The Federal Plan for Meteorological Services And Supporting Research

FISCAL YEAR 1978

FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

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

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The Federal Plan for Meteorological Services And Supporting Research

FISCAL YEAR 1978

JULY 1977
WASHINGTON, D.C.

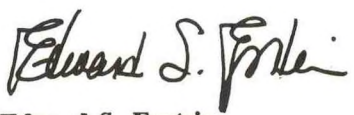
Preface

This Federal Plan is the thirteenth of an annual series developed by the Federal Coordinator for Meteorological Services and Supporting Research in response to Section 304 of Public Law 87-843. The document provides the Congress and the Executive Branch with an overall coordinated plan for Federal Meteorological Services and for those research programs whose immediate objective is to improve such services. The Plan describes the meteorological programs designed to reduce the economic and social impact of natural disasters, promote the Nation's welfare and economy, preserve and enhance the environment, and strengthen the national security.

The principal work of coordinating weather activities and of preparing and maintaining the Federal Plan is performed by two interdepartmental committees—the Interdepartmental Committee for Meteorological Services and the Interdepartmental Committee for Applied Meteorological Research. Membership is shown on the inside cover of this Plan. Those committees and their subcommittees conduct systematic reviews of basic and specialized meteorological requirements, services and related supporting research. They also prepare specialized plans that supplement these activities. A list of the current specialized plans is summarized in the publications section of this Plan.

Membership for two other activities, under the Federal Coordinator for Meteorological Services and Supporting Research, is also shown on the inside cover of this Plan—the Joint Committee for Space Environment Forecasting and the Interagency Committee for the World Weather Program. The former committee is a recent addition to the organization. The activities of these committees are documented elsewhere and are not included in this Plan.

Fiscal data for FY 1977 and FY 1978 are summarized briefly following the introductory section. Next, the basic and specialized meteorological services are each presented from an operational point of view along with the supporting research aimed at improving the individual services. This year the section on Operational Functions has been eliminated and the information on meteorological satellites, which was a separate section in previous editions, is covered under Basic Meteorological Service.



Edward S. Epstein
Federal Coordinator
Meteorological Services
and Supporting Research

Contents

Fiscal Summary

The following tables summarize fiscal information concerning meteorological expenditures of the Federal Government for meteorological services and supporting research for FY 1977 and FY 1978. The basis for increase or decrease in expenditures is presented for significant changes.

The fiscal information is presented by agency in Table 1, showing FY 1977 data, planned agency activities during FY 1978, and the net changes. Funds used throughout this Plan represent the total all agencies plan to obligate for the year in question. A comparison between last year's Plan and the present one shows some differences within agencies in funding for FY 1977, however the overall net difference considering all agencies amounts to less than 1% of the FY 1977 total appropriations for meteorological operations and supporting research that are reported in this Plan. These differences are due to correction in program entries or to differences between last year's estimates for FY 1977 and the funds subsequently appropriated. The distribution of dollars by basic and specialized meteorological services is summarized in Table 2.

A comparison between last year's Plan and the present one shows two significant differences in the FY 1977 figures for operations: a net decrease of $1,500,000 for the Department of Commerce and a net increase of $3,000,000 for the Department of Defense. For Commerce the net figure includes a decrease in operational reconnaissance funding and management obligations and an offsetting increase for marine weather and ocean forecasts. The Defense net increase is due principally to aircraft conversion costs in the Air Force reconnaissance program and increased costs in the meteorological satellite program. For the FY 1977 supporting research programs the only significant difference is a $5,000,000 reduction across several programs for the Department of Defense as reported by Air Force and Army.

In FY 1978, agencies are requesting $674,863,000 for operational programs. This represents a net increase of $38,940,000 over FY 1977. The total operational program increases being requested by the Department of Commerce amount to $15,548,000. A portion of this increase, $12,921,000, is an adjustment to the base funding for FY 1977 to allow for unavoidable increased costs of ongoing activities; $1,000,000 of the increase will be used to initiate a seven-year program for installation of emergency power units at key National Weather Service centers, offices and observatories; and an increase of $700,000 will be for operation and maintenance of nine deep-ocean, moored buoys. Another $1,500,000 is planned for mass storage equipment to be added to the computer system at the National Climatic Center and for operation of the Center for Climatic and Environmental Assessment. A net increase of $827,000 is planned for procurement and for covering additional costs in the satellite program. An offsetting decrease of $1,500,000 will be made to reflect a change in plans to upgrade the National Oceanic and Atmospheric Administration computer facility at Suitland, Maryland.

Table 1—Federal plan for meteorological operations and supporting research, by agency
(Thousands of dollars)

	Operations			Supporting research			Total		
Agency	FY 77	FY 78	Net difference	FY 77	FY 78	Net difference	FY 77	FY 78	Net difference
Agriculture	—	—	—	1,593	1,692	+99	1,593	1,692	+99
Commerce	297,269	312,817	+15,548	14,224	14,278	+54	311,493	327,095	+15,602
Defense	263,744	290,680	+26,936	22,563	29,198	+6,635	286,307	319,878	+33,571
EPA	700	750	+50	7,700	6,200	−1,500	8,400	6,950	−1,450
ERDA	2,278	2,375	+97	178	197	+19	2,456	2,572	+116
NASA	1,331	1,359	+28	27,717	23,992	−3,725	29,048	25,351	−3,697
Transportation:									
Coast Guard	4,753	3,113	−1,640	—	—	—	4,753	3,113	−1,640
FAA	65,848	63,769	−2,079	9,031	8,502	−529	74,879	72,271	−2,608
Total	**635,923**	**674,863**	**+38,940**	**83,006**	**84,059**	**+1,053**	**718,929**	**758,922**	**+39,993**

Table 2—Federal plan for meteorological operations and supporting research, by service (Thousands of dollars)

	Operations			Supporting research			Total		
Service	FY 77	FY 78	Net difference	FY 77	FY 78	Net difference	FY 77	FY 78	Net difference
Basic	321,244	337,218	+15,974	41,688	38,037	−3,651	362,932	375,255	+12,323
Aviation	218,143	233,667	+15,524	10,252	10,297	+45	228,395	243,964	+15,569
Marine	13,421	15,622	+2,201	2,727	3,929	+1,202	16,148	19,551	+3,403
Agriculture & Forestry	4,449	4,920	+471	1,593	1,692	+99	6,042	6,612	+570
General Military	48,905	50,857	+1,952	18,868	23,707	+4,839	67,773	74,564	+6,791
Other	29,761	32,579	+2,818	7,878	6,397	−1,481	37,639	38,976	+1,337
Totai	**635,923**	**674,863**	**+38,940**	**83,006**	**84,059**	**+1,053**	**718,929**	**758,922**	**+39,993**

In the Department of Defense, the FY 1978 net increase for operational programs is $26,936,000. The most significant increase is $20,270,000 for the meteorological satellite program, which includes purchase of long-lead satellite items, ground equipment improvements, ground receiver and communications equpment, and general cost increases. The Air Force plans a $10,594,000 increase and the Navy an offsetting decrease of $4,421,000 for data processing and display.

In the Department of Transportation the FY 1978 decrease of $1,640,000 by the U.S. Coast Guard is due to deletion of funding to operate Ocean Weather Station HOTEL. The Federal Aviation Administration net decrease of $2,079,000 is due mainly to curtailing procurement of meteorological equipment, planned termination of weather circuits, and canceling voice broadcasts of aviation weather where automatic recording and transmitting equipment is installed.

The other agencies reported essentially level funding for FY 1978.

In FY 1978 the supporting research programs amount to $84,059,000, representing a net increase of $1,053,000 over FY 1977. The Department of Defense plans an increase of $6,635,000 that represents a greater emphasis in most programs. The decrease of $1,500,000 planned by the Environmental Protection Agency (EPA) results from the completion in FY 1977 of a major study on regional air pollution. The reduction of $3,725,000 for NASA is due to portions of the TIROS-N and NIMBUS-G programs being completed.

The increases noted for Basic Meteorological Service in Table 2 are due in part to the Department of Commerce increase of about $13,000,000 plus $4,000,000 for the Department of Defense. For Aviation Meteorological Service the increase of $15.569,000 is primarily attributed to the Department of Defense programs. The increase of $3,403,000 for Marine Meteorological Service is due to additional funding in the Department of Defense programs. The decrease of $1,481,000 for supporting research in Other Specialized Meteorological Services reflects the completion by the EPA of the pollution study mentioned earlier.

Table 3 shows the extent to which Federal agencies make use of each other's capabilities through the purchase of meteorological services and/or supporting research by interagency fund transfers in FY 1977. Some of the more significant items include $3,700,000 (DOC to DOD) for operational weather reconnaissance, $51,847,000 (DOC to NASA) for the meteorological satellite program, $1,103,000 (DOD to DOC) for meteorological data and climatological services, most of the $1,715,000 (ERDA to DOC) for services and product improvement in suport of the Nation's nuclear testing program, and $1,097,000 (NASA to DOC) for services supporting space operations.

Table 4 lists agency manpower engaged in weather operations by function. The only significant change evident is a decrease of 180 positions in Department of Defense for FY 1978, and 125 of those positions are for the taking of observations.

The FY 1978 fiscal data contained in this Plan are reflected in the President's budget and should be used for planning purposes only. The scheduling and implementation of these programs after FY 1978 are subject to additional analysis and change.

Table 3.—Interagency fund transfers for meteorological operations and supporting research. (Thousands of dollars)

Agency Transferred from	Agency Transferred to	Funds Fiscal Year 1977 Operations	Funds Fiscal Year 1977 Research
DOC	DOD	3,700	
DOC	NASA	51,847	
DOD	DOC	1,103	274
DOD	DOT	19	
DOD	NASA		108
ERDA	DOC	1,577	138
FAA	DOC		999
FAA	NASA		436
NASA	DOC	1,097	240
NASA	DOD	5	

Table 4.—Agency manpower engaged in weather operations, by function

Agency	Observations		Analyses and forecasts		Communications		Dissemination to users		General agency support		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Commerce	1,605	1,605	2,002	2,010	149	149	1,106	1,106	1,362	1,373	6,224	6,243
(1)	35	35	204	204	—	—	—	—	35	35	274	274
Defense	3,229	3,104	1,022	1,022	663	655	2,044	2,040	1,497	1,454	8,455	8,275
(1)	5	5	8	8	2	2	2	2	9	9	26	26
(2)	307	308	614	616	192	192	249	250	1,187	1,170	2,549	2,536
Transportation:												
Coast Guard	145	—	—	—	—	—	—	—	—	—	145	—
(2)	162	160	—	—	33	32	9	9	13	13	217	214
FAA	—	—	—	—	—	—	—	—	—	—	—	—
(2)	335	321	—	—	555	527	745	760	548	587	2,183	2,195
Total	**5,823**	**5,538**	**3,850**	**3,860**	**1,594**	**1,557**	**4,155**	**4,167**	**4,651**	**4,641**	**20,073**	**19,763**

(1) Personnel funded by other agencies

(2) Man-years

Meteorological Services

Introduction

The objectives of the national meteorological services are to:

- Reduce the economic and social impact of natural disasters
- Promote the Nation's welfare and economy
- Preserve and enhance the environment
- Strengthen the national security

To meet these objectives the Federal Government provides two types of meteorological services—Basic and Specialized. The Basic Meteorological Service which the Department of Commerce provides is designed to meet public needs or the common needs of other agencies, and constitutes the foundation for disaster warnings and the specialized services. The Specialized Meteorological Services provide the facilities, products, and distribution mechanisms for servicing the needs of specialized users such as those involved in aviation, marine, agriculture and forestry, and general military.

Basic Meteorological Service

Description

The Basic Meteorological Service provides fundamental observations and forecasts used by the general public, many segments of private industry, and departments and agencies of the Federal government. The effectiveness of the Basic Meteorological Service is dependent upon the cooperative efforts of several Federal agencies as well as the member nations of the World Meteorological Organization.

The Service includes:

- Observing current weather conditions
- Communicating weather data and information
- Preparing analyses and forecasts
- Issuing and disseminating warnings and forecasts
- Archiving weather information for ready retrieval

The first of these components is composed of four fundamental weather observing programs—surface, upper air (includes aerial weather reconnaissance), radar, and meteorological satellites. Our national programs are complemented by other countries' observation programs. Taken as a whole they represent our capability for detecting and tracking potentially hazardous weather as well as providing data for basic analysis and forecast services.

Table 5 shows the number of locations where each of the Federal agencies makes surface and upper air observations, together with the number of aircraft equipped to perform aircraft reconnaissance.

OBSERVING CURRENT WEATHER CONDITIONS

Surface Observations

Surface observations are taken by the Departments of Commerce, Defense, and Transportation, Energy Research and Development Administration, and National Aeronautics and Space Administration at about 1,400 land locations. These observations support basic analysis and forecasting functions and the specialized services. Observations are also taken for the Department of Commerce by citizen volunteers and by employees of the Departments of Agriculture and Interior at some 13,000 cooperative stations. The volunteer stations support climatological and specialized observational needs, and the stations of the Departments of Agriculture and Interior support agriculture and forestry needs.

Table 5.—Number of locations by observation function, fiscal years 1977-78

Observation function	Agency	FY 77	FY 78
SURFACE (land)	Commerce [1]	551	589
	Defense	261	255
	Transportation (FAA)	363	363
	Transportation (Coast Guard)	170	165
	NASA	3	3
	ERDA	9	9
SURFACE (marine)	Commerce (merchant ships cooperative program)	2,584	2,584
	Transportation (Coast Guard ships)	82	82
	Defense (ships with meteorological personnel)	47	47
	Commerce and Transportation (ocean stations)	1	0
	NOAA ships	30	30
UPPER AIR (rocket)	NASA (U.S.)	1	1
	NASA (overseas)	1	1
	Defense	11	11
	ERDA (U.S.) [2]	2	2
	ERDA (overseas) [2]	2	2
UPPER AIR (balloon)	Commerce (U.S.)	96	96
	Commerce (overseas)	24	24
	Defense (fixed)	14	14
	Defense (ship)	33	33
	Defense (mobile)	72	72
	NASA (U.S.)	3	3
	ERDA (U.S.) [2]	2	2
	Transportation/Coast Guard [3]	21	20
	Transportation/Commerce (OWS HOTEL)	1	0
WEATHER RADAR	Commerce (U.S.)	111	115
	Defense	109	117
	Transportation/Commerce (OWS HOTEL)	1	0
	NASA (U.S.)	1	1
WEATHER RECONNAISSANCE	Defense (No. of aircraft) [4]	20	20

[1] Cooperative stations operated by Departments of Agriculture, Interior, and Transportation, other public and private agencies, and those manned by volunteers are not included. Also excluded are approximately 300 Supplementary Aviation Weather Reporting Stations and foreign cooperative stations.

[2] Inactive but available for use.

[3] Balloon support facilities inactive, but available for use.

[4] 7WC-130s operated by AF Reserves.

Surface observations are taken at sea by Department of Defense ships, and vessels of the merchant fleet provide cooperative observations in a program operated by Department of Commerce. The Department of Transportation's Coast Guard operates ship as well as shore and island stations.

Automatic weather stations are increasingly used for essential observations as an adjunct to manned operations and at unmanned or inaccessible locations on land and sea. These stations are located in key areas to obtain weather observations for use in preparing forecasts and warnings. There are presently 60 automatic stations that measure wind, temperature, dew point, pressure, and amount of liquid precipitation plus 16 stations with limited sensor capability (e.g., wind data only). In addition, 17 automated buoys are positioned off the Pacific northwest, the Gulf of Mexico, and off the mid-Atlantic coast. In Table 5, most of the increase in surface (land) observation stations for Commerce in FY 1978 is due to additional automatic stations that will be installed.

The National Weather Service (NWS) successfully installed two automatic weather stations, one at Summit, Alaska and, more recently, at Wendover, Utah, in the fall of 1976 with improved sensing equipment to specify clouds and visibility. They are routinely providing completely automatic observations including cloud and visibility information for operational purposes. National Weather Service plans to extend this type of station to other locations to replace manned operations that are being curtailed or closed.

Upper Air Observations

Data from the upper air observing network provides the basic input to numerical analysis and forecasting. The Department of Commerce operates land facilities in the United States to make upper air observations (balloon) and funds meteorological programs for observations on islands of the U.S. Trust Territory in the Pacific Ocean. The Department of Defense participates both at U.S. and overseas areas through operating its land and ship facilities. While there is a regular network of upper air stations both in the United States and selected overseas areas, it is not economically feasible to have complete coverage of the adjacent oceans and other data-sparse areas. Supplemental upper air data over these areas are provided by Department of Defense weather reconnaissance flights, and from in-flight pilot reports by commercial, general, and military aviation. Also, the National Aeronautics and Space Administration and the Department of Defense use rocketsondes to obtain temperature and wind measurements from 30 to 100 kilometers at 13 locations on North and Central America and the surrounding ocean areas.

The Department of Defense performs tropical cyclone aerial reconnaissance in the Western Pacific in response to military requirements and in the Eastern Pacific, Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico in accordance with the provisions of the *National Hurricane Operations Plan* (revised annually). In general, up to eight storm center fixes per day may be requested whenever a storm is forecast to be within 300 nautical miles of the U.S. coast, Puerto Rico, the Virgin Islands, or Department of Defense installations. In the eastern and central Pacific Ocean, up to two consecutive 6-hourly fixes per day may be requested whenever a storm is forecast to be within 300 nautical miles of U.S. territory. In addition, extratropical winter storm reconnaissance is flown in the western Atlantic in accordance with the provisions of the *National East Coast Winter Storms Operations Plan* (revised annually). In October 1976 NOAA began reimbursing the Department of Defense for all reconnaissance flown for civilian purposes.

Radar Observations

Radar is a principal source of weather information for making the short-term warnings of severe weather that contribute heavily to saving lives and property in many areas of the Nation. These radar observations provide:

- The best methods now available for the remote identification and tracking of severe thunderstorms, squall lines, tornadoes, and other destructive storms
- A means for locating, tracking, and estimating the intensity of tropical cyclones as they approach the coast
- The information upon which estimates of precipitation rates and amounts can be based for use in flash-flood warnings and river stage and flow predictions
- A means for detecting potentially hazardous turbulence in convective storms.

The Basic Weather Radar Network includes 54 Department of Commerce and 14 Department of Defense radars plus 22 Federal Aviation Administration (FAA) Air Traffic Control radars used to provide data from the western U.S. mountainous areas. Basic network radars with long-range detection capability are manned around the clock to provide continuous severe storm surveillance. Local warning radars complement this network at 45 locations to detect and track severe local storms in susceptible areas not covered adequately by the basic network. Local warning radar data serve

as the basis for detailed short-period warnings and forecasts.

The FAA radars used as part of the basic network in the mountainous regions of the west are being modified to improve aircraft control. This modification reduces the amount of weather data transmitted into the ARTC Centers for processing by NOAA radar specialists. To insure no degradation in the availability of radar observations needed for detecting and tracking severe weather over this large region, equipment will be procured to obtain the weather data directly at ARTC radar antenna sites for transmission directly to NOAA/NWS radar specialists in the ARTC Centers.

Meteorological Satellites

The fourth Basic Meteorological Service observing program is that consisting of polar-orbiting and geostationary satellites. Operational systems include those operated by the Department of Commerce and the Department of Defense.

The Department of Commerce, through the National Environmental Satellite Service (NESS), of NOAA, is the agency responsible for a national operational environmental satellite system. The Department is charged with operating and improving the system to meet the common requirements of all Federal agencies. The objectives of the operational system are:

- Provide global imagery of the earth and its environment on a regular basis, day and night, including direct readout to local ground stations within radio range of the satellite.
- Obtain quantitative environmental data on a global basis, such as temperature, moisture, winds, radiation flux, and solar energetic particle flux, for use in numerical analysis and prediction programs.
- Obtain near-continuous observations of the earth and its environment, collect data from remote observing platforms (including automatic weather stations, balloons, aircraft, ships, buoys, and river and tidal stations), and broadcast weather data to remote locations.
- Contribute to improved monitoring and prediction of the atmospheric, oceanic and space environments by developing applications of satellite information.

The operational system includes polar-orbiting and geostationary satellite programs directed toward satisfying the above objectives. The system also includes command and data acquisition stations; a satellite operational control center through which the satellites are controlled and data are acquired; facilities for processing and analyzing satellite data and products; and laboratories for satellite sensor experiments and developing applications of satellite data. Within the conterminous United States, some direct readout and processed data and products are distributed to users over NWS facsimile networks. Also, Satellite Field Services Stations (SFSSs) have been established to analyze, interpret, and distribute processed geostationary satellite products to regional NWS, and other Federal agencies. The products are also made available to private sector activities at their own cost. SFSSs are located in Washington, D.C., Miami, Kansas City, Honolulu, San Francisco, and Anchorage. The Anchorage, Alaska SFSS distributes mainly data from the polar-orbiting satellites and limited data from the geostationary system.

The current polar-orbiting satellite system, the Improved TIROS Operational Satellite (ITOS), became operational in December 1970. The ITOS satellites obtain measurements of the vertical temperature structure and total water vapor content of the atmosphere in cloud-free areas using the Vertical Temperature Profile Radiometer (VTPR). The temperature soundings produced are distributed nationally and internationally for use in quantitative numerical analysis and prediction programs. Unprocessed VTPR data are broadcast continuously from the satellite for local reception. This is known as the direct sounder transmission service and is available worldwide to any properly equipped ground station. The ITOS system also provides height resolution (1 km) observations of the earth's cloud cover, cloud top temperatures, and in cloud-free areas, sea surface temperatures using the very high resolution radiometer. Global day and night cloud imagery with resolutions of 4 and 8 km are obtained using the Scanning Radiometer (SR). Worldwide readout of local area SR imagery is available through the automatic picture transmission system. Also, global SR infrared measurements are processed as large scale analyses of sea surface temperature. The ITOS system solar proton monitor obtains data on the energetic particle flux in polar areas.

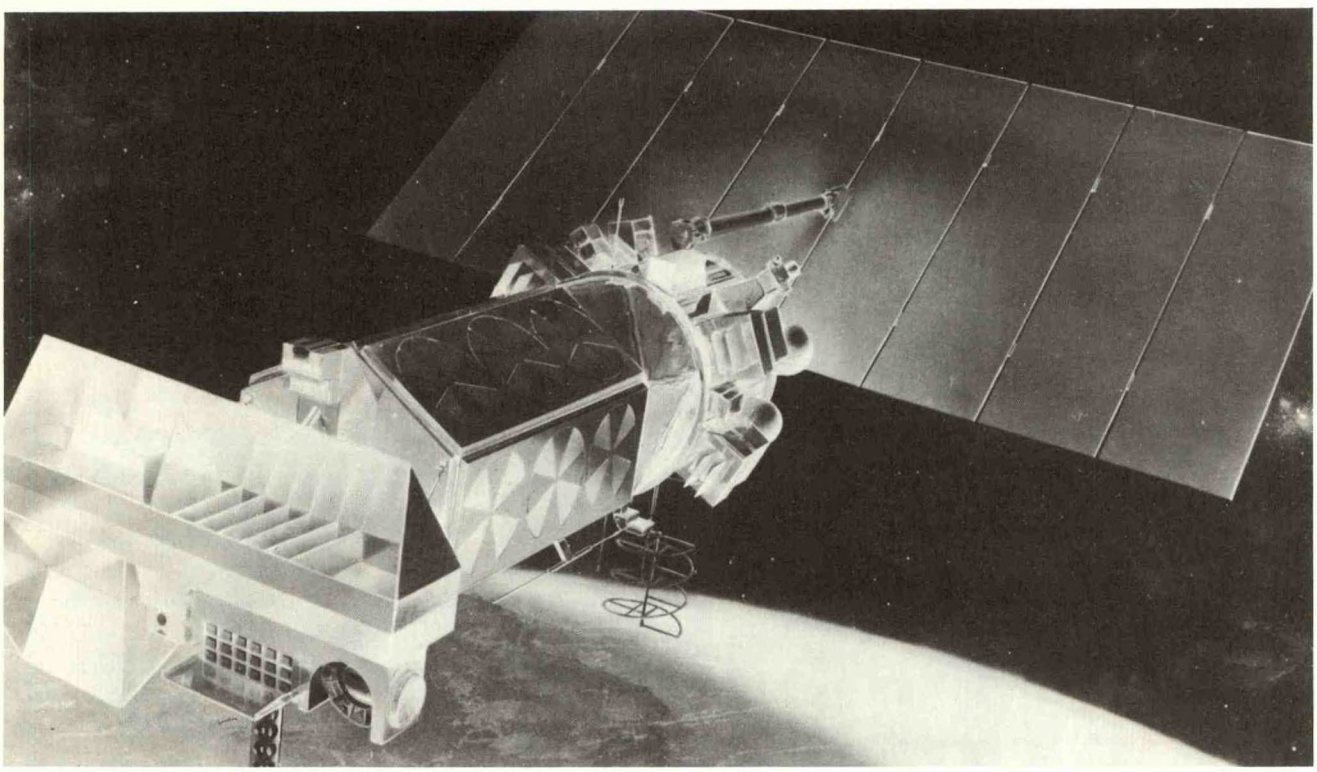
Satellites in the ITOS system are called NOAA and numbered consecutively following launch and successful insertion into orbit. The current operational satellite is NOAA 5. NOAA 4 is in orbit on standby and is available as a limited backup to NOAA 5 should the need arise. The ITOS system (the second generation of polar-orbiting satellites) will be succeeded during 1978 by a third generation of operational satellites. The NASA funded prototype known as TIROS N, planned for launch in mid-1978, will be followed in four to six months by the first of seven NOAA funded satellites. The NOAA funded satellites will retain the

NOAA name and will be numbered consecutively beginning with the number immediately following that last used in the ITOS program. The third generation system is expected to be fully operational by the end of 1978.

The TIROS N system will focus on increasing the accuracy of weather forecasting by providing quantitative data required by improved numerical models. A comparison of the ITOS and TIROS N series features is given in table 6.

The geostationary satellite program began during the latter half of the 1960s as an operational experiment in which the imaging capability and broadcast system (WEFAX) of the NASA Applications Technology Satellites 1 and 3 were used. The program became an operational reality following the launch of NASA's Synchronous Meteorological Satellites (SMS) 1 and 2 in 1974 and 1975 respectively. Both SMS 1 and 2 were released by NASA to NESS for operational control and use following the initial checkout period. These satellites were the prototypes for NOAA's Geostationary Operational Environmental Satellite (GOES). The current operational system consists of GOES 1, launched October 16, 1975, and SMS-2. SMS-1 remains in orbit and is the backup for the other two satellites. It is planned to launch GOES B and C during FY 1977 and 1978 respectively as replacements for SMS-2 and GOES 1.

The two operational satellites in the GOES system are located over the equator near 75° West longitude and 135° West longitude. These satellites provide repetitive viewing of the development and movement of destructive weather systems, such as thunderstorms, hurricanes, and major mid-latitude storms, over much of North and South America and adjacent oceans. The principal instrument is the Visible and Infrared Spin Scan Radiometer (VISSR). The VISSR provides near-continuous cloud viewing with resolutions of 1, 2, 4, and 8 km in the visible wave lengths and 8 km in the infrared wavelength. Full earth disc pictures are available at 30-minute intervals throughout the day and night; partial disc pictures can be obtained at more frequent intervals to meet special requirements such as viewing development and movement of severe storms. The GOES data collection system is used to collect and relay environmental data observed by remotely located sensing platforms, such as automatic weather stations, buoys, and river and tide gages. These satellites also broadcast environmental data to remote locations using the WEFAX system, and collect data for warnings of solar activity, using the space environment monitor. In the contiguous United States and



Artist conception of NOAA's third generation operational polar-orbiting satellite. The NASA prototype, planned for launch in mid-1978, is known as TIROS N. Subsequent satellites will be called NOAA.

Table 6.—Comparison of ITOS and TIROS N Series Features

	ITOS	TIROS N Series
Atmospheric soundings	Restricted by clouds or other moisture and ability to correct for their presence.	Additional channels and improved geometry will increase probability of obtaining soundings from the infrared measurements. Also, the microwave sounder provides a capability, within limits to sound through clouds.
	Accurate to 3°C root mean square (rms)	Accurate to 1.5° rms
	Temperature profiles to 30 km	Temperature profiles to 48 km. The Stratospheric Sounding Unit will be provided by the United Kingdom.
	Provides total water vapor content in lower 5 km.	Provides water vapor content in three layers in the lower 10 km of the atmosphere.
High Resolution Radiometry	Sea surface temperature accurate to 2-3°C rms	Accurate to 1.5°C absolute, and 0.5°C relative on a 10 km grid at least once each day, and to 1.0°C absolute on a 100 km grid once per day.
	Scanning Radiometer—two channels (visible and infrared); resolution 4 km (visible) and 8 km (infrared). Very High Resolution Radiometer (VHRR)—two channels (visible and infrared) resolution 1 km both channels	Advanced VHRR—four channels in early spacecraft, five channels in later spacecraft. Resolution 1 km and 4 km depending on function. More accurate sea surface temperatures; better differentiation of clouds, snow and ice, and liquid water.
Data Collection	Not available	Provides for receipt, processing and retransmission of data from fixed and moving platforms, and locates the latter accurate to 5-8 km rms. Spacecraft system will be provided by France.
Space Monitoring	Measures energetic particle flux along local vertical and normal to spacecraft.	Monitors solar proton and electron flux density and total energy distribution in the near-earth space environment.
Design lifetime/ growth potential	12-15 months/none	24 months/25% growth potential

Hawaii, the Department of Defense uses drops from the GOES dissemination systems to the maximum extent possible.

The Defense Meteorological Satellite Program (DMSP) is an operational meteorological satellite system managed by the United States Air Force under the Department of Defense. The Air Force furnishes DMSP data and all specifications for their use to Department of Defense meteorologists and to NOAA/NESS. NOAA/NESS is responsible for further dissemination of DMSP data to other U. S. government agencies and to the U. S. and international scientific communities. To help reduce costs, DMSP and TIROS N will have common spacecraft except for on-board sensors and certain specialized equipment. Also, TIROS N will use surplus Department of Defense boosters and Air Force launch crews. Details on DMSP are covered in the section titled General Military Meteorological Service. Operational program costs for weather satellites in the Department of Commerce and Defense are shown in Table 7.

COMMUNICATING WEATHER DATA AND INFORMATION

The utility of the Basic Meteorological Service depends upon an effective communications network. Weather observations are collected and distributed nationally by communications systems operated by the FAA, NOAA, and the Department of Defense. Exchange of data between nations is accomplished by international and Department of Defense weather communications circuits linking the U. S. with overseas data sources. Using these observations, centers prepare analyses and predictions for transmittal to forecast offices, local weather offices, and other government and authorized private users over Departments of Commerce and Defense facsimile networks and teletypewriter circuits. High quality satellite photos are distributed over other circuits to forecast offices, other government and authorized private users.

The major meteorological communications systems in use are given in Appendix A.

Table 7.—Agency operational weather satelliate program costs, by function
(Thousands of dollars)

Agency	Spacecraft and launching		Command and data-acquisition		Data processing		Technical management-and-support		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Commerce	54,289	53,730	8,647	10,786	11,105	11,363	11,206*	11,768*	85,247	87,647
Defense:										
Air Force	52,300	67,900	12,454	15,282	2,699	2,724	1,600	1,900	69,053	87,806
Navy	—	—	4,403	6,632	5,231	765	200	200	9,834	7,597
Total	**106,589**	**121,630**	**25,504**	**32,700**	**19,035**	**14,852**	**13,006**	**13,868**	**164,134**	**183,050**

* Includes SFSS and local display

PREPARING ANALYSES AND FORECASTS

Basic analysis and forecast products for Federal agencies and industrial and commercial users are provided from NOAA's three national centers—the National Meteorological Center at Camp Springs, Md., the National Hurricane Center at Miami, Fla., and the National Severe Storms Forecast Center at Kansas City, Mo.

The National Meteorological Center (NMC), provides basic weather analyses and forecasts for the Northern Hemisphere and for portions of the Southern Hemisphere. During a typical day, NMC processes more than 40,000 surface observations, 2,000 ship reports, 1,500 upper air soundings, several hundred vertical soundings derived from satellite data, 2,800 aircraft reports, and global cloud-cover data from weather satellites. NMC products include more than 400 charts for facsimile transmission and 200 messages for teletypewriter distribution daily to its users primarily in North America, but including others in overseas areas as well. Emergency backup for NMC is provided by the Air Force Global Weather Central in Nebraska and by the Navy Fleet Numerical Weather Central in California in accordance with the *Federal Plans for Cooperative Backup Among Operational Processing Centers,* December 1976, FCM 76-4.

The NMC operation is designed to produce forecast guidance products on a scheduled basis. Computer support for processing both NMC and National Environmental Satellite Service products is currently satisfied by three advanced computers on a shared basis.

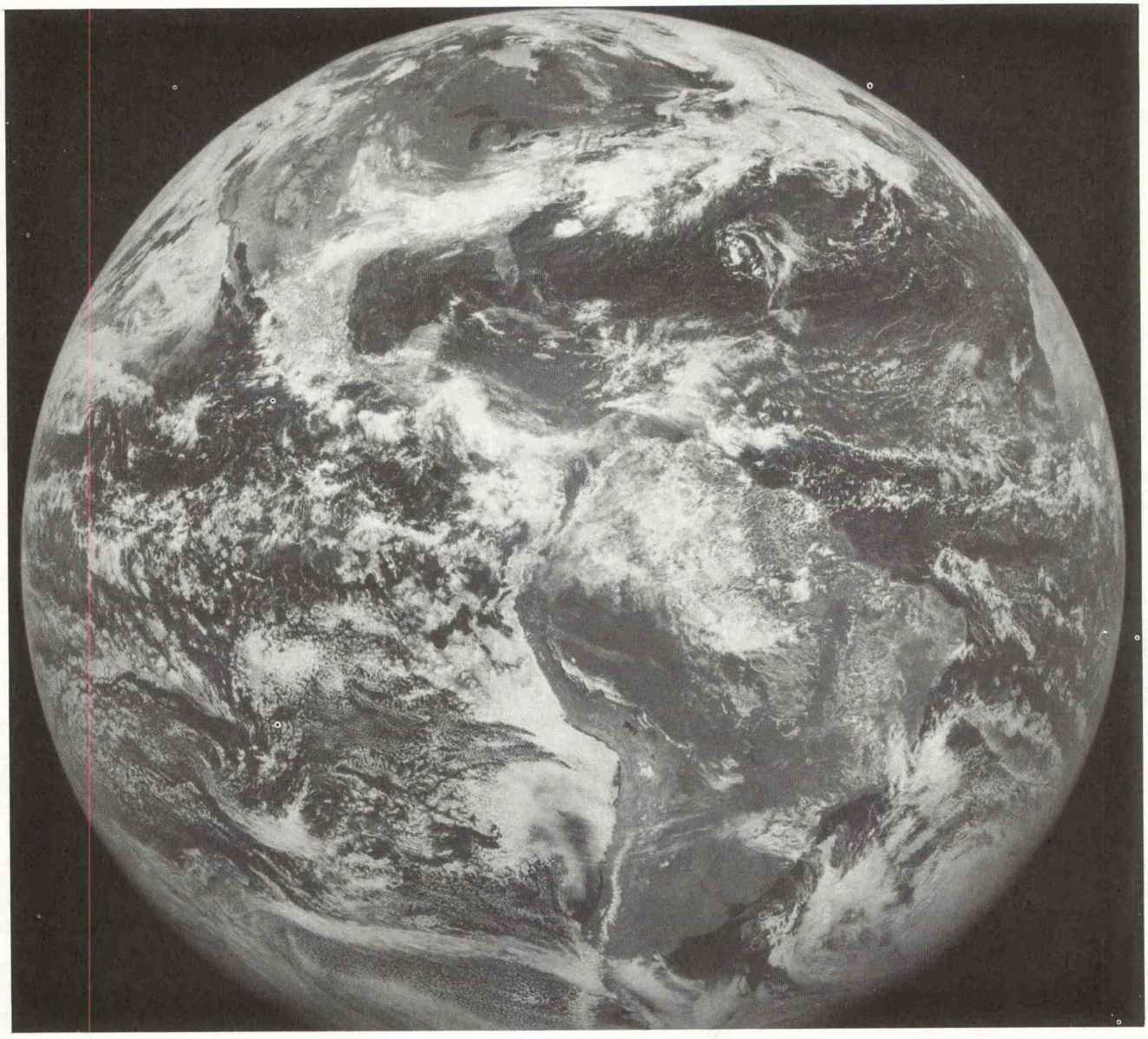
The National Hurricane Center (NHC) provides basic forecasts and warnings of hurricanes in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico for all Federal agencies and user groups.

The National Severe Storms Forecast Center issues convective outlooks, and severe thunderstorm and tornado watches, in support of civil needs. Severe weather watches are issued on an as needed basis and indicate areas where severe thunderstorms and/or tornadoes are possible. Convective outlooks in graphical and written form discuss both general and severe thunderstorm possibilities. These outlooks are issued twice daily, except for the period February-August when they are issued three times per day.

ISSUING AND DISSEMINATING WARNINGS AND FORECASTS

In response to the need for streamlining and improving field operations, NOAA's National Weather Service (NWS) has a significant automation effort underway to increase the productivity of its operating personnel and the effectiveness of its forecast and service offices. The purpose of this program, Automation of Field Operations and Services (AFOS) is to apply modern methods of data handling, display, and communications to the needs of field offices, thereby enabling them to provide more effective forecast and warning services to the Nation. Mini-computers, mass storage capability, TV-type displays, and hard-copy devices modularly assembled will be used to equip a systems monitoring and coordination center, four national centers, six satellite field services stations, 13 river forecast centers, 52 Weather Service Forecast Offices (WSFOs), and 136 Weather Service Offices (WSOs). In addition, 65 WSOs will receive only TV-type displays and a hard-copy device. The computer and mass storage support for these offices will be provided by an adjacent office.

The coordination center, national centers, and the WSFOs will be interconnected with a telephone quality full-duplex communications line called the National Distribution Circuit. Alphanumeric and graphic data will be carried throughout the system replacing several internal teletypewriter and facsimile circuits. In addi-



Weather as seen from the Geostationary Operational Environmental Satellite (GOES-1) at 1:00 p.m. EDT, July 4, 1976. Data resolution at the satellite subpoint is four km.

tion, through the use of minicomputers, each WSFO will be interfaced with the WSOs within its area of responsibility. The WSFOs will serve as the collection points for data and act as automated dissemination points for forecasts, warnings, and other information.

AFOS prototype equipment for an experimental WSFO, WSO, and river forecast center has been installed at the NWS headquarters. The NMC is interconnected by means of a communications link with this equipment as an integral part of the model facility. Procurement of the total AFOS system, now underway, will take four years. Concurrently, coordination is underway between the Departments of Commerce and Defense and the FAA to insure that AFOS and related Defense and FAA systems will be able to communicate and exchange data.

The general public receives weather forecasts and warnings through several dissemination means designed to reach, either directly or through an intermediary, people engaged in normal day-to-day activities (working, travelling, and recreation). The methods used include teletypewriter (NOAA Weather Wire Service and

Weather as seen from the Synchronous Meteorological Satellite (SMS-2) at 1:45 p.m. EDT, July 4, 1976. Data resolution at the satellite subpoint is four km.

the press wire services), NOAA Weather Radio, recorded telephones, Coast Guard radio systems, and the mass media (radio, television, and newspapers).

The NOAA Weather Wire Service is now available, either throughout or in parts of 35 states. Approximately 2,500 subscribers are currently using this service. This method is invaluable for reaching the mass media with information, especially warnings of dangerous conditions, for transmission to the public. Department of Commerce provides funds for the lines from a National Weather Service office to a radio or television station or daily newspapers. Subscribers pick up the costs for terminal equipment and for connection and local line charges. Other subscribers are at liberty

to connect to the NOAA Weather Wire Service at their own expense for the lines in addition to all other charges. Plans for nationwide expansion of the NOAA Weather Wire Service within the remaining states will not be completed at this time to effect savings following guidance from the Office of Management and Budget.

The NOAA Weather Radio, operating at 162.4, 162.475, or 162.55 MHz, provides continuous radio transmission of weather information out about 40 miles from the transmitter site. In a policy statement issued by the Office of Telecommunications Policy of the Executive Office of the President on January 13, 1975, the NOAA Weather Radio was designated as the only Federally sponsored radio transmission of disaster warning information to receivers optionally available to the general public. There is a variety of receivers available on the market. An increasing number of manufacturers are including a "weather button" as part of a regular AM/FM radio. Special receivers with warning-alert features are especially important in disseminating warnings to disaster agency and police officials, schools, institutions, and local governmental offices, as well as commercial radio and television stations. This service is now provided from about 130 locations. Additional installations planned over the next two years will bring the total number of transmitters to over 330. The importance of completing this vital service throughout the Nation was demonstrated conclusively during the April 3-4, 1974, widespread tornado outbreak. At the few locations with NOAA Weather Radio available in the 13-state outbreak area, immediate transmission of severe thunderstorm and tornado warnings from warning offices directly to the general public and responsible officials was considered invaluable in warning of these hazards.

In a companion effort, the National Weather Service, the Federal Communications Commission, the Defense Civil Preparedness Agency, and the National Industry Advisory committee (which represents the broadcast industry) have begun to develop state and local disaster warning dissemination procedures for the Emergency Broadcast System (EBS). The use of the EBS will complement the NOAA Weather Radio in the dissemination of warnings.

ARCHIVING WEATHER INFORMATION

Collecting, summarizing, archiving, and retrieving of data are climatological activities within the Basic Meteorological Service. Climatology includes the continuing use of historical weather data for long-range planning and for improving knowledge of weather and its effects upon life, property, energy resources, and economic development. The National Climatic Center at Asheville, N.C., receives and processes over 30 million meteorological observations annually and makes data and summaries including satellite data and related products available to a large and diverse user community. Data are gathered from the National Weather Service, the National Environmental Satellite Service, military services and international sources to provide a National Climatic Data Base (both digital and analog) for multiple uses. Over 80,000 subscribers regularly receive published data. The data and publications are used by planners, designers, engineers, lawyers, academic groups, government agencies, and the public. General publications serve the needs of broad user audiences. The Climatic Atlas of the United States presents widely used climatic data in graphic forms and tabulations. Climatological Data National Summary issued monthly, lists pressure, temperature, and wind data for a large sampling of selected stations. Local climatological data publications are issued monthly for about 300 cities; these contain daily and monthly data on temperature, heating and cooling degree days, dew point, precipitation, wind, sunshine, and clouds. Other publications are designed to meet specific needs of large user groups. These include development of data archiving systems and studies undertaken for: (1) ground-based analyses of the state of the atmosphere; (2) the interrelationship between satellite-based weather observations as sources of integrated data products; (3) the statistical nature of climatic change including: the interrelationships among various climatic elements over land and water, evaluation of climatic change; (4) the use of large climatic data collections in efforts to improve food production and health, and optimize environmental quality; and (5) the use of data analyses in decisions concerning trade-offs between environmental considerations and the economics of construction, power production, location of offshore ports, and continental shelf and deepwater mineral recovery.

Because of the increasing importance of climatic fluctuations upon domestic and foreign food and fiber production and energy shortages, a Center for Climatic and Environmental Assessment (CCEA) has been established at Columbia, Mo., and Washington, D.C. The CCEA operated on a real-time basis during the 1976 growing season, deriving yield estimates from first generation wheat yield models for the United States, Russia, and Canada. The yield estimates for these countries were generally close to estimates generated by the Department of Agriculture. Statistical models for other countries are in a final testing phase and will be used in the 1977 growing season. This work

represents the NOAA contribution to the interagency Large Area Crop Inventory Experiment. CCEA also has developed models for linking the weather impact to natural gas demand. In addition to the modeling effort, CCEA is globally monitoring weather patterns and issuing weekly assessment reports which relate the impact of anomalous weather conditions to crops and energy demand and distribution. Products from this Center are intended to provide information to assist in the management and distribution of our Nation's food and energy resources.

Table 8 lists the costs of the Basic Meteorological Service, by agency, for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

Of those agencies participating in the Basic Meteorological Service, increases of $13,473,000 are planned by the Department of Commerce (which includes adjustments to base of $10,846,000) and $3,760,000, which will be attributed to this service by the Department of Defense. The Department of Transportation plans a decrease of $1,529,000.

In the Department of Commerce, installation of the new local warning radars is continuing. At the beginning of FY 1978 about 50 should have been installed with the remaining 10 to be completed in FY 1978. Completion of this program will improve our capability for surveillance of severe storms.

As part of a continuing program to automate observations from unmanned and inaccessible locations, 35 more automatic meteorological stations will be installed in FY 1978. In addition, 22 stations providing wind data only will be installed.

In the AFOS Program, which provides for significant improvements in the forecast and warning services for the Nation, equipment deliveries to the field will start in FY 1978 and continue for four years. Initially, the AFOS delivery rate will be to six offices per month, increasing to about eight per month in FY 1979. By the end of FY 1978, AFOS systems will be in place at three National centers, 30 WSFOs, seven RFCs, 31 WSOs, and three SFSSs. In addition, the Systems Monitoring and Coordination Center will have been established and staffed.

The NOAA Weather Radio system will be completed nationwide in June 1979. The eventual total of approximately 340 transmission sites will put about 90 percent of the Nation's population within listening range of continuous radio broadcasts of severe weather warnings and forecasts.

In addition to these improvements, the Department of Commerce is planning a net increase of $2,627,000 for FY 1978. An increase of $700,000 will be for operation and maintenance of nine deep-ocean, moored buoys which will be in inventory from FY 1975-76 procurements. Six of these buoys will be located off the northwest Pacific coast and in the Gulf of Alaska, two will be located off the Atlantic coast, and one buoy will be placed in the Gulf of Mexico. $1,000,000 has been requested to initiate a seven-year program for installation of emergency standby power at all National Weather Service field offices and centers. The increase requested for FY 1978 will permit installation of emergency power units at one National Center, nine river forecast centers, and 20 Weather Service Forecast Offices (WSFOs). In the following years through FY 1984, emergency power installation will be completed at remaining WSFOs, network radars, local warning radars, and Weather Service Offices and Observatories. $500,000 is planned to provide for the operation of the Center for Climatic and Environmental Assessment

Table 8.—Basic Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Commerce	267,444	280,917	13,971	14,045	281,415	294,962
Defense:						
Air Force	33,836	38,191	—	—	33,836	38,191
Navy	7,851	7,256	—	—	7,851	7,256
NASA	—	—	27,717	23,992	27,717	23,992
Transportation:						
Coast Guard	3,788	2,259	—	—	3,788	2,259
FAA	8,325	8,595	—	—	8,325	8,595
Total	**321,244**	**337,218**	**41,688**	**38,037**	**362,932**	**375,255**

whose mission is to furnish the environmental assessment factors needed for prudent management and distribution of our resources—including crops, energy, and fish production; and $1,000,000 to provide for a mass storage system at the National Climatic Center. Offsetting these increases will be a decrease of $200,000 in other National Climatic Center programs. In meteorological satellites an increase of $1,174,000 is planned to continue procurement of GOES spacecraft and for additional costs of launch vehicles and ground equipment. For polar orbiting satellites the planned net decrease of $347,000 is principally due to a decision not to launch additional ITOS spacecraft plus changes in costs for launch vehicles and services. An increase of $300,000 is planned for a newly established Climate Diagnostics Project for new data resources, analysis techniques, and exploration of statistical applications to improve climatic predictions. An offsetting decrease of $1,500,000 will be made to reflect a change in plans to upgrade NOAA's computer facility at Suitland, Md.

Table 9 shows the planned launch schedule for polar-orbiting and geostationary satellites in the Department of Commerce.

In the Department of Defense the Air Force attributes 16% of its operational program to Basic Meteorological Service. Therefore, of its planned program changes, a net increase of $4,355,000 will be applied to this service. Offsetting this will be a decrease of $595,000 in the Navy that is attributed principally to a lowering in base funding following acquisition of computer equipment for the satellite processing center at Monterey in FY 1977. Discussion of the Air Force program changes will be found under General Military Meteorological Service.

The significant program change in the Department of Transportation is in the U.S. Coast Guard. Ocean Weather Station HOTEL off the east coast of the United States will be withdrawn from service. The Department of Commerce plans to replace the vessel with one or more moored buoys and on-call weather reconnaissance for tropical storms and east coast winter storms.

Research Program for Fiscal Year 1978

In the Department of Commerce, while the first operational implementation of the basic AFOS system begins in FY 1978, research and development activities in AFOS will also continue at a high level. Specifically, design, development, experimentation and refinement of AFOS system hardware and software will be conducted in the following areas: human factors design and analysis; follow-up design work on a centralized weather watch and warning coordination facility; detailed design studies for individual stations (national centers, WSFOs, WSOs, and RFCs); data acquisition preprocessing and integration interfaces; WSFO and WSO simulation experiments in both the Experimental Facility and the initial AFOS field sites; forecast applications for monitoring and updating NWS predictions and warnings, and continued software applications development.

New weather products and better services will be developed to take advantage of the advanced technology of the AFOS system. New meteorological forecast

Table 9.—Projected Launch Schedule—Polar-Orbiting System

Satellite Designator	Planned Launch Date	Instruments
ITOS I	(in storage)	SR—Scanning Radiometer; VTPR—Vertical Temperature Profile Radiometer; VHRR—Very High Resolution Radiometer; SPM—Solar Proton Monitor
ITOS E2	(in storage)	
TIROS N (NASA funded)	2Q FY 78	AVHRR—Advanced Very High Resolution Radiometer; TOVS—TIROS N Operational Vertical Sounder; SEM—Space Environment Monitor; DCPLS—Data Collection and Platform Location System; HIRS/2—Modified High Resolution Infrared Sounder.
NOAA A	3Q FY 78	
NOAA B	FY 1979*	
NOAA C	FY 1980*	
NOAA D	FY 1981*	

Projected Launch Schedule—Geostationary System

Satellite Designator	Planned Launch Date	Instruments
GOES B	3Q FY 77	VISSR—Visible and Infrared Spin Scan Radiometer; SEM—Space Environment Monitor; DCS—Data Collection System; VAS—VISSR Atmospheric Sounder (GOES D and subsequent spacecraft)
GOES C	2Q FY 78*	
GOES D	FY 80*	
GOES E	FY 81*	

* Launch date is dependent upon performance of prior spacecraft.

applications will involve the automatic monitoring and updating of forecast guidance as needed; the automatic production of guidance in the same form as the final products; and the introduction of new products relative to a local area.

One AFOS forecast application is the automatic generation, update and display of computer-worded public forecasts. This effort involves the development of complete, objective, three-period (e.g., today, tonight and tomorrow) automated forecasts in a worded form suitable for use by NWS public forecasters on a real-time basis. The forecaster can accept the computer-produced forecast, push a button on the AFOS console and the dissemination will be automatic. Slight alterations can be made by simple text editing. Forecasts can be changed completely by entering a new set of forecast values in lieu of the objectively derived ones, and instructing the AFOS minicomputer to generate a new forecast for dissemination.

In FY 1978 after conversion of the program to the AFOS minicomputer, experiments will be run in the AFOS Experimental Facility to determine forecaster acceptance of the form of display, structure of the message, and complexity of the forecast. The program will be modified to make forecasts for additional stations. Terminology unique to a particular station will be developed and incorporated when ready. The program will be expanded to handle a tonight, tomorrow, and tomorrow night cycle. The initial AFOS software will include computer-worded public forecasts in the package developed for its first field implementation at Pittsburgh and Philadelphia, Pa., and Raleigh, N. C., in January 1978.

Also of vital importance is a new effort aimed at the automation of guidance to NWS forecasters who are responsible for issuing flash flood warnings and advisories on a real-time basis. The flash flood forecaster can request, via the AFOS console keyboard, information regarding probable maximum precipitation amounts based on derived correlations between manually digitized radar data and precipitation amounts.

Research continues in developing and refining automated techniques for forecasting thunderstorms and severe local weather (e.g., tornadoes, hail and damaging winds) in each of the key ranges: medium, short, and very short.

The objective of research in medium-range forecasting is to develop automated techniques for predicting general thunderstorm activity, and the occurrence and intensity of severe local storms for projections of 12-48 hrs. In FY 1978 procedures will be developed to update severe local storm probability forecasts by using surface synoptic observations, satellite data, and radar reports. An early guidance package based on 12Z initial data will be developed to provide NSSFC with thunderstorm and severe local storm probabilities for a 24-48 hr. forecast projection. Equations giving thunderstorm probabilities for the 12-24 hr., 24-36 hr., and 36-48 hr. forecast projections will be developed for use in the AFOS system. Separate probability equations for tornadoes and hail will be developed from model predictors and severe local storm reports.

Short-range forecasting's goal is to develop automated techniques for generating accurate and timely forecasts, 2-6 hours in advance, of severe local storms and general thunderstorms over most of the United States east of the Rocky Mountains. Simple prediction schemes, amenable to processing by AFOS minicomputers, will be tested for potential implementation at WSFOs. Also in FY 1978 procedures to incorporate satellite observations into existing short-range prediction systems will be developed and tested. Six 2-6 hr. prediction cycles per day for all seasons of the year will be implemented.

The objective of very short-range forecasting for periods up to 2 hours is to develop automated techniques using NWS digital weather radar to identify and track the development and movement of thunderstorms and/or severe local weather. Results should prove useful in providing timely warnings to the general public and special users such as the aviation industry. Techniques to be developed and tested include implementing an automated forecast in the 0-2 hr. range using radar data alone in the NWS radar data processing minicomputer system, and using radar in conjunction with other type data for forecasts using the AFOS communication system.

Since the lower atmosphere strongly influences severe local storms, work is continuing on the development of a three-dimensional numerical forecast boundary layer model to aid in severe storm prediction. Output will consist of detailed wind, temperature and humidity profiles for incorporation into severe storm prediction equations for use as guidance to NSSFC and field forecasters. FY 1978 work in boundary layer modeling will include development of a fine-mesh (10-20 km grid spacing) model, and extending the forecast area over the entire U. S.

Severe storm research principally emphasizes improving fundamental understanding through comprehensive description and explanation of storm characteristics which will lead to improved forecasts and warnings. Motion field studies provided by multiple Doppler radar observations have led to important new insights concerning tornado development and the con-

vection systems that spawn them. Continued multi-Doppler efforts are expected to yield additional knowledge.

Information gained in previous years documenting early detection of mesocyclones has evolved into a cooperative effort led by NOAA, involving agencies of the Departments of Transportation and Defense, to evaluate operational use of single Doppler radar for improved storm warnings and aviation safety. These data will be augmented with observations from surface and rawinsonde networks, conventional radar, a meteorological tower instrumented at six levels, and research aircraft. A tornado intercept project, in cooperation with the Energy Research and Development Administration, National Research Council, and the University of Oklahoma, will provide both visual support and photographic records.

Sferics studies of severe storm systems will receive renewed concentrated emphasis in attempts to isolate cloud regions generating such activity and to relate those observations to theoretical expectations and Doppler radar measurements of internal storm flows.

Research is continuing to develop improved forecast techniques to better predict occurrence of severe convective storms. Skill in use of video-displayed, computer generated, meteorological data for purposes of these predictive efforts is being developed.

Evaluation of the FAA's ASR-8 approach control radar for weather intelligence retrieval will be accomplished. The effort here is to address the radar's capability in detection and display of critical weather events hazardous to aircraft.

The development and testing of atmospheric remote sensors, and their application to atmospheric research will be stimulated by the erection of a well-instrumented meteorological tower to be located at the Boulder Atmospheric Observatory situated 16 miles east of Boulder, Colo. Ground-based studies will test a pulsed CO_2 Doppler lidar wind sensor. The FM-Doppler radar will incorporate on-line computer processing and control to provide velocity profiles in real time throughout the boundary layer.

The National Hurricane and Experimental Meteorology Laboratory will continue research efforts designed to provide basic and applied research results directed toward improvements in techniques for predicting formation, movement and changes in intensity of hurricanes. The efforts will include special observational programs utilizing research aircraft, meteorological satellites and other data; and diagnostic studies of hurricane structure, behavior, and interaction with the large-scale tropical environment. Special efforts will continue to improve both the two- and three-dimensional mathematical models which already represent the most sophisticated existing for the numerical simulation of hurricane structure and behavior.

The hurricane research program is focusing on reducing tropical cyclone track prediction error, preparation of statistical and dynamical diagnostic studies, and forecasting intensity changes in tropical systems. Increased emphasis will be placed on the prediction potential of satellite data in both track and intensity forecasts. A joint project with other NOAA agencies will focus on developing storm surge models for bays and estuaries. In severe thunderstorm forecasting a dynamic climatology of tornadoes is being generated and new data analysis techniques are being developed with the view toward producing automated analyses of mesoscale data fields in real time for use by the severe weather forecaster.

Research and development on automatic weather stations continues toward automating more parts of the observation that still require manual input. The most recent step forward was automation of cloud and visibility information. Development efforts include work on a laser system for observing the "present weather" parameters—rain, snow, sleet, smoke, and fog.

Department of Commerce research programs for meteorological satellites will continue to emphasize derivation of quantitative data from satellite observations of the earth's atmosphere and surface. These data will be used to develop improved techniques for environmental prediction and warning. Major data applications program efforts include derivation of temperature and moisture fields, wind vectors, energy balance, and concentrations of ozone and other atmospheric constituents. During FY 1978 NESS will continue to cooperate with NASA in the development of the VISSR Atmospheric Sounder (VAS). The VAS will be included on the GOES D, E, and F spacecraft in lieu of the current VISSR.

In the National Aeronautics and Space Administration (NASA) research on weather and climate emphasizes (a) applying space technology to improve long-range forecasting (1-3 weeks), (b) developing space and ground systems to aid in detecting, predicting, and warning of severe storms, and (c) establishing the potential of space technology in monitoring and predicting climate changes.

The NASA developed TIROS-N, planned for launch in 1978, is the prototype of the next generation of operational weather satellites. It will provide global monitoring of weather systems and highly accurate quantitative measurements of the atmospheric state. NASA will develop advanced instrumentation for the TIROS-N series of satellites for improved atmospheric soundings, higher spatial and temporal resolution im-

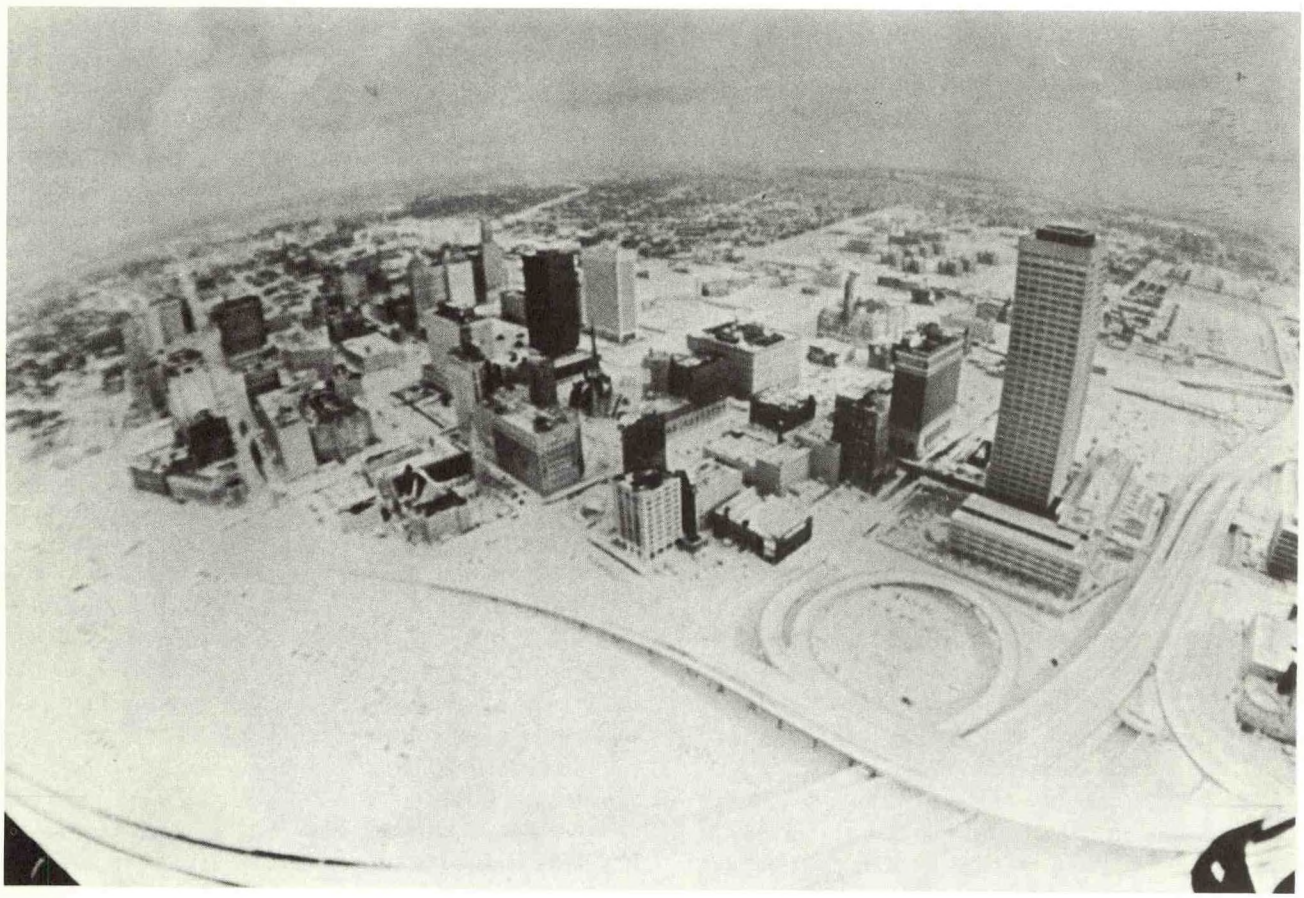
agery, and observations of the distribution and total content of atmospheric constituents such as ozone.

Development is underway on models and forecast techniques using data from satellites, aircraft, and other sources to improve the prediction of severe storms. Studies are being done on very high resolution satellite sensors designed to detect incipient storms and measure the atmospheric conditions under which the storms develop.

An Atmospheric Cloud Physics Laboratory (ACPL) will be flown on Spacelab III in 1981 and twice per year thereafter. The ACPL will significantly increase the level of knowledge of cloud microphysical processes. The experimental results will then be used to improve severe storm models and severe weather prediction techniques.

An experiment in improved detection and prediction of frost and freeze conditions in Florida was initiated in FY 1977 to utilize geostationary meteorological satellite data. The experiment will be brought to an operational capability in FY 1979.

NASA's climate research emphasizes understanding the physical basis of climate and will be directed mainly toward modeling and developing a space-observational capability. Space data already gathered can yield information vital to national climate interests when additional analyses and corroborative data are collected. These data include global total ozone measurements from Nimbus 4, global precipitation, soil moisture, snow, and ice cover from the microwave sensors of Nimbus 6. These climate analyses will incorporate additional data on atmospheric constituents from Nimbus G and oceanographic data from SEASAT-A when these satellites are launched. Studies conducted with leading climate scientific investigators and in conjunction with national planning for climate research have identified the need for additional satellite sensor development.



Aerial photo of Buffalo, New York following a winter snowstorm in 1977 illustrates the paralyzing effect of recent severe winter weather on business and the community. Note that there is no traffic evident on the streets and cars are stranded in parking areas. Photo by Mickey Osterreicher, Time Magazine.

Aviation Meteorological Service

Description

The Aviation Meteorological Service furnishes specialized weather information to pilots, dispatchers, air traffic controllers, and fixed base operators to promote safety, efficiency, and operational effectiveness in civil and military aviation. Responsibility for the Service is shared among three Federal Departments—Commerce, Transportation, and Defense.

- The Department of Commerce provides meteorological services used by domestic and international civil aviation, and is responsible for meeting the common requirements of other agencies.
- The Department of Transportation makes recommendations to the Department of Commerce on civil aviation meteorological services, provides specialized equipment and surface observations at certain airfields, disseminates weather information to users, and distributes weather data over civil teletypewriter systems.
- The Department of Defense serves the specialized global needs of military aviation and makes meteorological information from its facilities available to civil aviation.

Specialized surface observations, primarily in support of aviation, are made at 525 civil and military locations in the United States. On the civil side, the National Oceanic and Atmospheric Administration (NOAA) provides these observations at eight locations and the Federal Aviation Administration (FAA) at 348 locations. The remainder are provided by the Department of Defense. These figures do not include cooperative observations by private operators at many smaller airports and by those supporting the Basic Meteorological Service. At several locations the surface observation program is coordinated between NOAA and the FAA or Department of Defense.

Pilot reports supplement surface observations by describing weather conditions encountered by aircraft in flight. They are valuable for pilot weather briefings and as data for the preparation and updating of forecasts and warnings. Since October 15, 1976, domestic pilot reports have been prepared in a standardized format. International pilot reports continue to be encoded in their own standardized format.

Weather observations and other information in support of domestic civil aviation are collected and distributed over the FAA digital data Service A and the Basic Meteorological Service teletypewriter systems. Department of Defense agencies use a continental U. S. meteorological communications system to meet the needs of military aviation and ground units in the United States. International meteorological data are exchanged on high-speed circuits of the Basic Meteorological Service, and, where necessary, on the Aeronautical Fixed Telecommunications Network operated by the FAA. The Automated Weather Network of the Department of Defense provides for high-speed collection and relay of data between overseas areas and the continental United States to meet Department of Defense aviation and other military requirements. Data from this system are provided to the National Meteorological Center (NMC) as an essential ingredient to NMC's data base. NMC places selected North American data on the Department of Defense network for distribution to military users.

Analyses and forecasts for aviation are prepared by weather centers, and by weather forecast and service offices. National centers of the agencies provide guidance and forecasts for use by lower echelon forecast offices. Cooperative efforts are in being to facilitate the exchange of information between agencies. For example, at the Navy's Fleet Weather Central in Hawaii, two National Weather Service people assist in computer programming and adapting Navy products for use by the National Weather Service in the Pacific region. At Suitland, Md., the Naval Fleet Weather Facility provides operational sea ice analyses to NOAA and backup communications for transmission of meteorological products from the NMC over computer-to-computer links, at no cost to the Federal Government, for computerized flight planning. The Department of Defense also prepares computer flight plans—an average of 600-700 daily—to support worldwide tactical and strategic aircraft movements. In the event the NMC's computational center should experience a significant outage, arrangements have been made, as outlined in the *Federal Plans for Cooperative Backup Among Operational Processing Centers,* December 1976, FCM 76-4, for the Air Force Global Weather Central to provide aviation wind forecasts for commercial flight planning.

Analysis and forecast centers of NOAA distribute specialized weather charts for aviation purposes to weather offices and briefing facilities that include

Weather Service Forecast Offices (WSFOs), Weather Service Offices (WSOs), FAA Flight Service Stations (FSSs), and military offices, over the several facsimile networks. The Department of Defense operates additional facsimile circuits to meet its specialized requirements and has weather service offices that also support international civil aviation.

Fifty-two NOAA WSFOs (including San Juan) prepare detailed local forecasts for 469 terminals and 320 routes on a scheduled basis, and six NOAA WSFOs provide forecasts for international civil aviation for the North Pacific, North Atlantic, and Caribbean areas and for Central America and West Europe according to procedures of the International Civil Aviation Organization.

Aviation weather briefings by the FAA and the Departments of Commerce and Defense are available to pilots through 640 manned facilities. At air terminals where FAA-FSS and NOAA-WSO facilities are collocated, the FSS handles routine weather briefings and refers the pilot to the WSO or nearby WSFO for more technical meteorological assistance if necessary. The FAA maintains extensive weather briefing outlets. These outlets include toll-free telephone service from many airports without a local weather briefing service; recorded forecast and observation material at more than 60 locations available by telephone; scheduled broadcasts over more than 800 air navigational aids; and separate continuous transcribed weather broadcasts from 110 radio outlets. Pilots may also get weather information by direct radio contact with a Flight Service Station. At 33 FSSs throughout the country, specially trained personel provide additional air-ground radio service for pilots over a discrete radio frequency 16 hours daily. A total of 44 FSSs will provide this service by December 1977. This service, designated Enroute Flight Advisory Service, maintains a continuous weather watch, provides time critical assistance to enroute pilots facing hazardous or unknown weather, and recommends alternate or diversionary routes. These flight watch control stations are also focal points for rapid receipt and dissemination of pilot reports and other weather information.

The Department of Defense operates a network of air-ground radio facilities to provide observations, forecasts, and warnings on request to airborne military pilots and to obtain inflight weather reports from military aircraft.

FAA provided over 16 million pilot weather briefings last year, NOAA about 1.6 million, and the Department of Defense approximately 2 million. FAA projects a continuing annual increase in requests for weather services from its Flight Service Stations, i.e., 18.6 million for FY 1977 and 19.9 million in FY 1978.

The FAA, the Department of Defense's Air Weather Service, and the Department of Commerce's National Weather Service completed a one-year test of an experimental weather unit in the Kansas City Air Route Traffic Control Center (ARTCC) at Olathe, Kansas. The test was conducted to merge significant weather information with ARTC activities. National Weather Service and Air Weather Service personnel monitor and interpret significant weather from FAA radars supplemented by NWS radar information, pilot reports, and synoptic weather data. Potentially hazardous weather information can then be made readily available to aircrews through air controllers. Operation of the unit was considered successful and is being continued pending study of extending the concept to other centers.

Needs exist for responding to increased briefing requirements and to replace outdated radio and observational equipment. Improvements also are required in data handling and in forecasting of severe weather, ceiling, visibility, slant range visibility, precipitation, wind velocity and wind shear for use in aircraft operations. Finally, techniques are required to provide:

- Automatic measurements of visibility
- Slant range visibility measurements
- Runway visual range measurements under 600 feet at 100-foot increments down to zero visibility
- Automatic measurements of precipitation
- Automatic detection and identification of selected weather phenomena
- Low-level wind shear including wake turbulence vortices

Table 10 lists the costs of the Aviation Meteorological Service, by agency, for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

The Department of Defense is planning a net increase of $16,496,000. Of this amount, $16,604,000 represents 61% of the Air Force operational program that is attributed to Aviation Meteorological Service. Details are discussed under General Military Meteorological Service. In the Department of Commerce, the difference in program amounts for FY 1977 and FY 1978 is due solely to adjustments to base funding.

The Department of Transportation is planning a net decrease of $2,349,000 for FY 1978. The more significant changes include a decrease of $2,500,000 due to curtailing procurements of meteorological equipment and planned termination of teletypewriters at NWS offices after AFOS is installed. An additional $1,500,000 decrease is for cancellation of voice broadcasts of aviation weather where automatic recording and transmitting equipment is being installed.

Table 10.—Aviation Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Commerce	21,307	22,684	51	51	21,358	22,735
Defense:						
Air Force	128,999	145,603	—	—	128,999	145,603
Navy	10,314	10,206	1,170	1,744	11,484	11,950
Transportation:						
FAA	57,523	55,174	9,031	8,502	66,554	63,676
Total	**218,143**	**233,667**	**10,252**	**10,297**	**228,395**	**243,964**

This is offset by an increase of $1,450,000 for weather equipment maintenance and supply support costs, increased operating staff and leased communications at the Weather Message Switching Center in Kansas City, Mo., and anticipated growth in pilot briefings.

Research Program for Fiscal Year 1978

Within the FAA, a development program is underway to provide accurate information and warnings of hazardous wind shear conditions to pilots. The program plan includes provisions for (1) efforts to better characterize low-level wind shear; (2) hazard definition of wind shear for the aviation community; (3) development of ground-based devices for hazardous wind shear detection and movement; (4) investigations into the use of airborne equipment to detect hazardous wind shear; (5) wind shear data processing, analysis, and reporting; (6) integration of wind shear data into the National Airspace System for use by pilots, air traffic controllers, and the National Weather Service; (7) testing of forecast techniques and dissemination methods.

NOAA, under reimbursable agreements with FAA, will undertake to develop remote sensing instrumentation that will measure wind shear in support of this program. A prototype Doppler acoustic-microwave system for all weather detection of wind shear will undergo FAA operational tests in 1977 at Dulles International Airport. Under this agreement NOAA will also operate networks of pressure jump detectors in conjunction with anemometers to measure gust-fronts in the vicinity of O'Hare and Dulles airports. An extensive hardware development effort is underway to simulate airborne solutions to wind shear hazards. New systems are planned to combine acoustic, microwave, and/or optical techniques that can provide an improved airport weather observing capability. The resources of five other Federal agencies have been added to those of the FAA in seeking viable solutions to the wind shear problem.

FAA has a sustaining engineering effort to improve existing weather equipment and to develop new instruments for measuring wind, pressure, temperature, humidity, visibility, and ceiling. Development work on methods for reporting runway visual range values under 600 feet is being conducted primarily in-house, with consultative support from the Transportation Systems Center and test and evaluation support at the National Aviation Facilities Experimental Center. Development of the Aviation Automated Weather Observation System (AV-AWOS) by the National Weather Service, with FAA direction and funding, will be completed. The AV-AWOS equipment and software will automatically generate readouts of wind (speed, direction and gusts), altimeter setting, temperature, dewpoint, visibility, cloud height and cover, and present weather (e.g., yes/no precipitation, freezing rain, hail and thunderstorms) from sensed data. These AV-AWOS surface aviation observations will ultimately be disseminated via FAA's Service "A" teletypewriter network, via one-minute updated terminal weather for cathode ray tube display, and by a computer-generated voice over telephone or FAA's VOR transmission.

The Department of Commerce (National Weather Service), has an ongoing program to develop improved automated techniques for the prediction of aviation weather elements. The present model output statistics aviation forecast system will be improved through the use of predictors from other numerical models, principally the subsynoptic update model.

The automatic monitoring and updating of aviation terminal weather forecasts will be part of the initial AFOS software package to be implemented and tested at the first three AFOS field station installations. An

AFOS system minicomputer will automatically compare current surface aviation observations to terminal weather forecasts within each WSFO's area of responsibility to determine if a problem or potential problem exists. If so, a terminal alerting procedure message will be generated to alert the forecaster of the situation and provide him with an objective forecast of ceiling and visibility as guidance in preparing a revised, official terminal forecast.

Prediction equations will be developed for about 25 additional AFOS field unit installations and work will begin on prediction techniques for additional weather elements in guidance forecasts.

NWS research in developing automated techniques for forecasting severe local weather will result in objectively-derived probability and categorical forecasts of value to aviation. FAA is particularly interested in the impact of thunderstorms on total air traffic flow in local terminal areas and enroute travel along designated air lanes.

Work will continue by the NWS, with funded support from FAA, to develop objective techniques for short-range (0-6 hrs.) prediction of thunderstorms and low level shear for aviation. Thunderstorm forecasts for the 0-2 hour time period will be implemented on the NWS RADAP system. Simple local thunderstorm prediction techniques for implementation on AFOS minicomputers will be developed and tested. Forecasting techniques will be implemented to differentiate between various types of severe local weather including low level wind shear.

Department of Defense research efforts are oriented toward specific military requirements and are described in the General Military Meteorological Service section. In general, those aspects related to military aviation services include the application of data gathered from a small-scale network to improvements in short-period terminal forecasts; continued development of techniques for dissipating fog at airfields; and the design of instruments and techniques to support land and seabased aviation operations.

Marine Meteorological Service

Description

The Departments of Commerce, Transportation and Defense share statutory responsibility for the Marine Meteorological Service, designed to promote the efficiency of the civil and military marine operations and to insure the safety of life and property at sea and on coastal and inland waters. Many segments of the economy—including transoceanic, coastal, and Great Lakes shipping, commercial fishing, offshore drilling and mining, deep water port activities, and recreational boating —need warnings and detailed forecasts of winds, sea and swell, surf and breakers, ice conditions, anomalous water levels, sea surface temperature, and ocean current regimes.

- The Department of Commerce is responsible for collecting observations, issuing forecasts and warnings, and disseminating marine meteorological information to benefit marine industry, navigation, sport fishing, and the general boating public.
- The U. S. Coast Guard, because of its search and rescue and maritime law enforcement missions, and as lead agency for the reporting and monitoring of discharges of hazardous substances and oil spills and their amelioration, has the capability to cooperate with the Department of Commerce by making weather observations and disseminating weather warnings and forecasts on radio broadcasts to the high seas and waters over which the United States has jurisdiction.
- The Department of Defense is responsible for providing marine meteorological information to its forces as well as for cooperatively providing ship and coastal observational data to other agencies for marine services use.

Marine meteorological observations include those from the cooperative merchant ship program, the tide and wave gage network, environmental data buoys, off shore oil platforms, satellites, and from about 200 cooperative marine reporting stations along the U. S. coastline. Practically all these coastal stations are operated by the Coast Guard and provide 3-hourly observations upon request.

Environmental data buoys, funded and operated by the National Oceanic and Atmospheric Administration (NOAA), are used to obtain observations from offshore areas. The data are relayed to shore by satellite. The U. S. Coast Guard, through a cooperative agreement with NOAA, places the buoys on station and removes them for overhaul and maintenance purposes. Additionally, NOAA has wind speed sensors on eight Coast Guard large navigational buoys. Data from these are relayed to shore via Coast Guard communications.

Forty-seven naval vessels have sophisticated equipment for detailed surface observations, with 33 of these equipped to make upper air observations. Twenty Coast Guard cutters are also equipped with balloon inflation shelters for making upper air observations. These observations are made available to other Federal agencies through routine data collection and exchange. There is a need for improvements in data handling, for meteorological personnel on more ships, and for better marine forecast techniques.

The Department of Commerce supplements the analysis and forecasting functions of the Basic Meteorological Service with specialized marine support operations at a number of its Weather Service Forecast Offices (WSFOs). WSFO San Francisco is one example of locations that disseminate marine environmental information in cooperation with the Coast Guard. Weather and sea forecasts and storm warnings are provided by radiofacsimile, voice, and radio telegraphy from the Coast Guard Communications Station at Point Reyes, Calif. WSFOs Honolulu, San Francisco, Washington, and Miami provide high seas marine information for the North Pacific and the western North Atlantic. WSFO Honolulu also provides services for part of the South Pacific. Within these areas the United States is responsible for shipping forecasts and storm warnings under the Safety of Life at Sea Convention in accordance with agreements with the World Meteorological Organization. In the extreme western North Pacific, the Department of Defense provides those services. In Alaska, NWS operates five coastal radio stations to broadcast marine warnings and forecasts, and to expedite the receipt of marine data. WSFO Anchorage, Alaska, provides marine support in the Gulf of Alaska and the Bering Sea. WSFO Fairbanks provides marine weather and ice forecasts for the Chukchi and Beaufort Seas. WSO Valdez has been augmented to provide 24-hour service at the trans-Alaskan pipeline terminal where super tankers will load and begin their voyage down the stormy Prince William Sound and across the Gulf of Alaska to U. S. ports. At WSFO Seattle, NOAA has begun a develop-

ment program directed toward improving marine environmental support activities.

In other areas, such as coastal and offshore waters, marine advisories and warnings are issued by 19 WSFOs. The Great Lakes weather and ice service program, provided by five WSFO's has been substantially aided by resources of the Great Lakes and St. Lawrence Seaway Navigation Season Extension Demonstration Program, which is managed by the Department of Defense's Corps of Engineers. NWS is adding an ice forecaster position to the staff at WSFO Detroit and WSFO Cleveland to support this important service.

Four Fleet Weather Centrals and one Fleet Weather Facility supplement the broadscale products from the Navy's Fleet Numerical Weather Central (FNWC) and NOAA's National Meteorological Center by preparing detailed analyses, forecasts, and warnings for their assigned areas of responsibility. In addition, FNWC and one of the Fleet Weather Centrals provide optimum-track ship routing services to naval vessels and commercial ships operating under Department of Defense contract.

Dissemination channels provided by the Department of Commerce for weather information and warnings in coastal areas and the Great Lakes include a Great Lakes teletypewriter system, NOAA Weather Radio broadcasts, messages over the NOAA Weather Wire Service, and recorded telephone forecasts.

A special service for high-seas shipping is provided by NOAA in cooperation with the National Bureau of Standards, using the time-signal broadcast facilities of WWV (Colorado) and WWVH (Hawaii). It consists of three brief 45-second broadcasts each hour, giving information on major storms in the North Atlantic and the North and South Pacific. Facsimile radio broadcasts from Coast Guard and Department of Defense are available to ships. Department of Defense naval broadcasts—voice and facsimile—primarily support naval forces and are subject to changes in schedule and content on short notice.

Marine users rely on the various communications systems or on the Coastal Warning System for their information. The latter system is a cooperative network of about 300 visual (flag and light) signals at prominent locations along the coasts, Great Lakes, and inland waterways to advise marine interests when advisories or warnings are in effect. The U. S. Coast Guard and NOAA operate about one-half of these displays. Non-Federal interests operate the remainder. This system is being phased out in favor of the NOAA Weather Radio continuous weather broadcast system which offers up-to-date information. The Navy has 38 weather offices at shore stations and 47 weather offices aboard ships which provide marine briefing services in support of naval operations. Support of warning services on the west and gulf coasts are provided in part by a dedicated Marine circuit. Stations are a mix of commercial marine radio, Coast Guard, and NOAA, functioning both as points for gathering reports from ships and disseminating warnings and forecasts for shipping. Plans to expand along the entire west coast including Alaska are in progress.

Table 11 lists the costs of the Marine Meteorological Service, by agency, for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

The Department of Defense (Navy) is projecting an increase of $2,137,000 for FY 1978 that includes procurement of two shipboard receivers to read out satellite information and funds for addition bathythermograph probes. The Department of Commerce will maintain essentially level funding. In the U. S. Coast Guard there will be a decrease in Marine Meteorological Service due to the deletion of funding for the operation of Ocean Weather Station HOTEL.

Table 11.—Marine Meteorological Service costs, by agency
(Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Commerce	2,782	2,957	202	182	2,984	3,139
Defense:						
Navy	9,674	11,811	2,525	3,747	12,199	15,558
Transportation:						
Coast Guard	965	854	—	—	965	854
Total	**13,421**	**15,622**	**2,727**	**3,929**	**16,148**	**19,551**

Research Program for Fiscal Year 1978

The Department of Commerce is continuing to work on the development and improvement of automated marine environmental prediction techniques for oceanic, coastal and Great Lakes forecasting. The research and development effort has centered on wave conditions, storm surge heights, and surface winds, but has recently been expanded to include oil spill trajectory, beach erosion, and fog forecasting.

In FY 1978, automated techniques for forecasting surface waves on the high seas will be improved. Additional forecast techniques for ocean variables such as sea ice, sea surface temperature, and ocean currents will be developed.

Under an interagency funding agreement between NOAA and the Environmental Protection Agency, National Weather Service has contracted for a numerical model to be developed to predict the movement and concentration of petroleum in the ocean following an oil spill as a function of time and space. Forecast techniques will be developed to predict local current, wind, and wave fields for 54 stations in coastal areas of the 48 states and Alaska.

Coastal forecasting research and development in FY 1978 will include automated techniques for forecasting hurricane storm surges, extra-tropical storm surges, winds for offshore locations, and beach erosion for the U. S. east coast. The special program to list amplitudes of surges from hurricanes for operational hurricane storm surge forecasting will be improved to consider variable water depths. The extra-tropical storm surge technique will be modified to consider surge-tide interaction. The offshore wind forecast method will be expanded to include the Alaskan area. Beach erosion forecast methods will be verified, improved, and expanded.

In regard to the Great Lakes, work on automated forecast techniques for wind, storm surge, waves and visibility reduction due to fog will continue. New wind forecast equations based on input from the limited area fine mesh model will be developed. New forecast points on the Great Lakes will be added to expand the wave forecast program.

Research, development, test, and evaluation on buoy components and systems will focus on the problems of withstanding the severe ocean environment. The buoy program of about $8 million in base funding is not reflected here, but is described and accounted for in the *Federal Plan for Marine Environmental Prediction* (revised annually).

The Navy is continuing research on marine fog, haze, thunderstorms and other small-scale hazards to marine operations through field experiments, laboratory studies, and numerical modeling. Analysis and prediction models and techniques are also being developed for providing a global, automated prediction system. The system would collect, process, disseminate, and display environmental information for use in problems unique to military operations on a near real-time basis.

Agriculture and Forestry Meteorological Services

Description

These services are becoming more vital to the Nation's welfare and economy with the increased need to maintain and protect our food and forest resources. The Departments of Commerce and Agriculture cooperatively share responsibility for providing the Agriculture Meteorological Services. The service includes specialized observations, forecasts, advisories, warnings, assessments of the impact of weather and climate upon agricultural production, and supporting research directed toward the needs of agricultural interests.

The Department of Commerce has the responsibility for planning and conducting the service while the Department of Agriculture carries out supporting research, assists in planning, and cooperates in observing, communicating, and distributing weather information.

The present agricultural weather services provide specialized local observations for farming areas, technical studies in weather-crop relationships, extension advisory services, and crop-specific, site-specific weather forecasts tailored to local farming operations. In many cases, observations are made on a cooperative basis between the Department of Commerce and other Federal and State agencies or private interests. Observers for Federal and State agencies at agricultural experiment stations, colleges, and universities obtain detailed small-scale meteorological data for studying agriculture-weather relationships.

Forecasts for agricultural users—ranging from a short-period forecast which affects planting, harvesting, crop dusting, and spraying to a 30-day outlook for general agricultural planning—are prepared at National Oceanic and Atmospheric Administration (NOAA) Weather Service Forecast Offices (WSFOs). Interpretive and extension services are provided by advisory agricultural meteorologists from five Weather Service Offices (Agriculture) and four Environmental Studies Service Centers. A service for wool growers and livestock producers in Wyoming and North and South Dakota makes recorded forecasts and warnings continuously available by telephone from mid-October to mid-May. Similar weather services for fruit and vegetable growers are available in New Jersey and Michigan.

A special fruit-frost service is concentrated in the western states, Wisconsin, and Florida. This service has been integrated into the Agriculture Meteorological Service in western lower Michigan, the lower Rio Grande Valley, New Jersey, Utah, and in West Virginia. Warnings of low temperatures for specific stations along with an outlook for the next three to five nights; an advisory service to growers on how to prevent frost and freezing temperature damage; annual reports on the general character of each season with respect to crop-weather relationships; temperature surveys in agricultural areas; and studies of temperature and crop relationships are provided.

Specialists from NWS, NESS, NASA, and the University of Florida have cooperated on a test to use satellite thermal infrared data in the operational frost warning service provided by the WSO at Ruskin, Florida. Results of the test have been encouraging and plans are underway to investigate the use of a more comprehensive data base and computer models for operational testing.

Agricultural forecasts, warnings, and advisories are disseminated to the Agriculture Extension Services, directly to users, and to the mass media over the NOAA Weather Wire Service, NOAA Weather Radio, and the press wire services.

The Department of Commerce, in cooperation with the Department of Agriculture, participates in publishing the *Weekly Weather and Crop Bulletin*. This publication includes crop condition reports along with national and worldwide crop summaries and has about 5,000 subscribers across the country. Continuing extreme drought conditions in the middle and far western states are adversely affecting the nation's agricultural products and emphasize the importance of current and reliable weather information for agriculture.

In an effort to further improve the Agriculture Meteorological Service, existing resources are being concentrated into the new Environmental Studies Service Centers. The first was established at Auburn, Ala., to serve the States of Alabama, Georgia, and Florida; the second located at Stoneville, Miss., to serve the States of Arkansas, Louisiana, Tennessee, and Mississippi; the third to serve the States of N. Mex., Oklahoma, and Texas from a location at College Station, Tex., and the fourth to serve Michigan, Illinois, Ohio,

Indiana, and Kentucky from a location at Lafayette, Ind.

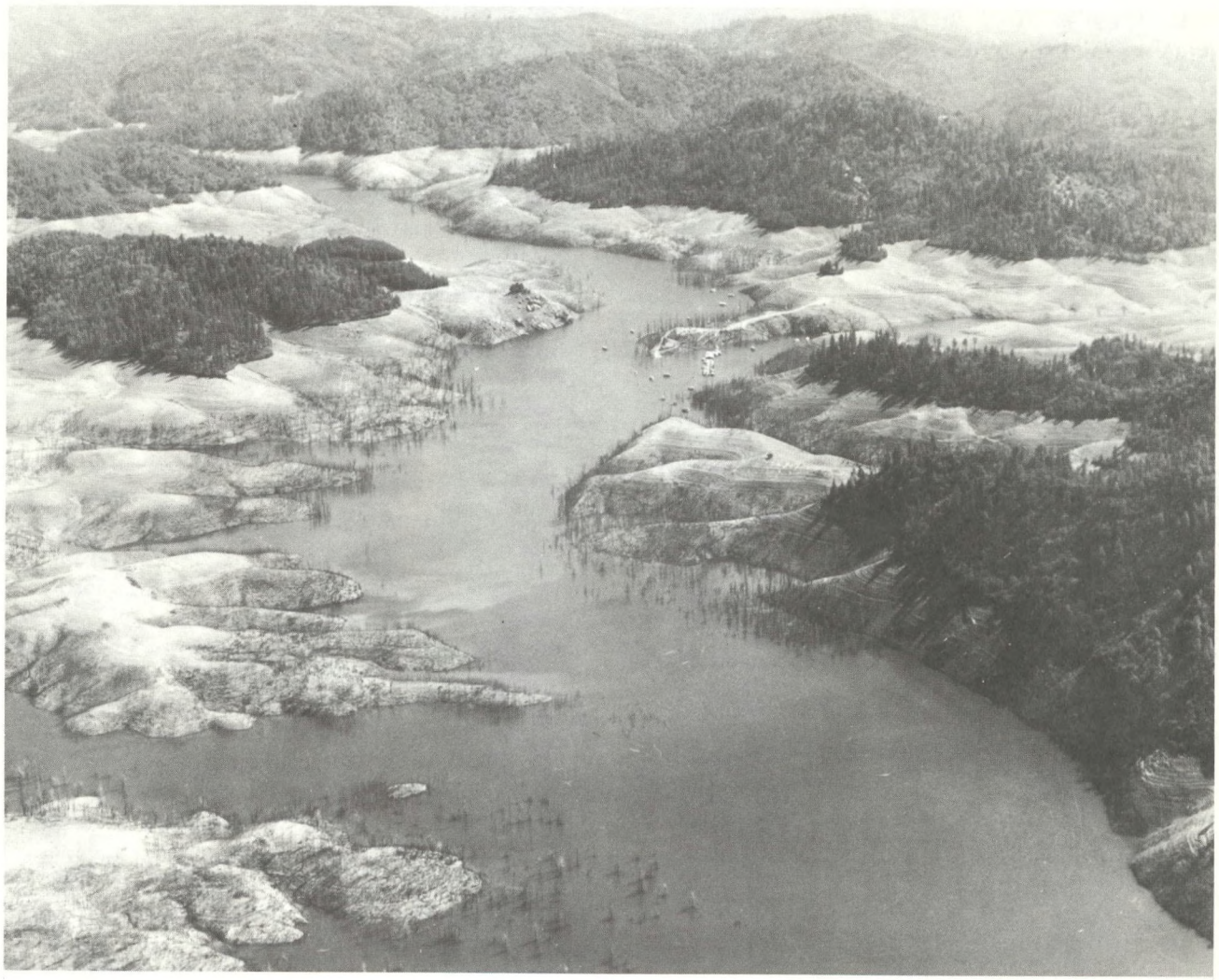
The Centers provide:

- Agricultural weather summaries and advisories
- Technical studies relating weather to agriculture
- Consulting services for agricultural research efforts
- Liaison services with agricultural organizations and users

A further effort to improve this service has been made through agreements between NOAA and the States of Nebraska, Kansas, Minnesota, Iowa, and South Dakota. These agreements provide for current exchanges of information between the respective WSFOs and the State Agriculture Extension Services. On the basis of this guidance the WSFOs issue forecasts three times a week directed to current agricultural needs.

The agricultural meteorological service is not yet fully available for all major crop belts. As a result, there is a need for improving organizational support for this service. In addition, a need exists for continuing research in such areas as weather-crop relationships and the effect of climate on crops and insects. An updated *Federal Plan for a National Agricultural Weather Service* will be published in 1977.

Federal, State, and local agencies charged with protection and maintenance of the Nation's forests depend on reliable meteorological data and forecasts provided by the Department of Commerce. A special-



Aerial view of Shasta Lake shoreline in California in September 1976 showing low level of reservoir resulting from long period of extremely low rainfall. Bureau of Reclamation photo by J. C. Dahilig.

ized national plan is being developed that describes in more detail the services available to forestry interests.

The Forest Service of the Department of Agriculture and the Bureau of Land Management of the Department of Interior, along with State forest agencies contribute to the Forestry Meteorological Service by supplying observations for some 2,000 locations scattered through state and national forests. The Forest Service also conducts forestry research that supports this service.

Within the framework of broad-scale guidance produced by the National Meteorological Center, specialized forecasts and warnings for use by fire control agencies are provided by 50 selected weather offices of the National Weather Service. These WSFOs and WSOs are responsible for specialized forecast, advisory, and warning services to forestry and rangeland fire control interests. These services include five-day outlooks, 36- to 48-hour general forecasts of winds, temperature, rainfall, humidity, and fuel moisture on a twice per day basis in most areas during the forest fire season. Forecasts are issued, as required, during a fire.

The National Weather Service and the Forest Service of the Department of Agriculture are jointly supporting an experimental Forestry Weather Interpretation Unit in Macon, Ga. This unit develops and provides specialized services that help forestry interests make better use of National Weather Service forecasts. The unit also develops procedures and products that help National Weather Service forecast offices improve their forecast, advisory, and warning services to forestry interests.

Twenty-one camper-type mobile units and one trailer-type air portable mobile unit, manned by fire weather meteorologists, are available in the western United States for dispatch to major forest fires. Contact with the home station is maintained by two-way radio and radio facsimile for relay of appropriate meteorological data. Through this means, fire control interests receive immediate forecasts and advisories from the unit on the scene of action.

NOAA also supports smoke management programs for control of prescribed burning operations for the removal of forestry and agricultural wastes. Forecasts are issued to help State and Federal authorities in determining when, where, and how much debris to burn without degrading the air quality.

Table 12 lists the costs of the Agriculture and Forestry Meteorological Services, by agency, for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

Changes in the Department of Commerce funding for FY 1978 are the result of increased costs of operations.

Research Program for Fiscal Year 1978

The Department of Agriculture will maintain essentially level funding for the supporting research program. Studies are being conducted on the effect of climatic factors on various insect species, including their development and behavior, and on better uses of beneficial species. Basic studies are being conducted to determine the relationship between climate and such factors as crop hardiness, quality, productiveness, and drought resistance. Methods are being developed for the establishment of windbreaks and for the determination of their effect on air, soil, water, and snow movement. The Department of Agriculture is directing a national research program on plant disease epidemiology and forecasting in which extensive use is made of micrometeorological data observed at plant level. Studies are being performed to determine the action of air pollutants on plants and methods of controlling the damage. Investigations are being carried out to determine the potential economic effects of weather on foreign crop production. A worldwide meteorological data base is being compiled and re-

Table 12.—Agriculture and Forestry Meteorological Services costs, by agency (Thousands of dollars

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Agriculture	—	—	1,593	1,692	1,593	1,692
Commerce	4,449	4,920	—	—	4,449	4,920
Total	**4,449**	**4,920**	**1,593**	**1,692**	**6,042**	**6,612**

search is in progress to determine crop-yield patterns associated with various meteorological factors. Department specialists are consulting with climatologists to review and better define the best judgments of the probabilities of changes of climate and its variability and the resultant effects on United States and world food production and on related areas affecting national policy to the year 2000.

In the area of mountain meteorology, the Department of Agriculture is conducting studies on the interaction between mountainous terrain and the atmosphere in relation to such problems as wind flow, temperature specification, and precipitation. A significant part of this research will be concerned with the definition of mesoscale variation. The Southeast Forest and Range Experiment Station of the Forest Service and the National Weather Service are jointly conducting an experiment to develop, test, and demonstrate a new format for fire weather service in the South.

General Military Meteorological Service

Description

The Department of Defense requires worldwide meteorological services to support specific military operational and planning activities. The General Military Meteorological Service provides military users with support not available from the Basic Meteorological Service or from other Specialized Meteorological Services. Support for explicit users, such as aviation, marine, and space operations, is covered in the sections on the relevant Specialized Meteorological Service.

Military user groups require meteorological information directed to the needs of:

- Weapon systems being developed or employed
- Command and control systems
- Army and Naval firing units
- Research, development, test, and evaluation
- Training and deployment of military forces
- Contingency operations

To provide these special meteorological services, the Department of Defense maintains analysis and forecasting facilities in the United States and abroad. These facilities include the Air Force Global Weather Central at Offutt AFB, Nebr., the Navy Fleet Numerical Weather Central at Monterey, Calif., plus forecast centers and tactical forecast units in Europe, the Pacific, and the Far East. Specialized centers—such as the Air Force Environmental Technical Applications Center at Scott AFB, Ill., and the Joint Typhoon Warning Center at Guam—also fulfill unique military meteorological requirements. Similarly, Department of Defense observation facilities are operated to obtain data in direct support of military operations. Military communications networks are maintained to collect and exchange observations and to disseminate forecasts.

The Navy is actively continuing the development of the Naval Environmental Display Station (NEDS). This new system is designed to overcome present system (e.g., facsimile, teletypewriter) limitations, to permit expansion of environmental support (both meteorological and oceanographic), and to conserve personnel and equipment resources. The primary functions of NEDS are transmission, receipt, storage, manipulation and display of graphic, alphanumeric and satellite data. NEDS includes multi-colored visual displays of environmental parameters of tactical significance to the operator. It has the capability to encode, transmit (via landline or multi-channel broadcast), and decode for viewing a graphical picture in less than 10 minutes using existing 100 wpm teletypewriter circuits. Coordination continues to insure that automated systems such as NEDS and the Department of Commerce's Automation of Field Operations and Services will be able to communicate and exchange information.

Aerial weather reconnaissance plays a vital role in specific Department of Defense operations. Essential weather observations from tropical cyclone penetrations, refueling and enroute weather observations for tactical deployments and contingency exercises, and weather observations for missile recovery areas are the types of information obtained from aircraft reconnaissance.

Storm detection radars are selectively employed by the military meteorological services to provide an essential capability to detect severe, hazardous weather affecting military activities.

In support of tactical operations, Department of Defense has developed a series of air-transportable van complexes and is capable of deploying mobile tactical weather stations, radiosonde teams, weather radars, and meteorological satellite direct readout equipment. The Air Force is procuring six tactical weather radars for weather radar watch and support of its deployed forces.

The Defense Meteorological Satellite Program (DMSP) was designed and developed under a total systems concept to provide specialized meteorological data required by the Department of Defense. Sensors, communications, and ground processing facilities were developed with the primary objective of providing maximum responsiveness to the military decision maker. DMSP provides visual and IR images of the entire globe plus temperature and moisture profile soundings, auroral electron count, and other specialized meteorological data to the Air Force Global Weather Central, Offutt AFB, Nebr., at four observation times per day. DMSP provides direct real-time readout of regional visual and IR data to selected military locations around the world.

The DMSP routinely employs two polar-orbiting satellites. Each satellite is in an approximate 830

kilometer polar sun synchronous orbit with a period of 101 minutes. One satellite has an early morning local ascending equator crossing time and the other has a near-noon ascending equator crossing time.

DMSP Block 5C satellites employ scanning radiometers operating in the visual and infrared (IR) wavelengths. The visual sensors detect the brightness of reflected solar illumination from .4 to 1.1 micrometers. The IR sensors measure emitted radiation from 8 to 13 micrometers. The IR products are images of the earth and its atmosphere which are representative of their temperatures. Both IR and visual data are obtained at a resolution of 3.7 kilometers and either IR or visual imagery is obtained at a resolution of 0.6 kilometers. The spectral band width of the visual sensors was selected to optimize distinction among clouds, ground, and water. Electronic circuitry in the sensor converts the sensed IR energy directly into equivalent blackbody temperature, making temperature the directly displayed parameter. The sensitivity of the 3.7 kilo-

Operational tactical site van for the Defense Meteorological Satellite Program.

meter visual channel covers seven orders of magnitude; this enables it to provide useful meteorological information from full day light over highly reflected scenes to an illumination level roughly equivalent to half moon light.

A new series DMSP spacecraft (Block 5D) incorporates selective redundancy and other reliability improvements to achieve longer operational life. It uses both stellar and inertial reference, together with on-board processors, to maintain stability and pointing accuracy significantly better than that exhibited by earlier DMSP satellites.

The Block 5D primary sensor system is an Operational Linescan System (OLS). This improved sensor system produces pictorial visual and infrared imagery while maintaining data quality, bounding data storage and relay impacts. The OLS is a digital system with increased on-board data processing and storage. The sensor segment was developed to format and store data from a number of anticipated special sensor systems. Both infrared and visual imagery may be obtained at a near constant cross-track resolution of 0.5 km (called fine data). Data in a smoothed form will also be available at 2.8 km resolution.

DMSP communications and ground processing systems are designed to produce usable products within five minutes after the data stream terminates. For direct readout, this means a data age of five to twenty minutes when ready for application to operational decisions. The central processing facility, AFGWC, is linked to the DMSP readout facilities by a real-time, commercial satellite link. This allows for real-time recovery of (stored) recorded data such that the only timing increment added to the processing time is the transit time of the DMSP satellite from the observation scene to that part of the orbit where data can be acquired by the ground station. The data display units at AFGWC and other direct readout ground receiving stations were designed with the following features to facilitate data interpretation:

- Orbital Normalization—Compensates for altitude and attitude differences.
- Equal Area Projection—Foreshortening at the edges is removed.
- Large Scale Transparency—The nominal scale is switch selectable at either 1:7.5 or 1:15 million.
- Enhancement Options (Visual data)—Variations in solar illumination are compensated for. The visual imagery displayed can be enhanced in the low, high, or a low-high mode.
- Thresholding and Scale Expansion (IR Data).

The entire ground system for direct, local readout is contained in a self-enclosed unit, including antenna, which is air transportable, making overseas deployment to full-scale operation a matter of hours. Additionally, the Navy has developed a similar local readout system for shipboard use. The centralized processing facility at the AFGWC has the capability to:

- Display high quality imagery for manual use.
- Input the raw DMSP data stream directly into computers where it is converted into cloud parameters and collated with conventional meteorological data to produce a comprehensive numerical cloud analysis.

Table 13 lists the cost of General Military Meteorological Service for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

The Department of Defense is planning to increase spending for General Military Meteorological Service operations by $1,952,000 in FY 1978. The Air Force plans a total net program increase of $27,220,000 of which 14% or $3,811,000 is attributed to General Military Meteorological Service. Significant changes include $17,000,000 in the meteorological satellite program for purchase of long-lead items, equipment improvements, ground receivers and communications, and general cost increases; $10,000,000 for data processing, display, and associated operational costs; $3,000,000 for personnel, training, and maintenance;

Table 13.—General Military Meteorological Service costs, by agency (Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
Defense:						
Air Force	29,606	33,417	4,420	5,047	34,026	38,464
Army	6,792	7,808	10,986	13,482	17,778	21,290
Navy	12,507	9,632	3,462	5,178	15,969	14,810
Total	**48,905**	**50,857**	**18,868**	**23,707**	**67,773**	**74,564**

and an offsetting decrease of $2,500,000 in weather reconnaissance costs.

The significant change in the Navy program is a decrease of $2,875,000 following acquisition of computer equipment in FY 1977 for the satellite processing center at Monterey, Calif.

Research Program for Fiscal Year 1978

Some of the Department's research programs have been categorized and discussed under previous subsections of the Plan as research directed toward improvements in a specific Service. These are also considered as research in support of the General Military Meteorological Service because they are directed toward improvements in meteorological support to the overall Department of Defense mission.

The Air Force research program in the development of advanced techniques, as required for fully automated systems, for the observation and short-range (0-to 3-hr) prediction of local aviation weather conditions will be continued in FY 78. An experimental model of a modular automated weather system is being evaluated at Scott AFB, Ill. The system has the capability to produce and display observational data and trends, and automated forecasts of runway visual range. Follow-on development efforts will be conducted to apply similar techniques to the automation of a transportable tactical weather observing system. At the Weather Test Facility at Otis AFB, Mass., candidate systems for automated measurements of slant visual range in the approach zone, ceiling, and cloud cover will be developed.

The effective use of weather radar for timely detection and prediction of hazardous storms requires automated presentation of key weather features. In FY78, Doppler radar measurements in severe storms, to be acquired in Oklahoma in the 1977 tornado season in a cooperative effort with the National Severe Storms Laboratory and the Air Weather Service, will be used for research studies. An automatic weather radar calibrator will be evaluated by the Air Force Geophysics Laboratory as a means of enabling all Air Weather Service radars, both Doppler and conventional, to be calibrated on an absolute basis.

Two methods of remote sensing of low altitude wind profiles will be examined in FY 1978. One is based on the acoustic Doppler radar approach and will be evaluated in fog modification experiments at Otis AFB. The other is based on FM-CW Doppler radar approach and will be examined to determine its value in providing timely warning of hazardous wind shear in an airport environment.

The research program will also include specification of the characteristics of sensors which can be installed on DMSP satellites, and development of automated techniques for reducing and filtering satellite imagery data and determining vertical profiles from microwave and IR radiances. In FY 1978, a 1.5 micrometer sensor for discriminating between snow and clouds will be tested in space flights. The satellite data collected will be compared with ground truth data. An analysis will be conducted of data to be collected from the first microwave sounder on DMSP satellites. Methods of specifying cloud types through combined utilization of infrared and visible imagery and imagery at near infrared and microwave frequencies will be developed.

Climatological statements provide another useful form of weather prediction. In FY 1978 a low-altitude atlas of probabilities of haze-free and cloud-free lines of sight will be prepared. A model for estimating the 1-, 5-, and 10-percent extremes of surface winds will be developed and then used in the preparation of an atlas of wind extremes. Stochastic techniques for modeling unconditional, conditional, and joint frequency distributions will be extended to include many weather elements, time periods, and geographical locations.

The Army's research program in atmospheric sciences is directed toward developing equipment and techniques that will help increase the effective use of weapon systems, conduct of field operations, and support of research, development, tests, and evaluation missions. An Automatic Meteorological System to collect, analyze and disseminate near real-time information is being developed in support of artillery, aviation, chemical and nuclear defense and other tactical operations. Another system under development is the Field Artillery Meteorological Acquisition System which is designed to provide soundings over the battlefield area. The system will have the option of deploying a sensor by balloonsonde, artillerysonde, or airdropsonde. Sonde development will follow two approaches, one using Loran, Omega, or other navaids and the other approach is a fully automated, miniaturized radio direction finding system. Mesometeorological research is underway to provide information on the properties of the atmosphere within the theoretical areas of combat. Experiments are conducted that include intensive data collection from balloon-borne and airborne instruments and an automated small-scale network of observation stations. Data will be used in validating models of atmospheric processes.

The Army is developing an automated nuclear fallout prediction system based on satellite radiometric data from the DMSP that will provide the commander

with real-time information concerning burst effects on the battlefield. The Army has in operation for R&D studies at White Sands Missile Range a direct readout ground station capable of handling all geosynchronous satellite data. These data are being used for studies on cloud cover and severe storms to determine optimized applications to battlefield operational problems. Also a data collection and display system for the battlefield is being designed.

The Navy will continue laboratory and field experiments in its marine fog investigations to study cloud and fog composition and processes. Equipment is being developed to improve the accuracy and increase the density of atmospheric observations over ocean areas. With the view toward achieving maximum use of environmental satellite sensor output required to support naval operations, existing subsystems will be modified and improved, electro-optic subsystems and radiometers will be tested to develop a capability to measure portions of the oceanic and atmospheric environment from airborne and spaceborne platforms. New techniques will be developed including numerical models for analysis and prediction of atmospheric conditions, air-sea interaction effects, and weather. These will be employed on an automated prediction system, concurrently being developed. Emphasis is on capabilities to measure, assess, and predict the effects, in the tactical situation, of those atmospheric properties in the marine boundary layer which affect the performance of detection, weapons, and communications systems.

The Navy is developing the means to fully exploit data from all satellite sources as the method of acquiring an adequate data base over ocean areas to improve its description and prediction capabilities. Senors to measure sea surface conditions such as water temperature, wind, waves, and sea ice are under development. Preparations are underway to evaluate SEASAT-A data to meet certain of these Navy requirements. SEASAT is a research polar-orbiting satellite to be launched by NASA in mid-1978.

Other Specialized Meteorological Services

Description

The specialized services in this section include those required by:

- National Aeronautics and Space Administration (NASA) and Department of Defense to plan and conduct the Nation's space and missile programs.
- Federal, State, and local governmental agencies responsible for dealing with urban air pollution, and the general public concerning serious air pollution episodes.
- Department of Defense civil works projects and some research, development, test and evaluation activities such as equipment design and testing, geophysical laboratories support, and polar research operations.
- Laboratories and test sites of the Energy Research and Development Administration.

The first two of these specialized services are discussed in more detail below. Specialized services for the latter two requirements are small and relatively stable with little change planned.

To support its space operations NASA relies heavily on the Department of Commerce through several reimbursable agreements for providing forecasting and staff support service for the:

- Space programs of the J. F. Kennedy Space Center and the Johnson Space Center.
- Earth-sensing unmanned satellites in the LANDSAT and Geodynamic Experimental Ocean Satellite-3 programs.
- Deep-space missions of the Jet Propulsion Laboratory—for which the optimum communication mode is weather dependent.
- Varied programs of the Wallops Flight Center.

Support to the NASA programs largely involves planning and background studies for the extensive Space Shuttle program schedule to begin late this decade. The earth-sensing efforts require daily, near-global predictions of cloud cover. Weather satellite products are especially valuable in making such forecasts. Department of Commerce support to global space operations is provided from the World Weather Building at Camp Springs, Md. This arrangement allows for ready access to both weather analysis and forecast information and satellite data.

The Department of Defense's Air Force Eastern Test Range provides a wide range of meteorological observations needed for its missions and for the Kennedy Space Center. The Air Force also provides the forecasting services for its operations and for NASA's unmanned launches at the Kennedy Center.

The Department of Defense provides specialized meteorological services for the:

- Space and Missile Test Center at Vandenberg AFB
- Pacific Missile Range which includes Pt. Mugu, San Nicolas Island, and Barking Sands, Hawaii.

Surface, rawinsonde, and weather radar stations located on islands and ships support the Atlantic and Pacific test ranges. Specialized staffs at range stations provide weather observations, forecasts and planning studies. Observations for Department of Defense space activities are taken, partly by Department of Defense personnel and partly through contracts with private industry. The observations are needed to determine the conditions that missiles and space vehicles will encounter either at launch or upon reentry into the atmosphere.

The Department of Defense range stations and the NASA Wallops Flight Center participate in the Cooperative Meteorological Rocketsonde Network through which atmospheric measurements above 30 kilometers are collected to support missile operations, space exploration, and atmospheric research.

Meteorological support is also provided to the White Sands Missile Range, N. Mex., to the Kwajalein Missile Range, and to other Department of Defense research and test facilities.

In both NASA and Department of Defense programs, weather observations from local, national, and international networks are used along with weather radar, satellite, and aircraft reconnaisance data as a basis for forecasts and warnings of weather that might affect launch or recovery areas.

The Department of Commerce's responsibilities for the Air Quality Meteorological Service include the surface and upper air observations necessary to describe the weather in urban areas, air stagnation forecasts in sufficient detail to provide the basis for air pollution control decisions, and applied research to improve these observations and forecasts. Fifty-two Weather Service Forecast Offices have the responsibility to prepare air stagnation advisories. Fourteen of these offices are staffed with specially trained air pollution meteorologists and six provide meteorological advisory

service for smoke management. Each office provides local and State air pollution control agencies with a daily outlook on the atmosphere's capability to disperse and dilute air pollutants. When restricted atmospheric dispersion is expected to persist at least 30 hours, an air stagnation advisory is issued. Advisories are updated at least every 12 hours and re-issued in 24 hours. For additional observations within urbanized areas, seven cities have low-level sounding stations that provide vertical profiles of temperature, relative humidity, and winds to three kilometers above the station.

The Environmental Protection Agency (EPA) is responsible for working with State and local government agencies to insure adequate air quality meteorological support programs. Applied research and operational meteorological support to EPA is provided by the Meteorology Laboratory, Air Resources Laboratory, NOAA. Operational support provided to the Office of Air and Waste Management, the EPA Regional Offices and other EPA components includes review of the meteorological aspects of environmental impact statements, State implementation plans, the application of dispersion models and the preparation of dispersion studies and evaluations.

Table 14 lists the costs of Other Specialized Meteorological Services, by agency, for FY 1977 and FY 1978.

Operational Program for Fiscal Year 1978

The increase of $2,450,000 shown by the Department of Defense (Air Force) for FY 1978 represents 9% of the total Air Force program that is attributed to Other Specialized Meteorological Services. Discussion of the changes may be found under General Military Meteorological Service. Other agencies are maintaining essentially level funding.

Research Program for Fiscal Year 1978

The Energy Research and Development Administration's supporting research in meteorology is responsive to the need to evaluate the various safety aspects of transport and storage of nuclear power systems utilized on space missions and to provide radiation exposure/dose prediction capabilities in support of nuclear test activities.

Studies performed under the space nuclear power project involve the transport of materials released as a point source; these include particulates released: (1) on the ground, (2) as a vapor cloud in a launch-pad abort environment, and (3) in the upper atmosphere during reentry abort conditions.

Studies in support of nuclear tests are conducted to improve the equipment and procedures for measuring, analyzing, and predicting the atmospheric processes involved in the transport of any radioactive effluents from nuclear tests. Plutonium and other radionuclide contamination in the environs are studied with special emphasis on the resuspension and transport of radioactive material by the wind.

This supporting research function also requires continuing development and implementation of radiological prediction methodologies unique to varying test configurations, release modes, and radionuclide inventories.

In the Environmental Protection Agency applied research support is in the area of model development and application, climatic analyses and atmospheric effects of pollutants. Dispersion models for inert and reactive pollutants are under development and evaluation. The Regional Air Pollution Study ends in FY 1977 and resources will be used to initiate a study of the emission, transport and transformation of sulfates in the atmosphere in FY 1978. Studies continue on the occurrence of urban heat islands, on the variations in carbon monoxide, and on a plume rise climatology.

Table 14.—Other Specialized Meteorological Services costs, by agency (Thousands of dollars)

Agency	Operations		Supporting research		Total	
	FY 77	FY 78	FY 77	FY 78	FY 77	FY 78
ERDA	2,278	2,375	178	197	2,456	2,572
Commerce	1,287	1,339	—	—	1,287	1,339
Defense:						
Air Force	19,033	21,483	—	—	19,033	21,483
Army	280	247	—	—	280	247
Navy	4,852	5,026	—	—	4,852	5,026
EPA	700	750	7,700	6,200	8,400	6,950
NASA	1,331	1,359	—	—	1,331	1,359
Total	**29,761**	**32,579**	**7,878**	**6,397**	**37,639**	**38,976**

Appendix A

Digital Data Systems

The digital data and high-speed communications systems provide the needed collection and distribution of alphanumeric weather data and information.

Federal Aviation Administration Systems

The Modernized Weather Digital Data Communications System consolidates the circuit control and relay functions of Services A, C, and O into a single Weather Message Switching Center (WMSC) at Kansas City. These functions are performed automatically by computers combined to operate as a real-time store and forward communications switch. All Service A and C circuits extend directly into the WMSC. Certain Service O circuits also extend directly into the computer switch, while others, from overseas points, pass through the Aeronautical Fixed Telecommunications Network switch which is collocated and interconnected with WMSC. Computer-to-computer links provide for the exchange of data between WMSC and the National Meteorological Center (NMC) at Suitland and between WMSC and the Air Force Automated Weather Network switching facility at Carswell AFB, Tex.

Circuits of the Modernized Weather Digital Data Communications System are described as follows:

- *Service A Area Circuits:*

(a) Sixty-six 100-words per minute (wpm) multipoint half-duplex circuits designed solely to meet the collection and routine distribution requirements of the FAA and NWS user. Other users may obtain receive-only drops on these circuits if their needs are compatible with those of FAA and NWS.

(b) Eighteen 100-wpm multipoint half-duplex polled circuits designed to meet the collection and routine distribution requirements of the NWS. Other users may obtain receive-only drops on those circuits if their needs are compatible with the NWS.

- *Service A Request/Reply Circuits:* Forty-five 100-wpm half-duplex circuits that parallel the Service A Area Circuits and enable Government flight briefing facilities to obtain information not routinely transmitted to the associated area circuit.
- *Service A Low-Speed Nongovernmental Circuits:* Sixteen 100-wpm multipoint circuits for distributing data to meet the requirements of nongovernment users, principally airlines whose needs are not satisfied by the area circuits.
- *Service C Area Circuits:* Seven 100-wpm multipoint half-duplex circuits for collecting and distributing basic meteorological data to serve both government and nongovernment users.
- *Service O Area Circuits:* Five 100-wpm multipoint half-duplex circuits for collecting and distributing international meteorological data to both government and nongovernment users.
- *Department of Defense Circuits:* Fifteen 100-wpm multipoint circuits and two 100-wpm point-to-point circuits for distributing selected civil environmental data to military customers in the continental United States.
- *Weather Service Forecast Office Point-to-Point Circuits:* Fifty-three 100-wpm full-duplex circuits to the Weather Service Forecast Offices (WSFO) for transmission of forecast products to WMSC and receipt by WSFOs of supplementary weather data.
- *Service A Point-to-Point Circuits:* Sixty-seven 100 wpm full-duplex circuits to high activity and/or flight service stations which provide enroute flight advisory service for transmission of special products to WMSC and receipt of special weather data.
- *High- and Medium-Speed Links:*

2,400 bits per second (bps) full-duplex computer-to-computer circuit for exchanging Service A, C, and O data between WMSC and NMC.

1,200-bps full-duplex computer-to-computer circuit for exchanging Service A, C, and O plus military data between WMSC and the USAF Automated Weather Network terminal at Carswell AFB, Tex.

1,200-bps full-duplex Notice to Airmen circuit between WMSC and the National Flight Data Center.

1,200-bps full-duplex point-to-point circuit for distributing Service A, C, and O data to the FAA's Central Flow Control Facility.

2,400-bps full-duplex computer-to-computer circuit for exchanging Service A, C, and O data between the Aeronautical Fixed Telecommunications Network and WMSC.

2,400-bps full-duplex computer-to-computer circuit for distributing Service A, C, and O data to the NWS's National Severe Storms Forecast Center.

2,400-bps full-duplex computer-to-computer circuit for exchanging Service A data between the Aviation Weather and NOTAM System and WMSC.

2,400-bps full-duplex computer-to-computer circuit for use in developing pilot self-briefing techniques.

2,400-bps multipoint circuit for distributing Service A, C, and O data to very high volume airline and other non-government users whose needs cannot be satisfied by low-speed circuits.

1,200-bps multipoint circuit for distributing Service A, C, and O data to very high volume airline and other non-government users whose needs cannot be satisfied by low-speed circuits.

Department of Commerce Systems

Radar Report and Warning Coordination (RAWARC) Teletypewriter Network—This network is used to collect and distribute radar reports and storm warning information. *RAWARC* is composed of five circuits terminating at the Radar Analysis and Development Unit in Kansas City as well as at the automated relay center in Suitland, Md. Traffic on RAWARC is basically unscheduled and is handled according to a priority system. The only regularly scheduled operation on RAWARC is an hourly collection of radar reports which is relayed to other circuits as required.

NOAA Weather Wire Service—See page 12

Special Communications Links Between Guidance Centers—A high-speed alphanumeric and graphic computer link has been established between the National Meteorological Center/National Environmental Satellite Service and the National Hurricane Center to allow exchange of aircraft reconnaissance data, satellite data, and other processed information. A similar link has been established between the National Meteorological Center/National Environmental Satellite Service and the National Severe Storms Forecast Center.

International Circuits—In addition to the Service O circuits funded by the FAA, the Department of Commerce has eleven international circuits to exchange meteorological data among the United States and Canada, Russia, Cuba, Great Britain, Japan, Mexico, Brazil, the Central American nations, Argentina, the Bahamas, Jamaica, and South Africa. These include a Washington-Toronto high-speed circuit, a Washington-Moscow circuit for exchange of satellite information, a Washington-Central American loop, a Washington-Mexico low-speed circuit, a Washington-Buenos Aires low-speed circuit, a Washington-Bahamas low-speed circuit, a Washington-Jamaica low-speed circuit, a Washington-South Africa high-speed trunk circuit, and three other circuits—Washington-Bracknell (England), Washington-Tokyo, and Washington-Brasilia—that are part of the World Weather Watch main trunk circuit. The Washington-Bracknell circuit is also used to exchange facsimile charts.

Radio Circuits—Weather messages and observations prepared aboard ships at sea are transmitted by radio, primarily by Morse code, to shore-based radio stations and are relayed to NMC. The Teletypewriter Exchange Service, international communications carrier facilities, and Coast Guard circuits are used for the relays. More than 1,000 observations are automatically processed, separated geographically and consolidated into bulletins each day for distribution on domestic and international meteorological communications facilities.

NESS Satellite Communications System—The National Environmental Satellite Service (NESS) telecommunications system (SATCOM) is divided into two discrete subsystems, one serving the NOAA polar orbiting satellites (NOAA), and the second serving the geostationary satellites (GOES) and the associated GOES Satellite Field Services Stations (SFSS). The major elements in the polar orbiting satellite subsystem are the Command and Data Acquisition Stations (CDAS) at Wallops Station, Va., and Gilmore Creek, Alaska, and the Satellite Operations Control Center in Suitland, Md. The synchronous satellite subsystem connects Wallops Station, Va., with the Central Data Distribution Facility (CDDF) at Camp Springs, Md. The CDDF is connected in turn with the Gilmore Creek CDAS, with five SFSSs located in Washington, D.C., Miami, Kansas City, San Francisco, and Honolulu, and with the NWS San Juan, Puerto Rico WSFO. The Gilmore Creek CDAS relays satellite information via the GOES Satellite Distribution Circuit in Alaska by microwave circuit to the NWS WSFOs at Fairbanks and Anchorage, and then to Juneau via satellite.

The SATCOM consists of the following high and medium speed links:

- 12-megahertz full-duplex terrestrial microwave circuits between the World Weather Building and the Federal Office Building 4, at Suitland for relay of GOES data.
- 48-Kilohertz full-duplex satellite and terrestrial microwave circuits for relay of NOAA data from the CDAS to Offutt AFB, Nebr., and Suitland, Md.
- 2,400-hertz full-duplex circuits from computer output at the CDDF to display units at the FSSs, the Gilmore Creek CDAS, and the San Juan WSFO.
- 2,400-hertz circuits from the Suitland computer to the Wallops Station, Va., CDAS to transmit WEFAX information.

- 2,400-hertz circuits from the Wallops Station CDAS to the Suitland computer for relay of GOES Data Collection System (DCS) information.
- 110-, 1,200-, 2,400-, 4,800- and 9,600-baud circuits for delivery of DCS information from the World Weather Building computer to a multitude of users. Computer-to-computer transmission is used in some cases.
- 7,200-hertz full-duplex computer-to-computer circuits for exchange of vertical profile radiometer data between New York City and Suitland.
- 512-, 3,000- and 3,900-bps full-duplex circuits carrying beacon and engineering data from the CDAS to the computer at Suitland.
- One 100-line, two 50-line, and one 40-line multipoint voice coordination and conferencing networks connecting NESS operating facilities.
- Three 100-WPM multipoint teletypewriter circuits connecting various elements of the SATCOM.
- A direct alternate voice, data facsimile circuit between Washington and Moscow for exchange of satellite information.

Department of Defense Systems

Automated Weather Network—This network, operated and maintained by the Air Force, is the backbone of the military weather communications system. It consists of four real-time communications switching computers at Carswell AFB, Tex., RAF Croughton, England, Fuchu Air Station, Japan, and Clark Air Base, Philippine Islands linked by high-speed data circuits. The overseas automatic digital weather switches collect data from radio intercept sites and low-speed feeder circuits. These data are transmitted at 3,000 wpm to the continental United States switch at Carswell AFB where the information is examined, sorted, edited, compiled into specific weather messages, and switched to military and civil customers. Besides low-speed distribution to Department of Defense weather units, data are transmitted by high-speed circuits to the Air Force Global Weather Central, Navy Fleet Numerical Weather Central, NMC, and the WMSC at Kansas City. All circuits are full-duplex, permitting a total exchange of data that includes reports from field units to military and civil processing centers and products from these centers to the field units.

Continental United States Meteorological Data System (COMEDS)—The COMEDS network is the primary communications system for collecting, editing, and disseminating environmental data at military locations within the United States. COMEDS consists of 19 regional circuits in the United States and one regional circuit for Hawaii. These regional circuits are full-duplex and operate at 1,200 words per minute; each circuit includes approximately 25 terminals. In addition, the USAF plans to integrate into COMEDS in early 1977 the unique weather data requirements of North American Air Defense/Aerospace Defense Command; this integration will eliminate the Air Defense Tactical Weather Circuit Network.

Naval Environmental Data Network—This network provides for high speed dissemination of unique meteorological and oceanographic computer products from FNWC at Monterey to specially equipped locations in the United States and overseas. The network provides for rapid collecting, processing, disseminating, and displaying of environmental data and consists of on-line telecommunications equipment, automated display devices, digital computers, and associated circuitry.

Facsimile Networks

Facsimile networks and broadcasts are designed to transmit graphical weather information from selected centers to civil and/or military weather offices and users. The Department of Commerce is responsible for the basic facsimile circuits, including those that fulfill international commitments. The Department of Defense has responsibility for those circuits filling unique military requirements.

Department of Commerce

The various internal and external networks listed below were established to serve different users and different geographical areas, and include both long-line and radio systems.

National Facsimile (NAFAX) Network—NAFAX is a long-line network used to distribute a comprehensive set of charts depicting analysis, forecast, and selected observational data to civil and military weather service offices and to a variety of other users. Basically a graphics network, NAFAX serves approximately 250 NWS offices, 450 military and civil governmental offices, and nearly 350 non-governmental users—more than 1,000 drops in all.

With the exception of the radar summary charts prepared by the National Severe Storms Forecast Center and digitized cloud pictures prepared by the National Environmental Satellite Service (NESS), all materials originate at NMC. The network extends throughout the United States.

National Aviation Meteorological (NAMFAX) Network—NAMFAX is a long-line network designed to provide selected civil and military weather offices with graphic guidance materials including satellite products

in support of international high-altitude aviation operations. The network operates at 120 and 240 scans per minute with automatic selection of speed and mode depending on the type of product being transmitted. The network extends to the U.S. borders, and carries products to Alaska for relay to the Intra-Alaska facsimile network. The network is also extended to Canada, Mexico, San Juan, Curacao, and Nassau.

Forecast Office Facsimile (FOFAX) System—FOFAX is a long-line network designed to distribute NMC forecast guidance materials and NESS satellite products to the WSFOs. It is also used to distribute NESS-prepared geostationary satellite photographs and digital mosaics prepared from NOAA polar-orbiting satellite data. FOFAX operates at 120 and 240 scans per minute and has automatic selection of speed and mode.

Tropical Regional Analysis Facsimile Circuit (TROPRAN)—TROPRAN is a long-line network used to distribute tropical area analyses and prognoses. It carries NMC products for use by the National Hurricane Center and provides NESS tropical area satellite data for all users on the circuit. It also carries charts manually prepared by NHC to NMC for relay to the Caribbean HF radio broadcast from Brentwood, N.Y., and to FOFAX.

Intra-Alaska Facsimile Network—This network is a system of microwave, troposcatter, satellite links, cable, and high-frequency radio facilities used to distribute graphic materials throughout Alaska. Besides the charts prepared by WSFO Anchorage, charts received from NMC are switched automatically into the network. At present the Intra-Alaska Facsimile Network serves 11 NOAA, one Coast Guard, three FAA, 13 Department of Defense offices, and private users. FAA and NOAA provide funds for that portion of the NAMFAX circuit to Alaska by means of a satellite channel Valley Forge, Pa., to Talkeetna, Alaska. NOAA provides approximately 90 percent of the funds for circuitry within Alaska, and the Department of Defense funds the remainder. Parts of the backside of the intra-Alaska facsimile network are employed to deliver tsunami and tide gage information to the Palmer Observatory in Alaska.

Department of Defense

Strategic Facsimile Network—The Strategic Facsimile Network is a landline and microwave net that extends to selected Department of Defense users at about 70 locations in the United States. AFGWC at Offutt AFB serves as the transmitting facility. The Strategic Facsimile Network supplements the facsimile systems of the Department of Commerce by providing specialized graphical data oriented to military operations. It is used primarily to support the readiness of U.S. strategic weapons forces and secondarily to support airlift and tactical forces. The Network operates at 120 or 240 scans per minute. Most products are computer generated and introduced into the system through digital-to-analog converters.

Overseas Facsimile Networks—In order to satisfy the needs of military customers overseas, AFGWC at Offutt AFB transmits specialized products to locations in Europe over the European Facsimile Network (EURFAX) and to the Pacific over the Pacific facsimile network. The Pacific network operates at 120 to 240 scans per minute while EURFAX operates at 120 scans per minute. The Air Force has a program to upgrade the EURFAX system with modernized recorder hardware. Most products are generated by AFGWC; however, a limited number of specialized manually prepared products are injected into EURFAX by the European Tactical Forecast Unit at Kapaun Barracks, Germany. Some Japanese indigenous products are entered into the Pacific network at Yokota Air Base, Japan.

Fleet Weather Broadcasts—The Naval Communications System supports the Naval Weather Service in its requirements for specialized operational communications. Meteorological traffic is handled in the same manner as other Navy traffic; no center or unit is dedicated exclusively to meteorological communications. Meteorological information is transmitted to operating forces of the Navy by means of radio (continuous wave, teletypewriter, and facsimile) broadcasts. Designated Fleet Weather Centrals are responsible for contents of these broadcasts which include observations, analyses, forecasts, and warnings. In preparing broadcasts, the centrals and facilities make use of, not only their own specialized products and those from FNWC, but also—to the extent possible—products from the Basic Meteorological Service and data from Department of Defense's Automated Weather Network.

Other Facsimile Broadcasts

International radio facsimile meteorological broadcasts are transmitted by means of leased commercial high frequency (HF) radio transmitter facilities. These broadcasts are beamed primarily toward the Caribbean, Central America, South America, and southwest Pacific areas.

Several facsimile broadcasts are relayed through the NASA satellites ATS 1 and 3, as well as the SMS/GOES systems.

Marine HF radio facsimile meteorological broadcasts are transmitted from the west coast of the United

States by means of Coast Guard transmitter facilities and are intended primarily for reception by ships at sea. A special HF radio facsimile service is provided to the Pacific coast and high seas tuna fleet by a cooperative NOAA-Scripps Institute of Oceanography effort via Radio Station WWD, at La Jolla, Calif.

Real-time reconstructed radar images consisting of weather echoes with added handwritten annotations and geographical overlay are transmitted in facsimile mode from WSR-57 radar sites equipped with transmitters. There are 35 transmitter sites presently equipped with the capability. The two operational modes being employed are hard-wire private line circuits leased from common carriers and direct-distance dialing. Either of these services is available to interested government and nongovernment users on a cost-basis.

Publications

The Federal Coordinator for Meteorological Services and Supporting Research has either prepared or is preparing a series of publications covering the broad spectrum of meteorological programs in the Federal Government. The following is a list of these publications and their status:

The Federal Plan for Meteorological Services and Supporting Research (Published annually)

World Weather Program Plan (Published annually)

National East Coast Winter Storms Operations Plan (Revised annually)

National Hurricane Operations Plan (Revised annually)

National Severe Local Storms Operations Plan (Revised annually)

Federal Plans for Cooperative Backup Among Operational Processing Centers (December 1976)

Federal Plan for Meteorological Rocket Observations (September 1976)

Federal Computer Plan for Operational Forecasting and Atmospheric Modeling Research (August 1975)

Federal Plan for National Climate Services (February 1974)

National Plan for Rocketsonde Support for Special Events (February 1974)

Federal Plan for Weather Radars (November 1974) (To be updated)

Comparison Test of Meteorological Measurements from Weather Reconnaissance Aircraft on May 28, 1971 (June 1973)

Federal Plan for Natural Disaster Warning and Preparedness (June 1973) First Supplement FY 1976-1980 (June 1975)

Federal Plan for a National Agricultural Weather Service (January 1971) (Under revision)

Report on Hurricane Weather Reconnaissance (September 1969)

Federal Plan for a National Fire-Weather Service (March 1967) (Under Revision)