celsius of accuracy. The basis of the operation of RASS is a combination of acoustic and radar techniques. RASS uses a coherent radar to measure backscattered radiation from fluctuations in atmospheric density induced by an acoustic source to determine the local speed of sound. This is then related to the virtual temperature in the layer determined by the radar range gate. Wind profilers can measure the clear air signal as well as the RASS signal so that simultaneous measurements of wind and temperature are possible with increased accuracy.

Techniques to produce atmospheric temperature soundings from combined measurements from the ground based systems, RASS and perhaps the microwave radiometer, and satellite based remote sensors are being investigated. These systems are both capable of producing nearly continuous measurements and complement each other at the higher and lower levels of the atmospheric. The resulting temperature profiles are expected to be significantly more accurate and useful than each taken separately. One limitation of thermodynamic profilers, as currently designed, is the serious attenuation of the radiometric signal when rain falls at a rate of more than 5 mm hr-1.

The Wind Profiler Demonstration Project will install and operate an experimental network of 29 wind profilers in the Central and Southern Midwest beginning in late 1990 and continue at least through 1992. As part of the project an Assessment Program was established in 1987. One of its purposes is to better understand how data from the Network can be used in an operational environment to improve NWS forecasts and warnings. An engineering assessment will also be conducted on the individual profilers and the entire network. Results from both assessment efforts will provide the basis for designing and establishing a national network of wind profilers in the middle and late 1990's.

2.2.3 Automated Aircraft Observing and Reporting System

Wide-bodied commercial jet aircraft equipped with sophisticated navigation systems have been flying transcontinental and oceanic routes since the late 1960's. Meteorological observations have been taken and reported manually by air crews for many years. The manual reporting and processing of the data contributed to errors and delays in the receipt of the observations. Over the past decade newer commercial airliners and rapid changes in communications technology have made the automated reporting of meteorological data from aircraft a reality. ACARS and ASDAR are the two principal air-to-ground systems which report meteorological data from commercial aircraft. Hundreds and perhaps thousands of ACARS aircraft will report meteorological data whereas ASDAR equipped aircraft will number less than 25 worldwide.

2.2.3.1 AIRINC Communications Addressing and Reporting Systems (ACARS)

The ARINC (Aeronautical Radio, Incorporated) Communications Addressing and Reporting System (ACARS) is an air-ground data link which is used by the airlines to pass operational information between their aircraft and ground facilities. Aircraft departure and arrival times, fuel loading, aircraft weight and engine performance data are among the many types of information transmitted. On the newer digital commercial aircraft, when augmented with specialized software, ACARS together with other on-board avionics can be used to automatically collect and transmit meteorological data. The meteorological report consists of the aircraft's position (latitude and longitude), altitude, time of the observation, wind, static air temperature and an indicator of turbulence. Normally, in level flight, an observation will be taken once every 7 minutes, but this may vary with different carriers. Eventually, some aircraft will make observations at a higher frequency when ascending or descending at airports so a vertical profile of wind and temperature may be obtained. Data is passed from the aircraft to one or more ground receiving stations on ACARS by means of a line-of-sight VHF radio link. After being collected centrally at ARINC headquarters, it is then processed and sent to the National Meteorological Center where it is used in numerical analyses and models. The ACARS system is limited to those land areas having receiving stations and because it is line-of-sight is not able transmit over long oceanic routes.

2.2.3.2 Aircraft to Satellite Relay (ASDAR)

In the late 1970s, as part of the enlarged observation network for the First GARP Global Experiment, the Aircraft to Satellite Data Relay (ASDAR) System was developed to more fully exploit the potential of obtaining aircraft observations from data sparse ocean areas. This successful demonstration fielded fifteen prototype ASDAR units installed on aircraft of several international carriers. The units provide wind, temperature, time and position data every 7-1/2 minutes (120 km between observations). Reports containing eight observations are transmitted hourly to the ground via the global "system" of geostationary meteorological satellites. ASDAR wind speeds at flight levels are accurate to 3.5 knots, comparable to the accuracy of radiosondes; temperatures are accurate to 1 degree Celsius. Thus ASDAR can produce a high-density set of reliable wind and temperature observations for use by meteorological processing centers within one to two hours of observation time.

An operational ASDAR system, sponsored by a Consortium for ASDAR Development and the World Meteorological Organization, is currently nearing the end of the development stage. In addition to sampling at flight levels, the operational system is capable of providing detailed wind and temperature profiles during both ascent and descent at airports. This new system also has the capability to provide both turbulence and maximum wind sampled with each hourly report. Consortium members purchasing the units will select international carriers for their ASDAR units. While U.S. carriers have no immediate plans to participate, the State Department will purchase units for installation on the airline of a developing nation whose aircraft fly in U.S. airspace. Plans call for approximately 13 ASDAR installations to be in operation by 1991.

The principal limitations of the ASDAR and ACARS systems are that the meteorological information is observed primarily at a single level, and profiles are concentrated near major airports.

By the mid or late 1990's hundreds of long range aircraft equipped with aeronautical satellite communication systems will be flying international and transoceanic routes. Many of these aircraft will provide meteorological data similar to that reported by ACARS and ASDAR. This should substantially improve the upper air coverage over data sparse oceanic and land areas.

2.2.4 Satellite Remote Sensing of the Atmosphere

Meteorological satellites have provided reliable information for more than 25 years. They have become virtually indispensable to the science and practice of meteorology, and future satellites will provide significantly improved information.

NOAA's National Environmental Satellite Data and Information Service (NESDIS) is responsible for the procurement and operation of weather satellites. NWS operations are currently based on having two polar orbiting and two geostationary satellites in orbit. At this time, the NOAA-10 and NOAA-11 polar satellites provide temperature and humidity soundings as well as imagery. One geostationary satellite, GOES-7, is available for imagery and sounding data.

NWS operational use of satellite data in forecasting began in the mid-1960s when NMC began to routinely use Applications Technology Satellite (ATS-3) and polar orbiter mosaic imagery to fill in data-sparse portions of synoptic analyses. In 1972 the first Satellite Field Services Station (SFSS) was established at Washington, DC, collocated with the WSFO. This SFSS provided the first regular uses of satellite data at field locations,supplying interpretation of weather conditions based on still pictures and animated ATS imagery to the WSFO for the local warning and forecast program. In 1974, three more SFSSs were established: at Miami, FL, collocated with the National Hurricane Center (NHC); at Kansas City, MO, collocated with the National Severe Storms Forecast Center (NSSFC); and at San Francisco, CA, collocated with the San Francisco WSFO. At that time, the SFSSs began to be conduits for GOES satellite imagery sent via high quality telephone lines to all WSFOs within the SFSS area of responsibility, and to a growing number of other users, both in the Federal Government and in the private sector.

In 1984, the SFSSs were transferred from NESDIS to NWS. They were subsequently renamed Satellite Field Distribution Facilities (SFDFs). All SFDFs rely on electronic forms of data presentation. A video disc system produces up to 24 hours of data in animated loops. Typically, the SFDF uses TV monitors/ located at the various forecast areas within the collocated NWS facility to display a number of loops as well as the most current image. The SFDF does not transmit loops to users; this capability is available at WSFOs by means of a Satellite Weather Information System (SWIS; refer to Section 4.2) device. The San Francisco SFDF is also equipped with a Digital Weather Image Processing System (DWIPS) and an AVHRR direct readout station. The Anchorage SFDF is also procuring a AVHRR direct readout station.

2.2.4.1 Satellite Imagery

Imagery continues to be the most important product from the satellites. From the earliest images supplied by TV cameras on the Television and InfraRed Observation Satellites (TIROS), imaging technology has progressed to its current state as used by the geostationary and polar-orbiting spacecraft of the late 1980s. The GOES satellite sensor is the VISSR Atmospheric Sounder (VAS), which has three operating modes:

- the Visible/Infrared Spin Scan Radiometer (VISSR) mode, which provides hemispheric visible and one channel IR imagery every half-hour and covers smaller areas at more frequent intervals;

- the multispectral imaging (MSI) mode, which can provide visible and up to four simultaneous IR images selected from the 12 IR channels of the VAS; and

- the dwell-sounding (DS) mode, which provides observations in up to 12 IR spectral channels.

In both the MSI and DS modes, an onboard processor is used to control scanning sequences.

The visible and IR images produced every half hour, as well as the water vapor images produced hourly, are processed, sectorized and enhanced at NESDIS's Central Data Distribution Facility (CDDF) in Camp Springs, MD, and are relayed to WSFOs through the SFDF GOES-TAP communications hubs. Visible and IR imagery produced as often as every five minutes over small areas are sent to NMC, NSSFC and NHC, to support continuous monitoring of rapidly developing severe weather or tropical cyclone activity. SWIS (Section 4.2) provides imaging capabilities to WSFO operations. VAS Data Utilization Centers (VDUC, Section 4.5) have sophisticated imaging capabilities. A VDUC has been installed at NMC, NSSFC and NHC. Imagery from NOAA Polar Orbiting Environmental Satellites (POES) has a very important use in NWS National Center and field operations. Since polar orbiters were technologically feasible for many years before geostationary satellites, NWS has been able to use their imagery in many analysis and forecasting areas -- synoptic analysis and tropical cyclone detection, for example -- over virtually the entire globe for as long as weather satellites have been orbiting. Current NOAA polar satellites provide visible and IR imagery by means of their Advanced Very High Resolution Radiometer (AVHRR) sensor, by limited direct readout or to users of GOES imagery served by the SFDFs. Over high-latitude areas such as Alaska, POES imagery is available through the Anchorage SFDF every 90 minutes with each satellite orbit. POES imagery is quite useful for weather monitoring in these areas because of high earth curvature in GOES imagery at great distances from the satellite subpoint. Polar-orbiter imagery and soundings are also very important to hydrometeorological services and for numerical model initial analysis across all parts of the world.

2.2.4.2 Satellite Sounders

Recognizing that critical gaps in atmospheric data were not limited to the earth's surface, NOAA and NASA have been developing and refining satellite-borne sounders to obtain tropospheric measurements of temperature and moisture. Polar-orbiting sounding sensors were developed experimentally in the early 1970s and have become an important part of operational synoptic upper-air analysis and numerical weather prediction (NWP). The POES sounding device onboard the current NOAA satellites is the TIROS Operational Vertical Sounder (TOVS), which consists of the High Resolution Infrared Sounder (HIRS/2), the Microwave Sounding Unit (MSU), and the Stratospheric Sounding Unit (SSU). The TOVS produces atmospheric profiles of temperature from the surface to 10 mb and water vapor and total ozone contents from the surface to about 250 km. The MSU makes it possible to obtain atmospheric temperature profiles under all conditions of cloud cover, complementing the cloud-free sounding capabilities of the HIRS/2. POES sounder data are obtained worldwide for use in global NWP activities.

Atmospheric sounders for GOES satellites have paralleled the development of geostationary satellite technology. Since 1980, experimental VAS temperature sounding and moisture data have been made available to NMC, NSSFC, and NHC at selected times of the year. The data are used to derive a number of fields for weather monitoring and forecasting. For example, VAS-derived stability fields are used at NSSFC to monitor and forecast severe weather, wind fields are derived at NHC for tropical cyclone environment monitoring, and sounding data have been used at NMC for input to the Limited Fine Mesh (LFM) model over the data-sparse North Pacific Ocean. Geostationary sounders of the future will need to overcome problems of limited vertical resolution to significantly enhance their utility in NWS NWP operations.

VAS soundings cannot be reliably delivered in an operational mode using current GOES satellite sensors. Deployment of GOES I-M with their independent imaging and sounding capabilities will make better operational reliability possible. NWS will continue to focus on using VAS sounding data effectively. There are compelling reasons to pursue refinement of geostationary sounders. Geostationary satellites produce real-time data every half hour or more often, in contrast to data from rawinsondes every 12 hours. Also, the unchanging perspective of geostationary satellites allows constant monitoring over a fixed area.

2.2.4.3 Satellite-Borne Lightning Detectors

Detection of lightning in cloud systems has many uses, as given in Section 2.1.7. The concept of lightning detection by remote sensors applied to the satellite perspective offers a possible planetary-scale extension of these uses. Some potential applications of satellite lightning detector data are: examining relationships between lightning activity and storm intensity, and between lightning and tornado occurrence; describing electrical activity in tropical cyclones; and comparing lightning occurrence over oceans to that over land. Currently, a NOAA-National Aeronautics and Space Administration (NASA) team is investigating the suitability and cost of including a lightning detector aboard a GOES N+ series.

2.2.4.4 Remote Sensing of Marine Surface Winds by Satellite

The surface wind over the oceans produces stress that leads to waves and swells, which affect shipping interests. A consistent, reliable definition of the surface wind field is essential in providing useful sea-state information to users. NWS currently uses observations from Voluntary Observing Ships (VOS) and NOAA data buoys to collect data on winds and seas. Obtaining information on sea conditions using polar-orbiting satellites has been a promising idea since the short-lived Sea Satellite (SEASAT) in 1978. SEASAT as well as the research satellite Nimbus-7 had a scatterometer on board which measured the radar return from capillary waves on the ocean surface. It is possible to construct surface wind estimates from this backscatter because capillary waves respond to wind stress. The U.S. is planning to obtain remotely sensed wind, wave, and sea-ice measurements from the European and Japanese polar orbiting satellites (ERS-1, JERS-1) scheduled for launch in the early 1990s. These satellites will carry Synthetic Aperture Radars (SAR) which will provide these measurements under all weather (cloudy or cloud-free) conditions. Similar technology is planned by NASA for the late 1990s through the Earth Orbiting System (EOS) Polar Platform. NWS operations of the 1990s envision the use of these measurements for improving ocean forecast guidance at NMC as well as contributing to a better understanding of air-sea interaction on global and regional scales.

2.2.4.5 Future Plans

Imagery from the GOES satellites will continue to be the product most immediately useful operationally to NWS, but satellite soundings are growing in importance and application to NWS operations. Time sequences, enhancement techniques, wind vectors from paired imagery -- these will continue to be major applications of imagery data. Planned NWS interactive data-processing systems will enhance the use of these and other applications at field forecast sites and National Centers, when used with data from ASOS, radar, and wind profilers. The constant location and perspective of GOES satellites will greatly improve coverage over small-scale areas, which will benefit the study of subsnyoptic scale processes. It will also support the construction of a satellite climatic data base.

U.S. satellites are also integral elements of the WMO World Weather Watch (WWW). Other geostationary satellites in the WWW used in NWS operations are Japan's GMS and the European Space Agency's METEOSAT. It is likely that NWS offices with special needs will make use of GMS and METEOSAT data. In addition, NWS offices will be able to use data from ocean satellites of other agencies such as the DOD Defense Meteorological Satellite Project (DMSP) and N-ROSS.

The next series of geostationary meteorological satellites, GOES I-M, is already under development. A contract has been awarded, and the first satellite in the series is expected for deployment in 1992. GOES I-M will offer the following improvements to the current GOES sensor technology: increased IR resolution and number of channels; flexibility of scanning different geographic areas; independent imaging and sounding capability; better navigation; and increased radiometric accuracies and spatial resolution of the sounder. Additionally, requirements and feasibility studies are underway in NOAA and NASA for the definition of GOES N (next generation after GOES I-M) characteristics. Requirements for improving navigation and accuracy of the imager and sounder, increasing the number of channels, providing a capability to provide full disk and mesoscale imaging concurrently and extending performance at solar midnight are being considered, subject to cost and technical feasibility. The Phase A Study has been completed. GOES N spacecraft would be flown in the year 2005 timeframe.

Future POES capabilities are also being developed for the NOAA-K,L,M satellites, scheduled for deployment beginning in late 1993 and continuing through 1996. The most significant improvement in sensor technology will be the Advanced Microwave Sounding Unit (AMSU), which will combine and improve the capabilities of the current MSU and SSU (Section 2.2.4.2). AMSU-produced temperature soundings will be, for up to 30 km altitude, at least as accurate as current POES TOVS sounders (1.5K accuracy for IR [SSU] soundings and 3k for microwave [MSU] soundings). The AMSU's horizontal and vertical sounder resolution will be improved by a factor of about 1.7 over current resolutions. There will be five water vapor channels on the AMSU compared to four on the MSU, including three frequencies around a strong water vapor resonance at 183 GHz for more accurate soundings.

Other more-advanced POES sounders have been proposed that would offer still better resolution and accuracy. These include the Advanced Meteorological Temperature Sounder (AMTS) proposed by

NASA's Jet Propulsion Laboratory, the High-resolution Interferometer Sounder (HIS) advanced by NESDIS, and the Conical Atmospheric Tropopause Sounder (CATS) proposed by the United Kingdom Meteorological Office. Technologies required to develop these sounders have not been developed or cannot be tested as yet. Similarly, the NASA Wind Satellite (WINDSAT) project, which calls for the use of lidars on polar satellites for vertical wind profiles, will not be feasible until well into the 1990s.

World recognition of the importance of studies of the environment and global climate change has encouraged the development of a number of experimental satellite instruments. These are planned for the late 1990's to provide global satellite measurements of a number of climate parameters. A number of these instruments hold the promise of providing more detailed and accurate soundings of temperature, winds and moisture. NOAA efforts are underway to acquire and archive these data in real time, and as one task, to examine their utility in numerical weather prediction schemes. This data will be used to help judge whether similar instruments should be part of future NOAA operational spacecraft.

2.3 Radar

For more than 35 years, weather surveillance radar has been the foundation of NWS warning and forecast services, particularly in monitoring severe local storms. Radar will be even more essential in the future as one of several improved technological capabilities in the NWS's increasing focus on small-scale weather systems.

The present NWS basic weather network provides coverage over the 48 states from a variety of NWS, FAA and DOD radars, some of which (FAA radars) are not primarily for weather detection, and some of which (NWS WSR-57) are more than 25 years old. Newer NWS local warning radars (WSR-74) cover portions of the U.S., mainly east of the Rockies, and they serve to back up the basic network. The oldest NWS and DOD radars have become costly to maintain. Moreover, nationwide scheduled radar observations from network stations are still done manually, although the digital parts of the observations are composited by computer into a national summary chart.

Sustaining the NWS radar network in the pre-NEXRAD time period will be done by combination of interim measures, plus limited introduction of new technologies. Modifications to current DOD radars will prolong their life by replacing vacuum-tube units with solid-state electronics. The FAA is improving their radars' coverage, resolution, and remoting-and-display capabilities to meet Department of Transportation (DOT) needs; these improvements will upgrade the NWS network coverage as well.

2.3.1 Radar Data Processors (RADAP)

NWS computerized efforts to improve the operational use of radar began with the Digitized Radar experiment (D/RADEX) in 1971. There are now 12 NWS sites with RADAP II (RAdar DAta Processor, Version II) equipment. The RADAP II equipment consists of the radar system, a minicomputer, and interface devices. The radar system includes the collocated radar, the Digital Video Integrator and Processor (D/VIP), and the Isolation Distribution Equipment (IDE). From observations taken every 10 minutes, RADAP II provides echo intensity and motion, accumulated rainfall, and input to the manually digitized part of the radar observation. Tilt scans, made every 10 minutes if needed, result in gridded displays of the locations and top heights of all echoes, mapped vertically integrated liquid (VIL) water content values, storm structure, and severe-weather probability estimates. The RADAP II display capability has been enhanced by the ICRAD (Interactive color Radar display), which can produce color graphics on a map background, time looping, product overlays, interactive determination of cell movements, and aids to hourly report generation. RADAP II has demonstrated the feasibility of processing large amounts of radar data in near-real time. It will not be deployed at any additional sites, but it has provided new types of data (VIL, image loops) for operational users and continues to provide valuable information for the development of the NEXRAD radar system and its algorithms.

2.3.2 Remote Display Systems

Current NWS sites without collocated radar, as well as other non-NWS users, are increasingly using electronic display capability. Paper-facsimile machines have been replaced with TV monitors linked by phone line to the radar site; users can also dial into any radar site having the FAA Radar Remote Weather Display System (RRWDS) or private-sector developed display systems. The NWS Radar Information Display (RADID) terminals allow users to dial up RRWDS sites and display up to four images at once, loop up to eight images, and zoom in on nine sectors of the normal plan-position indicator (PPI) display.

A total of 100 RADID terminals have been installed, with two each going to NMC, NHC, and NSSFC, and the rest to RFCs, most WSFOs, and some WSOs with 24-hour warning responsibility. The FAA has installed RRWDS receivers at all Center Weather Service Units (CWSU) and Enroute Flight Advisory Service (EFAS) sites. Three WSFOs use RRWDS receivers. WSOs with warning responsibility that did not receive RADIDs are using remote display systems.

2.3.3 Next Generation Weather Radar (NEXRAD)

The Next Generation Weather Radar (NEXRAD) program is a joint effort among the Departments of Commerce, Defense, and Transportation to build and install Doppler weather radars in the United States and overseas. This new generation of weather radars, called the Weather Surveillance Radar, 1988-Doppler (WSR-88D) will make up the first network of operational Doppler weather radars. It will be installed at over 175 locations between 1990 and 1995.

The WSR-88D is a 10 cm, S-band, Doppler radar that provides forecasters in the National Weather Service, Air Weather Service, and Federal Aviation Administration with estimates of velocity, spectrum width, and reflectivity. Doppler data (velocity and spectrum width) is provided out to 230 km (124 n mi) and reflectivity data out to 460 km (248 n mi) from the radar. The narrow 1 degree beamwidth, large antenna (diameter of 28 feet), peak transmitter power of 750 KW, and modern electronics of the WSR-88D, make it an extremely sensitive radar that detects weather phenomena in both clear air and precipitation better than existing conventional radars.

Clear air observations will allow operators to examine processes in the boundary layer, such as low level wind field characteristics. During convective storms, areas of greatest threat from severe thunderstorm and tornadic activity can be quickly pinpointed using derived products and the automatic alert features. Output from precipitation processing algorithms provides estimates for 1-hour, 3-hour, and storm total accumulated rainfall. This information is extremely valuable for issuing flood and flash flood statements and warnings.

It is expected that the WSR-88D will enhance the forecasters ability to warn in an accurate and timely manner. Data obtained will increase scientific knowledge of the meteorological processes that lead to storm development and severity.

3.0 TELECOMMUNICATIONS

Advances in communications technology over the last decade have paralleled advances in computer technology. NWS has made extensive use of advances in both fields, so that it is now rare for operational NWS products to be composed and disseminated within NWS by nonautomated and non-computerized means. The process of composing and transmitting a forecast, for example, has been revolutionized. As late as the mid 1970s, most forecasts as well as warnings, observations, and other products were prepared initially by hand or by typewriter, formatted on paper tape, manually entered for transmission on teletype circuits, and received by users or other NWS offices in the form of paper tape and teletype paper copies. This entire process was labor-intensive and very time-consuming. In the case of warnings, the process could significantly reduce the warning's lead time and hence its potential effectiveness. At this time, the entire process from message composition to receipt by the user has been greatly speeded up with the use of automated and computerized communications facilities.

3.1 Automation of Field Operations and Services (AFOS)

AFOS is the primary internal data distribution network of the NWS. It is used to interconnect NWS field offices and to distribute centrally produced forecast products (graphics, grid point data, etc.) from the National Meteorological Center (NMC) to NWS field offices (Weather Service Forecast Offices (WSFO), Weather Service Offices (WSO), River Forecast Centers (RFC), and National Centers (NC)). All data forecasts generated at NWS field offices are also carried on this network and are available to all offices on the network. Each AFOS-equipped office has forecaster workstations that include communications interfaces for dissemination. Any product originated anywhere in the system is available on the AFOS network and can be stored and displayed at any office. The AFOS system will be replaced in the late 1990's by the Advanced Weather Interactive Processing System (AWIPS).

The AFOS system consists of a nationwide packet data network which operates at 2400 bps and interconnects the AFOS data handling computers at over 200 AFOS equipped NWS offices. The AFOS data network is monitored and controlled from the System Monitoring and Coordination Center (SMCC) collocated with the NWS Telecommunications Gateway (NWSTG) in Suitland, MD. The AFOS packed data network consists of four Regional Distribution Circuits (RDCs - one for each CONUS NWS region) each of which terminates at SMCC. In addition, each of the 50 NWS WSFOs drive direct circuits to the WSOs and RFCs in their area.

AFOS has already approached its limit for data transmission capacity. Improvements to the AFOS, data communications capability, are planned for introduction in the 1991/1992 time frame. The major enhancement will be a new front-end processor to provide increased data processing capacity. Further information on AFOS is included in Section 4.1

3.2 International Systems

The Global Telecommunications System (GTS) is an international data exchange network sponsored by the World Meteorological Organization (WMO). The NMC has global responsibilities as part of the international World Weather Watch Program. The GTS is used to exchange weather with meteorological forecasting centers in other nations (England, Japan, Canada, Brazil, Argentina, Mexico, etc.). The GTS consists of a variety of landline, satellite and radio communications facilities.

In addition to the GTS, a variety of telecommunications facilities are used to exchange meteorological data with a variety of other countries and regions (Mexico, Caribbean, etc.) via a mixture of point-to-point circuits and regional networks such as the Antilles Meteorological Network (ANMET) and Central American Meteorological Network (CEMET).

3.3 NOAA Weather Wire Service (NWWS)

NWWS is a nationwide satellite broadcast system used to disseminate severe weather and flood warnings, forecasts, and other information to the mass news media and public safety agencies for relay to the public, state and local users.

The system includes satellite uplink facilities at all NWS WSFOs within the 50 states and Puerto Rico. All NWS products uplinked from NWS offices are available in one composite data stream to any outside user (over 1200) who obtains the necessary low cost satellite receiver equipment from the NWWS system contractor. Further information on NWWS is provided in Section 5.1.1.

3.4 NOAA Weather Radio (NWR)

NWR is a network of 380 Very High Frequency, Frequency Modulation (VHF/FM) radio broadcast stations throughout the United States which provide continuous weather broadcasts to the public and can provide alerts by activating receivers to warn of hazardous weather conditions. Broadcast material prepared at NWS WSFOs are transmitted to the VHF transmitter sites via a combination of dedicated telephone lines and UHF radio links. NWR is further described in Section 5.1.2.

3.5 Facsimile Broadcast Systems

The NWS currently distributes weather graphics "charts" in facsimile form to selected NWS, FAA, and DOD field offices via a satellite broadcast system. Two different data services are currently provided as separate channels of the broadcast - Digital Facsimile (DIFAX) and National Facsimile (NAFAX). The DIFAX service is a high speed digital system which provides nearly 300 charts per day. The DIFAX charts include products related to international aviation, agriculture, and many charts also carried on NAFAX. The NAFAX service is a slow speed analog system which provides weather analyses, prognoses, selected observed data and limited satellite imagery. The NAFAX broadcast channel will be discontinued in mid 1991.

3.6 Family of Services (FOS)

The NWS provides external users access, for a connection fee, to near real-time weather and flood information through a family of medium speed communications services called the Family of Services which are provided in the Washington, DC area. The services provided are detailed in Section 5.1.5.

3.7 GOES Data Collection System (DCS)

The GOES DCS is a communication relay system that uses the GOES transponder to relay transmission from data collection platforms (DCP) to NOAA processing and transmission facilities in Camp Springs and Suitland, MD. The data are sent to field offices via AFOS and remote job entry (RJE) links. The primary NWS use of the GOES DCS is the collection of hydrometeorological and oceanic data; the DCS also is used to determine the physical characteristics of the individual DCPs transmitting through the system (DAMS, Digital Automated Monitoring systems). NOAA maintains 1,085 DCPs on data buoys, river-gauging sites, and remote observing sites, out of a total of 8,024 DCPs using the GOES DCS. The NWS uses about 75 percent of the 8,024 DCPs in river-stage and flood forecasting, collecting routine reports every one to six hours and special observations as needed. The GOES DCS is also the most reliable communicator of weather observations over ocean areas from data buoys, offshore platforms and tide gauges.

3.8 NOAAPORT

NOAAPORT satellite communication capabilities are identified with the AWIPS communications capabilities described in Section 3.4 and represent a consolidation of the two programs.

3.9 POES Communications

Communications capabilities of the current NOAA POES are used to collect environmental data from instrumented observing platforms worldwide and relay them to data collection centers such as NMC. The satellites also store polar imagery and soundings for relay to users and to data collection centers. Raw sounding data are received at Gilmore Creek, AK, and Wallops Island, VA, and sent to the NESDIS satellite data processing and distribution facility in Suitland, MD, then processed and relayed to NMC for use in NWP models. Other data relayed by POES include observations from drifting buoys, moored buoys, free-floating balloons, and remote automatic observing stations. The communications capabilities of the NOAA polar orbiting satellites just described are expected to be maintained by future polar orbiters through the mid 1990s.

3.10 Advanced Weather Interactive Processing System for the 1990s (AWIPS-90)

Observing systems of the future, such as ASOS, satellites, NEXRAD, and wind profilers, will produce quantities of data far greater than can be distributed by the data communications capability of the current AFOS system. The NWS AWIPS-90 system is being designed to be a cost-effective replacement for the AFOSsystem and to provide increased processing and capabilities needed for the 1990s. The AWIPS-90 interactive capabilities are described in Section 4.6

AWIPS-90 site level systems will receive and exchange of data by means of:

- o Point-to-multipoint broadcast (NOAAPORT) for satellite data, national guidance products and centrally collected observations.
- o Point-to-point network for exchange of local warning and forecasts and of locally taken observations including NEXRAD, surface, and upper-air observations; and
- o local communications unique to specific locations for exchanging information with local authorities for emergency services.

The communication capabilities of AWIPS-90 will necessitate an examination by the NWS of data exchange with other agencies such as FAA, DOD and COE. How and whether the methods of data exchange will change has not yet been determined.

The communications capabilities of the AWIPS-90 system at each NWS field office include the acquisition of data/products from other offices, such as satellite imagery, satellite soundings, and numerical and manually produced guidance products; display of products by users at multiple sites to support forecast coordination; interactive access by one site to another site; the provision of RJE capabilities at National Centers (NC) and RFCs to the NOAA Central Computer Facility; and communications links to external systems by direct link, by dial-out and/or by initiation from the external system. Interfaces to AWIPS-90 will vary widely and include interfaces to NEXRAD, ASOS, local mesonets, marine observations, NOAA Weather Wire Service, NOAA Weather Radio, emergency centers, and CWSUs collocated with FAA facilities. The variety of external interfaces will be complicated by the unique requirements of individual AWIPS-90 sites.

4.0 INTERACTIVE PROCESSING AND DISPLAY SYSTEMS

The acceleration of computer technology and the prospect of receiving vast quantities of observational data from new systems have made it necessary for the NWS to determine efficient ways to process data and extract information quickly, both at field forecast offices and at National Centers, for efficient use in preparing warnings, forecasts, guidance, and other services. For these data to be most efficiently used, graphic product displays, both of individual products and combinations of products, will be required. Observing systems such as satellites are near a state of development that threatens to overwhelm present NWS data processing and communications capabilities. Interim measures will be taken over the next several years to upgrade current capabilities until AWIPS-90 is fully operational.

4.1 Automation of Field Operations and Services (AFOS)

AFOS communications capabilities have been described in Section 3.1. AFOS also receives NMC graphic products -- analyses and NWP model outputs -- and distributes them to all NWS offices in the contiguous U.S. AFOS users can overlay up to three graphical products on one map background. AFOS by itself is not, however, capable of processing or even displaying high-resolution data such as from radar or satellites; enhancements such as SWIS (see below) are needed. AFOS has been the first step in the development of NWS operational interactive processing systems. The System Z upgrade to AFOS will increase the application processing capabilities of AFOS by making available another background partition at dual computer sites. Improved NWS interactive processing capabilities will culminate in AWIPS-90.

4.2 Satellite Weather Information System (SWIS)

SWIS, with its capability to combine satellite imagery and NMC-generated graphic material acquired from AFOS, has been in operational use since 1987. SWIS can acquire, store, display in color, and animate GOES visible, IR and water-vapor imagery, at full scale or on smaller sub-sectors. A microprocessor in the SWIS device converts NMC graphics to the satellite map projection and overlays the graphics upon the imagery. The master SWIS display device also provides the video output of both imagery and graphics to the AFOS Graphic Display Modules. SWIS provides the user with the capability to color-enhance the satellite data. Up to 16 enhancement curves can be stored in SWIS. Sixty-three SWIS units are in operation at all the WSFOs, NCs, and Regional Headquarters. The SWIS program will operate until AWIPS-90 is in place. A Forecaster Application and Imaging System (FAIS) or

Micro SWIS is being procured as a backup for SWIS and to expand the satellite display network to an additional 90 NWS Offices. The FAIS uses standard PC based hardware and a software package developed at NWS Western Region Headquarters.

4.3 Centralized Storm Information System (CSIS)

CSIS is based on the Man-Computer Interactive Data Processing System (MCIDAS) developed by the University of Wisconsin. NSSFC has used CSIS since 1982. CSIS interactively enables forecasters to assimilate large amounts of satellite and conventional data for a quick and thorough look at the state of the subsynoptic scale atmosphere, and to provide reliable analytical and interpretive information for developing subsynoptic scale forecasts and techniques.

Conventional surface and upper-air observations, radar, satellite imagery, satellite soundings, and profiler data may be combined; animated image sequences are available; and derivation of parameter fields is readily accomplished. All of these capabilities have been brought to bear on the important but incompletely understood processes at work in severe convective storms. CSIS, with its interactive capabilities, has since its installation enabled the NSSFC forecasters to be increasingly precise in the timing and positioning of tornado watch areas. At the present time it is not possible to transmit CSIS-derived analyses and products to field users; however, the users reap the benefits of improved NSSFC guidance products. CSIS continues to evolve in support of the specific needs of NSSFC. It is another intermediate system bridging the gap between NWS present and future operations and providing information on functional requirements and performance specification for AWIPS-90. It will be replaced in FY 90 by VDUC (Section 4.5) but will remain at NSSFC as a backup system.

4.4 Program for Regional Observing and Forecasting Services (PROFS)

ERL's PROFS program, initiated in 1980 and located in Boulder, Colorado, has as its mission the improvement of short-range operational weather observing and forecasting services by the development, testing, and transfer to the operational arena of scientific and technological knowledge. PROFS has developed an interactive system that acquires, processes, and displays the data necessary to monitor and forecast the weather in a real-time operational setting. PROFS-developed workstations access data from many sources, including Doppler radar, satellites, conventional surface and hydrologic stations, mesoscale surface networks, profilers, and lightning detectors, as well as numerical forecast guidance from the National Meteorological

Center. The PROFS workstation is a functional prototype of interactive systems that will be built by the private sector for NWS operational deployment in the 1990s. As part of DARE (Section 4.6.1), PROFS has developed a significantly upgraded, advanced meteorological workstation, DARE-II. At the end of 1989, the new DARE-II workstation replaced DARE-I at WSFO Denver which was originally deployed in 1986. During calendar year 1990, DARE-II systems will replace the AFOS systems at both the Denver, CO and Norman, OK forecast offices as part of the NWS modernization risk reduction activities.

PROFS supports DARE-II at WSFO Denver around the clock. In addition, several DARE-II and PC-based workstations are used at PROFS for continued development. Until the end of summer 1987, data from PROFS were available to the CWSU at Longmont, CO. Valuable experience in real-time interactive data use has been gained through exercises conducted by PROFS involving field personnel and through regular use of workstations at CWSU Longmont and WSFO Denver. This experience has demonstrated that significant improvement can still be made in NWS forecasting, particularly on the subsynoptic scale. The information gained through PROFS experience has been incorporated into requirements documents for AWIPS-90.

4.5 VAS Data Utilization Centers (VDUC)

The VDUC equipment was built by the University of Wisconsin as part of their Man computer Interactive Data Access System (McIDAS) development efforts. In addition to display of satellite sounding data, the VDUC systems have capabilities for processing and displaying satellite images, surface observations, upper air observations, radar images, and model forecasts. Development efforts are underway for the display of lightning and Profiler data. The VDUC systems have been installed at the World Weather Building for the use by the National Meteorological Center (NMC) and the National Environmental Satellite Data and Information Service (NESDIS), at the National Severe Storms Forecast Center (NSSFC) and at the National Hurricane Center (NHC). The VDUC systems are being used at the National Centers for the interactive processing support of forecasting. The VDUC systems interactive capabilities are considered as an interim solution to the National Center needs for interactive processing equipment until AWIPS-90 equipment becomes available.

For several years, the NOAA Operational VAS Assessment (NOVA) Program has expended considerable effort in determining how best to use VAS sounding data operationally and interactively. VAS sounding data have been used interactively at NSSFC by means of CSIS, and in combination with satellite imagery at NMC and NHC through the use of remote terminals, to derive meteorological information from areas where conventional data is lacking; i.e., between conventional data stations over land, and over much of the ocean areas. Products derived from VAS sounding data that have shown potential utility include: multispectral and especially water-vapor imagery, mesoscale stability indices, storm motions for steering currents, and initial flow fields. Promising tests have also been conducted using VAS data in NMC forecast models. All these experiments have shown that VAS sounding data may be quite useful to NWS forecasters, particularly in combination with other information. The VDUC, developed with the help of NESDIS, will be the system by which VAS data will be processed at NCs and used operationally.

4.6 Advanced Weather Interactive Processing System of the 1990s (AWIPS-90)

The communications capabilities of AWIPS-90 have already been described in Section 3.10 Equally important to NWS operations will be the interactive processing capabilities of AWIPS-90. Both capabilities, unified in one system available to field personnel, will be a major part of NWS technological modernization efforts that will occur during the 1990s.

With the implementation of AWIPS-90, the warning and forecasting functions of today's WSFOs and WSOs will reside at Warning and Forecast Offices (WFO). AWIPS-90 will provide support for WFO operations, both for communications and for data processing. In the latter capacity, AWIPS-90 will also be able to run simple forecast models tailored to the WFO's area of responsibility, using advanced observational data from satellites, NEXRAD, profilers, and ASOS; and it will automatically monitor the WFO warnings and forecasts as well as the weather in the WFO area of responsibility. In times of noncritical weather, when the WFO's warning and forecast mission would not be affected, AWIPS-90 capabilities will support forecast techniques development, products and services evaluation, and scientific training for the WFO staff. AWIPS will acquire, store and manage large sets of data from a wide variety of sources. NMC is now beginning to upgrade to the Class VII super computers. Field offices will be able to acquire more frequent and finer scale model guidance including the new mesoscale or "stormscale" model output. Data from ASOS, radiosondes, profilers, local mesonets and river gages will be collected and stored. Centrally processed (remapped) imagery products derived from the advanced GOES satellites will be broadcast and sectorized at each AWIPS site as it is received. Finally, data and products will be acquired from the collocated NEXRAD.

AWIPS will provide a much more powerful set of data manipulation and display tools. On an animation workstation, a forecaster will be able to select, view and compare satellite and NEXRAD imagery. Imagery will be loaded at up to four frames per second with looping animation rates up to 10 per second. Data will be overlaid quickly. For example, surface data can be overlaid on top of NEXRAD and satellite imagery. To facilitate the use of large amounts of model output, the forecaster will be able to animate graphics composed of up to 11 composited fields. Selection of fields for compositing and the "on/off" toggling of individual fields will be under the interactive control of the forecaster. This capability is called composited graphics and is similar to the family of graphics demonstrated on DAR3E II.

AWIPS User Interface Menus (UIM) will be similar to that used on DAR3E II. It will be easy to learn and use. The UIM will be integrated within the workstation's image-graphics display screens. The UIM will include features such as dynamic status updating to allow the forecaster to visually monitor when new products arrive at the site. Common sense hydrometeorological names will be used rather than the current cryptic command language terms used in AFOS.

Product composition will be integrated into AWIPS. Interactive warning generation techniques will allow the forecaster to define the warning area on top of a NEXRAD image and generate the text of the warning more quickly and accurately.

AWIPS will also provide a number of improved system support capabilities. Much more powerful computers and more modern software resources will be provided at each office to support data base management, local techniques development and training.

One of the major improvements to field operations will be the significant increase in computing resources to support the local development and running of applications programs. The ability to run these applications programs at each site should improve NWS's service to the public because local processing will help the forecaster to quickly integrate high resolution data and because analyses and products can be tailored to a forecaster's area of responsibility.

The total set of applications programs that must be supported will increase throughout the life of AWIPS. Many applications programs currently exist in forms that can be modified to be used with AWIPS. Some of these programs are now under development, and others are at the conceptual stage. Last but not least, AWIPS is being designed as a modular system of hardware and software, structured to support future change and growth. Over the next decade, advances in such areas as sensor systems, analytical techniques, data communications and information handling are expected to be incorporated into AWIPS. Also, high system availability will be achieved through a combination of new, more inherently reliable systems and selective redundancy focused on critical system functions.

To understand user needs better, NWS has undertaken extensive prototyping involving existing interactive systems in specific operational environments.

Two areas in which AWIPS-90 prototyping programs have been defined are the operations of the WFO and hydrologic forecast services. Accordingly, the following two sections of this report are devoted to these AWIPS-90 prototype programs.

The Development Phase RFP has been issued, and the contract will be awarded to one of the two Definition Phase Contractors. Work is proceeding on the Extended Definition Phase of the contract.

4.6.1 Denver AWIPS Risk Reduction & Requirements Evaluation DAR^{3}E

In late 1986, a "limited" functional prototype of AWIPS was installed at WSFO Denver. Under the cooperative direction of NWS and PROFS, the DAR^{3}E program began direct support to the NWS modernization. Under the direction of NWS Office of Systems Development, DAR^{3}E was begun to "provide the AWIPS Program Office with specific insights relating to required performance and design characteristics" of AWIPS. PROFS simulates the AWIPS environment by incorporating the latest meteorological research using new data sets produced by new technologies, and by developing other tools such as higher spatial- and temporal-resolution models, new data display and manipulation techniques, and new products.

The requirements for the DAR^{3}E system were developed by the AWIPS Requirements Task Team (ARTT). The ARTT was a NWS-wide committee to assist the AWIPS Program Office in setting and validating requirements for AWIPS. The ARTT is led by the Office Of Meteorology (OM) and provides recommendations to the AWIPS Program Office.

DAR^{3}E I

The first PROFS-built DAR^{3}E system was a "limited" functional prototype of AWIPS. DAR^{3}E was envisioned to simulate the AWIPS within a real-time operational forecast office, as opposed to earlier systems at PROFS, a research environment. It consisted of single advanced meteorological workstation and host processor, a local graphics and image database, an advanced, multi-windowed text interface to AFOS, and a high speed data link to PROFS. This workstation supported the Public Forecaster, and physically replaced an AFOS console which supported that function. DAR^{3}E-I introduced these new AWIPS-era data sources, techniques, and workstation functions to the operating forecast office setting.

DAR^{3}E-I focused on many of the key "system" issues facing the NWS, and contributed directly to a better understanding of AWIPS operational requirements, technical capabilities, training, and transition problems. It has been used to justify changes to the AWIPS System Requirements Specification for the development phase.

DAR^{3}E-I also served as a demonstration system for a wide variety of individuals and groups. As such, it contributed to a better understanding of both AWIPS and future NWS operations.

DAR^{3}E-II

In late 1989, DAR^{3}E-I in the Denver WSFO was replaced by DAR^{3}E-II, the next generation AWIPS functional prototype. This system is important for several reasons. First, it incorporates the latest technology advances in processing and display hardware and software. Second, it supports all office functions rather than just the Public desk and adds a substantial hydrologic component to the integrated workstation capabilities. Finally, DAR^{3}E-II provides a platform for testing operational concepts that are candidates for implementation in the AWIPS era.

The early aspects of these risk reduction efforts (primarily DAR^{3}E-I) focused on the specification of the AWIPS system. However, as we move forward into DAR^{3}E-II, the emphasis necessarily shifts toward "transition" issues associated with modernization. In particular, the focus becomes the changing responsibilities, work environment, and forecaster workload. We must also investigate the evolving training requirements, and new or revised warning and forecast products and services.

4.6.2 Prototype Real-Time Operational Test, Evaluation and User Simulation (PROTEUS)

The PROTEUS Project is designed to demonstrate enhanced computer hardware and software required by the River Forecast Center (RFC) to operate in the AWIPS environment. The PROTEUS Project will refine AWIPS hydrology requirements, provide a framework from which RFC next generation operational concepts will be expanded, and provide a core group of RFC Hydrologists trained in the new technology. Led by the Office of Hydrology, participating RFC's include TURFC, MBRFC, MARFC, CBRFC, and AKRFC.

PROTEUS activity at TURFC and MBRFC are focused on components essential for MARD AWIPS-90 Initial Operational Capability (IOC). They are: Automatic Data handling and Quality Control, NEXRAD Stage II and Stage III Precipitation Processing, baseline interactive features of the NWS River Forecast System (NWSRFS), and the exchange of information between RFCs and water resources agencies. Risk Reduction activity at MARFC, CBRFC, and AKRFC are centered on more long term AWIPS-90 RFC capabilities; the deferred AWIPS-90 capabilities to be implemented after MARD. The deferred capabilities include: enhanced NWSRFS calibration; long-range water resources forecasting procedures; enhanced utilization of the NOAA Central Computer Facility (NCCF), RFC operational backup; data archive and retrieval.

Additionally, the PROTEUS activity at TURFC and MBRFC, in cooperation with DAR³E and NORMAN, will demonstrate the interaction of WFOs and RFCs in the AWIPS era. This risk reduction activity will emphasize the new Hydrometeorological Analysis and Support (HAS) function at the RFC which is intended to facilitate meteorology and hydrology interaction in the AWIPS era. Also to be examined in the RFC/WFO interaction realm, are the space/time resolution of WFO data needed to produce AWIPS era products at the RFC, and the type and space/time resolution of RFC guidance needed to support WFO hydrologic operations.

4.7 Concepts in Interactive Processing using Artificial Intelligence (AI)

As part of NWS efforts to modernize its operations, a host of new data observing systems, such as NEXRAD and wind profiler, will come on-line over the next decade. These systems all have in common the ability to sense the atmosphere at higher spatial and temporal resolutions than ever before. The meso-alpha finer scale information contained in data from these systems will form the foundation on which the NWS can enhance and improve its warning and forecast operations, especially for severe weather. The new data sets will allow for better monitoring and diagnosis of severe weather, and will be used as input into higher resolution numerical weather prediction (NWP) models of the National Meteorological Center. These models will provide increased temporal and spatial resolution guidance to support NWS operations. They will allow for improved forecasts of mesoscale storm systems.

Combined, this tremendous increase in data from both the new sensors and enhanced NWP guidance, leads to the phenomena of information overload of forecasters. Of course, the NWS is striving to modernize its information processing systems through procurement of AWIPS, which will better equip forecasters to examine these enhanced data sets. However, the user must be able to quickly examine sufficient data sets to produce a forecast. Some form of assistance in sifting through these data is necessary.

The NWS is exploring the use of AI, especially knowledge-based expert system (KBES), to ease information overload. One way is to provide users with forecast decision assistance to better monitor this future immense data stream flowing into NWS field offices and even national centers. In this regard, the NWS has defined interpretive processing as the use of computer interactive procedures and functions to generally assist and organize the forecast decision-making process (See Zubrick and Racer, 1988). The NWS views AI as a potential tool for constructing and maintaining these interactive procedures. In addition, to forecast decision assistance, several other areas of AI applied to NWS operations are currently being explored. Among them are data monitoring, event-driven data surveillance, product quality control, and forecast product formatting and dissemination.

The NWS fosters small, prototype efforts at several of its offices to examine AI. Although the NWS is not a research organization, it recently participated in an research experiment of AI systems that forecast severe convective storms in Northeast Colorado. This experiment, called SHOOTOUT-89 and conducted by NOAA's Environmental Research Laboratories, evaluated each AI system's forecast skill, along with other factors such as user acceptance, forecast timeliness, and portability. There were six systems participating in this exercise, including one from the NWS.

Results from the SHOOTOUT-89 experiment are still being evaluated and will be described in a forthcoming paper to appear in the Bulletin of the American Meteorological Society. Early results show that the AI systems tested do have skill in this area and point the way for further research.

The NWS participates in a number of endeavors designed to increase awareness of the potential of AI applications in the hydrometeorological operations. The NWS, along with NOAA members, was instrumental in helping the American Meteorological Society (AMS) form a new Scientific and Technical Advisory Committee (STAC) called the Committee on Artificial Intelligence Applications to Environmental Science. Although this committee will not hold AMS conferences on its own, it will help sponsor AI sessions at other conferences when there is sufficient interest in AI applications to report. One possible area this committee is examining is establishment of an electronic mail capability for the exchange of AI topics among all NWS offices with NWS Headquarters.

The NWS in 1987 chaired a special session on AI/KBES at the Spring, 1987 meeting of the American Geophysical Union. The NWS also helped sponsor international workshops associated with the independent Committee on Artificial Intelligence Research in the Environmental Sciences (AIRIES). In 1989, the NWS co-sponsored the third AIRIES workshop held in Washington, DC. A number of NOAA-sponsored reports were given, including an AI application developed at an NWS field office and used for local-area quantitative precipitation forecasting. The AIRIES committee encourages reports on AI applications not only in the hydrometeorological area, but in other scientific disciplines as well, ranging from aerospace to wildlife management. The fourth AIRIES workshop will be held 24 - 27 September 1990, near Montreal at the Far Hills Inn, Val Morin, PQ, Canada.

5.0 DISSEMINATION OF NWS WARNINGS, FORECASTS, AND OTHER PRODUCTS TO EXTERNAL USERS

The last 15 to 20 years have brought about a radical change in NWS methods of getting its products to its users. Around 1970, the primary methods of disseminating NWS products were by teletype circuits and, especially in critical weather events, by telephone. But teletype circuits were slow at best; their traffic flow was often chaotic in bad weather. Manual methods of message composition such as typing and cutting tapes were labor-intensive and error-prone. Telephones to the weather offices were overburdened at the very times information was most needed. NWS has developed a number of dissemination methods over the years which have led to more efficient dissemination of products and retention of the generally high esteem long held by the public towards NWS. Even better dissemination techniques are being planned as NWS seeks to make maximum use of technological improvements in satisfying what is certain to be an escalating demand for its products and services. The following sections describe current and future NWS methods of product dissemination.

5.1 Current Dissemination Operations

5.1.1 NOAA Weather Wire Services (NWWS)

The NWWS is the primary NOAA/NWS medium for disseminating hydrometeorological and other environmental information primarily in plain language to the media, emergency management agencies, and other users. It is a leased satellite telecommunications system operated for the NWS by a private-sector contractor.

The NWWS will accept messages simultaneously entered through all NWS office data entry nodes (WSFOs and national Centers) via an interactive, two-way microearth station. It delivers the information via satellite broadcast, through a master control station having overall monitoring control of the satellite network and message processing functions, to end users throughout the U.S. at an output rate of 1200 bps using the eight level ASCII data code.

End users, including NWWS nodes, receive the information by means of a very small aperture terminal microearth station. In addition, end users have the capability to select NWWS products from a catalog produced by the system contractor. This catalog contains AFOS product identifiers for products on the NWWS entered by any NWS office. Users may further discriminate among selected products by specifying the appropriate Universal Generic Code (UGC).

5.1.2 NOAA Weather Radio (NWR)

NWR provides continuous 24-hour weather broadcasts from selected NWS offices on seven VHF-FM frequencies, from 380 transmitter sites in or near population centers across the nation. NWS warnings and forecasts are recorded on tape cassettes and are broadcast in sequence; warnings and other important weather information can be broadcast live when issued, with tone-alert signals to activate specially equipped receivers. In addition to the primary transmitting sites, NWS by agreement with state and private organizations has been able to disseminate NWR information further to parks and highway rest stops, telephone voice-paging systems, and commercial media for rebroadcast.

NWR Specific Area Message Encoder (WRSAME) is a new technology that has been successfully tested and is being installed for operational use at some NWR stations. WRSAME is a device connected to a standard NWR program console that puts a special code at the beginning and end of selected messages broadcast over NWR. The code specifies the type of message and area the message applies to. This provides any users with a decoding device within listening range of the NWR signal the ability to choose which site specific hazardous messages will automatically interrupt the normal programming.

WRSAME users may include radio stations, including Emergency Broadcast Systems, television, cable television, schools, large companies and office background music suppliers. WRSAME will be especially useful for those automated broadcast stations that do not have personnel on station to rebroadcast the messages. Other users may include local emergency managers, civil defense, police, etc.

The NWS has an agreement with the NEMAR Company of Dallas, Texas to supply WRSAME systems. WRSAME is the first private sector owned unit integrated into an NWS operational system. There will be no cost to the government for this technology as NEMAR will supply the necessary equipment and support.

With NWS assistance, some local and state government agencies have installed low-powered AM radio transmitters to broadcast not only weather information heard on NWR, but additional items such as road conditions. Also, some companies have added NWR receivers as a safety feature on new cars either as standard or optional equipment. The NWS is encouraging greater use of NWR in both areas.

5.1.3 NOAA Weather-by-telephone (WBT)

NWS uses about 300 recorded telephone systems at field sites nationwide to provide users with current forecasts. Ring-through devices which allow direct contact by users with NWS personnel are used at 130 sites. Also, in some areas, NWS still disseminates warnings directly by phone to selected users. In cooperation with telephone companies in some metropolitan areas, NWS provides forecasts and current weather to the companies, which record the information and offer the service to users for the cost of a local call. All of these methods of dissemination have been in use for many years, but they have become labor-intensive and costly.

To provide cost-effective services that satisfy the dissemination needs of both NWS and the public, NWS has entered into a memorandum of understanding (MOU) with private-sector cooperators for the provision of weather-by-telephone (WBT) at no cost to the Government. This encourages private-sector activity in this area. Under the terms of the MOU, NWS discontinues its regular WBT services from its local offices, but maintains an administrative line for public access. The cooperator provides a sponsored recording of the latest weather at no extra cost to the caller and provides at least an equivalent number of lines as was previously required by NWS for the public. The cooperator is also required, at its own expense, to access the data required from the local NWWS and broadcast the official NWS forecasts with attribution.

The current practice is to enter into a MOU with any entrepreneur who will provide a locally sponsored WBT service under the terms of the MOU. The MOU, however, does not give the cooperator exclusive rights to the WBT service in the area. NWS must deal with as many private WBT services as the marketplace will bear. Weather Line, Inc. of St. Louis has signed MOU's to provide this service to about 30 metropolitan areas.

In June 1985, NWS concluded an agreement with AT&T Communications and NBC News to provide recorded information from NHC to AT&T on named tropical cyclones in the North Atlantic Ocean. The recorded information is made available on a "900" number at a cost to the caller, and is updated whenever new advisories are issued by NHC.

5.1.4 Facsimile Distribution Systems

Two national facsimile distribution systems are currently in operation: the Digital Facsimile Network (DIFAX) and the National Facsimile Network (NAFAX). The DIFAX service is a high speed digital system (720 spm) which can provide about 300 charts per day. The DIFAX charts include products related to the international aviation, agriculture, and the NAFAX transmission, excluding satellite photos. The NAFAX service is a slow speed analog system which can provide about 100 charts per day. The NAFAX charts include analyses, prognoses, selected observed data, and some satellite photos. Both of these facsimile networks serve users at NWS, FAA, DOD, and nongovernment organizations. The NAFAX broadcast channel will be discontinued in mid-1991.

5.1.5 NOAA Family of Services (FOS)

Since 1983, NWS has provided for external-user access to near real-time weather and flood information through a family of communications services which are accessed in the Washington, DC area. Called the Family of Services (FOS), it includes the following services:

- o Public Product Service (PPS, 2,400 bps), carrying: all public warnings and watches, and various hydrologic, agricultural, and miscellaneous forecasts and products;
- o Domestic Data Service (DDS, 2,400 bps), carrying: basic observations, and various aviation, marine, and miscellaneous products;
- o International Data Service (IDS, 2,400 bps), carrying: worldwide surface and upper-air observations and other miscellaneous products;
- o Numerical Products Service (NPS, 4,800 bps), carrying: analyses and forecasts derived from NMC's Nested Grid Model and the global spectral model out to 7 days. Forecasts prepared by the European Centre for Medium Range Forecasts are also carried;
- o Direct Connect Services (DCS 4,800 bps), carrying the same information as the NPS but for users requiring error controlled NPS data;
- o AFOS Graphics Service (AGS), carrying centrally produced graphic products from the NWS AFOS system;
- o National Facsimile Service (NAFAX), carrying analyses, prognoses, observed data, and satellite photographs in graphical form; and
- o Digital Facsimile Service (DIFAX), carrying analyses, prognoses, and other information similar to that on NAFAX.

- o Climate Analysis Center's Climate Dial-up Service (CACCDUS), providing near real-time climate data via a computer modem with user fees assessed on a use basis.

All the above services may be obtained from NWS for set user fees which are reviewed and updated annually. Private-sector companies resell data as received and/or provide value-added services for specialized users based on information derived from the FOS.

5.1.6 TV, Radio, and Newspapers

TV and radio stations rely on NWWS, FOS, and NWR for routine weather information. They will often communicate directly with NWS offices, including visits and live, on-air interviews, to disseminate information about significant weather events.

NOAA cooperates with the FAA, the Aircraft Owners and Pilots Association (AOPA), and private aviation oriented companies in funding "A.M. Weather" a 15 minute television weather presentation which is broadcast on 300 stations of the Public Broadcast Service (PBS) network in the early morning. The program uses NWS forecasts and warnings, emphasizing aviation weather, tailored to various parts of the nation. Information on the show is compiled and broadcast by NWS and NESDIS meteorologists.

Among the primary cable-TV disseminators is the Weather Channel, which is staffed by private-sector personnel but broadcasts NWS warnings, forecasts, and observations along with brief segments of reformatted alphanumeric NWS product displays tailored to specific communities by local cable companies.

Twenty-five years ago, direct commercial radio broadcasts from NWS field offices were common. They were encouraged as a basic method of disseminating NWS (then the U.S. Weather Bureau) products to the American public. NWS has since progressed with its ability to provide broadcast weather services. NWR has been deployed across the country and now reaches over 90 percent of the population. With growth and development of the private meteorological sector, NWS has encouraged private meteorologists to enhance the provision of vital weather information to all sectors of the country. Consequently, even though routine commercial radio broadcasts have served a useful purpose, they are being phased out. NWS will continue its policy of permitting its offices to provide direct commercial radio weather broadcasts on a non-routine basis during periods of hazardous weather conditions. It will also continue its policy of permitting the rebroadcast of NWR programming on commercial radio and television stations.

Newspapers, once the primary means for disseminating weather information, have now assumed a dissemination role subordinate to that of television and radio. The weather page of USA Today, however, has sparked a renaissance in newspaper weather reporting, with many newspapers including an improved forecast map and more expanded data and forecast coverage in their daily weather sections.

NWS has long enjoyed a generally cordial relationship with the print media and cooperates with it in every way possible, especially when called upon to furnish interviews and background information in connection with news reports of weather disasters or unusual events. With the growth of the private weather information service sector, the NWS role of direct provision of routine services to newspapers has diminished, such support being considered basically the province of the private sector.

5.1.7 Marine Dissemination

The dissemination of marine weather products is currently undergoing a major transformation. Computers, satellite relays, and cellular phones are becoming increasingly important as complements to VHF and HF radio broadcasts and will soon relegate CW (Morse Code) transmissions to the pages of history.

Several systems operated by the NWS, the USCG, and by various private and public institutions and organizations work together to reach the largest number of mariners possible. The NWS has delineated four distinct areas, each of which is served by a different one of these systems. These include the High Seas, the Offshore areas, and the Coastal zones of the various oceans surrounding the U.S. and the Great Lakes.

Mariners on the High Seas and those in the Offshore areas, hundreds to thousands of miles at sea, receive weather data via radiofacsimile, radiotelephone, radiotelegraph, or radioteleprinter, from the USCG, from certain commercial radio stations, and from a few individuals or academic institutions working with the NWS as part of the MAREP program.

During the 1990's, two new internationally recognized systems, INMARSAT and NAVTEX, will become the standards for message dissemination throughout the High Seas and Offshore areas respectively. Using satellite and computer technology, each of these will be able to automatically target messages to ships in specific areas, quickly relaying the latest applicable warnings and forecasts.

Nearshore mariners, those cruising within a few tens of miles from the coast, will continue to rely on VHF NWR and USCG radio transmissions for weather information.

Mariners on the Great Lakes, especially those near to shore, will be served by the same type of VHF radio broadcasts now available. In addition, radiofacsimile or radioteletype products especially geared to the larger lake carriers will continue to be available from the commercial radio station, WLC. Also, selected NWS data are accessible through cellular phones and shipboard computers from various NWS offices and from WLC.

5.1.8 Telephone Circuits

Virtually all of the current NWS dissemination methods discussed already have been predicated on the assumption that data, products and services will be sent via telephone circuits which may be composed in whole or in part of land lines, radio transmissions, and satellite links. Computer-to-computer communication will for the foreseeable future make use of telephone circuitry. While satellite transmission technology will be increasingly used for NWS dissemination, the humble telephone will still play a very important role in how the NWS communicates -- from the virtually instantaneous transfer of huge quantities of data between computers to the inquiry of a citizen about the hurricane near Bermuda. Recorded information available by phone -- forecasts and other services -- will continue to be important in the dissemination of NWS weather products. The days might be gone when people called their local weather offices for all kinds of weather information, primarily because of the many ways NWS now uses to dispense its messages; but there will always be legitimate user requests that can be dealt with in no other way than by a phone call.

5.2 Planned and Future Dissemination Systems

5.2.1 Automated Voice Techniques

In June, 1989, a final agency decision was made to replace the existing electro-mechanical AMPRO NOAA Weather Radio (NWR) consoles with state-of-the-art microprocessor-based technology. Such a system will improve upon the current system in that it will increase the timeliness of broadcast products and associated warning response time, reduce operational and maintenance related labor intensive human involvement, and reduce recurring costs for operation and maintenance.

The NWS has developed the functional and systems requirements for the NWR Console Replacement System (CRS). The CRS shall be capable of providing "live" broadcasts, as well as broadcasts from digital storage of human voice that have been input via microphone, or that have been prerecorded in digital or analog format upon an appropriate portable medium.

The system shall also be capable of providing broadcasts of text-to-speech using automated synthesized voicing techniques. Synthesized speech translates text messages into combinations of predefined digital electronic sounds that result in understandable, speech-like messages. It is presently the most versatile form of text-to-speech voicing technology, as the extent of it's vocabulary is without constraint. Mispronounced words can be easily and permanently corrected at the keyboard. However, synthesized voice quality does suffer from the presence of a persistent accent.

Also included within the CRS requirements is the provision for Weather Radio Specific Area Message Encoding (WRSAME) capabilities. This capability will, for the first time, allow certain NWR broadcasts to become product selective and site specific in their distribution to designated users such as the media, emergency management officials, schools, hospitals, and federal, state and local governments/agencies.

As an additional enhancement to the NWR dissemination process, the CRS will provide for the automatic initiation, with verification of completion, of multiple and simultaneous programmable telephone dial-out of all assigned messages, also programmable by the operator. This function may be utilized in combination with, or independent of, the WRSAME tone generating capabilities described above.

5.2.2 Graphics Dissemination

The ability to use low cost and non-labor intensive technologies to improve the timeliness and efficiency of watch and warning dissemination, while increasing the resolution, scope and/or volume content of the associated products is an important NWS dissemination requirement. This requirement is being addressed in part through the operational use of low-powered radio transmitters known as Packet Radios.

Packet Radio uses radio technology to minimize communications costs, and has the ability to automatically transmit data, alphanumeric text, and graphics to specialized users such as the EOC and disaster preparedness agencies. It utilizes a radio modem (called a Terminal Node Controller or TNC) to take digital information and transfer it to another TNC by way of radio waves instead of conventional hard lines. The TNC relays the received information only after checking that all the data intended for relay was indeed received. The information is sent in "Packets" of 256 characters and includes the origination, destination routing, and content of the message.

5.2.3 Direct Links to Federal, State and Local Agencies

Direct data communications links are permitting an increased number of data interfaces between operational NWS computer networks and federal, state, and local government networks, state law enforcement and emergency management agencies. These links provide:

- o Timely receipt by NWS operational sites of spotter reports, observations and other pertinent information generated by external agencies;
- o Rapid dissemination of tailored weather information to support decision-making officials.

For maximum effectiveness, the interfaces are eventually to be automated, allowing the instantaneous routing of pertinent products such as watches, warnings, zones, radar, and special, severe and flood statements.

The return flow of information to the NWS office is also a critical element of the warning and dissemination process. Eventual upgrades to a full duplex asynchronous line between the network and each respective host computer at the NWS office will make a significant contribution in addressing this requirement, by permitting receipt of damage/storm/severe reports, road conditions, etc., from the network. An alternative to the full duplex asynchronous line being considered is the development of an interface between the network and the upgraded NWWS for outgoing information from the NWS. Implementation of such an interface would then allow use of the network/host computer interface for incoming data.

The implementation and management of such interfaces will be under the control of the NWS.

5.2.4 Satellite Imagery and Interpretive Services

GOES-TAP, an analog satellite data distribution system, was established to meet the operational requirements of the NWS. The GOES-TAP is currently funded jointly by NESDIS and the NWS. Within the NWS, the GOES-TAP is in operation primarily to support the NWS' SWIS and FAIS display systems. However, GOES-TAP data are also currently available to external users from the six distribution Hubs. The process by which an external user may subscribe to GOES-TAP involves request and approval by NESDIS and a payment of about $1000 as a one-time connection fee (plus recurring charges for the telephone line).

Currently under consideration by the NWS is how these external users may continue to receive these data at a reasonable cost once the NWS receives NOAAPORT/AWIPS, and therefore no longer has a requirement for the GOES-TAP system. It is unlikely that NESDIS will create a field organization to deal with it. It is more likely that all the subscribers will either be required to convert to NOAAPORT or purchase the data from a NOAAPORT subscriber. The latter options may incur higher and potentially prohibitive costs for some external users than GOES-TAP. However, various options already under consideration (such as the UNIDATA system) may actually provide a lower cost and higher quality alternative to the GOES-TAP.

6.0 FIELD RESEARCH EXPERIMENTS EMPLOYING NEW TECHNOLOGIES

6.1 Modernization and Associated Restructuring Demonstration (MARD)

The modernization and associated restructuring of the NWS features improved services through the effective and efficient use of the new technologies. Demonstrations of new capabilities and services will take place through a wide range of activities. The MARD will be the centerpiece for demonstrating the fully modernized and restructured NWS of the 1990s. As currently planned, MARD will take place in a multi-state area in the central US which is extremely prone to severe weather. Once the proper number and mix of staff is in place, along with the new technology, and training has been completed, a number of WFOs supported by RFCs and National Centers will operate in the modernized and restructured mode as the first step towards national conversion to the new structure.

The primary objectives of MARD are to demonstrate more accurate and timely warning and forecast services and to provide an opportunity to evaluate service performance and responses of users within the context of the most cost effective organizational structure.

MARD will help refine new operational procedures and resolve implementation issues that can best be addressed through actual field experience. MARD will provide an opportunity to examine additional organizational efficiencies that may be gained from application of the new science and operation of the new technology.

Based upon the MARD experience, full implementation of modernization and restructured operations will proceed on a national basis.

6.2 Wind Profiler Demonstration Project (WPDP)

Experimental wind profilers have been operated by ERL in Colorado since 1980. A mini-network of three profilers has been operated in Colorado since 1986. While these units have been primarily for research, their data have been used by WSFO Denver, CWSU Longmont and NSSFC to assist in the preparation of warnings and forecasts.

In the mid 1980's the Wind Profiler Demonstration Project was established to field a network of 30 profilers in the central U.S. A major component of the project was the development of the Wind Profiler Assessment Program in 1987. One of the goals of the Program is to use experimental information from the Wind

Profiler Demonstration Network to understand how best to make use of the data to improve NWS operational forecasts and services. An engineering assessment is also being carried out as part of the program. Its primary goal is to assess the system characteristics of the wind profilers both individually and in networks and to determine those characteristics required for a fully operational national network. A number of NWS and ERL organizations are participating in the Assessment Program. The Central and Southern Region Scientific Services Divisions are coordinating the training of field personnel as well as local assessment activities at WSFO and other field offices. The National Meteorological Center's Development Division is modifying its data analysis system to be able to assimilate large quantities of profiler data at hourly or three hourly intervals. Development work is also proceeding on the mesoscale Eta model so it can make use of the profiler data. The Techniques Development Laboratory (TDL) has contracted for encoding software to display profiler data in graphic form on AFOS. A set of 4 training manuals and videotapes have been developed by the PROFS group of ERL and are being used for training NWS personnel at field and Regional Offices. The first profilers of the Demonstration Network were being installed during the summer of 1990 with the full network expected to be in place in about 14 to 18 months later. The Profiler Control Center and Hub used for monitoring data quality and system reliability and maintenance began operations in mid 1990. Assessment activities are expected to continue at least through the end of FY 1992 and probably well into FY 1993.

Results from the Assessment Program will play a major role in determining whether to proceed with a national network of wind profilers. The system design, network spacing and training procedures will also be strongly influenced by the results of the assessment.

6.3 Convection And Precipitation/Electrification (CAPE)

NWS will be involved in the CAPE Experiment, proposed to operate in central Florida during the summer of 1991. CAPE will focus on four central themes that have been the basis of extensive research activity in recent years.

The first theme has a goal of understanding the aspects of charge generation and ultimately, separation, leading up to lightning production. The second theme involves the use of a mesoscale model to develop the capability of 2 - 12 hour forecasts over central Florida. The goal of the third theme is to predict where and when convection will develop and subsequently decay, and whether or not it will have the potential to produce damaging winds, lightning and heavy rainfall. The final theme will deal with quantitative precipitation totals.

6.4 Lake Ontario Winter Storm (LOWS) Experiment

The NWS provided support to the LOWS Experiment, conducted during the late winter of 1990. Its objectives were to study the structure, dynamics, cause, characteristics and microphysics of the intense lake-effect snowstorms that occur to the lee of the Great Lakes.

Lake effect snowstorms have been difficult to observe and forecast due to their shallow (3 km) depth, often passing under NWS surveillance radars, and their sensitivity to wind direction and thermal stratification of the lower atmosphere.

Through the use of newly developed profiling systems, wind and temperature profiles were monitored and the snowfall resulting from the air/lake interaction observed using advance Doppler radar. A comprehensive analysis is expected by the end of the 1990 calendar year.

7.0 SUMMARY

This report has been an attempt to freeze in time a picture of the rapidly changing evolution of NWS programs for observing and forecasting the weather and for disseminating information. It is a larger report than its predecessors of 1981, 1986 and 1988 because of technological advances, new programs, and the sharpening of focus of current programs. It is quite possible in this report that a program may have received insufficient attention or may have been left out. To rectify any omissions, and to keep abreast of further rapid advances in the NWS use of technology in its mission, the Office of Meteorology will attempt to update this report on a biennial basis. Copies of this report may be obtained from the NWS Office of Meteorology.

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APPENDIX A

Glossary of Acronyms and Abbreviations Used in this Report

ACARS	ARINC Communications and Reporting System
AFCU	Area Forecast Coordination Unit
AFOS	Automation of Field Operations and Services
AHOS	Automatic Hydrologic Observation Systems
AI	Artificial Intelligence
AIRIES	Artificial Intelligence Research in Environmental Services
AKRFC	Alaska RFC
ALDS	Automatic Lightning Detection System
ALERT	Automated Local Evaluation in Real-Time
AMOS	Automatic Meteorological Observing Station
AMSU	Advanced Microwave Sounding Unit
AMTS	Advanced Meteorological Temperature Sounder
ARINC	Aeronautical Radio, Incorporated
ART	Automatic Radio Theodolite
ARTT	AWIPS Requirements Task Team
ASAP	Automated Shipboard Aerological Program
ASDAR	Aircraft to Satellite Data Relay
ASOP	Automation of Surface Observations Program
ASOS	Automated Surface Observation System
ATDDCS	Automated Tone Dial Data Collection System
ATS-3	Applications Technology Satellite
AVHRR	Advanced Very High Resolution Radiometer
AWIPS-90	Advanced Weather Interactive Processing System for 1990s
BLM	Bureau of Land Management
bps	Bits per second
C-MAN	Coastal Marine Automation Network
CATS	Conical Atmospheric Tropopause Sounder
CBRFC	Columbia Basin RFC
CDDF	Central Data Distribution Facility
COE	Corps of Engineers
CRS	Console Replacement System
CRT	Cathode Ray Tube
CSIS	Centralized Storm Information Service
CW	Morse Code
CWSU	Center Weather Service Unit
CY	Calendar Year
D/VIP	Digital Video Integrator and Processor
D/RADEX	Digitized Radar Experiment
DAMS	Digital Automated Monitoring Systems

DAR^{3}E	Denver AWIPS-90 Risk Reduction and Requirements Evaluation
DBMS	Data Base Management System
DCP	Data Collection Platform
DCS	Data Collection System
DDS	Domestic Data Service
DIFAX	Digital Facsimile Network
DMSP	Defense Meteorological Satellite Program
DOC	Department of Commerce
DOD	Department of Defense
DOI	Department of the Interior
DOMB	Deep Ocean Moored Buoy
DOT	Department of Transportation
DS	Dwell Sounding
EDF	PROFS Experimental Data Facility
EFAS	Enroute Flight Advisory Service
EOS	NASA Earth Orbiting System polar platform
EPA	Environmental Protection Agency
ERICA	Experiment on Rapidly Intensifying Cyclones over the the Atlantic
ERL	Environmental Protection Agency
ERS-1	European polar orbiting satellite on the 1990s
FAA	Federal Aviation Administration
FDN	Field Distribution Network
FEMA	Federal Emergency Management Agency
FFAS	Flash Flood Alarm System
FGGE	First GARP Global Experiment
FOS	Family of Services
FSS	Flight Services Station
FY	Fiscal year (October through September for U.S. Government)
GALE	Genesis of Atlantic Lows Experiment
GARP	Global Atmospheric Research Project
GMS	Geostationary Meteorological Satellite (Japan)
GOES	Geostationary Operational Environmental Satellite
GOES I-M	Nest-generation GOES
GOWON	Gulf Offshore Weather Observing Network
HAS	Hydrometeorological Analysis and Support
HIRS	High-resolution Infrared Sounder
HIS	High-resolution Interferometer Sounder
HOD	OH Hydrologic Operations Division
HRL	OH Hydrologic Research Laboratory
IBM	International Business Machines
ICRAD	Interactive Color Radar Display
IDE	Isolation Distribution Equipment
IDS	International Data Service
IFLOWS	Integrated Flood Observing and Warning System

INMARSAT	International Marine Satellite program
IOC	Initial Operational Capability
IR	Infrared
JAWOP	Joint Automated Weather Observing Program
JERS-1	Japanese polar orbiting satellite of the 1990s
KaPP	Kansas Pilot Project
KBES	knowledge based expert system
LFM	Limited Fine Mesh
LFWS	Local Flood Warning System
LNB	Large Navigational Buoy
LORAN-C	Long Range C-Band
LWO	Local Weather Office
MARD	NWS Modernization and Restructuring Demonstration
MAREP	Marine Report
MARFC	Mid Atlantic RFC
MBRFC	Missouri Basic RFC
MCIDAS	Man/Computer Interactive Data Acquisition System
MCS	Mesoscale Convective System
METEOSAT	European Space Agency geostationary meteorological satellite
MOU	Memorandum of Understanding
MSI	Multi-spectral imaging
MSU	Microwave Sounding Unit
N-ROSS	U.S. Navy's Remote Ocean Sensing System
NAFAX	National Facsimile Network
NASA	National Aeronautics and Space Administration
NC	National Center
NCAR	National Committee on Atmospheric Research
NCCF	NOAA Central Computer Facility
NDBC	National Data Buoy Center
NESDIS	National Environmental Satellite, Data, and Information Service
NEXRAD	Next-Generation Radar
NHC	National Hurricane Center
NMC	National Meteorological Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA-K,L,M	Next-Generation NOAA polar-orbiting satellites
NOAAPORT	NESDIS program to upgrade satellite communications
NOS	National Ocean Service
NOVA	NOAA Operational VAS Assessment
NPS	Numerical Products Service
NSF	National Science Foundation
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
NWP	Numerical Weather Prediction
NWR	NOAA Weather Radio

NWS	National Weather Service
NWSH	National Weather Service Headquarters
NWSRFS	NWS River Forecast Service
NWWS	NOAA Weather Wire Service
OH	NWS Office of Hydrology
OM	NWS Office of Meteorology
OWSE-NA	Operational World Weather Watch System Evaluation of the North Atlantic
PBS	Public Broadcast System
PC	Personal computer
POES	Polar-Orbiting Environmental Satellite
PPI	Plan-position indicator
PPS	Public Product Service of FOS
PPS-2	PPS backup of FOS
PRE-STORM	Preliminary Regional Experiment for STORM-Central
PROFS	Program for Regional Observing and Forecasting Services
PROTEUS	Prototype Real-time Observational Test, Evaluation and User Simulation
RADAP	Radar Data Processor
RADID	Radar Information Display
RAMOS	Remote AMOS
READ	Remote Entry Alphanumeric Device
RFC	River Forecaster Center
RJE	Remote Job Entry
ROSA	Remote Observation System Automation
RRWDS	Radar Remote Weather Display System
SAR	Synthetic Aperture Radars
SBN	Satellite Broadcast Network
SEAS	Shipboard Environmental Acquisition System
SEASAT	Sea Satellite
SFSS	Satellite Field Services Station
SHEF	Standard Hydrologic Exchange Format
SITOR	Simplex Teletype Over Radio
SMCC	Systems Monitoring and Coordination Center
SOP	STORM Project special observing period
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit
STAC	Scientific and Technical Advisory Committee
STORM	Stormscale Operational and Research Meteorology
SUNYA	State University of New York at Albany
SWIS	Satellite Weather Information System
TIROS	Television and Infrared Observation Satellite
TNC	Terminal Node Controller
TOGA	Tropical Ocean Global Atmospheric Experiment
TOVS	TIROS Operational Vertical Sounder
TURFC	Tulsa RFC

UHF	Ultra High Frequency
USGS	United States Geological Survey
VAS	Vissr Atmospheric Sounder; Vertical Atmospheric Sounder on GOES-IM
VDUC	VAS Data Utilization Center
VHF	Very High Frequency
VIL	Vertically Integrated Liquid
VISSR	Visible and IR Spin Scan Radiometer
VOS	Voluntary Observing Ship
WBT	Weather-by-telephone
WFO	Warning and Forecast Office
WINDSAT	Wind Satellite
WMO	World Meteorological Organization
WPDN	Wind Profiler Demonstration Network
WPDP	Wind Profiler Demonstration Project
WR	NWS Western Region
WRP	Weather Research Program
WRSAME	Weather Radio Specific Area Message Encoding
WSFO	National Weather Service Forecast Office
WSO	National Weather Service Office
WSR-57	Weather Service Radar, 1957 version
WSR-74	Weather Service Radar, 1974 version
WWW	World Weather Watch