22. NASA METEOROLOGICAL SATELLITE PLANS FOR THE FUTURE

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The NASA objectives in planning a meteorological program may be stated as follows:

The first objective is to obtain data essential to (1) improved knowledge and understanding of the atmosphere, and (2) development of weather analysis and forecasting techniques.

The second objective is to develop satellite prototypes and principles of a national operational meteorological satellite system.

The final objective is to conduct basic and applied research and development for continued improvement of the operational system. Contributions toward meeting this objective will, it is hoped, come from many persons in many countries.

Hopefully, these basic objectives will be achieved through a flight program of progressively more sophisticated meteorological satellites and related programs of supporting research and development.

Tiros I, II, and III have been discussed in the preceding papers in this Workshop. Subsequent Tiros launches to a total of at least seven, including those already launched, are scheduled at approximately 4-month intervals. The objective is to provide a continuity of operating meteorological satellites in orbit through the first successful Nimbus launches.

The fourth Tiros is expected to be substantially the same as Tiros III, except that one of the two wide-angle television cameras will be equipped with a lens providing slightly less coverage, about 20 percent decrease, but with correspondingly improved resolution, and, what is more important, much less distortion. Consideration is being given to launching Tiros satellites into orbit at angles of inclination greater than those used at present (about 50°). This will provide meteorological data farther north and south—poleward, of course—and in the winter season, a better chance to study the applications of the data to sea ice analysis.

Figure 22–1 shows the reason for progressing from the Tiros series to the Nimbus series. The Tiros satellites are limited in coverage potential by two features. One, the satellites are in an inclined orbit. In other words, the earth can be viewed essentially between two latitudes, roughly 50° north and 50° south. The polar regions are not accessible to the Tiros view. The second feature of Tiros which is undesirable for an operational system is the fact that it is spin stabilized with respect to space; that is, it presents more or less the same orientation in space throughout its lifetime. In part of its orbit it views the earth; in another it views space. This, too, limits the coverage potential. Nimbus is designed to overcome these two deficiencies. Nimbus will be in polar orbit so that it will view the entire earth as the earth rotates underneath it, and it will be oriented to view the earth at all times.

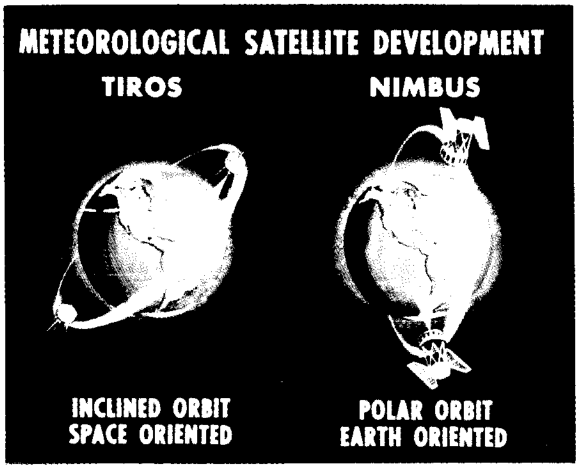

Figure 22–1

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The Nimbus family will be a family of satellites with many common components, such as data storage, controls, orientation, stabilization, data transmission, structure, and so on. It will have a flexible capability for improving old and introducing new systems as required. The first satellite in the Nimbus family is due to be launched late in 1962, with subsequent launches at about 6-month intervals. Since Nimbus will be earth stabilized, its cameras and other atmospheric sensors will always face the earth. Moreover, because of the polar orbit, Nimbus will view each area of the earth about twice a day.

Figure 22–2 shows the Nimbus satellite in the early development stage. It will be about 10 feet tall and about 5 feet across at the base. The weight of the first Nimbus satellite will be about 600 pounds. Later versions with more sophisticated sensors are expected to weigh up to 800 pounds, or possibly more. The satellite will have a lower part shaped like a hatbox where the sensor equipment will be located; the upper part is the control section and will orient the satellite properly. The two sections will be connected by struts. The solar platforms, indicated in figure 22–2, will be fastened to a shaft extending from the control section. These platforms, which will be controlled always to face the sun, will be covered with solar cells to provide power. The section on the top of the connecting struts will provide the controls to keep the satellite axis and the sensors always pointing toward the earth. The lower section contains the sensing units.

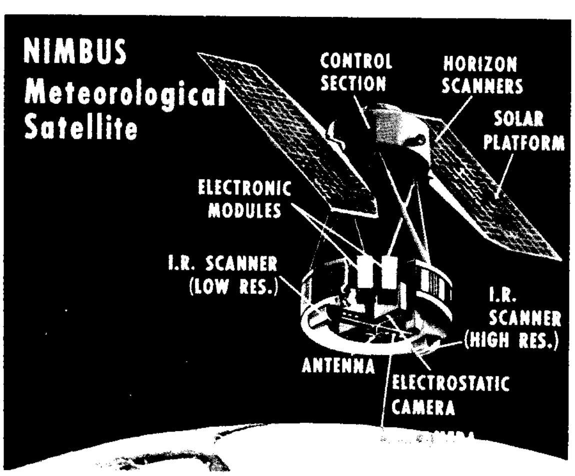

FIGURE 22–2

As presently planned, the Nimbus will contain vidicon cameras with wider coverage and better resolution than those in TIROS and a number of improved radiation sensors. The lower section of Nimbus is being designed on a modular or standardized compartment basis. The electronic modules shown in figure 22–2 can therefore be replaced in later versions of the satellite with improved or new types of equipment without redesigning the entire satellite. In later Nimbus satellites it may be possible to include new types of sensing equipment, such as image orthicon television cameras that can provide cloud data pictures at night, a radar set to provide data on the areas of precipitations, a radiation spectrometer to provide information on the temperature structure in the stratosphere, and a sferics detector to identify thunderstorm areas. An electrostatic-tape camera for a more detailed view of significant weather systems is also under development. Also planned is a device for measuring the solar constant or the total solar energy impinging on the earth. The general characteristics of the Nimbus family are presented in table 22–I.

Even the first Nimbus, although primarily an experimental research and development spacecraft, can be used to provide data for operational purposes. Plans exist for these data to be sent in real time from the data acquisition station in Fairbanks, Alaska. The reason for a station in Fairbanks is the fact that the spacecraft will be in polar orbit and a northern station can acquire more data as the satellite orbits the earth. The ideal locations would be exactly at the poles, of course, or close to them. The data will go from Fairbanks to the National Meteorological Center of the U.S. Weather Bureau at Suitland. There, the data will be analyzed and the resulting weather information distributed to both civilian and military weather stations. From its earliest conception Nimbus has been planned to serve as the basis for the spacecraft of the first operational meteorological satellite system. As the TIROS and Nimbus satellites rotate around the earth they view different portions of the geography of the earth. Thus, the evolution of a weather system can be followed only by studying data obtained in successive passages of the satellite over the same area. Several hours may elapse between passes. The meteorologist is

TABLE 22–I.—*Nimbus Meteorological Satellite*

Spacecraft:	
Size	114 in. high by 56 in. diameter.
Weight	550 to 600 lb.
Power	Solar cell paddles; nickel, cadmium batteries.
Stabilization	Earth-oriented pneumatic jets and inertia wheels; ±1° pitch and roll; ±2° to 3° yaw; rates <0.1° per second horizon scanners; integrating gyro.
Sensors:	
Advanced vidicon subsystem TV cameras.	0.3-mile resolution; nearly horizon-to-horizon coverage.
Radiation detector subsystems	Medium resolution, 5 channels, similar to TIROS. High resolution, night clouds, 125-mile resolution. Low resolution, total and thermal radiation, 400 miles.
Solar constant	±0.2 percent.
(Later spacecraft: electrostatic tape camera; spectrometer; image orthicon cameras; radar.)	
Orbit:	
Inclination	80° retrograde (quasi-polar; constant local time).
Altitude	600 nautical miles (±30 nautical miles; 3 sigma).
Period	108 min.
Launch	Pacific Missile Range.
Command and Data Acquisition: Station	Fairbanks, Alaska.
(Immediate relay of TV cleared data to NMC via 48 kcs line).	

interested in continuously observing developments of a particular storm area. This is particularly true of the short-lived and severe local storms where the entire life history may be a matter of only a few hours. It is also important to be able to follow the development of nascent storms before they explode into fully maturity.

Figure 22–3 shows the Aeros satellite which is now in the planning stage. The Aeros satellite will be launched into a stationary orbit. The orbit is called stationary because, due to its distance from the earth, 22,300 miles, the satellite will be moving at about the same speed as the rotation of the earth. Therefore, it will appear to be stationary over the subsatellite point. The orbit will be equatorial and the Aeros will view events essentially in the temperate and tropical regions. The principal instrumentation to be developed will be a cloud-cover observational system, with vidicon cameras having a variable focus; the wide-angle camera will view a great portion of the earth, and a high-resolution camera will view a smaller portion. It may not be necessary to have two cameras; one may be sufficient. That is a matter of development. The purpose of the high-resolution camera would be to obtain sharper details in a smaller geographic area. Under present plans the first Aeros satellite will be launched between 1964 and 1967.

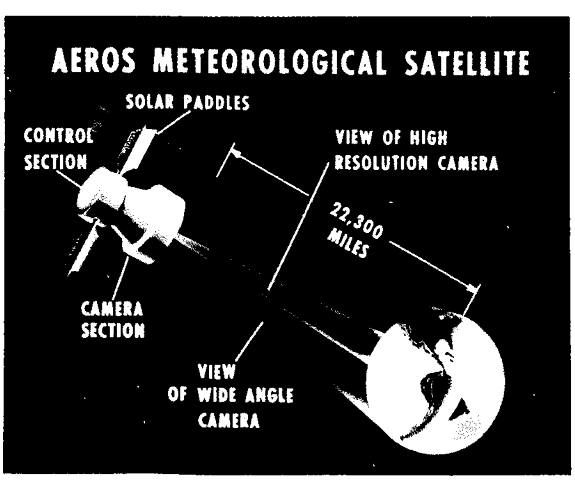

FIGURE 22–3

Following the termination of the currently planned Nimbus series, the launching rate is expected to be about one research and development meteorological satellite a year in addition to the Aeros satellites. This program will be used to develop and test improved or new sensing systems to be incorporated, as they become proved out, into the operational meteorological system.

Figure 22–4 shows several possible systems. The first sketch shows the original concept of

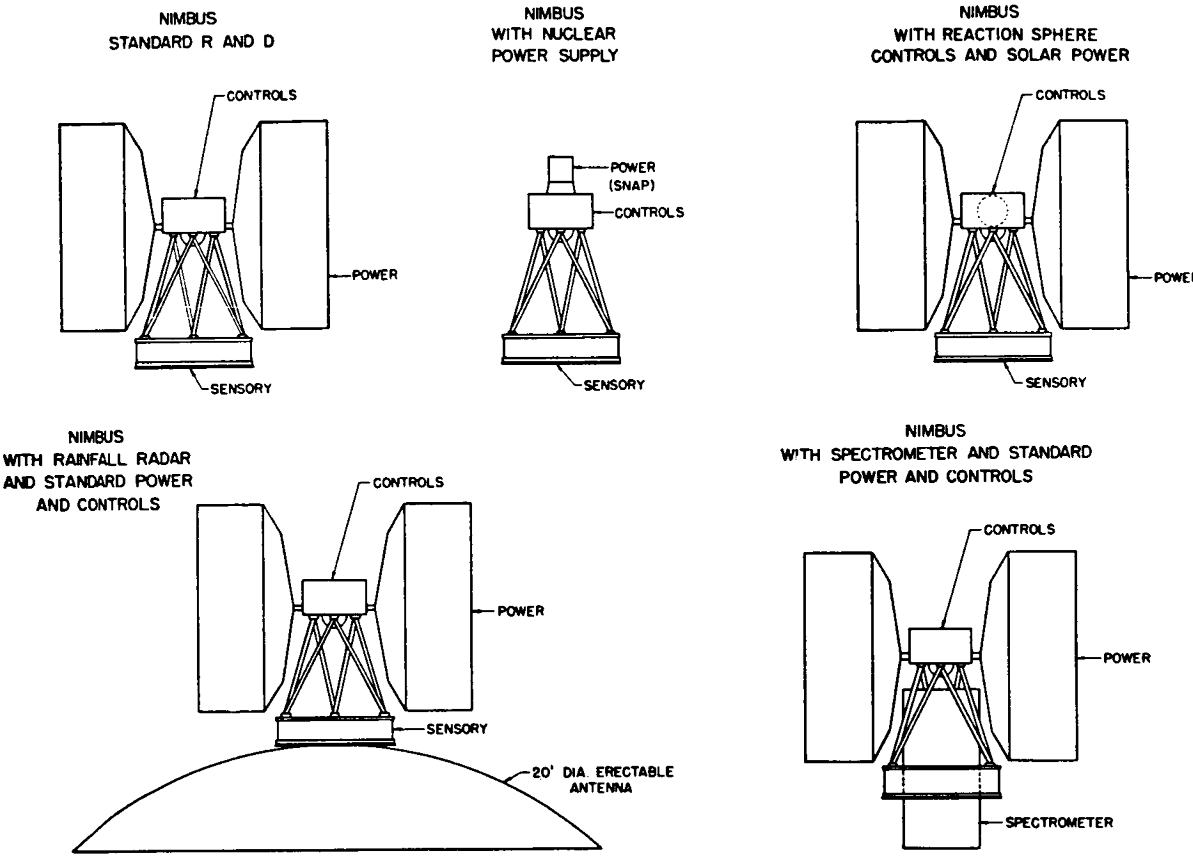

FIGURE 22-4

Nimbus with the controls, the power, and the sensory configuration. A change that might be possible in future developments would be, for example, the incorporation of a nuclear power supply where the present paddles are replaced by a smaller power supply. Another possible change is to incorporate reaction sphere controls instead of the present jets as indicated in the top right sketch. The rest of the configuration is shown to remain the same. Also, the sensors may be changed by including a radar, with a 20-foot erectable antenna as shown in the bottom left sketch. Another possibility would be to add a spectrometer as shown in the bottom right sketch. These changes are all conceptual at present. There are no specific engineering drawings.

The flight program is based on a continuing research and advanced technical development program for developing techniques, components, and prototypes in such areas as improved radiation sensors, studies of atmospheric quantities that can be measured by improved sensors, improved mechanical and electronic components of flight systems, and improved and new meteorological sensors such as those mentioned previously. The most critical areas in these programs deriving from the volume of meterological data and the requirements of the operational meteorologists are the reduction, the processing, the transmission, and the presentation of the meteorological data to the weather forecasters in as near real time as possible.

The determination of signficant meterological content of the satellite output is a key factor in resolving these problems. The meteorologists must determine beforehand the real meteorological content of the data output because only through this type of study will it ever be possible to reduce the volume of information so that it may be transmitted with the existing facilities or even with improved facilities. Thus, if the significant meteorological content of the output is determined, rapid transmission techniques may be refined to make this information available to the field personnel in time for use.

Developments under study in this field include satellite onboard analysis techniques for extracting the useful meteorological information so that all the data do not have to be transmitted. Other developments required are special techniques for data presentation, automatic analysis instrumentation, improved transmission facilities, and advance communications relays. Data compression techniques, in which a good deal of progress has already been made, are used to reduce the bandwidth in the transmission of pictures and should be included in this list.

In addition to the efforts that are required for the development of advanced spacecraft and associated systems, continuing attention is also needed for the solution of another fundamental data problem: The study and analysis of the data in order to provide better analysis and forecasting techniques and improved understanding of atmospheric processes. In this study the primary responsibility rests with the Meteorological Satellite Laboratory of the U.S. Weather Bureau, the research agencies of the military services, the universities, and other research organizations.

The volume of data already acquired by the TIROS satellites and of data expected from future meteorological satellites is enormous. The Weather Bureau and the other weather-data users are analyzing these data in research programs and applying the results to operational weather purposes. Attempts are being made to encourage increasing numbers of investigators to study these data through aggressive contacts with the scientific community in general and with university research groups in particular.

By means of this International Workshop and other similar ones to follow it is hoped that the scientists in countries all over the world will consult one another with regard to their individual data-analysis endeavors. Other international aspects may be listed as follows:

(1) **The transmission of nephanalyses.**—It is planned to continue the current practice of disseminating internationally the analysis of data.

(2) **Non-U.S. command and data acquisition stations.**—The fully operational system currently being developed in the United States is dependent on a least one command and data acquisition station on foreign soil. This phase of the program is in its early planning stages.

(3) **Ultimate direct readout of the data by foreign countries.**—A more direct way of making available to any country the weather information in its immediate area of interest would be by means of a direct readout of satellite transmissions. Under study at present are problems connected with making available to a foreign country acquisition stations programed for nondestruct readout of stored data as well as direct readout of the satellite transmission. This would be a very significant and important development.

At present, when the satellite data are read, the data are destroyed to make room for the subsequent gathering of data. When a nondestruct readout capability is developed, then a country with an acquisition station will be able to interrogate the satellite and obtain the data without destroying these data for another country. Here, another problem will be encountered, however, and that is the power supply. If there are too many interrogations, there might be an excessive power drain on the satellite.

(4) **The possibility of international participation in a unified global operational meteorological satellite system.**—A truly international operational system can be foreseen with satellites transmitting global observations to a World Meteorological Center and more restrictive data directly to regional, national, and local centers and nations. The World Center would provide global analyses and longer period forecasts, whereas the other centers would concentrate on meteorology of a more local nature.

Question Period

McCULLOCH, Canada: Dr. Tepper, is it safe to assume that the high-resolution camera planned for Aeros could be pointed at any location within the temperate and tropical zones and that the pointing of this camera could be changed from time to time as various areas of interest move?

TEPPER: The answer is yes; this is what we would like to be able to do.

VAN DER HAM, Netherlands: Could you tell to what latitudes the camera of Aeros would be able to move? What northerly and southerly latitudes?

TEPPER: I think that it goes to about the Arctic and Antarctic Circles. Of course, there will be considerable data compression in those areas.