U.S. DEPARTMENT OF COMMERCE / Environmental Science Services Administration

REPORT TO THE FEDERAL COORDINATOR FOR METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH

U.S.
OFFICE OF WORLD WEATHER SYSTEMS

WORLD WEATHER PROGRAM

PLAN FOR FISCAL YEAR 1969

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C O N T E N T S

P R E F A C E

This report was prepared by the Office of World Weather Systems, Environmental Science Services Administration, and:

- Provides a broad view of the international activity concerned with the World Weather Watch and the Global Atmospheric Research Program -- which together constitute the World Weather Program.
- Outlines the U.S. activity to be undertaken during FY 1968 in support of the World Weather Program.
- Describes the planned FY 1969 efforts of the several government agencies in furtherance of the World Weather Program.

The report does not review the historical development of the World Weather Program, nor are the objectives and expected benefits discussed to any extent. These topics have been discussed extensively in the World Weather Program Plan for FY 1968 and in other publications.

WORLD WEATHER PROGRAM PLAN FY 1969

1.0 INTRODUCTION:

President Johnson, on the occasion of the opening of the Fifth World Meteorological Congress, April 3, 1967, instructed the U.S. delegation "to pledge the full and continuing participation of the United States in this important endeavor." He was speaking of the World Weather Program which was the most significant and far-reaching item on the agenda of the Congress. The activities leading up to this phase, both nationally and internationally, have been described in previous documentation.

The World Weather Program includes the World Weather Watch (WWW) and the Global Atmospheric Research Program (GARP). The WWW is a new international system for the regular observation of the atmosphere over the entire globe, and for the rapid and efficient communication, processing, and analysis of worldwide weather data for daily use by the world's nations. GARP is a comprehensive research program designed to give us the deep scientific understanding of the atmosphere which is required to achieve the World Weather Program objectives of more accurate weather predictions, of developing a capability in long-range weather prediction, and of exploring systematically the feasibility of large-scale weather modification.

The WWW is being planned and coordinated by the World Meteorological Organization (WMO). The international activities

of GARP are being planned jointly by the International Council of Scientific Unions (ICSU) and the WMO through a Joint Organizing Committee. In this country the National Academy of Sciences (NAS), at the request of the government, has established the GARP Committee to serve as an advisory body to the U. S. Government on the conduct of the Global Atmospheric Research Program.

The basic policies concerning U. S. Government participation in the World Weather Program (WWP) are established by the Federal Committee for Meteorological Services and Supporting Research. The Federal Committee assumed this responsibility from the Inter-agency Committee for International Meteorological Programs (ICIMP), which was dissolved in June 1967. A committee has been created under the Federal Coordinator for Meteorological Services and Supporting Research - the Interagency Committee for the World Weather Program (ICWWP) - to maintain working level coordination among the agencies involved. The Director, Office of World Weather Systems, is chairman of ICWWP.

The implementation of the World Weather Program is shared by a number of government agencies:

o <u>The Department of Commerce</u>: Provides a focal point (Office of World Weather Systems, ESSA) to coordinate our nation's efforts in this program, implements those service improvements in the existing international weather system for which the United States assumes responsibility, develops new technology as relates

to its responsibilities under existing authority, and cooperates with the National Science Foundation to stimulate and intensify general circulation research.

o The Department of State: Coordinates relations with international meteorological organizations, assists the less developed nations in improving their national weather services, and develops appropriate bilateral and multilateral arrangements to further international participation.

o The National Science Foundation: Stimulates and intensifies research on general circulation of the atmosphere among non-government scientists, and promotes the education and training of new scientists who can enter and advance atmospheric research.

o The National Aeronautics and Space Administration: Develops that new technology required for an economical global weather system as related to its responsibilities under existing authority.

o The Department of Defense:* Assists in the planning and provides logistical and operational support to GARP data-gathering projects.

o The Department of Transportation:* Supports the GARP data-gathering projects and conducts tests on the hazard of horizontal sounding balloon systems to aircraft.

* Specific contributions of these departments to the World Weather Program have been expanded or developed during the last year.

o The Atomic Energy Commission:* Supports the GARP data-gathering projects.

o The Department of Interior:* Assists in the planning and provides logistical and operational support to GARP data-gathering projects.

* Specific contributions of these departments to the World Weather Program have been expanded or developed during the last year.

2.0 STATUS OF PROGRAM INTERNATIONALLY:

During 1967, major international actions were taken on the World Weather Program. The Fifth WMO Congress adopted the World Weather Watch implementation plan for the period 1968-71, approved a program to develop new technology for incorporation into the Watch during the period 1972-75, adopted a program to assist the less developed nations in fulfilling their responsibilities to the WWW plan, and approved an expanded training program. The plan for the Global Atmospheric Research Program was developed at the joint WMO/International Council of Scientific Unions study conference held in Stockholm.

The next round of decisions on the World Weather Program will take place in 1970. At this time, the WMO Executive Committee will decide on the World Weather Watch implementation plan for the period 1972-75. Final approval of the plan for 1972-75 will be carried out at the Sixth WMO Congress in 1971. In regard to GARP, decisions must be taken in 1970 on the Tropical Meteorological Experiment (1972 or 1973) and a more specific date must be established for the Global Meteorological Experiment. All of these decisions depend critically upon the progress made in the World Weather Watch implementation and the development of new technology during the calendar years 1968 and 1969.

2.1 World Weather Watch Implementation

The WMO World Weather Watch implementation plan includes improvements in the observing, communications, and processing subsystems.

2.1.1 The Global Observing System (The observational networks and facilities). To remedy the more critical deficiencies, the plan is to:

- o Establish or upgrade 130 land-based upper-air stations.
- o Equip 100 merchant ships to take regular upper-air observations.
- o Continue and improve the meteorological satellite systems of the U. S. and USSR.
- o Complete the national surface observation networks.
- o Continue and expand the international Ocean Station Vessel Program.

2.1.2 The Global Data Processing System (The Meteorological Centers and arrangements necessary for the processing of observational data and for the storage and retrieval of data) The World Meteorological Centers (WMC's) at Melbourne, Moscow, and Washington, will produce global weather analyses and prognoses, directly supporting Regional Meteorological Centers (RMC's) and National Meteorological Centers (NMC's) using advanced numerical procedures. The plan requires:

- o That WMC's become fully operational by 1971.
- o That RMC's be established where the need exists.

2.1.3 The Global Telecommunications System (The facilities and arrangements necessary for the rapid exchange of

observations and meteorological products) During the period 1968-71, the WMO plan requires the establishing of a high-speed global main trunk which will interconnect the World Meteorological Centers, selected Regional Telecommunications Hubs, RMC's and NMC's. Each link in the telecommunications system will be funded, installed, and maintained jointly by the countries in which terminals are located.

2.1.4 Implementation Mechanism. The implementation of World Weather Watch activities within a country shall be the responsibility of that country. Implementation in regions outside the territories of individual countries (e.g. outer space, oceans, Antarctica) shall be through voluntary participation by the various countries. However, since the developing nations will need assistance in carrying out their responsibilities under the WMO WWW Plan, the following sources of support will be used:

- o The United Nations Development Program which should be used to the maximum possible extent.
- o Bilateral or multilateral arrangements without WMO participation.
- o The WMO Voluntary Assistance Program (VAP).

The Voluntary Assistance Program was adopted and the procedure under which it will operate was specified by the WMO Congress in April 1967. It will consist of two parts, (a) a voluntary assistance fund with an annual target of $1 million

and (b) an equipment and service program which has an annual target of $4 million. This level of funding was established on the basis of an analysis of the foreign exchange need of developing countries to implement the World Weather Watch plan in their territories. The developing nations will be expected to provide requisite local facilities and personnel from their own national resources.

2.2 Global Atmospheric Research Program (GARP)

The Fifth Congress of the WMO adopted a resolution endorsing GARP as the program within which all WWP research activities shall be coordinated, planned, and implemented. The Congress suggested a formal mechanism for cooperating with ICSU on GARP. As a result, a Joint ICSU/WMO Organizing Committee for GARP was established. This Committee will be responsible for the international planning and design of the GARP data-gathering projects.

ICSU and WMO jointly laid the ground work for GARP during a Study Conference in Stockholm during the summer of 1967. Approximately fifty scientists from throughout the world participated in the Conference. The Conference report delineates the major scientific problems that must be solved to meet the objectives of GARP. These problems fall into two areas: atmospheric modeling research and data-gathering experiments to support that research. The modeling research will include the initial efforts

required for exploration of the feasibility of large-scale weather modification.

2.2.1 Atmospheric Modeling. This research is directed toward improving the fidelity with which mathematical models simulate the physical processes of the atmosphere. Current models do not adequately represent such physical processes as the release of latent heat, diabatic heating, and planetary boundary layer exchange of heat, momentum, and moisture. Progress has been substantial, but it is limited by lack of the observations required to define the atmospheric conditions initially, and against which to evaluate subsequently the performance of the models.

2.2.2 Data-gathering Experiments. Extensive field activities are necessary to supply the data needed for the atmospheric modeling research. The experiments proposed by the Study Conference are:

a. Planetary boundary layer experiments concerning air/sea and land/air interaction in which the boundary fluxes are measured and related to large-scale atmospheric motions. Experiments of this type must be carried out in various parts of the world under various climatic conditions. Such experiments are planned by the United Kingdom, Japan, Soviet Union, and the United States during 1969 or 1970.

b. A tropical meteorological experiment to provide a physical description of tropical circulations which constitutes one of the largest gaps in our scientific knowledge at the present time. This international experiment is planned for 1972 or 1973. The Conference recommended that at the time of this experiment global observations be acquired to the degree possible.

c. A full global meteorological experiment to obtain a complete set of data required for large-scale numerical simulations of the atmosphere. Tentatively this experiment is planned for the mid-1970's but will require the development of new technology. Final decisions on the implementation will depend upon the rate of progress of new technology.

2.3 Technological Development

In response to a request by ICSU, the International Committee on Space Research (COSPAR) formed a Working Group to give special attention to the technical requirements of the global data-gathering function.

The reports of this group reflect the status of current work and plans in this area as of mid-1967. These reports serve as a guide to the ICSU/WMO Joint Organizing Committee on future planning for GARP.

There is substantial technology development in progress

among the nations. Although individual projects are national responsibilities, the WMO is coordinating the effort and is developing a base for exchange of information. Technological development activity for WWP is proceeding to varying degrees in most of the developed countries. The program of greatest international significance centered outside the U. S. is the French "EOLE" horizontal sounding balloon program. They have an extensive development effort in this area, and are planning a 500 balloon test in the Southern Hemisphere in 1969.

2.4 Education and Training

The WMO Congress approved an intensified training program to meet the growing need for trained meteorologists for the World Weather Watch and a new initiative through a fellowship program to train research atmospheric scientists for GARP. The use of the World and Regional Centers as locations of training will be developed, especially as a place for "on-the-job" training and training seminars.

3.0 U.S. EFFORT, CURRENT AND BUDGET YEARS (FY 68 and 69)

It is in the U.S.'s interest not only to participate in the WWP, but to encourage other nations and assist the less developed countries as appropriate in the implementation of the program. It has always been the policy of the U.S. to cooperate with other nations on matters pertaining to meteorology. The WWP represents a new emphasis in an expanded and accelerated international cooperative effort and the U.S. was a major participant to the development of the implementation plan. Certain aspects of the plan are very specific and the responsibilities of the U. S. are clear. Other aspects of the plan, particularly in the areas of technological development and research, cannot be so specific nor can the national responsibilities be so clearly determined. Because it has the technical and scientific capability and a base for the resources, it has been the policy of the U.S. to take the lead among the nations in these latter areas.

Summarized below, by project area, are the current and planned efforts for fiscal years 1968 and 1969. At the end of each summary is a table showing increases in the level of funding now available in FY-68 and that being requested for FY-69. The base program for each project, i.e., the amount obligated in FY-67, is indicated only where applicable. The dollar amounts shown in each table conform to these conventions:

- Amounts are increases over what was allowed each previous year (except NASA, see comment below)

- o Funds are for the WWP specifically, or when so noted, have been included in other programs but contribute directly to the WWP as well.
- o The NASA tables reflect ongoing programs not specifically designed for the WWP per se, but which will contribute significantly.

The funds reflected are annual totals.

3.1 World Weather Watch Implementation

This effort constitutes the direct U.S. contributions to the WMO WWW implementation plan. As indicated earlier, the WWW implementation plan is to be carried out by 1972. The U. S. has responsibility for projects in observing, satellite observations, data processing, telecommunications, and for contributing to the Voluntary Assistance Program. During FY-1969, projects are planned in all areas except observing which are planned to begin in FY-70.

3.1.1 Satellite Observations. The existing operational meteorological satellite system will be continued through FY-69. In addition, TIROS M -- an R&D satellite with an operational capability -- will be launched late in FY-69. This satellite will enable cloud patterns to be observed by night, as well as by day. Since the satellite program was not specifically generated as part of the World Weather Program, its cost is contained in the ESSA and NASA base programs.

3.1.2 Data Processing. The World Meteorological Center, Washington, has been established as an extension of the National Meteorological Center. The Tropical Analysis Center at Miami will also function as a World Weather Watch Regional Meteorological Center to serve the nations bordering on the Gulf of Mexico and the Caribbean Sea. It is planned, beginning in FY-68, to improve these centers to meet the WMO plan for the production of required analyses and prognoses.

WWP Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69
R&D Budget	90	100

3.1.3 Telecommunications. The U. S. is responsible, jointly with the nation at the other terminal, for implementing the Global Telecommunications System links between Washington and Tokyo, Washington and Brasilia, and Washington and Offenbach, as well as facsimile broadcasts from the Regional Meteorological Center at Miami. The Offenbach link is operational. The Brasilia link is being established late in FY-68. The Tokyo link is planned at low speed in FY-69, and the facsimile broadcasts from Miami are to be upgraded.

WWP Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69
S&E Budget	0	285

3.1.4 Foreign Assistance. Currently the United States is participating in bilateral cooperative agreements by which several developing nations are furnished meteorological equipment, supplies, and technical assistance in exchange for the taking and transmission of observations which are of direct benefit to this country as well as to those receiving the assistance. While these programs contribute to the World Weather Watch and should continue, they are inadequate in light of the assistance requirements of the developing nations as envisaged by the international WWW plan. Therefore, the WMO has established a Voluntary Assistance Program as the primary means of implementing WWW improvements in developing countries.

The State Department has included in its FY-69 budget $2 million for the U.S. contribution to the WMO Voluntary Assistance Program. This sum includes a U.S. cash contribution of $400,000 to the Voluntary Assistance Fund on the basis of matching at a 40% rate the total unrestricted cash contributions of all WMO Members. This sum also includes $1,600,000 under the WMO Equipment and Services Program for U.S. equipment, U.S. experts and the training in the United States of WMO nominees from underdeveloped countries (this program will be administered by the Environmental Science Services Administration of the Department of Commerce).

Annual Total Funding (Dollars in thousands)

Dept. of State	FY-68	FY-69
Budget	0	2000

3.2 Systems Design

There are a number of areas which require systems design effort in the development of the total WWP. The most critical of these are as follows:

Studies are required to establish the potential of newly proposed techniques for observing the atmosphere, as well as their compatibility with methods presently in use. A determination of the optimum mix and deployment of these techniques is required for the design of both the World Weather Watch and the GARP experiments.

A specific design of the future data collection and communication system must be developed. The conversion from conventional communications to the use of satellites is already foreseen. Thus, a careful analysis is needed of the optimum approach to this conversion.

A basic consideration in the design of a total WWW -- affecting the observing, communications, and data processing systems -- is the required dispersion of observations in space and time, and the minimum acceptable accuracies of the data. Studies, based on mathematical simulations, are required in this area.

During FY-68 and FY-69, the planned projects will be concerned primarily with the study of the optimum mix of observing equipment for both the advanced WWW and the GARP experiments. A major item in this area will be to support a science and technology advisory group at a major university to assist in these studies.

Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69
R&D Budget	89	200

3.3 Global Atmospheric Research Program

3.3.1 NAS GARP Committee. The National Academy of Sciences has established, as a result of interagency committee recommendations, a GARP Committee. The Committee is an advisory group of scientists who will provide advice to the government on all phases of GARP. To give continuity to its efforts, the Committee will establish a small permanent staff, to be located at NAS headquarters in Washington. Funding for this staff will be shared by the National Science Foundation and the Department of Commerce. The primary function of the Committee and its staff will be to specify the scientific objectives, establish the data requirements, and assess the technological feasibility of acquiring the data for field projects associated with GARP.

Annual Increase (Dollars in Thousands)

DOC	FY-68	FY-69
R&D Budget	21	50

NSF	FY-68	FY-69
R&D Budget	30	50

3.3.2 The Barbados Oceanographic and Meteorological Experiment (BOMEX). Planning for a GARP national planetary boundary layer experiment will be continued in FY-68. This experiment, BOMEX, will be conducted in May, June and July of 1969 in the international waters east of Barbados.

The central theme of BOMEX is ocean-atmosphere interaction. Detailed observations of the exchange of momentum, heat, and moisture at the ocean-atmosphere interface will be made so that the manner in which these fluxes can be incorporated into the long-range weather prediction models may be determined. The experiment will also provide for study of the tropical circulation and the time and space variation of oceanographic parameters.

A BOMEX Project Office, with representation from several of the participating agencies, has been established in the Office of World Weather Systems, ESSA. Participating agencies include the Departments of Commerce, Defense, Interior, State and Transportation, the National Aeronautics and Space Administration, the Atomic Energy Commission, and the National Science Foundation.

In addition, non-government agencies participating in BOMEX include the National Center for Atmospheric Research (NCAR), several universities, and possibly some foreign nations.

ESSA will furnish several ships and buoys instrumented for oceanographic and meteorological measurements, several weather reconnaissance research aircraft, the project headquarters staff, and a minimal scientific staff. The Atomic Energy Commission will measure the budgets, fluxes, and deposition rates of radionuclides over the sea, and will investigate the scavenging efficiency of rain for natural aerosols to which radionuclides are attached. AEC will also take micrometeorological measurements near the surface, and will provide an instrumented aircraft (with sonic anemometer) for measurements aloft. The Department of Transportation (Coast Guard) will provide a fully equipped meteorological-oceanographic ship, SAR and communications support. The Department of Interior will contribute ship time and staff to measure ocean-atmosphere interaction processes and the effect these processes have on distribution of physical properties in the sea and ultimately the effect on biota of the sea. The Department of Defense participating programs have not yet been fully determined. NSF will fund the contributions of NCAR and of several universities. These contributions are to be programmed for study in the transport of heat, water vapor and momentum, radiation, and convection. The studies will include both field

measurements and analysis and interpretations of the data. The Department of State will take care of all necessary international arrangements and agreements. NASA R&D satellites that are operating at the time of the experiment will provide pictures of clouds and other data that can be obtained over the experimental area.

The costs to DOD and Interior have not been identified. The costs to the other agencies are estimated below. The DOC funding shown is identified in the ESSA budget as Caribbean Studies (Marine Environmental Program) since the effort contributes equally to both that program and GARP. There are other BOMEX costs to ESSA and Coast Guard -- such as organic research manpower and ship operation -- which are not shown because they are incorporated into their bases.

Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69
R&D Budget	360	650
Base program - 311		
AEC	FY-68	FY-69
Budget	75**	217
NSF	FY-68	FY-69
Budget	365*	250*

* NSF participation will be based on the number and cost of university research efforts proposed for participation in BOMEX.

The total NSF budget for this effort is somewhat flexible. The funds in the budget category for both FY-68 and FY-69 can be augmented by funding some of the proposals from the basic research program in meteorology.

** AEC will provide balance of required funds by relocating ongoing research to the BOMEX area.

3.3.3 Atmospheric Modeling. Mathematical modeling of the atmosphere continues as a major research effort of WWP. The principle modeling efforts are conducted with NSF funds at NCAR and at universities, and by ESSA. This area needs substantial increases in funding to be responsive to the international effort, to determine the detailed design of future experiments and to place the U.S. in a position to capitalize on the overall WWP activities. Computational capacity and scientific and technical personnel must be added to the U.S. effort.

The DOC funds for this effort are programmed as Atmospheric Dynamic Studies under the Marine Environmental Program. But the effort contributes equally to WWP.

Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69	NSF	FY-68	FY-69
R&D Budg.	90	420	Budg.	135	165

DOC base - $1,590k*

NSF base - $400k*

*This amount is the base for GFDL and NSF. The effort contributes

to the WWP but was not programmed specifically for it and so is not added to the total WWP budget.

3.4 Technological Development

3.4.1 Merchant Ship Observations. During FY-68 and 69, ESSA plans completion of the development of a suitable system for obtaining complete upper air observations from moving merchant ships. This is an ongoing program which will contribute significantly to the WWP.

3.4.2 Horizontal Sounding Balloons. ESSA is responsible for the development of suitable superpressure horizontal sounding balloons (and associated sensor-telemetering equipment) in cooperation with NASA and the National Center for Atmospheric Research. It is planned that these balloons, which circle the earth at constant density levels to sense the winds, temperature, and pressure, will function as part of a NASA DATALOCOL system (3.4.5 below). The Federal Aviation Administration, DOT, will continue with hazard testing of balloon electronic packages to guide the development of instruments and power supplies which will not be hazards to air travel and $50,000 has been budgeted in FY-68 for this purpose.

Annual Increases (Dollars in thousands)

DOC	FY-68	FY-69	NSF	FY-68	FY-69
R&D Budget	0	185	Budg.	20	40

NSF base - $250k

3.4.3 Ocean Buoys. To augment the merchant ship program over large ocean areas where ship traffic is sparse, the World Weather Watch and the GARP field experiments will require ocean buoys equipped with automatic sensors and telemetering equipment. These buoys will be designed to serve the needs of both meteorology and oceanography. Much development effort is still required to obtain economical, survivable, long-lived, and easily-deployed buoys for these purposes. A contract study, which was managed by the Coast Guard and supported by interagency funding, provided insight into the total Federal requirements for oceanic data which can be acquired by buoys on a cost-effective basis. The study also recommended a five-year research and development program leading to the operational deployment of buoys which will meet the needs of the entire oceanographic-meteorological community. The buoy development effort is not solely for the World Weather Program, but would contribute to it. It is envisaged that ultimately buoys would also be a part of a DATALOCOL System (3.4.5). The Coast Guard is requesting $5,000,000 in its FY-69 R&D budget, which amount is reported separately under the national marine science program.

3.4.4 Satellite Remote Sensing. Preliminary estimates indicate that WWP costs can be materially reduced by use of satellites for remote sensing, communication, and data collection. Progress in utilizing the satellite for observing

the atmosphere has been rapid and encouraging. While remote sensing of wind represents a very difficult problem for which there is no immediate solution, the precise measurement of other key atmospheric variables, such as the vertical structure of temperature, moisture, and ozone by satellite-borne remote sensing instruments, holds considerable promise. Development, test and evaluation of several similar instruments and techniques, each with distinct advantages and disadvantages, is being continued. At the present time, it is not possible to determine which techniques and which instruments are the more appropriate. However, it is essential that the development of the various techniques for remotely sensing the atmosphere be pursued vigorously so that they can be evaluated and the more appropriate can be selected and made available for use in the WWP.

3.4.4.1 Optical Techniques. Improvements in optical sensing of cloud cover for meteorological purposes will focus on increasing the sensitivity, improving the resolution and expanding the dynamic range of current sensors.

To meet these needs, continuing development, integration, and flight test of improved vidicon, spin scan, image dissector, and image orthicon cameras will be pursued. The performance of the image dissector camera on an orbiting, low altitude satellite will be evaluated on Nimbus B & D. An improved spin-scan camera

and the image dissector camera will be evaluated from the standpoint of use in a synchronous satellite on ATS III. The day-night (image orthicon) camera will be flight tested from synchronous altitude on ATS-D.

3.4.4.2 Infrared Techniques. In addition to providing global nighttime cloud cover and surface temperature observations, radiometers or spectrometers operating in the infrared portions of the spectrum can measure the vertical profile of temperature, ozone and water vapor. Instruments currently under development of primary importance to the World Weather Program are:

Satellite Infrared Spectrometer (SIRS)

Infrared Interferometer Spectrometer (IRIS)

Medium Resolution Infrared Radiometer (MRIR)

Filter Wedge Spectrometer (FWS)

Temperature Humidity Infrared Radiometer (THIR)

High Resolution Infrared Radiometer (HRIR)

Selective Chopper Radiometer (SCR)

Cloud Top Altitude Radiometer (CAR)

Temperature Profile Radiometer (TPR)

Infrared Temperature Sounding Radiometer (ITSR)

In early 1968, IRIS, SIRS, HRIR, and MRIR will be flown on Nimbus B. The FWS, THIR and SCR, in addition to an improved IRIS and SIRS, are being developed for flight on Nimbus D about twenty

two months after Nimbus B.

3.4.4.3 Ultraviolet Techniques. An instrument for obtaining the spatial distribution of atmospheric ozone, the Backscattered Ultraviolet Spectrometer (BUV), is being developed for flight on Nimbus D. In addition, a technique for measuring the ultraviolet flux incident at the top of the atmosphere is the Monitor of Ultraviolet Solar Energy (MUSE), being developed for flight on Nimbus B and D.

3.4.4.4 Microwave Techniques. The vertical structure of temperature and moisture can also be derived from spectrometric measurements of radiation at microwave frequencies. Microwave emissions at certain wavelengths penetrate some clouds and permit observations of regions impenetrable by infrared remote probes. Passive microwave satellite sensors for use in meteorology are in an early stage of development. Such an experiment is being considered for flight in the Nimbus follow-on series.

3.4.4.5 Laser Sounding Techniques. The development of the laser offers another approach to global measurement of meteorological parameters from satellites. This technique may offer the possibility of measuring density, temperature, water vapor, ozone, aerosol content and air turbulence between approximately 100,000 feet and 10,000 to 15,000 feet (or cloud top). Theoretical and laboratory investigations to determine the

feasibility of measuring the vertical profiles of various atmospheric parameters by lasers will continue in both FY-68 and 69.

3.4.4.6 Refraction Techniques. Refraction techniques provide a means for obtaining the vertical profile of the mass density in the atmosphere. Two methods are being considered: refraction of stellar images and refraction of microwaves. Evaluation of the potential of these techniques will continue in FY-68 and 69.

3.4.4.7 Sferics Observations. Measurement of the amplitude and frequency of UHF sferics (610 MHz) will provide information on the distribution of thunderstorm activity and may furnish information on the intensity of thermal convection.

3.4.4.8 Advanced Techniques Development. The capability of the various sensors under development to measure the required physical parameters of the atmosphere adequate for use in the mathematical models must be tested and evaluated. Further, advanced theories and proposals for remotely sensing the atmosphere must be studied and evaluated. Generalized specifications and initial sensor development through the bread-board or prototype stage is to be accomplished.

Annual Increase (Dollars in thousands)

DOC	FY-68	FY-69
R&D	0	105

The NASA remote sensor research and development will contribute significantly to the WWP. The funds indicated below include the cost of sensors, in-house support, data analysis and supporting research and technology. (Costs for ground operations and integration of the experiments are included later with the spacecraft figures).

Annual Total Funding (Dollars in Thousands)

NASA	FY-68	FY-69
R&D Budget	16,876	15,890

3.4.5 Satellite DATALOCOL (Data Location and Collection.) During FY-68 and FY-69, NASA will continue development of two DATALOCOL systems: The interrogating, recording, location system (IRLS), and the OMEGA position location experiment (OPLE). In addition, the French EOLE system planned for a 1969 launch will be evaluated in comparison to the IRLS and OPLE systems. These three systems use satellites for identifying, locating and collecting and forwarding meteorological data from remote atmospheric and surface platforms. They differ however, in the method of locating the sensor platforms. Each of the three techniques has distinct advantages and disadvantages. At the present time, it is not possible to determine which is the most appropriate. These three systems will be developed to the point where they can be fully evaluated.

The first IRLS test will be conducted on the Nimbus B spacecraft in early 1968. An advanced model of IRLS is being developed for test on Nimbus D in 1970.

An initial OPLE experiment will be conducted during the flight of the Applications Technology Satellite (ATS III) which was launched in November, 1967. Future development and test of advanced versions of OPLE depend on the decision to implement the OMEGA system in additional geographical areas.

3.4.5.1 DATALOCOL Funding. The NASA research and development in this area will contribute significantly to the WWP.

Annual Total Funding (Dollars in Thousands)

NASA	FY-68	FY-69
R&D Budget	4,008	1,875

3.4.6 Meteorological Spacecraft. The NASA meteorological spacecraft development program falls into two broad areas. The first is the development, fabrication, and launch of experimental spacecraft (such as Nimbus) specifically designed to serve as test platforms for new satellite-borne sensing and communications equipment. The second is the design of new operational meteorological spacecraft, the building of test prototypes, their launch and subsequent evaluation. TIROS M is an example of the second class of spacecraft.

The Nimbus and ATS series are test platforms. Nimbus I and II and ATS I and III have already flown in support of the Meteorological satellite program. Nimbus B is scheduled for launch in 1968, and Nimbus D about twenty-two months later. In mid-1968, ATS-D will be flown. Other spacecraft of the ATS series are planned for subsequent years.

During FY-68 and 69 effort will be devoted to the development of an advanced TIROS spacecraft (TIROS M) which incorporates in a single spacecraft advanced vidicon camera systems, automatic picture transmission camera systems, and high resolution infrared radiometers for operational local and global, day and nighttime coverage. Experience gained with TIROS M, the Nimbus satellites, and the ATS series will provide guidance for subsequent operational meteorological satellites.

3.4.6.1 Meteorological Spacecraft Funding. The NASA research and development meteorological spacecraft program will contribute significantly to the WWP. The experience gained will be invaluable in the design of the WWP meteorological satellites. The funds indicated below include costs for the TOS improvements, TIROS M, and the Nimbus satellites. The cost of the ATS satellites have not been included since these satellites were not developed solely for meteorology. All spacecraft costs, including ground operations and experiment integration, are included.

Annual Total Funding (Dollars in Thousands)

NASA	FY-68	FY-69
R&D Budget	31,870	27,719

3.5 Education and Training

The U.S. effort in this area is based upon presently functioning programs of the National Science Foundation. The Foundation has several programs designed to foster the training and education of researchers. The first is a series of fellowship programs for U.S. citizens that encourage the continuous education of teachers and the holders of doctor's degrees. The second program is the continuing effort to support graduate students education through fellowship and traineeship programs as well as research assistance on research grants.

Several new programs are in the early planning stages but implementation will depend upon both the response to the currently available programs and upon the need for such new programs as an aid in making GARP a successful program.