

AIR WEATHER SERVICE AND METEOROLOGICAL SATELLITES

1950-1960



AWS HISTORICAL STUDY NO. 5

**MILITARY AIRLIFT COMMAND
UNITED STATES AIR FORCE
SCOTT AIR FORCE BASE, ILLINOIS**

A I R W E A T H E R S E R V I C E
AND
M E T E O R O L O G I C A L S A T E L L I T E S

1950 - 1960

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Edited By
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Air Weather Service
Military Airlift Command
United States Air Force
Scott Air Force Base
Illinois

The heights by great men reached and kept
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night.

Longfellow, The Ladder of Saint Augustine

FOREWORD

With the removal of the rigid security trappings from DAPP--Data Acquisition and Processing Program--products a year ago, public attention was refocused on the Air Force's and Air Weather Service's--AWS--efforts and accomplishments in the field of meteorological satellites. Light entered where darkness had prevailed--at least publicly. Only a handful within the Air Force and the Defense Department, carefully screened on a strict need-to-know basis, were privy to DAPP's details theretofore. Even within AWS most were unaware of its existence and significance. In unveiling some of the DAPP pictures before a Pentagon press conference in March of this year, Under Secretary of the Air Force John L. McLucas said that DAPP would "furnish the best data possible to decision makers anywhere in the world whose operations are affected by weather," and in a subsequent issue of the Air Force Magazine he described DAPP as "a meteorological tool of great usefulness and importance."* DAPP's public debut sired a rebirth of identity with meteorological satellites within the AWS "family" at large.

* "USAF Admits Weather Satellite Mission," Aviation Week & Space Technology, Vol. 98, No. 11, 12Mar73, p. 18; "A New Look From USAF's Weather Satellites," Air Force Magazine, Vol. 56, No. 6, Jun73, p. 67.

This study is both timely and appropriate, therefore, because it traces the genesis of AWS' identity with, and involvement in, meteorological satellites through 1960--the year meteorology moved out into space with the launch of the first two TIROS satellites. Designed as a general reference and orientation tool rather than a technical text, the study is primarily a compilation of the events and activities--especially those pertinent to AWS--related to those two satellites.

A rough draft of the study, entitled "Meteorology In Space," was originally completed by the authors in 1961.* It had been coordinated with both the Scientific Services Directorate and Operations, and approved by the AWS command section for publication as the fifth in a series of AWS historical studies** --General Peterson writing that it was a "very good" document that "should be useful to all AWS organizations."† While some of the appendices had been final typed for multilithing, a shortage of secretarial

* At that time Mr. Dickens was the AWS historian and MSgt Ravenstein an assistant. As of today, Mr. Dickens is the Military Airlift Command historian and Charles Ravenstein is employed as a civilian by the Historical Research Branch, Albert F. Simpson Historical Research Center, Air University, Maxwell AFB, Alabama.

** The other four studies, in order, were: The Air Weather Service Reorganization, Fiscal Year 1952; Inspections and Surveys, Fiscal Year 1952; Measuring the Wind: The AN/GMD-1A; and "Weather Reconnaissance - Its Role In the Modern AWS," an unpublished, 147-page draft, completed in the mid-Sixties, which traces the history of AWS weather reconnaissance through mid-1959.

† Peterson's comments were penciled to DD Form 95, Memo Routing Slip, Dickens to Col Walter C. Phillips, chief of staff, AWS, 10Mar61.

help and the press of other duties prevented the authors from seeing the love of their labor published. For the ensuing dozen years it collected dust in the AWS historical archives.

I believe that with DAPP's emergence from the catacombs of security, General Peterson's words ring as true today as they did then. This study is DAPP's legacy, its heritage. It is DAPP's deepest roots. Further, I visualize it as merely the first curtain on a trilogy. The second would relate DAPP's classified history, blanketing the decade from 1961 through 1972. Of course the concluding study would depart from DAPP's declassification and the subsequent unveiling of its pictures.


I sounded my thoughts with Colonel Castor Mendez-Vigo, Jr.,* and, after reading the rough draft, he concurred in General Peterson's earlier assessment: published, the study had utility. With his and Mr. Dickens' encouragement, I decided to see it through.

The draft required extensive editing--primarily a reorganization for the sake of continuity and readability. To preserve the study's character and flavor, however, no source material was introduced that was not available to the authors in 1961, with the notable exception of the 1962 Senate subcommittee staff report on meteorological satellites and Mr. Klass' book. In addition I changed the footnoting mechanics. Perhaps the most significant alteration, however, was the introduction of pictures and charts to illustrate graphically the textual themes.

* The assistant DCS for Systems, Headquarters AWS.

I screened hundreds of them in the AWS historical photo archives before settling on the thirty-one included.

My edited draft was then reviewed by selected key individuals, including Colonel Mendez-Vigo again and some of the text's personages--Colonel Blankenship, Mr. Pearse, and Mr. Woffinden. Mr. Dickens reviewed it too. I want to acknowledge my debt to those who willingly invested their time on the study. Wherever possible their constructive comments and suggestions were incorporated. It was then approved by the AWS command section for publication and dissemination.



John F. Fuller (Editor)
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10 December 1973

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Early Plans

Interest in high-altitude cloud photography was stimulated as early as World War II by the Japanese successes in sending balloons across the North Pacific to North America in 1944. It was obvious to meteorologists that high-altitude, free-floating, manned and unmanned balloons might prove convenient vehicles for very-high-altitude photographic cloud reconnaissance. While the idea was not new, the development of techniques for the radio transmission of visual materials broadened the area of opportunity in the opinions of some meteorologists. Air Weather Service--AWS--meteorologists of the United States Air Force--USAF--experimented with model depictions of cloud cover over militarily strategic areas as early as 1944 to encourage such developments.¹

Although a few scattered articles on the use of rockets to acquire cloud photographs appeared in various meteorological publications prior to 1950,² it was not until

¹U.S., Congress, Senate, Committee on Aeronautical and Space Sciences, by the Library of Congress, Staff Report, Meteorological Satellites, 87th Cong., 2d Sess., 29Mar62, p. 27. Hereafter cited as Senate: Meteorological Satellites.

²See for example Maj Delmar L. Crowson, Geophysical Svcs Br, Eng Div, Dir of R&D, DCS Materiel, Hq USAF, "Cloud Observations from Rockets," Bulletin of the American Meteorological Society, Vol. 30, No. 1, Jan49, pp. 17-22. Maj Crowson's was one of the first published references to the meteorological use of cloud pictures from space.

April 1951 that anything appeared in regard to meteorological satellites. At that time, Drs. William W. Kellogg and Stanley N. Greenfield of the RAND Corporation authored a classified report on the subject, published as RAND publication R-218.³ Actually, RAND documents provided clear evidence that weather observation from satellite vehicles had been proposed by Dr. Kellogg prior to 1950. Later, other individuals, including Dr. Greenfield, were hired by RAND and subsequently contributed to the first published studies.⁴

Dr. Kellogg headed a committee of the Advanced Research Projects Agency--ARPA--which formally proposed the use of satellites to picture the earth's weather. ARPA began the study in the summer of 1958 and the project was turned over to the National Aeronautics and Space Administration--NASA--in April 1959.⁵

Subsequent to the Greenfield-Kellogg paper, an increasing number of scientists began to study, research, and develop equipment for meteorological satellites.⁶ RAND publication R-218 was revised slightly to an unclassified format and in August 1960 was reissued as RAND publication

³ RAND--Research and Development--Corporation, established by the Air Force in 1946, was the first U. S. agency to design a satellite. See ltr, Dr. Robert D. Fletcher, HQ AWS, to Prof Jule Charney, Dept. of Met., MIT, 7Jun60.

⁴ Ltr, J. Doyne Sartor, RAND Corp., to Fletcher, 1Jun60.

⁵ Ltr, Fletcher to Charney, 7Jun60.

⁶ Ibid.

R-365, "Inquiry into the Feasibility of Weather Reconnaissance from a Satellite Vehicle."⁷ It was, basically, an examination of weather conditions by a television camera placed in an unmanned satellite vehicle.⁸

The RAND Corporation, as well as other independent workers both in the United States and abroad, continued to suggest that certain atmospheric physical properties could be measured more effectively from outside the earth's envelope of air than from the surface. Although most of these scientists were able to prove that even crude photo-cell scanners could transmit cloud-cover data of great potential value, the satellite-borne television cameras were considered by many as an impractical dream.⁹

The optimistic belief that meteorological satellites would be more effective in some respects than earth-measured weather conditions was by no means unanimous. Some scientists held that modern meteorological analysis was based almost entirely upon dynamic and kinematic concepts, *e. g.*, upon the fields of temperature, pressure, and motion. Therefore, satellite observations, which would measure those quantities rather poorly, would be of limited value to practical forecasting.

Such a conservative viewpoint was dominant in the thinking of the general meteorological community when ARPA --at that time, in charge of the meteorological satellite aspects of the national space program--awarded to the Radio

⁷ Ltr, Dr. William W. Kellogg, Head, Planetary Sciences, RAND Corp, to Fletcher, 27Feb60.

⁸ Ltr, Sartor, to Fletcher, 3May60.

⁹ Information furnished by Capt Daniel H. Lufkin, HQ AWS (AWSSS--Directorate of Scientific Services), in article

Corporation of America--RCA--the contract for the construction of a vehicle to be known as the Television and Infrared Observation Satellite--TIROS.

With the design of TIROS completely committed to meteorology, but with the actual uses to which the observations would be put still in some doubt, ARPA, on 29 September 1958, issued ARPA Order No. 26-59, assigning certain portions of the meteorological satellite program to the Air Force Cambridge Research Center--AFCRC.

In particular, AFCRC's Geophysical Research Directorate--GRD--was asked to begin a formal project to study methods by which the televised cloud pictures from TIROS could be used in routine forecasting activity. The GRD formed a small Meteorological Satellite Branch under the direction of Dr. William Widger,¹⁰ who had already been studying the possibilities of satellite meteorology for more than a year. The point of view from which GRD, as well as other small groups in the Army Signal Corps and within RAND, approached the problem of satellite data was illustrated in Dr. Widger's early survey:

Present-day forecasting techniques and the data to be expected from a satellite are not compatible. The primary factors a forecaster uses in his business are the four-dimensional fields of motion, pressure, and temperature. While it is hoped the satellite will

⁹ (Cont'd) "The Background of Present Meteorological Satellite," n.d. (circa 1960).

¹⁰ Dr. Widger was appointed as the number two man in NASA's meteorological satellite program in September 1960. There he worked under Dr. Morris Tepper--described by The New York Times (23 Nov 70) as the "Brain Behind Tiros," and an ex officer who served with AWS in the Pacific in World War II.

be able to gather some data of these types through the use of radiometers, at best they will be far inferior in both quality and quantity to our present domestic observations.

It is expected the primary observations made by a satellite will be of clouds, which are presently treated as secondary factors in forecasting. This leads to two possible avenues of attack: to tailor the satellite data to the forecaster or to tailor the forecaster to the data. The former seems the surer path. It means the primary aim is not to devise true forecasting techniques based on satellite data; instead, it involves means of translating satellite data into the kinds of information that are important to present-day techniques.¹¹

Just after GRD began its work, Headquarters USAF's Directorate of Research and Development suggested that AWS assign a full-time liaison officer to the agency. The offer was declined. AWS officials felt that the 4th Weather Group's staff weather officer could provide sufficient liaison; that Major James Sadler, an AWS officer then in the process of being reassigned to the GRD, would be able to represent the viewpoint of the practical forecaster in the GRD research effort. However, the invitation did generate a sharpened interest in the problems and promises of meteorological satellites within AWS. Beginning in October 1958, AWS became closely involved with monitoring the progress of the satellite program.¹²

¹¹Lufkin, "The Background of Present Meteorological Satellite."

¹²AWSSS' Research Rqmts Br had been unofficially monitoring satellite research and received project status under direction of Maj Jerry C. Glover in Oct 1958.

the wobble changed as the satellite dipped slightly into the outer fringe of the atmosphere at each perigee. The degree of change varied, depending on whether the perigee was on the dark or the light side of the earth. As a result, much of the data received from the Vanguard II package had not been rectified by late 1960, although there was some hope that the data records could eventually be unscrambled and interpreted.¹⁶

The 91½-pound Explorer VII was carried aloft and placed into orbit--with an apogee of 672 and a perigee of 346 statute miles, as of 1 March 1960¹⁷--from the tip of a four-stage Army Juno II rocket. By far the most sophisticated United States satellite to that date, it was crammed with instruments that would identify and count heavy particles of cosmic rays (knowledge crucial to manned space flight), study the transfer of heat from tropical to polar regions and from the earth back into space (basic to weather forecasting), and carry out other experiments. The pill-box shaped satellite was spun to stabilize it and had two transmitters--one powered by a chemical battery and the other solar powered.¹⁸

Meteorologists, of course, were principally interested in the heat-balance experiment of Explorer VII, and several things were learned from Dr. Suomi's experiment. The heat loss at equatorial latitudes was shown to average

¹⁶ Ibid.

¹⁷ "Current Orbiting Satellite Situation Report," AWSSS Review, Vol. 2, No. 1, 2Mar60.

¹⁸ "Hat Trick," Time, 26Oct59.

about twenty-five percent more than at polar latitudes. Non-periodic variations almost as large as these, and of a few days' duration, were noted over the United States. Dr. Suomi related the latter to broad synoptic conditions. However, since the data analysis was still in its early stages, AWS expected that much more useful information from this experiment would eventually be gained. Certain obstacles and problems had to be overcome. For example, the instrumentation aboard Explorer VII broadcast continuous measurements with no provision for storage and rapid "dumping" on command from a ground receiving station. Also, the sparsity of ground stations limited the reception to less than one-fourth of the observed information.

To alleviate the latter problem, AWS agreed to help NASA and the United States Weather Bureau by operating an Explorer VII ground-receiving station at Lajes Field in the Azores. The 9th Weather Group's Detachment 3 at Lajes was charged with the responsibility. The necessary equipment was installed late in December 1959.¹⁹

Potentially significant new data about trapped and cosmic radiation near the earth were also reported by Explorer VII--the last of the IGY satellites. The limited heat-balance measurements substantiated the usefulness of satellites for meteorological observation purposes. Despite comparatively primitive earth heat-balance measurements, the early results indicated that the more sophisticated meteorological satellites already under development by NASA could probably recognize storm areas

¹⁹ See vol. I, "Narrative," pp. 549-50, of "History of Air Weather Service," 1Jul-31Dec59.

even on the dark side of the earth. According to Dr. Suomi it was possible to see a direct correlation between earth-measured weather conditions and the heat-balance recordings from space, in spite of the relatively coarse-grain data available from the Explorer VII package. However, Dr. Suomi announced that considerably more experience and better data would be needed before it would be possible to predict future weather conditions on earth, based solely on satellite radiation data.²⁰

Dr. Suomi advised AWS on 6 June 1960, that the heat-budget data from Explorer VII were being processed by an IBM--International Business Machines--704 computer. Preliminary results, from hand-processing, were then available and were to be forwarded to AWS. Dr. Suomi said that he had found the radiation patterns to be closely related to the broad synoptic weather patterns and the TIROS I cloud patterns which were available by that time. Captain James R. Blankenship, of AWS' Scientific Services Directorate, monitored Dr. Suomi's work closely.²¹

Detachment 3 at Lajes Field continued its support of Explorer VII on a routine basis. This work was described in the AWS command newspaper in May 1960 as follows:

Weathermen of Detachment 3, 9th Weather Group, at Lajes Field, Azores, have recently begun operating a receiving station to record important observations from the National Aeronautics and Space Administration's Explorer VII satellite. Thus, TIROS is not the only weather satellite on which AWS men are active.

²⁰ Philip J. Klass, "Explorer VII Reports Sporadic Radiation," Aviation Week, 11Jan60, pp. 29-30.

²¹ AWSSS Staff Briefing Item, 8Jun60.

Early Experiments

By 1956, plans had been formulated for the use of earth satellites to collect data of meteorological significance during the International Geophysical Year--IGY--then approaching. As a member of the Technical Panel of Meteorology for the United States National Committee for the IGY, Dr. Robert D. Fletcher, AWS' Director of Scientific Services, participated in the planning for the IGY meteorological satellite program. The panel functioned from January 1955 until the late 1950's.¹³

By the close of 1957, experimental payloads were ready to be boosted into orbit around the earth. And, by the close of 1959, two meteorological packages were actually in orbit. The first was the Stroud cloud-cover experiment, launched by Vanguard II on 17 February 1959. The second was the Suomi¹⁴ heat-budget package, one of eight experiments conducted aboard Explorer VII, launched from Cape Canaveral, Florida, on 13 October 1959.¹⁵

The Stroud cloud-cover experiment instrumentation--using a simple photo-electric cell--worked, but the satellite unfortunately was injected into orbit with a wobble. Had it been anticipated, a simple wobble could have been overcome by a more sophisticated system of geometrical rectification of the observations. To make matters worse,

¹³ MATS Form 44, "Quikcom," Fletcher to AWS DI (Hist Div, Directorate of Info), "Draft Chapter for AWS History," 30Aug70.

¹⁴ Prepared by and named after Dr. Verner E. Suomi, Prof of Meteorology, U. of Wisconsin.

¹⁵ "Satellite Meteorology," AWSSS Review, Vol. 2, No. 1, 2Mar60.

Five times a day, as Explorer VII passes over the Azores at an altitude of from 345 to 673 miles, an automatic time switch turns on a tape recorder to record tone signals transmitted from space. These signals represent observations of heat radiation entering and leaving the earth's atmosphere.

Each morning the men of the detachment's rawinsonde and sferics sections check the equipment's master clock, place a fresh reel of magnetic tape in the recorder and put a verbal "label" on the tape by means of a microphone. Once a week recorded tapes and logs are mailed to Washington. Here, the observations are decoded by scientists of the U.S. Weather Bureau and the University of Wisconsin. Another weekly chore at Lajes is programming the time switch from satellite passage predictions computed by NASA.

Because Explorer VII has no recorder on board for storing data, it transmits its observations continuously. If scientists are to understand the world-wide nature of the earth's heat balance, observations from many parts of the globe must be made every day so that many bits of data may be fitted together, jigsaw-puzzle-fashion, into a coherent pattern.

Dr. Verner Suomi . . . expects the satellite's heat radiation observations to aid in improving science's understanding of the basic forces which drive the circulations of the atmosphere.

Explorer VII will remain in orbit for years to come, but its transmitters will be turned off by remote control this October to free radio channels for use by newer and more sophisticated space observatories.²²

In addition to the specialized data gained from the Vanguard II and Explorer VII satellites, other important meteorological information was gained from observation of other satellites' orbital changes. For example, changes in apogee height from circuit to circuit revealed the air's drag effect. In this way, the mean temperature and density

²² AWS Observer, Vol. 7, No. 5, May 60.

at heights above 200 miles was found to be considerably higher than previously estimated by meteorologists. The change in orbital elements from one pass to the next was not a regular one, but showed small fluctuations which apparently paralleled the variations in intensity of very short-wave solar radiations measured by radio-telescopes on the ground. Attempts to put into orbit a very large, light-weight satellite that would be more sensitive to density variations had not proved successful by early 1960,²³ but was finally achieved on 12 August 1960, when Echo I was successfully launched. It was expected to provide considerable useful "drag effect" data for the meteorological community.

The densities inferred from the satellites did not show the apparent latitudinal variation which appeared in the IGY rocketsonde data. Scientists determined that the inconsistency was probably due to the "sampling" effect of the rocket data, which were made at different latitudes in different years and thus included a secular trend associated with sunspot cycles.

All things considered, satellites had furnished a great amount of useful meteorological information by early 1960, although in most cases the instrumentation was not designed for that specific purpose. Data on atmospheric composition, ion density, type and intensity of radiations, and even geomagnetic anomalies, could all help to answer the basic long-range research question: how were variations in the heat source of the atmospheric engine translated

²³AWSSS Review, Vol. 2, No. 1, 2Mar60.

into changes in the tropospheric weather patterns? That problem, it appeared, would engage the efforts of researchers for many years to come.

The major event awaited by meteorologists of AWS and many other agencies in early 1960 was the appearance of a satellite designed specifically to measure parameters of direct and immediate meteorological significance. In a manner of speaking, it was "just around the corner" as the year opened.²⁴ The launch of the first in a series of NASA meteorological satellites was imminent. The potential utility of a photographic satellite cloud-observation system had been substantiated by a GRD analysis of cloud photos taken from an Atlas Intercontinental Ballistic Missile--ICBM--nose cone over the Atlantic, which had produced "a remarkable definition of the large-scale tropospheric flow pattern."²⁵

While the first meteorological satellite was to have a television capability, later models in the NASA series would include infrared sensors to measure surface and cloud-top temperatures and the water-vapor content for various layers. Inclusion of radar for observing precipitation patterns of the earth was also under study.²⁶

²⁴See Vol. I, "Narrative," of "History of Air Weather Service," 1Jul-31Dec59, pp. 529-31.

²⁵AWSSS Review, Vol. 2, No. 1, 2Mar60.

²⁶NASA requested bids for the development of radar meteorological satellite observation platforms. Weather Bureau plans for an operational weather radar network over the eastern portion of the U.S. were also being realized early in 1960 and it was obvious that any launching of an experimental meteorological satellite observation platform of the radar type should be carefully planned so that the

Within the Air Weather Service, the Scientific Services directorate felt that AWS weathermen had already learned "a little" from satellites up to early 1960, and were expected to learn "a great deal more" in the near future. Although meteorological satellites were not to be looked upon as the forecaster's panacea, as some news accounts implied, they were expected to plug many observational and theoretical gaps.²⁷

The First Meteorological Satellite

In response to a request by Headquarters USAF,²⁸ AWS' initial requirements for information from meteorological satellites were set forth formally in February 1959. Basically, AWS' operational concept was that the satellites would provide much basic meteorological and geophysical information of common value to both civil and military users. Continuous day and night observation of the amount and distribution of clouds over the earth's surface was needed to enlarge and refine AWS' cloud climatology background; to recognize peculiar cloud configurations possibly associated with jet stream location and intensity; to observe and track tropical storms from birth; and to improve the capability to determine the extent of cloud systems associated with major extra-tropical storms. Some

²⁶ (Cont'd) orbit into which it would be launched would take full advantage of the surface network in being. See "Program of the Eighth Weather Radar Conference, April 11-14, 1960, San Francisco, California" in Bulletin of the American Meteorological Society, Vol. 41, No. 3, Mar60.

²⁷ AWSSS Review, Vol. 2, No. 1, 2Mar60.

²⁸ Msg, HQ USAF (AFDRQ-S/C), 56578, 13Feb59.

of the basic geophysical data AWS indicated a need for included solar-terrestrial radiation balance, aurora and ion density, meteoric activity, magnetic and electrical fields, and atmospheric constituents such as liquid water, ozone, and carbon dioxide content.²⁹

From a purely military standpoint, AWS believed that continuous meteorological satellite coverage would enhance cloud climatology in areas of special interest such as Eurasia and the polar regions. It would improve the capability to observe and forecast cloud cover in the data-sparse, air-refueling areas utilized by the Strategic and Tactical Air Commands (SAC and TAC), and it would improve AWS support to the missile ranges. In addition, AWS hoped to improve its support of the Emergency War Plan--EWP--by using the coverage to make its extended-period, three-to-five day forecasts as accurate as its twenty-four hour forecasts.

Some special EWP requirements were also outlined by AWS. In the event of hostilities, it recognized that weather data would be denied from many areas. A series of meteorological satellites would fill the synoptic gap. They would have to have a capability to take high-resolution photographs; a combined photographic, infrared, and radar capability to produce observations of cloud coverage and type, surface and cloud-top temperatures, and precipitation and storm areas; a capability to completely cover specific areas of military interest at six hour intervals and provide

²⁹ Ltr, Maj Gen Harold H. Bassett, comdr, AWS, to DCS/Development, HQ USAF, "Requirements for Information from Meteorological Satellites," 24Feb59.

for the reduction and dissemination of the data to selected weather centrals and command-and-control sites within one hour; and, if the above were feasible, have the capability to transmit a limited number of specific parameters directly to the same facilities.³⁰

In September 1959 AWS also accepted a Weather Bureau invitation to place a full-time liaison officer with the Bureau's Meteorological Satellite Section at Suitland, Maryland.³¹ Major James B. Jones was the officer eventually selected.³² Under instructions to assist in the development of procedures for incorporating satellite data into operational weather programs, Major Jones' efforts became increasingly important as the level of activity heightened in anticipation of the scheduled launching of the first purely-meteorological satellite, TIROS I, in late 1959.

AWS' early activities were confined largely to attendance at TIROS technical-direction meetings. Those meetings, which brought together representatives from agencies involved in the design and construction of the payload, and from agencies which were prospective users of the satellite data, enabled AWS personnel to become familiar with most of the details of the TIROS program before mid-1959. It was during that early period of AWS participation that NASA was created from the former NACA--National Advisory

³⁰ Ibid.

³¹ Ltr, Dr. Francis W. Reichelderfer, chief, USWB, to comdr, AWS, 26Aug59, and ltr, Maj Gen Bassett to Dr. Reichelderfer, "Liaison Officer to Meteorological Satellite Section," 8Sep59.

³² Maj Jones became a one-man operating location under HQ AWS, supervised by AWSSS' Tech Svcs Br.

Committee For Aeronautics. As part of its area of responsibility embracing non-military satellite operations, NASA was, on 13 April 1959, put in charge of the entire meteorological satellite effort, absorbing from ARPA and ARPA-affiliated military agencies, many of the people then active in TIROS development. The Weather Bureau, which by then had formed a small study group concerned with satellites, was named as NASA's operating agency for meteorological matters. Funds transferred from NASA were used to expand the Bureau's nucleus group into the Meteorological Satellite Section. From its inception, the new section worked with GRD's Meteorological Satellite Branch on problems connected with the operational use of TIROS observations.

As the scheduled launch date of TIROS I approached, and was subsequently slipped to early 1960, it became apparent to all of the agencies involved that the best use of TIROS facilities and data would be gained by pooling people and communications at the ground readout stations. Accordingly, the Weather Bureau, AWS, GRD, the Army Signal Corps, and the Naval Weather Service agreed informally to operate jointly the readout stations at Camp Evans, New Jersey, and Kaena Point, Hawaii. The manpower contribution was to be divided as follows:³³

| <u>READOUT STATIONS</u> | <u>USWB</u> | <u>GRD</u> | <u>AWS</u> | <u>USN</u> | <u>SIGNAL CORPS</u> |
|-------------------------|-------------|------------|------------|------------|---------------------|
| Camp Evans | 2 | 4 | 1 | 1 | 1 |
| Kaena Point | 1 | 2 | 1 | 1 | 0 |

GRD's representatives at Camp Evans would include Allied Research Associates contract personnel; the Signal Corps man

³³Lufkin, "The Background of Present Meteorological Satellite."

would work part time.

By mid-1959, AWS had made arrangements to relay televised pictures of cloud formations from the satellite to its forecasters on the east coast and in Hawaii.³⁴ This was later enlarged to include facsimile pictures for European-based forecast facilities.

As events proceeded, more plans were made public. For example, the August 1959 issue of the American Meteorological Society's Weatherwise carried an article entitled, "On Observing the Atmosphere from Satellites--I. Cloud Observations," by the Weather Bureau's Dr. Sigmund Fritz. It described the cloud and radiation data expected from the initial TIROS vehicle. In January 1960, the Bulletin of the American Meteorological Society contained another significant article entitled, "Plans for Dissemination of Satellite Meteorological Data from Project Tiros," which detailed how cloud and radiation data would be made available to interested individuals and agencies. It was emphasized that the plans were subject to change, dependent upon the success of the experiment, data retrieval, and processing problems.

The principal activity of the Defense Department portion of the TIROS team was the engineering of "real-time" operational use of the satellite's observations. In effect, it meant that the satellite would become part of the active weather service from the very beginning, and would not be just another research instrument.³⁵

³⁴ Ltr, Maj Gen Bassett to Lt Gen William H. Tunner, MATS comdr, 31Jul59.

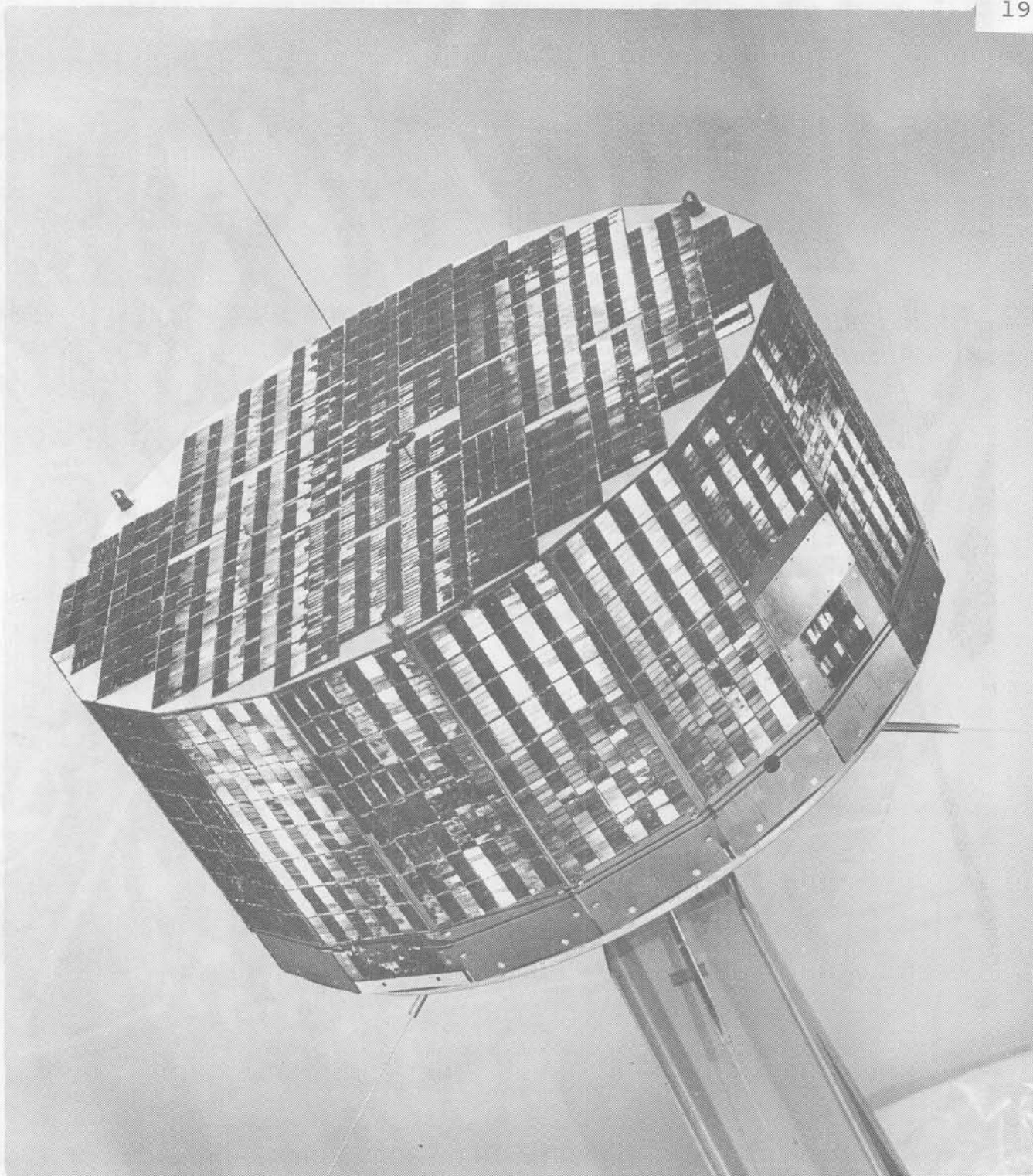
³⁵ "How Goes It" briefing, presented to HQ AWS staff agencies by AWSSS directorate, December 1959.

Air Weather Service officials took a hard look at the programmed instrumentation of the satellite and of anticipated observations to be derived, concluding that although TIROS would show cloud patterns indicating a tropical disturbance, for instance, other methods would still be required to determine the intensity of such disturbances and the meteorological structure. In other words, the satellite was not expected to replace weather reconnaissance or other observation means. If AWS was to forecast storm development and movement, TIROS would be of some value in determining upper-level winds, but it would not provide all of the parameters necessary for accurate prognoses.³⁶

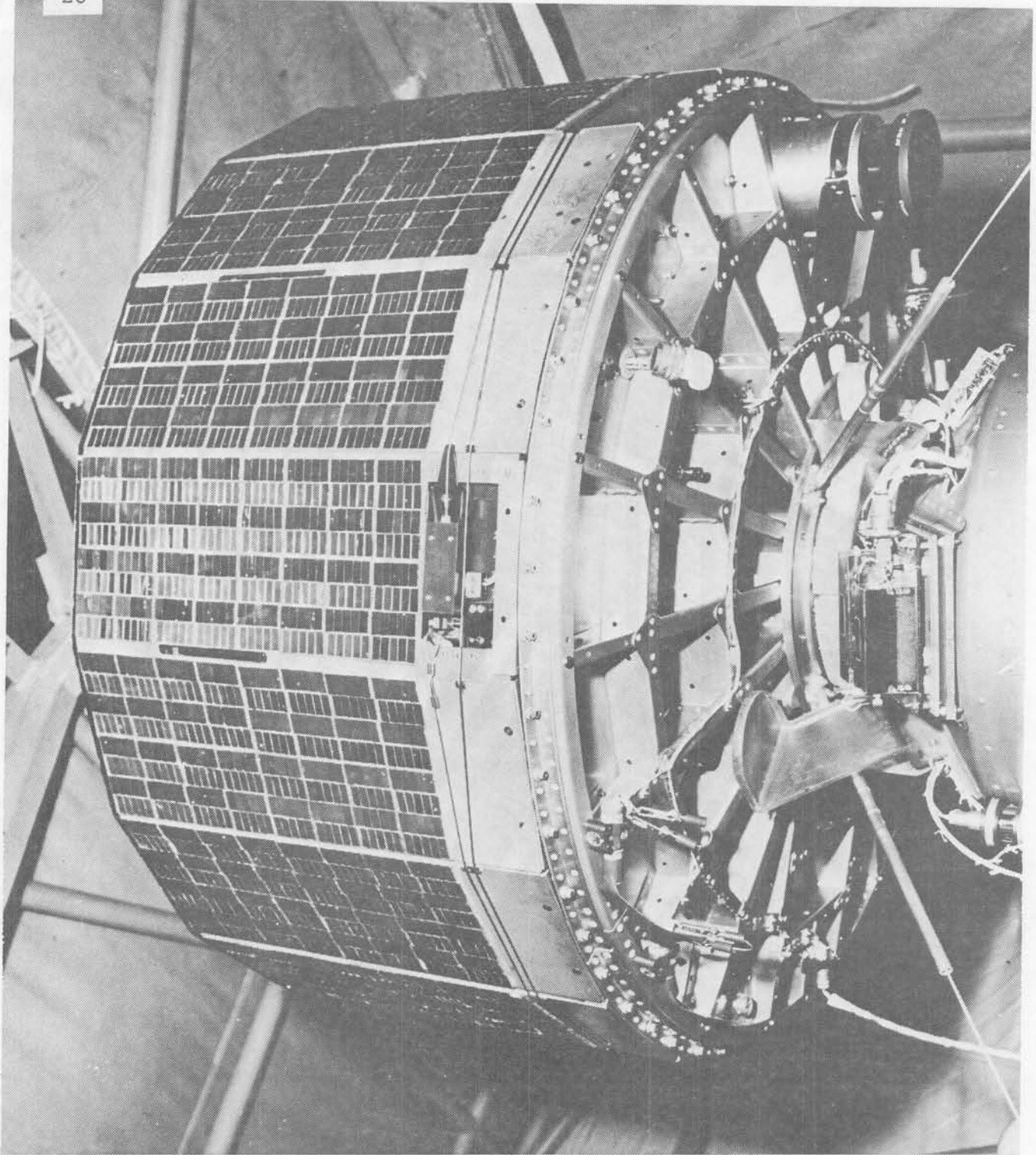
Nevertheless, for an over-all cloud picture, TIROS was expected to be the best means yet devised. The television cameras would provide actual pictures of clouds over a strip about 800 miles wide and some 6,000 miles in length. Although clouds alone were not all that was important in defining weather patterns, they would provide clues to the middle-scale behavior of the atmosphere. AWS was thus enthusiastic about the project.

Over regions where conventional weather stations were reasonably plentiful, such as the continental United States, TIROS observations--when combined with those made at the surface or by rawinsonde--would permit a more detailed understanding of the structure and mechanism of meteorological phenomena. Over oceans and other "silent" areas, cloud pictures would initially be useful for locating fronts

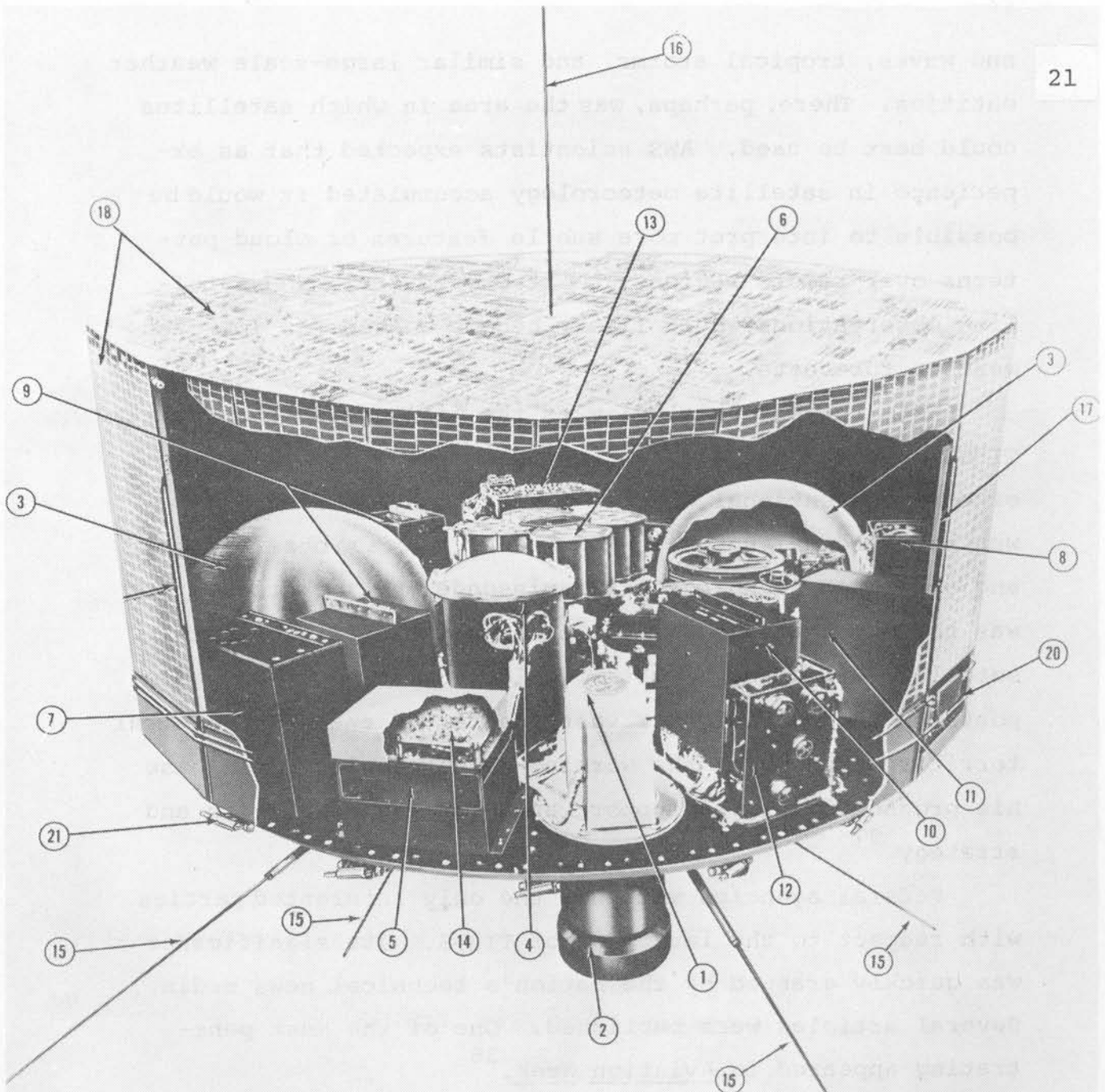
³⁶"COMATS" briefing, presented to HQ MATS staff agencies by chief of staff, AWS, on 19Nov59.



TIROS I--a 270-pound experimental weather satellite designed and built for NASA by RCA's Astro-Electronics Division. (NASA Photo)



TIROS I. (NASA Photo)



A cutaway view of TIROS I indicating the principal components: (1) one of two $\frac{1}{2}$ -inch Vidicon cameras; (2) wide-angle camera lens; (3) television tape recorders; (4) electronic "clock" for controlling sequence of operations; (5) television transmitter; (6) storage batteries; (7) camera electronics; (8) tape recorder electronics; (9) control circuits; (10) auxiliary controls; (11) power converter for tape motor; (12) voltage regulator; (13) battery charging regulator; (14) auxiliary synchronizing generator for TV; (15) transmitting antenna; (16) receiving antenna; (17) solar sensor to measure position of satellite with respect to sun; (18) solar cells; (19) precession damper to eliminate "wobble" after satellite is orbited; (20) de-spin "yo-yo" mechanism; and (21) spin-up rockets. (NASA Photo)

and waves, tropical storms, and similar large-scale weather entities. There, perhaps, was the area in which satellites could best be used. AWS scientists expected that as experience in satellite meteorology accumulated it would be possible to interpret more subtle features of cloud patterns over remote regions. If it proved true, then satellite observations would likely become a base for improved weather forecasts.

From the parochial view of the military meteorologist, TIROS observations seemed to supplement the global network of more conventional weather observing systems such as weather reconnaissance, weather radar, surface observations, and upper air soundings via rawinsonde and rocketsonde. It was obvious that the satellite, or better still, several satellites in spaced orbits, would provide "eyewitness" reports on the weather over vast reaches of enemy and neutral territory upon which the working meteorologist could base his prognoses for the support and planning of tactics and strategy.³⁷

Federal agencies were not the only interested parties with respect to the launching of TIROS. Its significance was quickly grasped by the nation's technical news media. Several articles were published. One of the most penetrating appeared in Aviation Week.³⁸

AWS Support

Within Air Weather Service, planning for the TIROS I

³⁷ "How Goes It" briefing, AWSSS, Dec59.

³⁸ "Tiros I Will Scan Cloud Cover, Earth Temperature," 14Mar60, pp. 26-28.

launch moved at an accelerated pace early in 1960. Major Jones continued his study of cloud photographs taken from various rockets and missiles in preparation for operational use of satellite observations.³⁹ AWS field units gathered preliminary information on various aspects of the project for study and evaluation, including sample analyses of cloud observations from rocket and missile photos.

The job of interpreting and disseminating the TIROS observations was the responsibility of seven-man teams at both readout points, under general leadership of the Weather Bureau. Although studies to develop interpretation and dissemination methods had been in progress for more than a year, it was a difficult chore because meteorologists had such limited experience. It had been confined mostly to the analyses of photos made from V-2 and Aerobee rockets until the successful recovery of Atlas and Thor nose cones during the summer of 1959.⁴⁰

Other specific support to be rendered the TIROS project by AWS field units concerned both ground and airborne weather radar. Dr. Myron Ligda of the Stanford Research Institute completed a test with the 55th Weather Reconnaissance Squadron⁴¹ early in 1960, which indicated that radar scope photos taken during weather missions were valuable to

³⁹For his outstanding service during the TIROS I operation, Maj Jones was awarded the Air Force Commendation Medal on 9Aug60.

⁴⁰"Military, Civilian Agencies Preparing New Weather Satellite for Shoot," Observer, Vol. 7, No. 2, Feb60, p. 5.

⁴¹Based at McClellan AFB, California.

his study of the relationships between TIROS photographs and radar observations. Accordingly, AWS planned to issue enough 0-15 cameras to permit the routine photography of radar scopes on all over-water, weather reconnaissance missions.⁴² In addition, Dr. Ligda's study called for the use of ten AWS AN/CPS-9 weather radars overseas to provide extensions of the Air Defense Command network which he depended upon stateside.

The Army Signal Corps' Research and Development Laboratory at Fort Monmouth, New Jersey, in addition to participating in the immediate operational-use program at the Camp Evans readout site, planned to compare TIROS pictures with weather radar scope photographs from a network of stations along the eastern seaboard. That study, initiated by a Mr. Bastian, planned for the installation of automatic cameras on AWS AN/CPS-9s at eight east coast bases from Massachusetts to Florida.⁴³ The cameras operated automatically, requiring only a correction to the scope video circuit and about 200 watts of 115-volt, AC power. AWS' role was confined to changing film spools weekly.

Because both of the studies were, in a sense, duplicative, AWS asked Mr. Bastian and Dr. Ligda to coordinate their efforts to ensure that no unnecessary data-gathering was required of AWS units.

Shortly before the TIROS I launch, NASA's ground rules for dissemination of satellite data were tightened. No distribution of cloud analyses based on the satellite's

⁴²AWSSS Staff Conference Notes, 23Mar60.

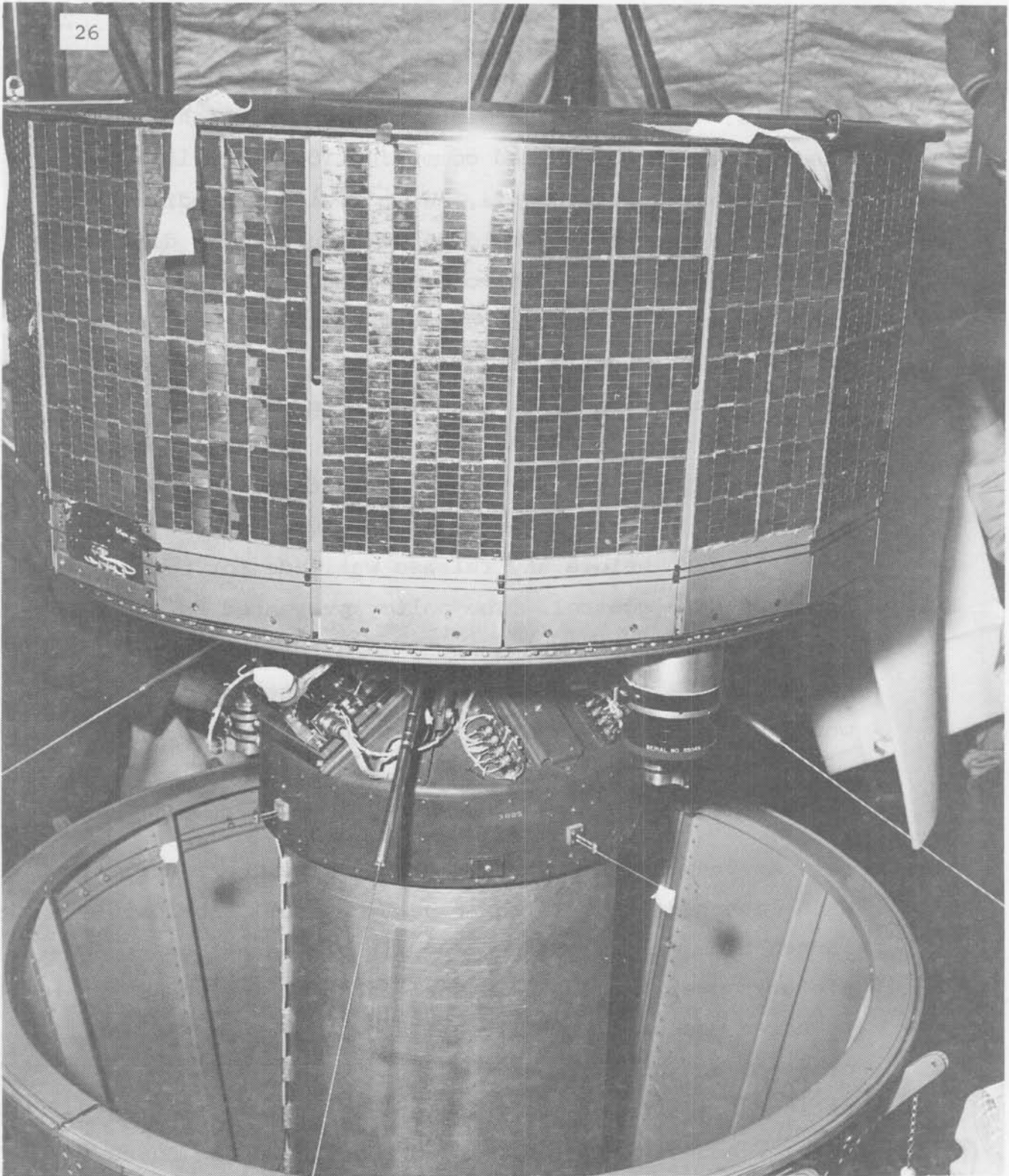
⁴³Ibid.

photographs was authorized to any agency outside of AWS channels. That included Weather Bureau stations. Since the Weather Bureau shared communications facilities with AWS at Kaena Point, Hawaii, AWS officials immediately recognized that there would be difficulties in distributing TIROS observations to Hickam and Kunia. NASA's position in the matter apparently stemmed from a desire to protect the entire meteorological satellite program from unfavorable publicity in the event that a bad advisory was attributed to TIROS data. NASA also believed that since TIROS was an experiment, its meteorological agency, the Weather Bureau, should have a chance to evaluate all data before any release was made for applications beyond NASA's control. The policy presented no cause for concern insofar as AWS' general requirements were concerned. AWS officials were, however, hopeful that most restrictions would be relaxed once TIROS was functioning properly.⁴⁴

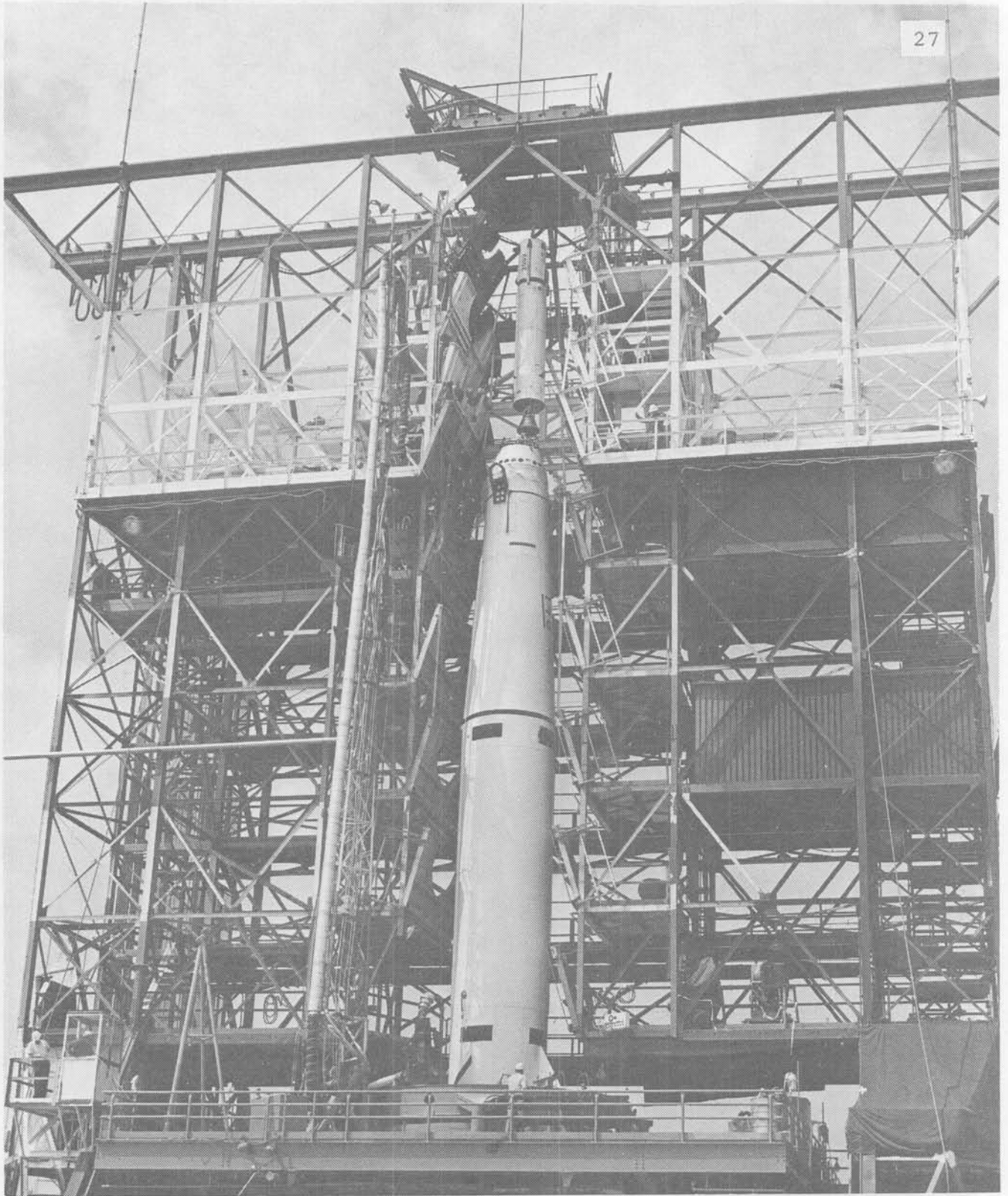
Success!

At 0640 hours Eastern Standard Time, on 1 April 1960, NASA launched TIROS I from Cape Canaveral, Florida. The launch time was selected to permit the satellite to take pictures over the Northern Hemisphere during the first two to three weeks of its life. TIROS I was injected into an orbit at an inclination of about 48 degrees and at an altitude of approximately 450 statute miles, with an excursion--coverage--between 48° North and 48° South latitudes--or approximately from La Paz, Bolivia, to

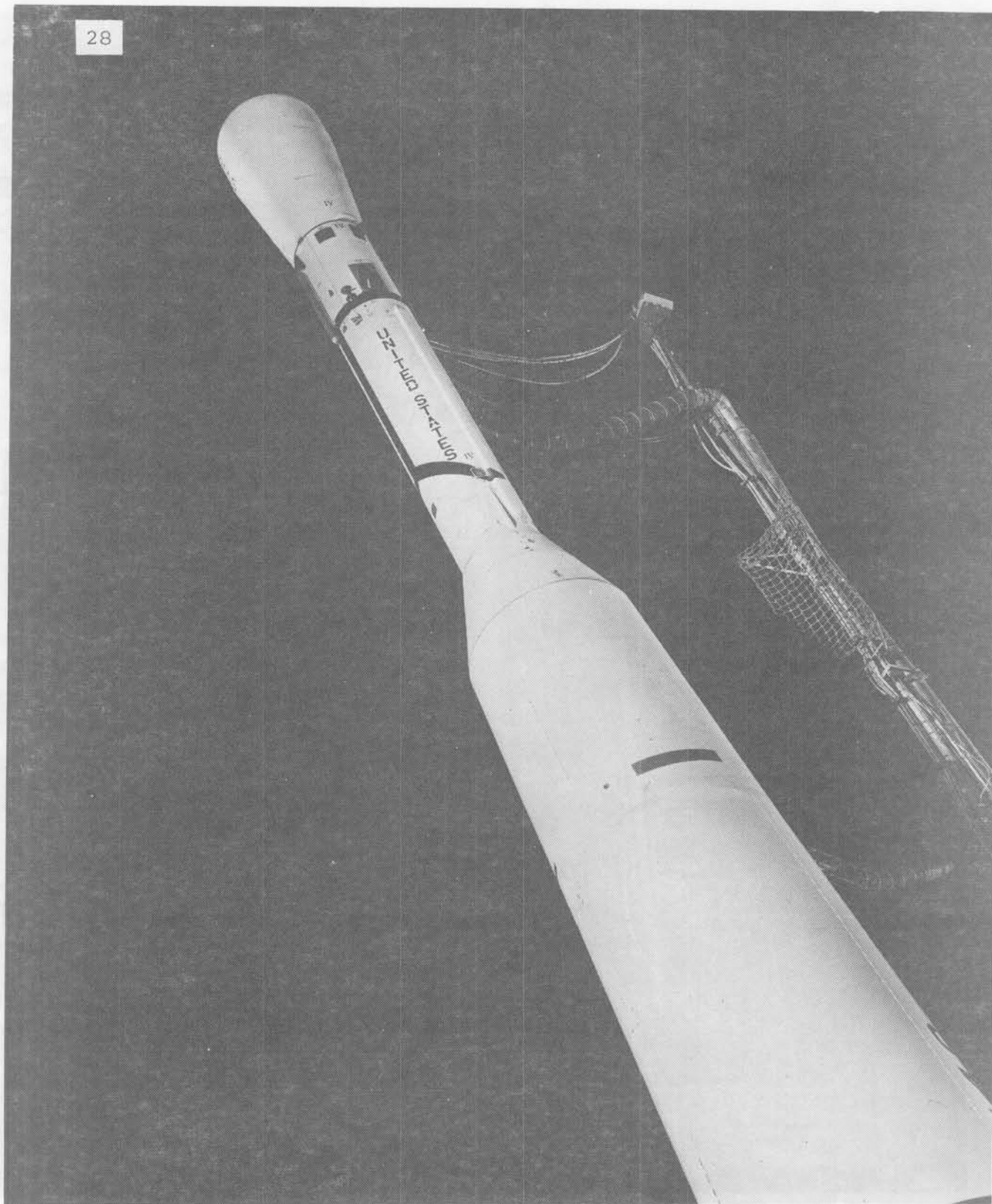
⁴⁴ Ibid.



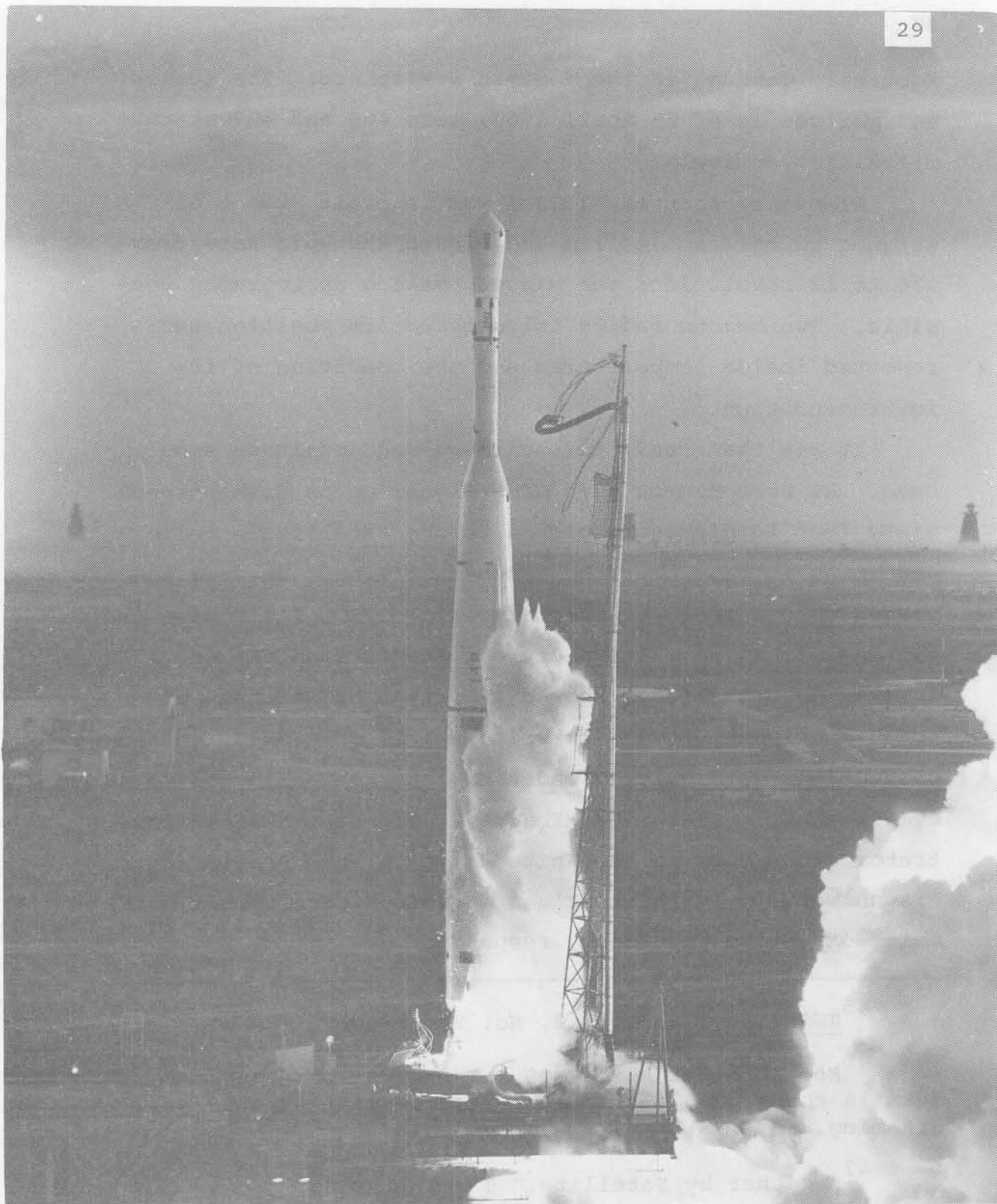
The TIROS I meteorological satellite and the live, third-stage of the Thor-Able boost vehicle. (NASA Photo)



Erection of TIROS I atop the Thor-Able boost vehicle
at Cape Canaveral, Florida. (NASA Photo)



TIROS I ready for launch. (NASA Photo)



The launch of TIROS I from Cape Canaveral, Florida,
on 1 April 1960. (NASA Photo)

Montreal, Canada, in the Western Hemisphere. Its apogee and perigee as of 26 April 1960, were 468 and 429 statute miles, respectively.⁴⁵

Almost as soon as TIROS I was in orbit, two small weights swung from its rim and slowed the spin rate from 136 to 12 revolutions per minute, making photography possible. Two beacon radios telemetered its position and reported inside temperatures and the condition of its instrumentation.⁴⁶

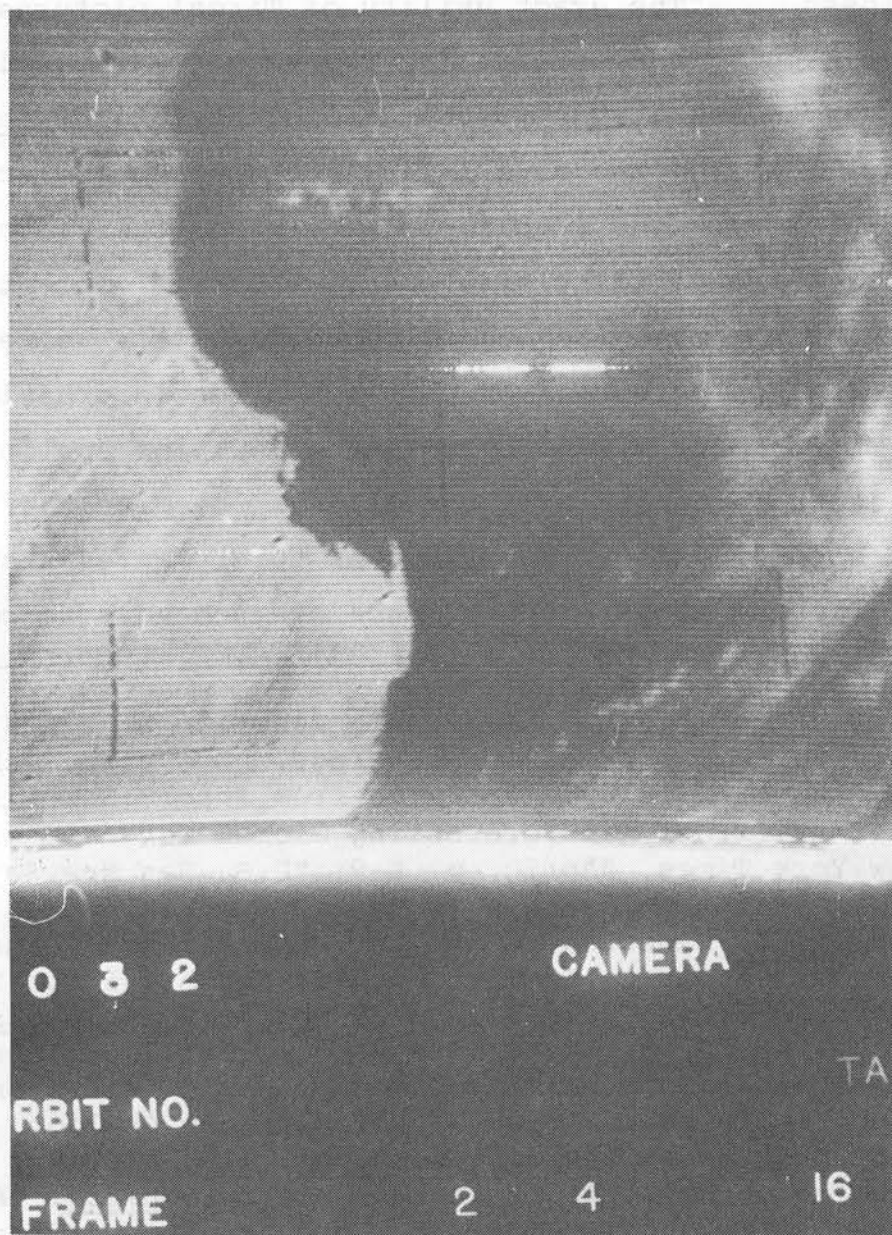
It was then ready for business--and business soon came. At Fort Monmouth an Army Signal Corps dish antenna, sixty feet in diameter, picked up the satellite's radio beacon as it came over the earth's horizon. Up from the ground went a coded signal triggering TIROS I's transmitting mechanism. The picture returned from the satellite's television transmitter showed a portion of northeastern North America spotted with white swirls of clouds. Reproductions were quickly made and sent to Washington, D. C., by wirephoto. There, Dr. Thomas K. Glennan, NASA Administrator, took them to the White House to show President Eisenhower.⁴⁷ "I think it's a marvelous development," the chief executive reportedly responded.⁴⁸

⁴⁵AWSSS Review, Vol. 2, No. 2, 10May60.

⁴⁶See Appendix A, "TIROS I Technical Data," for the details concerning its launch, instrumentation, and programming.

⁴⁷"Weather by Satellite," Time, 11Apr60.

⁴⁸"New Weather Satellite in Nearly Perfect Orbit for More Photographs; President Calls First Cloud Pictures From 270-Pound Tiros Marvelous," St. Louis Post-Dispatch, 2Apr60, p. 1.



One of TIROS-I's earliest photographs, received at Kaena Point, Hawaii, on 4 April 1960, during its thirty-first orbit, clearly defined the western coast of French West Africa from approximately Cape Blanco to St. Louis. (NASA Photo)

As anticipated, the President's reaction was one echoed by the press. Headlines in newspapers coast-to-coast cited the importance of TIROS I and related its usefulness.⁴⁹ "The exact utility of Tiros' pictures in weather mapping and forecasting was hard to assess immediately after the launch," the credible Aviation Week magazine reported ten days later, "but meteorologists are pleased with the results and the proof the photographs provide of the validity of weather satellite concepts."⁵⁰

While the magazine acknowledged TIROS I's value for meteorological purposes, it also noted the international problems it posed by demonstrating principles applicable to military reconnaissance satellites. Despite the fact it had been repeatedly described as purely a research satellite, and despite the absence of much adverse comment

⁴⁹ See Appendix B, "News Media Reaction to TIROS I Launch," for examples of the coverage. See also: John W. Finney, "Weather Televised; Image from Space; New Tiros Satellite Will Help in Forecasting Global Conditions," The New York Times, 3Apr60, p. E-9; "U.S. Has New Satellite; It Carries TV Cameras To Photograph Weather; 270-Lb. Payload Is Expected To Aid in Prediction of Tornadoes; Device, Called Tiros, Is Carried Aloft by Air Force Thor-Able Rocket--Orbit 400 Miles Up Is Sought," St. Louis Post-Dispatch, 1Apr60, p. 1; "Countdown Held Periled Tiros Firing; Another Four Minutes and Shot Would Have Been Put Off," Baltimore Sun, 2Apr60, p. 1; Courtney Sheldon, "Weather Unit Accents Practical Hopes; TIROS I Hints at New Satellite Era," The Christian Science Monitor, 4Apr60, p. 6; David Lawrence, "Today in World Affairs: 'Tiros I' Is Called a Lesson to Critics of U.S. Program," New York Herald Tribune, 6Apr60; and Frank Carey, "Future Satellites to Probe Many Weather Mysteries," St. Louis Globe-Democrat, 4Apr60, p. 1.

⁵⁰ Craig Lewis, "NASA Tiros I Demonstrates Potential Satellite Reconnaissance Utility," 11Apr60, pp. 28-30.

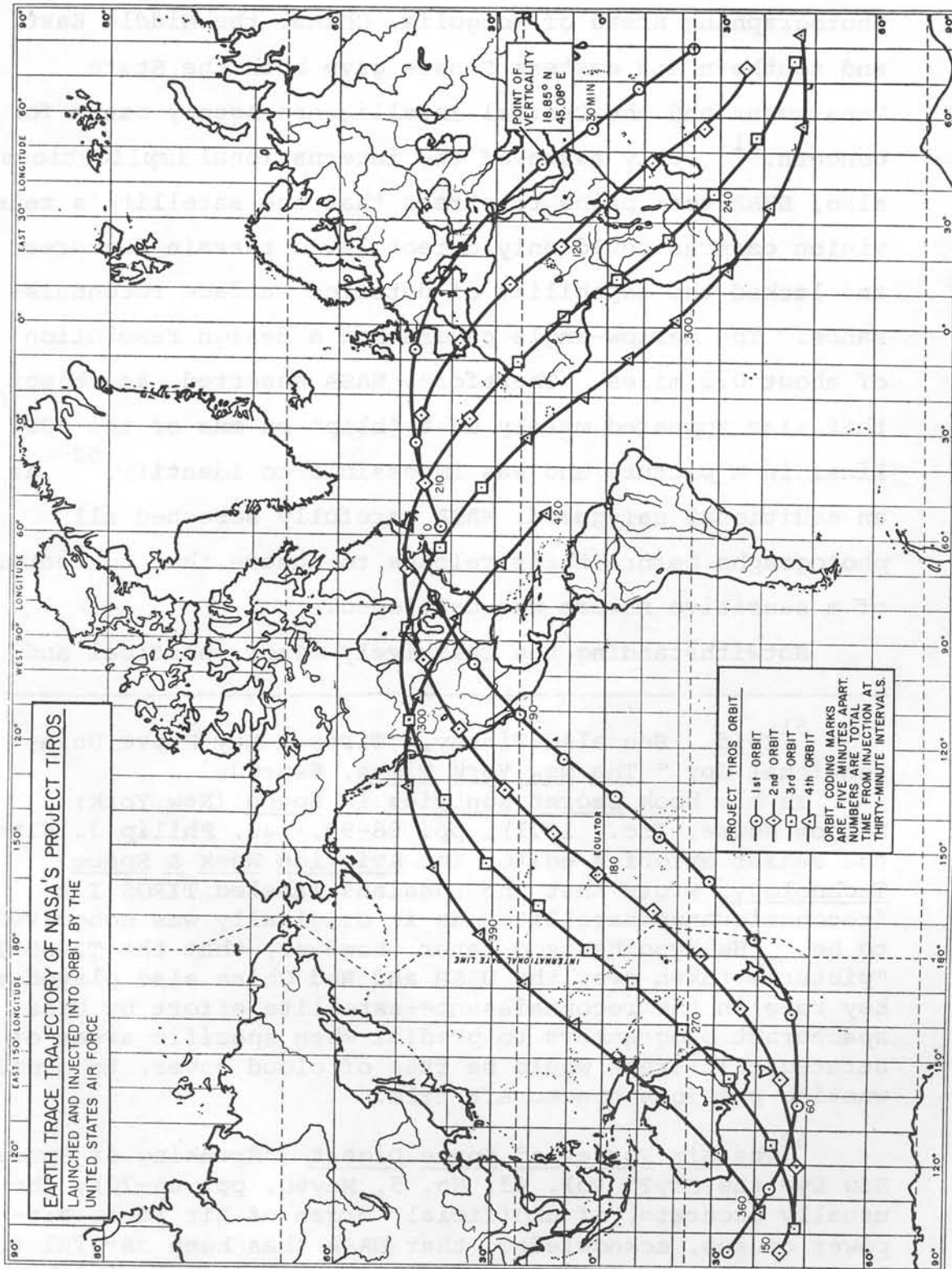
from the communist countries, the fact that TIROS I was photographing areas of Mongolia, China, the Middle East, and southern and eastern Russia gave both the State Department and the Central Intelligence Agency cause for concern.⁵¹ Fully aware of the international implications also, NASA took pains to stress that the satellite's television cameras could only detect large terrain features and lacked the capability of detailed surface reconnaissance. The narrow-angle camera had a design resolution of about 0.2 miles. Therefore, NASA asserted, an object that size appeared merely as a "blip" on one of the 500 lines in a picture and was impossible to identify.⁵² As an additional safeguard, NASA carefully screened all photographs before their release to insure that no feature of a sensitive nature was developed.

Notwithstanding the relatively minor political and

⁵¹ Ibid. See also Finney, "Tiro I May Prove Unintentional Spy," The New York Times, 6Apr60.

In his book Secret Sentries in Space (New York: Random House, Inc., 1971), pp. 98-99, 140, Philip J. Klass, the senior avionics editor for Aviation Week & Space Technology, wrote that the Russians labeled TIROS I a "reconnaissance satellite--as it originally was conceived to be." He hypothesized later, however, that the TIROS I "pictures taken over the USSR and Red China also played a key role in the reconnaissance-satellite effort by USAF spacecraft programmers to predict when specific areas of strategic interest would be free of cloud cover, to avoid wasting precious spacecraft film."

⁵² The Air Force and Space Digest ("Speaking of Space: How Eye the Sky?" Vol. 43, No. 5, May60, pp. 66-70), the usually accurate, if unofficial, organ of Air Force air-power causes, acknowledged that NASA "has been careful to insist that no real ground detail is discernible in the photographs" and that it "was doubtless true now." However,



TIROS I's orbital path. (NASA Chart)



A TIROS I photograph, taken on 4 April 1960, showing clearly the Red Sea, the Gulfs of Suez and Aqaba surrounding the Sinai Peninsula, the Nile River, and the eastern tip of the Mediterranean Sea. "Just like Rand McNally," the National Broadcasting Company's television newscaster David Brinkley remarked upon seeing it.* (NASA Photo)

*"Speaking of Space: How Eye the Sky?" Air Force and Space Digest, Vol. 43, No. 5, May60, p. 66.



TIROS I photograph of the Caspian Sea taken during orbit 657 on 16 May 1960. The shore line runs vertically through the picture's center and a cloud mass dominates its lower portion. (NASA Photo)

technical problems, it was immediately evident to the agencies concerned that TIROS I was a complete success.⁵³ To the skeptics who had claimed that satellites were a little more than spectacular stunts, its photographs provided a spectacularly practical answer. During its first ten days, TIROS I transmitted some 2,000 photographs of the earth and its cloud cover in a convincing demonstration that satellites could indeed be used to survey weather conditions and surface features from space. At the very least, TIROS I ushered in a new era in meteorology.

Air Weather Service meteorologists were most enthusiastic about its products. Although TIROS I photographs were limited to what could be scanned along the satellite's pre-determined orbit, it was obvious to AWS officials that enough was observable to be of operational value.⁵⁴

Transmitting the Data

Early in June it was revealed that a circuit between TIROS I's high-resolution camera and the recorder that stored its information had failed a day after launch. However NASA noted that on 11 May the circuit had cleared and

⁵² (Cont'd) in the course of making a pitch for the Air Force being designated the single manager for the military space mission, and thereby printing the unprintable in official Air Force circles, it averred that "today's Tiros is cousin to tomorrow's Samos [Satellite and Missile Observation System], the Air Force's projected reconnaissance satellite."

⁵³ Evert Clark, "Tiros Exceeds Weather Bureau Hopes," Aviation Week, 2May60, p. 30.

⁵⁴ AWS News Release No. 60-9, "USAF Weathermen Start Test on TIROS Satellite Data," n.d. (circa Apr60).

TIROS was thereafter able to store and relay high-resolution pictures. RCA speculated that an internal temperature change was responsible for the failure and later operation of the circuit.⁵⁵

Transmission of nephanalysis TIROS data on communications circuit 1R9--Strategic Facsimile Network--commenced during the first week of operation. A bottleneck in data handling developed but was alleviated by AWS through the assignment of one airman from the headquarters and three airmen from 4th Weather Group detachments to the east coast readout station.⁵⁶

Cloud-pattern charts transmitted over facsimile circuits 1R9--to stateside stations--and 21x19--to High Wycombe Weather Central in England--were produced by a team of meteorologists at Camp Evans, New Jersey, under the direction of the Weather Bureau's Meteorological Satellite Section. AWS members there were headed by Major Jones--AWS' liaison officer to the satellite section. A similar team at Kaena Point, Hawaii--on which AWS was represented by the 1st Weather Wing's Major William H. Staten--analyzed that readout station's pictures for local use. Since the aspect angle for each picture had to be computed by manual methods, the Camp Evans' team was hard-pressed during the first few days of activity. But with the help of the four AWS observers under Major Jones, the information was disseminated much quicker.⁵⁷ Additionally, MANAM--communica-

⁵⁵"TIROS Spin Rate," Aviation Week, 7Jun60, p. 30.

⁵⁶AWSSS Staff Conference Notes, 6Apr60.

⁵⁷The four observers were A/2C Stanley Fell, A/2C Donald Fry, and A/3C Stephen Hirjak, from the 4th Weather

tions schedule change--action was requested by AWS for two open periods on facsimile circuit 21x19--at 1800 and 0255 hours--and for all open periods on circuit 1R9 for the unscheduled transmission of satellite nephanalyses. In effect, such action merely "legalized" what was then transpiring.⁵⁸

From the TIROS readout stations, bulletins describing cloud observations were sent to the selected forecasting agencies and facsimile analyses were transmitted on the communications circuits. Because these analyses had to wait for free periods on the facsimile circuits, the information was often six-to-eight hours old by the time it reached field units.⁵⁹ Often it was older. Although communications difficulties resulted in the charts being delayed for an average of nearly ten hours between observation and receipt of the data in the field, a survey of AWS stations revealed that many field forecasters still judged the data's potential operational utility as "very promising."⁶⁰

The lateness of the data prevented many stations from making operational use of the information, but several detachments commented that the cloud-pattern analyses could

⁵⁷ (Cont'd) Group's Detachments 3, 6, and 12, respectively, and A/2C Gary Grabau from HQ AWS' Directorate of Scientific Services. See Capt Lufkin, "TIROS I, World's Photographer," Observer, Vol. 7, No. 5, May60, p. 5.

⁵⁸ AWSSS Staff Meeting Items, 13Apr60.

⁵⁹ "TIROS I, Pioneer Weather Satellite, Proving Successful," Observer, Vol. 7, No. 4, Apr60, p. 1.

⁶⁰ Lufkin, "The Background of Present Meteorological Satellite."

have taken the place of locally-prepared charts if they had been received earlier. For example, the 5th Weather Group's Detachment 5 at Homestead AFB, Florida, noted that the 5-April TIROS analysis over the eastern United States showed remarkable correlation with their own analysis over the areas for which ground observations were available.⁶¹ Over the Atlantic, where the Homestead chart had only three observations, the TIROS chart had just as much detail as over any other region.⁶²

Not long after the satellite was launched, AWS personnel were informally advised that from about the middle of April until about the third week of May, the point from which TIROS looked vertically at the earth's surface would be located in the Southern Hemisphere. Those pictures of the Northern Hemisphere which could be seen at all would be so distorted by perspective that no reliable analyses could be made from them. Thus, those stations which were receiving charts of TIROS observations were warned to expect fewer during the "dark period" before about May 24. Other plans were also outlined:

When TIROS reappears on the Northern Hemisphere scene, the meteorological teams at the readout stations hope to have overcome the delays in picture processing and communications. The goal is to have TIROS data in the hands of field forecasters within about two and a half hours.

Working to such a schedule, TIROS data will reach the field at about the same time as the major synoptic

⁶¹The TIROS chart also confirmed the efficiency of the Homestead station's charts, drawn independently of TIROS data.

⁶²"TIROS I, Pioneer Weather Satellite, Proving Successful," Observer, Vol. 7, No. 4, Apr60, p. 1.

charts, bringing a wealth of fresh information on the state of the atmosphere over very large regions. (Exactly what uses, aside from the obvious ones of pilot briefing and oceanic analysis, TIROS data will serve, no one yet knows.) The TIROS teams invite AWS men everywhere to inspect their charts and bulletins carefully, to try to integrate the information into their usual forecasting methods, and to report their ideas and opinions to the AWS team member. Send questions, comments, and suggestions to Maj James Jones.⁶³

The expected change in attitude of TIROS I transpired late in April, and the readout stations at Camp Evans and Kaena Point went to a standby status for a period. The lack of landmarks and exact attitude data made observations unprofitable, so manning at the readout stations was kept to a minimum. However, a few observations continued to be transmitted as a check on the instrument package's condition and to provide further data to refine the computer program for position and attitude forecasts.⁶⁴

In mid-May, when TIROS began to see the Northern Hemisphere again, the readout teams went back to full operation. Captain Searle D. Swisher of Detachment 3, 1st Weather Wing, replaced Major Staten as the AWS representative at the Kaena Point readout station. More AWS meteorologists began participating in the program, and the teams sought ways to speed data transmission, the principal bottleneck. Although the goal of two-and-one-half hours from satellite to forecaster was optimistic, a gradual speeding up of data dissemination and increasing emphasis

⁶³ Ibid.

⁶⁴ AWSSS Staff Conference Notes, 20Apr60.

on operational use of TIROS observations was expected.

During the attitude change period, AWS learned that NASA had reworked the TIROS aspect program, so as to use an identifiable landmark as initial data. It was expected to enhance considerably the usefulness of TIROS photos over ocean areas.⁶⁵

Headquarters AWS, commenting on the value of the satellite's observations, noted that:

Recognizable features of cloud systems have been and are being located accurately with respect to points on the earth's surface. From these features, major storms have been spotted and their progress watched with interest as successive passes of TIROS yielded more pictures and information.⁶⁶

When the satellite's attitude was changed to permit Northern Hemisphere observations again, three additional AWS forecasters--Lieutenants James Giraytys, Richard Rudy, and John Hillsman--were temporarily assigned to the Camp Evans readout station to assist Major Jones.⁶⁷ All three were well acquainted with the requirements of SAC, the Air Defense Command (ADC), and general aviation forecasting. TIROS I continued to function and promised to have a longer useful life than had previously been anticipated. By the third week of May, some AWS officials were estimating that a six-month lifespan was a "good estimate."⁶⁸

⁶⁵ Ibid., 18May60.

⁶⁶ AWSSS Review, Vol. 2, No. 2, 10May60.

⁶⁷ Assigned respectively to Det 14, 12 WSq, Det 30, 5 WGp, and Det 2, 4 WGp. See "TIROS I, Resting After 2½ Months of Top Performance," Observer, Vol. 7, No. 6, Jun60, p. 4.

⁶⁸ AWSSS Staff Briefing Item, 25May60.

A dissemination problem cropped up in mid-May. The 2d Weather Wing advised AWS that the Deutscher Wetterdienst was monitoring radio facsimile circuit 21x19 to pick up TIROS displays. Since AWS had promised NASA that TIROS informational dissemination would be controlled to keep it within official channels, it appeared that transmission of the data on that circuit would have to be discontinued. In effect, it would have denied the data to the High Wycombe Weather Central. On 18 May, Major Jones and Captain Daniel H. Lufkin, from AWS' Scientific Services Directorate, met with NASA personnel on the matter.⁶⁹ NASA agreed to relax its restrictions on dissemination to permit wider transmission of the TIROS data both stateside and abroad.⁷⁰

By late May, the spin rate--which had originally been slowed from 136 to 12 revolutions per minute (rpm) shortly after launching⁷¹--had decayed to 9.3 rpm because of the earth's magnetic field. Since 9 rpm was about the critical minimum speed for stabilization and photography, a pair of spin rockets attached to the satellite's base plate were fired on 27 May upon command from a New Jersey ground station as TIROS I made its 819th pass. The spin rate achieved by the firing was 12.85 rpm.⁷²

⁶⁹ AWSSS Staff Briefing Item, 18 May 60.

⁷⁰ Interview with Capt Lufkin, 23 Aug 60, by MSgt Charles A. Ravenstein, Hist Div, Directorate of Info, HQ AWS. Hereafter cited as "Lufkin Interview."

⁷¹ See Appendix A.

⁷² "TIROS Spin Rate," Aviation Week, 6 Jun 60, p. 30; RCA advertisement, "TIROS Ground Stations--Nerve Centers For a Satellite," Aviation Week, 11 Jul 60; and "Tiro's Scores

The End of TIROS I

Early in June, AWS learned that TIROS I's television equipment would be turned off because the cameras were beginning to point toward the sun during part of the orbit. If the shutter opened with the sun in the field of view, the vidicon plate would be ruined. It was estimated that the equipment would be turned on again about mid-July. AWS personnel at the readout stations were directed to return to their parent units while the television equipment was turned off.⁷³

TIROS I officially closed down after orbit 1,302 on the ninety-first day of its operation, 29 June 1960. A stuck relay, probably caused by the low solar power and resultant low power level of the nickel-cadmium battery, had kept the shutter of the wide-angle camera open as the satellite looked toward the sun. As anticipated, the sun's fiery image must have crossed the camera's vidicon plate and destroyed it. Although the narrow-angle, high-resolution camera still functioned, its limited--eighty-mile square--field of view did not permit practical operational use. Some limited experimental work was continued, but the main effort of the Weather Bureau and Geophysics Research Directorate's satellite sections was redirected to case analyses of the data on hand--some 22,952 photographs, of which some sixty percent were estimated to contain useful meteorological information.⁷⁴

⁷² (Cont'd) Another First--Spin Increased While In Orbit," St. Louis Post-Dispatch, 1Jun60, p. 9A.

⁷³ AWSSS Staff Conference Notes, 8Jun60.

⁷⁴ See AWSSS Review, Vol. 2, No. 3, 27Jul60; Lufkin,

Discrepancies appeared in some news coverage of TIROS I's death. Aviation Week, early in July, reported that satellite interrogation was discontinued "temporarily" because the batteries' weakened condition had caused erratic operation since early June. "Tiros' orbit," the magazine continued,

recently has been keeping it in the earth's shadow a great deal of the time. Lack of sunlight reduces battery-charging capability of solar cells, and low internal temperature may have affected internal circuits. It is now in sunlight most of the time, and attempts to obtain television transmission of cloud cover photographs from its wide- and narrow-angle cameras may be resumed . . . [NASA] said.⁷⁵

However, a United Press International release, issued about that time and similarly based on NASA information, noted that TIROS I's "useful life ended at midnight June 29 after a failure of electronic equipment."

NASA was of the opinion that a limited operational capability remained in the narrow-angle camera, but that it would be extremely difficult for meteorologists to identify and orient its pictures. Without the wide-angle camera, identifiable geographic landmarks were unavailable. Moreover, the satellite's attitude sensors were inoperable.⁷⁶ The Weather Bureau remained prepared to photograph

⁷⁴ (Cont'd) "The Background of Present Meteorological Satellite"; and Senate: Meteorological Satellites, p. 52.

⁷⁵ "Tiros Interrogation Discontinued by NASA," 4Jul60, p. 38.

⁷⁶ Final Operational Report: TIROS I Meteorological Satellite System (Princeton, N.J. : Astro-Electronics Div, RCA, 10Oct60).

a tropical storm if the occasion presented itself. Such a likelihood, however, depended not only upon the occurrence of such a storm, but on the faint possibility that the satellite would pass over the storm in the proper attitude and at the right time of day. AWS, on the other hand, planned to acquire no further TIROS I data.⁷⁷

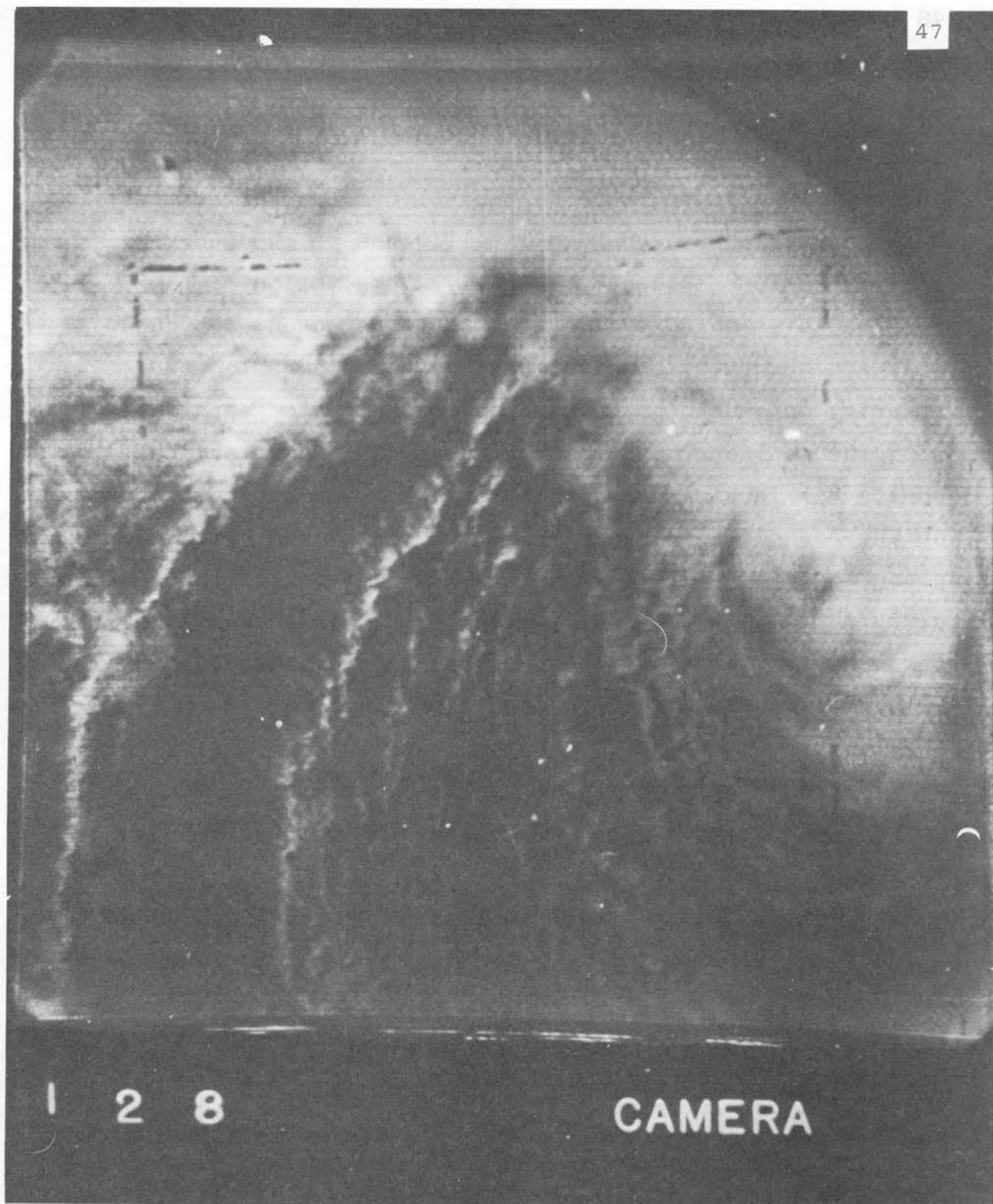
TIROS I Evaluated

Even while TIROS I was functioning, it was apparent that its data had made important contributions to meteorological research. NASA observed that among the most striking cloud patterns captured by the satellite were the large-scale cyclonic storms or vortices whose spiral bands sometimes reached over 1,000 miles in diameter. The frequency and extent of highly organized cloud systems associated with those vortices had not been fully realized before TIROS I. NASA also noted that some of the photographs revealed the presence of jet streams, regions of moist and dry air, thunderstorms, fronts, and other meteorological phenomena.

Of the 22,952 frames transmitted by TIROS I, 17,449 were received at Fort Monmouth--4,698 from the narrow-angle camera, and 12,751 from the wide-angle camera. Kaena Point received some 5,503 frames--1,117 from the narrow-angle camera and 4,386 from the wide-angle.⁷⁸

⁷⁷AWSSS Staff Conference Notes, 6Jul60.

⁷⁸Ibid.



TIROS I photograph of a typhoon in the South Pacific approximately 1,000 miles east of Brisbane, Australia, taken on 9 April 1960, during the satellite's 125th orbit. (NASA Photo)

Air Weather Service drew several conclusions from the TIROS I photographs. Cyclonic circulations such as tropical storms were easily recognizable. In some instances general cloud types--such as cirrus, cumulus, or stratus--were identifiable, and some intelligence on cloud-cover density could be gleaned. Finally, some motion of the more rapidly-moving cyclones could be detected, depending on the accuracy with which the clouds could be located--accuracy depending on recognizable geographic features.⁷⁹

The AWS detachments which received TIROS cloud-pattern charts via facsimile responded enthusiastically to a survey on the uses of the observations to be utilized by AWS in planning fuller participation in future satellite programs.⁸⁰ Although crowded circuits had delayed most charts for an average of nearly ten hours, some forecasters cited actual missions which benefited from TIROS data, including the launch of at least one Bomarc missile.⁸¹ "Very little

⁷⁹ AWSSS Review, Vol. 2, No. 3, 27Jul60.

⁸⁰ An unidentified "Air Force official" was quoted by correspondent John W. Finney in The New York Times ("Weather System To Use New Tiros; 2d Cloud-Filming Satellite Set for Fall--Plan Beats Schedule by 3 Years," 17Jul60) as saying that "the success of Tiros I caught us with our plans down."

⁸¹ In ibid., Finney described a "B-52 refueling incident" as one where "Air Force meteorologists showed how they could have steered a B-52 bomber away from a cloudy rendezvous with an aerial tanker over the Atlantic" by using TIROS I photographs. The reference to their use with Bomarc launches was found in MATS Form 44, "Quikcom," Mr. John D. Rugg, Dir of Info, AWS, to AWSCS (chief of staff, AWS), "Recommendation for News Release on Use of TIROS Data," 3Jun60. See also "TIROS I Resting After 2½ Months of Top Performance," Observer, Vol. 7, No. 6, Jun60, p. 4.

operational meteorological data was obtained . . . from the project," a 1st Weather Wing report read which generally reflected the field's viewpoint,

even though the Kaena Point Tracking Station is located on Oahu. The major reasons were lack of communications and reluctance of project authorities to release information which might be misinterpreted. The positioning of cloud systems on the earth was considered by some authorities to be inadequate for operational use and highly vulnerable to misinterpretation. Late in the project, however, valuable operational data was relayed on at least five separate occasions by telephone from Kaena Point to the Pearl Harbor Weather Central and the Kunia Weather Center.⁸²

In addition to providing assistance to the teams at the readout sites, AWS supported Dr. Ligda's and Mr. Bastian's radar scope photography projects described above. Participating in research under the direction of Dr. Ligda and the Stanford Research Institute were the AWS detachments at Eniwetok, Kadena, Schilling, Ramey, Brize Norton, Keflavik, Hahn, Lowry, Albrook, and Kindley bases. While fuel cell problems grounded them for much of TIROS I's functional life, aircraft of both the 55th and 56th Weather Reconnaissance Squadrons were used to make special radar observations.⁸³ Cooperating with Mr. Bastian and the Army Signal Corps' Research and Development Laboratory were the weather detachments at Pope Hunter, Robins, Patrick, and McDill Air Force Bases.⁸⁴

⁸²"Historical Report, 1st Weather Wing," 1Jan-30Jun60, pp. 20-21.

⁸³See Vol. I, "Narrative," pp. 143, 511-31, of "History of Air Weather Service," 1Jan-30Jun60.

⁸⁴"TIROS I, World's Photographer," Observer, Vol. 7, No. 5, May60, p. 5, and "Brize Norton Weathermen in

Briefings on AWS' experiences with the TIROS I data were presented to Military Air Transport Service--MATS--officials by Major Glover, and to ADC, TAC, and SAC by Major Jones and Captain Lufkin. At each presentation the officers discussed the operational utility of the satellite pictures to both the forecaster and operator.⁸⁵



Captain Lufkin, right, discussing a working RCA model of TIROS II with Mr. Max Roby--a television newscaster with Channel 4, KMOX, St. Louis--at headquarters AWS in 1961. (USAF/AWS Photo)

⁸⁴(Cont'd) Operation Weather Watch, "Observer, Vol. 7, No. 7, Jul60, p. 6. The work of Detachment 12 of the 2d Weather Wing's 28th Weather Squadron at Brize Norton consisted of mounting a polaroid camera to one of their radar scopes. Each fifteen minutes the camera took a scope photograph, indicating weather at and near the base. At the end of each day the photos were shipped to the Stanford Research Institute for analysis and comparison with TIROS I pictures. The same procedure was followed by each of the detachments participating in the program with radar sets.

⁸⁵Lufkin, "The Background of Present Meteorological Satellite."

In June 1960, the commander of AWS, Brigadier General Norman L. Peterson, visited the 2d Weather Wing and took with him a collection of TIROS I photographs. So much interest was generated by the striking views of the earth that the general was invited to appear as a special feature speaker at the annual SHAPE--Supreme Headquarters Allied Powers, Europe--commanders meeting--SHAPEX-60. In addressing more than 300 NATO--North Atlantic Treaty Organization--commanders, the AWS commander labeled TIROS-I "one of the most valuable tools in the memory of the military meteorologist."⁸⁶ A fully operational system of such satellites, he said, would "bring to the field commander of a few years hence a view of the battlefield which has until now been reserved for the historians." He pointed out some of the satellite's potential advantages, including that of forecasting the weather for the earth's "silent" areas. By correlating the appearance of cloud systems as seen from space with ground weather reports, meteorologists were learning to interpret TIROS pictures in terms of surface weather. To the military meteorologist the possibilities offered by that technique had great potential value. "Here in Western Europe," General Peterson continued, "we would usually have the opportunity of examining a storm and comparing its TIROS portrait with known surface weather." "Later, after the storm had moved into Eastern Europe or the Baltic," he concluded, "we could, by examining later

⁸⁶ See text of Gen Peterson's briefing, "The Weather Reconnaissance Satellite," presented to SHAPEX-60, Paris, France, 21Jun60. See also Capt Theodore R. Strum, "Eye-witness. . . . To Weather," The Airman, Nov60, pp. 42-46.



General Peterson and the TIROS photographs.
(USAF/AWS Photo)

TIROS pictures, determine weather conditions even though we were to be denied reports from that area."⁸⁷

The SHAPEX-60 attendees reportedly received General Peterson's briefing enthusiastically. Many were eager to examine at close range the TIROS I pictures of their home countries, and nearly 200 such photographs were distributed for use in later staff briefings.⁸⁸

The most important result of the TIROS I observations, of course, was to show that cloud patterns as observed from space displayed a much higher degree of organization than had ever been suspected.⁸⁹ Centers of lows, fronts, waves, squall lines, cumulus cells, etc., were all readily identifiable from TIROS I pictures. That property of organization permitted a detailed analysis of the state of the atmosphere based strictly on satellite observations.

Air Weather Service's survey or post-analysis of TIROS I surfaced the problem of what form the observations should be presented in to the ultimate users--the field forecasters. Most of the TIROS I pictures were disseminated as schematic diagrams which delineated areas of more or less homogeneous cloud cover and added sketchlines to show the essential features of cloud patterns. That method of presentation, it was believed, did not do "full justice" to the immense amount of information available from good

⁸⁷ Ibid.

⁸⁸ Capt Lufkin, "NATO Commanders Briefed on TIROS by General Peterson," Observer, Vol. 7, No. 7, Jul60, p. 1.

⁸⁹ Senate: Meteorological Satellites, p. 71

satellite pictures. AWS officials felt that although communications would probably always limit the amount of information which could be disseminated by the ground station to less than a thousandth of the informational content of the original pictures, well thought-out methods of interpretation and presentation could make that fraction "most effective."⁹⁰

Rapid dissemination of the data was critical because TIROS I pictures were as perishable as all other forms of weather data. Consequently, much of the data actually transmitted to field stations was unusable because of late receipt. Nearly six hours of the average ten-hour delay was attributed to "waiting time," *i.e.*, to the time the data had to wait for an open transmission period on the communications circuits.

As for the personnel needed to man the readout stations, AWS believed that it was unnecessary to have highly-trained research specialists. In fact, there appeared to be some advantage in having men who were primarily "practicing weather forecasters." It was believed that such a meteorologist would be more keenly attuned to the needs of the operational weather service than the research-oriented meteorologist.

In summation, AWS believed that its experience with the first purely meteorological satellite was worth while. Observations from space appeared to point toward changing procedures for the future. In regions for which the usual synoptic observing network was sufficiently dense--as in

⁹⁰ Lufkin, "The Background of Present Meteorological Satellite."

the United States, with its surface, upper air, and radar networks--satellite observations would be useful mainly for displaying the mesostructure of the atmosphere in a way no other mode of observation could match. In that large portion of the globe for which only sparse observations were available, if at all, the value of satellite observations increased; here, they offered an information-gathering system of essentially unlimited range which was, in the long run, competitive in cost with conventional aircraft reconnaissance.⁹¹

Air Weather Service made a computer run in late July 1960 using TIROS I data to determine its value for silent-area forecasting. In the first run, the clouds were used to estimate the streamline directions which were, in turn, used to alter the analysis in the silent area. Work continued on the use of such data in hopes of eventually making an input into the basic analysis of the Joint Numerical Weather Prediction Unit at Suitland, Maryland.⁹²

By mid-1960 it appeared as if scientists of the Weather Bureau and cooperating meteorological agencies would be analyzing TIROS data for many months in the future. "Thousands upon thousands of man-hours of research lie ahead of us," said David S. Johnson, chief of the bureau's satellite section.⁹³ Dr. Francis W. Reichelderfer, the

⁹¹ Ibid.

⁹² AWSSS Staff Conference Notes, 27Jun60.

⁹³ Jonathan Spivak, "Tips From Tiros II: Next Weather Satellite May Help Pave Way for Automatic Meteorology; It Will Aid Forecasts for Fliers; Later Satellites May Flash Storm Warnings; A Computer Predicts Wind," The Wall Street Journal, 11Oct60, p. 1. Spivak's article hereafter cited as "Tips From Tiros II."

bureau's chief, went to Congress for a \$36,000 emergency appropriation to permit indexing and classification of the photographs. In a preliminary analysis of the data, the bureau's Drs. Fritz and Harry Wexler reported that it revealed a large degree of organization in cloud systems, and that spiral-banded clouds existed around well-developed, extra-tropical storms. "But one of the significant results from Tiros," they cautiously noted, "is the clear indication that although storms have similarities, there may also be very marked differences."⁹⁴ Satellite "cloud pictures give us a tip-off days ahead when new storms are getting started," said Charles M. Woffinden of the bureau's extended forecast section, "and they can tell us how quickly a storm will clear."⁹⁵

Some overly-exuberant press reports claimed that meteorological satellites would "revolutionize weather forecasting." While such claims were unrealistic, satellites did promise to become revolutionary observing systems. Some immediate improvement could be expected in weather analyses over the vast areas where few current observations were available, but basic improvements in forecasting would evolve only from a careful study of cloud pictures, radiation data, and other measurements from meteorological satellites. An increased understanding of atmospheric processes from these studies was expected to contribute to the solution of some forecast problems.

⁹⁴ Fritz and Wexler, "Cloud Pictures from Satellite Tiros I," Monthly Weather Review, 88-3, Mar60, pp. 79-87.

⁹⁵ Spivak, "Tips From Tiros II," The Wall Street Journal, 11Oct60, p. 1. In October 1972, Mr. Woffinden was assigned to AWS as the National Weather Service's liaison officer.

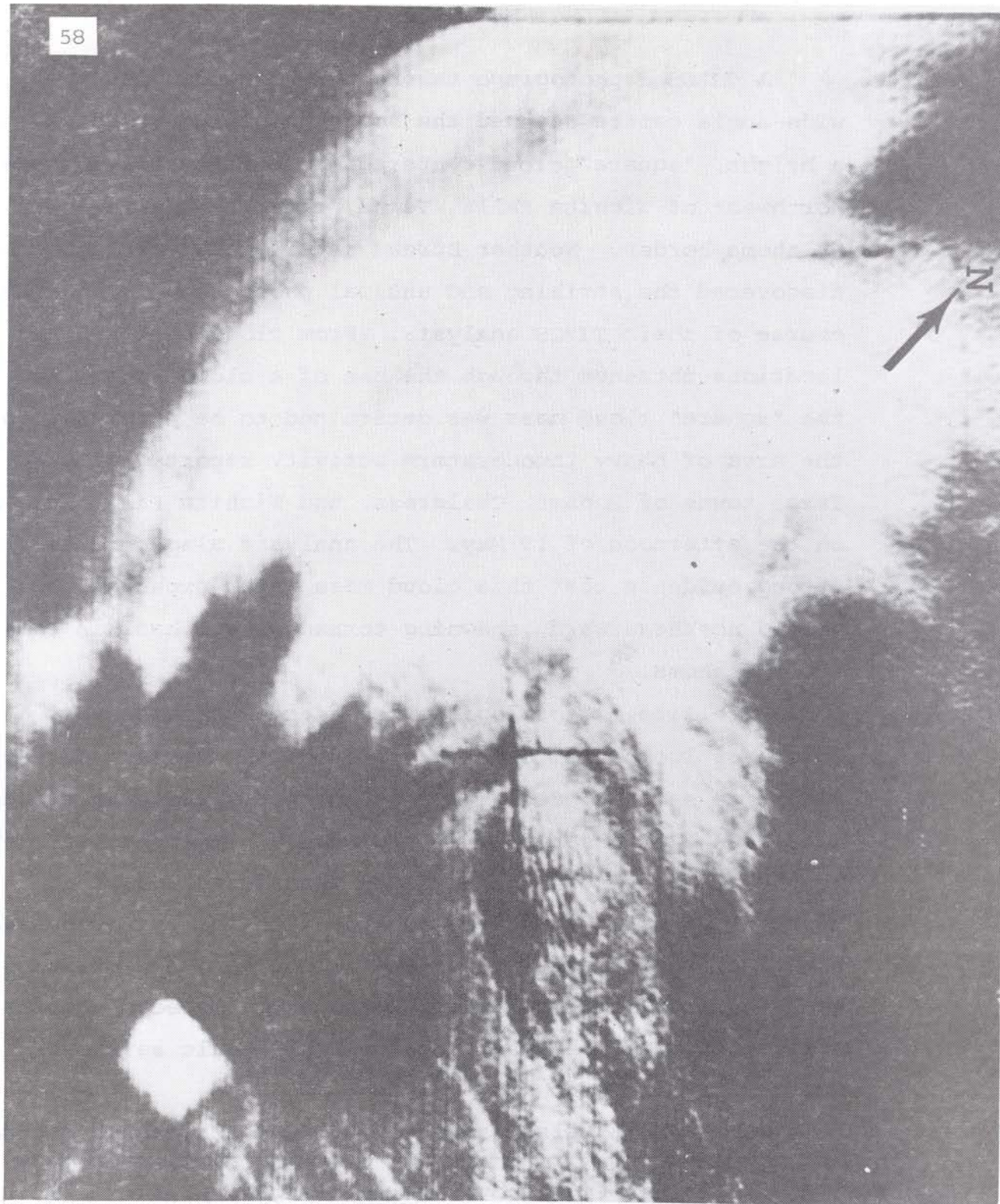
A TIROS I photograph taken on 19 May 1960, as the wide-angle camera scanned the southern plains, revealed a bright, "square" cloud centered about fifty miles west-northwest of Wichita Falls, Texas, close to the Texas-Oklahoma border. Weather Bureau satellite specialists discovered the striking and unusual photograph during the course of their TIROS analysis. From cloud analysis and locations obtained through the use of a cloud schematic, the "square" cloud mass was determined to be precisely in the area of heavy thunderstorm activity reported at the Texas towns of Hobart, Childress, and Wichita Falls late on the afternoon of 19 May. The analysis also produced strong evidence that this cloud mass later expanded and spread northeastward, spawning tornadoes and hail in central Oklahoma.⁹⁶

Satellite meteorologists considered the discovery a stroke of luck. Mr. Johnson, chief of the Weather Bureau's satellite section, declared that not every isolated cloud mass seen from a satellite would warn of impending severe weather. However, he pointed out that detection of unusual cloud masses, when considered with their geographical location, the climatology of the region, and the existing weather situation, might well enhance the meteorologist's ability to recognize and pinpoint small-scale severe weather situations.⁹⁷

On 19-20 May also, several of TIROS I's orbits crossed

⁹⁶ "Weather From Above," Time, 1Aug60, p. 56.

⁹⁷ See "Birth of Tornado Filmed by Tiros I; Lucky Photo of a Square Cloud Mass Gave Clue on Oklahoma Storm," The New York Times, 24Jul60. See also "Tiros I Concludes Mission; Tiros II Readied," Weatherwise, Vol. 13, No. 4, Aug60.



The photograph of a "square" cloud over Texas, taken by TIROS I on 19 May 1960, which was published in many of the nation's leading newspapers and magazines, including The New York Times and Time. (NASA Photo)

the North Pacific, the United States, and Central America. Its pictures showed with unusual clarity a series of frontal storms that extended from north of Japan eastward across the Pacific to the western United States. Meteorologists for many years had known the general nature of storms, but had lacked a measure of their individuality--a cloud "print" of a storm to identify it uniquely. The 19-20 May pictures made excitingly clear the details of cloud patterns as well as the general structure of storms.⁹⁸

In general, the Weather Bureau's evaluation of TIROS I could be summed up in the words of its chief, Dr. Reichelderfer, who was quoted as saying that the "spectacular operation of Tiros I had opened a new era in weather surveillance."⁹⁹ His declaration reflected the general attitude among meteorologists of almost every weather agency. "In the meteorological satellite the meteorologist has been provided with an observational tool that far exceeds his wildest dream of a decade ago," read a subsequent Senate subcommittee staff report.¹⁰⁰

Satellites vs Reconnaissance Aircraft

Confusion about the capabilities of meteorological satellites and the aims of the satellite program prompted differences of opinion between partisans of aircraft reconnaissance and those of meteorological satellites. On the

⁹⁸ "Tiros Pictures a Pacific Frontal Storm," Weatherwise, Vol. 13, No. 5, Oct60.

⁹⁹ "Tiros I Concludes Mission; Tiros II Readied," ibid., Vol. 13, No. 4, Aug60.

¹⁰⁰ Senate: Meteorological Satellites, p. 87.

one hand, satellite enthusiasts were prone to believe that satellite observatories were capable of supplying all of the remote observations required to define completely the state of the atmosphere. Those with reconnaissance experience scoffed at the theory.

Actually, the AWS position was that neither side was right or wrong. The two systems complemented one another almost ideally, the strong points of each making up for the other's shortcomings.

Satellite observations covered a very broad area but were, so to speak, indifferent to the data's worth. On the other hand, reconnaissance aircraft observed a relatively small area, but crew personnel were capable of varying their mode of observing to suit particular meteorological or operational circumstances.

On 1 June 1960, General Peterson, prompted by arguments on the subject making it necessary to clear the air, forwarded AWS' position regarding it to all the field units, AFCRC, and USAF. It would be helpful, he related, if people thought of the total process of acquiring weather data from remote regions as two separate operations: surveillance and reconnaissance. The former carried a connotation of close watch under relatively fixed conditions, of sentry duty or vigilance. On the other hand, reconnaissance implied a more active seeking-out of information; a sortie out of home territory to discover the opponent's disposition. Considered together, the two words encompassed the whole of the classical military information-gathering process. The AWS commander proposed that Air Force people carefully discriminate between the two words when describing the collection of

meteorological data. "We should make it clear in speech and writing that there is a fundamental difference between these two processes," he concluded, "and that satellites do not in the least compete [editor's italics] with reconnaissance aircraft, but rather free them from routine sentry duty for more important and more productive tasks."¹⁰¹ "In a normal refueling mission you must send out planes to observe conditions," said Major Jones succinctly, as quoted by The Wall Street Journal, but "with Tiros pictures you can often save a weather sortie."¹⁰²

¹⁰¹Ltr, Peterson to AWS Wgs and Gps, HQ USAF (AFOWX), and HQ AFCRC, "Meteorological Surveillance and Reconnaissance," 1Jun60.

In truth, Peterson's letter was not altogether altruistic regarding meteorological satellites because, in one sense, they represented ill-timed "competition" to his dwindling aircraft reconnaissance resources. By mid-1959 AWS was well aware that, unofficially, USAF had a low regard for the AWS weather reconnaissance function--it was an expendable luxury that could be drastically reduced and eventually eliminated. To solve budget problems compounded by its money-hungry missile program, USAF planned to cut fat from the support forces. Accordingly, in late 1959, it directed AWS, by March 1960, to reduce its reconnaissance resources by approximately forty percent. And on USAF's books the entire function was to be scrapped by July 1963. Further complications arose for Peterson and AWS in April 1960 when MATS grounded all of the remaining WB-50s because of fuel cell leaks. By the time of his letter only a handful of Peterson's WB-50s had completed the costly fuel cell repair. Therefore, the general's letter was as much or more a plea for the retention and modernization of his reconnaissance fleet as it was for a unified Air Force position vis-a-vis meteorological satellites. See Vol. I, "Narrative," pp. 37-48, of "History of Air Weather Service," 1Jul-31Dec59, and Vol. I, "Narrative," pp. 46-50, 121-25, 171-80, 511-31, and 577-96, of "History of Air Weather Service," 1Jan-30Jun60.

¹⁰²Spivak, "Tips From Tiros II," 11Oct60, p. 1.

NASA Planning For New Satellites

A series of NASA-Weather Bureau meetings was held in Washington, D. C., late in May 1960 to review TIROS I's value and to make plans for its successors--the remainder of the TIROS and Nimbus families. AWS' views and requirements were ably presented thereat by Major Jones.¹⁰³ In its role of supporting SAC, the 3d Weather Wing supplied AWS its evaluation of TIROS I, suggesting several areas for improved presentation, improved dissemination of analyses to within three-to-six hours of orbit time, and a means for annotating storm systems to provide future continuity. The wing believed that the TIROS data was of questionable value to individual base weather stations.¹⁰⁴

The TIROS Family

NASA officials visualized many satellite applications including weather observing, radio communication, geodesy measurements, and navigation. TIROS I was, of course, merely the first in a series of meteorological satellites they planned. It was a part of a meteorological program designed to explore the type and use of parameters that could be acquired by means of satellite techniques. An extremely important part of that research effort, in NASA's opinion, was to determine what could be learned from TIROS' cloud cover pictures and, where possible, to relate evidence from them to heat-balance measurements obtained from the Explorer VII satellite, and observations made with

¹⁰³AWSSS Staff Briefing Item, 25May60.

¹⁰⁴AWSOP--DCS Ops., AWS--Staff Briefing Item, 27May60.

sounding balloons and rocketsondes. Only after the proper groundwork was laid by such research and development and correlation did NASA plan to proceed with the design and development of a "truly-operational meteorological satellite system."¹⁰⁵ The launch of TIROS II, originally programmed for August 1960, was slipped to mid-autumn.¹⁰⁶ It was to be followed by TIROS III, originally scheduled for launch in the late fall of 1960, but subsequently slipped to July 1961.

Late in July 1960, NASA held a conference in Washington, D. C., to provide industrial representatives with an overall picture of the NASA program. Among the subjects discussed were experimental satellite applications in meteorology and communications. NASA emphasized that, while TIROS I was a milestone in meteorology, its value was limited because of its spin stabilization problem and because it could only photograph the earth's sunlit areas. Thus, the infrared equipment--used to measure radiation and the earth's heat balance--deleted from TIROS I because of slippages, would be aboard both TIROS II and III.¹⁰⁷

The Nimbus Family And Beyond

¹⁰⁵ NASA Release No. 60-202, 24May60--speech by Dr. Homer E. Newell, Deputy Director, NASA Office of Space Flight Program, 24May60, at the International Symposium of Rockets and Astronautics, Tokyo, Japan.

¹⁰⁶ "NASA Reorients Delta Launch Schedule," Aviation Week, 4Jul60; "Lufkin Interview."

¹⁰⁷ NASA script, "Satellite Applications," portion of NASA-Industry Program Plans Conf., 28-29Jul60, Wash., D.C.

The Nimbus series of meteorological satellites--four launches planned during the period 1961 to 1963--were under development by 1960. NASA reported that a Nimbus package would weigh from 600-to-700 pounds and would be orbited by a Thor-Agena launch vehicle. Its stabilization system was designed to keep the cameras pointed earthward continually--differing in that regard from the TIROS family. Sensors aboard the improved vehicle would include not only television cameras, but wide area, and scan-type, radiation-sensing equipment as well as other experimental sensors. Considered for later in the series were a simplified radar for observing precipitation, a spectrometer for measuring temperature, and an image orthicon camera for observing night cloud cover. Paddles that could be continuously oriented sunward would carry solar cells to provide power for the Nimbus sub-systems.¹⁰⁸

The Nimbus project, including the writing of specifications, was under the management of NASA's Goddard Space Flight Center. Early in 1961 the General Electric Company was named the system integration contractor with RCA as the sub-contractor for the television equipment. Mid-1960 NASA plans called for the initial Nimbus launch in late 1961. However, by early 1961 it became apparent that the first launch would not occur until sometime in mid-1962.

Programs beyond Nimbus were "very tentative" according to NASA. Experience gained from it and the remainder of the TIROS family would have a large influence on future planning. The Centaur launch vehicle would provide the

¹⁰⁸ Ibid.

capability for placing meteorological satellites into a 23,300-mile orbit and such a satellite in an equatorial orbit would appear to stand stationary over a point on the earth because its orbital period would coincide with the earth's rotational period. NASA estimated that three such "stationary" satellites would view most of the earth's surface and thus permit continuous observation on an operational basis. The moniker "Aeros" was selected for the twenty-four hour satellite in mid-1960, although the project still had not been officially approved for implementation. NASA believed that work might be initiated on Aeros during 1962 with a possible launching in 1964.¹⁰⁹

The entire NASA program for meteorological satellites was predicated upon rapid advancement in the state-of-the-art with regard to launch-vehicle development, instrumentation, analytical techniques, and communication. The level of effort being supported directly by NASA, exclusive of vehicle funding, was expected to be about \$15 million for fiscal year 1961.

NASA was anxious to receive ideas from industry regarding feasible methods and devices for observing and measuring atmospheric parameters such as cloud cover and storm location, precipitation, temperature, wind direction, heat-balance, and water vapor. Measuring those elements from a satellite was both a unique and challenging task. As of mid-1960, most of the instrumentation and techniques for measuring such parameters either did not exist or were in very early stages of development. Automated data-

¹⁰⁹ Ibid.

processing systems aboard the satellites and at the ground readout stations was another area in which NASA needed industry help. That problem was a principal consideration in the development of an operational system. When sufficient experience was gained with in-being experiments, and meteorologists had analyzed the problems, then specific requirements for specialized equipment and methods would be forthcoming.¹¹⁰

Proposal For A USAF Meteorological Satellite

From the very earliest indications of TIROS I's successes, Air Weather Service's leaders openly coveted an "operational meteorological satellite system" of their own, under Air Force control, completely independent of NASA or the Weather Bureau. In late April 1960, while many were preoccupied with TIROS I's unique pictures, General Peterson laid the groundwork for formally proposing such an idea by alerting the MATS commander to the "unusual significance and importance" of the satellite, and to the "immediate operational use [editor's italics]" AWS was making of its photographs. "Even at this early date it is obvious that this is the most significant development affecting meteorology since the introduction of weather analysis and forecasting by . . . computers," he wrote, and "I believe that its eventual significance will far surpass our most optimistic hopes."¹¹¹

Heartened by the initial reactions to his trial balloon, General Peterson chartered his staff to draft a

¹¹⁰ Ibid.

¹¹¹ Ltr, Peterson to Tunner, 26Apr60.

formal proposal for an operational meteorological satellite system while he, Captain Lufkin, and Majors Glover and Jones attempted to enlist the support of other major air commands by hitting the road with a briefing on the lessons from TIROS I.¹¹² On the day the general briefed the NATO commanders in Europe, as noted above, Major Jones briefed the NORAD--North American Air Defense Command--staff.¹¹³ Following the reception given his presentation in Europe, Peterson briefed TAC officials in mid-July, advising them that "TIROS I has . . . provided us with a sound basis for the development of a comprehensive plan for a meteorological satellite program to support future Air Force operations." "My headquarters is presently working on this plan," he said, and "I hope that Tactical Air Command will support the need for this program."¹¹⁴

¹¹²Not all within the Air Force were enraptured by AWS' avant-gardism, including an AWS' alumnus in a key position. GRD's Meteorological Satellite Branch and the 433L--Weather Observing and Forecasting System--system project officer, Col George A. Guy, were also interested in an operational weather satellite since all the observations from such a vehicle would eventually be an input into 433L--the long-range, AWS modernization program then being expanded through Federal Aviation Administration and Weather Bureau participation into a national meteorological system. Col Guy expressed his opinion to the Air Research and Development Command that an operational system could be developed, but he favored a joint effort rather than a system solely for USAF use. See AWSSS Staff Meeting Notes, 3-and-31Aug60.

¹¹³See Appendix No. 1, "History of 4th Weather Wing, Detachment 1," pp. 3-4, to "History of 4th Weather Wing," 1Jan-30Jun60.

¹¹⁴See text of Gen Peterson's briefing, "The Weather Reconnaissance Satellite," p. 11, presented at Langley AFB, VA, on 13Jul60. See also the following articles from

Two weeks later a similar pitch by Peterson to General Thomas S. Power evoked the SAC commander-in-chief's full personal support.¹¹⁵ General Power believed that when TIROS was declared an operational system, it should be USAF's project instead of NASA's.¹¹⁶

Backed by such testimonials, Peterson, on 26 August 1960, submitted through MATS a formal AWS proposal for an organic Air Force weather satellite which had been drafted by Majors Glover and Stanley E. Pearse.¹¹⁷ AWS suggested an earth-stabilized satellite with a polar orbit to give global coverage. AWS estimated that costs for construction and operation of a meteorological satellite would be around \$26 million for the first year, and about \$19 million for subsequent annual operations.¹¹⁸ MATS strongly endorsed AWS' proposal on to USAF, commenting that "development and employment of a meteorological satellite system would contribute immeasurably to the advancement of the application of meteorology to existing and future weapons systems."¹¹⁹

¹¹⁴ (Cont'd) The Times-Herald of Newport News, VA: "Air Weather Chief Slates Visit Here," 12Jul60, p. 12; "Weather Chief Speaks," 13Jul60, p. 15; and Virginia Biggins, "Langley Briefing: Tiros Satellite Uses Explained," 14Jul60, p. 11.

¹¹⁵ AWSSS Staff Meeting Notes, 3Aug60.

¹¹⁶ Following Peterson's visit to SAC, the 3d Weather Wing drafted a letter to USAF for Power's signature recommending the feasibility of a military-controlled meteorological satellite to support Air Force operations. Unexplainably, it was never posted. See "History, 3d Weather Wing," 1Jul-31Dec60, "p. 46.

¹¹⁷ Ltr and atch., Peterson to HQ MATS and HQ USAF, "An Air Force Meteorological Satellite System," 26Aug60.

¹¹⁸ Appendix C, Glover and Pearse, "A Proposal for an Operational Meteorological Satellite System."

¹¹⁹ 1st Ind., MATS to USAF, 12Sep60, to ltr, Peterson

In the meantime, a 19-September NASA letter to the Defense Department on the subject of operational meteorological satellites created "a flurry of activity in the Pentagon," and resulted in an October meeting to establish a Defense Department position. The position was presented to NASA on 10 October at a meeting attended by NASA's Drs. Glennan, Hugh L. Dryden and Robert C. Seamans, Jr., the Secretary of Commerce, and others. The meeting was to consider the various agencies' responsibilities in regard to operational meteorological satellites and the best way of financing them.¹²⁰ Because of decisions made at the 10-October meeting, which General Peterson attended as the Air Force representative and at which AWS' proposal was used as a guide in preparing USAF's position, the recommendation for an Air Force satellite system was turned down. Although USAF officials agreed that there was an urgent requirement for the data obtained by such a meteorological satellite, they did not believe it essential that the system be USAF controlled. Further, it appeared to be in the national interest to have a single meteorological satellite system rather than separate systems for each weather agency.¹²¹

Toward a Common Operational Met Satellite

Following the 10 October meeting, and in line with

¹¹⁹ (Cont'd) to HQ MATS and HQ USAF, 26Aug60.

¹²⁰ AWSSS Staff Meeting Notes, 60Oct60. See also Appendix D, Reichelderfer, NACCAM Chairman, "Resume of Action Toward NACCAM Coordination of Operational Meteorological Satellite Developments," n.d. (circa Nov60).

¹²¹ 2d Ind, USAF to MATS, 16Nov60, to 1tr, Peterson to HQ MATS and HQ USAF, 26Aug60.

NASA's view that it was the responsibility of the user agencies to determine the nature of the system, the Weather Bureau proceeded to develop a national plan for a "Common System of Meteorological Observation Satellites"--COSMOS.

It was agreed at the 10 October meeting that the Joint Meteorological Satellite Advisory Committee--JMSAC¹²²--established by NASA in 1959, would continue as the inter-departmental coordinating group on research and development of meteorological satellites. In November, NASA suggested that an "Interagency Meteorological Satellite Planning Committee"--IMSPC--be established to coordinate the planning for an operational meteorological satellite system. The committee's objectives, NASA said, would be to review the requirements submitted by the various weather agencies and incorporate them into a technical, operational, and management plan responsive to both civil and military requirements.

On 25 November Lieutenant General Donald N. Yates,¹²³ Deputy Director of Defense Research and Engineering, met with Dr. Reichelderfer to discuss possible revisions to the NASA suggestion. During that meeting it was agreed that development coordination of the meteorological satellite would be continued by JMSAC.¹²⁴ However, the general

¹²² In June 1960 AWS asked for permission to designate an official to serve on JMSAC and subsequently named Maj Jones as the principal observer with Capt Lufkin as the alternate. The appointment expanded official recognition of AWS' role in planning and operation of meteorological satellite systems.

¹²³ A former Air Weather Service commander.

¹²⁴ Ltr, Yates to Dr. Glennan, 6Dec60.

feeling was that any further plans or activities in which interagency coordination would be necessary would relate basically to operations and uses of satellite output. Those matters were largely identical to questions already being treated by the Joint Meteorological Group--JMG--of the Joint Chiefs of Staff, for responsibilities that were primarily military, and the National Coordinating Committee for Aviation Meteorology--NACCAM--for matters of common concern for civil, military, and general public interests.

Regarding NASA's proposed IMSPC, General Yates advised Dr. Glennan, the NASA Administrator, that:

For preparation of the operational plan . . . I feel we have the best solution through our agreement that such should be accomplished by the National Coordinating Committee for Aviation Meteorology (formerly ACCMET) which in the past has effectively coordinated matters of general meteorological support to both civil and military interests. It is my understanding that the Chairman of the NACCAM has invited NASA membership on this committee and in addition has recommended the establishment of a NASA-chaired sub-committee to treat with the operational plan itself, particularly with respect to those items . . . which fall primarily into NASA's area of responsibility.

The Department of Defense recognizes the tremendous potential value of a meteorological satellite system and hopes that NASA will be able to develop a single operational system to meet the total national requirement. We trust that a workable plan for final operation can be evolved within the agreed framework and that you will encourage maximum exploitation of the useful results of your extremely successful development program during the transition period.¹²⁵

Meanwhile, work began to update a 1959 statement of requirements for a meteorological satellite system, adopted

¹²⁵ Ibid.

by the Joint Meteorological Group in December 1959.

In view of the coordinating framework in existence within NACCAM and the JMG, NASA concurred with suggestions that coordination for an operational meteorological satellite could be handled effectively without establishing the proposed IMSPC. However, NASA believed it desirable to establish a working committee on satellite meteorology within NACCAM to proceed as rapidly as possible with the development of an operational plan.¹²⁶

On 2 December 1960, Dr. Reichelderfer, in his capacity as chairman of NACCAM, advised General Peterson that while coordination of the requirements for an operational meteorological satellite, until then, had been accomplished at the departmental level, NACCAM was committed to the establishment of a working committee composed of representatives from the many user agencies directly involved.¹²⁷

The first meeting of the committee, subsequently known as the Panel on Operational Meteorological Satellites, National Coordinating Committee on Aviation Meteorology (POMS/NACCAM), was held on 8 December 1960, and was chaired by a NASA representative. Membership included representatives from NASA, the Departments of Defense and Commerce, and the other interested agencies represented on NACCAM.

Colonel Clarence E. "Ed" Roache, the Deputy Chief of Staff for Operations, represented AWS and helped develop USAF's guidance on COSMOS. The guidance was to be used by all Air Force agencies in connection with future develop-

¹²⁶ Appendix D.

¹²⁷ Ltr, Dr. Reichelderfer to Peterson, 2Dec60.

ment and use of such an operational system. USAF supported the common system so long as military requirements were not subordinated to routine civilian requirements. It was USAF's policy that the Nimbus and Aeros research and development programs should be exploited fully as a source of operational data prior to implementation of any comparable operational system.¹²⁸

AWS requirements for observing data from an operational satellite were based on the equipment capabilities that could reasonably be expected to materialize within the time period that AWS hoped to have an operational system effective--1962-1963. Basically, AWS requirements were for a vehicle designed to observe detailed daytime cloud, snow, and ice coverage of sufficient resolution to identify cloud types, and nighttime cloud cover through high-resolution infrared.¹²⁹

Although AWS believed that its requirements should be included, it recognized that any attempt to saturate the initial operational satellite with additional observing capabilities would probably result only in unnecessary delays in implementing the proposed system. Therefore, AWS asked that the earliest possible launch date be met; that all data readout be accomplished without loss or delay; that data from one orbit be processed and made available at a military weather central within one and one-half hours after the completion of a given pass; that global coverage be accomplished on a daily basis; and that direct readout be available. Whereas the initial operational

¹²⁸ Appendix E, "USAF Guidance on Common Meteorological Observation Satellite System," n.d. (circa Dec60).

¹²⁹ Memo for record, Maj Pearse (AWSOP/OR--Forecstg and Concepts Br, Op Rqmts Div, DCS Ops, AWS), "Data

satellite would be limited in its capability to meet those criteria, AWS expected that, as equipment improved, additional requirements would be added to the operational system.¹³⁰

Although USAF had turned down AWS' proposal for an Air Force meteorological satellite, COSMOS continued to receive AWS support. However, control and funding problems in respect to meteorological satellites had to be resolved. In October, for example, AWS learned from General Yates that the Navy was spending money on meteorological satellites not specifically budgeted for that purpose. The general became aware of it when requests for \$1.7 and \$14.3 million appeared in the Navy's fiscal 1961 and 1962 budgets. The Navy built a 78-pound satellite which they proposed to launch with a Scout vehicle. It had no storage capability but, upon command, it scanned in the near infrared and transmitted one picture. It then shut off until another command was received. Yates was of the opinion that it would not meet the national needs. Additionally, a Weather Bureau radiation expert had viewed cloud photographs from an infrared package parasited on the Navy's "Transit" communications satellite. But the practical value of the infrared pictures was nil, seemingly, because their location could only be determined by matching them with conventional nephanalysis.

AWS also learned that Dr. Suomi had a new, twenty-

¹²⁹ (Cont'd) Requirements for an Operational Meteorological Satellite," 14Dec60.

¹³⁰ Ibid.

pound, infrared package he was anxious to orbit. He planned to submit it for NASA's consideration. The package had a six-hour storage capacity. With a readout station on the west coast and one in England, the package aboard a satellite in a near polar orbit could provide global coverage of the synoptic-scale infrared pattern.

Aware of such proposals, AWS believed that considerable money and effort would be wasted by different agencies proceeding in different directions. It was therefore imperative, AWS opined, that an early decision be made on a common system.¹³¹

Any common system for meteorological satellites had to consider not only AWS' requirements, but also those of the Naval Weather Service, the Weather Bureau, the Federal Aviation Administration, and others. The general consensus of most agencies--reached at an early-December, American Rocket Society meeting on future expectations in space flight--was that satellites would not offer any war capability in the near future, that the two satellite programs which offered the greatest promise for being operational in the near future were weather and communications, and that satellite launching costs would have to be reduced significantly.¹³²

Whether AWS' proposal, the Navy's, or a composite of all proposals would be adopted remained unsettled at the close of 1960. The Panel on Operational Meteorological

¹³¹AWSSS Staff Meeting notes, 19Oct60.

¹³²Memo for Record, Capt Leonard L. DeVries (Tech Rqmts Br, Tech Rqmts and Svcs Div, Dir of Scientific Svcs, AWS), "Future Expectations in Space Flight," 13Dec60.

Satellites was a forum where the pertinent agencies could air and coordinate their individual requirements so that JMSAC and NASA could proceed with development action. Through it all, AWS deliberately made its requirements for an operational system as simple as possible, recognizing that too many requirements would result in excessive delays.

Further Developments and Experiments

While planning progressed toward an operational meteorological satellite common to all users, there was no slackening in the work connected with the developmental weather satellites. Each of the NASA-sponsored satellites yet to be launched--the remainder of the TIROS family and the Nimbus series--received careful attention. Preparations for TIROS II's launch in the fall of 1960 continued at a steady pace. At the same time, work continued on the data gathered by TIROS I and Explorer VII.

During the period between TIROS I and II, the Explorer VII heat-budget package developed by Dr. Suomi continued to send back valuable meteorological information. In August, Captain Blankenship again visited the University of Wisconsin to observe the progress made on interpreting Explorer VII infrared data. Lieutenant Colonel Melvin Weinstein of the AWS, located at the University for doctorate-level training, had completed a preliminary study of the relationship between the radiation data observed by the Suomi package and the general surface synoptic pattern. His findings were encouraging, indicating that infrared observations could be of value in oceanic and other silent area analyses. More important, perhaps, were the techniques of

data-handling and analysis which the university's satellite laboratory had developed. What once appeared to be a hopeless job proceeded rather smoothly, although not yet in real-time. The AWS detachment at Lajes continued its support to the Explorer VII project by operating the tape recorder and telemetry receiver noted above.¹³³ By early October, the long-wave, terrestrial-radiation sensors on Explorer VII had become damaged and were registering noon temperatures ten degrees too high. Plans were thus made to terminate the program effective October 15.¹³⁴

Captain Blankenship revisited Dr. Suomi in October to determine why the outstanding work of the laboratory was not filtering through to the Weather Bureau's Meteorological Satellite Laboratory--formerly named the Meteorological Satellite Section. AWS continued urging that infrared packages be included on later TIROS satellites.¹³⁵

TIROS II

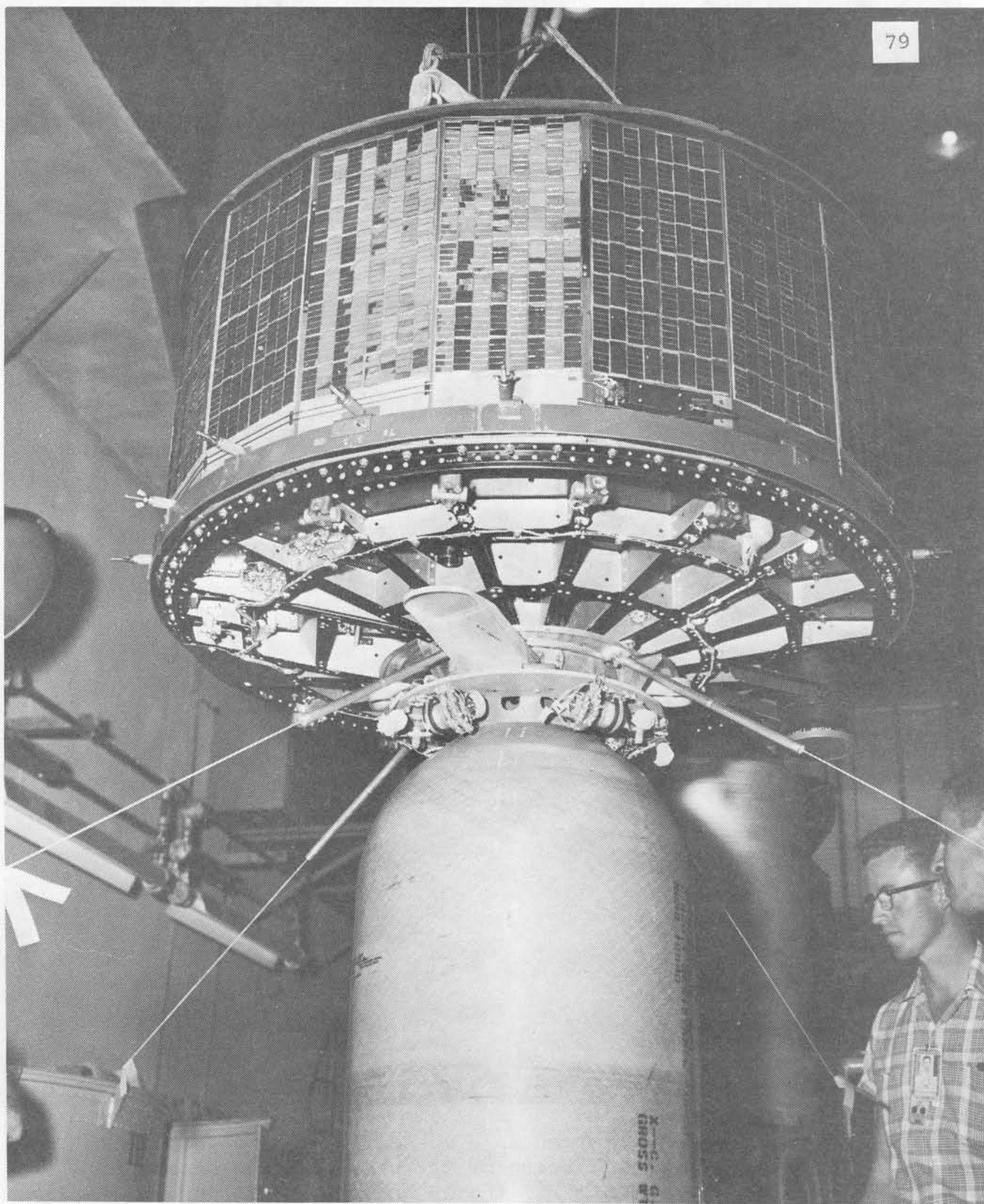
Attention continued to be focused toward the launching of TIROS II, however. Although cloud pictures from TIROS I were given wide distribution for limited operational use, AWS hoped that TIROS II cloud pictures would be distributed quicker for use in operational forecasting.¹³⁶

¹³³ AWSSS Staff Meeting Notes, 24Aug60.

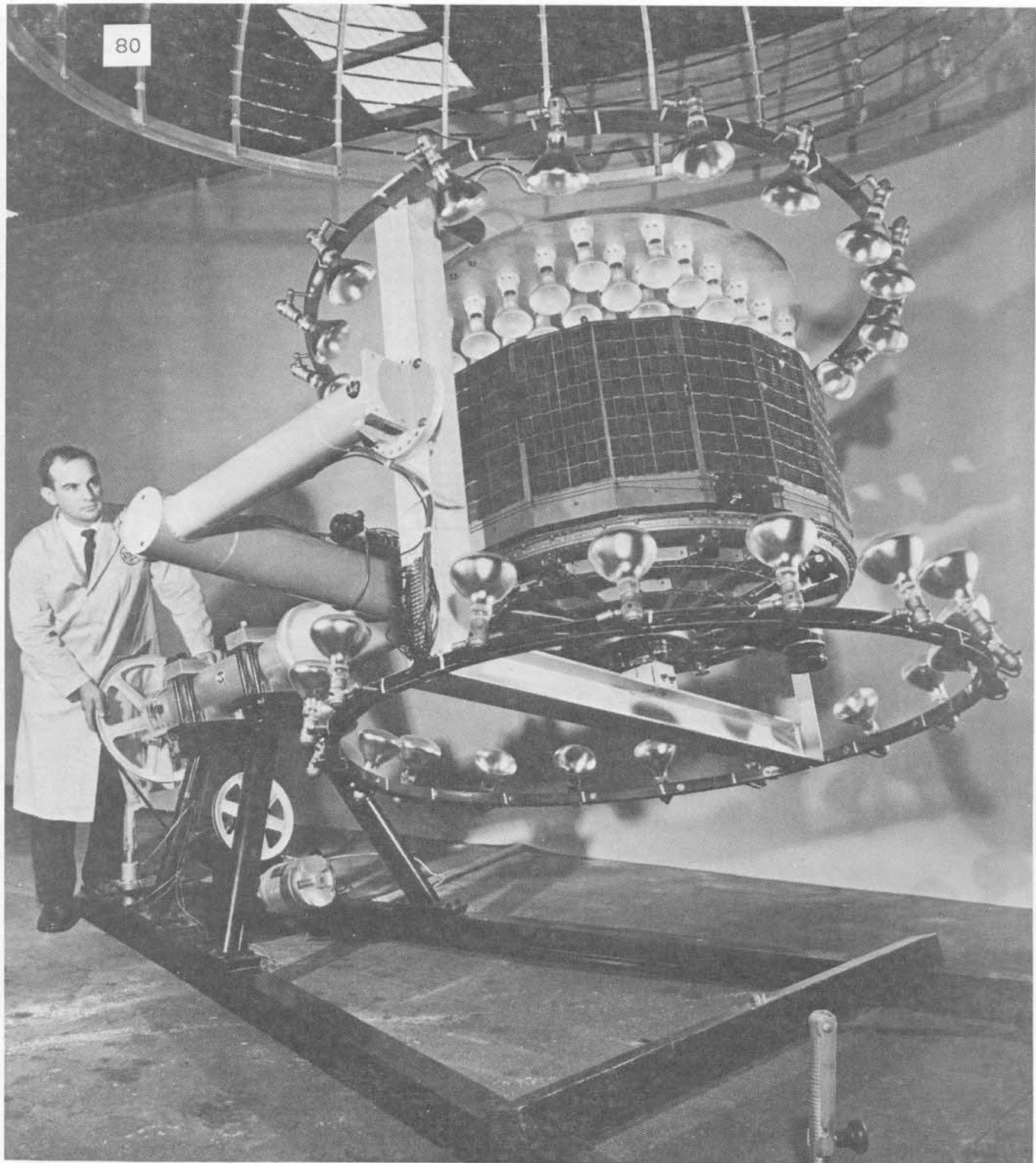
¹³⁴ Ibid., 6Oct60.

¹³⁵ Ibid., 12Oct60.

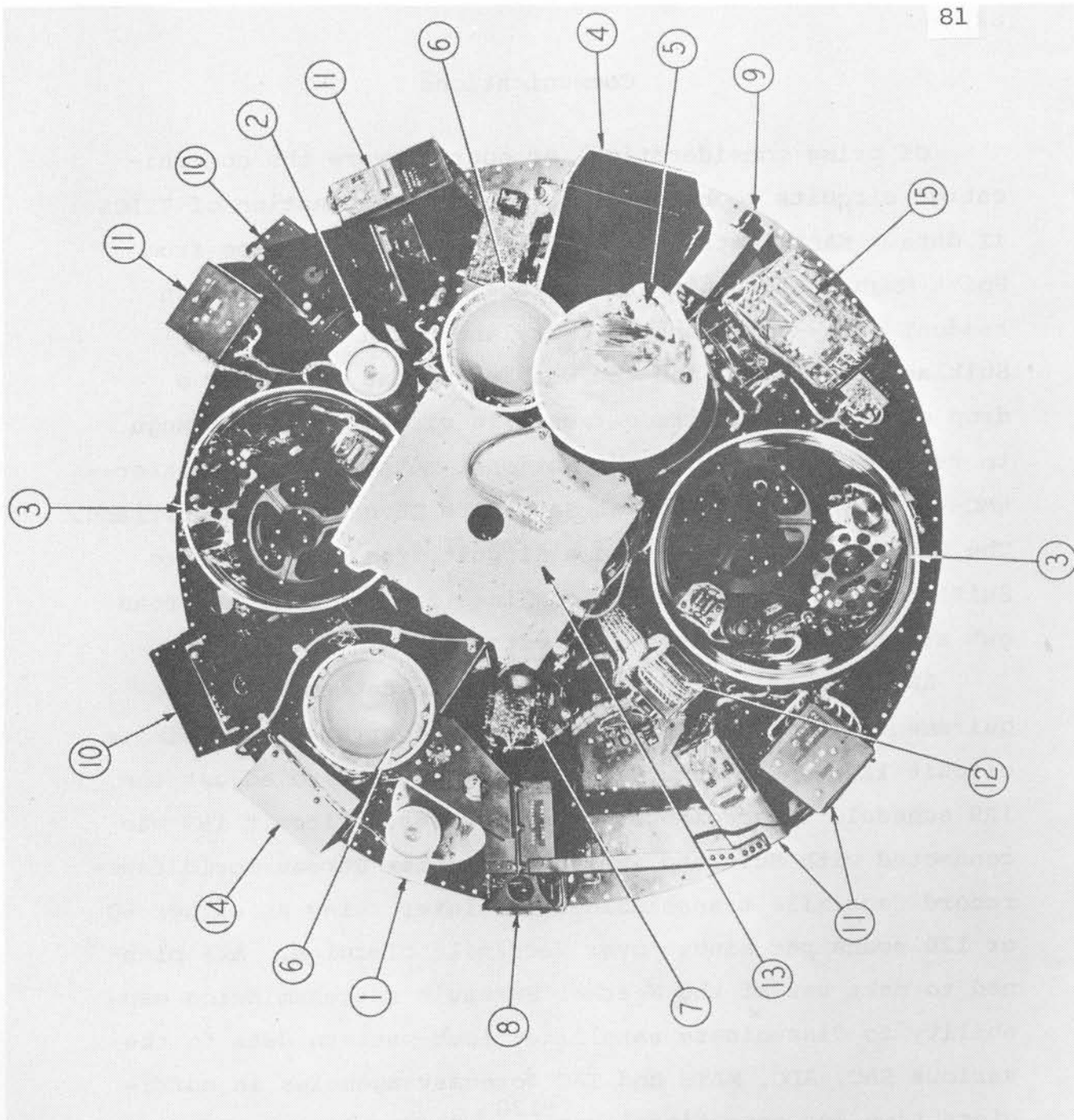
¹³⁶ Historical report, AWSOP (DCS Ops--Communications), 1Jul-30Sep60.



Sin check of the 270-pound TIROS II.
(NASA Photo)



TIROS II mounted in a special test machine which checked the functioning of its stabilization system in conditions similar to those encountered in space. Lights on the test assembly permitted testing of the solar cells on top and sides of the satellite.
(NASA Photo)



A view of TIROS II showing the following systems and devices: (1) wide angle TV cameras; (2) narrow angle TV camera; (3) TV tape recorders; (4) infrared system five channel radiometer; (5) infrared system electronics; (6) electronic clocks for sequencing operations; (7) relays for magnetic stabilization system controlling the satellite attitude; (8) control box for electronic systems; (9) infrared horizon scanner; (10) electronic circuits for cameras; (11) electronic circuits for TV tape recorders; (12) telemetry switches; (13) antenna diplexer (covering storage batteries); (14) automatic signal generator; (15) and fuse board and current regulator. (NASA Photo)