Communications

Of prime consideration, of course, were the communication circuits to be used for rapid dissemination of TIROS II data. NASA installed a 120-scan, facsimile line from Point Mugu, California--to replace Kaena as the western readout site--to Greenbelt, Maryland, with a drop at Suitland, Maryland, and the Weather Bureau installed a drop on its high altitude facsimile circuit at Point Mugu to relay information to the National Meteorological Center--NMC--and the Meteorological Satellite Laboratory at Suitland. The Weather Bureau also had a circuit from Camp Evans to Suitland. Thus, communication links from both of the readout stations to Suitland were established.[137]

AWS queried the 3d Weather Wing to determine its requirements for TIROS II products on the strategic facsimile circuit 1R9 and to determine if they planned to adjust the 1R9 schedule to accommodate the pictures. Circuit 1R9 was connected with Suitland where the Weather Bureau could tape-record facsimile transmissions for later relay at either 60 or 120 scans per minute over facsimile circuits. AWS planned to make use of the Weather Bureau's retransmission capability to disseminate satellite cloud-pattern data to the various SAC, ADC, MATS and TAC forecast agencies in sufficient time for operational use.[138] Consequently, AWS requirements for TIROS II data would largely be met by monitoring transmissions on the NASA and Weather Bureau

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[137] Staff Briefing Item, AWSOP (OR), "Preparation for TIROS II," 14Sep60.

[138] Historical report, AWSOP (Communications), 1Jul-30Sep60.

circuits from the readout stations to Suitland, editing and consolidating the data, and retransmitting it on circuit 1R9 from Suitland.[139]

It appeared as if the technique would work because NMC's tape recorder had passed several operational tests prior to mid-October 1960.[140] However, to assure its success, AWS arranged for the installation of two RJ-3 facsimile recorders at the 4th Weather Group's Suitland detachment to record separately the transmissions from the California and New Jersey readout sites. The precaution was vindicated when, by early November, the Weather Bureau's tape recorder was not functioning to AWS' complete satisfaction. Since its interests extended beyond the Weather Bureau's, AWS had to be able to reproduce the charts for retransmission--manually if necessary.[141] Coded nephanalyses for teletype dissemination would be transmitted to stateside and overseas areas on an unscheduled basis.

Data Evaluation Plans

Within Air Weather Service special observations were planned in connection with the correlation of TIROS II data. In August 1960 USAF had asked AWS to evaluate the TIROS II and Nimbus operational data and the headquarters started work to develop a program which would include

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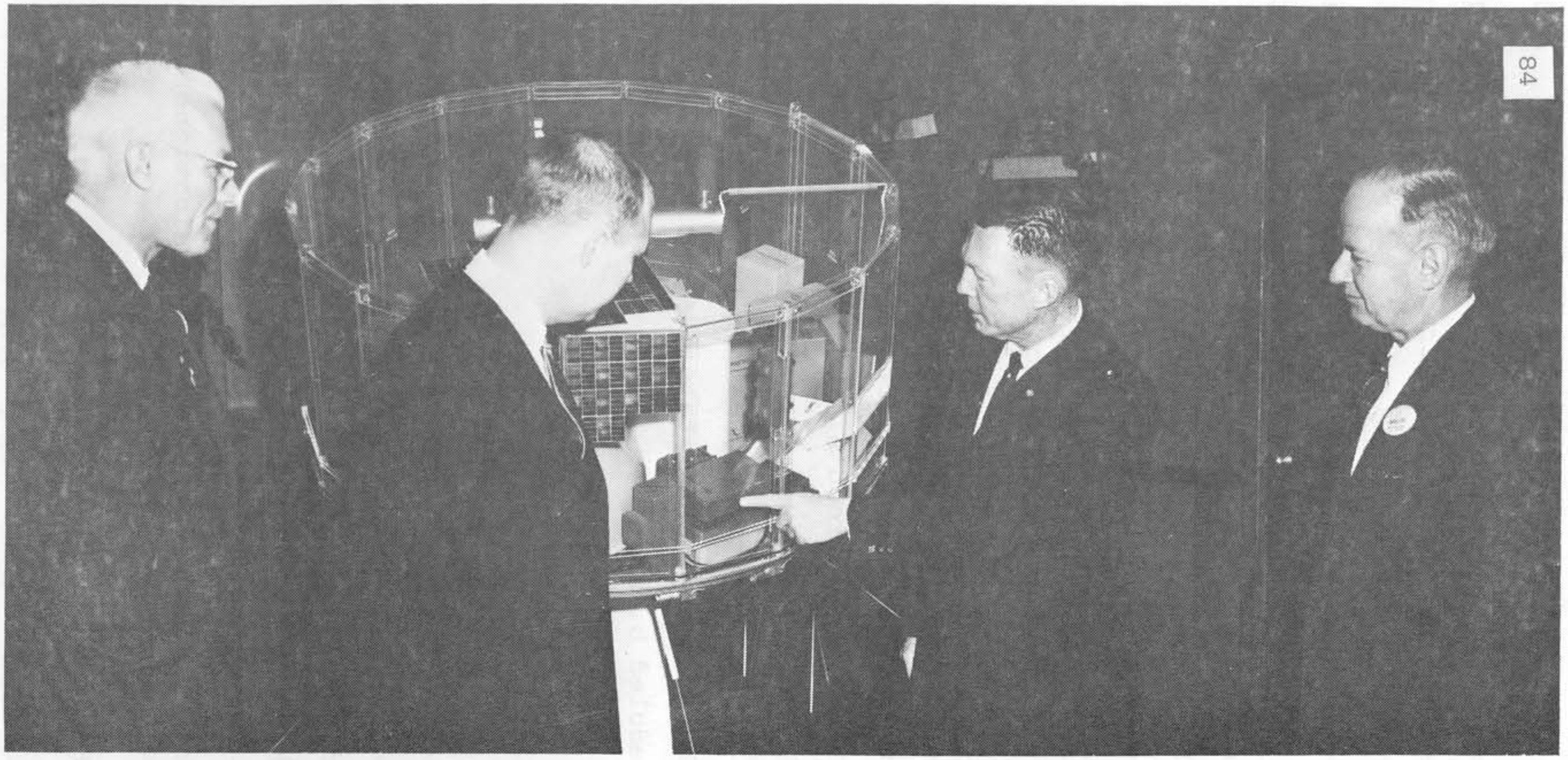
[139] Staff Briefing Item, AWSOP (Communications), "TIROS II Fax Support," 25Oct60.

[140] AWSSS Staff Meeting Notes, 12Oct60.

[141] Staff Briefing Item, AWSOP (OR), "Dissemination of TIROS II Data," 8Nov60.



General Peterson--second from right--pointing to a feature on the TIROS II scale model after addressing an early-1961 meeting of the Armed Forces Communications and Electronics Association in Belleville, Illinois. Left to right are: Colonel (USA retired) C. W. Evans, a Southwestern Bell Telephone Company military communications engineer and AFCEA vice president; Colonel David W. Baugher, 157th Tactical Control Group, Missouri Air National Guard, and AFCEA president; and Major General Daniel C. Doubleday, commander, Airways and Air Communications Service. (USAF Photo)

specific examples of the data's operational use, its correlation with comparable data gathered by conventional means, and examples of applying the infrared data.[142]

One phase of the AWS evaluation program called for special cloud reports from observers. Accordingly, a special postcard reporting form was developed. From sketches made by AWS observers of cloud patterns as seen from the ground, AWS, the Weather Bureau, and GRD would be able to locate the observation point in the TIROS II pictures. AWS officials hoped that rules for interpreting features of cloud patterns as seen from satellites could be developed in terms of actual surface weather. Once pictures were calibrated in this way, AWS would be able to use satellite observations more advantageously in various programs, including silent-area forecasting.[143] Special instructions on using the postcard reporting form were sent to AWS field units prior to TIROS II's launch, and the November Observer ran a feature on it.[144]

All news releases concerning TIROS II were controlled tightly by NASA. Press kits were prepared and distributed by NASA to information officers at various agencies. Material concerning AWS involvement had to be cleared through normal USAF channels to the NASA information office prior to launch.[145] In late October NASA published and

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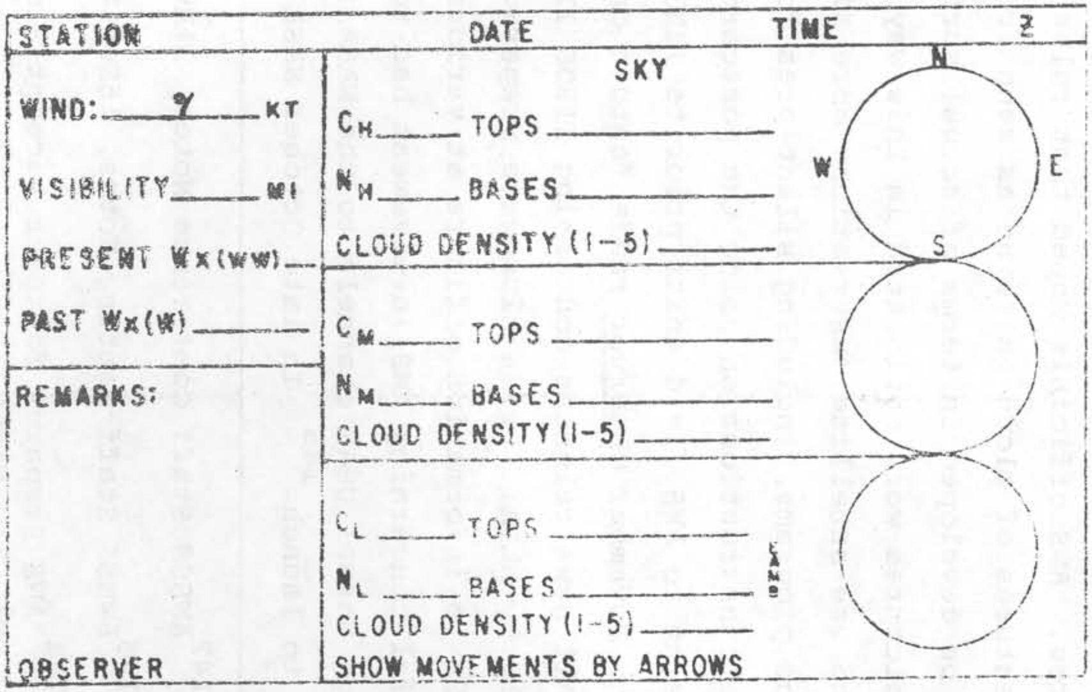
[142] AWSSS Staff Conference Notes, 31Aug60.

[143] AWSSS Staff Meeting Notes, 16Nov60.

[144] "AWS Prepares for Data Receipt From TIROS II," Vol. 7, No. 11, Nov60.

[145] AWSSS Staff Meeting Notes, 12Oct60.

POSTCARD REPORTING FORM



STATION | DATE | TIME Z

WIND: 7 KT

VISIBILITY ____ MI

PRESENT Wx(ww) ____

PAST Wx(W) ____

REMARKS:

OBSERVER

SKY

C_H ____ TOPS ____

N_H ____ BASES ____

CLOUD DENSITY (1–5) ____

C_M ____ TOPS ____

N_M ____ BASES ____

CLOUD DENSITY (1–5) ____

C_L ____ TOPS ____

N_L ____ BASES ____

CLOUD DENSITY (1–5) ____

SHOW MOVEMENTS BY ARROWS

Instructions

See instruction sheet. Try to make the observation within 15 minutes of the TIROS pass. Use one circle for each cloud layer. If you see more than three layers, use another card and staple it to this one. Consider each layer separately. If you can estimate what a higher layer looks like, even though it is hidden, sketch it in. N may total more than 10. Density 1 means transparent; 5 means as dense as CuNb or NbSt; 2, 3 and 4 are in-between degrees of cloud density.

distributed an information plan outlining the responsibilities for release of information about TIROS II.[146]

Major Jones prepared a news release regarding the "operational test" weathermen planned for the TIROS II data. Coordinated with NASA, it was edited to delete reference to the term "operational utility." Published in advance, it was not to be released until the conference following a successful launching. Despite editing, it contained the "meat" of the story, as evidenced below:

> A joint program to test and evaluate the utility of cloud pictures received from TIROS II has been implemented by the U. S. Weather Bureau and the military weather services of the United States.
>
> The program consists of three phases: data reduction and interpretation, dissemination to the forecaster, and an appraisal by the forecaster of the value of these data to the solution of analysis and forecasting problems. Experience gained during TIROS I has gone into the development of this program to use satellite pictures on an experimental basis.
>
> Data reduction teams composed of meteorologists from the Meteorological Satellite Laboratory and field stations of the U. S. Weather Bureau, the Air Weather Service, the Naval Weather Service, the Geophysics Research Directorate, and Allied Research Associates are presently at the data readout stations near Belmar, New Jersey, and Oxnard, California, where the pictures from TIROS II will be received. Prior to reporting for duty at these readout stations, the teams received intensive training for a period of one to two weeks at the Meteorological Satellite Laboratory. Making use of a completely equipped data reduction facility and film from TIROS I, the space age weathermen were schooled in procedures for data reduction, interpretation, and presentation to be used during TIROS II.

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[146] NASA Information Plan, "Tiros Meteorological Satellite (A-2)," 27Oct60.

These teams will prepare maps from the TIROS II pictures showing schematically the cloud distribution and organization relative to the earth. Interpretation in terms of cloud form and standard weather patterns such as storm centers and frontal systems will also be made part of the presentation where possible. A manual prepared by the Office of Forecast Development, U.S. Weather Bureau, comparing cloud pictures from TIROS I with clouds observed from the ground, has been distributed to the readout stations to serve as a guide in making these interpretations. Copies of this manual will also be distributed to operational forecast units to assist the forecasters in the use of the cloud maps.

After the accurate analysis of the cloud images, the most important phase of the program is dissemination of the information to the forecaster. When intended for operational use, weather information is a perishable item; its value drops off rapidly when time is lost in delivery. To move the data quickly from the readout stations, full period facsimile circuits connect the two stations with the Communications Center and the National Meteorological Center of the U.S. Weather Bureau in Washington. Via these circuits, cloud maps will be available for use in the National Meteorological Center and nearby weather facilities of the Navy and Air Weather Service within a few hours after the basic pictures are taken by TIROS II. These agencies, which will serve a long list of customers, will test the value of the TIROS data in preparation of analyses and forecasts over a large part of the northern hemisphere. To expedite further dissemination of the cloud maps, available time on existing weather facsimile circuits of the Air Force, Navy, and Weather Bureau has been rescheduled to minimize delays in delivering the data to forecast centers outside the Washington area. To reach units not served by these facsimile circuits, selected cloud analyses will be summarized for relay on landline and radio teletype circuits on a space available basis. Forecast centers outside the U.S. will receive the maps via radio facsimile and teletype. It must be emphasized that circuits on which time is available for relay of the TIROS data reach a representative sample of forecasters. Indeed, through the joint use of available communications, the operational test of TIROS II assumes global proportions. U. S. weathermen in Australia, supporting the resupply mission to the Antarctic expeditions, will receive word summaries of the cloud observations made by TIROS II over the vast ocean areas between Australia and Antarctica. Weathermen stationed at installations in many foreign countries as well as those within the United States will have an opportunity to participate in the evaluation of the satellite experiment.

Forecasters who use the TIROS II data in their daily routine will be on the lookout for answers to questions of operational importance which may be provided by the satellite. For example: Did the satellite find a storm center hitherto undetected with the conventional observing network? Was it possible, using satellite data, to provide a better picture of the weather significant to a commercial air carrier?

Examples of operational utility similar to those mentioned above were noted during the operational life of TIROS I. It is emphasized, however, that TIROS II is still experimental both from the standpoint of hardware and methods for using the data. The operational evaluation is being conducted in this spirit. Review and evaluation of the experimental operational use of the satellite data is another in a series of steps which may lead to a better understanding of the world's weather and to improving the design of future weather satellite systems.[147]

AWS personnel assigned to teams at the two TIROS II readout stations were selected prior to the launch. Each team was composed of three forecasters and an observer. Team chief at Point Mugu was the 4th Weather Group's Captain Leo S. Bielinski.[148] Captain Dwight R. Goodman,

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[147] NASA News Release No. 60-301, "Weathermen to Experiment and Test Satellite Pictures," 23Nov60.

[148] Other AWS personnel at San Nicholas Island, Point Mugu--a Navy installation that was part of the Pacific Missile Range--were: CWO John C. Garlock, MSgt Seymour M. Fonnesbeck, and SSgt Jack E. Sams. CWO Garlock was from the 3d Weather Wing while the enlisted men were from the 4th Weather Group.

of the 2d Weather Group, was the AWS team chief at Camp Evans.[149] Both officers visited Suitland in late September for indoctrination under the tutelage of Major Jones, and all team personnel were in place at the readout stations by 14 November, well in advance of the TIROS II launch.[150]

International Invitations

Invitations to foreign governments to participate in meteorological research connected with TIROS II were extended by the United States in September 1960. NASA and the Weather Bureau joined in the effort by tendering invitations to scientists of twenty-one different nations. It was suggested that if TIROS II was a success, weather agencies of other nations might obtain "useful synoptic results by intensifying standard meteorological observations, or by arranging for special observations, coordinated in time with passes of the satellite."[151]

The efforts were part of the United States program of encouraging international cooperation in space research and meteorology. Meteorologists abroad would thus have an opportunity to correlate cloud cover data as observed both below and from high above the clouds. In addition, the cooperation would provide NASA and the Weather Bureau

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[149] Other team members there were SMSgt Mervin L. Snyder, MSgt John J. Pappas, and A/1C Ramon C. Batts. Pappas was from the 2d Weather Group; Snyder the 3d Weather Wing; and Batts the 4th Weather Wing.

[150] Shortly before Christmas, AWS decided the workload did not support so many personnel and therefore, transferred SMSgt Snyder and SSgt Sams from the readout sites.

[151] NASA News Release No. 60-268, "U.S. Invites Over-

with a wide collection of meteorological research data.

NASA would provide orbital information to participants in the project to assist them in timing local weather observations. After processing, TIROS cloud cover photos would be sent them for comparison with their supplementary observations.

The invitations were sent to those countries having national space committees or membership on the international committee on space research. The nations to which invitations to participate were extended were: Argentina, Australia, Belgium, Canada, Czechoslovakia, Denmark, England, West Germany, France, India, Italy, Japan, Mexico, Netherlands, Poland, South Africa, Spain, Switzerland, and the Soviet Union. Norway and Sweden were also invited, although the satellite's orbit--with an inclination of about forty-eight degrees to the equator--was expected to make their participation marginal.[152] Countries expressing an interest in participating were Australia, Belgium, Denmark, England, West Germany, France, India, Japan, Mexico, Netherlands, South Africa, Switzerland, Norway, and Sweden.[153] No communist country responded.

Another Success

TIROS II was launched at 0613 Eastern Standard Time, 23 November 1960, by a Thor-Delta rocket from Cape

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[151] (Cont'd) seas Participation in Next TIROS Experiment," 26Sep60.

[152] Ibid.

[153] "AWS People at Readout Stations Are Working To Provide Useful Data," Observer, Vol. 7, No. 12, Dec60, p. 1.

Canaveral. Two hours later, NASA announced that it achieved a successful orbit at 98 minutes, close to the planned height of 400 miles.[154] Initially it attained an apogee of 435 miles and a perigee of 415 miles, but on 25 November NASA revealed that the apogee was actually 453 miles and the perigee 387 miles.

TIROS II's launch was entirely satisfactory, although the attitude and poor illumination on the first pass was unfavorable for video pictures. Radio signals from the satellite picked up at the Belmar, New Jersey, receiving station were "strong and clear."[155] Subsequently, it was discovered that the spin rate deceleration was too great, slowing the instrument package below the stabilization point. Two days after launch, during the thirty-first orbit, two of five pairs of spin rockets attached to the satellite's base plate were fired to increase the stabilization spin rate and eliminate a wobble. They increased the spin rate to 10.8 rpm on the initial firing and to 13.9 rpm on the second firing.[156]

On the day of the launch, Major Jones indicated that remote scanning by the satellite was programmed for the sixth orbit from Point Mugu, and that information

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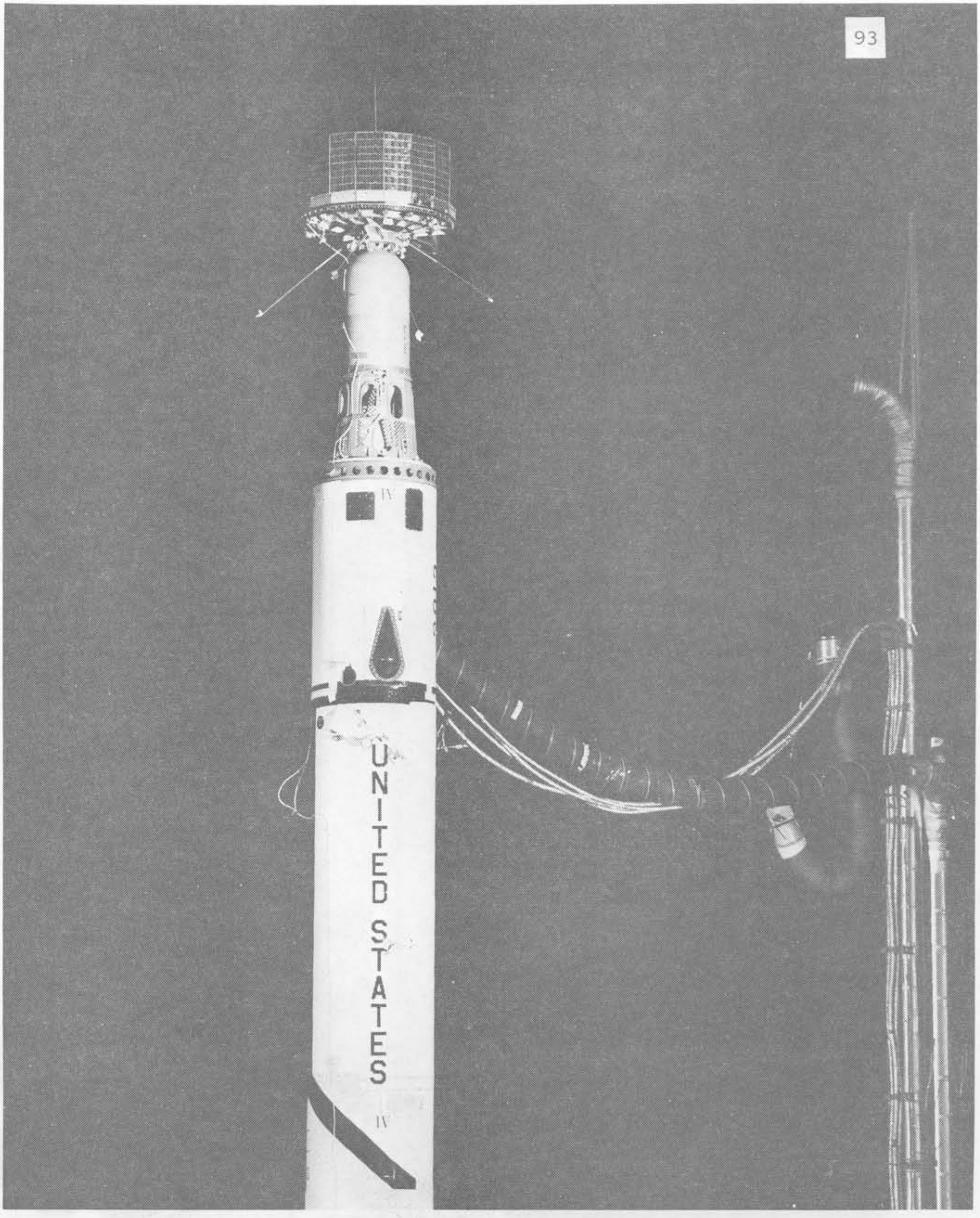
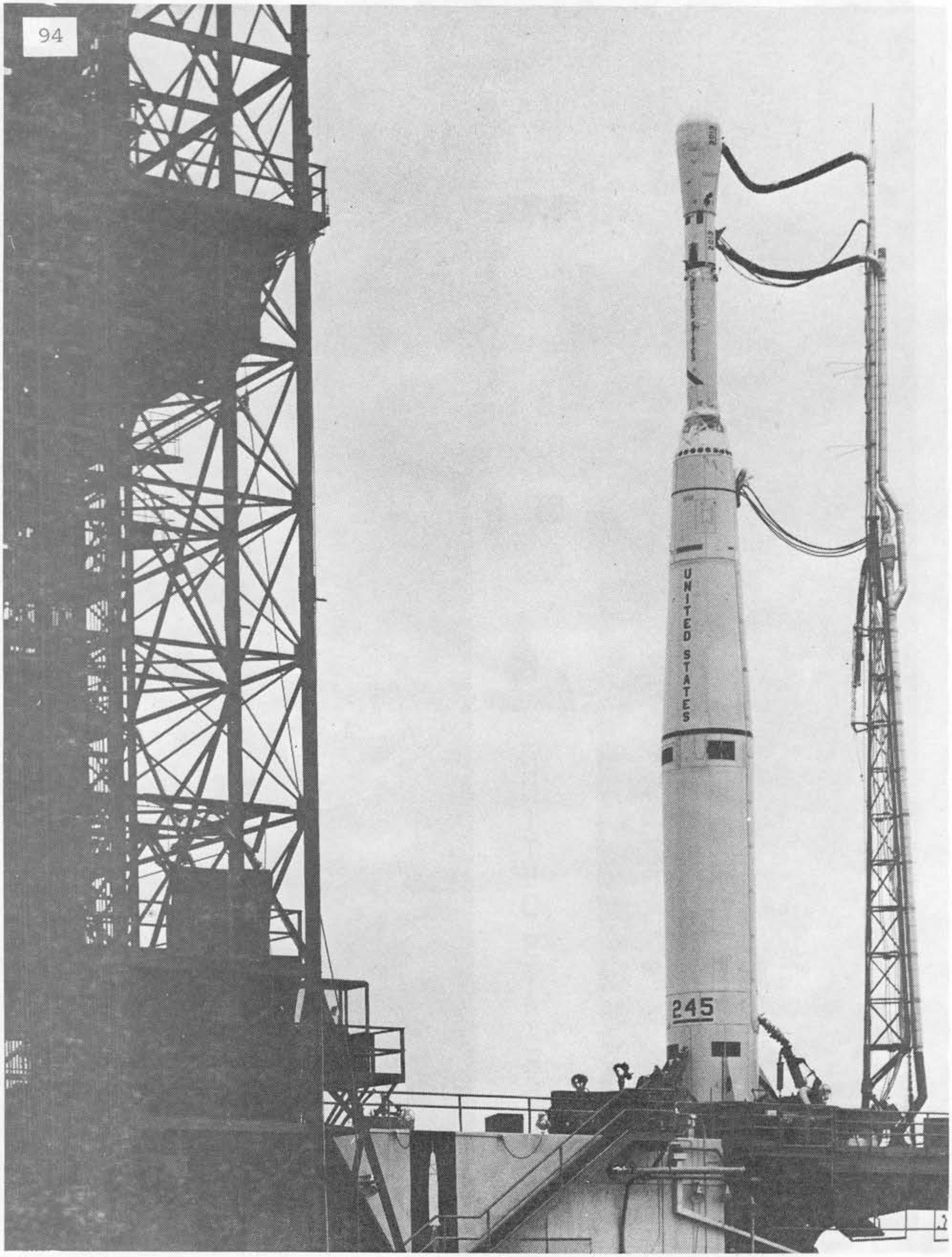
[154] "New Weather Satellite Fired into Orbit for Forecast Use; Meteorologists Plan to Start Reading Tiros II Cloud Photos Immediately--Nearly Circular Path Achieved," St. Louis Post-Dispatch, 23Nov60, p. 1A; "Tiros in Good Orbit But Cloud Shots Are Fuzzy," St. Louis Globe-Democrat 24Nov60, p. 4A; Finney, "Tiros Success Spurs Drive for World Forecast Chain," The New York Times, 25Nov60, p. 1A.

[155] AWSSS Staff Meeting Notes, 23Nov60.

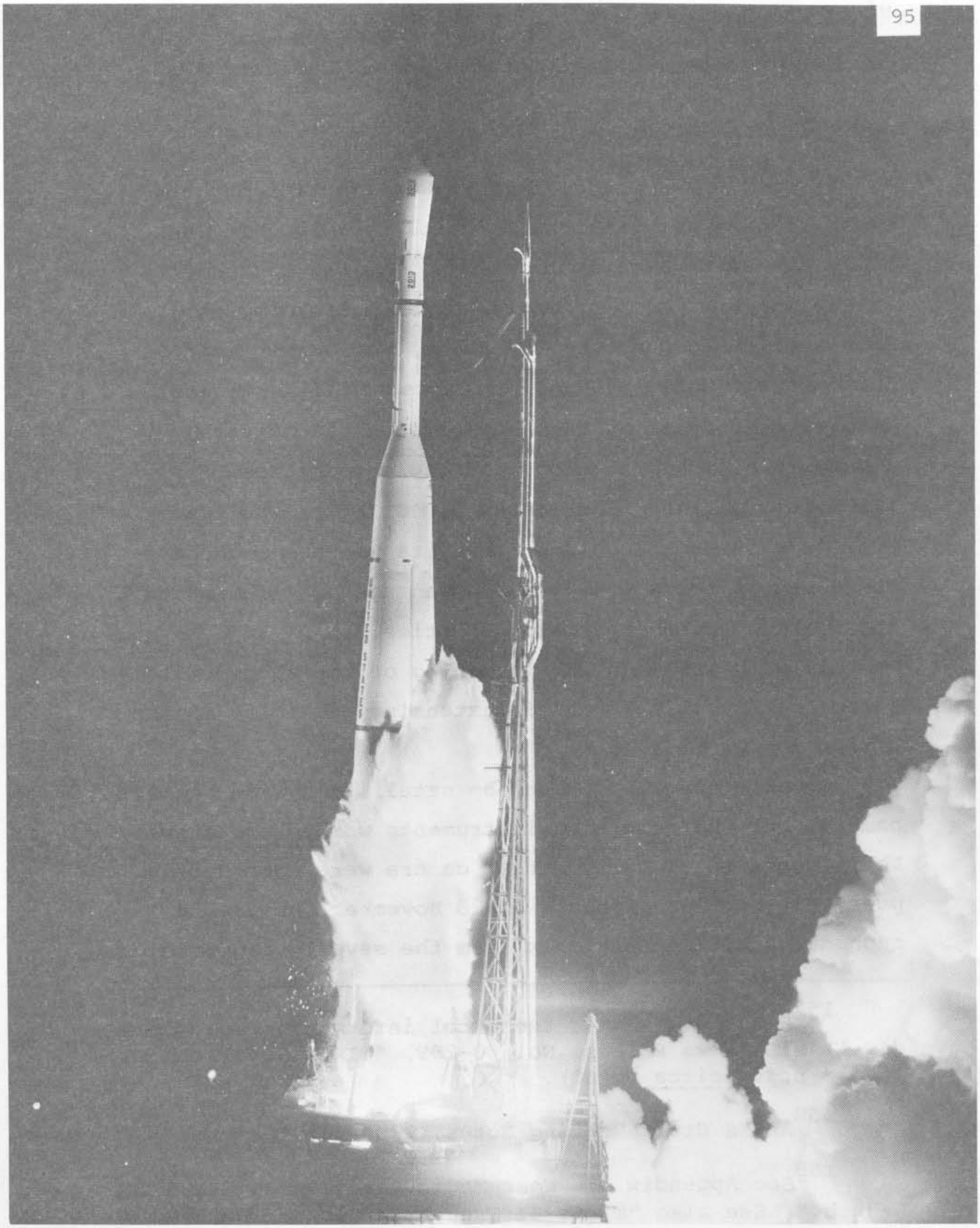
[156] "Tiros II Has Wide-Angle Camera Trouble," Aviation Week, 5Dec60, p. 28.



TIROS II atop the Thor-Delta rocket with cover removed. (NASA Photo)



TIROS II on the pad poised for launch. (NASA Photo)



The launch of TIROS II from Cape Canaveral on 23 November 1960. (NASA Photo) from the passes would be entered on national and AWS communications circuits as quickly as possible thereafter.[157]

From the AWS standpoint, it was imperative that TIROS II data get into the circuits rapidly. It was badly needed at several locations. At the detachment in Panama, for example, where normal meteorological data was inadequate; the TIROS data would help improve the forecast quality. TAC transoceanic flights could also make good use of TIROS-observed cloud patterns, and Ramey AFB, Puerto Rico, had expressed a need for TIROS information. AWS wanted TIROS II data to reach Guam as soon as it could so that its weather reconnaissance people there could take advantage of cloud-pattern information to schedule storm sorties.[158]

As with TIROS I, the launching of the second meteorological satellite received extensive publicity in the nation's news media.[159]

Trouble developed with the satellite's wide-angle camera, but the remaining instruments worked effectively. Photographs received from that camera were considered poor, although good enough by 28 November for use in nephanalysis. Nephanalysis from the seventy-fourth orbit,

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[157] For the TIROS II technical information see Appendix F: NASA News Release No. 60-299, "TIROS Satellite Payload," n.d. (circa Oct60).

[158] AWSSS Staff Meeting Notes, 23Nov60.

[159] See Appendix G, "News Media Reaction to TIROS II Launch." See also "Tiros II Transmits Cloud, Infrared Data," pp. 14-15, and "Global Forecasting System Planned With Network of Weather Satellites," p. 27, Aviation Week, 28Nov60.

covering the northeastern United States and western Atlantic Ocean, was transmitted to AWS field units that day, seven hours and fifteen minutes after observation time. That particular analysis was accepted for transmission by the Weather Bureau's Meteorological Satellite Laboratory without a thorough check and was the source of some embarrassment because later examination uncovered an error of two minutes--about 500 miles--in the location of the analysis. A correction was then transmitted.

The error resulted from the satellite's tape recorder not recycling completely. Consequently, on readout, four frames from the previous orbit and twenty-eight from the orbit in question were received. The error source was clearly identified the following morning and, for the next several days, the Meteorological Satellite Laboratory made a check of the analyses to ensure accuracy. The check required about five minutes.[160]

Nephanalysis of the European and Mediterranean area was transmitted on 29 November.

The reduction of a sampling of the Channel 4, broadband (7-30 microns), infrared data indicated that the data made sense. Cloud and clear areas were readily distinguished. It was the same wave band Dr. Suomi had used in his Explorer VII experiments.[161]

By 30 November it appeared that the tape recorder

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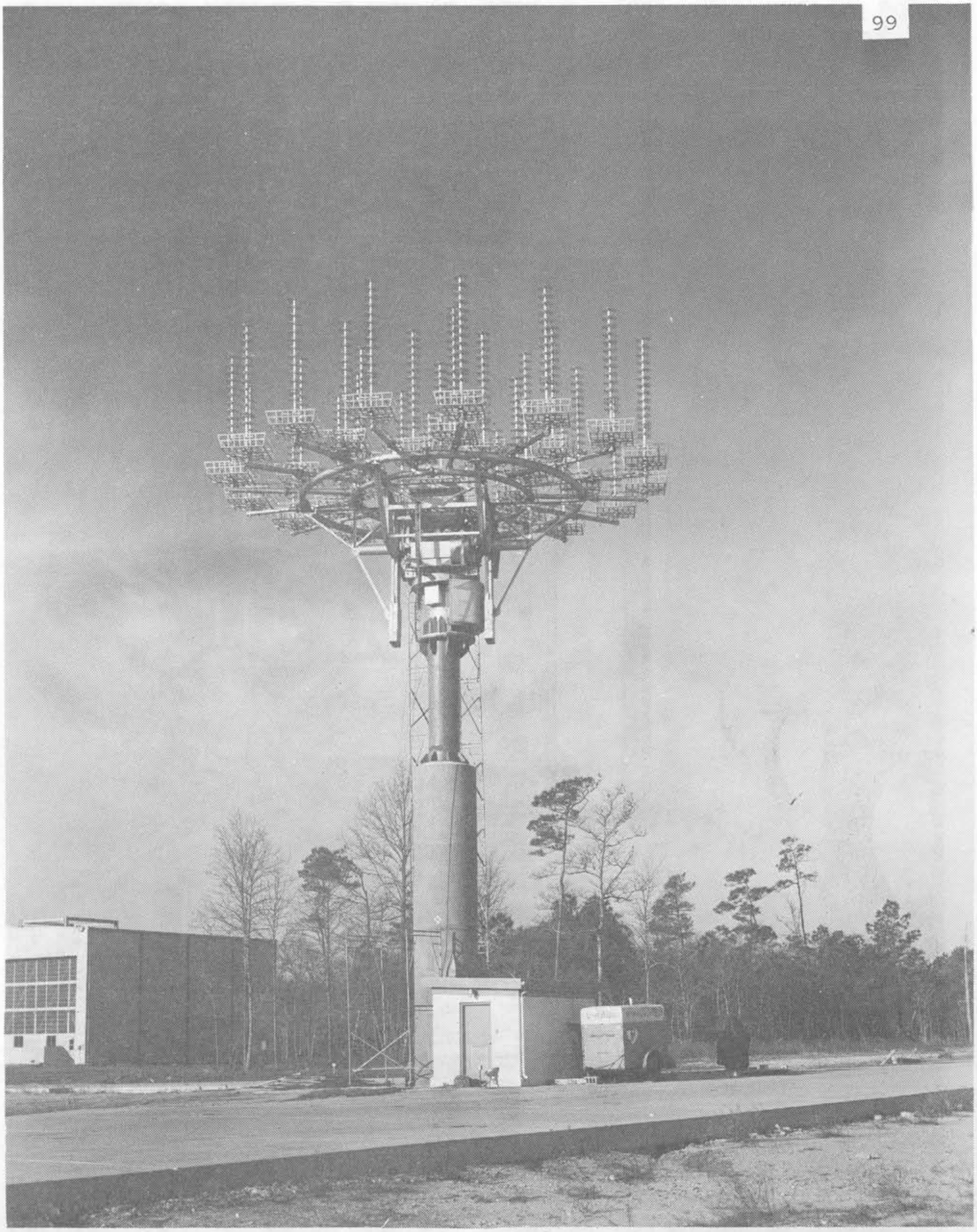
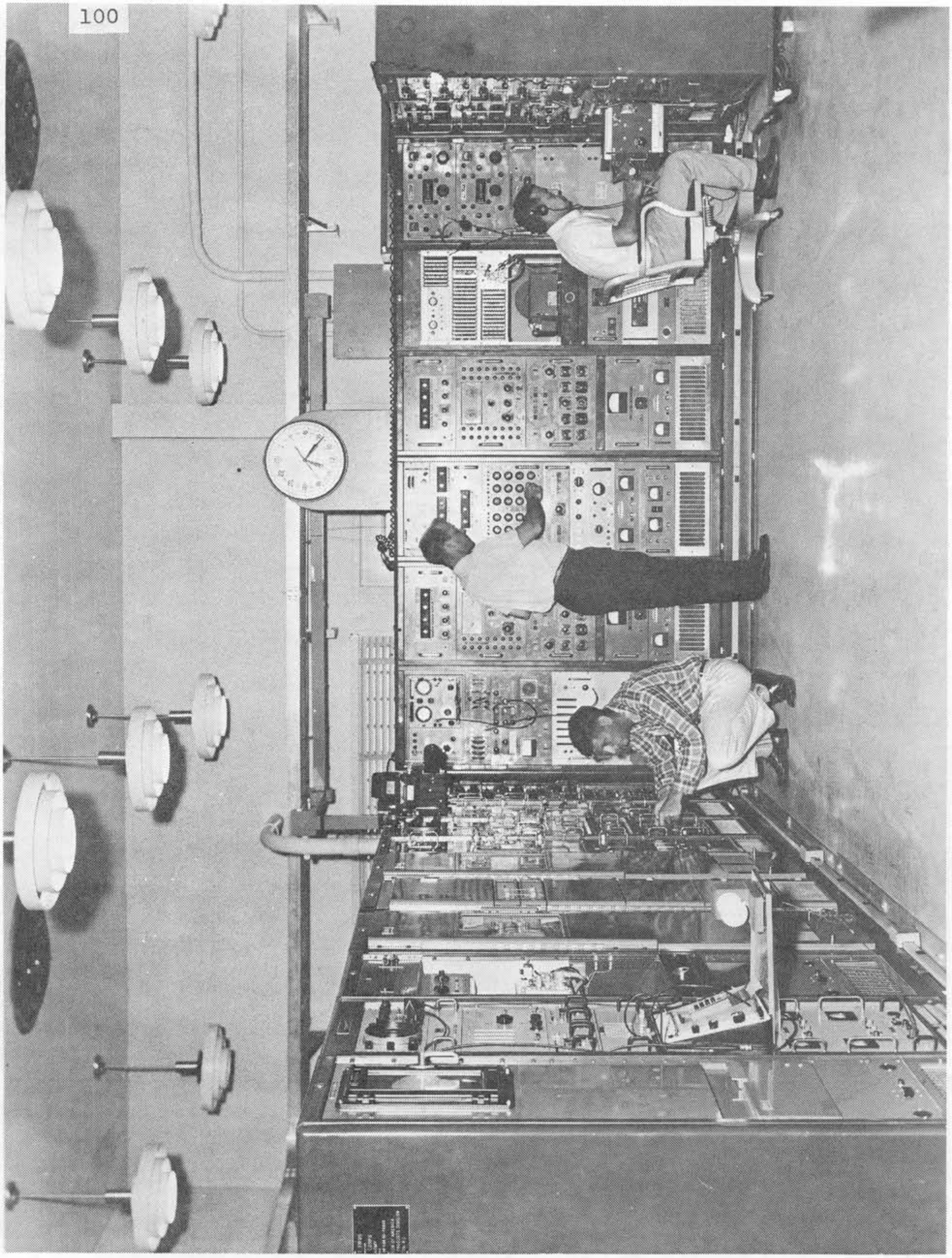
[160] AWSSS Staff Meeting Notes, 30Nov60.

[161] On 28 November Lt Col Weinstein, at the University of Wisconsin, advised AWS that he had considerable success in determining the upper-level winds from Explorer VII radiation charts. He sent the data to AWS for further study.

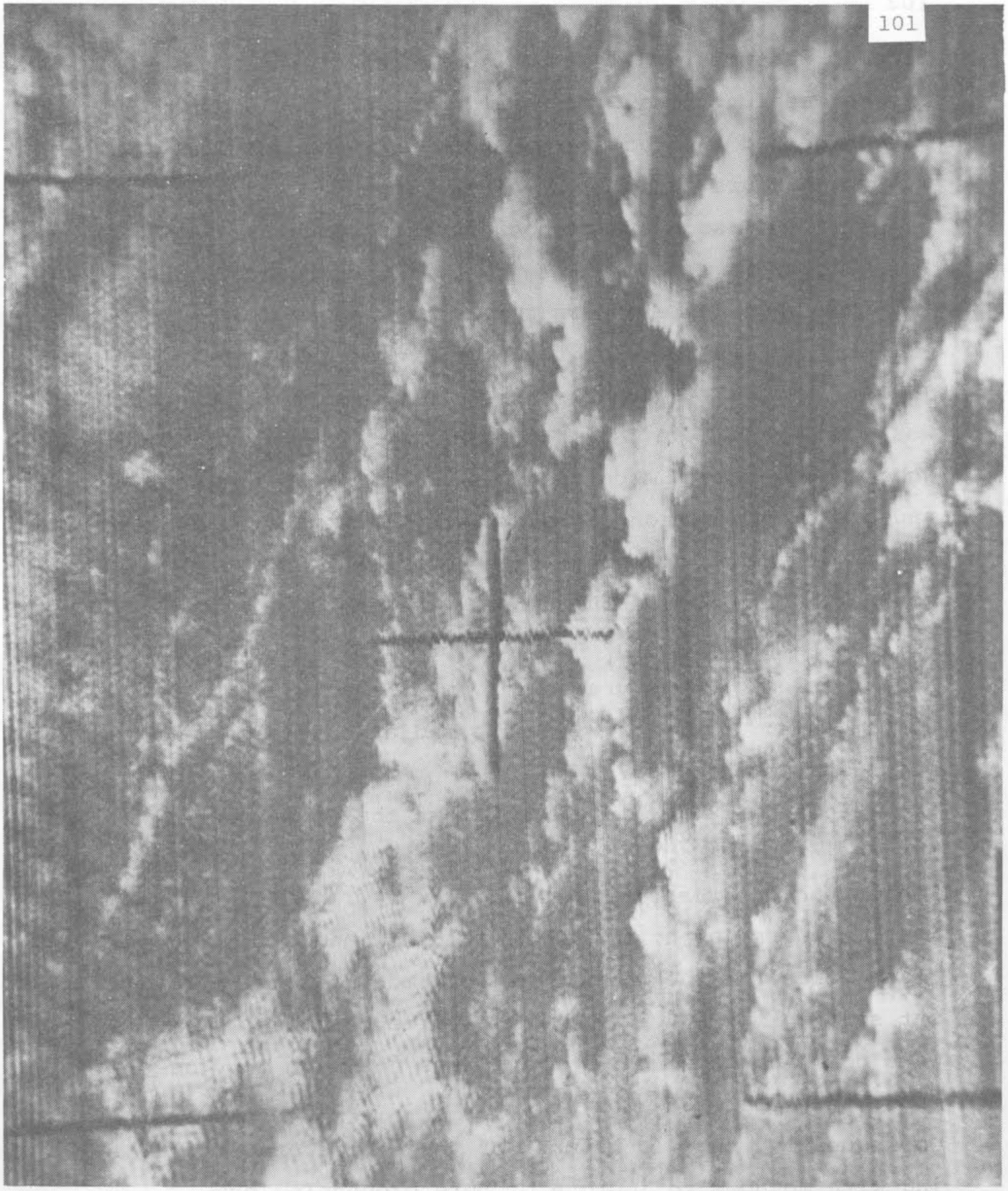
NASA's Wallops Island, Virginia, tracking station. The two antennas immediately left of the photo's center were used with TIROS satellites, while the tower in the photo's center was a boresight tower used to calibrate the antennas. (NASA Photo)



The high-gain, receiving antenna at NASA's Wallops Island facility used to receive data and track TIROS II. (NASA Photo)



General view of the receiving station interior at Wallops Island where thousands of TIROS pictures were received. (NASA Photo)



An example of the poorer quality, TIROS II pictures. Using the narrow-angle camera the picture was taken on 28 November 1960, as the satellite was northeast of Los Angeles pointing west. (NASA Photo) problem was working itself out. The satellite's power source was functioning properly. The AWS field units were expected to receive nephanalyses approximately every two hours during most of the day.[162]

TIROS II soon experienced further troubles. By 7 December, two weeks after launch, the picture quality from the wide-angle camera system had improved only slightly and was far below the standard established by TIROS I's camera systems. While many of the pictures were good enough for making nephanalyses, they were not good enough to be of much value in refining the attitude and orbit computations through direct observation of landmarks. And, the satellite's magnetic, attitude-control device had malfunctioned--the control switch kept slipping out of the neutral position, resulting in undesirable attitude precession. But the infrared system kept functioning and some radiation fields were plotted from the data.

Captain Bielinski reported that the Navy was very active in support of TIROS activities at Point Mugu. Senior ranking reservists were given a TIROS familiarization course as active duty training, and almost every flag officer in the naval district had visited the read-out station for a briefing. Air Force personnel there were doing an excellent job but were not kept busy because they processed only three or four passes a day. Consequently, they spent much of their time experimenting with methods to improve picture processing procedures.

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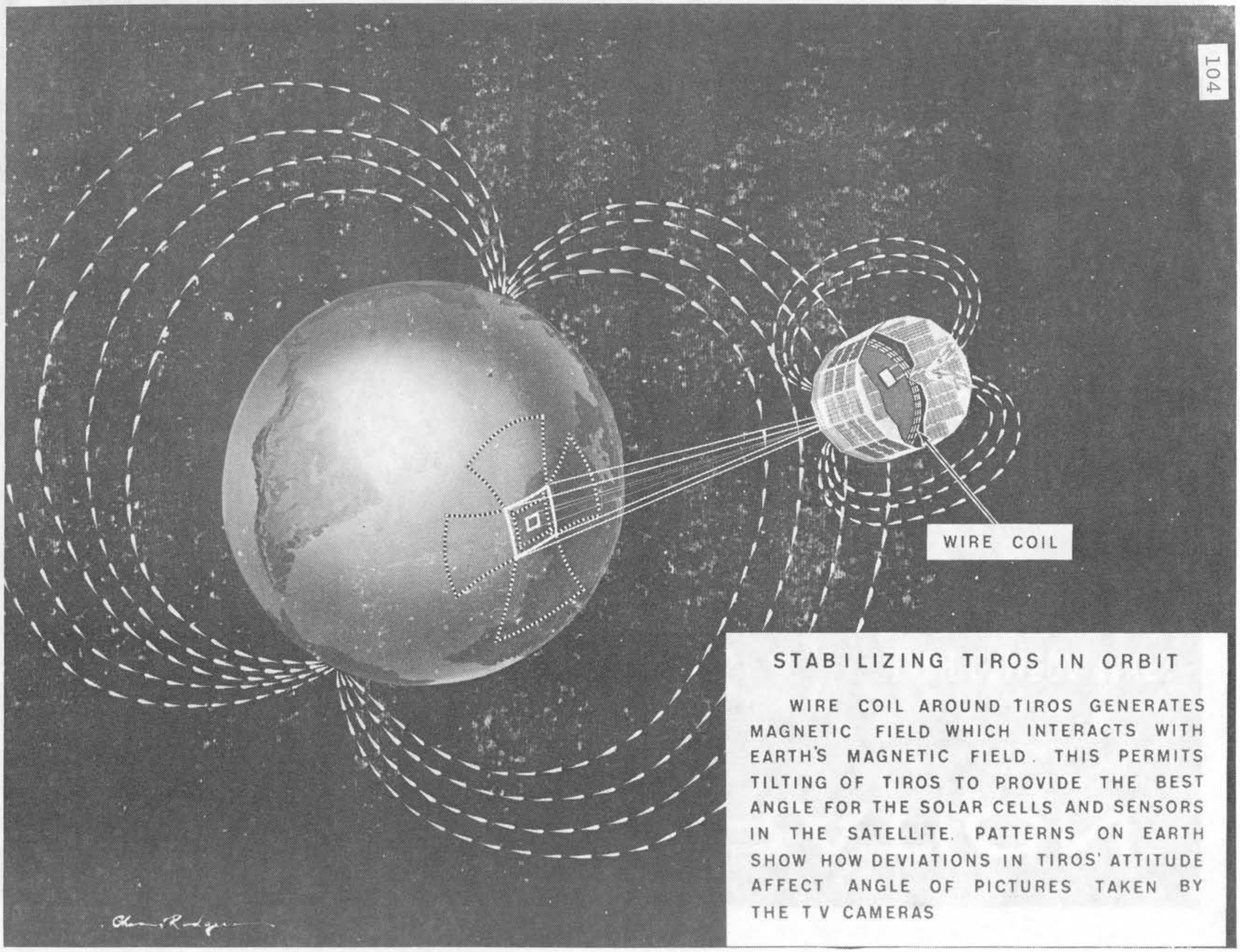
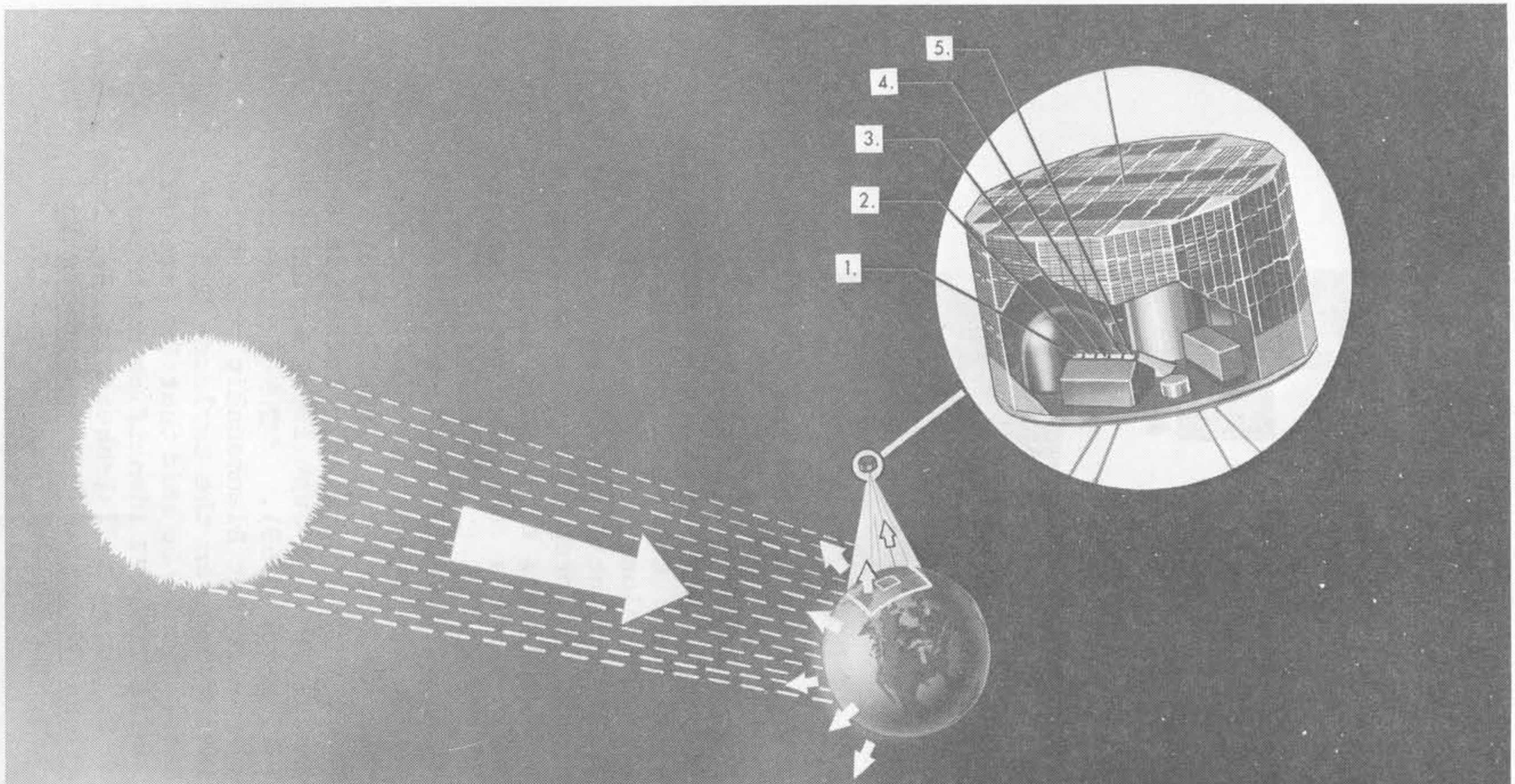
[162] AWSSS Staff Meeting Notes, 30Nov60.


TIROS OPERATION
ORBIT INCLINED 48°
TO EQUATOR
TIROS CIRCLES EARTH
ONCE EVERY 100 MIN.
AT AVERAGE HEIGHT OF
475 MILES
EACH CAMERA TAKES
32 PICTURES ON EACH
ORBIT
100 MINUTES OF
RADIATION DATA
ACQUIRED EACH
ORBIT
NEPHANALYSIS
CHANNEL 2
8-10 MICRONS
MAPPED RADIATION DATA
(TIROS II - NOV 23 1960)



STABILIZING TIROS IN ORBIT

WIRE COIL AROUND TIROS GENERATES MAGNETIC FIELD WHICH INTERACTS WITH EARTH'S MAGNETIC FIELD. THIS PERMITS TILTING OF TIROS TO PROVIDE THE BEST ANGLE FOR THE SOLAR CELLS AND SENSORS IN THE SATELLITE. PATTERNS ON EARTH SHOW HOW DEVIATIONS IN TIROS' ATTITUDE AFFECT ANGLE OF PICTURES TAKEN BY THE T V CAMERAS



INFRARED SYSTEM IN TIROS II

INSTRUMENTS IN TIROS II DETERMINE THE AMOUNT OF RADIATION REFLECTED OR EMITTED BY THE EARTH AND ITS ATMOSPHERE. CONSTANT KNOWN AMOUNT OF RADIATION STRIKES EARTH FROM SUN, LEFT. IN TIROS, RADIATION IS MEASURED IN DIFFERENT PARTS OF VISIBLE AND INFRARED SPECTRUM TO SHOW

1 REFLECTED SUNSHINE;
2 TOTAL RADIATION OF EARTH AND ATMOSPHERE;
3 RADIATION DIRECT FROM EARTH'S SURFACE OR CLOUD TOPS;
4 RADIATION FROM EARTH'S WATER VAPOR LAYER;
5 VISIBLE SPECTRUM FOR REFERENCE;

By 9 December, sixty-two TIROS II nephanalyses had been transmitted over the strategic facsimile circuit 1R9 with an average delay between observations and relay of 8.7 hours. The average, however, included five charts prepared from pictures stored with the satellite for 8-to-10 hours before readout. Waiting for free time on circuit 1R9 resulted in a delay estimated at 42 hours total for the 16 slowest moving charts. Had that particular delay been avoided, the average delay would have been reduced to about 7.3 hours. It compared favorably with regular, upper-air analyses, but was considerably short of AWS' goal of three hours from observation to transmission.

Scanty information received by AWS from NASA in December indicated that TIROS II's infrared data was good. Accuracy was estimated at plus-or-minus one degree centigrade from the broad-band, high-resolution infrared sensors. Dr. Suomi was quite enthusiastic about the data he saw. Beginning late that month, his laboratory at the University of Wisconsin planned to make balloon-borne, radiometer flights, timed to coincide with TIROS II passes.[163]

AWS input to the programming of TIROS II's picture taking was effective. The satellite's coverage of the Atlantic Ocean during a TAC aircraft deployment late in November was good, and its pictures of the recovery area

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[163] Soundings were made at Weather Bureau stations at Miami and San Juan; cooperative hurricane observation stations at Curacao, Grand Cayman, and St. Martin Islands in the Caribbean Sea and West Indies; at the Naval Air Station at Trinidad; and the AWS detachment at Albrook AFB, Canal Zone.

near Hawaii aided in the successful air-catch of the reconnaissance satellite, Discoverer XVIII.[164]

Acting on the USAF request above, AWS continued evaluating the operational utility of TIROS data. It included the correlation between satellite observations and actual surface weather conditions, and the winds and temperatures aloft, as well as other weather elements of military importance. AWS was also responsible for preparing an estimate of the degree to which an operational meteorological satellite system would improve AWS forecasting capability. Such an evaluation had to be based upon the most complete information obtainable. No amount of theoretical speculation would replace actual operational experience with satellite data. For that reason, many of its units were participating in several tasks which would give AWS scientists the information needed to make a valid judgment on the applicability of TIROS observations for operational use.

The major task, from the viewpoint of total participation, was the cloud pattern sketching program carried out by some 130 base weather stations across the United States. At year's end, most of the difficulties related to distribution of time and track information were overcome and AWS expected that all stations would receive adequate notice of each day's observation schedule. In addition to coded messages disseminated over weather teletype, maps showing satellite-pass schedules were transmitted over the 1R9 facsimile circuit.

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[164] See AWSSS Staff Meeting notes, 15Dec60, and Klass, <u>Secret Sentries in Space</u>, pp. 103-04.

A parallel task was accomplished with a JB-57 special reconnaissance aircraft of the 55th Weather Reconnaissance Squadron that was flown along a track below the satellite while strip photographs were taken of the clouds below for correlation studies.

In addition, a number of AWS units took photographs of their AN/CPS-9 weather radarscopes so that areas of precipitation captured by the TIROS II pictures could be properly analyzed.

Most important of all the evaluation programs, however, was that being made by AWS recipients of the TIROS II nephanalyses in applying the satellite observations to their daily weather forecasting activities. Despite a lack of specific guidance originally, many AWS units cited examples of improved analyses, especially over oceanic areas, resulting from an intelligent interpretation of the nephanalyses.[165] AWS advised its field units at the close of 1960 that some guidance would be forthcoming soon on the nephanalyses' use.

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[165] "TIROS II - A Preliminary Report on the Nephanalysis Program," AWSSS Review, Vol. 2, No. 4, 30Dec60, pp. 2-3.

APPENDIX A

TIROS I
Technical Data

The Launch Vehicle[1]

TIROS I was boosted into orbit by a THOR-ABLE launch vehicle very similar to the THOR-DELTA that NASA expected to launch for the first time during 1960. Like DELTA, the TIROS THOR-ABLE carried a Bell Telephone Laboratories radio command guidance system designed for the TITAN ICBM. This Bell Telephone system was also used in THOR-ABLE phase two nose-cone re-entry tests. The Aerojet-General second stage used in the TIROS launch was a surplus stage from the re-entry test program.

The Douglas THOR first stage (150,000-lb. thrust) burned approximately 160 seconds and, just before burn-out, the plastic fairing around the third stage and payload was jettisoned. The second stage Aerojet-General liquid-propellant AJ10 (7,600-lb. thrust) with its Bell Telephone Laboratories guidance system, powered the vehicle for about 100 seconds and, at burn-out, spin rockets stabilized it at 136 rpm. The second stage separated 1.5 seconds after the spin rockets fired. The third stage Hercules-Allegany Ballistics Laboratory X248-A7 solid-propellant rocket (3,050-lb. thrust) coasted for about 400 seconds before it ignited. The third stage separated from the payload 25 minutes after it burned out. The third stage carried a beacon designed by Lincoln Laboratory and built by Texas Instruments. For the first time in a NASA satellite launching, the third stage could be beacon-traced by radar.

The Orbit Achieved[2]

The orbit achieved by the TIROS I package was almost circular. TIROS I had a perigee of 435 statute miles and an apogee of 468

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1. "Tiros I Will Scan Cloud Cover, Earth Temperature," in Aviation Week magazine, March 14, 1960; and "NASA Tiros I Demonstrates Potential Satellite Reconnaissance Utility," in Aviation Week magazine, April 11, 1960.

2. "NASA Tiros I Demonstrates Potential Satellite Reconnaissance Utility," by Craig Lewis, in Aviation Week magazine, April 11, 1960; and "Weather by Satellite," Time magazine, April 11, 1960.

statute miles. Inclination to the equator was 49.326 degrees -- a value within .003 degrees of the intended inclination. Velocity at burn-out of the third stage was within 22 feet per second of the desired value. The orbital period was 99.15 minutes. Thus, its furtherest point from the earth was only 33 miles higher than the lowest point. This feat of orbital precision, unequaled by either U. S. or Soviet satellites to that time, was attributed to the Bell Telephone guidance system in the rocket's second stage.

Package Configuration and Power Supply[3]

TIROS I had been developed for NASA by the Radio Corporation of America's Astro-Electronic Production Division under technical direction of the Army Signal Corps' Research and Development Laboratory. TIROS I was drum-shaped with a diameter of 42 inches and a height of 19 inches, and weighed 270 pounds. Power was supplied by nickel-cadmium batteries charged by 9,200 solar cells, yielding about 19 watts of electricity. Cells were mounted in a series arrangement in groups of five on printed circuit boards, each accommodating 80 cells. A total of 63 nickel-cadmium storage batteries were aboard the satellite, supplied by Sonotone Corporation and with DC-to-DC power converters by Sorenson and Company. The solar cells were made by the International Rectifier Corporation for RCA.

Spin Rate[4]

The spin rate of the instrument package when it achieved orbit was too high for the television cameras to arrest the view. Slow-down to 12 rpm was achieved with a yo-yo device -- a pair of 180-degree-apart, cable-attached masses which were extended by centrifugal force radially from the satellite. When proper rotational speed was reached, the masses were released. Because of its spin rate, TIROS I was gyroscopically stabilized, keeping its axis pointed in a single direction as it circled the earth. Because the satellite was spin-stabilized, areas of the earth which could be seen were limited, since the TV

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3. "Tiros Satellite is Powered by 9200 Solar Cells," in Space and Aeronautics magazine, May 1960; "Weather by Satellite," in Time magazine, April 11, 1960; and "Tiros I Will Scan Cloud Cover, Earth Temperature," in Aviation Week magazine, March 14, 1960.

4. "Weather by Satellite," in Time magazine, April 11, 1960; "Tiros I Will Scan Cloud Cover, Earth Temperature," in Aviation Week magazine, March 14, 1960; and advertisement (sponsored by RCA Corp.), "TIROS I...mission accomplished," in Aviation Week magazine, June 20, 1960.

cameras looked at the earth only during a portion of each orbit. Spin-up rockets manufactured by the United States Flare Corporation and Associates were mounted around the base perimeter of the satellite, to be used when necessary to restore the satellite's spin rate to the optimum value of 12 rpm.[5]

Photographic Systems

Two TV cameras in the satellite photographed cloud cover in a relatively wide north ear h belt. The camera frame size was 1/4 by 1/4 inch. Each camera had 500 lines per frame, speed was 1/2 frame per second, shutter speed was 1.5 milliseconds, video band width was 62.5 kc. and power consumption was 9 watts. The wide-angle camera had a lens speed of f/1.5 and the narrow-angle camera a lens speed of f/1.8. Both TV camera systems were similar except for the specific optical systems. Each camera functioned as an independent unit and failure of one did not affect the other. Information from both cameras was transmitted in sequence to the ground receiving station. The projected field of the wind-angle camera was a square area, 800 miles on each side. The narrow-angle, high-resolution camera focused on a relatively small area (80-mile square) within the 800-mile square area.

For picture taking while within range of a ground station, the cameras could be commanded to feed their information directly to the transmitters, by passing the tape storage. Various programs of picture taking for each orbit could be pre-set by command into the clock mechanism that triggered the cameras at the proper points.

Each camera was connected to a magnetic tape recorder that could record as many as 32 pictures at 30 second intervals while the satellite was out of transmission range of ground stations, although the camera did not necessarily take 32 photos on each pass. By passing of the recorder was followed after the stored pictures had been transmitted to a ground station and while TIROS was still in range. The two camera systems and their associated equipment operated independently and transmitted data through 2-watt telemetry systems operating on 235 mc. These 330-ounce FM telemetry transmitters were built by Radiation, Inc.

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5. "NASA Tiros I Demonstrates Potential Satellite Reconnaissance Utility," by Craig Lewis, Aviation Week magazine, April 11, 1960; "Tiros Satellite is Powered by 9200 Solar Cells," in Space and Aeronautics magazine, May 1960; and advertisement (sponsored by RCS Corp.), "TIROS I...mission accomplished," in Aviation Week magazine, June 20, 1960.

The tape recorders were the heart of the satellite's remote picture storage capability. The castings were produced and machined by the Bridge Tool and Die Works, Inc., according to specifications supplied by RCA Corporation. Recorder tapes were 400 feet long and moved at 50 inches per second in recording and playback.

The photographic programs were run through a General Time Corporation electronic clock system that could be set as much as five hours in advance as TIROS passed over one of the ground readout stations. The clock system triggered the cameras at the proper time and controlled the picture-taking and recording program.

Programming[6]

TIROS I was programmed for succeeding orbits while within range of a ground station. Pulses received by the command receiver (the antenna protruding from the top of the package) established the time interval to start the clock in the satellite and also start the clock "alarm," which triggered the picture taking operation. The maximum interval which could be programmed between "start" and "alarm" signals was five hours. In operational sequence, the ground station sent a command signal to the satellite at some specific point in orbit to set the clock. A short time later the clock-setting phase was complete, and in a succeeding position in orbit the clock was started. At still another pre-determined orbital position, the clock signaled the "alarm" and the cameras began to scan.

Ground Stations[7]

A radar station at Millstone Hill, Mass., pinpointed the position in the trajectory where the satellite entered its orbit. Minitrack stations tracked the satellite and sent back position data to NASA's computation center, where subsequent orbits were calculated. NASA's Goddard Space Flight Center planned the actual program the satellite cameras would follow. Instructions were then sent to the two main ground stations which instructed the satellite system and received its photographs. Projected programs were coordinated with data compiled by the USWB's Meteorological Satellite Section.

Ground readout stations were at Fort Monmouth, New Jersey, and Kaena Point, Hawaii -- the former operated by the Army Signal Corps

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6. "Tiros I Will Scan Cloud Cover, Earth Temperature," in Aviation Week magazine, March 14, 1960.

7. Ibid. Also, "NASA Tiros I Demonstrates Potential Satellite Reconnaissance Utility," by Craig Lewis, in Aviation Week magazine, April 11, 1960.

and the latter by Lockheed Missile and Space Division. Back-up stations were at NASA's Cape Canaveral, Florida, facility and the RCA site at Princeton, New Jersey. These back-up stations could receive data but could not instruct the satellite.

After processing by the readout stations' photographic laboratories, TIROS photos were sent to the U. S. Weather Bureau for study and archiving.

APPENDIX B

News Media Reaction to TIROS I Launch

St. Louis (Mo.) Post-Dispatch[1]

WASHINGTON, April 2 (AP)--The first weather-eye satellite raced on today in one of the most perfect global orbits ever achieved, ready to feed back more pictures of how clouds cover the earth.

The first cloud pictures radioed yesterday by the new satellite launched by the United States brought an expression of "marvelous" from President Eisenhower. Needless to say, they delighted scientists who had fired the satellite, called Tiros, into its round-the-world orbit.

The first photographs, taken from 450 miles in the sky, were regarded as remarkably clear for such an experimental forerunner of what may be a network of weather watchers that could forecast big storms all over the world.

They took in an enormous quadrant of the earth, centered on the Gulf of St. Lawrence. Fleecy clouds spread over much of the United States-Canadian area.

Everything about the Thor-Able launching rocket and the 270-lb satellite worked in fine style after they rose from Cape Canaveral, Fla. All three stages of the rocket fired with split-second precision.

Tiros was supposed to go into a circular orbit 450 miles out. When the checking was finished, scientists found it varied from this ideal by less than 20 miles at its high and low points.

The angle of inclination from the equator, which determines what part of the earth the photo scanners will cover, was off less than three one-thousandths of a degree.

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1. News story, St. Louis, Mo., Post-Dispatch newspaper, edition of April 2, 1960.

"I think it's a marvelous development," said President Eisenhower when the first pictures were shown to him at the White House by T. Keith Glennan, head of the National Aeronautics and Space Administration.

The name Tiros stands for Television and Infra-Red Observation Satellite. It is pronounced Tie-ross.

The infra-red sensors, which can detect differences in temperature in the earth's atmosphere, were not ready in time to go into Tiros. They may go into Tiros II this summer.

The two television cameras for Tiros were both ready and working. They can snap up to 32 pictures on command, a few seconds apart. These can be relayed instantly to earth stations, or stored on magnetic tape to be sent back on command. When the tapes are full, they can be erased to start all over again.

Although Tiros, shaped like an oversized hatbox, is covered with solar energy cells, its batteries will play out in about three months because of the heavy demand on them.

Because of its near-perfect 100-minute orbit, Tiros may continue to orbit for many years.

Though it swings over much of the Communist world, Tiros is not likely to raise the temperatures of Russian leaders. Its pictures are not nearly detailed enough to show military installations on earth.

Belleville (Ill.) News-Democrat[2]

WASHINGTON (UPI)--The spectacular photos flashed back to earth by America's new Tiros TV satellite made it clear today that such eyes-in-the-sky eventually could be used to spot Russian military moves.

Scientists emphasized that the 270-pound Tiros, carrying two television cameras, was designed only to snap pictures of the earth's cloud cover that will lead to more accurate weather forecasts and could help man control the climate.

But Tiros pictures--whose clarity surprised even scientists working on the project--plainly were a giant first step toward a military reconnaissance satellite.

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2. News story, Belleville, Ill., News-Democrat newspaper, edition of April 2, 1960.

President Eisenhower exclaimed, "A marvelous development," when he was shown four photos of the gulf of St. Lawrence area just seven hours after they were taken by Tiros from an altitude of 450 miles.

The drum-shaped Tiros was launched into orbit at 6:40 a.m., e.s.t. Friday by a three-stage Thor-Able rocket from Cape Canaveral, Fla. It is circling the earth once each 99.15 minutes.

The Tiros pictures released for public viewing were not sharp enough to disclose details on the ground that would be of military value.

But there was no way of knowing how many possibly clearer photos were withheld on security grounds. The satellite's orbit takes it over Russia.

The Tiros project--standing for television and infrared observation satellite--is not connected with military reconnaissance satellite programs. Scientists, however, are sharing data.

The Defense Department is planning a Midas infrared satellite to detect the flaming exhaust of Russian intercontinental ballistic missiles almost as soon as they are launched and a Samos military spy-in-the-sky satellite.

Even without its military implications, Tiros opens new vistas for weather forecasting and control.

/The obvious "slant of the UPI dispatch was toward greater military reconnaissance capability than TIROS possessed. Within a few days subsequent to the launching, the AWS statement for use in answering queries from news media was worked up to specifically point out how AWS was using the data./

AWS Statement for Answering Questions from the Press[3]

Unlike the Army Signal Corps and the Office of Naval Research, AWS possessed no R&D capability of its own, and thus was concerned mainly with operational utilization of any available observation sensor, including the cloud-cover photographs from TIROS I. The statement worked up to answer questions from news media representatives, therefore, discussed only operational use of the data. News media representatives were to be informed, if and when they queried AWS officials, that data received from TIROS I was being fed into the

3. "Statement for Press Use of TIROS Data," Hq AWS, undated (about 8-10 April 1960).

regular transmission system of AWS for use of AWS forecasters; that such data provided valuable information regarding cloud coverage in remote areas. Further, it was possible to relate the satellite's cloud coverage data to other factors such as rain and wind. Although AWS made no news release about TIROS I as such, the statement to be used in answering questions read as follows:

(Statement)

The Air Weather Service has been able to collect cloud photographs transmitted by TIROS I and to send them to field forecasting stations on a real-time basis. That is to say, the cloud information was in the hands of the forecaster about, on the average, ten hours after TIROS passed over the area which it photographed.

On a number of occasions the accuracy of specific predictions was considerably improved because the forecaster had been provided cloud-coverage information over remote areas from which such information otherwise would have been unattainable. As an example, the forecaster at Eglin AFB, Florida, secured timely photographs of cloud formations over the Gulf of Mexico from which he had only a few widely scattered spot observations of clouds overhead from surface vessels. Because of the vastly greater cloud-coverage information provided by TIROS, the forecaster was able to predict cloud coverages, several hours in advance and with accurate detail, required by rocket-test personnel at Eglin.

Air Weather Service will continue its assessment of satellite cloud photographs during the coming tests of TIROS and NIMBUS vehicles. It will do so for two purposes. The first is to avail itself, on a real-time basis, of cloud information for use in forecasting for current Air Force operations. The second is to isolate system deficiencies, from the operational point of view, which must be overcome in order that a successful, economical, operational system can be launched at a later date.

Air Weather Service suspected at the outset, and then found from experience, that cloud-cover data from the vantage point of the satellite would greatly augment the sources of data otherwise available. It also found that the value of the new data depended considerably on the number of other cloud observations made in a particular area of interest. As suspected, it turned out that the accuracy of forecasts over remote ocean and land areas were the most enhanced. Air Weather Service believes that, for at least the near future, the greatest value of the meteorological satellite will continue to be its provision of cloud-cover, and cloud-type, data.

Experience has also shown that cloud-cover and cloud-type information by no means obviates other kinds of weather observations.

Other systems (such as the present operational ones) are required for data on ceilings, visibilities, turbulence, rainfall, and other factors of great significance to aviation. Other systems, too, are needed for measurement of winds which affect the in-flight time of aircraft and which, in the form of severe storms, can cause great damage to ground installations. These other systems include radiosonde installations for measurement of upper-air conditions and aircraft reconnaissance systems which probe the winds and other elements of storms such as hurricanes. In connection with the latter phenomena, it must be remembered that TIROS can tell precisely where the hurricane center is located and what its cloud coverage is, but that it can not tell how strong the winds are throughout the storm, nor where it will be in the future. Here, the satellite and aircraft must act as a team--the first vehicle telling the second one where to go to make its detailed measurements and, at the same time, freeing the aircraft from its former inefficient function of searching more or less blindly for significant weather features.

In summary, the satellite is a tremendously important augmentation to other observational tools insofar as cloud coverage is concerned, especially for remote areas. Cloud data derived therefrom definitely provides the means for preparation of more accurate and detailed predictions of cloud coverages as well as, to a somewhat lesser degree, of other phenomena (such as rain) which can be indirectly, and with some amount of error, related to cloud cover.

Other News Media Reaction[4]

Practically all of the major magazines featured TIROS I in editions subsequent to the launching. Life and Time news magazines featured the satellite in April 1960 issues, in a more carefully researched and objective manner than some of the initial press syndicate dispatches. Business and Commercial Aviation magazine included data in its June issue which highlighted the AWS use of TIROS data. And, finally, the AWS Observer -- AWS's own internal publication -- reported on the initial success of the satellite in its April 1960 edition.

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4. "TIROS Begins a New World of Weather," Life magazine, April 11, 1960; "Weather by Satellite," Time magazine, April 11, 1960; "Intelligence" section of Business and Commercial Aviation magazine, June 1960 issue; and "TIROS I, Pioneer Weather Satellite, Proving Successful," in AWS Observer newspaper, Vol. 7, No. 4, April 1960.

C O P Y

APPENDIX C

A PROPOSAL FOR AN OPERATIONAL METEOROLOGICAL SATELLITE SYSTEM

I. Requirement

The Air Weather Service in providing required specialized meteorological service to the United States Air Force must be prepared to support the command and control systems and operations within the aerospace. To provide this meteorological support we rely on observations from specific points on or near the earth's surface where a small percentage of these observations include a sounding of the lower atmosphere to measure wind, temperature, pressure, and humidity. From measurements at these discrete points we make certain assumptions and convert point values to a continuous pattern designed to represent the actual continuous motions and activity of the meteorological atmosphere. Where observations are plentiful we have achieved reasonable success in partially describing the lower atmosphere. However, the cold hard fact which has always faced the meteorologist is that by far the greater portion of the earth's surface is covered by water or ice. Ironically, it is over these areas where most of our air masses originate, yet it is also here where our surface and atmospheric sounding data are generally the sparsest.

We are particularly concerned about the increased number and frequency of operations and proposed activities over these sparse data areas requiring rather detailed descriptions and forecasts of cloud cover. For example, aerial refueling, missile firings, DISCOVERER and DYNASOAR shots, and reconnaissance satellites are all sensitive to cloud cover. Typhoons and hurricanes originate over these same areas and with our restricted reconnaissance capability we are faced with an even greater dearth of critical observational data essential to the protection of military life and property. The Air Weather Service cannot be expected to provide accurate forecast service over areas where little or no data are available. An accurate forecast requires accurate and existing observed weather information.

The advent of TIROS I has suggested that a very promising means of supplementing our current observational network with cloud-picture data is now operationally feasible. We can, for the first time, obtain more complete essential weather information from normally sparse data areas. In addition, if we are forced into hostilities with any nation and are denied the use of data from its national weather network, the meteorological satellite will offer the meteorologist relief from such war-imposed "silent areas."

II. Application

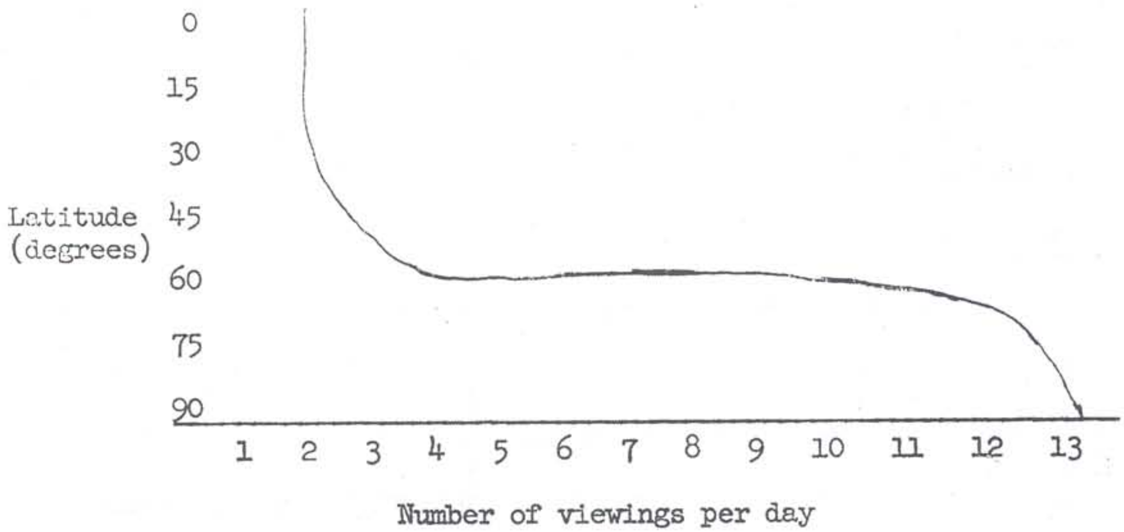
The information to be available from the follow-on vehicles to TIROS I will be directly applied to our forecast support activities. As of the present time with suitable communications we can use the data for direct weather support to refueling activities, down-range requirements for missile firings, DISCOVERER activities, and typhoon and hurricane surveillance.

In addition, development efforts are already underway so that wind direction and apparent wind speed will be extracted from cloud pictures for input to computer prognostic programs. Success in these efforts will materially improve our capability to forecast upper level winds over sparse data areas. Over wartime "silent areas" we could, for the first time, accurately indicate cloud cover for low altitude bombing, reconnaissance, and damage-assessment missions. The improved wind forecasting capability could be directly applied to route, target, and ballistic wind forecasts.

Although data from the several NASA research meteorological satellites will be extremely useful to us, these satellites will not necessarily cover and/or read-out data over the areas of primary military interest. Blank periods must be expected between launchings when no transmitting meteorological satellite will be in orbit. Further, we are not aware of any attempts or plans, on the part of NASA, to develop supporting components necessary to an operational system. We do not feel that we should be in the position of a supplicant to a research organization. Plans should be made for an operational meteorological satellite system to provide a more complete and continuing global observational coverage. If meteorological support is expected to evolve consistent with the accuracy and timeliness demanded by aerospace vehicles and the command and control systems, we must plan for such a program now.

III. Concept

Our concept for operation of a meteorological satellite system is that an earth-oriented satellite will be placed in a near-polar orbit. This type of orbit will provide complete global coverage twice daily over low latitudes, once near noon with high resolution and once around midnight with infra-red. Over high latitudes, regions may be viewed several times a day because of overlapping of the viewing swaths.



Cloud-picture information from the read-out sites will be processed so that the cloud patterns are properly located on a flat map. Next, information will be derived for input to the AWS IBM 7090 at Offutt AFB. In addition, mapped cloud data in the form of facsimile charts will routinely flow from Offutt Weather Central over military circuits to forecast centers and detachments.

An automatic picture-taking and direct read-out feature, included in the meteorological satellite system, would make data in the area of any read-out station available to that station. This feature would satisfy the requirements of ships at sea and overseas elements of the U. S. Armed Forces. As an instrument of peace in the cold war, the system could satisfy the commitments of this nation to the United Nations and the World Meteorological Organization by making data in the area of a read-out station available to any nation who wishes to build and operate such a station. This feature could give the USSR pictures of their own area only, and even this feature could be denied by command control.

More detailed information on some of the system requirements as we know them plus cost estimates are specified in Appendix A.

IV. Control Responsibility

Doubtless there are enough gaps in meteorological knowledge for NASA to conduct fruitful experiments and research for the next decade. The Weather Bureau, although vitally interested in the meteorological satellite program, is primarily concerned only with forecasting for the United States and monitoring those nearby regions from which weather directly affects the U. S. Therefore, we feel that the operational meteorological satellite should be under military control to support adequately the global interests of the United States Air Force.

APPENDIX A - SYSTEM REQUIREMENTS

1. Orbit.

A 600-n.m. circular orbit is desired with a retrograde 80.1° inclination and a period of 108 minutes. Launched at the proper time, the satellite would cross the equator going northward at local noon and going southward at local midnight. This orbit has the property of using the equatorial-bulge effect to maintain the plane of the orbit properly oriented in relation to the earth and the sun. The 108-minute period produces 13-1/3 passes each 24 hours with the subsatellite path described across the surface being repeated once each three days.

2. Instrument Capabilities Aboard the Satellite

Cloud patterns of the entire globe must be viewed. Because of the rate at which weather systems move and change and new systems develop, cloud observations must be made at least twice daily. The conditions for televising are best near local noon to identify cloud types. The second of the two daily observations (at low latitudes), accomplished by use of infra-red around local midnight, needs only to depict the gross cloud picture to measure weather system motion and development.

a. Power Subsystem. Chemical storage batteries sufficient to run the control, sensing, and transmission subsystems are required. Sufficient auxiliary nuclear power or solar cells will also be necessary to keep the chemical batteries charged.

b. Control Subsystem. IR horizon scanners and a rate gyro are required to sense attitude and rate of attitude correction along the three axes. Pneumatic or small rocket power will provide rough correction, and inertia wheels fine corrections. Automatic-attitude correction should maintain an earth-oriented attitude with an accuracy of $\pm 2^{0}$ on all axes for a period of six months - the estimated active life of each satellite.

c. <u>Sensory Subsystem.</u>

(1) <u>Automatic Picture-taking Camera</u>. No storage is required for this camera which is an 800 lines-to-the-inch vidicon type with 105^{0} field of view. The camera automatically takes a picture for immediate transmission every 4 minutes. From a position 600-n.m. above the earth, this produces a picture 1000 n.m. square with an overlap between pictures of about 200 n.m. The resolution capability is $1\frac{1}{2}$ miles.

(2) <u>Electro-static Tape Camera</u>. A 100^{0} X 6^{0} field is viewed with a resolution of 0.3 mi. From 600 n.m. this camera will scan and record a swath 1620 n.m. wide. Storage is required for 1/2 orbit.

(3) <u>Infra-red Scan-type Sensor.</u> A 100^{0}-long field is viewed to cover a 1620-n.m. swath with a 2-n.m. resolution. It will operate at the wave-length required to sense cloud cover at night. Storage is required for 1/2 orbit.

d. <u>Transmitter Subsystem.</u> This system should be capable of "dumping" data stored from one orbit in 5 minutes. Separate transmitters will be required for the automatic camera and tracking beacon.

e. Instruction Subsystem. A clock and instrumentation to store and put into operation instructions for 7 orbits is required. This is so that only one read-out station need to be equipped to send instructions.

3. Data Read-out Stations.

Only two read-out stations with 1200-n.m. pick-up range are needed to receive all passes of the proposed 80.1° inclined (near polar) orbit provided they are properly located. It is proposed that the stations be located at Fairbanks, Alaska, and in northern Norway. The TLM 18 with 60 foot steerable dish is capable of 1200-n.m. range reception from a powerful transmitter aboard a vehicle 600 n.m. above the earth. The Alaskan station should have the added capability of transmitting a half-day's set of instructions twice a day. No transmit capability is required of the Norway station.

4. Communications.

The satellite will transmit a voluminous amount of data which must be rapidly relayed and reproduced in accurate detail. High-quality communications support will be required between the read-out stations and the processing center.

5. Rectification.

The laborious task of transposing cloud images by hand from one map projection (spherical) to another (mercator) and finally to a chart for facsimile transmission is not only time-consuming but much of the original picture is lost in the process. Rectification equipment is required to faithfully reproduce the cloud picture from the original electrical message. This equipment, by adding the feature of removing the earth's curvature, could then retain the quality of the original observation and, at the same time, provide a much more useful product. Such rectifying machines can be based on either an optical or electronic principle. There are some being built for the Air Force which probably could be modified to treat a larger geographical area. (The original TIROS concept included a rectifier; but it was dropped in an economy move.) Rapid communications and a rectifier will provide cloud-cover data in a useable form in 1/2 to 2 hours after observation time.

6. Cost Estimates.

a. Equipment.

These figures must be regarded as rough estimates based, where possible, on comparative costs of TIROS.

(1)	The launch vehicle, one THOR-AGENA B each 6 mos	$5,200K
(2)	Launching costs at the rate of one each 6 months including post-launch support	200K
(3)	The satellite, one each 6 months	3,000K
(4)	Engineering test and check-out facility	300K
(5)	Read-out stations - original construction of two TLM 18-type tracking stations with facilities for forwarding data once received	6,500K
(6)	Annual operating expenses of the read-out stations	150K
(7)	Communications to Offutt, annual cost	10,000K
(8)	Annual ground-control center costs	75K
(9)	Picture rectifier, original cost	100K

b. Manpower not Including Launching Personnel.

(1) At the two read-out stations .. 60 men - about the size of a small AC&W site. (It may be possible to have Norway man the Norwegian read-out station as a NATO contribution.)

(2)	Increase at existing ground-control center	7 men
(3)	Data handlers at Offutt	10 men
(4)	Extra weather analysts	no increase

c. Total Outlay.

First year, construction and operation $26 million

Subsequent annual operation - $19 million plus 77 men.

APPENDIX D

RESUME OF ACTION TOWARD NACCAM COORDINATION OF OPERATIONAL METEOROLOGICAL SATELLITE DEVELOPMENT

Events leading up to the present status stated on page 3 are essentially as follows. A BACKGROUND SUMMARY is given on page 3.

On October 10, 1960, a meeting was called by NASA and attended by the Department of Commerce, Department of Defense, U. S. Air Force, U. S. Navy, FAA, and NASA for the purpose of

a. exchanging views on policy questions relating to both the R&D and the operational aspects of meteorological satellites;

b. exchange of information of related activities in the several agencies; and

c. to consider methods of consultation, advice and coordination.

Following this meeting and in line with NASA's view that it is 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.

Pursuant to the meeting of October 10, NASA by letter of November 14, 1960 and Enclosure B thereto suggested a course of action for planning for an operational meteorological satellite system. The major action recommended was the establishment of an Interagency Meteorological Satellite Planning Committee (IMSPC). The objectives of this committee would be to review the requirements submitted by the individual departments and incorporate them into a technical, operational and management plan responsive to civilian and military requirements.

Discussion

It was recognized at the October 10 meeting that it was desirable for the Joint Meteorological Satellite Advisory Committee (JMSAC) established by NASA in 1959 to continue as an interdepartmental coordinating group on research and development of meteorological satellites.

With the R&D functions thus coordinated through that committee (JMSAC) under NASA leadership, it was subsequently concluded that any other plans or activities with respect to meteorological satellites in which interagency coordination would be necessary will relate basically to operations and uses of satellite output. These matters immediately involve meteorological service functions and in many ways are identical to matters now treated by the Joint Meteorological Group (JMG) of the Joint Chiefs of Staff for responsibilities that are primarily military, and the National Coordinating Committee for Aviation Meteorology (NACCAM) for matters of common concern for civil, military, and general public interests. As regards requirements for meteorological satellites, the Joint Meteorological Group in December 1959 adopted a preliminary statement of requirements which are presently under review.

Based on existing meteorological coordination arrangements including work currently under way by JMSAC and the JMG and recognizing that NACCAM is responsible for general interagency coordination in all common service activities in meteorology in the Federal Government, NASA concurs with the Weather Bureau's suggestion that certain proposals or items listed in their Enclosure B to their letter of November 14, 1960, be coordinated within the framework of JMG and NACCAM. Many of these items involve operating plans which from the standpoint of overall coordination it would be best to have considered by these committees along with other meteorological matters of the same general nature. Accordingly, NASA agrees that it would be desirable to establish a working committee on satellite meteorology within NACCAM and to have this committee proceed as rapidly as possible with the development of an operational plan.

Because of budget considerations and the need to have a comprehensive plan ready to turn over to the new Administration, NASA has urged prompt action, and NACCAM is considered the responsible interdepartmental committee.

Background Summary

The value of meteorological satellite output anticipated in articles published in 1954 and subsequently has been abundantly verified by the photographs transmitted through TIROS I and later developments. Photographs and other information given by TIROS satellites bring important new knowledge, not only for research purposes but also for daily weather analysis and forecasting for aviation and many other operations and for storm warnings to the public. The possibilities imply that a new era is beginning in many features of weather service.

Because satellite data will vitally amplify synoptic weather data from other sources and will be most useful if integrated into the common flow of weather reports from surface and upper air stations, ships at sea and other national and international sources representing many different agencies, coordination in planning and operating activity in meteorology is very important. Only in this way can best use be made of all data pertaining to weather analysis and wasteful gaps in coverage or duplication be avoided. For many years it has been the function of the interdepartmental committee on meteorology dating back to the mid-40's, to bring about the necessary coordination and this committee has been very successful in accomplishing this function. From time to time the name of the committee has been changed to adjust to other departmental machinery. The committee is now designated by the name - National Coordinating Committee for Aviation Meteorology (NACCAM). By the nature of things with no sharp dividing line possible between the various applications of synoptic meteorology, the committee has functioned as a general coordinating committee in meteorology with special attention to aviation aspects.

Present Status

1. In view of the urgency, action has been taken by telephone to establish a Working Committee on Satellite Meteorology under NACCAM to be chaired by the

NASA representative on NACCAM and to be composed of members from NASA, DOD, Commerce, and other agencies represented on NACCAM who have an interest.

2. Because of the urgency involved, the Chairman (Mr. Cortwright--NASA) plans to hold a meeting of the Working Committee on December 8 at 3:00 p.m.

3. The above action will be presented for further review and formal action at the next meeting of NACCAM. A special meeting will be called next week for this purpose if desired by a majority of the members of NACCAM but present discussion by phone indicates that the action outlined above is satisfactory and will be taken up at the next regular meeting of NACCAM.

(signed) F. W. Reichelderfer

F. W. Reichelderfer
Chairman, NACCAM

APPENDIX E

USAF GUIDANCE ON COMMON METEOROLOGICAL OBSERVATION SATELLITE SYSTEM

1. USAF policy guidance on the proposed Common System of Weather Observation Satellites (COSMOS) follows:

a. The Air Force supports a common meteorological satellite system operated by a non-military agency provided the system meets military satellite data requirements.

b. The agency designated as the National Executive Agency for the operation of this common system should:

(1) Anticipate departmental budgetary support;

(2) Recognize that the military application potential of meteorological satellites cannot be subordinated to normal civilian data requirements.

(3) Appreciate the need for, and be prepared to insure interdepartmental coordination of:

(a) Launch facilities.

(b) Orbit scheduled and characteristics.

(c) Tracking and read-out facilities.

(d) Data processing and utilization operations.

c. The Air Force prefers to have a single agency budget for the entire satellite system. However, the plan must include management and coordination mechanism that will insure the budgeting agency is responsive to overall requirements.

d. If it is absolutely necessary to the success of the system, the Air Force will participate on a minimum funding basis. In this connection we are exploring the economic feasibility of launching meteorological satellites as a by-product of other funded USAF space activities.

f. The NASA NIMBUS and AEROS R&D Program should be fully exploited as a source of operational data prior to implementing comparable operational systems.

g. The Bureau of Budget should participate in drafting the operational plan to assure that budgetary planning is consistent with policy and resources availability.

h. Air Force representatives should not agree to any plan provision which violates the foregoing guidance without prior Headquarters USAF approval.

APPENDIX F

C O P Y

NASA News Release No. 60-299 (Hold for Release Until Launch)

TIROS SATELLITE PAYLOAD

Today's launch from Cape Canaveral will attempt to place a 280-pound meteorological satellite into a circular orbit, 400 miles above the earth. Primary satellite instrumentation consists of two television cameras to photograph cloud cover and infrared sensors to map radiation in various spectral bands. Launching vehicle is a Delta rocket.

With the exception of the infrared equipment, this spacecraft is similar to TIROS I launched April 1, 1960. Tiros is a contraction of Television and Infrared Observation Satellite.

Shaped like a round pillbox, the satellite measures 42 inches in diameter and 19 inches high. Its top and sides are covered with over 9000 solar cells. Extending beneath the payload are four transmitting antennas. A single receiving antenna is located on the top.

The Delta launching vehicle is programmed to place the satellite in a circular orbit, about 400 miles high with an orbital inclination to the equator of 48 degrees. Travelling at nearly 17,000 mph, the satellite will circle the earth about every 100 minutes.

Following is a description of the Tiros Meteorological satellite experiment.

POWER SUPPLY. The 9260 solar cells supply electrical energy to 63 nickel-cadmium storage batteries which in turn provide power to operate the experiments within the satellite package. Power conservation is expected to average about 20 watts.

TRANSMITTERS. There are five transmitters to relay data from the satellite to ground stations.

a) Two 235.0 mc transmitters operating with a power output of 2 watts; one associated with each TV system and operated by ground command.

b) One 3-watt 237.8 mc transmitter for the infrared experiments; operated by ground command.

c) Two 30-mw tracking beacons operating continuously on frequencies of 108 and 108.03 mc; beacon frequencies will be modulated by ground command to relay satellite environmental data such as temperature, pressure and battery charge. For backup purposes, both frequencies carry the same data.

TELEVISION SYSTEM. The satellite's two TV cameras, identical except for lens equipment, are each the size of a water glass and use a ½-inch Vidicon tube especially designed for satellite use. The cameras, which peer through the baseplate of the Tiros, are aligned parallel to the satellite spin axis. Each camera consists of a Vidicon and a focal plane shutter which permits still pictures to be stored on the tube screen. An electron beam converts this stored picture into a TV-type electronic signal which can be transmitted to ground receivers. Characteristics of the camera systems are:

	Narrow Angle	Wide Angle
Lens speed	f/1.8	f/1.5
Shutter speed	1.5 millisec.	1.5 millisec.
Lines per frame	500	500
Frames per second	1/2	1/2
Video bandwidth	62.5 kc	62.5 kc
Coverage (cameras vertical to earth)	75 miles (app.)	750 miles(approx.)
TV resolution (cameras vertical to the earth)	0.15-0.2 mile	1.5-2.0 miles

Connected to each camera is a magnetic tape recorder and timer. Out of ground station range, each TIROS camera can record up to 32 pictures on the storage tape for later relay; this can be done by programming the timer. Or, picture data from the cameras can be commanded to by-pass the tape for direct transmission to the ground when within the range of a station (1000-mile radius). The plastic tape is 400 feet long and moves 50 inches per second during recording and playback. The two TV systems operate independently of one another.

Photo data are transmitted from one camera at a time. Tape readout from both cameras will take about 3 minutes. The satellite will be within transmission range of ground stations up to 10 minutes. This means TIROS can transmit directly over 3 minutes of photo data collected by each camera while within range of the ground station.

HORIZON SENSOR. An infrared sensor, mounted on the rim of the spinning satellite, senses when its field of view crosses the earth's horizon. This data is carried continuously by the two tracking beacons unless they are commanded to transmit environmental information. The horizon sensor can be used to determine the satellite's attitude in space.

NORTH INDICATOR. Around the sides of the payload are nine solar cells. These cells generate impulses which measure the position of the satellite with respect to the sun. This data is transmitted with the TV transmission to the ground stations, where it is processed by a computer to show which direction is north in each picture.

MAGNETIC ORIENTATION CONTROL. A satellite spinning in space can develop a magnetic dipole which is equivalent to a small bar magnet. This is caused by closed circuit loops in circuitry and by any magnetic materials present in the satellite. The magnetic dipole, interacting with the earth's magnetic field as the satellite orbits, produces torque -- a turning force. This slowly changes the direction of the satellite's spin axis in space, and so changes the direction in which the TV cameras are pointing. This effect was discovered in the changes in direction of the spin axis of TIROS I.

Scientists say the strength of the magnetic dipole, and therefore the spin-axis direction changes, can be controlled to some extent by programming by ground command various steady currents through a coil of wire wound around the outside of the satellite. An experiment to test this thesis has been incorporated in this TIROS satellite, and attempts will be made to orient the spin axis to obtain optimum performance from the TV and infrared systems.

An aluminum wire is wound around the sides of the satellite, just above the baseplate. Current from the TIROS' power supply will be fed at ground command through the coil. The current can be turned off or on or varied when the satellite is under control of one of the ground stations.

INFRARED RADIATION EXPERIMENTS. There are two radiation experiments. One consists of five infrared detectors. These are oriented at 45 degrees to the spin axis and scan through a combination of the satellite's rotation and its movement along the orbit. The spectral bands and objectives of these detectors are:

1. Earth's albedo -- the percentage of reflectivity of radiant energy or light: 0.2-5 microns.

2. Infrared radiation emitted by earth and atmosphere combined: 7-30+ microns.

3. Emitted radiation through the atmospheric "window" (where the atmosphere is quite transparent): 8-12 microns. Information here should include: (a) cloud detection, especially at nighttime and over areas where the TV cameras are not operated; (b) cloud top temperature and, accordingly, a rough measure of cloud top height; (c) surface temperatures over cloud-free areas.

4. Radiation from water vapor band: 6.3 microns +5%. This will measure the geographic distribution of water vapor at the tropopause, which is about 25 to 30 thousand feet altitude.

5. Visual range: 0.5-0.7 micron. This visual channel is intended to give a map similar to the other radiation maps which could be used to relate the TV pictures and radiation maps.

The second IR experiment consists of two sensors, one white, the other black, which together measure the heat balance of the area of the earth viewed by the wide-angle TV camera. The white body measures the heat radiation from the earth while the black body measures both visible (reflected solar radiation) and heat radiation.

The purpose behind the IR experiments is to find out how much solar energy is absorbed and emitted by the earth and its atmosphere, which may lead to a better understanding of the meteorological effects of this phenomenon.

GROUND STATIONS. The two primary ground command and data readout stations are located at San Nicolas Island, California (part of the Pacific Missile Range), and at Fort Monmouth, New Jersey. A back-up station is located at Princeton, New Jersey.

OPERATION. When the payload is separated from the third stage of the Delta launch vehicle, it will be spinning at about 126 rpm. About 10 minutes after separation, a timer will release a de-spin mechanism to slow the revolutions to about 12 rpm. The de-spin mechanism consists of two weights attached to cables wound around the satellite. As the weights unwind they slow the rate of spin, and when completely unwound they drop off, automatically.

To remain stable in orbit, TIROS must maintain a spin rate of at least 9 rpm. When spin slows to this minimum, one of five pairs of control rockets will be fired to speed up rotation. Located around the baseplate of TIROS, each pair, activated by ground command, can be used only once.

Since TIROS is spin stabilized, it will not be "looking" at the earth at all times. Based on tracking information, Ft. Monmouth and San Nicolas Island will program the cameras to take photographs only at those times when the satellite is viewing the earth and when the area to be photographed is in sunlight. Program commands can be given as much as five hours in advance. Pictures taken while TIROS is out of range of the ground stations will be stored on tape for later relay. In the remote mode, an electronic timer starts the camera, power, and transmitter functions. Each readout wipes the tape clean. It immediately rewinds for its next recording.

When the satellite is within range of a station, ground command can directly turn on the cameras and photographs taken above the station will be relayed immediately below, by-passing the magnetic tape.

Data from the infrared experiments is recorded continuously for one orbit on magnetic tape for playback on command from one of the ground stations. If not read off after one orbit, the tape will automatically start erasing its previous data as it begins recording radiation data during the next orbit. However the tape always has the last 100 minutes of radiation data stored on it for playback whenever commanded.

At the ground stations, cloud-cover pictures will be displayed on kinescopes for photographing. In addition, both photo and infrared data will be recorded on magnetic tapes.

Infrared tapes will be sent to NASA's Goddard Space Flight Center for processing and analysis. Negatives of cloud pictures will be sent to the U. S. Naval Photographic Interpretation Center for photo developing and processing.

There will be meteorological teams at both primary ground stations. They will analyze some of the most immediately useful data and some pictures will be transmitted in real time through weather communications networks for limited experimental use.

The TIROS satellite is expected to operate for about three months. When its usefulness ends, the tracking beacons can be commanded off.

This U. S. launching is part of a long-range program designed to develop a satellite capability for providing world-wide meteorological information. The ultimate goal of the weatherman is to have world-wide meteorological observations at his finger tips for analysis. Such a wealth of data would lead to a more complete understanding of our weather, and this would assist him in preparing his weather forecasts.

The three major aims behind the development of meteorological satellites are:

1. To produce global observations of the atmosphere over the entire globe -- oceanic and desert areas as well as inhabited areas.

2. To provide as completely continuous observations as is scientifically required and technologically possible.

3. To study how the sun's energy is converted into atmospheric motions by measuring the variations in the solar energy and variations in the earth's use of this energy.

TIROS I, launched April 1, 1960, demonstrated the feasibility of meteorological satellites. It transmitted 22,952 cloud cover photos during its operating lifetime of nearly three months. It relayed meteorological information from many sections of the world where weather information had been scanty or until this point nonexistent.

This later TIROS satellite is an experiment -- in itself it cannot be considered an operational weather system. Its useful lifetime is expected to be only about three months. However, the Weather Bureau, the Air Force Air Weather Service and the Navy Weather Service plan to use some of the cloud-cover data on a limited, experimental operational basis.

NASA and the U. S. Weather Bureau have invited weather agencies in 21 foreign countries to participate in meteorological research in connection with this TIROS experiment. It was suggested that weather agencies abroad might obtain useful synoptic results by intensifying standard meteorological observations, or by arranging for special observations, coordinated in time with passes of the satellite. The invitation is representative of the U. S. effort of encouraging international cooperation in space research.

NASA will provide orbital information to those countries interested in participating to assist cooperating groups in timing local weather observations. After processing, TIROS cloud cover photos will be forwarded to participants for comparison with their supplementary observations. If the infrared radiation experiment proves successful, this data will also be sent to cooperating foreign weather agencies. The cooperative effort will probably get under way about one month after successful launch.

Weather agencies which have already expressed an interest in participating are: Australia, Belgium, Denmark, England, German Federated Republic, France, India, Japan, Mexico, Netherlands, South Africa, and Switzerland. Norway and Sweden have also expressed their desire to participate although the satellite's orbit may make their participation marginal.

Other interested countries may also ultimately obtain the scientific data, including cloud cover photos, through the world data centers.

Officials concerned with the TIROS experiment include: Dr. Morris Tepper, Chief of Meteorological Satellite Programs, NASA headquarters; Dr. Rudolf A. Stampfl, Project Manager, NASA's Goddard Space Flight Center; William G. Stroud, Head of the Meteorology Branch at Goddard; Abraham Schnapf, Project Manager for RCA's Astro-Electronics Division; Dave Johnson, Project Manager for the Weather Bureau's Meteorological Satellite Laboratory; John Maskasky, U. S. Army Signal Corps Research and Development Laboratory, NASA's Senior Representative at the Fort Monmouth ground station; and John Masterson, Pacific Missile Range, Point Mugu, Calif., NASA's Senior Representative at the San Nicolas ground station.

TIROS PROJECT PARTICIPANTS

The over-all responsibility for the project rests with the National Aeronautics and Space Administration. The operational phase of the project is under the direction of NASA's Goddard Space Flight Center. Goddard will prepare the command programming which the ground stations will relay to the satellite. These programs will be based on information from NASA's Computing Center and the Meteorological Satellite Laboratory of the U. S. Weather Bureau. The radiation experiments were designed and the data storage and telemetry equipment associated with them were constructed by Goddard where the IR data will be analyzed. Operational tracking will be provided by the Minitrack network.

With the exception of the infrared experiments, the satellite was designed and constructed by the Astro-Electronics Division of RCA, Princeton, N. J., under contract to NASA. In addition, RCA was responsible for the special ground station equipment. Barnes Engineering Company, Stamford, Conn., under NASA contract, provided the radiation detectors. The U. S. Army Signal Corps monitored the payload and ground station equipment contract for NASA during the developmental phases of the TIROS experiment.

The U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J., operates one of the TIROS ground stations. The other, operated by the U. S. Navy, is on San Nicolas Island, California, a part of the Pacific Missile Range. A back-up station is located at RCA's facility in Princeton, N. J.

Douglas Aircraft Company is prime contractor for the Delta launch vehicle. In addition, it is responsible for launching services, supported by the Air Force Missile Test Center which operates the Atlantic Missile Range. The Delta uses a Bell Telephone Laboratories guidance system, employing Remington Rand Univac equipment.

The Meteorological Satellite Laboratory of the U. S. Weather Bureau, under NASA funding, is responsible for analysis of cloud cover data. Cooperating in the project are the U. S. Navy Photographic Interpretation Center, the Geophysics Research Directorate of the Air Force Cambridge Research Laboratories, the Air Force Air Weather Service, and the Navy Weather Service. The Weather Bureau and the military weather services will attempt to use some of the cloud cover data on a limited, experimental basis.

LAUNCH VEHICLE

The Delta vehicle used to launch TIROS II has three characteristics:

Height - 92 feet
Max. diameter - 8 feet
Lift-off weight - a little less than 112,000 pounds.

First Stage (modified USAF Thor):

Fuel - liquid (LOX and kerosene)
Weight - about 100,000 pounds fueled
Thrust - about 150,000 pounds
Burning time - 160 seconds
Guidance - radio guidance system (mounted on second stage) and roll and pitch programmers

Second Stage (Aerojet General):

Fuel - liquid
Weight - more than 4,000 pounds
Thrust - about 7,500 pounds
Burning time - 109 seconds
Guidance - radio guidance system (Douglas Aircraft flight controller plus Bell Telephone Laboratory)

Third Stage (Allegany Ballistics Laboratory X248):

Fuel - solid
Weight - more than 500 pounds
Thrust - about 3,000 pounds
Burning time - 40 seconds (after 7-minute coast)
Guidance - spin-stabilized

Orbit planned:

Circular, about 400 miles high and 48 degrees to the equator.
Launching angle - 46.5 degrees
Orbital period - 100 minutes

Firing sequence:

The first stage falls away on burnout. The second stage ignites immediately. The nose fairing which covers third stage and payload is jettisoned after 20 seconds of second stage burning. The third stage doesn't ignite until 7 minutes of coasting after second stage burnout. Then the third stage is spin-stabilized and the second stage falls away. The third stage reaches an orbital velocity of almost 17,000 miles per hour.

The second Delta launched the ECHO I communications satellite on August 12, 1960. The first Delta was unsuccessful in launching a similar satellite on May 13, 1960.

NASA Hq Delta Project Manager - Vincent L. Johnson.

Delta Technical Director, Goddard Space Flight Center - William Schindler.

Head, Goddard Field Projects Branch at Atlantic Missile Range - Robert Gray.

Delta Project Manager, Douglas Aircraft, Santa Monica, California - Horace Irwin.

Douglas Manager at AMR - Bill E. Stitt.

APPENDIX G

News Media Reaction to TIROS II Launch

St. Louis (Mo.) Post-Dispatch[1]

NEW WEATHER SATELLITE FIRED INTO ORBIT FOR FORECAST USE

First Cloud Pictures Received, Will Be Sent to Washington -- Nearly Circular Path Achieved

CAPE CANAVERAL, Fla., Nov. 23 (AP) -- The United States put a robot weatherman into orbit today and quickly started getting back cloud pictures which scientists hoped to use in actual weather forecasts.

The camera-carrying satellite, Tiros II, was launched at 6:13 a.m. from the missile test center at Cape Canaveral, Fla.

Two hours later the National Aeronautics and Space Administration announced it had achieved successful orbit very close to the planned height of 400 miles.

Then in another two hours NASA reported that pictures had been received at the Fort Monmouth (N.J.) station of the Army Signal Corps from the smaller of the two television cameras aboard.

Dr. Morris Tepper, chief of NASA on meteorological satellites, told a press conference in Washington that pictures had not yet been received from the second camera but it was expected they would be received during a subsequent pass around the earth.

Being Developed

He said the pictures already received were being developed at Fort Monmouth and would be sent immediately to Washington.

(The satellite sent eight blanks after its first pass, United Press International said, because it was tipped at an angle when the photographs were taken. The second time around it sent pictures of cloud patterns over the Dakotas and the northern plains area. The satellite still was somewhat tipped when these pictures were taken but it was expected to straighten itself out later by means of stabilizing rockets.)

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1. St. Louis, Mo. Post-Dispatch newspaper, edition of 23 Nov 1960.

Tepper said that today marked a "very happy occasion" for NASA.

He said the first look at the orbit and other characteristics of the new "weather eye" was "very good."

Tiros II was fired into orbit on the nose of a 92-foot Thor-Delta rocket.

It takes Tiros II about an hour and a half to circle the earth.

The satellite was aimed to sweep over an area stretching from 50 degrees north latitude to 50 degrees south. In the Western Hemisphere, this extends roughly from Montreal, Canada, to Santa Cruz, Argentina.

An NASA statement said: "Initial calculations show a perigee (low point) of 415 statute miles and apogee (high point) of 435 miles. The orbital period is 98 minutes."

Near Circular Orbit

The variation of only 20 miles between the near point and the far point of the orbit indicated that the satellite is in the most nearly circular orbit of any satellite yet launched.

The regular orbit also would indicate a relatively long lifetime for the satellite.

The orbit announcement came at 8:20 a.m.

Shortly before that signals from the satellite indicated that a de-spinning mechanism operated as planned, about 10 minutes after Tiros separated from the third stage.

The satellite at separation was spinning rapidly for stabilization, at about 126 revolutions a minute. Had it continued to turn at this speed, all its pictures would have been blurred.

Weights Unwind

Two weights attached to cables wound around the satellite were set by a timing mechanism to unwind slowly, gradually reducing the spin to a satisfactory rate. When completely unwound they were set to drop off automatically.

Should Tiros continue to reduce its spin rate below the nine revolutions a minute required to hold the satellite stable in its orbit, a ground command can fire control rockets to increase the spinning. There are five pairs of these rockets, for a total of five spin speed-ups should they be needed.

Tiros II, the fourteenth space success of the United States, is sending back signals on two frequencies. One was given as 235 megacycles. First information on Tiros II did not indicate what the other frequency was.

First Was Experimental

This is the second Tiros but the first was purely experimental--to see if the mechanism would work and produce anything useful. This time the plan is to use information from the satellite in regular forecasts.

Although pictures from Tiros I turned out clearer and more interesting than expected -- it found a tornado and a hurricane -- assembly and analysis of the information was too slow for any practical value in forecasting.

Tiros II, while still experimental, is expected to be of real aid because of the speed with which data will be assembled and distributed.

The satellite will pass over and take pictures of southern Russia and southern China, but will not cross the northern parts of those countries.

The original NASA invitation to participate in the Tiros weather observation program was sent to 21 countries, including Czechoslovakia and the Soviet Union.

Russia Does Not Accept

Among the 13 that have accepted the invitation, there are no Iron Curtain countries. However, Communist weather officials may still be able to join the program if they wish because the co-operative international phase will not get into full swing for three to four weeks.

Tiros II is shaped like a large drum, with two television cameras protruding from its base. It resembles Tiros I which spun into orbit last April. That satellite relayed 22,952 cloud cover pictures before its instruments went out after 78 days. Tiros II is an advanced model.

No effort was made to predict the weather with the first Tiros, but comparison of the high altitude photos with ground observations made it possible to relate certain cloud formations to cold fronts, storms and other phenomena. NASA scientists said this proves the feasibility of satellite weather forecasting.

Teams of meteorologists were stationed at two key Tiros II ground stations to process and analyze pictures swiftly. Those considered useful for weather forecasting were to be transmitted rapidly to the National Weather Center in Washington, D. C., for distribution.

Satellite Network Planned

If this weather eye in the sky works as planned, it could pave the way for an operational network of six or seven satellites which could quickly forecast big storms all over the world. It is believed such a system could be functioning within four or five years.

Major difference between Tiros I and Tiros II is that today's vehicle carried seven infrared sensors to record the temperature of the earth, clouds and oceans below, and to measure the heat balance between the earth and the sun. This information is vital to weather reporting because heat from the sun is the prime force which makes the atmosphere circulate, thus causing our weather.

Tiros II is 19 inches high and 42 inches in diameter. Its top and sides are spangled with 9200 solar cells to draw power from the sun for its estimated useful life of three months. Four transmitting antennas extend from the bottom and a single receiving antenna from the top. The inside of the package was micro-miniaturized electronic gear.

One of the TV cameras is designed to take pictures covering an area 800 miles square. The second camera narrows down the field to a square 30 miles on a side, providing an enlarged picture to enable weathermen to identify cloud types.

Belleville (Ill.) News-Democrat[2]

NEW WEATHER SATELLITE
IS FIRED INTO ORBIT

CAPE CANAVERAL, (UPI) -- The United States shot a camera-bearing Tiros II weather satellite into a near perfect orbit today and it began sending back pictures of the earth's cloud cover as a forerunner of weather forecasting from space stations.

The first Tiros satellite, sent up last April, found a tornado and a hurricane, and today's more sophisticated vehicle was expected to do even better although both are experimental devices.

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2. Belleville, Ill. News-Democrat newspaper, edition of 23 Nov 1960.

After its first pass Tiros II sent eight blank pictures because it was tipped at an angle at the time. But then it sent a series of pictures to Ft. Monmouth, N. J., where they went through processing before being sent to Washington.

The first pictures were taken by the smaller of the 280-pound satellite's two television cameras. Still to be tested was its larger, wide-angle lens camera and infrared sensors which are to be used when the portion of the earth being photographed is dark.

A Thor-Delta rocket carried the 280-pound Tiros II to America's 14th space success of the year. A Transit III - a navigation-aid satellite - was poised on a nearby pad for an attempt at No. 15 next week.

The federal space agency said initial calculations showed Tiros II was traveling around the earth once every 98 minutes. It hit an almost precisely circular orbit, carrying it 435 miles into space at its furthest point and 415 miles at its nearest approach to the earth. This was very close to the orbit scientists had hoped for.

St. Louis (Mo.) Globe-Democrat[3]

TIROS IN GOOD ORBIT BUT
CLOUD SHOTS ARE FUZZY

CAPE CANAVERAL, FLA. (AP)--A camera-carrying weather-eye satellite zipped into orbit Wednesday and quickly started transmitting cloud pictures which meteorologists hope to use in actual forecasts. However, there was indication of disappointment with early results.

The 280-pound robot weatherman--Tiros II--rode into space atop a thundering Thor-Delta rocket. Its near-perfect circular orbit ranged from 406 to 431 miles above the earth.

Within hours, the drum-shaped satellite transmitted pictures snapped by the smaller of its two television cameras. Officials of the National Aeronautics and Space Administration expressed satisfaction at the time and said the larger camera would begin transmitting soon.

It did, but the resulting pictures appeared disappointing. It wasn't certain whether there was an equipment malfunction or whether the poor results were a temporary situation caused by an initial power drain.

NASA was hopeful the quality of prints would improve.

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3. St. Louis, Mo., Globe-Democrat newspaper, edition of 24 Nov 1960.

The purpose is to use pictures of cloud cover over large portions of the globe in forecasting large weather systems such as snowstorms, making Tiros II the world's first working space weatherman.

The large camera takes photos covering an area 800 miles square, and the second camera snaps a zone 30 miles on a side in the center of the larger area. The enlarged photos taken by the second camera enable weathermen to identify cloud types. But without the over-all pictures of the large lens, it is difficult to pinpoint the exact portion of earth photographed by the small camera.

The first pictures relayed by the satellite were of a section of the Dakotas and northern plains and their cloud cover.

Dr. F. W. Reichelderfer, chief of the United States Weather Bureau, told newsmen in Washington that it was doubtful pictures received Wednesday would be beneficial in forecasting Thursday's weather.

He said it was too soon to make predictions because such factors as the position of the satellite at the time of exposure cannot always be read off promptly in a way that would allow immediate use of a given picture.

He said: "If a hurricane had been developing this morning and had not yet been picked up, it might be picked up by the satellite."

The indication was that day-to-day detailed forecasts such as "will it rain tomorrow?" will have to await more advanced satellites. But any major storm weather might be analyzed swiftly even with Tiros II pictures.

New York Herald Tribune[4]

BIRTH of TIROS II

U.S. Agencies and Industry
In Top Roles

PRINCETON, N.J. -- How is a satellite born? It arises in the minds of men and from the work of their hands. One hundred engineers and scientists fathered Tiros II, the cloud-catching, heat-handling weather satellite now wriggling across the sky.

These men designed and built its fifty important sections composed, in all, of some 20,000 individual parts ranging from two sensitive TV cameras to 9,300 solar batteries to power the scientific equipment aboard.

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4. N.Y. City, N.Y., Herald Tribune newspaper, edition of 24 Nov 1960.

They came from four large companies and government agencies plus a dozen smaller firms. Most of the men work for the Astro-Electronic Products Division of the Radio Corporation of America which designed and built Tiros I. Others joined in from the National Aeronautics and Space Administration, the Army Signal Corps, and the United States Weather Bureau.

The Idea Man First

A scientist -- his name now lost in endless committee discussions -- germinated the original idea: he wanted a way to photograph the distribution of clouds over the earth. He also wanted to measure the amount of heat this planet lost and gained each day. With this information, he could better predict tomorrow's weather. Or so he believed.

The job of translating this idea into hardware fell to the RCA scientists, who received from NASA the prime contract for constructing Tiros (television and infrared observation satellite). Three of these satellites will cost between $10,000,000 and $13,000,000 altogether.

The Task

As did all satellite makers, from those who built the first Sputnik and the first Explorer onward, they faced the peculiar conditions of the space beyond the earth. They had to deal with the brutal shaking the satellite equipment would get from a rocket launching.

But most important of all, the delicate electronic parts had to operate for at least three months without a human being around to tinker with it should any part fail. Once the satellite is launched, no screw driver can reach it.

The Testing

The design of the various components involves the highest art of electronics. To test the performance in space conditions, the RCA scientists built a huge tin can into which Tiros (forty-two inches in diameter and nineteen inches high) would fit. They pumped all the air out of the can. They had a vacuum approaching that of space.

Inside that can they had heating and refrigeration coils to cook the satellite at temperatures of 96 degrees Fahrenheit or to chill it down to 32 degrees below zero. In that way they discovered that some parts just wouldn't work in that temperature range. New designs were made.

Man's Failings

To mimic the thunderous vibrations of take-off, the scientists placed the satellite on a shaker table in the hope of knocking something loose. Or they put the gadget on a merry-go-round to subject it to thirty-five times the force of gravity -- the force it would feel as the rocket roared aloft. (Twice the centrifuge failed, but the satellite held out.)

But the scientists' biggest hurdle was their own human failure. A wrongly placed screw, a miscalculation, a component poorly designed -- all these errors can combine with overwhelming frequency when you are dealing with 20,000 different parts.

"If only we could keep our dirty hands off things," one scientist said here with a sigh.

Yet they got Tiros I to work. In the three months its electronic gear circled aloft, the device took 23,000 pictures of the clouds around the world. It didn't work perfectly. One of the timing devices went on the blink, cutting out one of the tape recorders.

After two and a half months, a relay -- "five-cent gadget," one engineer said with disgust -- apparently clogged so that one camera was on continuously and burned out the batteries.

Tiros II has two extra pieces of gear. One is the infrared gadget that picks up the heat of the earth. The other is a coil of wire wound around its belly. This coil, intermittently filled with electricity, turns the satellite into a magnet. The magnet interacts with the earth's magnetism and in this way the scientists on the ground can steer the axis of the box.

Inevitably, too, the scientists could not help improving things in a technical way. Tiros II should work even better than Tiros I. Perhaps it will operate longer than three months. In that case it can go into the shadow of the earth for several months, come out again and be ready to take pictures.

Belleville (Ill.) News-Democrat[5]

WASHINGTON, Nov. 25 (UPI) -- Scientists today studied information radioed from the Tiros II weather satellite to determine what is wrong with one of the television cameras and whether it can be remedied.

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5. Belleville, Ill., News-Democrat newspaper, edition of 25 Nov 60.

The National Aeronautics and Space Administration reported there had been "some indication of improvement" in the quality of cloud cover pictures being transmitted by the wide-angle camera, which has failed from the start to provide clear photos.

The narrow-angle camera, meanwhile, continues to send back good pictures of weather patterns around the world as the 280-pound drum-shaped satellite circles the earth. Tiros II was launched from Cape Canaveral, Fla., Wednesday. New calculations showed the high point of the orbit was 453 miles above the earth and the low point was 387.

The small camera takes pictures of cloud areas that cover a square of 75 miles. These photos, however, need support from the large camera's photos to give scientists useful weather information.

The large cameras snap pictures of clouds that cover areas of 800 miles square. These pinpoint the locations of the small photos.

In an effort to find out what's causing the malfunctions in the wide-angle camera, NASA yesterday "interrogated" the satellite--send an electronic signal to which Tiros II responded by radioing back certain scientific information.

The data from the satellite are being analyzed at ground stations near Fort Monmouth, N.J., and Oxnard, Calif., where pictures from Tiros II are being received. An NASA spokesman said the study "may make it possible" to do something about the malfunctioning camera.

Tiros I, the predecessor in a series of satellites designed to improve weather forecasting, also worked improperly for a time.

A failure in the timer on the narrow-angle camera prevented the satellite from taking cloud cover pictures over Russia and Red China for a while. The trouble corrected itself after more than a month.

In a spectacular space feat, a scientist diagnosed a malfunction in the Pioneer V sun satellite when it was 5,500,000 miles from earth last April and sent electronic instructions to the satellite to by-pass a piece of faulty equipment.

St. Louis (Mo.) Globe-Democrat[6]

WASHINGTON (AP)**Tiros II, the new weatherman satellite, was reported doing a good job Thursday in checking the heat balance of the earth.

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6. "1 Tiros Camera Doing Well," in St. Louis, Mo., Globe-Democrat newspaper, edition of 25 Nov 1960.

Also the smaller of its two cameras was working well, while scientists tried to find out, and correct, what went wrong with the bigger one.

The bigger one, taking pictures of the earth's clouds over an area of 800 miles square, was sending back photos that were too poor in quality to reveal much.

The little one covers a 30-square-mile zone in the center of the big one's field, but a wider area is needed to make it easy to spot just where on earth the camera was snapping pictures.

Tiros II was sent into orbit Wednesday from Cape Canaveral, Fla. New calculations showed its high point was 453 miles above the earth and low point was 387. Early estimates figured these at 431 and 406, whereas the desired orbit was about 400 miles.

Headquarters of the National Aeronautics and Space Administration reported Thursday that the infrared experimental equipment carried by Tiros II was doing its job.

This equipment provides information on the amounts of radiation from the earth and its atmosphere, the amount of reflected sunlight, and the amount of visible light reflected back into space.

The scientists hoped that the one spot of trouble -- with the big camera -- might correct itself. Pictures from Tiros I, purely an experimental satellite, grew better as time went on and the theory was that the power supply built up after an initial drain. Batteries get their power from sunlight.

Aviation Week Magazine[7]

Washington -- Tiros II weather satellite is providing excellent infrared data, but scientists doubt that performance of the wide-angle camera will improve much beyond its current 5-10% usefulness.

Although initial operation of the system showed high promise . . . the wide-angle camera apparently was jarred out of focus at launch, staging, or possibly by being struck by a de-spin weight.

The early difficulty in the camera was believed to have resulted from a high power drain at launch, and the situation was expected to be corrected by functioning of the solar cells. After a week of operation, with 160-170 cloud cover pictures transmitted daily, the trouble was believed to be in camera focus.

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7. "Tiros II Has Wide-Angle Camera Trouble," in Aviation Week magazine, Dec. 5, 1960.

Although Tiros is an experimental vehicle, the problems and benefits created by an operational weather satellite are being investigated by feeding Tiros data into standard meteorological communication channels for use in regular forecasts. Meteorologists in the program estimate that it is now taking between two and three hours to reduce Tiros data and make it available to forecasters. This time should become shorter as experience increases.

Tiros readout stations at the San Nicolas Island station of the Pacific Missile Range and at the Ft. Monmouth, N. J., Army Signal Laboratory collect raw data telemetered from the satellite. Information collected by the 60-ft. dish antenna on San Nicolas is relayed directly by microwave data transmission system to the meteorological analysis center at Pacific Missile Range headquarters, Pt. Mugu. Infrared readings of the earth's albedo taken by Tiros are teletyped from Pt. Mugu to Goddard Space Flight Center, which directs Tiros II operations.

Cloud photographs televised from the satellite, recorded on video tape at San Nicolas and retransmitted to Pt. Mugu are analyzed there and plotted on standard charts called nephanalysis for facsimile transmission to the U.S. Weather Bureau meteorology satellite section, and to Navy and USAF air weather services via the National Meteorological Center at Suitland, Md., and to the U.S. Pacific Fleet via Fleet Weather Facility, Alameda, Calif.

Analysts and forecasters are using a manual prepared by the Weather Bureau showing cloud pictures taken from Tiros I compared with cloud pictures taken from the ground. The nephanalyses will be used in preparing forecasts over a large part of the northern hemisphere.

Photo enhancement techniques are being used to extract as much useful data as possible from the pictures, since the wide-angle camera furnishes photographs which permit fast orientation when used with data from the narrow-angle camera. Photos from the narrow-angle camera are considered about 85% useful.

Two days after launch, two of five pair of spin rockets were fired on ground command to increase stabilization spin rate and eliminate a wobble. Atlantic Research Corp. rockets increased spin from 8 to 10.8 rpm. on the first firing, and to 13.9 rpm. on the second.

Despite a malfunction in one camera, the Tiros II satellite provided the basis last Monday for cloud charts which showed movement of a storm which brought the season's first snows to the Midwest. Charts also showed heavy seas in the North Atlantic and northeasterly movement of a large low pressure area.

Time Magazine[8]

Among the satellites so far shot into orbit, perhaps the most useful to man was Tiros I, the "weather eye," whose pictures of the earth's cloud pattern gave a valuable overall view of global weather. Last week the U.S. launched Tiros II, to improve on the work of its predecessor. The 280-lb., drum-shaped satellite, spangled with 9,260 solar cells, went into a nearly circular orbit about 400 miles above the earth. All except one of its instruments worked fine; only the wide-angle TV camera for photographing large-scale cloud cover was out of kilter.

Tiros II has two cameras. Both are water-glass size, containing midget tubes that impress electronic photographs on magnetic tape. The pictures are sent down to earth on command from stations in California and New Jersey.

The wide-angle camera was designed to cover an area about 750 miles on a side, the exact figure depending on the altitude of the satellite and the slant at which it is viewing the earth. The narrow-angle camera covers an area 75 miles on a side. Its job is to observe cloud formations in fine detail, showing individual thunderclouds and other weather minutiae.

When Tiros II went into orbit, the narrow-angle camera started right off to take good pictures, but the wide-angle camera balked. There is some chance that it will take better pictures later, or that it can be "repaired" by deft electronic twiddling from stations on earth. Even if it never does function properly, the narrow-angle camera alone will yield valuable weather information. But the scientists who interpret the cloud pictures will have to take special pains to identify the places around the earth that are covered by its Rhode Island-size snapshots.

Tiros stands for Television and Infra-Red Observation Satellite, but in Tiros I the infra-red instruments were omitted. Tiros II has five detectors that measure different kinds of infra-red radiation coming up from the earth. They are working splendidly, and their reports will give new information about the earth's albedo (reflectivity) and about the temperature and humidity of the upper layers of the atmosphere. This sort of data is precious to meteorologists.

Tiros I misbehaved in an unexpected way. Its internal electrical circuits reacted with the earth's magnetic field and made the satellite's axis swing slowly away from the desired direction. To keep this from happening again, Tiros II has turns of aluminum wire running around its girth. On signal from the earth an electric

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8. "The Second Tiros," in Time magazine, issued Dec. 5, 1960.

current can be shunted through the wire. This will modify the effect of the earth's magnetism and should keep the satellite's axis pointing properly.

Life Magazine[9]

From its orbit 400 miles over the earth, the second U. S. weather satellite -- Tiros II -- began sending TV pictures of the earth's cloud cover last week. Launched by NASA, it will be the first satellite used for actual trial forecasting by the U. S. Weather Bureau. Tiros I, launched in April, was considered purely experimental. But the 22,952 pictures it took in its three months of active life so impressed the Weather Bureau that it decided to make real use of the next satellite.

A nearly circular orbit takes Tiros II over a belt around the earth wide enough to stretch from Canada to Argentina. Besides cameras, it carries infrared sensors to study the earth's heat balance, a major factor in regulating the weather. Though one of its two cameras was not yet working properly, the Weather Bureau hailed Tiros' potential and invited 21 other nations, including Russia, to participate in the Tiros II project.

Note: More information was also presented in photo captions in the Life magazine story about Tiros II.

AWS Observer[10]

Tiros II, the second purely meteorological satellite to be placed in orbit around the earth, was successfully launched early on November 23 from Cape Canaveral, Fla. The 280-lb. satellite package was launched at a 48-degree inclination by a Delta three-stage rocket and achieved a circular orbit at about 380 miles altitude.

Primary satellite instrumentation consists of two television cameras to photograph cloud cover and infrared sensors to map the earth's heat radiation in various spectral bands. With the exception of the infrared equipment, this satellite is very similar to Tiros I, launched April 1, 1960.

NASA Vehicle

Over-all responsibility for the project rests with the National Aeronautics and Space Administration, with the operational phase of

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9. "400-Mile-Up Forecaster," in Life magazine, issued Dec. 5, 1960.

10. "AWS People at Readout Stations Are Working To Provide Useful Data," in AWS Observer newspaper, Vol. 7, No. 12, December 1960.

the project under direction of NASA's Goddard Space Flight Center. Command programming, relayed to the satellite from ground stations, is prepared at Goddard, based on information from NASA's Computing Center and the Meteorological Satellite Laboratory of the US Weather Bureau.

Under NASA funding, the Meteorological Satellite Laboratory is responsible for analysis of cloud cover data. Cooperating in the project are the US Navy's Photographic Interpretation Center, the Geophysical Research Directorate of the AF Cambridge Research Center, Naval Weather Service and Air Weather Service.

AWS Participation

The program to test and evaluate the utility of cloud pictures received from Tiros II consists of three phases: data reduction and interpretation, dissemination to the forecaster, and appraisal by the forecaster of value of this data to solution of analysis and forecast problems.

Experience gained during the life of Tiros I (April-June 1960) has gone into development of the program to use Tiros II data on an experimental basis.

Data-reduction teams composed of meteorologists from the Meteorological Satellite Laboratory and field stations of the US Weather Bureau, AWS, Naval Weather Service, GRD and Allied Research Associates are presently at the data-readout stations where the pictures from the newest weather satellite are being received.

In addition to Maj. James B. Jones, AWS liaison officer to the Weather Bureau's satellite laboratory at Suitland, Md., who has been in this job since before the launch of Tiros I, AWS people are on duty at the two readout stations.

At San Nicolas Island, Point Mugu, Calif., (a Navy installation which is part of the Pacific Missile Range) are Capt. Leo S. Bielinski, team chief, CWO John C. Garlock, MSgt Seymour M. Fonnesbeck and SSgt Jack E. Sams. CWO Garlock is from the 3d Weather Wing and the others are from 4th Weather Group.

The US Army Signal Research and Development Laboratory, Fort Monmouth, N.J., operates the other primary readout station. At this location are Capt. Dwight R. Goodman, team chief, SMS Mervin L. Snyder, MSgt John J. Pappas and A/1C Ramon C. Batts. Captain Goodman and Sergeant Pappas are from 2d Weather Group, SMS Snyder from 3d Weather Wing and Airman Batts from 4th Weather Wing.

Each AWS team is composed of three forecasters and one observer. Team chiefs went to Suitland, Md., on September 26 for a period of indoctrination under Major Jones, and all team personnel were in place at the readout stations on November 14, preparing for the satellite launch.

Readout Teams

Readout teams prepare maps from Tiros II pictures showing schematically cloud distribution and organization relative to the earth. Interpretation in terms of cloud form and standard weather patterns such as storm centers and frontal systems are part of the presentation, when possible.

A manual prepared by the Office of Forecast Development, US Weather Bureau, comparing cloud pictures received from Tiros I with clouds observed from the ground, is used at the readout stations to guide meteorologists in making interpretations. Copies are used at operational forecast facilities to assist forecasters in using the cloud maps.

Use of Data

After accurate analysis of the cloud images, the most important phase of the project is getting data to the forecaster. To move data quickly from the readout stations, full-period facsimile circuits connect the stations with the communications center and National Meteorological Center in Washington, D. C. Via these circuits, cloud maps are available for use in the NMC and nearby weather facilities of the Navy and AWS within a few hours after basic pictures are taken from the satellite.

To expedite further dissemination, available time on existing weather facsimile circuits of AWS, Navy and Weather Bureau has been rescheduled to minimize delays.

To reach units not served by facsimile, selected cloud analyses are summarized for relay on land-line and radio teletype circuits on a space-available basis.

Through joint use of available communications, the operational test of Tiros II assumes global proportions. For example, US weathermen in Australia, supporting resupply missions to the Antarctic expedition, receive word summaries of cloud observations made by the weather satellite over vast ocean areas between Australia and Antarctica.

The satellite is expected to have a useful life of about three months, after which its tracking beacons can be shut off by command from the ground.

Only an Experiment

NASA stressed that the newest weather satellite is only an experiment, although many agencies in addition to AWS will probably make operational use of the cloud pictures and infrared data.

Weather agencies in 21 foreign countries have been invited by NASA and the Weather Bureau to participate in meteorological research in connection with the experiment. The invitation indicates US efforts to encourage international cooperation in space research.

To assist cooperating groups in timing local weather observations, NASA will provide orbital information to those countries interested in participating. After processing, Tiros photos will be sent to these nations for comparison with their supplementary observations.

Countries which have expressed an interest in participating are Australia, Belgium, Denmark, England, German Federated Republic, France, India, Japan, Mexico, Netherlands, South Africa and Switzerland. Norway and Sweden also expressed a desire to participate, but the satellite's orbital inclination may make their participation marginal.

G L O S S A R Y

ADC Air Defense Command

AFCRC Air Force Cambridge Research Center

ARPA Advanced Research Projects Agency

AWS Air Weather Service

AWSSS Scientific Services Directorate, Air Weather Service

COSMOS Common System of Meteorological Observation Satellites

DCS Deputy Chief of Staff

FAA Federal Aviation Administration

GRD Geophysical Research Directorate, Air Force Cambridge Research Center

IBM International Business Machines

ICBM Intercontinental Ballistic Missile

IGY International Geophysical Year

IMSPC Interagency Meteorological Satellite Planning Committee

JMG Joint Meteorological Group

JMSAC Joint Meteorological Satellite Advisory Committee

MATS Military Air Transport Service

NACA	National Advisory Committee for Aeronautics
NACCAM	National Coordinating Committee for Aviation Meteorology
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
POMS	Panel on Operational Meteorological Satellites, National Coordinating Committee for Aviation Meteorology
RAND	Research and Development Corporation
RCA	Radio Corporation of America
SAC	Strategic Air Command
SAMOS	Satellite and Missile Observation System
SHAPE	Supreme Headquarters Allied Powers, Europe
TAC	Tactical Air Command
TIROS	Television and Infrared Observation Satellite
USAF	United States Air Force
USWB	United States Weather Bureau

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