U.S. Weather Bureau.
National Operational Meteorological Satellite System.
NATIONAL OPERATIONAL METEOROLOGICAL SATELLITE SYSTEM

The NIMBUS Meteorological Satellite

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The NIMBUS Advanced Meteorological Satellite

NIMBUS and the National Operational Meteorological Satellite System (NOMSS)

The NIMBUS artificial satellites are advanced meteorological spacecraft that will obtain a large part of the information needed for the National Operational Meteorological Satellite System to provide "for the continuous observation of worldwide meteorological conditions..." The National Aeronautics and Space Administration plans to launch the first NIMBUS satellite in mid Fiscal Year 1963. Data from this research and development spacecraft will also be used for operational purposes. NASA plans to launch a total of four research and development NIMBUS spacecraft during the period 1963 through early 1966. These will not provide the continuous observational capability required for the NOMSS, so the Weather Bureau plans to fund procurement of at least four additional NIMBUS spacecraft and four launch vehicles. These are expected to supplement the NASA R&D program sufficiently to assure the required continuity.

Orbit and Attitude

NIMBUS will orbit the earth approximately once every 100 minutes, with its meteorological sensors directed toward the earth. This earth-oriented attitude will permit the sensors to view the earth's atmosphere or surface directly below the spacecraft from every point in its orbital path. The nearly polar orbit into which NIMBUS will be launched will make possible almost total daily meteorological coverage of the earth, in contrast to the approximately 20% maximum daily coverage possible with TIROS, the present meteorological satellite. The first NIMBUS will cross the equator at local noon and local midnight on each circuit of the earth; thus every part of the earth, except where there is polar darkness, will be seen in sunlight at least once each 24 hours.

Sensors

The sensory system of the first NIMBUS satellite will include an improved vidicon (television) camera system to provide almost complete coverage of global cloud patterns in daylight, and a radiation sensing system to provide measurements of atmospheric and terrestrial radiation, from which nighttime cloud cover can be derived.

1 from Pub. Law 87-332, 9/30/61
Pictures

The camera system will consist of three cameras, one pointing straight downward, and two flanking cameras pointing sideward at a slight angle from the vertical. These cameras will take pictures simultaneously during daylight at about 100 second intervals. This will provide three side-by-side pictures; the pictures from each of the side cameras will overlap the pictures from the central camera by about 5%. Each set of three pictures, covering an area about 400 miles by 1200 miles, will slightly overlap the preceding set.

Radiation

NIMBUS will carry a high resolution infrared system to measure, during the night part of each orbit, the approximate temperatures of cloud tops or, in cloud free areas, the ground or ocean surface temperatures. The measurements will be used to obtain nighttime cloud maps and to approximate the height of the cloud tops. This sensor will be the "eye" of the satellite during the time the area beneath it is in darkness, but will not be used to obtain daytime data. A lower resolution radiation sensor to obtain heat balance measurements will be included on future NIMBUS satellites.

Future Experimental Sensors

The modular design of NIMBUS will permit the addition of new or improved sensory systems. As these systems are developed they can be tested as part of the R&D program. Some of those contemplated are electrostatic tape cameras for continuous picture strips, spectrometers for measuring atmospheric temperatures and constituents, image-orthicon cameras for nighttime photography, and radar to detect precipitation. New sensors will be included in the operational spacecraft when proven to be of operational value.

Data Acquisition

Two Command and Data Acquisition (CDA) stations are planned for operational purposes during FY 1963-66. Control signals are sent to, and data are received from the spacecraft at these stations. The data are processed into a form suitable for transmission to the Weather Bureau's Meteorological Satellite Activities (MSA) organization at Suitland, Maryland. One of the stations will be located at Fairbanks, Alaska; the other at a northerly latitude on the east coast of North America.
Data can be received at Fairbanks from only nine of the nearly fourteen orbits per day. With two CDA stations in operation, data from all orbits will normally be received.

Communications

Transmission of the picture and radiation data from the data acquisition stations to the Meteorological Satellite Activities organization at Suitland, Maryland requires a high quality wideband communications system. An indication of the quality needed can be gained by comparing the desired 96 kilocycle bandwidth with high quality telephone circuits, which operate at 3 kilocycle bandwidth. Initial operational plans call for a wideband communications data-link between Fairbanks, Alaska and Suitland, Maryland.

Central Data Processing

Central data processing and analysis procedures will be used by the Meteorological Satellite Activities organization to convert data from NIMBUS into forms suitable for meteorological purposes, such as their use in daily analysis and forecasting operations. These data also will be placed in the archives in formats suitable for rapid retrieval to facilitate their use in research and development in the fields of forecasting, atmospheric circulation, physical meteorology, and for climatological study.

Processing will include computer preparation of geographic (latitude-longitude) grids for pictures, computer processing of radiation data, and picture processing. A computer will be used to prepare maps showing cloud cover, heights, and types, and maps of snow and ice cover. These products, after checking by professional meteorologists, will be turned over to the National Meteorological Center, co-located with the processing center at Suitland, Maryland for operational use. These data also will be used to produce a storm detection and tracking chart. All products will be distributed to using meteorological agencies by the most expeditious means. Maps and pictures will be transmitted in original form by facsimile, and in coded form by radio and teletypewriter. Distribution will be made to users in the United States and abroad, it being understood that all data are freely available to the world community.

Meteorological Uses of NIMBUS Data

The meteorological uses of NIMBUS data must of necessity be discussed in terms of the experience with TIROS, an earlier version of a meteorological satellite. In general NIMBUS picture data will show more detail; the best resolution will be 0.5 miles in contrast to a best TIROS resolution of 1.5 to 2.0 miles. The constant attitude of NIMBUS will keep variation in resolution small, whereas the changing attitude of TIROS results in large variations in picture resolution. The characteristics of the NIMBUS radiation sensors will show a similar improvement over the TIROS sensors.
Seeing Broad-scale Weather Patterns

Pictures from six TIROS I orbits, on May 20, 1960, were assembled to make the picture mosaic on this page which shows a broad-scale view of the cloud patterns extending from the central North Pacific to the Great Lakes. The remarkable view of such an extensive area allowed research meteorologists to compare for the first time actual cloud patterns with theoretical cloud distributions. Prior to TIROS I, broad-scale cloud patterns were surmised on the basis of observations made from widely spaced ground stations. Over ocean areas, of course, even fewer reports are available. Thus meteorological satellites which make possible daily, operationally useful observations over wide areas, help to fill the gaps in standard observational networks, and furnish the observations needed for advanced meteorological research. Despite the demonstrated capability of TIROS, NIMBUS satellites will furnish greater quantities of higher quality data. While the TIROS looks at the earth at varying angles, NIMBUS will look directly down at the earth. Thus the problem of rectification, or adjusting cloud pictures to fit a map, will be greatly simplified. The area shown in this cloud mosaic will be seen by three orbits of NIMBUS as compared to the six needed by TIROS; and finally, NIMBUS will see the changing weather patterns of this area day after day, while TIROS can see it at most for only about ten successive days, after which about thirty days go by before the area can be seen again.
Hurricane and Typhoon Detection and Tracking

On more than fifty separate occasions, TIROS III, launched into orbit on July 12, 1961, photographed tropical cyclones in various stages of development. Five hurricanes and one tropical storm were followed in the Atlantic; two hurricanes and a tropical storm were followed in the eastern Pacific. Typhoons Kathy through Tilda, nine storms in all, were followed in the eastern Pacific.

Hurricane Esther, shown here with hurricane Debbie, was the first hurricane discovered by means of meteorological satellite pictures alone, in time for operational use. The information was used to direct aerial reconnaissance to the area to confirm the location of the storm and to gather detailed data. Post analysis of satellite pictures showed that hurricane Anna, also, might have been discovered in its formative stages had meteorologists had experience in recognizing satellite pictures of these storms. It is expected that, during future hurricane seasons, many hurricanes will be discovered by use of meteorological satellite pictures, and followed from day to day in the pictures. When this becomes routine, reconnaissance flights can be directed to each storm to obtain necessary detailed measurements, thus making scheduled, time-consuming surveillance flights unnecessary.

The weather of the tropics, like that of the great oceanic areas of the world, is observed inadequately by conventional means, but NIMBUS will see it on a daily basis. Satellite pictures from TIROS are now being used by research meteorologists for intensive studies of tropical weather. NIMBUS pictures and radiation data will furnish more complete and more continuous data for both operational and research uses.
Ice and Snow Reconnaissance

The picture mosaics on this page show ice in the Gulf of St. Lawrence photographed from TIROS II in March 1961. Ice floes, cracks in solid ice fields, and areas of unfrozen water are all easily seen. Use of satellite pictures to show the condition of ice fields over navigable waters will greatly decrease the need to use reconnaissance aircraft and patrol ships for this task, and will provide more frequent information over much larger areas than would be possible otherwise. Snow on the ground also can be seen in satellite pictures. The accurate survey of snow cover possible with satellites will provide information for estimates of water availability and for forecasts of spring flood potential.
Severe Storms

The cloud picture on this page was taken by TIROS I on May 27, 1960. The very large isolated clouds over the southwestern tip of Nebraska, western Kansas, and the Texas Panhandle were identified as areas of severe weather. At the time this picture was taken, hailstones as large as baseballs were falling over western Kansas. As these clouds moved eastward, hail continued and within three hours a tornado developed in the cloud seen over Texas. Large, bright isolated clouds have been seen in other satellite photographs, and in the few cases that have been thoroughly investigated, severe weather, such as heavy thunderstorms, hail, or tornadoes, was reported at or shortly after the time the pictures were taken. It is hoped that information of this type will be available in time to assist in the preparation of forecasts of severe weather.
Radiation Data

The radiation sensors of NIMBUS will measure the temperatures of the earth's surface, except where there are clouds, in which case the temperature measured will be that of the tops of the clouds. The sensors will also measure the water-vapor content of the atmosphere, the reflectivity of the earth, the long wave (heat) radiation from the earth to space, and the incoming radiation from the sun.

Radiation measurements will be mapped by computers, in the form shown on this page. Areas of warm and cold surfaces can be detected; the cold areas generally representing cloud tops and the warm areas the ground surface. Thus maps such as this can furnish information about cloud cover on the night side of the earth. Improved sensors should provide nighttime radiation maps that will approximate the television cloud pictures now available from TIROS.
International Aspects of Satellite Data

Weather, which knows no national boundaries, is the most international of sciences and requires close cooperation between nations in providing meteorological advice for protection of life and property. This was recognized over ninety years ago, when the International Meteorological Organization (now the World Meteorological Organization) was formed to facilitate free exchange of weather information between the nations of the world. The pictures from TIROS gave immediate evidence that here was an unprecedented source of weather intelligence, especially for areas for which other data are unavailable. For the first time, weather patterns and storms could be followed over oceans and unpopulated areas of the world.

The satellite data, just as conventional meteorological information, is made freely available to the world at large. For example, a TIROS picture taken in the southern hemisphere was used to warn the Australian weather service of an unsuspected storm moving in from the South Indian Ocean. TIROS III pictures were the basis for an advisory warning the tuna fishing fleet off the west coast of Mexico that a tropical storm was being spawned over the fishing grounds. Fifty advisories on storms and other significant weather tracked by TIROS III were sent to Japan, the Philippines, Mexico, Hong Kong, Formosa, and Guam, as well as to Weather Bureau stations in the United States and Puerto Rico. Maps showing the types, amounts, and locations of clouds seen in the satellite pictures were given the broadest distribution possible with the communications facilities available. These maps have been used, both in the northern and southern hemisphere, for weather analysis and forecasting, for storm warnings, and for briefing aircrews on the weather over transoceanic flying routes.

During the operational life of TIROS III, approximately thirty countries conducted intensified observational programs to coincide with the passage of the satellite overhead. These programs were initiated in response to a joint Weather Bureau-NASA invitation to participate in the experiment by comparing special supplementary observations with those taken by the satellite.

In November of 1961, an International Meteorological Satellite Workshop was sponsored jointly by the Weather Bureau and NASA. Thirty five participants from 27 nations attended, and expressed enthusiastically their satisfaction and thanks to the United States for sharing the results of the satellite experiments. Subsequent correspondence reveals greatly intensified interest on the part of the national meteorological services, and contains requests that satellite data be transmitted as quickly as possible for use in daily operations.
This reaction by the nations of the world to the value of the limited observations available from TIROS satellites is an indication of how much more in demand will be the worldwide daily observations from NIMBUS. The Weather Bureau is taking steps to assure the widest possible flow of information when the NIMBUS satellites are in orbit. Communications facilities are being expanded; as each link becomes available it will be used to transmit data from TIROS satellites until NIMBUS data are available.

The map below shows present and proposed communications arrangements. These will be expanded as necessary through collaboration of national and international efforts.