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M. J. Jablonski

MISSION PLAN
TIROS VI

PREPARED BY
AERONOMY AND
METEOROLOGY DIVISION

AUGUST 1962

GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

MISSION PLAN

TIROS VI

AUGUST 1962

Approved by:

Robert M. Rados

R. M. Rados
Project Manager
TIROS VI

INTRODUCTION

TIROS—Television and Infrared Observation Satellite

Technical and management direction of Project TIROS was transferred to the National Aeronautics and Space Administration by Amendment No. 5 to ARPA Order No. 17-59, dated April 13, 1959, in accordance with a Space Council decision that meteorological satellites would come under the control of the civilian space agency.

The TIROS satellites are designed to obtain weather information by means of television observation of cloud cover and infrared observation of reflected solar and terrestrial radiation.

Data to be obtained by the TIROS satellites is intended for support of meteorological research. The system is not, in general, classified. Classification, where it exists, pertains to the launching vehicle and the command control system. Appendix B contains the NASA TIROS Security Classification Guide.

This Mission Plan is intended as a general guide. Detailed plans for the functions of specified individuals are required for each supporting operational activity. Preparation of the detailed plans is the responsibility of the person in charge of the particular activity. In fulfilling its responsibility for management direction, NASA will review the detailed plans for compatibility with each other and with program objectives.

THE TIROS MISSION

The mission of Project TIROS is to obtain, by means of satellites, meteorological data that will assist scientists throughout the world in their search for a better understanding of the factors that control the world's weather.

MISSION PLAN
PROJECT TIROS

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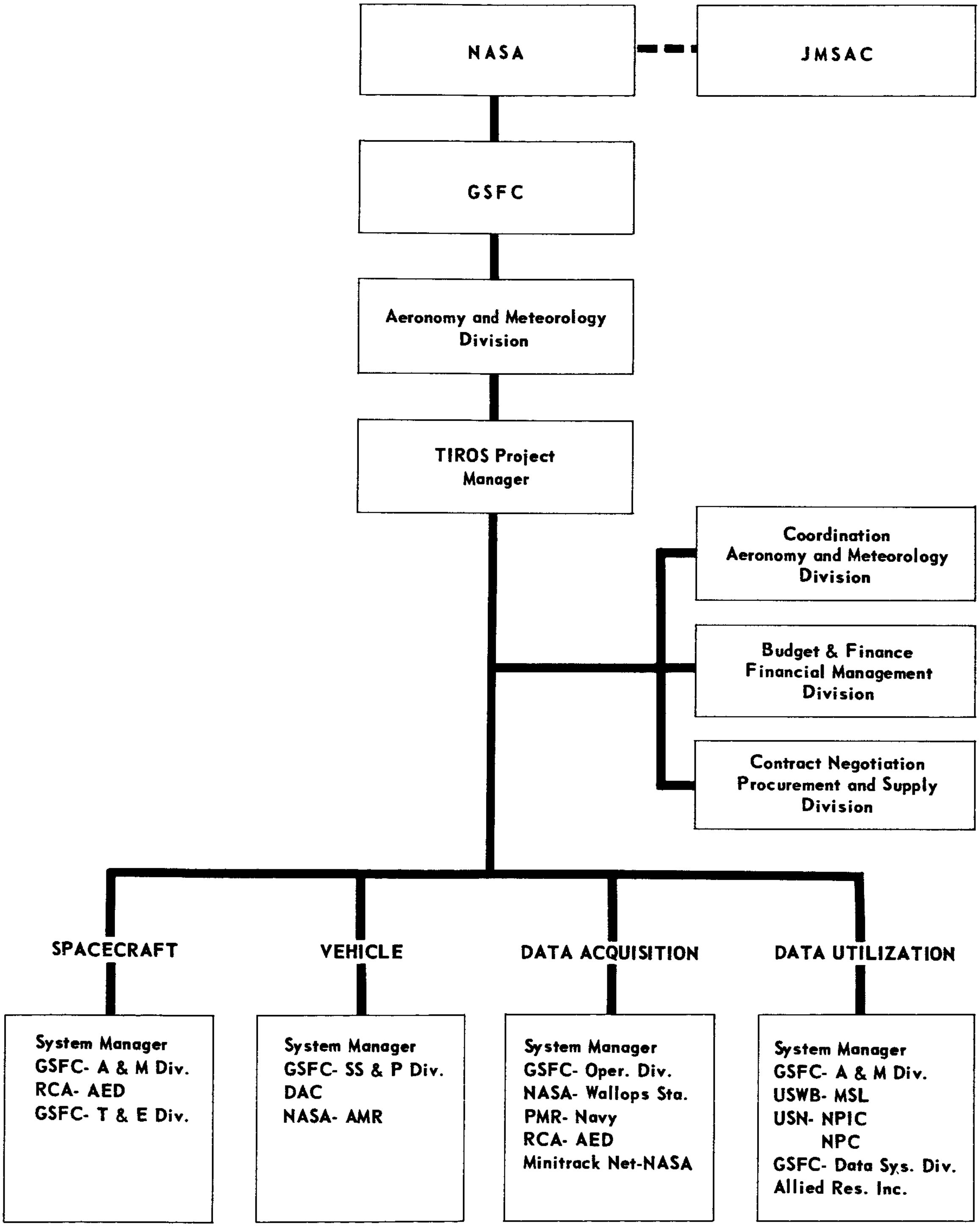

1.2

TIROS DIRECTORY

1.2.1

TECHNICAL AND MANAGEMENT DIRECTION

NASA Headquarters
400 Maryland Ave. S. W.
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Meteorological Program
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Director
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Assistant Director
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Associate Chief for Projects
H. Butler - DU 2-4700

Project Manager
R. Rados - DU 2-6628

Project Coordinator
E. Powers - DU 2-6629

Project Engineer
J. Maskasky - DU 2-3925

Project Engineer (Photo)
H. Oseroff - DU 2-3995

Contract Negotiation
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Budget and Finance
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1.2.2

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Manager
A. Schnapf - Ext. 2775

Project Leader
G. Corrington - Ext. 2606

1.2.3

VEHICLE

Goddard Space Flight Center **Spacecraft Systems and Projects Division** **Maryland 301 – 982-** **Systems Manager** **W. R. Schindler - Ext. 4257** **Delta Payload Coordinator** **A. G. Brozena - Ext. 4193**

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1.2.4

DATA ACQUISITION

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Meteorological Team Leader
W. Follansbee - Ext. 208

RCA Group Leader
L. Layton - Ext. 375

Allied Research Team Leader
H. Grenard - Ext. 267

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Meteorological Team Leader
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RCA Group Leader
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Allied Research Team Leader
T. Markham - Ext. 8562

RCA-AED
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1.2.5
DATA PROGRAMMING AND UTILIZATION

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Assistant Systems Manager
Data Utilization (Photo)
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E. F. Powers
RCA Representative

J. Parisi

GSFC - Applications Research Group
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A. G. Johnson - Ext. 4674

USWB Meteorological Satellite Activities
Suitland, Maryland
RE 5-2000

Assistant Director - Operations
A. W. Johnson - Ext. 7128

Project Liaison

and

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Archival Systems
R. Pyle - Ext. 7395

Naval P.I.C.
Suitland, Maryland
JOhnson 8-5075

Technical Assistance Office
E. Monsour - Ext. 202

Allied Research Inc.
43 Leon Street
Boston 15, Mass.
GArrison 7-2434
A. Glasser

2. GENERAL INFORMATION

2.1 Project Summary

The TIROS meteorological satellite is designed to obtain television data of extremely wide coverage. A Thor-Delta vehicle launched from the Atlantic Missile Range will place the satellite in a nominal circular 350-nautical-mile 58-degree orbit with the spin axis at minimum nadir angle 28.8 degrees north latitude. The Minitrack network will track the satellite. The NASA Computing Center will provide ephemeris information and illumination and earth-aspect data, which will be converted to data-collection programs by the TIROS Technical Control Center and sent to the primary command stations for transmission to the satellite. Observed cloud information data will be received from the satellite, recorded, and transmitted to the agencies responsible for processing and evaluation.

2.2 Objectives

2.2.1 Primary Objective

The primary object is to launch into orbit a satellite capable of viewing cloud cover and the earth's surface and atmosphere by means of television cameras; to acquire the collected data from the satellite; to process the data for meteorological purposes; and to control the satellite attitude by magnetic means.

Data to be acquired includes:

a. Video information by direct-link television or by readout of magnetic storage devices

b. Attitude determination from infrared sensor and television data

c. Data from instrumentation and sensors of an infrared subsystem normally received from TIROS will not be available on TIROS VI. TIROS VI will not contain an infrared subsystem.

2.2.2 Secondary Objectives

a. Monitor the thermal conditions in the spacecraft. Data required: Telemetry data from the temperature sensors in the spacecraft.

b. Demonstrate the performance of the payload subsystems. Data required: Telemetry data from various performance sensors in the spacecraft.

c. Determine the dynamic stability of the spacecraft configuration. Data required: Telemetry data from the attitude sensors in the spacecraft and televised pictures.

2.3 The Vehicle

TIROS will be launched from the Atlantic Missile Range, using a Thor-Delta three-stage rocket as the vehicle. The vehicle and the launching procedures are described in Detailed Test Objectives for Delta launch vehicle, addendum thereto and applicable portions of the Delta program requirements at AFMTC. The documents are CONFIDENTIAL.

2.4 The Spacecraft

2.4.1 The spacecraft is an 18-sided polygon, 22 inches high and 42 inches in diameter, weighing 286 pounds. Power supply consists of batteries rechargeable by solar cells. The spacecraft contains two television systems, each consisting of an independent chain of components. Two television cameras (one Elgeet and one Tegea lens) provide coverage with approximately 1-mile resolution, adequate for viewing cloud systems. The Elgeet camera covers an area approximately 725 nautical miles on a side; the Tegea camera covers an area approximately 450 nautical miles on a side. Two tape recorders are provided, each capable of storing a sequence of 32 television pictures for readout when commanded. Beacon transmitters are provided as an aid to tracking. The spacecraft is described in detail in Section 4.

2.4.2 The spacecraft TV picture-taking sequence is programmed, and readout of TV is commanded, on (nominal) 148 Mc. Readout data is received on 235 Mc. The spacecraft is silent on this frequency until commanded. Two tracking beacons operate continuously on 136.23 and 136.92 Mc. The beacon signals are modulated on command with satellite environmental information, and continuously with attitude information. The modulation is duplicated on both frequencies, for reliability. The beacons can be turned off and on by command, should the need arise.

2.5 Launch Scheduling Factors

2.5.1 The magnetic attitude control on TIROS will help to perfect photographic coverage throughout the 120-day operating life of the spacecraft and, if equipment performance and operational feasibility permit, considerably beyond this time.

Additional restrictions on attitude and orbit (imposed by the need to provide an optimum sun angle for power available to the satellite; provide optimum magnetic attitude steering for TV photography; and to avoid a condition of orbiting "in phase" with other satellites in similar orbits with the same beacon frequency) make calculation of optimum launch time and launch-time tolerances difficult. Hence, optimum launch time and launch-time tolerances will not be available until about three weeks before launch.

2.6 Launch Operations

2.6.1 Launch Organization and Responsibilities

The purpose of this section is to define the launch phase organization and responsibilities for the TIROS (Thor-Delta) launch.

2.6.2 Participating Groups

In addition to the AMR staff, Bell Telephone Laboratories, Aerojets, and Allegany Ballistics Laboratories, the following will be involved in launch activities:

a. The NASA Goddard Delta Field Projects Branch (FPB) is the chief technical group at AMR, charged with overall management of Delta launch operations, including scheduling of launch dates with AMR.

b. The Douglas AMR field group is responsible for the technical conduct of flight test operations, including preparing the overall vehicle for flight and performance of the countdown.

c. A NASA spacecraft group will be assigned to TIROS, headed by a spacecraft system manager responsible for readying the spacecraft and defining criteria for mission attainment. No change in spacecraft criteria may be made without the consent of the spacecraft manager.

d. A NASA Minitrack operations group will provide local spacecraft Minitrack services at AMR, and will also provide Doppler velocity data during pre-injection flight.

2.6.3 Prelaunch Organization

a. Each of the groups mentioned above will participate in day-to-day preparations for launch. Direct liaison between all groups is authorized, subject to the limitation that formal agreements can be made only in the areas of defined responsibilities and subject to final approval by the Flight Test Working Group.

b. The Flight Test Working Group, chaired by the head of the NASA Field Projects Branch, will act as the prime mechanism for coordinating flight preparations. Membership will include AFBMD, NASA, Douglas, BTL, Aerojet, ABL, NASA spacecraft group, NASA satellite and Doppler group, and AMR.

2.6.4 Launch Organization

a. The NASA project manager has responsibility and authority for insuring the ultimate success of the overall mission. In the launch organization, he is a member of project command with the title of mission director. The mission director has the responsibility for spacecraft, tracking, and data-acquisition aspects of the mission in the same sense the test director has for the vehicle. Although he is kept fully informed of vehicle status as transmitted to the test director, he does not participate in vehicle decisions. He is the only person with authority to waive any mandatory mission requirement, whether vehicle, spacecraft, or other. He is located in Hangar AE.

b. The test director has technical supervision of the test operation as it applies to the vehicle.

c. The test conductor, who has operational supervision of the test operation, is responsible for conduct of the countdown. He is located in the blockhouse.

d. The mission coordinator receives inputs from the payload, tracking, and data-acquisition monitors. He is located in Hangar AE and gives this information to Spacecraft Control and the mission director.

e. Spacecraft Control provides inputs to the test conductor concerning the status of the spacecraft, tracking, and data acquisition, which information he receives from the mission coordinator.

f. The Minitrack representative is in communication with the NASA Control Center. He also reports on AMR Minitrack readiness and the quality of the spacecraft tracking signals to the mission coordinator.

2.6.5 Launch Criteria

Criteria to be met by the vehicle before launch are established by the test director, and are contained in the appropriate launch procedure documents. Criteria to be met by the spacecraft and data-acquisition stations before launch are based on the following considerations:

(The objectives listed below constitute the basic reasons for conducting the flight. Proper operation of the spacecraft during prelaunch tests is mandatory if these objectives are to be attained.)

a. Demonstrate in orbit the ability of the meteorological satellite to view cloud cover and the earth's surface with television cameras during a 120-day period.

b. Demonstrate in orbit the satisfactory operation of the spacecraft spin-control equipment; i.e., precession dampening control, subsequent spin-down, and long-term spin control.

c. Demonstrate in orbit the following operational modes:

   1. Direct-camera mode commanded by ground stations.

   2. Remote-camera operation by programming from ground stations.

   3. Playback of remote camera pictures to the ground.

   4. Spin-up of control from the ground stations.

   5. Attitude data collection by north indicator and horizon scanner sensors.

   6. Attitude control from the ground station by magnetic means.

d. Demonstrate the ability to control the albedo of the satellite so that the temperatures of the solar cells, the structure, and the subsystem units are maintained within the prescribed limits.

e. Demonstrate satisfactory operation and potential lifetime of the solar cells and battery-pack power supply.

f. Demonstrate satisfactory operation of the supporting ground stations for acquiring, tracking, commanding, receiving data from the satellite and transmitting this data to the NASA TIROS Technical Control Center.

2.6.6 Countdown Hold Criteria

a. Spacecraft

T minus 1 day: Any malfunction shall be cause for spacecraft hold.

T minus 7 hours: A complete go-no-go program will be run. Any malfunction will cause a hold.

T minus 3 hours: A go-no-go check will be performed after the rocket fueling operation. Only the direct mode of operation will be programmed in TV subsystem; full IR playback will occur. Any malfunction in the spacecraft will cause a hold.

T minus 1 hour: A hold will be called as needed to bring the spacecraft batteries to at least 90 percent of full charge before the umbilical is dropped.

b. Data Stations

A hold will be called for nonreadiness of the data communications net or for nonreadiness of any station on the net except for:

1. Any single Minitrack station.

2. The RCA-AED secondary data station at Princeton, New Jersey.

3. The Weather Bureau Meteorological Satellite Center at Suitland, Maryland.

2.6.7 Readiness Procedures -- Communications

a. The communications network facilities external to Cape Canaveral which are used to support launch and initial trajectory tracking and orbit determination are established in advance and operated by the Communications Branch of GSFC Operations and Support Division. The network of stations and communications links which support prelaunch activities is shown in Figure 1, and the network supporting trajectory tracking and orbit determination, data acquisition and command is shown in Figure 2.

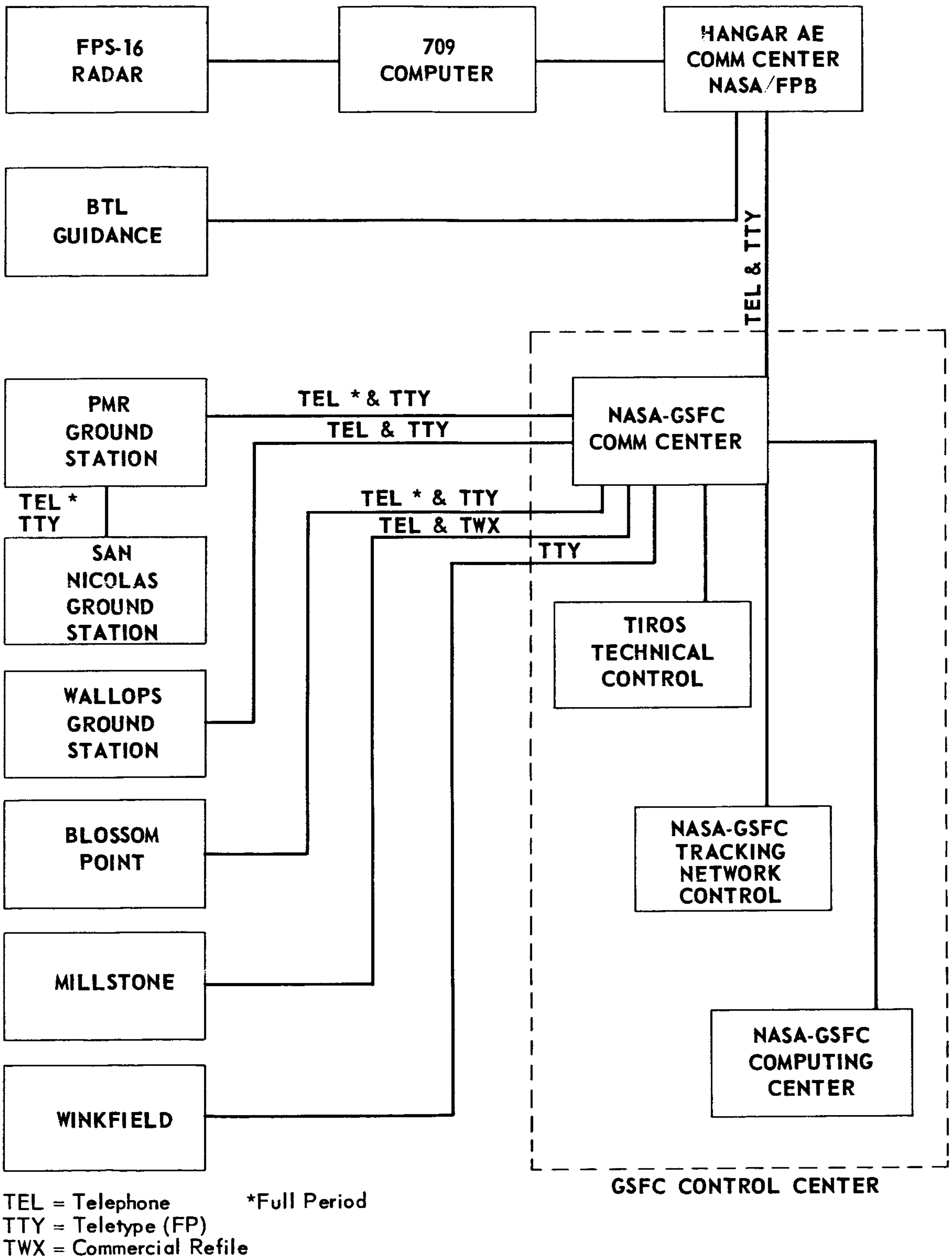


Figure 1 – Launch Communications Net

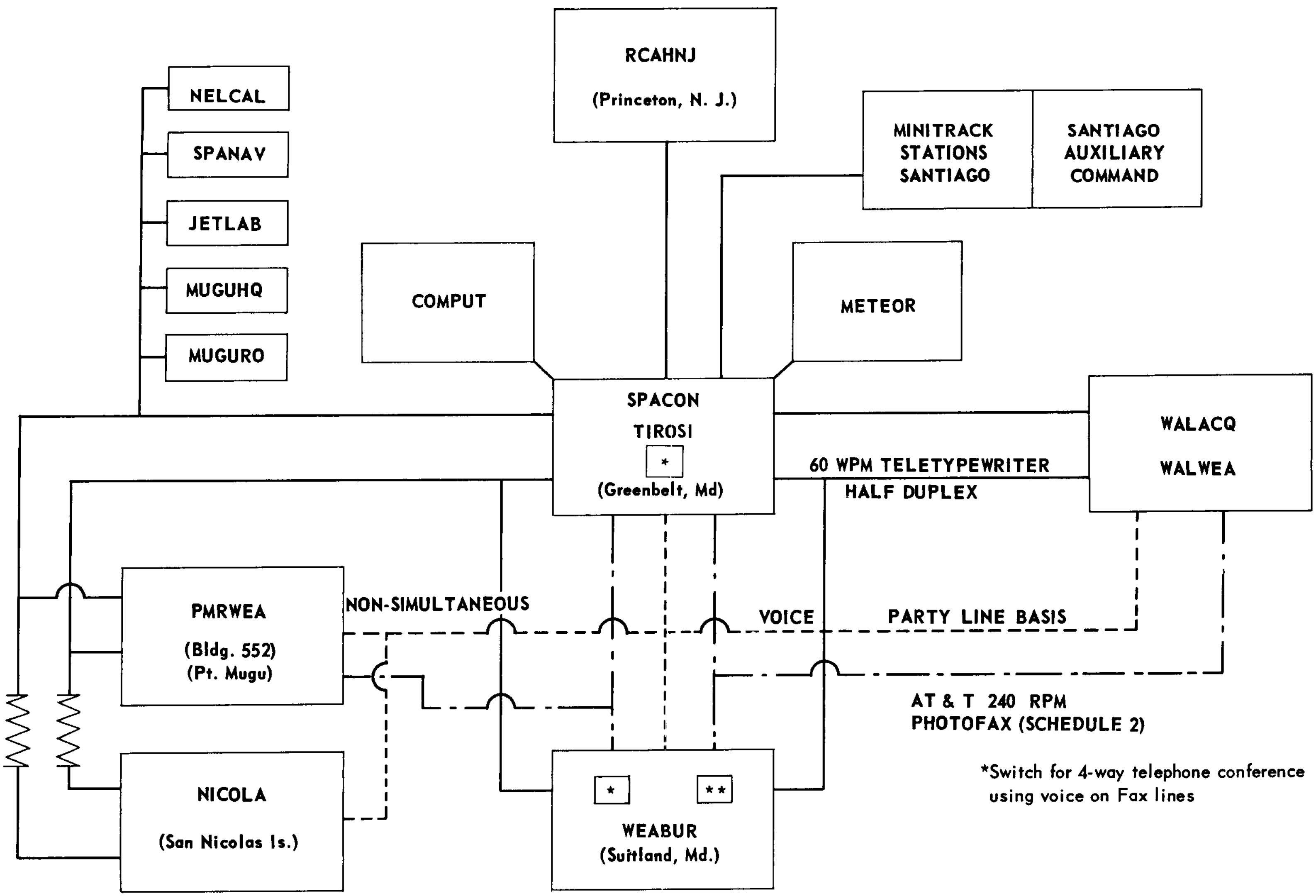


Figure 2 – Data Communications Net

b. Control of these networks is centered at GSFC, which has established general and detailed procedures for determining and reporting on its readiness. These procedures are covered in GSFC TCFP 1 COMM INST of August 1961 and in the operations plans prepared by the GSFC Operations Support Division. The GSFC Control Center established for the mission is composed of cooperating groups generally delineated as follows: (a) TIROS Technical Control, directing the activities of the data and command stations, (b) GSFC Operations and Support Division, operating communications facilities and directing tracking-station activities, (c) the GSFC Computation Center.

c. Telecommunications Operations

(1) Status conditions BLUE, GREEN, and RED will be used to describe the progress of launch operations.

(a) Condition BLUE - Launch operations are over 24 hours in the future.

(b) Condition GREEN - Launch operations expected within 24 hours.

(c) Condition RED - Launch operations in progress. Countdown is proceeding on schedule and is within two hours of lift-off. MINIMIZE (transmission of only operational traffic) will be imposed.

(2) Station Grouping - (a) when condition RED is initiated (approximately T-120) certain stations will be grouped into launch operations networks by combining them through use of the leg combining repeaters located at SPACON.

(b) Upon completion of groupings and notification from SPACON, stations will commence sending four lines of perfect FOX test in order called. SPACON will receipt for each individual test. SPACON will send their test after the last station in the group and will require receipts from all stations in order called.

(3) Communications Traffic

(a) When condition RED has been set, traffic on the network groupings will be limited to those messages relating to operations in progress.

Station-to-station traffic will be held to an absolute minimum and its transmission will be governed by SPACON. At approximately T-15 net control of one of the network groups will be turned over to CAPCAN who will manage this group until the launch phase is terminated.

(b) When stations are grouped together by the leg combining sets, all lines become the equivalent of half-duplex lines, the network group becomes a multi-point (party line) circuit and only one station may transmit at a time. For this reason circuit discipline must be rigidly observed by all stations in the group.

d. At D-12 days, TIROS Technical Control will hold a dress rehearsal of data communications, including transmission of sample messages through the system when necessary. These will be followed by communications drills which include all tracking stations and communications operators. A launch-alerting message will be put on the net approximately 24 hours before launch. Communications links will be validated at T-120 minutes and station readiness reports made to the Control Center. In the absence of a failure report, all stations will be assumed to be ready and standing by after this report. TIROS Technical Control will report readiness to the project coordinator at Hangar AE Communications Center for further transmittal to the blockhouse.

(In the following countdown, D denotes days and T denotes minutes referenced to the nominal launch time.)

Countdown	Action
D-12	1830Z--TTC will log the readiness reports received from WALACQ, WALWEA, NICOLA, PMRWEA, RCAHNJ, and WEABUR.
	1835Z--TTC will transmit instructions with explanatory notes as necessary to all the above-named stations.
D-10	1800Z--TTC will log the readiness reports received from WALACQ, WALWEA, NICOLA, PMRWEA, RCAHNJ, and WEABUR.
D-10	TTC will provide the Operational Computing Branch with the H1 messages

Countdown	Action
D-10	received from the CDA stations for processing through the CDC-160 computer to checkout the computer and programs. 1945Z to 2100Z--TTC will receive, log, and analyze the following types of messages received from the CDA stations: (1) pass summary, (2) telemetry summary, (3) picture summary, (4) nephanalyses, (5) horizon scanner (H1) message, (6) daily operational definitive attitude report, (7) daily prognostic attitude report.
D-10	2000Z--TTC will initiate tests to check the facsimile and voice circuits to the CDA stations.
D-5	1800Z to 2100Z--TTC will monitor the tracking and interrogation exercises being conducted by the CDA stations, and will receive, log, and analyze all incoming messages pertaining to the exercise. All current operations are now to utilize the new TIROS message types and procedures. TTC will ensure that nominal WMSAD predictions are sent to WALACQ, WALWEA, NICOLA, PMRWEA, RCAHNJ, WEABUR, SNTAGO, WNKFLD, Millstone, NEWFLD, Moorestown, CAPCAN and other participating stations.
D-1	TTC will send launch-alert message to all TIROS stations. T-minus times are to be equated with Greenwich (Z) time.
T-510	TTC will send a countdown-initiation message to all TIROS stations. Stations are to report 15 minutes prior to the T-minus times listed below.
T-480 and T-170	TTC will relay to the TIROS project manager in Hangar AE status reports which have been received from Minitrack, Millstone, WALACQ and NICOLA, and RCAHNJ.

T-120	TTC will perform same procedures as T-480 and T-170. Condition RED and MINIMIZE will be imposed at this time.

Countdown	Action
T-60 (1 hr. prior to scheduled liftoff)	Establish phone-circuits to Hangar AE, WALACQ, NICOLA-PMRWEA, and RCAHNJ.
T-50 to T-0*	TTC receives satellite frequencies and all pertinent prelaunch information by phones and teletype from the Cape. SPACON relays the information to all activities.

2.7 Tracking and Orbit Determination

Tracking activity is divided into two phases: trajectory tracking, which is part of the launch phase; and orbit tracking, which occurs in the post-launch phase.

2.7.1 Trajectory and Early Orbit Tracking

a. Data from the Cape Canaveral launch-support facilities listed in Figure 1 will be passed to the Communications Center in Hangar AE and to NASA Computing Center where the launch trajectory will be computed. The data-collecting functions of this net will be completed when the vehicle passes beyond the range of AMR on the launch trajectory. Trajectory and orbit computations will be passed to the NASA Computing Center through NASA Control Center for use in the succeeding orbit-refinement computations.

b. The Moorestown and Millstone radars shall track the vehicle throughout the launch trajectory and shall track the spacecraft for all those orbits which they can acquire during the day of launch. Data in the form of azimuth, elevation, range and time read at six second intervals are to be transmitted to the GSFC Control Center for use by the Computing Center in orbit computations.

c. Cape Canaveral Minitrack and Blossom Point Minitrack are to track on doppler from launch.

d. WALLOPS Station and Newfoundland Minitrack shall track as much of the trajectory as can be acquired and shall record vehicle second stage telemetry on 234.0 Mc.

*There is a built-in one-hour hold at T-35 minutes.

e. The U.S. Naval Space Surveillance System and the Smithsonian Astrophysical Observatory are requested to use their tracking facilities to track the TIROS spacecraft during the first 24 hours after launch and to forward tracking data via TTY and/or telephone to GSFC as soon as possible after it is obtained.

f. Until separation of the third stage from the spacecraft, the subcarrier on the 136.92-Mc beacon is offset from 1300 cps to 1400 cps. Upon separation, the bias input is removed and the subcarrier returns to 1300 cps. The subcarrier on the 136.23-Mc beacon is not offset but remains at 1300 cps throughout the launch phase as well as after third-stage separation. The subcarriers on both beacons (including the offset subcarrier through the launch phase) are continuously modulated with signals from the infrared horizon scanner. Maximum deviation is expected to be ±120 cps with modulating frequency components up to approximately 17 cps. Separation of the third stage from the spacecraft should occur over the Atlantic Ocean within range of the Winkfield, England, tracking station. Despin of the spacecraft from about 126 rpm to about 10 rpm should occur within ten minutes after third-stage separation. When the horizon scanner passes from sky to earth, a large deviation of the subcarriers should occur; when the horizon scanner passes from earth to sky, a large deviation should also occur but in the opposite sense. If despin has occurred, such large deviations in the same sense should occur about once every 6 seconds; if despin has not occurred, deviations in the same sense should occur at the rate of about two per second (provided the nadir angle is greater than 52 degrees, a condition which will prevail within range of the Winkfield, England, tracking station during the launch phase and orbit zero).

g. The beacon frequencies will be monitored by the Winkfield tracking station during launch and orbit zero for indications of third-stage separation and despin. The GSFC Control Center will be notified immediately by that station when separation or despin has definitely been established. If either event occurs during passage over the station, the time of occurrence will also be reported. If neither event has occurred at the end of satellite passage, the station will transmit a negative report to the GSFC Control Center immediately after the beacons fade out of range. If the events occur as programmed, it is expected that Winkfield will detect third-stage separation and despin during passage.

2.7.2 Orbit Tracking

The GSFC Control Center will receive the results of initial orbit calculations and trajectory data. NASA Computing Center will have been receiving raw data on the launch trajectory from Minitrack. The NASA worldwide Minitrack net will track each pass of the satellite and forward the data to the Computing Center. From these data, the orbit will be refined and ephemeris predictions obtained to be passed to TIROS Technical Control, which will schedule their transmission to the Weather Bureau and the data-acquisition stations. In order to program TV data acquisition effectively as soon as possible, every effort should be made to determine the orbit within 24 hours after launch and to make timely corrections as needed until it is firmly established.

2.8 Data Acquisition

2.8.1 TV Command and Data-Acquisition Stations

a. The primary command and data-acquisition stations are located at Wallops Station, Virginia, and at PMR, San Nicolas Island, California. Santiago, Chile, will act as auxiliary command station for the purpose of starting the clock. It will be activated on command from TTC. Except in case of casualty, the primary stations will be the only command stations in the operation. The secondary (RCA) station will record data transmitted from the spacecraft for local analysis of system operation.

b. Data-acquisition operations involve (1) programming the spacecraft to take TV pictures at the desired locations, (2) commanding the spacecraft to read out the stored TV data when it is within reception range, and (3) receiving and recording on film and on magnetic tape the readout data.

c. Decision on the region of greatest meteorological interest for each satellite pass will be made by the Weather Bureau, considering predictions from the NASA Computing Center on position information, the attitude of the spacecraft-camera axis as furnished by TTC from GSFC Theory and Analysis Office and Allied Research Personnel, and interpretation of data obtained on previous passes. These decisions will in turn determine the data-acquisition programs to be prepared and transmitted to the primary stations by TIROS Technical Control, if there are no overriding considerations of a technical nature.

2.8.2 Attitude-Recording Stations

a. Each primary command and data-acquisition station (Wallops and PMR) will be equipped with two attitude recorders.

b. The primary stations, during the pass, receive attitude recordings in real time from the horizon sensor which together sample nearly half of the orbit in a 24-hour period. (The Hl message.)

c. Real-time attitude determination will be made at the command and data-acquisition stations by Allied Research personnel, with the main effort at Wallops Station. The Allied Research personnel will use all possible sources of data including photo and Hl in carrying out their attitude determinations on a Bendix G-15 computer located at each command station. The Allied Research personnel will be responsible for determining the best attitude for each orbit from these sources. Weather Bureau personnel will provide additional attitude determinations derived photogrammetrically from selected pictures.

d. The Hl attitude recordings are transmitted to the NASA Computing Center where computations are made to determine the orientation of the spacecraft in space. The Hl data will be transmitted by teletype to TTC. The Operational Computing Branch will check the header information and transfer the data to magnetic tape by means of a CDC-160 electronic computer. These tapes will be used by the NASA Theory and Analysis Office -- Applications Research Group for further research computations on an IBM-7090 computer.

2.9 Data Processing Assignments

2.9.1 TV Data Interpretation

On-site processing for immediate operational use will be done at the primary readout stations by teams composed of Weather Bureau, Air Force, and Navy meteorologists. Further TV data processing and interpretation will be conducted by the Meteorological Satellite Activities, U.S. Weather Bureau, and by the Aeronomy and Meteorology Division, Goddard Space Flight Center.

2.9.2 TV Photogrammetry

Wherever feasible, photogrammetric techniques will be used to determine attitude by location of the TV pictures with respect to geographic coordinates. These techniques will be employed by Allied Research personnel in collaboration with the Weather Bureau and may be employed by NPIC in collaboration with the MSA Computations Unit.

2.10 Committees

2.10.1 Photo Support Committee

The Photo Support Committee is responsible for monitoring the photographic phase of the TIROS project, for advising the Project Manager on any specific questions in this area, and for making recommendations to the Project Manager for the modification of techniques and/or equipment to meet the quality and quantity requirements of TIROS Photography.

The Photo Support Committee will be composed of personnel from NPIC, MSA, GSFC, and RCA. The following is a list of the current members:

R. Pyle, Chairman -- MSA
G. Pope -- NPIC
C. Wood -- GSFC
H. Oseroff -- GSFC
W. Plew -- MSA
M. Harper -- RCA

The Chairman of the Committee will arrange periodic meetings to handle problems in this area as they arise.

2.10.2 Environmental Committee

The Environmental Committee is responsible for devising, modifying, and monitoring the environmental tests of the TIROS Spacecraft, for advising the project manager on any specific problems in this area, and for making recommendations to the project manager for the modification of techniques or equipment to improve the quality of the environmental tests.

The Committee is composed of:

J. Maskasky, Chairman -- GSFC
J. Stockel -- GSFC
C. Thienel -- GSFC
A. Schnapf -- RCA
G. Corrington -- RCA
E. Mowle -- RCA

The chairman of the committee will arrange periodic meetings to handle problems in this area as they arise.

3. POST LAUNCH OPERATIONS

3.1 Station Functions

3.1.1 TIROS Technical Control Center

The functions of the NASA TIROS Technical Control Center (Figure 3) are:

a. To accept, analyze, and catalogue engineering reports on satellite and ground station conditions.

b. To accept and analyze daily predictions by the Computing Center as to the sequence and locations of suitable TV photographic areas and the times of satellite passes near the ground stations.

c. To accept daily recommendations from the Meteorological Satellite Center as to the photographic areas of greatest meteorological interest.

d. To decide the actual sequence of operations for each day and to prepare and transmit specific operating instructions, and the quantities listed in paragraph 3.1.2 c below, to the data acquisition stations.

e. To accept performance reports and significant telemetry data from the data acquisition stations and to select and transmit courses of action in emergency situations.

f. To direct and coordinate all other TIROS activities during the operational phase.

g. To program the magnetic attitude control coil based on all available attitude information.

h. Operating and decision-making personnel will be provided by NASA as required. Three RCA representatives will be present during the pre- and post-launch periods, to assist in making the operating decisions.

i. Logging, Filing and Graphing. — All reports coming to and leaving the TTC are to be placed in a log book and after each piece of information has been processed, it is to be filed in the permanent TIROS file. Special graphic displays are to be made by using information coming from RCA, the Weather Bureau, Allied Research,

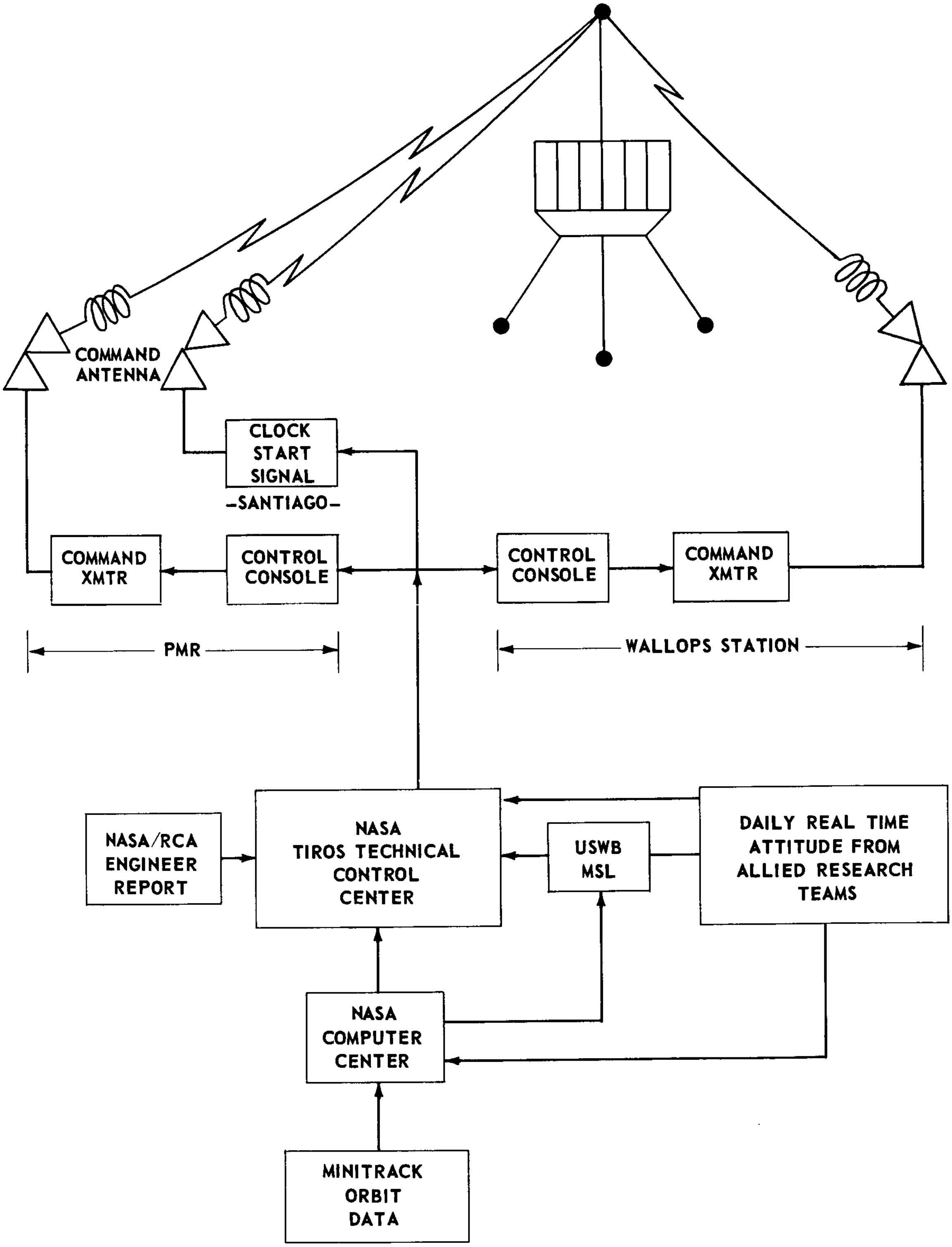


Figure 3 – Programming Data

the CDA stations, and the Theory and Analysis Office which shows the following:

1. Selected telemetry points versus time
2. Spin rate versus time
3. Spin vector coordinates (right ascension versus declination)
4. Minimum Nadir Angle (NON) and its time of occurrence (TOT)
5. Sun-spin vector angle γ versus time
6. Theorectical prognostication of spin vector motion
7. Theoretical prognostication of sun-spin vector angle versus time
8. Percent of time that the satellite is in sunlight versus time
9. Power available to the satellite per day and the daily programmed power consumption versus date
10. The position of the high noon portion of the orbit $\delta\phi$

3.1.2 NASA/GSFC Computing Center

The functions of the NASA Computing Center include:

a. Accept, collate, and analyze tracking data from the Minitrack network and other sources as available.

b. Accept and interpret spacecraft horizon sensor attitude and sun sensor data from the data acquisition stations.

c. Predict daily the following quantities necessary for programming of the spacecraft and conducting spacecraft operations.

   1. Spacecraft location versus time
   2. Times at which the spacecraft is above the horizon at the command and data acquisition stations and local coordinates of the spacecraft from each CDA station during contact intervals

3. Solar illumination or shadow condition of the spacecraft

d. Produce the above data in the form of a "WORLD MAP AND SATELLITE ACQUISITION DATA," (see Figure 4) and deliver to the TIROS Technical Control Center for analysis and final decisions as to each day's operating program.

e. Transmit the above data by teletype to the CDA stations for the use of the meteorological teams and RCA technical personnel.

f. Provide the TIROS Project with refined orbital and attitude information in the form of an "Attitude World Map," (see Figure 5) on a post mortem basis. These refined data will be based on all available information, including attitude data from Allied Research personnel at the CDA stations and photogrammetric measurement from the TIROS pictures.

3.1.3 USWB Meteorological Satellite Center Programming and Processing Section — MSA

(The Meteorological Satellite Center will be under the direction of the Assistant Director for Operations, Meteorological Satellite Activities, with participation of other interested groups.)

The functions of the MSC are to:

a. Analyze possible television coverage areas each day in terms of their meteorological interest and specify to the TIROS Technical Control Center the following:

1. The preferred choices among several possible orbits when not all can be used owing to absence of sufficient ground station contacts or owing to insufficient satellite power available for programming purposes.

2. The preferred camera and time of picture taking for each programmable orbit. (Priorities will be specified when uncertainties exist as to the total amount of picture taking possible on a particular day.)

SYMBOL	ITEM	SAMPLE	CHARACTER	SPACES FOLLOWING
	Time: Day (of month GCT)	24	2	2
	Hour (GCT)	11	2	1
	Minute	30.00	5	1
	Satellite Coordinates			
θ	Latitude (in degrees & tenths			
	South latitude indicated by -)	-28.1	5	1
λ	Longitude (in degrees east)	348.8	5	2
h_s	Height (in kilometers)	1092.3	6	2
	Sun Angle			
E_{ss}	Solar Elevation from sub-			
	satellite point	-21.1	5	2
	Station Name	WALACQ	6	3
	Ground Station Acquisition Data			
R	Range (in kilometers)	1345.2	6	3
A	Azimuth (in degrees & tenths)	231.2	5	2
E	Elevation (in degrees & tenths)	67.2	4	2
	Radiation Angle	174.4	5	

NOTES: 1. Ground station acquisition data is only printed when contact from a ground station is possible. Ground station entry is printed only when $E \geq 0°$.

2. When satellite passes through ascending node; new pass number is printed between last entry of old pass and first entry of new pass.

3. Prior to the indication of the new pass number, the percent of time that the satellite is in sunlight on the previous orbit will be printed-out.

4. Instructions are to be prepared for the two main CDA Stations, the secondary ground station and the auxiliary command station. Data may be made up during the prediction run. Acquisition data for the Minitrack network are to be computed on a separate run of the computer from that on which the main printout is prepared.

Figure 4 – Format of WMSAD

Figure 5. Format of the Attitude World Map Distributed to TIROS Technical Control, the U.S. Weather Bureau, Aeronomy & Meteorology Division and other using agencies.

SYMBOL	ITEM	SAMPLE	CHARACTER	SPACES FOLLOWING
E	Ersatz Point Indicator	E	(1)	(1)
	Time: Day (of month GCT)	24	2	2 (1)
	Hour (GCT)	11	2	2
	Minute	30	2	2 (1)
	Satellite Coordinates			
θ	Latitude (in degrees & tenths; S. Lat. indicated by -)	-28.1	5	1
λ	Longitude (in degrees east)	348.8	5	1
h_s	Height (in whole kilometers)	1092	4	1
	Satellite Sun Angle	-35.1	5	1
	Picture Center Coordinates			
	Latitude	-28.8	5	1
	Longitude	345.6	5	1
d	Slant Range (in whole Km)	1107	4	1
	Picture Boundary Coordinates			
	First Latitude	-22	3	2
	First Longitude	340	3	1
	Second Latitude	-35	3	1
	Second Longitude	352	3	3
E_{su}	Solar Elevation from Picture Center (in whole degrees)	21	2	2

NOTES: (1) When there is an Ersatz principal point the following contents of time (day, hour, minute) are shifted two (2) columns to the right and the contents of the satellite coordinates are shifted one (1) column to the right, removing one (1) allotted space following the minute of time and one (1) allotted space following the latitude of the satellite.

Figure 5 – Format of Attitude World Map

Figure 5 (Con't)

SYMBOL	ITEM	SAMPLE	CHARACTER	SPACES FOLLOWING
A_{su}	Solar Azimuth from Picture Center (in whole degrees)	213	3	2
E_{sa}	Satellite Elevation from Picture Center (in whole degrees)	35	2	2
A_{sa}	Satellite Azimuth from Picture Center (in whole degrees)	132	3	2
	Station Code Number	6	1	3
	Ground Station Acquisition Data			
R	Range (in whole Kilometers)	1345	4	1
A	Azimuth (in degrees and tenths)	231.2	5	2
E	Elevation (in degrees and tenths)	67.2	4	2
E_c	Nadir Angle (in whole degrees)	102	3	1
P_{supp}	Picture Sun Angle Angle in Picture Plane between Subsatellite Point - Picture Center Line projection and the Sun-Picture Center Projection (whole degrees)	115	3	
			81 (82)	38 (37)

NOTES: (2) Entry is only printed when either photography or contact from a ground station is possible; picture information is printed only when $E_{su} \geq 0°$ and $E_{sa} \geq 0°$; ground station entry is printed is printed only when $E \geq 0°$.

(3) When satellite passes through ascending node; new pass number is printed between last entry of old pass and first entry of new pass.

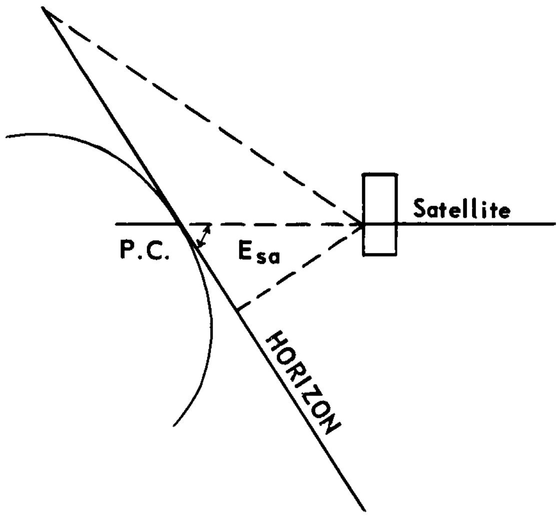
GLOSSARY OF TERMS

Principal Point (Picture Center)	The intersection of the camera axis (spin axis of satellite) with the surface of the earth.
The Ersatz Principal Point	A point on the earth's surface in the plane of the satellite's radius from the earth and spin-axis vectors having a nadir angle l_{ep} degrees (40°) less than the camera axis. It is defined only when the principal point does not exist.
Object Plane (Picture Plane)	A plane perpendicular to the camera axis located on the principal point.
Image Plane	A plane parallel to the object plane on the film.
Subpoint (Subsatellite Point)	A point lying on the earth's surface over which the satellite is located.
Vanguard Units	Used internally within computer program Length = 20,926,427.96 ft Time = 806.832 sec. Velocity = 25,936.53692 ft/sec.
Sensor Input Program (SIP)	Computer program designed to edit the sensor-observation data and to determine smoothed ratios of the time the horizon sensor observes the earth to the total time for one (1) revolution of the satellite on its axis.
Differential Correction Program	Computer program designed to compare observations with computed values to determine the declination and right ascension of the satellite vector.

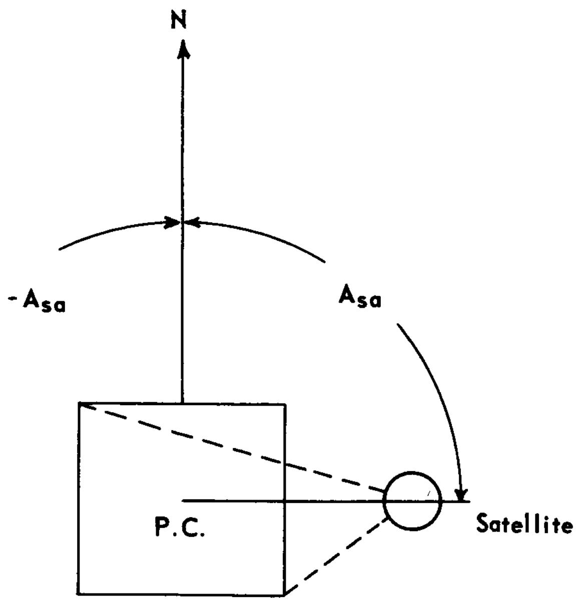
Attitude Map Program	Computer program designed to produce the best possible attitude of the satellite on a hindsight basis with regard to favorable conditions for picture taking and local station conditions for observation of the satellite. (See format of printout to Control and Meteorology.)
Option One Time	The best picture-taking time: the time when all of the following parameters are favorable for picture taking; (Phi) favorable latitude interval; (Lambda) favorable longitude interval; (D) maximum favorable slant range; (Mu) maximum favorable zenith angle of the satellite; (Nu) maximum favorable zenith angle of the sun. (See printout for option one times.)
Sensor Output Program (SOP)	Computer program designed to determine the observed nadir angles (E_o).

DEFINITION OF ANGLES

E_{sa} Satellite elevation from picture center (PC) in degrees measured from a plane tangent to the earth at the picture center and will lie between 0° and 90°.

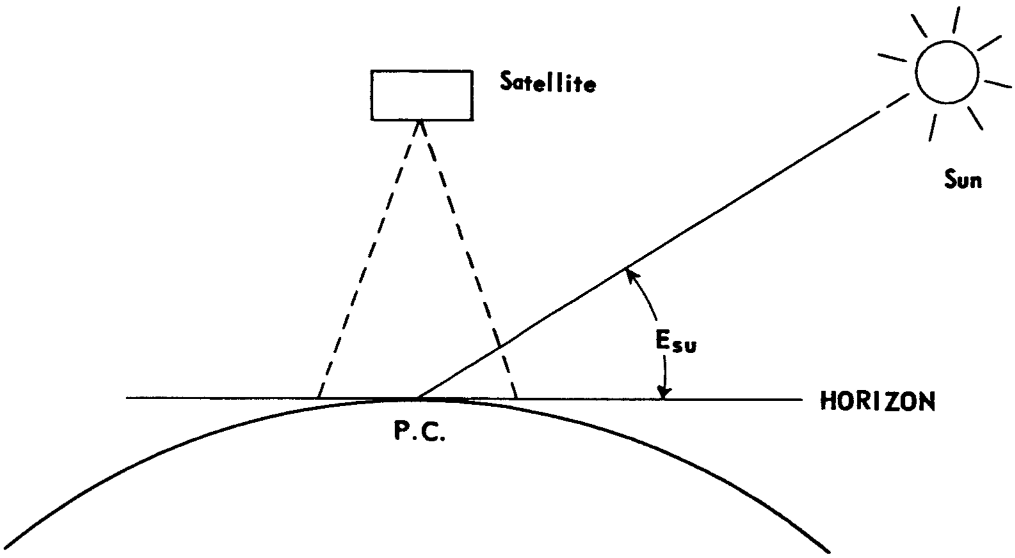


A_{sa} Satellite azimuth from picture center (PC) in degrees measured from north and will lie between 0° and ± 180°. (Printout 0° to 360°)

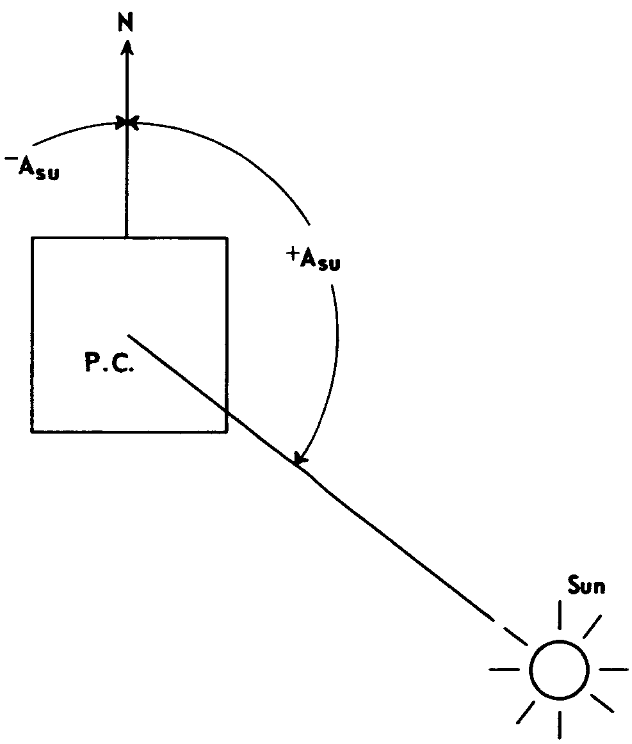


DEFINITION OF ANGLES (Cont'd)

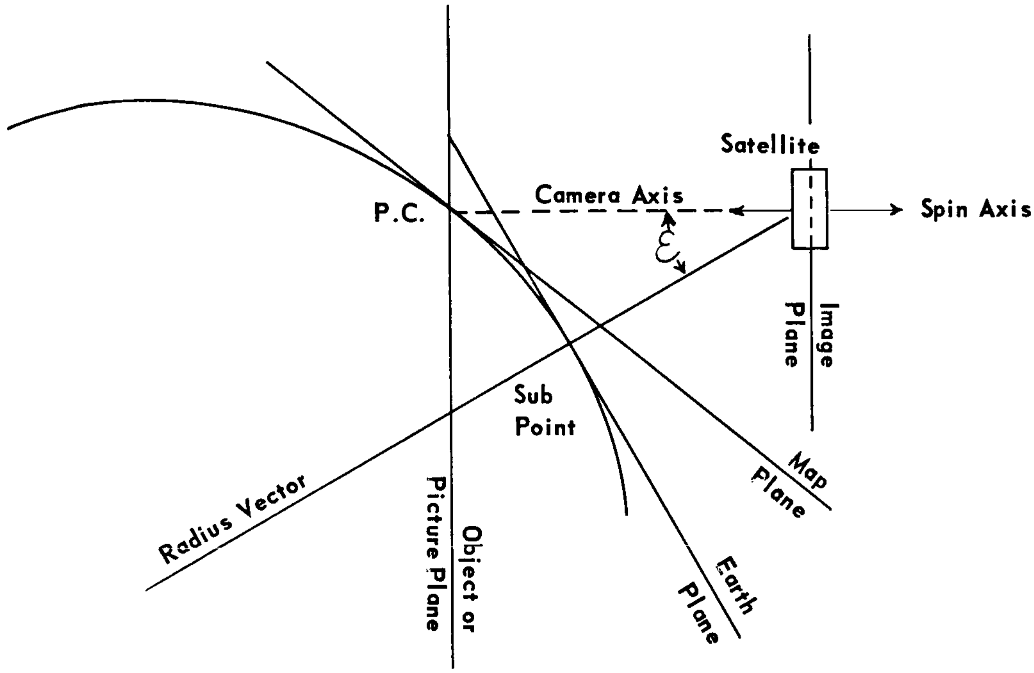
E_{su} Solar elevation from picture center (PC) in degrees measured from a plane tangent to the earth at the picture center and will lie between 0° and 90°.



A_{su} Solar azimuth from picture center (PC) in degrees measured from north and will lie between 0° and ± 180°. (Printout 0° to 360°)



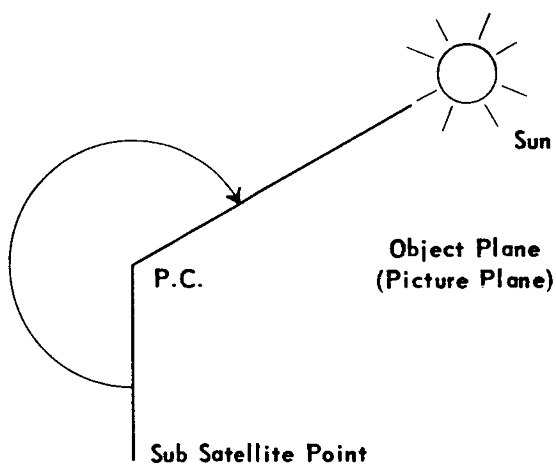
E_c Nadir angle (in degrees) measured from the radius vector to the spin axis of the satellite and will lie between 0° and 180°.



The spin axis direction is parallel to, but directly opposite to, the camera axis direction.

DEFINITION OF ANGLES (Cont'd)

P_{supp} Angle in picture plane between subsatellite point (SSP) in picture center (PC) line projection and sun (S) - picture center (PC) line (in degrees).



P_{supp} is defined as the angle in the object plane from a line drawn from the picture center to the subsatellite point, clockwise to the line from the picture center toward the projection of the sun onto the object plane along the normal to the object plane. The picture center can be replaced by the ersatz picture center.

3. The infrequent occasions when the time of readout of remotely-stored data should be changed somewhat from the optimum portion of a pass over a readout station to permit direct television observation of areas of special meteorological interest in the vicinity of the readout station.

b. Collect current cloud information transmitted from the two readout stations and make significant data available to National Meteorological Center, international weather circuits, and other interested parties. Because of the perishable nature of operational meteorological data, a facsimile network links the primary stations with GSFC and MSC. This network will be used for the immediate transmission of nephanalyses, photographs, and other data of a graphic nature to GSFC and MSC for operational use in conjunction with the more conventional data presently being used in weather analysis and forecasting.

3.1.4 Primary Command and Data-Acquisition Stations

The functions of the primary command and data-acquisition stations (Wallops Station, Virginia and San Nicolas Island, PMR, California) are:

a. To transmit radio signals to the TIROS satellite to program it in operation and data transmission.

b. To receive radio signals carrying the television, attitude, and telemetry data from the spacecraft.

c. To record and label the data received.

d. To compute real time attitude by ALL means available. (Allied Research Personnel).

e. To transmit horizon sensor, attitude data, telemetry data and status reports to the TIROS Technical Control Center.

f. To ship television film data to the Naval Photographic Interpretation Center and the Goddard Space Flight Center of NASA, respectively.

g. To make rapid on-site meteorological interpretations of the television pictures.

h. To transmit results of the picture interpretation to the MSC at Suitland, Maryland, GSFC, Greenbelt, Maryland, and to nearby USWB and DOD weather units.

i. To produce photographic enlargements of particularly interesting television pictures and distribute them through GSFC-NASA and USWB information channels.

j. Each CDA station will establish an operations log to document, in an easily accessible form, the pertinent information on each scheduled pass that would indicate the quality of the interrogated data and the disposition of the stations tape one's. The log should follow the following example, but any additional columns or types of comments that would be useful may be added.

Orbit NR	Tape 1 NR	Tape 2 NR	TV Quality	TV Remarks	IR Quality	IR Remarks	Comments
0039	W-349	W-792	Good	-	Good	-	Tape 1 fwd to RCA
0040	W-350	W-793	Poor	Inter-ference	Noisy	Inter-ference	-
0041	W-351	W-794	Good	Lost 6 frames Antennae lost track	Good		-
0042	-	-	-	-	-	-	Cancelled High winds
0043	N-121	N-392	Fair	-	Fair	-	Simultaneous signal fades
0044	N-122	N-393	Blank	Clock miss-set previous orbit	Good	-	-
0045	N-123	N-394	Blank	No play-back A-3 not sent previous orbit	Good	-	-

k. If there is a tape number under the Tape 1 and Tape 2 columns and no other remarks to the contrary, then the Tape 1 should be in the station file and the Tape 2 forwarded to GSFC. It is important that deviations from the normal routine be documented in this log.

l. The number of TV frames appearing on Station check negative films are to be recorded under "TV Remarks" in the Operations Log. The number of TV frames on subsequent film reruns are to be checked against this number to insure that all recorded TV data is reproduced on the new film.

3.1.5 Secondary Command and Data-Acquisition Station

The functions of the secondary data-acquisition station at RCA-AED, Princeton, New Jersey are to:

a. Monitor the spacecraft response providing backup recordings if needed.

b. In case of spacecraft malfunction, to enter the operation as necessary to determine programming procedures that will optimize the performance of the operable spacecraft equipment.

c. In case of limited malfunction of the Wallops Station, to provide the mission operation functions of that station until it can be repaired.

3.1.6 Auxiliary Command Station at Santiago, Chile

a. The function of the alternate command station will be to start the clock when desirable for picture sequencing on those orbits over areas which are beyond the control of both primary CDA stations.

b. Santiago will have the capability of transmitting either a Direct Camera One or Direct Camera Two tone for satellite TV "warm-up" and of sending the start clock tone. The sequence will routinely be accomplished in an automatic mode, but provisions for manual operation are made whereby either of the three tones may be transmitted at any time for as long as desired.

c. The clock set programming will normally be controlled by PMR and the play back interrogation will be handled by Wallops. TTC will control and schedule the programming of the auxiliary command station.

3.2 Data-Handling Plan

a. The principal data retrieved at the data-acquisition stations will be magnetic tape recordings of television pictures.

b. Each magnetic tape sent to the stations must be plainly identified in three-quarter-inch letters. All tapes in the inventory must receive a number. A log of the numbers used will be kept at each station.

c. Each CDA station will make a monthly tape inventory report by TTY as of 0001Z on the first and 16th day of each month. Data to be included in the report are the number of tapes:

- Received at the CDA stations during month.
- Forwarded to GSFC or to RCA.
- Released from the inventory for use.
- Removed from the inventory because of unserviceability.
- In reserve and listed by the satellite number (III, IV, etc.).
- Currently available for use.

No tape will be released from the reserved inventory for use except on direction from GSFC. Tapes removed because of unserviceability are to be sent to GSFC with a note explaining the condition of the tape. New magnetic tapes delivered to the CDA stations before launch are to be used only as Tape Two's.

3.2.1 Television Data

a. During the pass readout, the video polarity reversing switch will be in position to produce a negative image on the film. This film to be called the check negative is to be developed immediately and prints are to be made as soon as possible for use by the meteorological team for weather analysis. If necessary the tape-recorded information may be played back through the television monitor and film recorded for this purpose. Detailed pertinent notes based on the on-site picture study and evaluation will be entered into an appropriate log.

b. After each pass the magnetic tape containing the computed sun angle information (tape two) will be played back with the polarity reversing switch in position to produce a positive film image. One run of the orbit is to be accomplished. Following this operation the polarity reversing switch is to be placed in position to produce a negative image on the film. Two runs of the orbit are to be accomplished. The film strip containing the two exposed negatives will be developed simultaneously at the CDA station. The developed negatives will be checked for acceptable density. The best of the two negatives if they meet requirements will be forwarded to NPIC as the original archival negative. If neither of the two negatives meet the required standard they are to be rerun until acceptable density is achieved. Acceptable density of the calibrator step wedge shall be between 0.15 and 0.25 in step one (minimum density) and shall be between 1.10 and 1.30 in step fourteen (maximum density). The original negative will be marked "Processed Original Negative" and forwarded to the following adress:

Commanding Officer
US Naval Photographic Interpretation Center
4301 Suitland Road
Washington 23, D.C.

c. The remaining negative, to be called the "Project Negative", shall routinely be mailed to the Project Manager.

d. The check negatives are to be used by the CDA station meteorological team in preparing archival logs.

e. The check negative will be used to produce the photographic enlargements used each day by the Allied Research Group and Weather Bureau Personnel for attitude determination.

f. The check negative may also be used to produce photographic enlargements for distribution. Such distribution prints will be produced when in the opinion of the senior NASA representative or the senior meteorological team member, one or a few pictures received during a day's passes are of unusual interest. The senior meteorological team member will write a brief description for each distribution picture. The senior NASA representative will distribute twenty (20) copies of each picture and description to the Project Manager.

g. The film packages, forwarded to the U.S. Naval Photographic Interpretation Center (NPIC), will be logged into the Mail Room and handled through established administrative procedures. NPIC will provide for:

1. Logging (into gross filing system)

2. Rapid review ONLY to verify suitability of the film negatives for subsequent reproduction at the U.S. Naval Photographic Center (NPC).

3. Preparation of transmittals and pertinent note for NPC.

4. Summary analysis to determine overall picture quality and make a weekly report to the Project Manager and Data Utilization Manager on their findings.

h. NPIC will make necessary arrangements for delivery of original films to NPC. Reproduction of the original films will be accomplished at NPC under the direction of NPIC. The NPC will produce six copies of release positive transparencies and six copies of duplicate negatives. All film will be returned to NPIC for distribution according to the schedule in paragraph "k" below.

i. Allied Research personnel will be responsible for determining the best attitude for each orbit, using all possible sources of data including photo and H1. Weather Bureau personnel will provide additional attitude determinations derived photogrammetrically from selected pictures. In cooperation with MSA Computations Unit, NPIC may prepare additional attitude data. These data will be furnished to the NASA Computing Center and the Allied Research Attitude desk at Wallops Station to aid in the final determination of attitude.

j. MSA will routinely compute latitude and longitude grid overlays for all usable pictures. These bare grids will be prepared on 35 mm film and sent to NWRC for reproduction and distribution as requested. In addition, a limited number of pictures of particular synoptic interest will be selected by MSA for special gridding. GSFC and the MSA Computations Unit will produce the latitude and longitude grid overlays for the pictures. NPIC will superimpose these overlays on the corresponding pictures to produce a new 35 mm merged film transparency showing the cloud photographs with latitude and longitude lines and other pertinent information.

k. NWRC will produce and distribute release bare grids, and NPIC will distribute all reproduced duplicate negative and release positive films as well as merged grid films, in convenient lengths, according to the following distribution table.

Agency	Orig. Neg.	Master Pos.	Dup. Neg.	Release Pos.	Release Bare Grid	Dup. Neg. Merged Grid	Release Pos. Merged Grid
	/---------- Ungridded			----------/	/----------- Gridded		-----------/
USWB/NWRC*	1	1(archival)	1(archival)		1(archival)	1(archival)	
USWB/MSA			1	1	1	1	1
AFCRL			2	2	2	2	2
NWRF			1	1	1	1	1
NPIC			1	1		1	1
NASA/GSFC		1	1	1	1	1	1

*Reproduction of films and grids at cost for distribution to universities and other interested meteorological groups will be accomplished by the National Weather Records Center, Asheville, North Carolina.

No further initial distribution of films will be made without the specific written approval of NASA.

l. The individual prints and mosaics selected for photofax transmission shall routinely be mailed to the Project Manager for review. They will then ultimately be forwarded to MSA for retention.

m. The TTC shall maintain a record of all received photofax pictures from the CDA stations and compare the actual transmitted copies received to those pictures received over the facsimile lines in order to effect facsimile quality control.

3.2.2 Position and Attitude Data

a. A GSFC contractor, Allied Research Associates, Inc., will maintain teams at the CDA stations for the purpose of computing and predicting satellite position and attitude information to insure the most accurate possible picture analysis.

The Allied Research teams will also prepare daily grids for use in the making of nephanalysis. These grids are to be three inch EFL grids for use with the first prints from the check negative. After their real time operational use by on-site meteorologists, these grids will be mailed weekly to:

Mr. C. P. Wood, Code 651
Aeronomy & Meteorology Division
Goddard Space Flight Center, NASA
Greenbelt, Maryland

All possible sources of data, including photographic and HI will be used in computing the satellite attitude for each orbit on a Bendix G-15 computer which will be available at each CDA station. From the various attitude determinations, the Allied personnel will determine the operational provisional value to be used in the real time data analysis. A short-range (i.e. 36 to 48 hours) prognostication of attitude will be accomplished by means of an abbreviated computer program incorporating magnetic and gravitational torque effects. The attitude prognostication thus calculated will provide the basis for preparing grids in advance in order to shorten the processing time required for the following day's picture data.

b. The operational provisional data will be transmitted daily to TTC, all TIROS stations and the NASA Theory and Analysis Staff and, specifically, will include as a function of time, spin vector declination and right ascension, time of occurrence (TOT) of the minimum nadir angle (NON) after the orbital ascending node, the sun-spin vector angle gamma, and any other data for which a need may later develop. The short-range prognostic data is intended primarily for the purpose of preparing grids in advance of picture readout and will be transmitted daily from Wallops to PMR and TTC. If a further need should develop for short-range prognostic data, the scope and dissemination of this data will be increased accordingly.

   A three-day hindsight Operational Definitive Attitude message will be prepared to provide refined attitude information to TTC, the TIROS stations and the NASA Theory and Analysis Staff.

c. The horizon-scanner data will be transmitted by teletype to the NASA Computing Center after adding the required header information (see par. 3.4.5 g). The Theory and Analysis office-Applications Research Group will utilize the Horizon Scanner Data for further attitude calculations for research purposes.

d. The NASA/GSFC Theory and Analysis office - Applications Research Group will calculate long-term attitude prognostications on an IBM 7090 computer using an unabridged program incorporating magnetic and gravitational torque effects.

(1) These prognostications termed MGAP (Magnetic Attitude Predictions) shall be computed so as to always provide at least four weeks of valid data for magnetic steering of TIROS and the stepping of the Magnetic Attitude Control Switch.

(2) A real-time MGAP shall be computed which updates the long range booklet and shall be produced so as to be at least seven days in advance of the earliest date in the data.

(3) The TIROS operations office of the Applications Research Group shall notify TTC at least 48 hours in advance of each change of the Magnetic Attitude Control Switch and present the latest MGAP record of the values of Alpha, Delta, Gamma, NON, and TOT for at least seven days after the MAC switch change. These data will immediately be transmitted to the CDA stations by TTC.

e. TIROS Technical Control shall be responsible for the over-all direction of the magnetic steering effort for the TIROS program.

3.2.3 Telemetry Data

Telemetry recordings from the TV chains and the 136.23 136.92 Mcs beacon data will be initially reviewed at the sites for significant performance indications. The extracts of telemetry recording will be teletyped at once to NASA TIROS Technical Control Center. These recordings will then be mailed to RCA-AED for detailed analysis, and upon direction of the project manager, will finally be sent to GSFC for permanent retention with project records.

3.3 Data Communications Net

3.3.1 Summary of Types of Traffic

All major installations of the ground complex, and the types of traffic passing between them, are shown in Table I. Two highly important types of data are not listed because they are hand-carried or air-mailed between points: the attitude world maps from the Computing Center, which will be carried by hand to Meteorology and TIROS Technical Control; and the output data of the experiment (telemetry tapes, Sanborn recordings, etc.) which are distributed by mail. The meteorological groups at the readout stations will have direct facsimile circuits for transmission of weather maps, nephanalyses, and photofax cloud-cover pictures to the MSA via the GSFC.

3.3.2 Communications Service Required

Table II lists the type of service desired between all points to carry the above traffic. Teletype implies standard 60-word-per-minute capability. The communications net is shown in block diagram in Figure 2.

3.3.3 NASA Space Communications Center-TIROS Technical Control

a. Full-period teletype circuits (2) from the Communications Center to Wallops Station will be by leased commercial line.

b. Full-period teletype circuits (2) from the Communications Center to PMR will be provided by leased commercial line.

c. One full-period telephoto circuit from PMR to MSA via the TIROS Technical Control Center with non-simultaneous voice capability will be provided. Voice capability will be extended to San Nicolas Island.

d. One full-period telephoto circuit from Wallops Station to MSA via the TIROS Technical Control Center with non-simultaneous voice capability will be provided.

e. Connections from the GSFC Communications Center to Minitrack, the Computing Center, and the FPB Communication Center in AE exists.

f. One drop from one teletype circuit from PMR and from one teletype circuit from Wallops Station have been established at the MSA, Suitland, Maryland.

g. The address heading of all messages should begin with a precedence letter designation (OO Operational Immediate, PP Priority, or RR Routine). The Pass Summary is to be sent Operational Immediate to TIROSI and the Telemetry Summary is to be sent Priority. The following messages are to be sent Routine:

Telemetry calibrations
S-9 sensor spin data
Picture summaries
Nephanalysis
H1 Messages

h. If unusual or important events occur and TTC should be immediately notified "or" if operational instructions or important data are needed immediately from TTC, Operational Immediate (OO) precedence is to be used.

Another precedence (SS), Special Precedence, is available for use when important contact with a specific individual is needed or desired within a very limited time, and this may or may not relate to current operations. The use of precedence indicators is a very important part of communication relay operations. Care and discretion must be used in their application. For example: Operational Immediate (OO) will not normally be used by stations unless the important data is needed from TTC within a sixty (60) minute period.

i. All messages including WEABUR as addressee should in so far as possible be sent over the circuit on which WEABUR shares as a "drop station".

j. The correct address for all messages to TIROS Control is: TIROSI.

TABLE I

(A) Message Types

1. Launch information

2a. Equator-crossing predictions

2b. Orbital elements

3. Weather Bureau requests for TV camera sequences

4a. World Map and Satellite Acquisition Data extracts for direct camera sequences and/or acquisition.

4b. World Map and Satellite Acquisition Data extracts for remote camera sequences, consisting routinely of the central forty (40) minute portion of the favorable picture-taking periods. Both WALACQ and NICOLA will receive remotes for all orbits.

5. CDA pass summaries.

NOTE: WALACQ will verify the magnetic attitude control (MAC) switch setting during the first interrogation of each day and NICOLA will verify the MAC switch setting during the next to last interrogation of each day. The results will be included in the applicable pass summaries.

6a. Telemetry-recorder calibration

6b. Telemetry summaries

7a. Pass picture summary will be sent immediately after each orbit of received data has been given a summary analysis so as to report number of pictures received, general quality and any unusual features observed.

7b. Daily picture summary will be sent at the completion of the operational day. Data to be included are total number of pictures received for each orbit and for the day, number of pictures usable and unusable, number of pictures noisy and description of detailed analysis of each orbit of data. The message will be signed by the Meteorological Team Leader (or designated alternate) and the CDA Station Manager.

8. Nephanalysis

9. Horizon-scanner attitude message (H1)

10a. Daily operational provisional attitude report

10b. Short-range prognostic attitude data

10c. Daily operational definitive-attitude report

11. S9 sensor spin data

12. Magnetic-tape inventory message

13. Daily Weather Bureau operations summary

101a. CDA station programs and changes

101b. Start clock program

102. Power-consumption reports

103. Sun-angle computer setting

104. Periodic progress report

105. Weekly power-available report

(B) Distribution of Messages

NO.	TELETYPE MESSAGES ORIG. OUTSIDE TIROS TECH CONTROL	TIROSI	WALACQ*	WALWEA*	NICOLA*	PMRWEA*	RCAHNJ	WEABUR	COMPUT	DATA SYSTEMS (SPACON)	METEOR	VARIOUS - INC MINITRACK	SNTAGO	A-ACTION F-FROM I-INFO
1	Launch Injection etc	A										F		
2A	Equator Crossing	A	A	A	A	A	A	A	F		I			
2B	Orbital Elements	A	A	A	A	A	A	A	F		I			
3	Requests for TV Coverage	A		I		I		F						
4a	WMSAD "Predicts"		A	A	A	A	I		F					
4b	WMSAD "Remotes"			A		A			F					
5	Pass Summary	A	F/A	A	F/A	A	I	I		I	I		F	See par. 3.4.2(g) for format
6a	Tel. Recorder Cal.	A	F		F		I							
6b	Tel. Summaries	A	F		F		I							
7a	Picture Summary	A		F/I		F/I	I	A			I			
7b	Daily Picture Summary	A	I	F	I	F	I	A			I			
8	Nephanalysis	I		F/I		F/I		A						
9.	H1 Attitude	A	F	A	F	A	I		A					
10a	Daily Operational Provisional Attitude	A	F	A	I	A	I	A		A	I			
10b	Prognostic Attitude	A	F	A		A		I		I	I			
10c	Daily Operational Definitive Attitude	A	F	A	I	A	I	A		A	I			
11	S9 Sensor Spin Data	A	F		F		I		A					
12a	Magnetic Tape Inventory MSG	A	F		F						A			
13	Daily Weather Bureau Operations Summary	A		I		I		F						

No.	TELETYPE MESSAGES ORIG. FROM TIROS TECH CONTROL	WALACQ	WALWEA	NICOLA	PMRWEA	RCAHNJ	WEABUR	METEOR	SNTAGO	NASAHQ	A-ACTION I-INFO
101A	Programs	A /I	A /I	I /A	I /A	I A	I	I			
101B	Start Clock Program	I	I	I	I	I	I	I	A		
102	Power Consumption					A		I			
103	Sun Angle Computer Setting	A		A	A	I					
104	Progress Report	A	A	A	A	A	A	A	A	A	
105	Weekly Power Available Report					I	A	I			

(C) Explanation of Abbreviations

TIROSI	- NASA - TIROS Technical Control
WALACQ/WALWEA	- Wallops Station, Virginia, command & data-acquisition station
NICOLA/PMRWEA	- Pacific Missile Range, California, command and data-acquisition station
RCAHNJ	- RCA Astro-Electronics Division, Princeton, New Jersey, secondary data-acquisition station
WEABUR	- Meteorological Satellite Center, Suitland, Md.
METEOR	- Aeronomy and Meteorology Division, GSFC
LAUNCH	- NASA Comm. Center, Hangar AE, AMR
MINITRACK	- Minitrack Network
SNTAGO	- Santiago, Chile Minitrack station, auxiliary command station

TABLE II

From \ To	TIROSI	WALACQ/ WALWEA	NICOLA/ PMRWEA	RCAHNJ	WEABUR	Launch	Minitrack
TIROSI		(2) TTY* Fo	(2) TTY* Fo	TTY	(2) TTY, Fo	Fo*	TTY
WALACQ/ WALWEA	(2) TTY* Fo FAX		TTY Fo	TTY	FAX, TTY Fo		
NICOLA/ PMRWEA	(2) TTY* FAX Fo	TTY Fo		TTY	FAX, TTY Fo		
RCAHNJ	TTY	TTY	TTY		TTY		
WEABUR	TTY, Fo	TTY, Fo FAX	TTY, Fo FAX	TTY			
Launch	Fo*						
Minitrack	TTY						

*Open phone line, also, during immediate pre-and-post launch period

TTY - Teletypewriter
Fo - Phone line
FAX - Facsimile

3.3.4 PMR Data-Acquisition Station

a. The meteorological team will transmit its rectifications to the Meteorological Satellite Center via facsimile.

b. The voice capability on the facsimile circuit will be used for coordination and communication with the TIROS Technical Control Center.

c. Each nephanalysis transmitted during the first two weeks following launch is to be copied at TTC. The CDA station will notify TTC of all transmissions. After that date only the daily composite nephanalysis is to be received on a routine basis. Selected nephanalyses will be called for as conditions warrant.

3.3.5 Wallops Data-Acquisition Station

a. The meteorological team will transmit its rectifications to the Meteorological Satellite Center via facsimile.

b. The voice capability on the facsimile circuit will be used for coordination and communication with the TIROS Technical Control Center.

c. Each nephanalysis transmitted during the first two weeks following launch is to be copied at TTC. The CDA station will notify TTC of all transmissions. After that date only the daily composite nephanalysis is to be received on a routine basis. Selected nephanalyses will be called for as conditions warrant.

3.4 Daily Operating Procedures

3.4.1 Activities at Washington, D. C.

a. Assuming adequate launch trajectory data and Minitrack data are obtained, it should be possible to determine the satellite orbit with acceptable accuracy within one or two days after launch. Predictions of ground station contact can then be made for about a week in advance. These predictions will be made on a regular basis, for one-week and 30-day periods.

b. The format of the original printout of predictions (World Map and Satellite Acquisition Data - WMSAD) has been established and is shown in Figure IV. A separate printout of individual station acquisition data is provided to TTC for transmission to the individual ground stations. This data will be in the form of IBM magnetic tape and computer "listings" (see Figure IV).

c. TIROS Technical Control will use the World Map and Satellite Acquisition Data to:

1. Determine the orbits which will be programmed on any given day.

2. Select the command station which will interrogate on each orbit.

3. Derive the CDA station interrogation program.

4. Determine the time the satellite is in sunlight so that power available for programming may be calculated and receipt of sun sensor data may be predicted.

5. Compile Signal Strength versus Range log.

6. Evaluate satellite performance in various conditions of sunlight.

d. The coding for the interrogation program will use the abbreviations listed below. Insofar as practical, the abbreviations correspond to the labels appearing on the PROGRAMMER control panel.

AUTOSTART OR MANUAL START OR MANUAL OPERATE	Type of Operation
DCSI	Direct Camera Sequence I (to be followed by OFF; 1; 1 & 2)
DCSII	Direct Camera Sequence II (to be followed by OFF; 1; 2; 1 & 2)
PI	Picture Interval in Seconds (10S or 30S or OFF)
ET	Elapsed Time in Minutes (0.5M to 8.0M in half minute intervals)
PB	Playback Sequence (to be followed by OFF; 1; 1-2; 2; 2-1; 1N; 1N, 2N)
SET	Transmit set pulses to clocks designated (to be followed by OFF; ONE; TWO)
TO	Number of set pulses to use
A1, A2, A3	Alarm times 1, 2 and 3

Z	GMT time in hours, minutes and seconds
PB pix started ____________ Z	Time when remote TV picture sequence which will be played back during this program started
NEXT RMT PIX SET TO START________Z	Time when future remote TV-picture sequence will start as a result of setting the clocks during this program

An example of a typical coded message is given below:

DATE

ORBIT OR PASS NO. STATION

AUTOSTART

DCSI 1 PI 10S ET 5.0M

PB, 1 SET ONE TO 7879

DCSII 2 PI 30 Sec ET 5.5M

A1 11 31 00Z

A2 11 36 00Z

A3 11 37 40Z

PB PIX STARTED 11 03 30 Z (orbit 1217 min AAN 48)

NEXT RMT PIX SET TO START 1215 30Z (orbit 1218 min AAN 50)

Any special or unusual instructions or clarification of instructions will be sent at the end of the coded message in plain language.

Because of the gradual shift around the clock of the daily time of occurrence of the orbital operating period the time of interrogation program preparation and transmission of the instructions will vary. Normally, however, programs will be transmitted to the CDA sites at least eight hours in advance of the start of the pass day at each site.

e. Santiago Minitrack will be used to send the start clock tone.

The addition of SNTAGO as a command station will allow TV pictures to be taken of areas which normally would be impossible to program by the prime CDA stations due to the five hour clock timing limit.

The instructions for the SNTAGO station will be sent as follows:

Start Clock Program for 1961 Alpha November 12, 1961 Initiate Start Clock Sequence at 161800Z (orbit 1805)

November 13, 1961, Initiate Start Clock Sequence at 154000Z (orbit 1819)

Sgd/NETCON

WMSAD predictions will be sent to SNTAGO for antenna aiming purposes.

f. Receipt and relay of cloud data via facsimile and teletype will be accomplished through facilities of NMC, MSA, KWAF, and Fleet Weather Central. Personnel from the individual data-using organizations will process the analyses as required for relay to their respective services with minimum delay.

g. Facilities

1. Teletype: Send-receive terminal equipment on the TIROS net will be located in MSC to provide for 24 hour operation.

2. Facsimile receivers on circuits from Wallops and PMR will be located at TTC and NMC. Transmitters located in NMC, KWAF, and NSS will be used to relay pictorial TIROS information to field users.

3. The use of the facsimile circuits from PMR and Wallops is intended for the transmission of nephanalyses and pictures from the CDA stations to NMC and TTC, and for voice-coordination activities by TTC with the CDA stations.

   (a) Transmission of nephanalyses will have priority use of the line, except in emergencies, and when communication must be effected between TTC and the CDA station to prevent compromise or loss of data on an impending interrogation.

   (b) Transmission of photofax and certain nephanalyses (see Sec. 3.3.4 c and 3.3.5 c) data from the CDA stations will be coordinated between TTC and NMC so that both stations may copy the transmission.

(c) Whenever a facsimile (photo or nephanalysis) transmission is in progress, it will not be interrupted for any reason except as provided for above.

3.4.2 Command and Data-Acquisition Stations -- General Operation

a. The phases of operation for each pass are:

1. Program setup

2. Equipment checkout

3. Acquisition and operation

b. The real-time operation is followed by a number of other activities:

1. Immediate playback of video tape to produce project negative, archival film, and work positive.

2. Evaluate station performance and telemetry data

3. Report station success and significant telemetry data to the TIROS Technical Control Center

c. A daily and pre-pass telemetry calibration will be performed, using the procedures established in the handbook, Operational Procedures for Telemetry Data Processing and Power Supply Monitoring.

d. The 136-Mc telemetry data will be reported from both beacons.

e. The points which are to be reported are outlined in the handbook.

1. Transmit 136-Mcs beacon attitude and S-9 Sun Sensor data to TTC and RCA-AED

(a) The sun-sensor message transmitted after each pass during which data is obtained will have the following format:

RR TIROSI COMPUT INFO RCAHNJ

DE (Station Code) (Msg. Nr.)

R (dtg)

BT

TIROS (Nr.) Orbit 0000

S-9 sensor spin data (Z time-of-command tone initiation producing the first direct-camera sequence)

(b) One and one-half minute direct-camera sequences will routinely be used to produce S-9 data whenever the satellite is in sunlight, whether or not pictures are to be programmed.

(c) With the capability of recording H1 and telemetry data on magnetic tape, it is expected that loss of the 136-Mc data will normally occur only when loss of antenna track is experienced.

2. Take corrective measures of any station malfunction and, if another pass is due shortly, initiate program set up for it.

c. Operations will be performed in the order listed or concurrently if possible. At the beginning of the day's operation, a period of at least one hour before the first pass should be allowed for the crew to make its once-per-day preparations. Each station can contact the satellite almost always on 5 orbits. The first two (or three) are consecutive with a two orbit gap and the last two (or three) are consecutive. The station operating time including set up is approximately 14 hours.

d. These total operating times suggest the use of two-shift operation at each station. However, the starting time of the 16-hour period cannot be fixed, because the time of the first pass varies each day. Whenever the initial pass comes very soon after the first-shift starting time, the majority of the preparations for it can be made at the end of the previous day's work.

e. Data-Handling Responsibility

The senior NASA representative at each station will be responsible for assembling, packaging, and mailing recorded data to the appropriate agency. Weekly mailing of the records should be sufficient unless otherwise specified.

(1) The check negatives, work positives, original nephanalyses, events records, and sequence logs will be mailed to MSA for preparation of frame logs and for further evaluation.

(2) Copies of the events records are to be made immediately by MSA upon receipt and sent to RCA-AED and TTC.

f. Each readout station must report to the TIROS Technical Control Center the actual time programmed into the satellite for beginning the picture sequence, so that the other station can interpret the data if read out there on the next pass.

g. Each readout station will send a pass summary in the following format:

TIROS

Pass Summary Nicola (or WALACQ) Orbit ____________

1. Beacon Acq ________ Z
2. Beacon Fade ________ Z
3. TV Sys ON: ____ Z TV Sys OFF: ____ Z DCSI ____ Sec; PB ____ Sec; DCSII ____ Sec
4. A1 ________ Z
5. A2 ________ Z SET 1 ____ BACK UP 1 ____________
6. A3 ________ Z SET 2 ____ BACK UP 2 ____________
7. RCVD DCSI CAM 1 (or 2) ____ FRAMES
8. PB 1 (or 2) ____ FRAMES
9. RCVD DCSII CAM 1 (or 2) ____ FRAMES
10. RCVD OVERSETS CAM 1 (or 2) ____ FRAMES
11. FIRST OVERSET FRAME RECEIVED CAM 1 (or 2) ____ Z
12. (No) UNPROGRAMMED STEPPING OF MAC SWITCH WAS NOTED

    (OR) MAC SWITCH VERIFIED IN POS ____ AT ____ Z
13. TV Signal Strength TV V ____ H ____ Microvolts Signal Quality ____

14. Comments:

Signed ________________, Shift Chief ________________, Station Manager

NOTES: 1. Only those items which are pertinent to each report will be transmitted.

2. The shift chief and station manager at each CDA station are to sign the Pass Summary Message.

3. It is important that any abnormal ground station or satellite response be included in the comments section.

3.4.3 Command and Data-Acquisition Stations - Real Time Procedures

a. A transmission of acquisition instructions to the ground stations as they become available will be by teletype. Until specific acquisition instructions are available, the primary CDA stations will use independent manual acquisition on the 136-Mc beacon signals. There will be a prepared antenna program available at each CDA station (WMSAD predictions) based upon the most probable orbit. There is a prepared "MANUAL START" command program for the transmissions to the satellite on the first two orbits on the day of launch in which the operations to be performed are initiated by action of the programmer engineer as he verifies that the preceding command functions have been properly performed.

Before any use is made of the programmer, the engineer will verify receipt of the 136.23 and/or 136.92 beacon signals and adequate antenna tracking of them. He will then initiate the manual start command sequence.

b. TIROS Launch Day Programs

Four types of programs are listed (A through D). Instructions as to which programs to use will be made by telephone and verified by teletype on launch day.

The programs are to be run with alarm times started to the nearest full minute, i.e., xx xx 00Z two minutes after the beacons are received. Other alarm times on this first day are minutes and seconds after the Alarm one (A1) time on a given pass.

TIROS - Program A
Launch Day
Orbit 001 NICOLA
Manual Start
DCS I 1 PI 10S ET 2.0M
PB1 Set Off
DCS II 1 PI 10S ET 3.0M

A1 xx xx 00Z
A2 xx 02 00Z
A3 OFF

TIROS - Program A
Launch Day
Orbit 001 WALACQ
Manual Start
DCS I 1 PI 10S ET 8.0M

A1 xx xx 00Z
A2 xx 02 00Z
A3 OFF

TIROS - Program A
Launch Day
Orbit 002 NICOLA
Manual Start
DCS I 2 PI 10S ET 2.0M
PB 2 Set Off
DCS II 2 PI 10S ET 8.0M

A1 xx xx 00Z
A2 xx 02 00Z
A3 OFF
VERIFY MAC SWITCH POSITION

TIROS Program B
TIROS failed to separate from the third stage rocket.
Launch Day
Orbit 001 NICOLA "B"
Manual Operate
DCS I 1 PI Off ET 2.0M
PB 1 Set off
DCS II 1 PI Off ET 2.0M
A1 to be approximately 1 minute after receiving beacons.

Launch Day
Orbit 001 WALACQ "B"
Manual Operate
DCS I 1 PI 10S ET 8.0M
PB Off Set Off
DCS II Off

A1 should be approximately one minute after receiving beacons. Take a polaroid picture to confirm that the rocket is still attached. (Use the new 3000 speed film with 10 second development time.) Immediately upon checking the photo and confirming that the rocket is still attached, move the "spin-up rocket" switch two (2) positions. In order to transmit a "spin-up rocket" command, the attitude control pulse switch is to be placed in the "spin-up position" and then the "spin-up fire" push button should be manually depressed for ten seconds to advance the stepping switch in the satellite one position. The push button must be released for at least ten seconds before depressing it again to advance the rocket switch another step.

Report results immediately to TTC and send the pictures to TTC over the facsimile circuit.

Launch Day
Orbit 002 NICOLA "B"
Manual Operate
DCS I 2 PI 10S ET 8.0M
PB Off Set Off
DCS II 2 PI 10S ET 6.0M
A1 to be as on 001 NICOLA "B"

Launch Day 1962
Orbit 002 WALACQ "B"
Manual Operate
DSC I 2 PI 10S ET 8.0M
PB OFF Set Off

A1 to be about four (4) minutes after receiving beacons. This program is planned so that WALACQ will take over command from NICOLA without letting the TV carrier drop out as the satellite passes from one CDA station to another. WALACQ will begin its interrogation once pictures no longer are received from the NICOLA commanded 10 second interval interrogation.

TIROS control will provide additional programs for subsequent orbits as required.

TIROS Program C
TIROS failed to spin down

Launch Day
Orbit 001 NICOLA "C"
Manual Operate
DCS I 1 PI 10S ET 2.0M
PB 1 Set Off
DCS II 1 PI 10S ET 2.0M

A1 to be approximately two (2) minutes after receiving beacons.

Launch Day
Orbit 001 WALACQ "C"
Manual Operate
DCS I 1 PI 10S ET 6.0M
PB Off Set Off
DCS II 1 PI 10S ET 4.0M

A1 to be NICOLA "C". Advance "Spin-up rocket" switch one (1) position during DCS I.

Launch Day
Orbit 002 NICOLA "C"
Manual Operate
DCS I 2 PI 10S ET 5.0M
PB Off Set Off
DCS II Off

A1 to be as on 001 NICOLA "C". Advance "Spin-up rocket" switch one (1) position about midway through DCS I. Be sure that telemetry has been completed so that good attitude information can be obtained with the horizon and S-9 sensors during spin-down.

Keep telemetry record intact and mail to M. H. Harper, RCA-AED, Princeton, N. J.
Report success of spin-down to TTC immediately.

Launch Day
Orbit 002 WALACQ "C"
Manual Operate
DCS I 2 PI 10S 8.0M
DCS II OFF

A1 to be as on 001 NICOLA "C".

If spin-down is successful use program "A" on subsequent orbits.

If spin-down is unsuccessful TTC will advise for future orbits.

TIROS Program "D"
TIROS in poor orbit

Launch Day
Orbit 001 NICOLA "D"
Manual Operate
DCS I 1 PI 10S ET 8.0M
DCS II 1 PI 10S ET 6.0M

A1 to be as soon as beacons are clearly received.

On subsequent orbits both NICOLA and WALACQ will command all orbits they can contact with the same program as above until directed otherwise by TTC.

On all Programs A, B, C, D, the picture interval is to remain "off" until the 235 MC carrier is clearly received, and then, as indicated, it will be switched to 10 seconds.

On launch day only, the senior RCA-AED engineer at each of the CDA stations will have the authority to modify programs to the extent that sound technical check-out and evaluation of the satellite's performance demands. All such changes will of course be reported in detail in the applicable pass summaries.

TIROS Technical Control will keep a running total of power consumption changes occasioned by any such modifications to the programs and, depending upon how the power picture is affected, may have to specify restrictions for the last several orbits.

c. Revised antenna acquisition data programming instructions may be available by the second pass over NICOLA which occurs about (3 hours and 20) minutes after launch.

3.4.4 Attitude Indicator

a. Pre-Pass Operating Procedure

1. Turn power to all units on.

(The tape punch may be left off prior to the introduction of timing).

Motor on-off switch on Attitude Pulse Selector in off position.

Motor on-off switch on Sanborn Recorder in on position.

Selector on-off in on position.

DTMD in "stop" position with its power supply turned on.

Attitude-off time selector switch in "off" position.

Friden punch motor on.

2. With the Sanborn controls in "calibrate" and "1300 cycles", adjust the Sanborn zero-suppression dial so that the pens are in the center of their respective charts.

3. Monitor the output at the test jack on the front of the attitude-pulse selector (J9) with a voltmeter. Adjust the input bias control to obtain the optimum bias point as found in the initial calibration. (Approximately - 7 volts)

4. Operate the DTMD reset button several times.

5. Place the DTMD in "start" position.

6. Place the DTMD in "time" position. The punch will now record one second intervals.

7. Observe the master timing clock. Immediately after a conveniently recordable time, move the switch from "time" position to "off" position. A minimum of four one-second intervals shall have been recorded prior to switching to the "off" position.

8. At this point make a note of the time of the start of the one-second readings. This establishes the real time start.

9. If data is available as to the expected initial earth period, set the inhibit-gate length to this value. If no data is available, set the inhibit-gate length to approximately two seconds.

b. Operation During a Pass

1. At any time after three 10-second intervals have been recorded, the system is ready to accept attitude

data. When the satellite beacon is heard, place the selector switch on the Sanborn in "use" position and start the Sanborn motor.

2. To start taking attitude data, place the attitude-telemetry switch in "attitude" position.

3. Start input to the DTMD by switching the attitude-off-time switch on the selector to "attitude". Make sure at this point that the channel selector switch has as its input one of the Sanborn channels. Channel B will probably be preferred because of the proximity to the inhibit gate indication on the Sanborn chart.

4. The punch should start reading out at this point.

NOTE: In unusual instances the selector may not be triggering, due to low signal level, etc.; this should not happen if the equipment has been adjusted properly. If it does, however, the level controls on the appropriate detectors may be adjusted to bring the signal in. The sky-earth detector not triggering is evidenced by the inhibit gate not showing up on the chart. The earth-sky detector may be shown to be not operating by observing that the punch fails to read out when the earth-sky transition is known to be not inhibited.

5. Approximately 10 seconds before the receipt of telemetry (as is determined from the start of the program), switch the attitude telemetry switches on both channels to telemetry.

6. After telemetry has ended, switch back to "attitude" position on both channels.

NOTE: Due to the short time interval between the start of a pass and telemetry reception, it may not be advisable to try to get meaningful attitude data before the end of telemetry. In any event, since the closing of the tracking loop is rather difficult, this should not be attempted before the end of telemetry until the operator has achieved a certain degree of familiarity with the equipment.

7. When attitude data is no longer observed, switch the attitude-off time switch to "off", stop the Sanborn motor.

8. Establish a stop time by placing the appropriate switch in "time" position, and allow one-second readings which are to be terminated at some conveniently recordable time by switching back to the

"off" position. A minimum of four one-second readings should be recorded.

9. Make a note of the stop time. Allow a minimum of three 10-second intervals to be recorded on the tape.

c. Post-Operative Procedure

1. Tear off all "false starts" from the data tape, i.e., groups of one or more one-second readings not preceding the start of real time.

2. Complete the data header as shown in the punched-tape format (Table III), inserting start time and stop time.

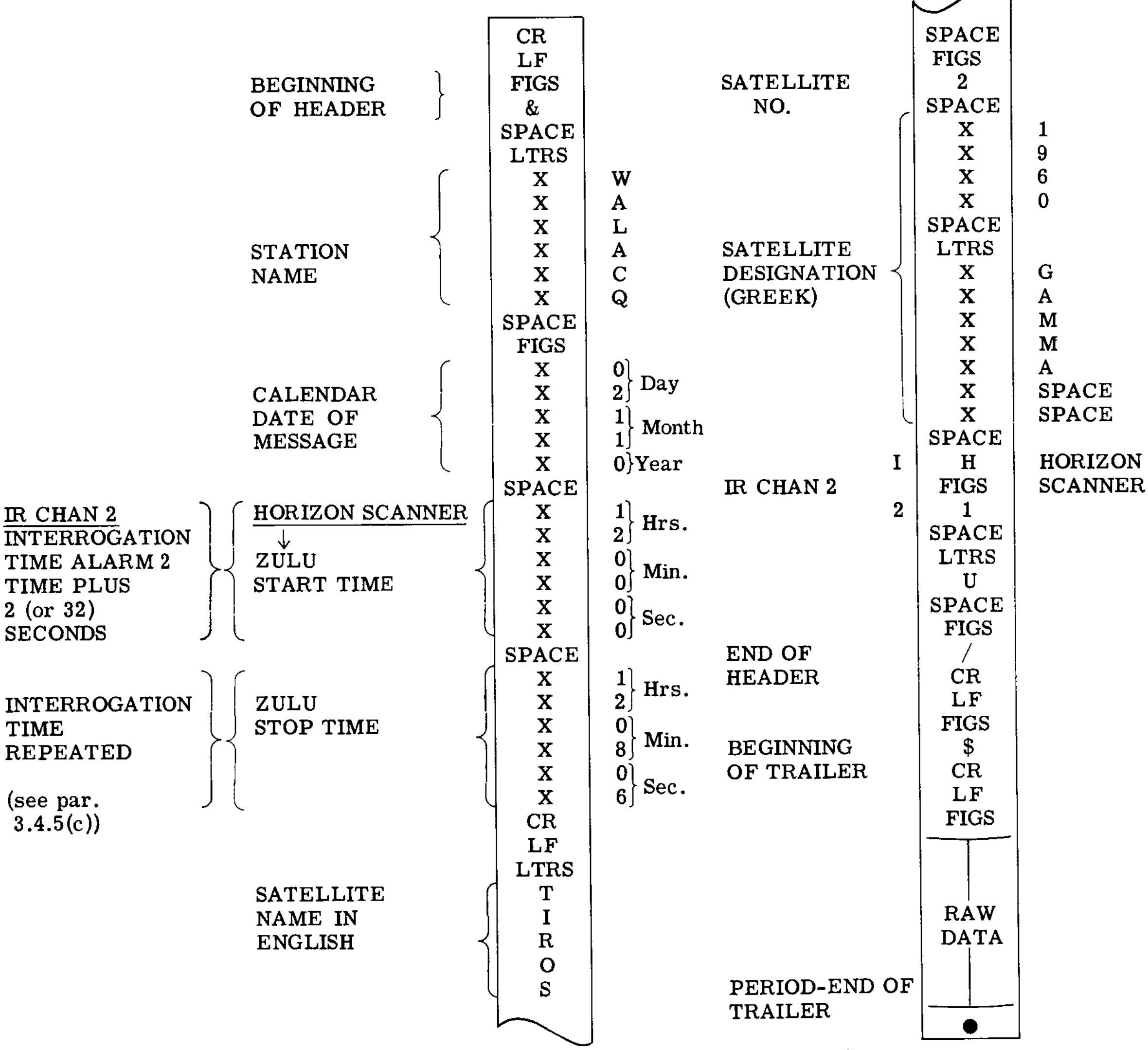
3. Insert raw data as shown in the punched-tape format. Punch a period at the end of trailer.

4. Insert the punched-tape format into a standard message format.

TABLE III

TIROS SATELLITE ATTITUDE DATA FORMAT

A1. PUNCHED-TAPE FORMAT



NOTE: Representative characters are shown at right of tape.

4. DETAILED DESCRIPTIONS

4.1 The Spacecraft

4.1.1 Spacecraft Configuration

The basic weather-observing instruments in the satellite are recording television cameras with their associated transmitters, receivers, and control circuitry. In addition, beacon transmitters, attitude sensors, and telemetry circuits are provided for reference purposes. Primary electrical power is derived from solar cells covering the sides and top of the vehicle, and from storage batteries that also provide the smoothing function for variations in solar radiation and electrical loading.

4.1.2 TV Components

The two television chains each consist of a camera, magnetic-tape recorder, record and playback amplifiers, transmitters, and control circuitry. The two cameras are axially aligned. The ELGEET wide-angle camera provides 104-degree coverage and the TEGEA camera provides 76-degree coverage, each adequate for viewing cloud systems. The ELGEET and TEGEA systems cover areas of approximately 725 and 450 nautical miles respectively. These conditions apply when the optic axes are normal to the earth's surface. Thirty-two pictures will be stored on each magnetic tape during each orbit for playback over the designated ground stations. A direct-link camera readout, bypassing the tape recorder, is provided for use when the satellite is within radio range of the ground stations.

4.1.3 TV Control Circuits

Complete programming flexibility is provided by the control circuits in the satellite for operating the cameras. They may be operated simultaneously or sequenced individually in both the storage and direct mode. Remote-storage programming is achieved by using clocks, one in each chain, set by the ground station from information received from the TIROS Technical Control Center. Picture information on a 85-kc sub-carrier is transmitted to the ground station on command by 2-watt FM transmitters at 235 Mc.

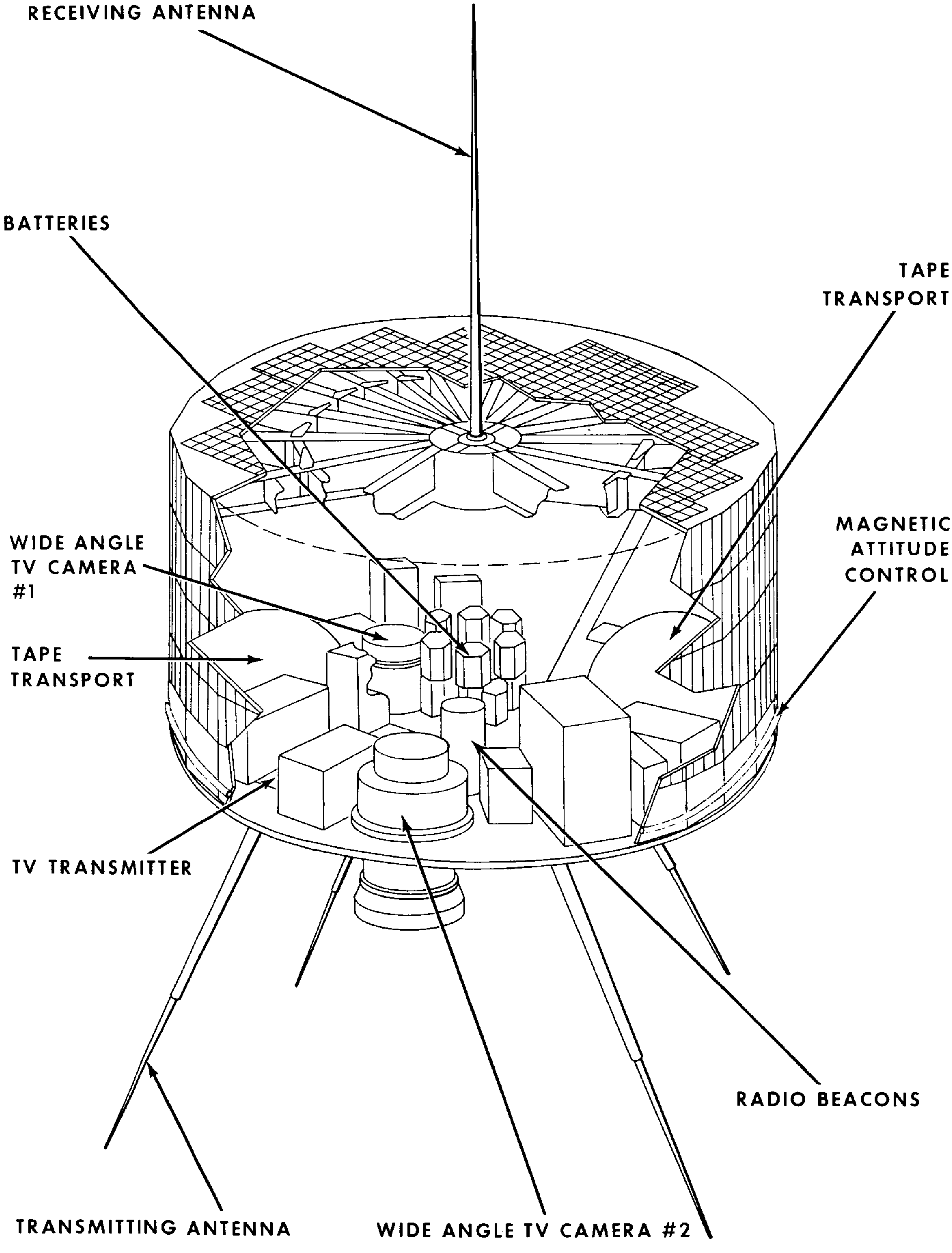


Figure 6 – The TIROS Satellite Configuration

4.1.4 North Indicator

The north indicator consists of nine solar cells spaced at 40-degree intervals around the side of the satellite cover. The nine cells are made of three different surface widths and are mounted in a special sequence. For each revolution of the satellite about its axis, nine pulses of three different durations are generated by the solar cells. Using any two successive pulses, the relative duration uniquely determines the angular position with respect to the sun. These pulses are shaped, amplified, and fed to the receiving station on a 10-kc FM subcarrier along with the TV signal (235-Mc carrier).

4.1.5 Beacons

Two beacon transmitters with 50-milliwatt outputs are provided in the satellite for tracking by the ground stations and to provide for telemetering internal environmental and unit operating conditions as well as attitude data. Forty telemetry channels are sequenced only when telemetry transmission is commanded. Attitude data in the form of 3-kc modulation bursts is transmitted continuously. The beacons are on continuously but may be turned off by command should the need arise. The beacons transmit on 136.23 Mc and 136.92 Mc. Modulation is transmitted on both beacons for reliability.

4.1.6 Spin Control

Spin rates of about 126 rpm may be imparted to the satellite by the second-stage rocket. Upon separation, a precession damping mechanism is activated to stabilize the satellite's spin. Also, upon separation, a 10-minute delay timer is activated which in turn sets off an inertial device to reduce the angular rate from 126 rpm to 10 rpm by release of the despin weights which unwrap from the outer surface of the payload. After despin, the weights and their trailing wires automatically separate from the vehicle. Angular velocity is then maintained within the limits of 9 and 12 rpm by firing any of 5 opposing pairs of peripheral rockets on command from the ground station upon direction from the TIROS Technical Control Center which constantly monitors the angular rate of the satellite by processing the output of the attitude sensors.

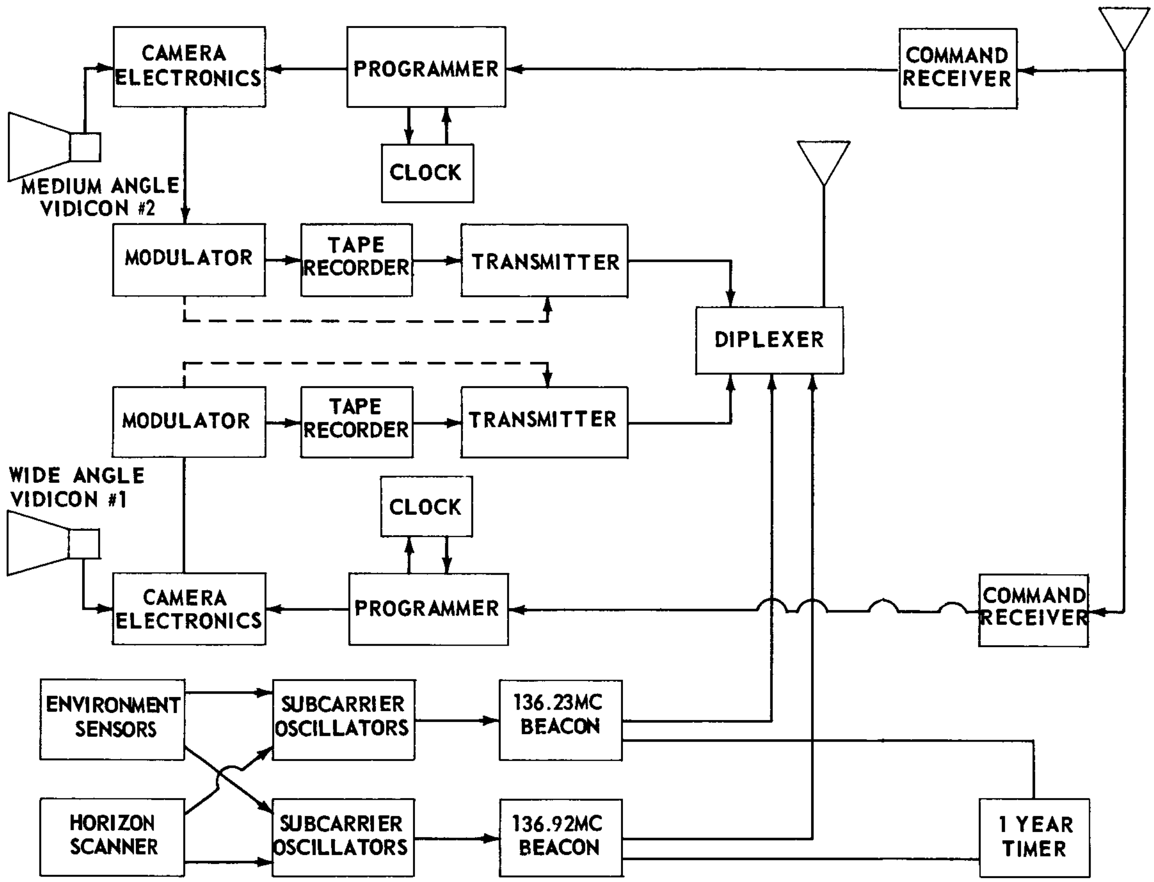


Figure 7 – TIROS Satellite, Block Diagram

4.1.7 Attitude-Control Coil

A current flowing in the magnetic attitude-control coil around the base of the satellite will produce a magnetic dipole moment along the spin axis. A torque caused by the interaction of this dipole with the earth's magnetic field will cause the satellite spin axis to precess in space in a predictable way, according to theory. The direction and magnitude of the current flowing in the magnetic attitude-control coil can be programmed from the command and data-acquisition stations by selecting one position of a stepping switch in the satellite which affords a choice of five levels of positive current, five levels of negative current, and two positions corresponding to a zero dipole moment for the satellite.

TIROS Technical Control will constantly monitor the spin-axis attitude of the satellite, comparing it with its desired value and providing instructions for adjusting the magnetic dipole moment of the satellite to precess the spin axis in a desired direction at a desired rate.

The principal procedure employed will be to verify adherence of the measured attitude to a precomputed track, and to command precomputed dipole adjustments at precomputed times to maintain adherence to the desired motion. If major external disturbances occur, or if the attitude begins to deviate markedly from the prescribed history, a secondary procedure is available. Nomograms will be provided from which the permissible short-term rates and directions of motion from any orientation can be obtained. The dipole value most closely realizing the desired rate and direction to restore the correct attitude will be selected, and instructions provided to the ground stations to adjust the moment to this value.

Information to be provided by RCA-AED to the TIROS Technical Control Center to support this activity includes:

a. Planned dipole program and predicted attitude history.

b. Generalized nomograms of permissible short-term rates vs orbit and satellite orientation.

c. Measured dipoles of each flight-model satellite in each switch position.

4.1.8 Structure

The satellite is an 18-sided polygon, 22 inches high and about 42 inches in diameter. The nominal weight is 286 pounds. The satellite structure has been designed to provide a flat mounting surface for the components, together with sufficient sun-cell area to provide for power generation in orbit.

4.2 Primary Command and Data-Acquisition Stations

4.2.1 Systems Components

The Pacific Missile Range is a primary operating point for the U. S. Navy Missile Center. For TIROS, use will be made of certain facilities on both San Nicolas Island and Point Mugu. The major system components include:

a. San Nicolas Island

1. A 60-foot self-tracking receiving antenna for television, beacon telemetry, and attitude data.
2. A command-transmitting antenna.
3. A microwave line between the PMR telemetry building and the Communications Center, Building 127.
4. A microwave link between Building 127 and Building 53 at Point Mugu.
5. Programming, transmitting, receiving, and recording equipment. This equipment is housed in two semi-trailers.
6. Two "office vans".

b. Point Mugu

1. TIROS film-recording system.
2. Photo-processing facility.
3. Meteorological photoanalysis and G-15 computer facility.
4. Cable connections between Buildings 53 and 552.
5. Sun sensor read-out facility.

c. Wallops Station

1. A Kennedy 136-Mc receiving (with command transmitting) antenna included.

2. A General Bronze self-tracking receiving antenna for television data.

3. Programming, transmitting, receiving, and recording equipment. This equipment is housed in the telemetry building.

4. A photo-processing facility.

5. A meteorological photoanalysis and G-15 computer facility.

4.2.2 Tracking Antennas

At PMR the 60-foot dish is equipped with proper feeds and the self-tracking feature. At Wallops two antennas are used and slaved: a 136-Mc (with command) antenna and a 235-Mc receiving antenna. The antennas at Wallops and PMR have separate feeds and output multicouplers for signals arriving with horizontal and vertical polarization. Space, power, and operating personnel for these receiving-antenna installations are in existence.

4.2.3 Tracking Antenna Auxiliary Equipment

a. Additional electronic and electromechanical equipment needed for command and data-acquisition functions at San Nicolas Island are mounted in two NASA semi-trailers, both located within 100 feet of the main telemetry building, on prepared level surfaces. The equipment complement and its distribution between vans is given in Tables IV and V, together with a breakdown of the rack space and power requirements. The command transmitters have been removed from the van and installed in the base of the transmitting antenna pedestal approximately 150 feet from the main control building. Remote-control equipment has been installed in the van for operation of the transmitters from the main control site.

b. The equipment at the Wallops site is mounted in existing building space. The equipment complement includes everything listed in Tables IV and V for San Nicolas Island, including two antenna programmers. Both sites

TABLE IV

Equipment in Command Van at PMR

Quantity	Component	Power (in KW)	Space
4	136-Mc receivers	0.8	1 rack
1	Telemetry recorder	0.4	1 rack
1	Master clock and power supply	2.0	3 racks
2	Command programmers	0.3	
2	Antenna programmers		
2	148-Mc transmitters*	1.9 (1.5 on operating unit, 0.4 on standby)	2 racks
1	Events recorder	0.1	
	Total	5.5	7 racks
	Air-conditioner	4.4	
	Lighting	1.0	
	Total Power	10.9 KW	

*Installed in base of AT-36 antenna

TABLE V

Equipment in Telemetry Receiver Van at PMR

Quantity	Component	Power (in KW)	Space
1	Slow-scan TV monitor, control unit, power supply	0.7*	2 racks
1	Calibrator unit	0.15	1 rack
2	FR-107 tape recorders	3.0	3 racks
5	235 - 237-Mc receivers plus diversity combiners	1.0	2 racks
1	Picture index computer and sun angle computer	0.8*	1 rack
1	Digital timer-measuring device	0.2*	1 rack
1	Quick-look IR demodulator	1.0	1 rack
	Total	6.85	11 racks
	Air-conditioner	4.4	
	Lighting	1.0	
	Total Power	12.25 KW	

*Installed at Weather Center, Pt. Mugu

will also be equipped with attitude recorders (see Section 4.4)

4.2.4 Command Antennas

The command transmitting antenna at San Nicolas Island is a crossed yagi array mounted on the edge of the 60-foot self-tracking dish. At Wallops the 136-Mc antenna carries a command yagi.

4.2.5 Photo Processing Facilities

Existing fixed station facilities and personnel of the NASA Wallops Station will perform the photo-processing function for the Wallops Station. A darkroom close to the data-receiving room has been provided. A TIROS project photographic laboratory staffed by RCA photographic personnel will perform the photo processing at PMR. Equipment and consultative personnel from the PMR photo laboratory will be available to the project upon request.

4.2.6 Meteorological Photoanalysis Facilities

a. The weather analysis facility at PMR, Point Mugu, is located in a room of approximately 500 square feet with suitable heating, lighting, and air conditioning. Three photoviewers are provided by the Weather Bureau; 60-cycle single-phase 115-volt power of about 1.5 kw is required. Allied Research personnel will operate a G-15 computer at the facility to produce attitude-determination and picture grids for the meteorological analysis.

b. The weather-analysis facility at Wallops is located in a room of approximately 400 square feet, suitably lighted, heated, and air-conditioned, and located near the data-receiving and photographic darkrooms. Three photoviewers will be provided by the Weather Bureau; 60-cycle single-phase 115-volt power of about 1 kw is required. Allied Research personnel will operate a G-15 computer at the facility to produce attitude-determination and picture grids for the meteorological analysis.

c. The weather-analysis team at each primary data station will consist of fourteen men, ten from the Weather Bureau and four from the Air Force.

4.2.7 Personnel Requirements

The operating personnel for each of two shifts at Wallops are:

1 photographic technician (NASA)

2 antenna operators (NASA)

1 video tape recorder and receiver operator (RCA)

1 beacon receiver and H1 attitude operator (RCA)

1 man to play back tapes (12 data) and prepare data for transmission and keep station log (RCA)

1 command program operator (RCA)

1 teletype operator (RCA)

Including three teletype operators, RCA will furnish a total of fourteen people; the remainder will be supplied by Wallops. The command program operator is normally a shift supervisor.

The operating personnel requirements for PMR are the same as for Wallops, except that 3 shift supervisors are required (2 at San Nicolas Island and one on the mainland). RCA will furnish a total of 25 people. The antenna operators and microwave personnel will be supplied by PMR.

4.3 Secondary Command and Data-Acquisition Station

4.3.1 Location and Components

At the engineering plant of the RCA Astro-Electronics Division in Princeton, New Jersey, a full complement of command and data-acquisition equipment is installed, together with a special-purpose automatic tracking antenna of low gain compared to the 60-foot dish and GB antennas at the primary stations. The equipment except for the antennas represents developmental models of the equipment supplied for the principal ground stations.

4.3.2 Operations

Within performance capability determined by limited antenna gain, the station can be used in several ways. The station initially provides the opportunity for development engineers to perform necessary station-integration engineering. It is also useful for detailed overall system tests of the satellites before they are supplied for launching.

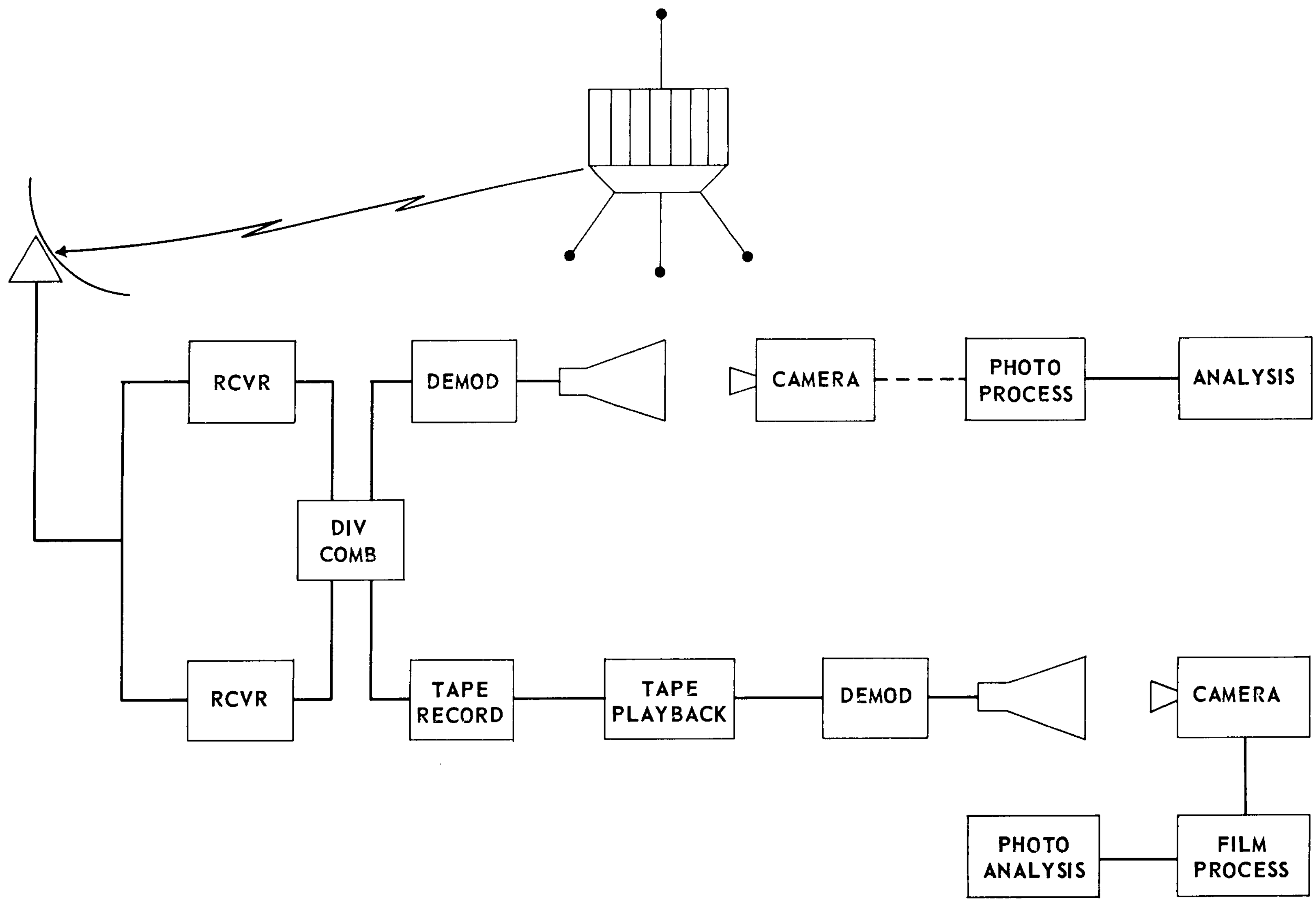


Figure 8 – TV Picture Data-Flow Chart

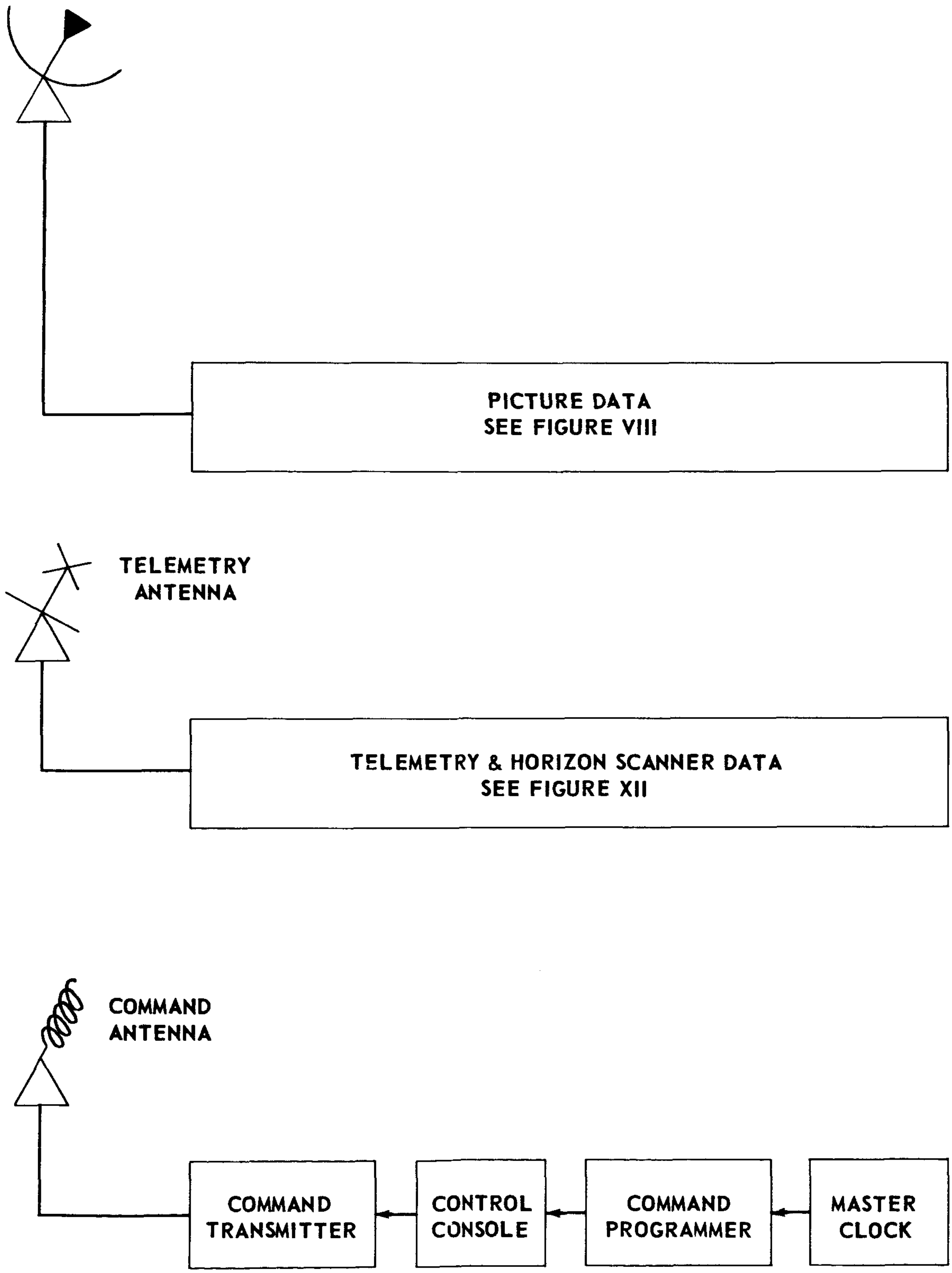


Figure 9 – Acquisition Station, Block Diagram

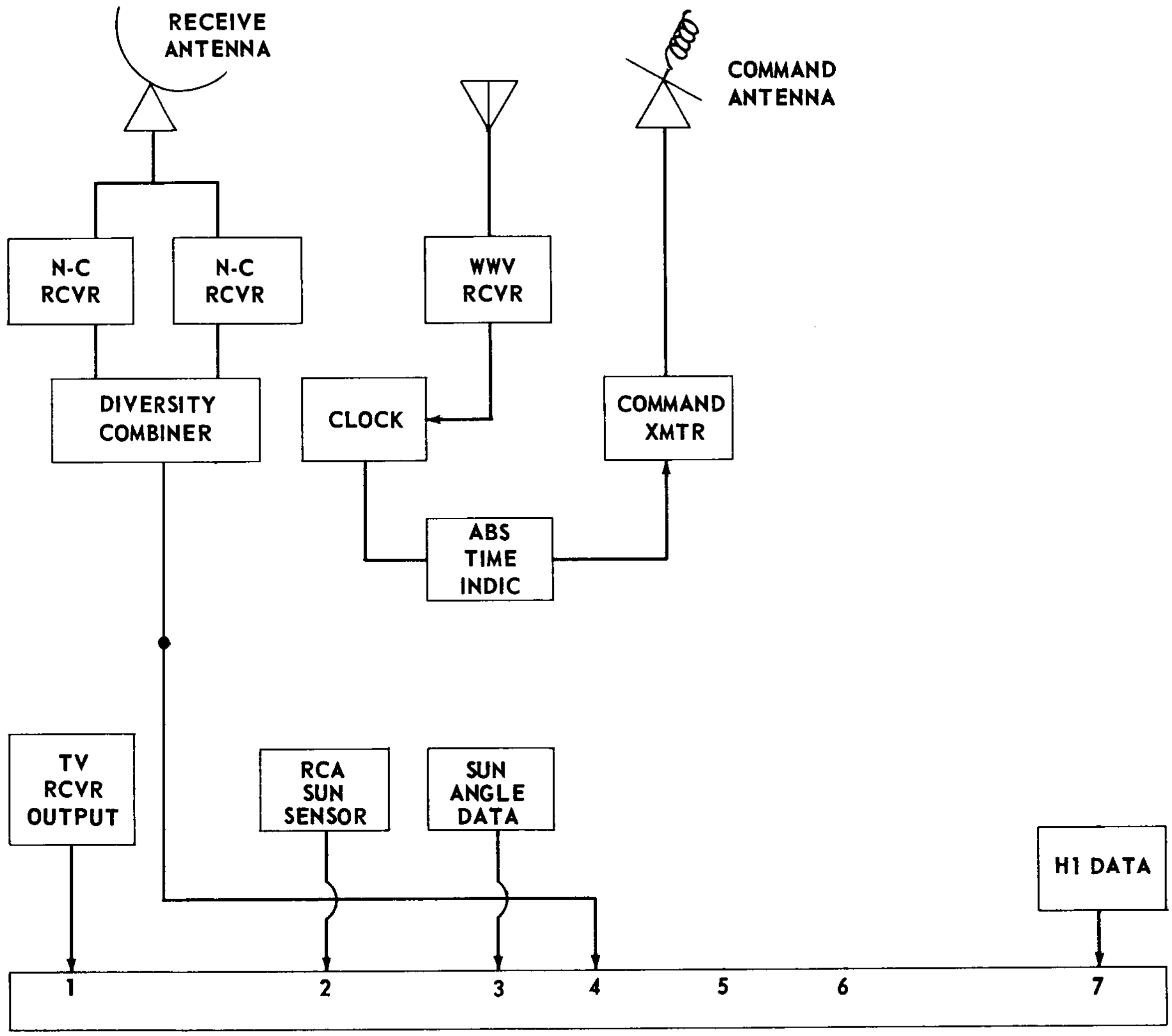


Figure 10 – Data Acquisition and Recording

It will serve to train the operating crews. During the operational phase of the program, the equipment can be used to monitor the output of the satellite in response to commands issued from Wallops, providing backup recordings if desired. Development personnel will be able to continue simulated operations, both for checkout of additional satellite packages and for refinement of ground station equipment and procedures, and advise as to the adequacy of performance. In case of an operating ground-station failure, the Princeton station can, on request, become an operating station temporarily. Also, in case of a satellite malfunction, the Princeton station can enter into the operation so that development personnel may analyze the malfunction and recommend modification of the programming procedures to optimize the performance of the unaffected satellite equipment. Except when requested by NASA for emergency operation, no regular operating personnel are to be assigned.

4.4 Attitude-Recording Stations

4.4.1 Location and Components

Attitude-recording equipment is located at the primary command and data acquisition stations.

4.4.2 Attitude Measurement Subsystem

a. The attitude measurement subsystem consists of the following components:

1. Satellite Equipment

   (a) Narrow-field infrared sensing bolometer

   (b) Amplifying and differentiating circuitry

   (c) Relay controls using the amplified horizon scanner output as the input to the 1300-cps telemetry subcarrier

2. Ground Station Equipment

   (a) Detection, pulse-shaping, and spurious-pulse rejection circuits on the audio output of ground receivers

   (b) Decade counters triggered by horizon pulses and driven by time standard

(c) Counter control and output-scanning circuitry

(d) Motor-driven paper tape punch

b. The sensor has a 1.3 degree by 1.3 degree square field of view and is mounted with its optical axis 70° to the spin axis of the satellite. The sensor has a time constant of 2.0 milliseconds, and a spectral response flat between 1.8 and 30 microns, falling off sharply at wavelengths shorter than 1.8 microns. The spectral response and time constant are chosen to give reasonably uniform and accurate response whenever the field of view crosses from space to earth, and vice versa. During the operating period the sensor will never view the sun if attitude variations are of the type predicted; if it does, it will not be damaged but will generate a spurious output. The moon also may occasionally generate spurious signals. Varying illumination and reflectivity on the surface of the earth will not generate such signals, because the reflected radiation is principally in the wavelength bands to which the sensor does not respond. Spurious signals generated by varying temperatures and emissivites on the earth are discriminated against by ground-inhibit circuits.

c. The electrical output of the sensor is then a trapezoidal wave. To avoid stability problems with extremely low-frequency or dc amplifiers, and to eliminate drift due to changing ambient temperature, the wave is differentiated and rectified to produce pulses corresponding to the times the sensor enters and leaves the horizon. The differentiated and amplified sensor output is used to frequency-modulate the telemetry subcarrier oscillators associated with the beacon transmitters. A perpendicular crossing from space to 275°K earth will generate a pulse amplitude of 3 volts, deviating the subcarrier enough to slightly overdrive the Sanborn recorder on the ground.

d. To prevent response of the time-measuring circuit to extraneous pulses generated by the scanner while crossing the earth, an automatic tracking inhibit circuit has been provided as part of the pulse-amplifying and shaping circuit coupling the Sanborn demodulator to the counter-scanner unit. The initial sky-earth transition triggers a delay circuit which blocks further pulses until shortly before the earth-sky is expected to occur. Manual adjustment of the inhibit delay by observation of the Sanborn chart accomplishes the initial setting on a particular pass, after which the inhibit delay is automatically adjusted to match the on-earth interval.

e. The counter circuitry on the ground is arranged to measure the time interval between all pairs of pulses. The three counters function in rotation as follows:

1. When the system is running, one of its counters is counting the 1-kc "clock" frequency at any given time.

2. Arrival of an input signal causes the running counter to stop and the next counter to start. Simultaneously, the control circuitry initiates the readout of the number stored in the counter just stopped. If a second input signal occurs during the 0.3 seconds required for the above readout, the count transfers to the third counter; the second counter stores its number until it can be read out in turn; and a gate circuit inhibits all further signals until the original counter has been completely read out and is free to accept a new count. If no input signal occurs for 10 seconds, the operating counter reaches its capacity and generates a "pseudo" input which transfers the count to the next counter and which is read out as 0.000 seconds. Each counter is reset to zero at the completion of its readout cycle.

f. θ = angle of rotation during which sensor views earth

$$\text{for } t_1 > t_2, \quad \phi = \frac{t_2}{t_1 + t_2} \times 360^\circ$$

$$\text{for } t_2 > t_1, \quad \phi = \frac{t_1}{t_1 + t_2} \times 360^\circ$$

θ = angle between satellite spin axis and local vertical

$$\theta = \sin^{-1}\left[\sqrt{1 - \left(\frac{R}{R + h}\right)^2} \sec\frac{\phi}{2}\right]$$

R = local effective earth radius of curvature
h = local altitude above effective horizon
The output record consists of the measured time intervals punched in teletype code into a paper tape. Of any

pair of successive readings, the short interval represents on-earth time and the long interval off-earth time. If it were not for satellite orbital motion during the 5-to 6-second interval required to complete one revolution, and the uncertainty of effective radius of curvature and effective horizon height, the simplified mathematical description above would suffice to determine the spin-axis elevation angle from a pair of consecutive time measurements, as shown.

4.4.3 Operating Characteristics

a. Programming

In programming the computer to interpret the attitude data, the possibility of spurious pulses or missing pulses should be taken into account. The equipment normally will not be susceptible to such failings, but severe fades may occur which can cause either problem. In any case, the cumulative readings will still represent total elapsed time, but extra or missed pulses will cause two adjacent readings to total less than one spin period.

b. Output Format

The DTMD output will be a punched paper tape using five-bit teletype characters in upper-case or "figures." Each reading of a time interval consists of a "word" of five, six, or seven characters. When read into a teletype page printer, ten words will be printed on each line.

First word of line - digit, digit, digit, digit, "space"

Second through ninth words - digit, digit, digit, digit, "space"

Tenth word - digit, digit, digit, digit, "space" "carriage return," "line feed", "figures."

The four digits of each word will be a decimal indication from 0001 milliseconds to 9999 milliseconds or 9.999 seconds. The order of digits will be from most significant to least significant. A reading of 0000 will indicate a time interval of ten seconds. Transitions from sky to earth will be distinguished from those from earth to sky by the insertion of a comma in place of the space character.

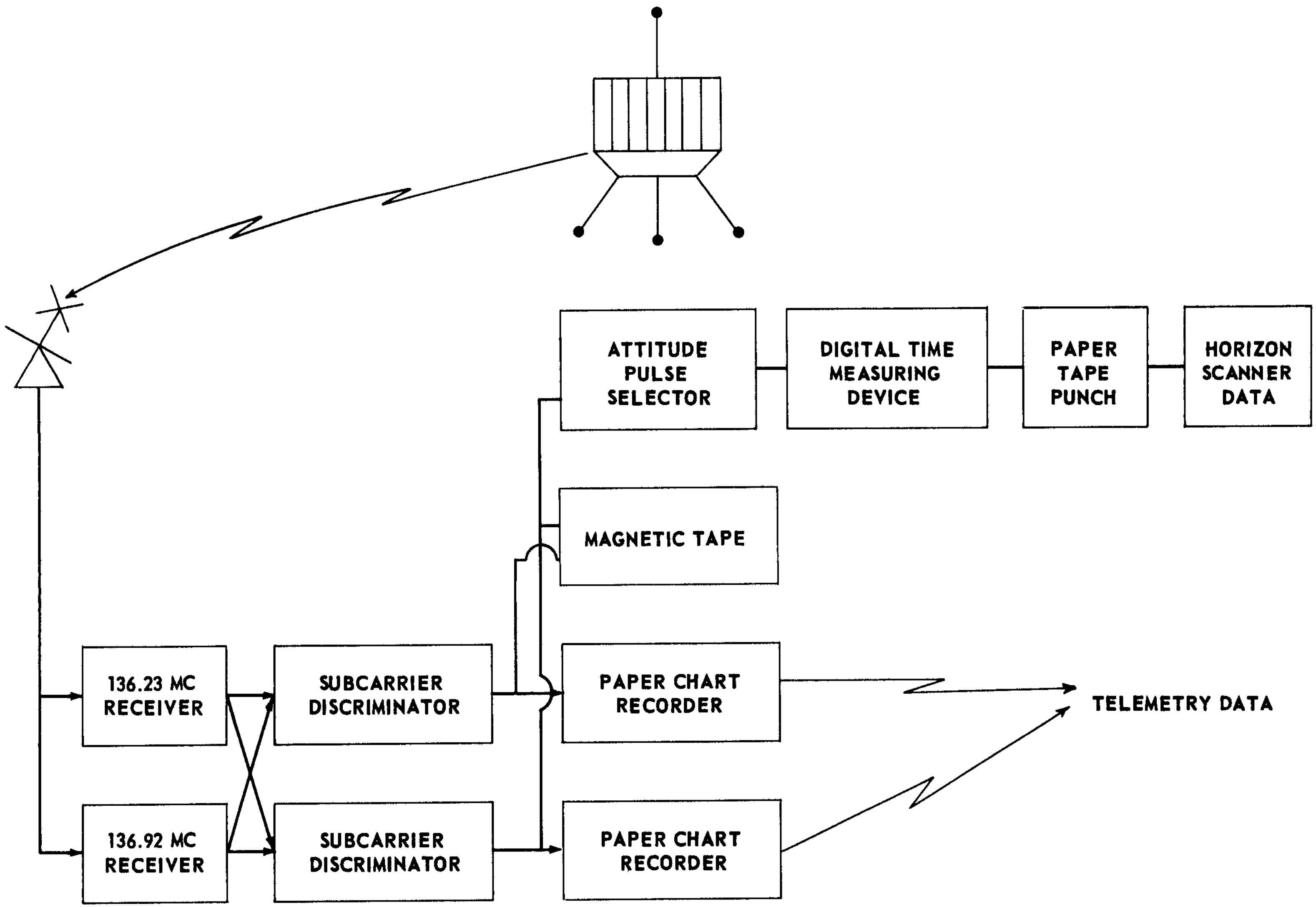


Figure 11 – Telemetry and Horizon Scanner Data-Flow Chart

APPENDIX A

TIROS Security Guide

Introduction

This Guide establishes the security classification for information concerning TIROS and where applicable shall be used by all personnel participating in the Program. Information means knowledge or intelligence that can be communicated by any means. Classified information is official information which requires protection in the interest of national security. In the interest of brevity, this Guide lists those areas of information requiring protection. All other information on Project TIROS is unclassified.

Scope

In content, this Guide emphasizes the classification of information. Contractual documents, specification, equipment, drawings, models, etc., are media which convey or reveal information and as such are marked according to the classification of the information which they convey or reveal. Persons generating the media will, through their professional knowledge in the field, recognize the information being revealed or conveyed and mark the media accordingly.

Release of Information

The National Aeronautics and Space Administration will be responsible for all news and photographic releases concerning TIROS until the satellite is in orbit and deemed successful by NASA. Following this period NASA will continue its information activities in that area concerned with the actual functioning of the satellite and to those experiments in the satellite which are the entire responsibility of NASA.

Contractors and cooperating agencies are responsible for initial screening of release proposals generated by, or submitted to them to determine that the matter covered is unclassified and authoritative. Such proposals, including the actual matter to be released, or where this is impractical, a representation that provides clear definition of the nature and scope of the matter, together with appropriate recommendations of the contractor or agency, shall be submitted to the GSFC/NASA Office of Public Information, Greenbelt, Md., for action.

Visits by public news representatives to contractor or agency facilities, when the subject matter involves TIROS will be coordinated with the GSFC/NASA Office of Public Information.

First level agencies reporting directly to the NASA are responsible for compliance by their contractors, subcontractors, and cooperating agencies with these requirements and for providing initial screening of proposals as indicated above.

On Launching Vehicle	- Douglas, through Goddard Space Flight Center
On Payload	- RCA, through Goddard Space Flight Center
On Data Acquisition	- RCA, Navy PMR and Wallops, through Goddard Space Flight Center
On Tracking	- Goddard Space Flight Center direct to Headquarters
On Meteorological Data	- NPIC through U. S. Weather Bureau

The above lines of communication are not inflexible. If, for a serious reason, a cooperating agency or a contractor deems it necessary to discuss information policy regarding a specific release with project management, an agency or contractor is authorized to contact the GSFC/NASA Office of Public Information directly, simultaneously notifying the prime contractor of his action.

Changes in Classification

Authorized changes in the security classification set forth herein will be published in loose-leaf form for insertion in the Guide, and will be identified as "Change No._______ (Date)."

Classification of Project Elements

In addition to the standards set forth below, all material generated in connection with TIROS which might convey or reveal information about a military equipment shall be assigned a classification marking high enough to be consistent with the standards prescribed by the appropriate military activity. For the Thor Missile System the guidelines appear in the Master Security Classification Guide, WS 315-A, dated 15 February 1959, issued by the Air Force Ballistic Missile Division.

Type of Information	Classification
a. Command Frequency	Confidential
b. Command Coding	Confidential
c. Original Contractual Document and Amendments #1 and 2, TIROS I	Secret
(1) Subsequent Amendments	Unclassified
d. Launch Date	Confidential
e. Detailed Test Objectives	Confidential