NRO APPROVED FOR
RELEASE 17 September 2011

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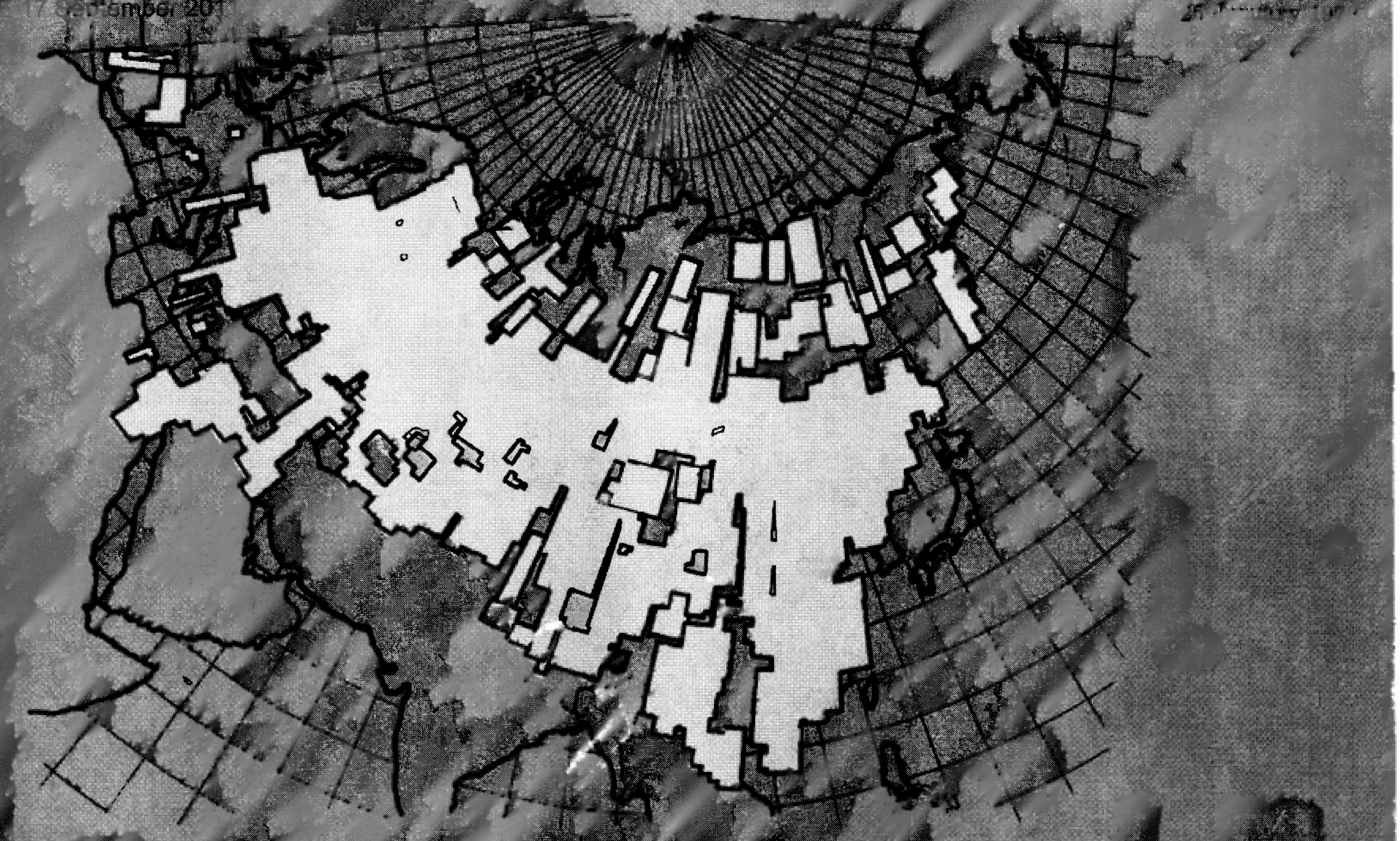

HEXAGON

CLASSIFIED BY BYEMAN
EXEMPT FROM GENERAL DECLASSIFICATION SCHEDULE
EXEMPTION CATEGORY:
AUTOMATICALLY DECLASSIFIED ON: IMPOSSIBLE TO DETERMINE

NATIONAL SECURITY INFORMATION
UNAUTHORIZED DISCLOSURE SUBJECT TO CRIMINAL SANCTIONS

WARNING NOTICE
SENSITIVE INTELLIGENCE SOURCES AND METHODS INVOLVED

HANDLE VIA BYEMAN
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BIF003W/2-093942-77
HEXAGON CY
31 DECEMBER 1977
72 SHEETS

PROJECT HEXAGON OVERVIEW

HEXAGON VEHICLE ON ORBIT

The Hexagon vehicle performs world-wide search and surveillance missions with two cameras that provide stereo panoramic photography. The film is recovered as each of four (4) large reentry vehicles (Mark 8) is filled. Each reentry vehicle is ejected from the Hexagon vehicle and is caught by USAF JC130 aircraft near the Hawaiian Islands. The film is then flown to Eastman Kodak at Rochester, N.Y., to be despooled, processed, and then copied for the using agencies.

The Hexagon vehicle also performs mapping and geodesy missions with stellar and terrain frame cameras. The film is retrieved via the small (Mark V) reentry vehicle mounted on the Hexagon vehicle nose. Accurate Hexagon vehicle location for the mapping mission is determined with the Doppler Beacon System and in the future via the Navigational Package.

The Hexagon vehicle flies in a near polar orbit (97 deg inclination) at a typical perigee/apogee of 88/155 NM, respectively. Mission durations of up to 180 days have been flown. In addition to the stereo panoramic cameras and the Mapping Camera System, the Hexagon vehicle [redacted]

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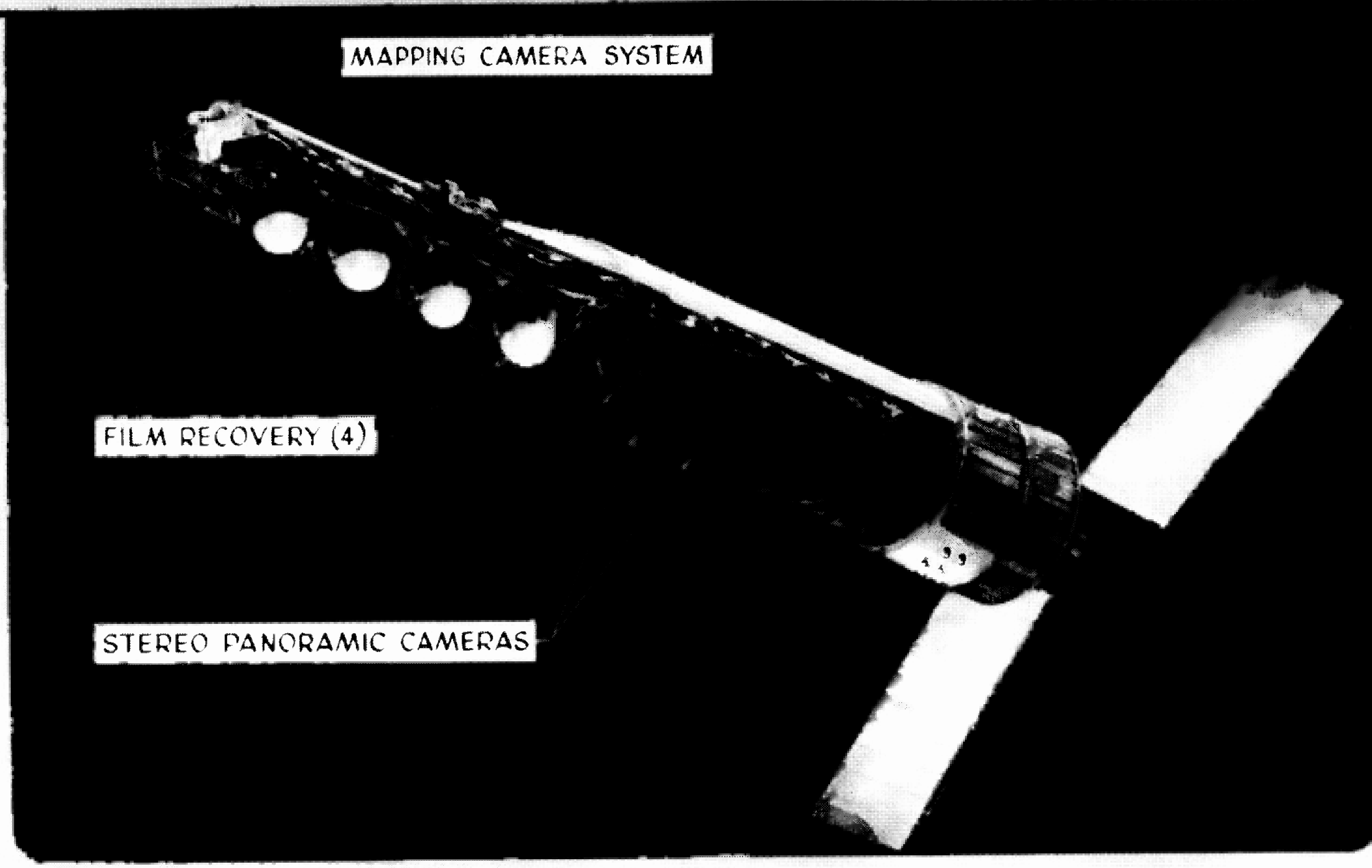
HEXAGON VEHICLE ON ORBIT



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SATELLITE VEHICLE (SV) CONFIGURATION

The SV configuration incorporates overall mission success considerations as well as weight minimization and structural efficiency. Film supply, cameras, and RVs are arranged in line for film path simplicity; the two-camera assembly is relatively close to the attitude control system in the Aft Section to enhance pointing accuracy. Aft Section electronic/electric equipment, mounted on trays in a modular fashion, is accessible through removable panels during the factory and pad spans. Access is provided to the RVs, two camera assembly, and film supply for necessary servicing. Propulsion/control force elements are grouped in a module for testing efficiency and brazed plumbing is used to assure the integrity of the propellant system through handling, launch, and flight.

In the factory the SV is brought to flight readiness by acoustic and thermal vacuum testing of the assembled vehicle; vehicle instrumentation is designed for such system level testing with RF command and data links.

The SV is shipped flight-ready to the launch base, with validation prior to launch. When required, equipment is replaced on a module/box basis to preserve factory verifications.

Provision has been made for alignment of critical elements during assembly and for verifying the alignment of the Attitude Reference Module with the two-camera assembly at the launch pad.

The SV configuration permits modification to meet specific mission requirements. The Mapping Camera System, [redacted] can be omitted, and propellant and RVs can be off-loaded at the base.

The overall length in orbit of the SV illustrated is 52 feet. At launch, with shroud and booster adapter, the length is 58.75 feet. The shroud, which protects all but the Aft Section, is 52 feet long. The solar arrays, when deployed, extend 17 feet outboard on each side of the vehicle. Injection weight for the SV illustrated is approximately 24,000 pounds.

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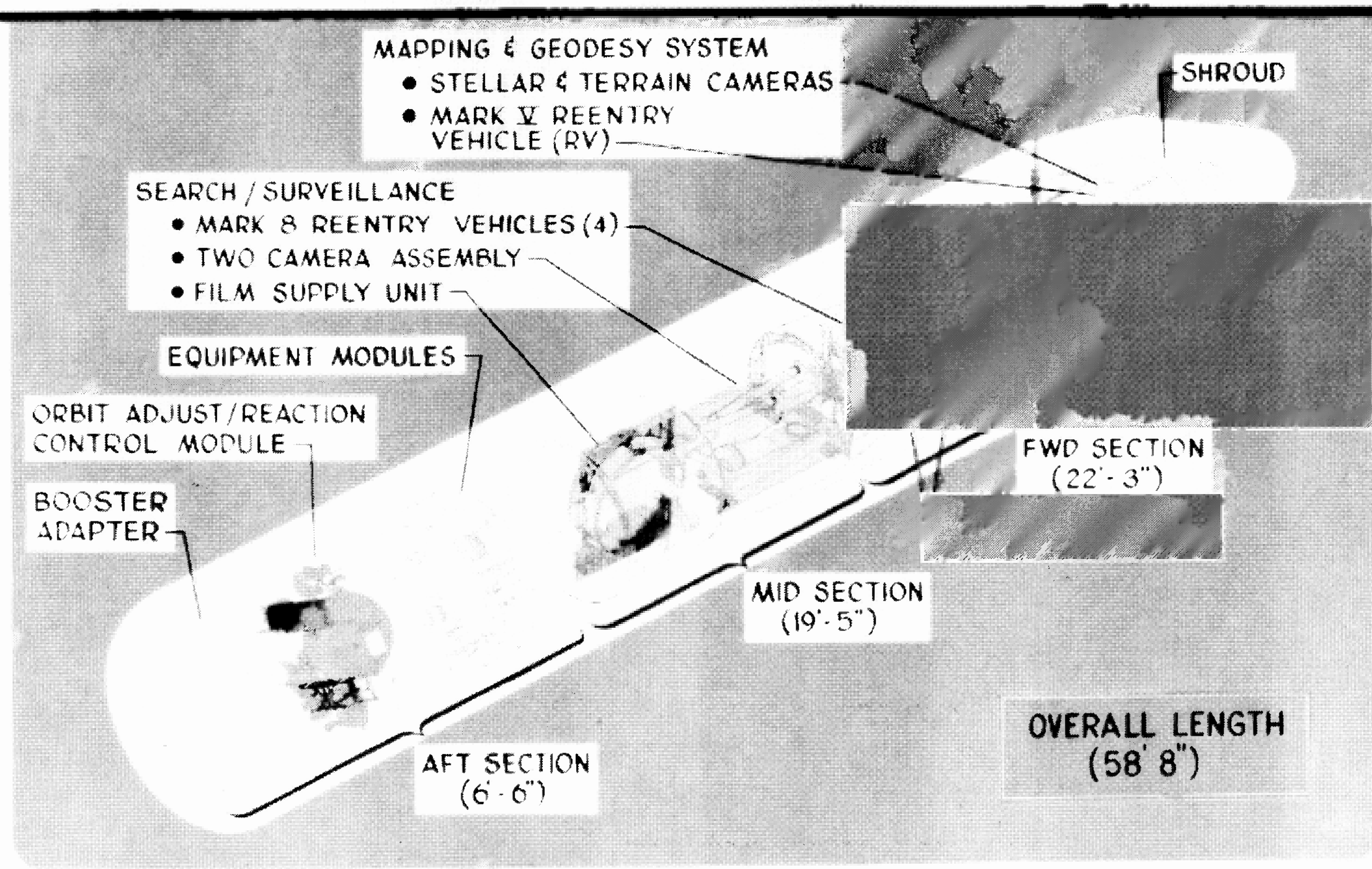
SATELLITE VEHICLE CONFIGURATION



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ASSOCIATE CONTRACTORS

Project HEXAGON is a team effort consisting of nine major contractors throughout the United States. These contractors provide a coordinated effort by using Interface Control Documents as binding technical agreement on responsibilities and performance of their respective equipments. The project HEXAGON team consists of:

Search/Surveillance (Stereo Panoramic)

- Two Camera Assembly – Perkin-Elmer, Danbury
- Film supply and take-up units – Perkin-Elmer, Danbury
- Shroud, Mid and Forward Section structure – Lockheed, Sunnyvale
- Reentry vehicles (Mark 8) – McDonnell Douglas, St. Louis
- Film – Eastman Kodak, Rochester

Mapping and Geodesy System

- Stellar and terrain cameras – Itek, Burlington
- Reentry vehicle (Mark V) – General Electric, Philadelphia
- Structure – Lockheed, Sunnyvale
- Film – Eastman Kodak, Rochester

Satellite Control Section

- Telemetry, power, and pyros – Lockheed, Sunnyvale
- Command system – General Electric, Utica
- Attitude control and orbit adjust – Lockheed, Sunnyvale
- Structure and booster adapter – Lockheed, Sunnyvale

Booster Vehicle – Titan IIID

- Stage O solid propellant – United Technologies Chemical System Division, Sunnyvale
- Stage I and II liquid propellant – Martin Marietta Corporation, Denver

The photographs were taken via the search and surveillance camera and magnified 40 times.

ASSOCIATE CONTRACTORS

OPERATIONS

AEROSPACE VEHICLE

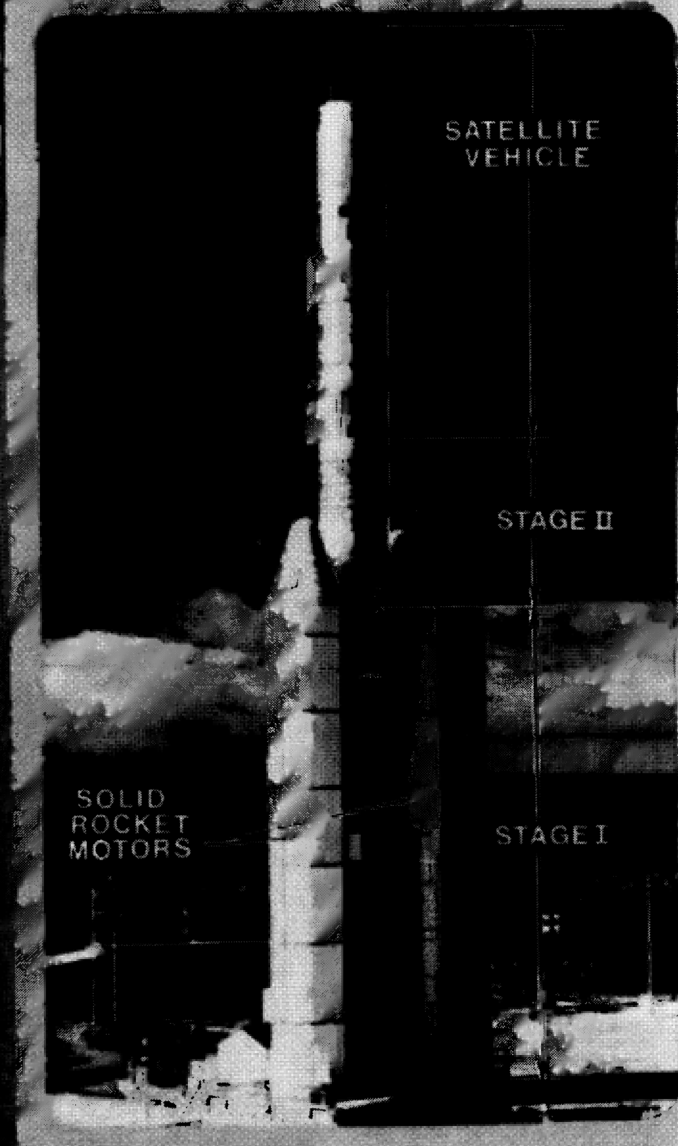
The HEXAGON Satellite Vehicle is launched by the Titan IIID Booster Vehicle. When mated together, the entire assembly is termed the Aerospace Vehicle.

The Aerospace Vehicle is launched from Space Launch Complex -4 East, Vandenberg Air Force Base. The Solid Rocket Motor, Stage I and Stage II are stacked at the launch site and functionally tested. The complete SV including the shroud is mated to the booster vehicle fourteen (14) days prior to launch. The Aerospace Vehicle is then functionally checked and all propellants and gases are loaded.

The booster vehicle can place 24,800 pounds into an 82 x 144 nm (perigee x apogee) orbit with an inclination (~ 97 degrees) that provides the nearly sun synchronous condition needed for long life missions.

AEROSPACE VEHICLE

[redacted]



TITAN IIID BOOSTER VEHICLE

The Titan IIID booster vehicle is a three-stage booster consisting of the standard liquid core for Stages I and II plus two solid rocket motors (SRMs) as Stage 0.

Each SRM is 10 feet in diameter and 85 feet long. It consists of five identical interchangeable segments, a six-degree canted nozzle, a gas generator type igniter, staging rockets, and an externally mounted thrust vector control (TVC) injectant tank. The TVC provides steering during Stage 0 burn by injecting nitrogen tetroxide ($N_2 0_4$) through 24 proportional valves around the SRM nozzle. Jettison is provided by pyrotechnic separation of the interconnecting structure between each SRM and the Titan core vehicle, followed by ignition of four solid staging rockets at each end of each SRM.

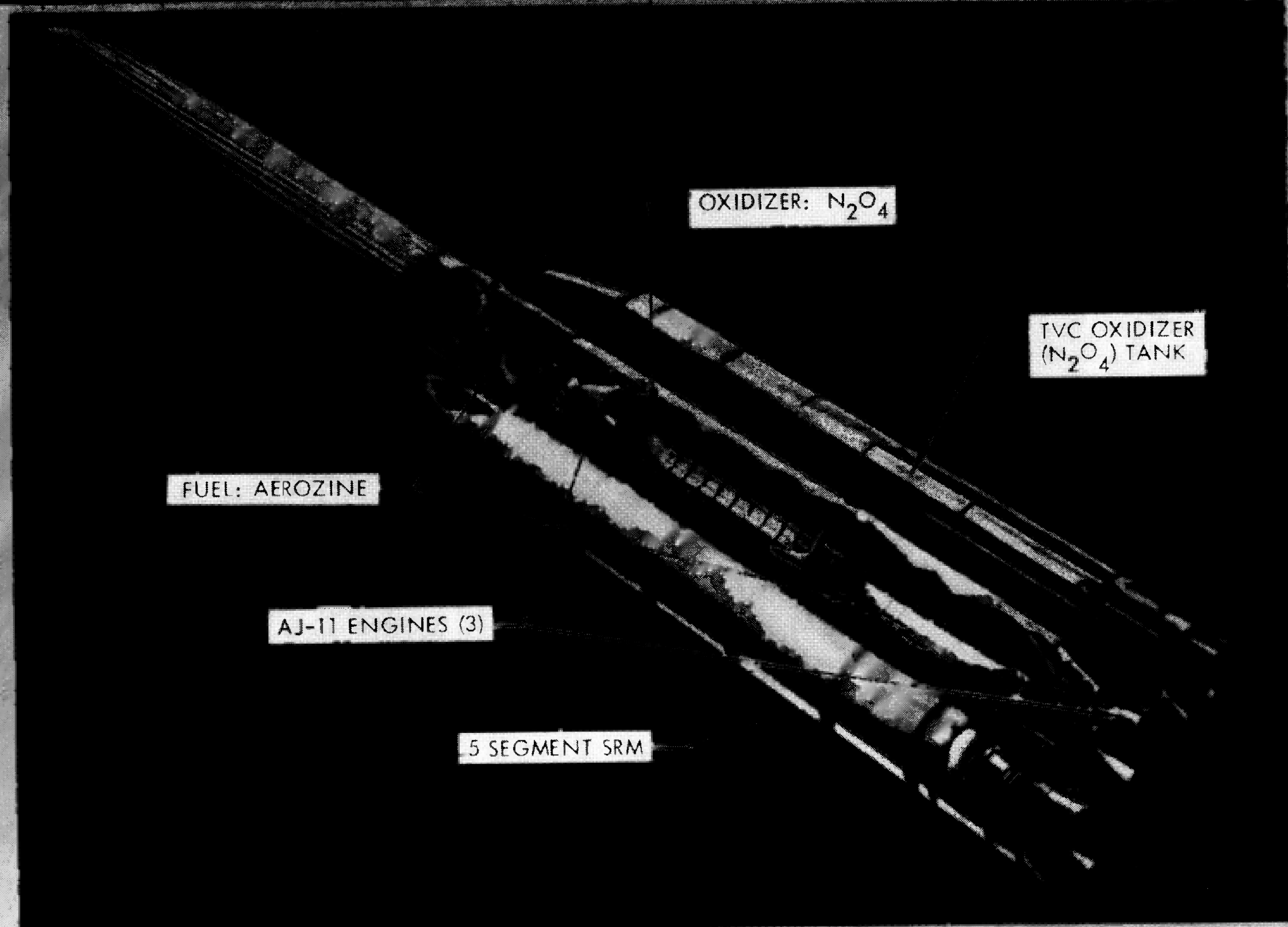
Stage I liquid core is 10 feet in diameter and 71.5 feet long. It is aluminum skin-stringer construction with propellant tanks arranged in tandem. The two turbo pump feed Aerojet LR87-AJ-11 engines burn a 50-50 blend of hydrazine/UDMH (Aerozine) as the fuel and nitrogen textroxide as the oxidizer. Each engine subassembly contains a regeneratively cooled gimballed thrust chamber combined with an ablative skirt extension giving a 15:1 expansion ratio.

The Stage II propulsion system is similar to that of Stage I. It is also 10 ft in diameter but only 31 feet long. The single engine thrust chamber is also regeneratively cooled and has an ablative skirt extension that provides an overall expansion ratio of 49:1.

The flight control system stabilizes the vehicle from launch to SV separation in response to (1) attitude data, (2) rate data, (3) command data – issued by flight control computer and/or the radio guidance system via ground tracking station.

Electrical power for the flight control system, instrumentation, flight safety, and electrical sequencing system is provided via silver-zinc primary batteries.

TITAN IIID BOOSTER VEHICLE



OPERATIONAL EVENTS

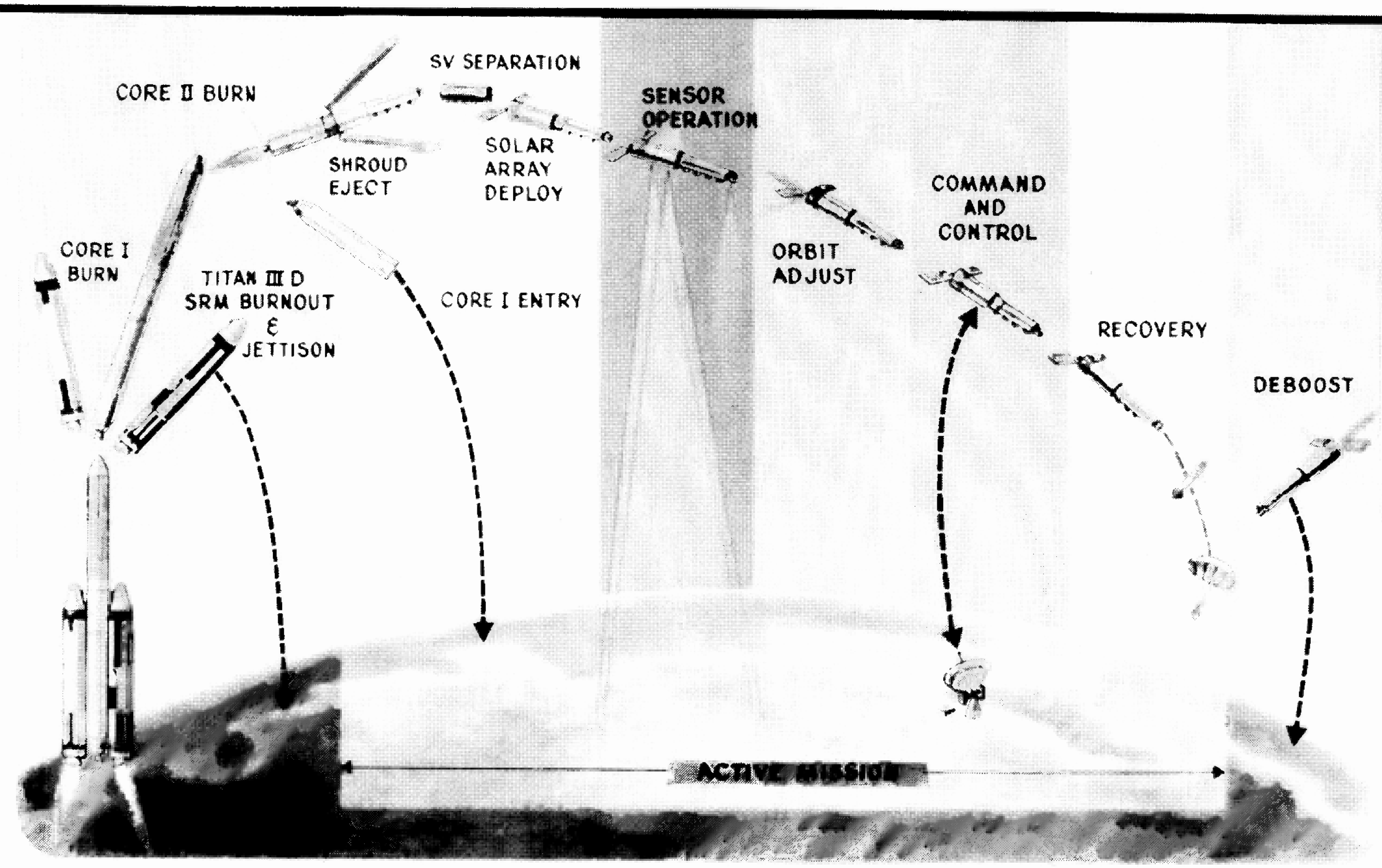
The major operational events are launch, orbit maintenance/payload operations, and RV recovery/SV deboost. Sequence of launch events:

0.0 sec	SRM Ignition
0.2	Lift-off
40.0	Transonic passage
54.0	Maximum dynamic pressure
113.9	Core I start burn
125.3	SRM separation
262.0	Core I shutdown and Core II start burn
262.7	Core I separation
276.0	Shroud separation
460.6	Core II shutdown
472.6	Core II separation (injection)

The solar arrays are deployed after SV stabilization on Rev 1 with payload operations starting on Rev 5. Orbit adjusts to correct period, altitude and perigee location occur every two to four days. All control of the SV and telemetry data is processed through the Air Force Satellite Control Facilities and associated remote tracking stations.

The SV is pitched down to a specified angle for each RV ejection. The SV is deboosted for ocean impact after the last RV is ejected.

OPERATIONAL EVENTS



USAF TRACKING NETWORK

The Sunnyvale Satellite Test Center (STC), part of the SAMSO Satellite Control Facilities, is organized to provide operational control of on-orbit satellites and does this function for project HEXAGON. The center directs the tracking and commanding of these satellites through a net of remote tracking stations (RTS). The STC also coordinates the aerial and surface recovery operations for reentry vehicles (RV). Launch activities are a coordinated effort between the Vandenberg AFB Test Wing and the STC.

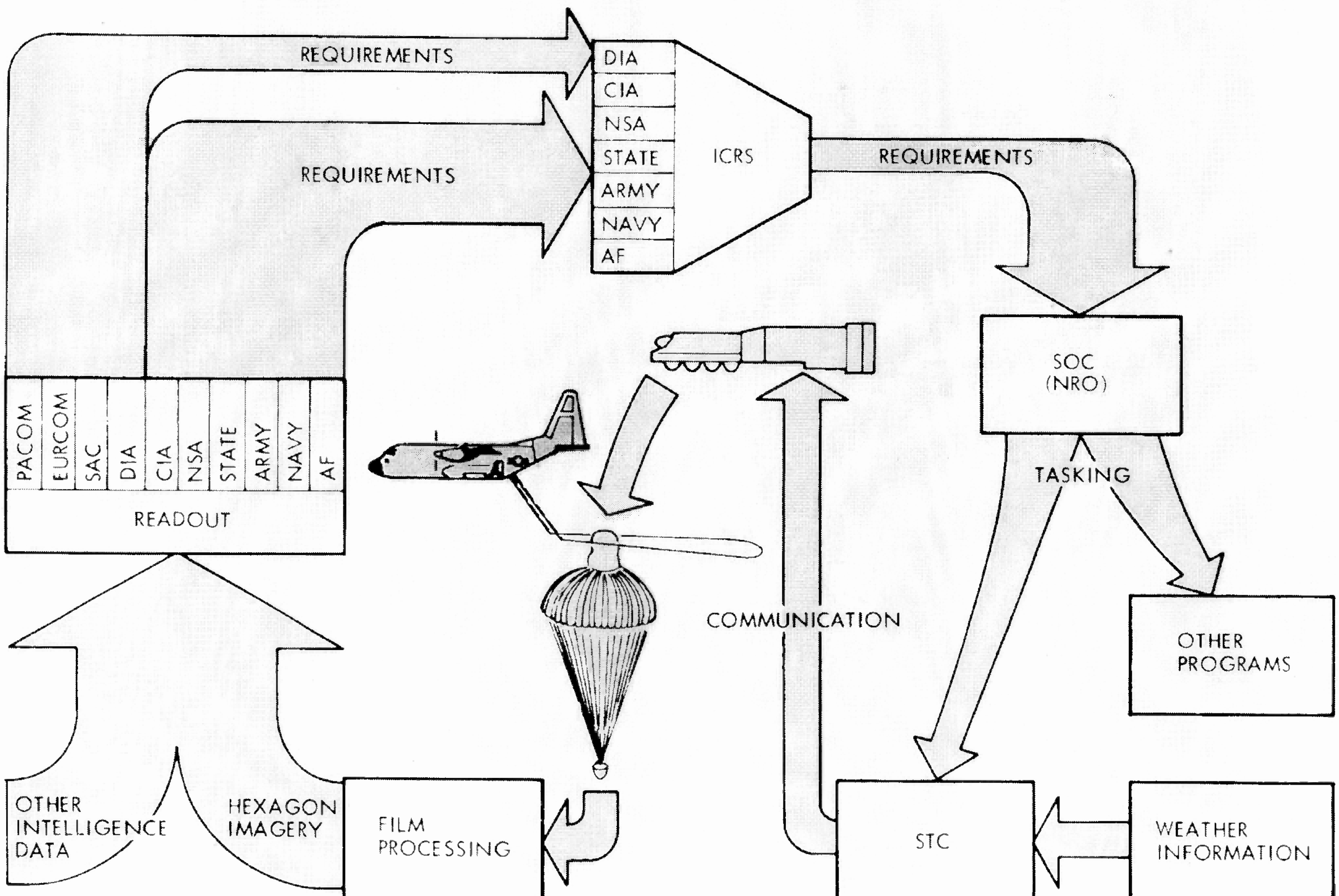
Servicing the HEXAGON vehicle requires skin and beacon tracking, recording and displaying telemetry data, and commanding that often needs more than one RTS each revolution. Because the STC supports several programs, the Mission Control Center (MCC) within the STC is used to direct the effort of each tracking station in support of each program. The SV real time telemetry data incoming to the RTS are processed and displayed in real time via 1200 bit lines or relay satellites to the STC. The SV real time and recorded data are recorded at the RTS for later playback to the STC. Complete RTS recorded tapes are flown to the STC as permanent records. Display and analysis of these data provides SV health and status information to the Technical Advisor (TA) staff on a continuous basis throughout the mission. The TA staff, located at the STC, includes operational specialist teams for each major contractor.

The remote tracking stations acronyms and locations are as follows:

- Vandenberg Tracking Station (VTS) or COOK at Vandenberg Air Force Base, California
- Guam Tracking Station (GTS) or GUAM on Guam Island
- Hawaii Tracking Station (HTS) or HULA at Kaeha Point on the island of Oahu
- Indian Ocean Station (IOS) or INDI in Seychelles Island group on Mahe' Island
- New Hampshire Station (NHS) or BOSS near New Boston, New Hampshire
- Thule Tracking Station (TTS) or POGO at Thule Air Force Base, Greenland

USAF TRACKING NETWORK

HEXAGON INTELLIGENCE TASKING LOOP



SEARCH/SURVEILLANCE CAMERAS

SEARCH/SURVEILLANCE CAMERAS

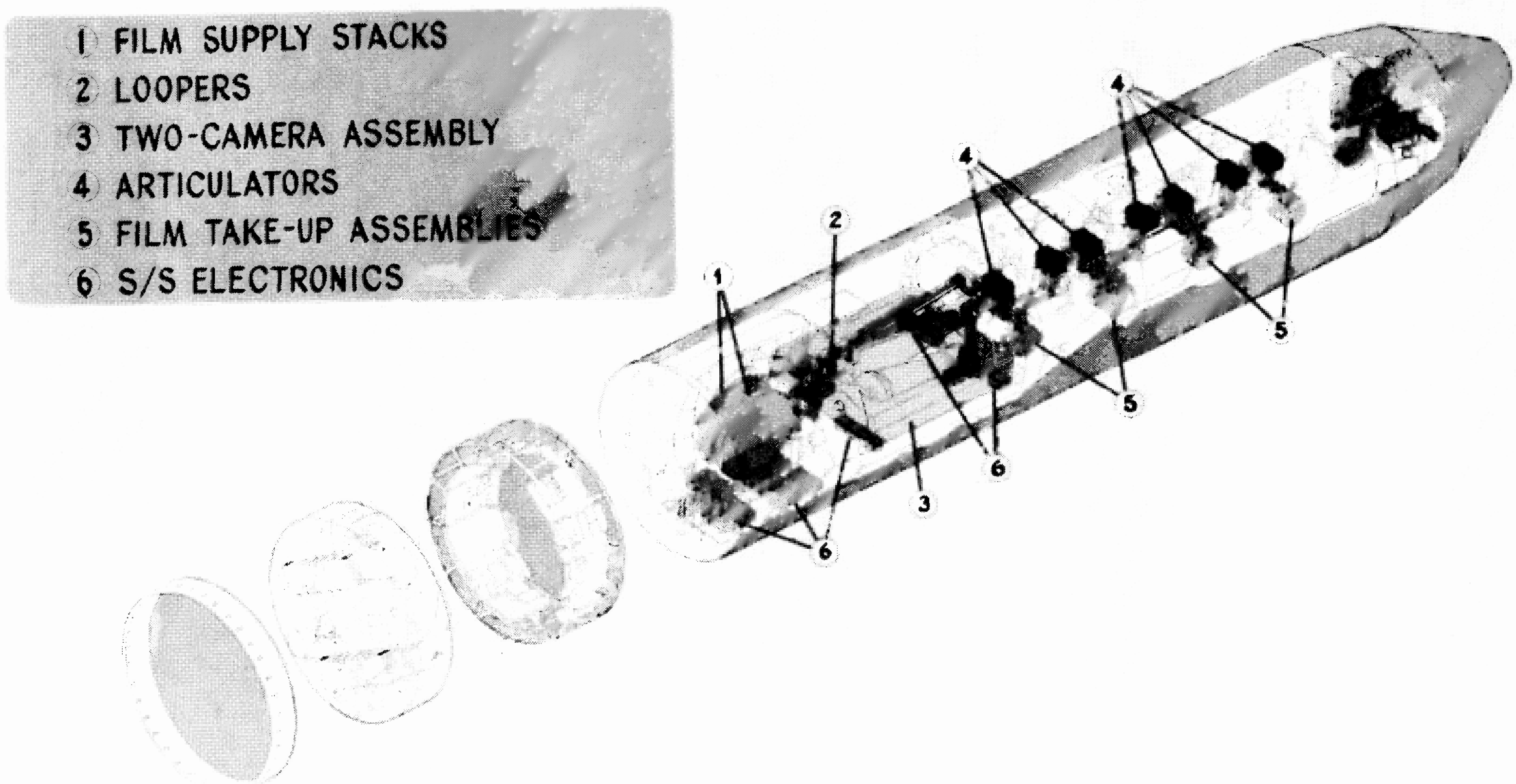
The search/surveillance cameras provide high-resolution stereoscopic coverage of selected areas on the earth's surface by using two independently controllable panoramic cameras. The system provides a target resolution of 2.7 ft or better at nadir when operating at primary mission orbital altitudes with an apparent target contrast of 2:1, sun angles greater than 30 degrees and using *S0-208 film.

The search/surveillance system has been designed with the following characteristics:

Optics	60-in. focal length, f/3 Folded Wright (Modified Schmidt) System
Film	6.6-in. wide film – Type 1414 or S0-208 (B & W), S0255 (Color), and S0130 (Infrared)
Film Load	123,000 ft Type 1414 or 144,000 ft S0-208 per camera (1950 lb total)
Film Resolution (2:1 Contrast)	Center of format ≥ 155 l/mm, elsewhere in format ≥ 94 l/mm
Field Angle	±2.85 Degrees
Scan Modes	30, 60, 90, and 120 degrees
Center of Scan	0, ±15, ±30, and ±45 degrees
Maximum Scan Angle	±60 degrees
Stereo Convergence Angle	20 degrees
Frame format (120 degree scan)	6-in. by 125-in.
Film Velocity	200 in./sec (maximum) at focal plane
Image Motion Compensation Range	0.018 rad/sec to 0.054 rad/sec for Vx/H ±0.0033 rad/sec for Vy/H
Weight (less film)	5375 pounds

*S0-208 is a thinner base equivalent to Type 1414 film used extensively for the first 13 missions.

SEARCH/SURVEILLANCE CAMERAS



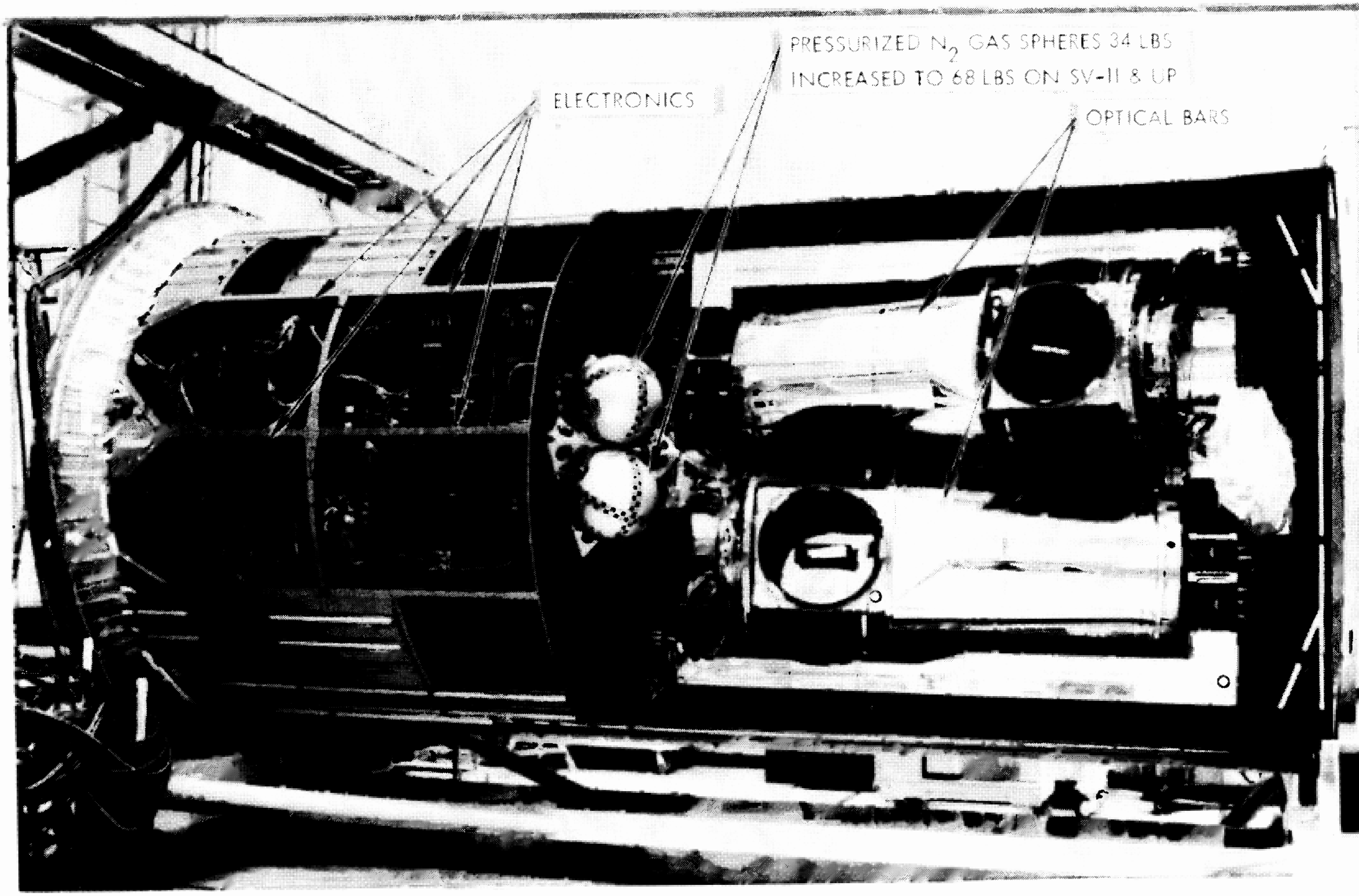
TWO CAMERA ASSEMBLY

The Mid Section has been rotated to show the side that looks toward the earth with the two Camera Assembly (TCA) exposed. In flight, a black fiberglass baffle and a multilayer insulation covers the gas spheres and optical bars except for view ports. Doors cover the electronics and then multilayer insulation blankets are installed. Not shown are the film take-up reentry vehicles in the Forward Section.

The two optical bars rotate in opposite directions indicated by the arrows adjacent to the lenses. The light is conducted along a folded path to the film platen where the film motion is matched to the image motion by the commands generated in the electronics.

Normally both optical bars are commanded on simultaneously to reduce vehicle roll torques. However, each camera can be commanded individually, and either may be operated alone, if desired.

TWO CAMERA ASSEMBLY



SYSTEM FILM PATH

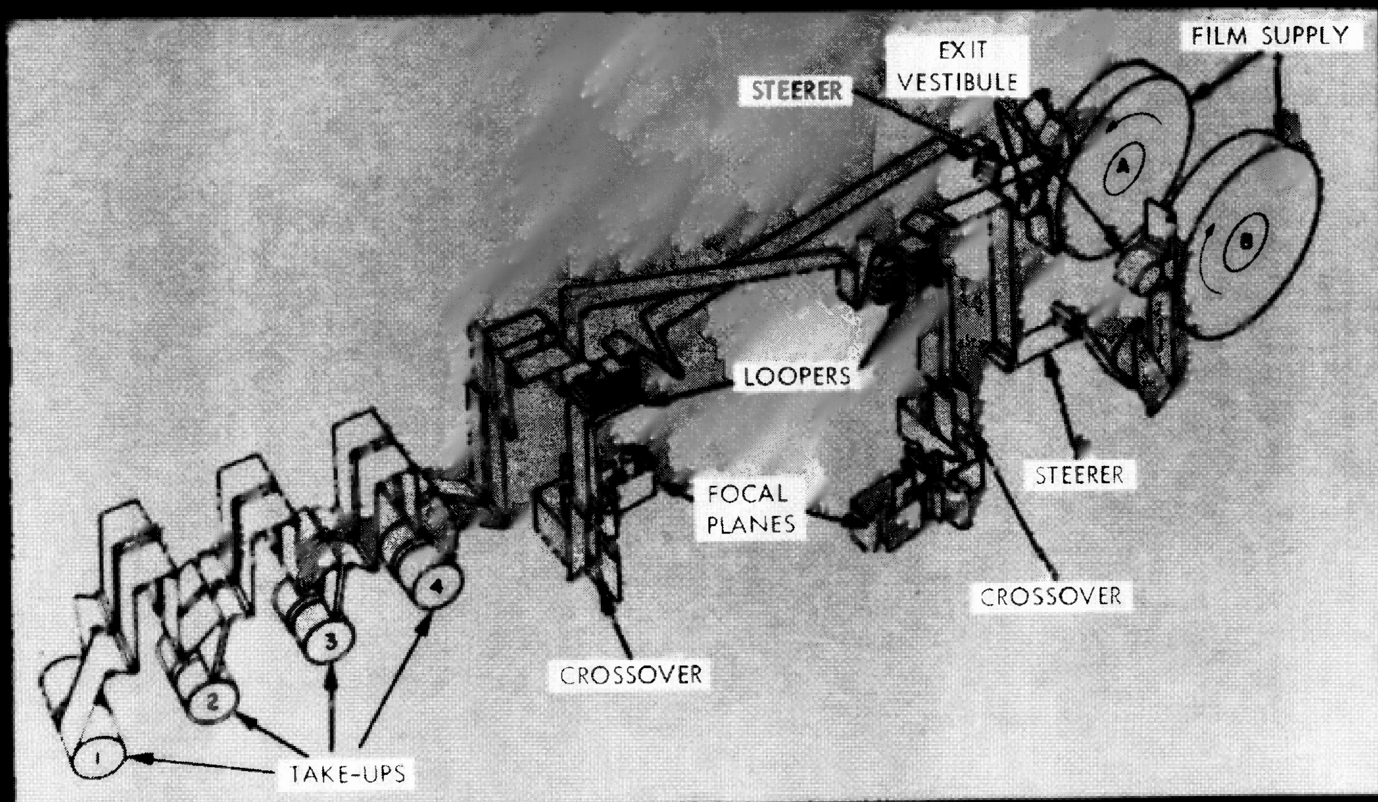
The coarse film transport includes all components that operate at nominally constant speed during photography and recycle, as well as the looper carriage which operates at the recycle frequency. The supply and take-up control system maintains a steady flow of film into and out of the loopers at precisely the average rate at which film moves through the platen. The loopers serve as an interface between the coarse and fine film transport system. Total film in the looper is constant but relative lengths in supply and take-up sides vary with looper carriage position.

The control of film tracking is by active and passive articulators. The film path of the forward camera functionally includes component assemblies in the following order:

a. Supply "B"
b. Seal Door/Exit Vestibule
c. Articulator Steerer
d. Looper
e. Crossover
f. Input Drive Capstan
g. Platen
h. Metering Capstan
i. Output Drive Capstan
j. Crossover
k. Looper
l. Articulator Steerer
m. Take-up 4
n. Articulator
o. Takeup 3
p. Articulator
q. Takeup 2
r. Articulator
s. Takeup 1

The film supply spools rotate in opposite directions, and the respective take-up spools rotate opposite to the supply spools in order to reduce vehicle torques. The start-up disturbances are minimized by accelerating the film path to the required coarse velocity before photographic operations are begun.

SYSTEM FILM PATH



OPTICAL BAR ASSEMBLY

The two cameras mounted in a frame make up a two-camera assembly with each camera having a folded Wright optical system mounted in a rotating optical bar. Structurally the bar consists of two rigid end bulkheads separated by a cylindrical tube with housings and hollow shafts at each end on which bearings are mounted. The platen end bulkhead is the member to which the optical components are referenced. The optics consist of the corrector plate as the aperture, a folding flat mirror, a concave primary mirror and a field group of refracting elements and a filter. The optics wavefront errors spec values are shown as a fraction of the wavelength. All values are root mean square (RMS).

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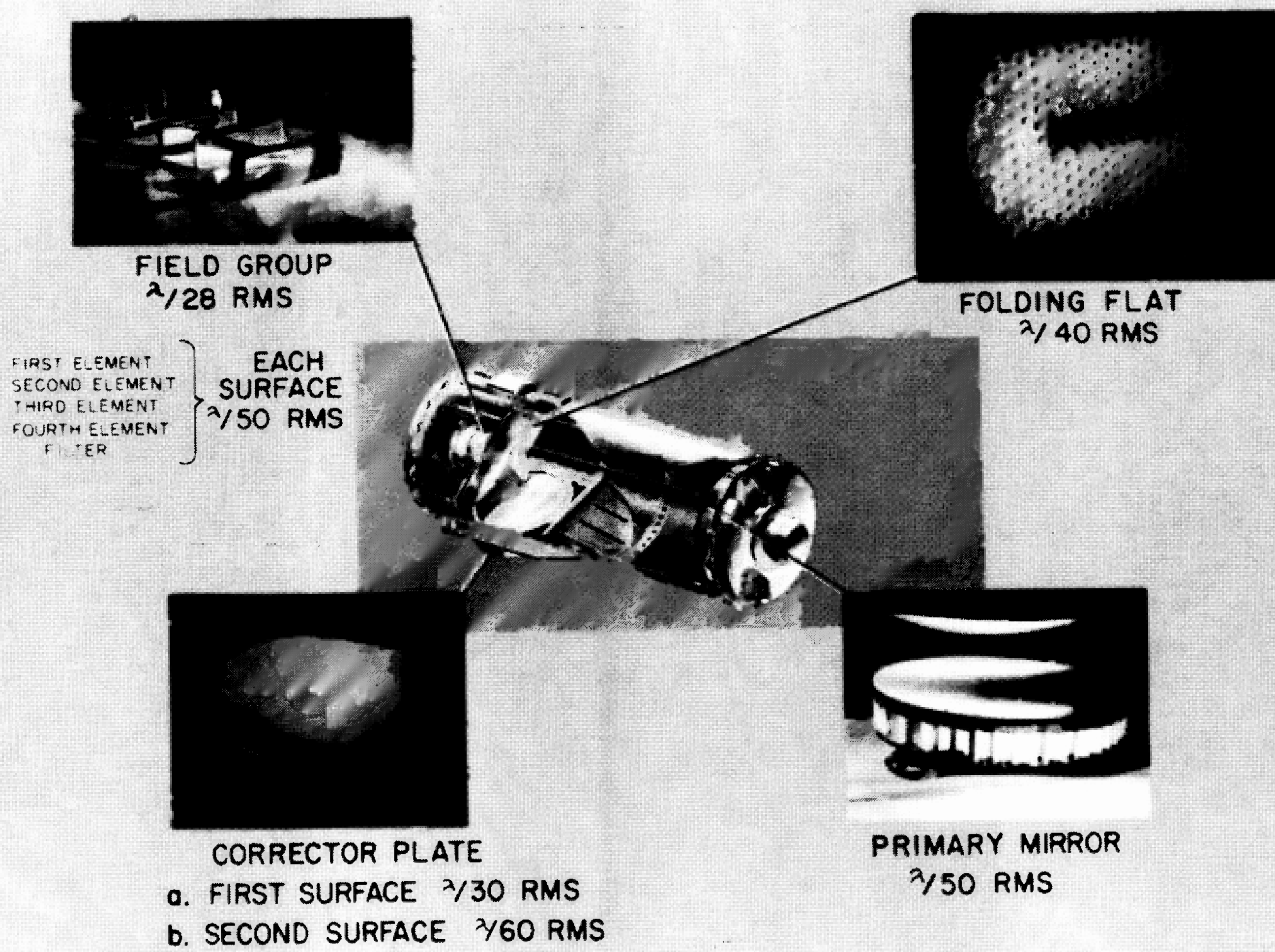
OPTICAL BAR ASSEMBLY



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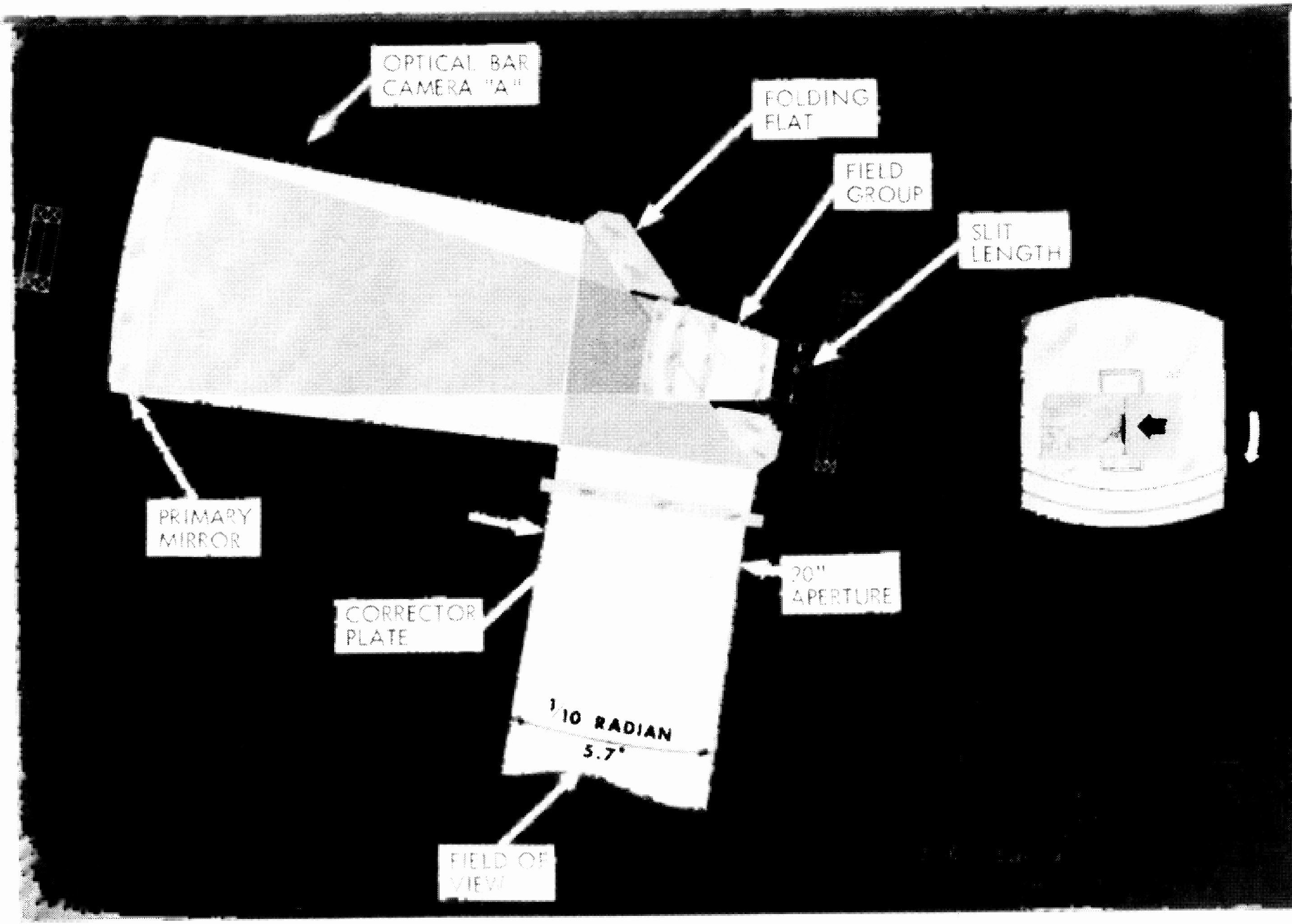
OPTICAL PATH

The optics for each camera are mounted in an optical bar (OB). The system is a f/3 folded Wright. The aperture is formed by an aspheric corrector plate that corrects for spherical aberration. Light entering the aperture is folded 90° by the folding flat and reflected onto the primary mirror at the far end of the OB. The primary mirror focuses the light back through the field group mounted in a center hole in the folding flat. The field group includes four refracting elements and a filter. The refracting elements provide correction for the field curvature and residual chromatic aberration characteristics of optical systems using a concave primary mirror.

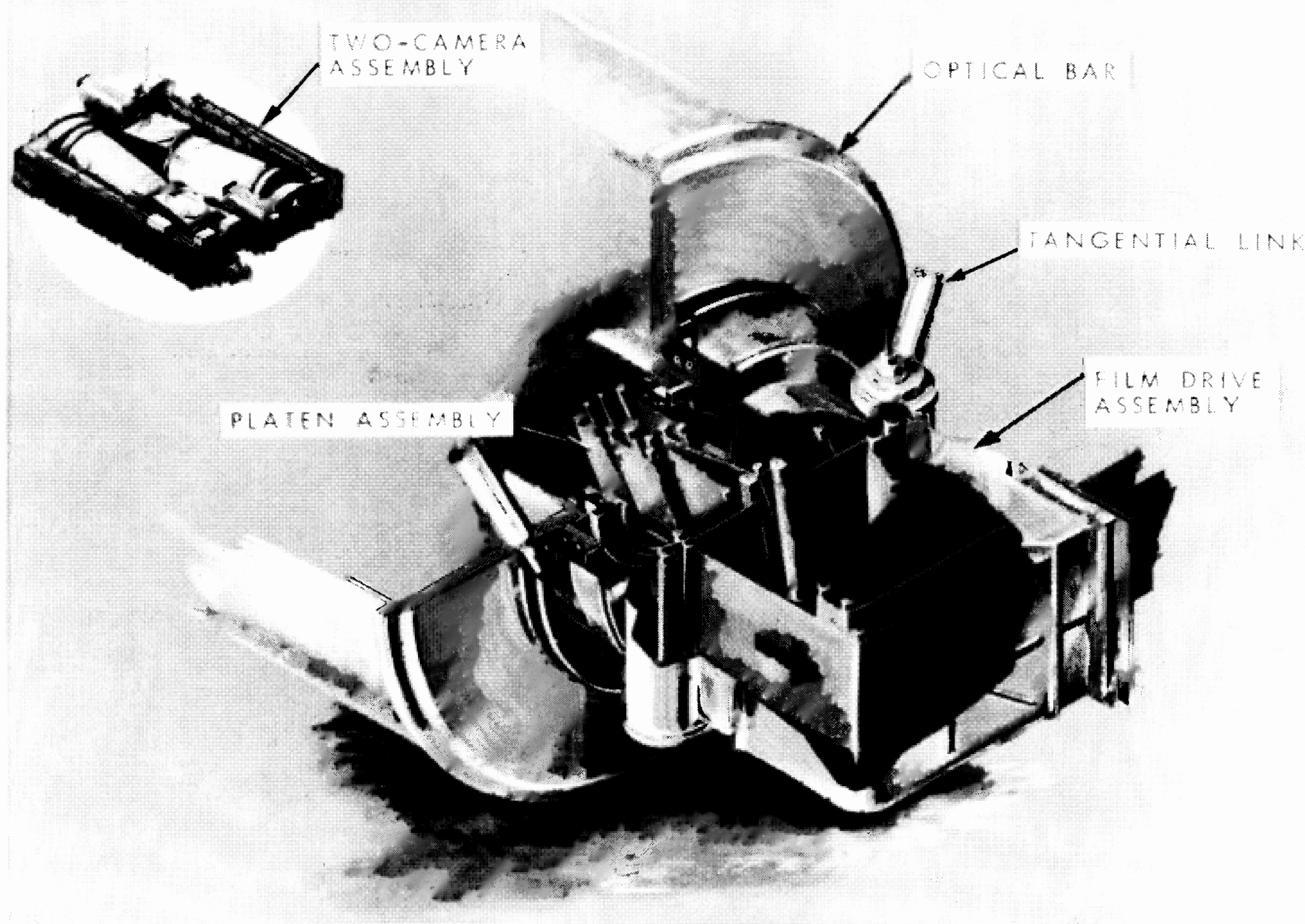
OPTICAL PATH



PLATEN AND FILM DRIVE

The platen is mounted at the focal plane end of the optical bar (OB). The platen assembly is mounted on the OB's inner housing to support the film in the camera focal plane, and to rotate on its own bearings independently of the OB. While the OB is rotating continuously on its end bearings, the platen assembly is free to oscillate through its 130-degree operational arc. The fine film drive assembly encloses the outer end of the platen assembly and is stationary. A twister assembly, included in the fine film drive assembly, accommodates the twisting of the film path at the interface between the stationary film drive assembly and the oscillating platen assembly. The twister assembly consists of a twin air-bar assembly and a housing that incorporates a manifold through which nitrogen gas is supplied to the bars. The use of air bars in the twister, rather than rollers, permits the film to translate along the length of the bars without damage as the film path twists.

PLATEN AND FILM DRIVE



PNEUMATICS SYSTEM

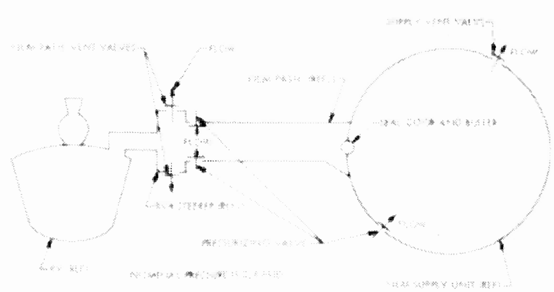
Dry nitrogen gas is supplied to the film path air bars at specified flow rates and pressures. Air bars are located in the twister, TCA cross-over, and the supply cross-overs. These bars are D-shaped in cross-section and hollow with small holes in their curved portion through which nitrogen is forced by the pneumatic system. This provides a practically frictionless bearing for the film, permitting both lateral film movement and film transport across the bar. The nitrogen supply is two spherical tanks with a combined storage capacity of 68 pounds of which 62 pounds are usable.

Pressure enclosures seal the entire film path including the film supply and the take-ups, maintaining the required relative humidity for film moisture content stabilization. The film path gaseous environment includes the 50 pounds of water in the film as outgassing water vapor plus the 62 pounds of nitrogen coming through the orifices of the gas bars. During non-operating periods the film supply unit is isolated from the rest of the film path by a commandable seal door to minimize leakage and moisture loss.

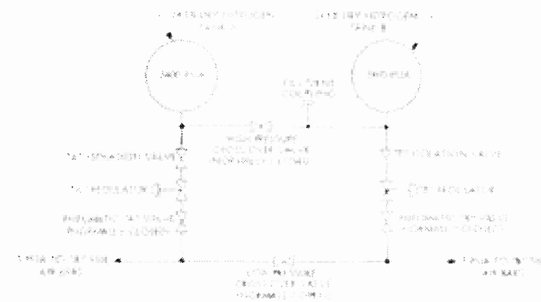
In test and during ascent the sealed film path accommodates atmospheric pressure changes through relief and pressurizing valves. When film is being transported, a lower pressure relief setting in the film path compared to that in the supply allows a system pressure bleed-off through vents on the forward steerer enclosure.

The pneumatics supply module is a self-contained unit consisting of high pressure storage spheres, regulators, and valves. The system is designed with individual paths from a supply sphere to a camera with cross-overs at the high pressure and low pressure portions of the system. The high pressure cross-over valve between the nitrogen tanks is normally closed. It is used to transfer gas from one tank to the other. To isolate a flow path, on external command or in response to a feedback signal of over-pressure downstream of the regulator, a solenoid latching valve in the high pressure portion is closed. Normally, a uniform simultaneous flow through both sides is maintained by the open low pressure cross-over valve, which is commanded closed only because of any failure requiring isolation. The shut-off valves in the low pressure paths are commandable, controlling on/off requirements of gas flow.

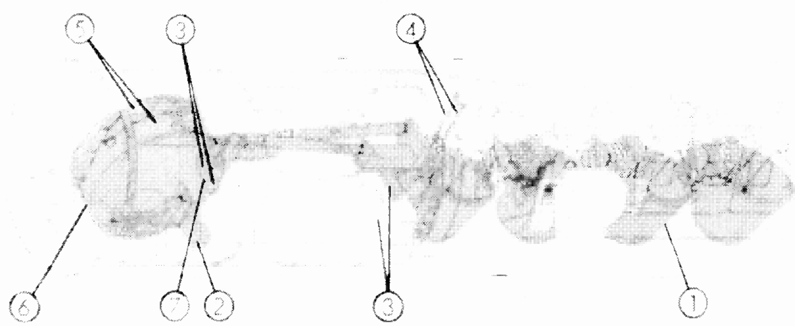
PNEUMATICS SYSTEM



FILM PATH VENTING SCHEMATIC



PNEUMATICS SUPPLY MODULE



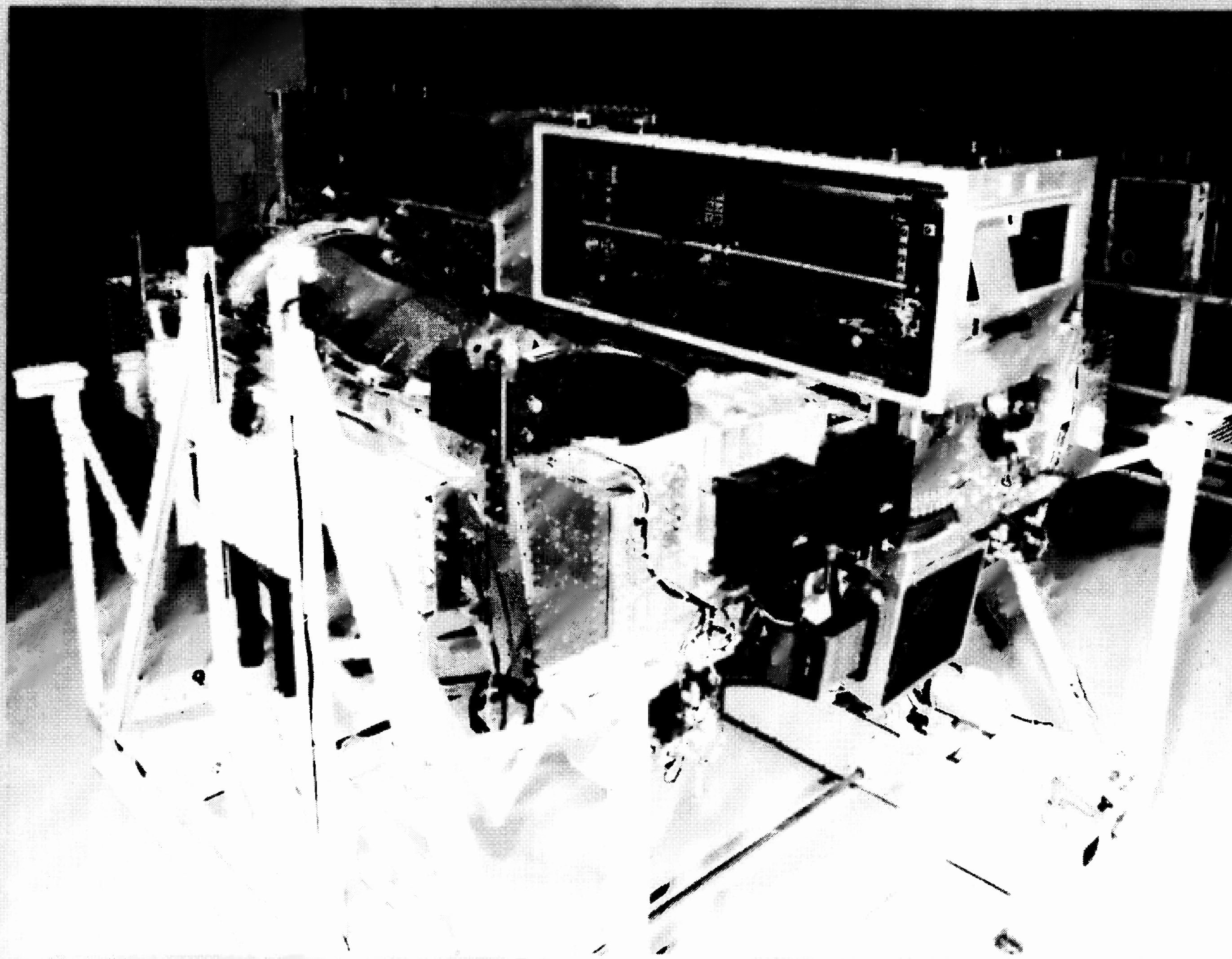
PRESSURIZED REGIONS - SHADED

1. REENTRY VEHICLES
2. PNEUMATIC SUPPLY MODULE
3. AIR BAR PAIRS
4. FILM PATH VENT VALVES
5. SUPPLY VENT VALVES
6. PRESSURIZING VALVE
7. SUPPLY SEAL DOOR

LARGE LOOPER

The accompanying illustration shows a Two Camera Assembly (TCA) incorporating the large looper which will become operational with SV-17. The increased film capacity (45 feet versus the 13 feet on the original design) enables the platen to be fed film at the desired rate during the time the coarse transport system is accelerating and to be stopped while the coarse film transport system is decelerating. Film management is greatly simplified since all the film is used in sequence. The present delay in the start of photography until the coarse film transport has accelerated to the average rate and the rewind of unexposed film passed through the platen is eliminated. This removes rewind as a possible source of contamination or as a wastage of film when rewind could not be accomplished between nested operations. Because this major change is being accomplished in-line, full provisions are retained to operate the coarse transport system in the original mode.

LARGE LOOPER



MARK 8 REENTRY VEHICLE

When the take-ups in the RV are filled, the next in-line RV is enabled and the full RV is ejected from the optimized pitched down SV at a 3 ft/second rate. The spin-up to 10 radians per second is accomplished via hot gas generator to stabilize the RV during the retro rocket motor burn. The retro rocket provides a 1623 pound thrust to slow the RV for reentry. The despin system then slows the spin rate to 1.4 radians per second, which provides the needed stability during the coast period and still permits the aerodynamic torques to align the RV angle-of-attack with the flight path early in the reentry period. The drogue parachute is deployed upon closure of an acceleration switch at approximately 60,000 ft altitude. The drogue parachute is released and main parachute deployed upon closure of a barometric pressure switch at about 50,000 feet.

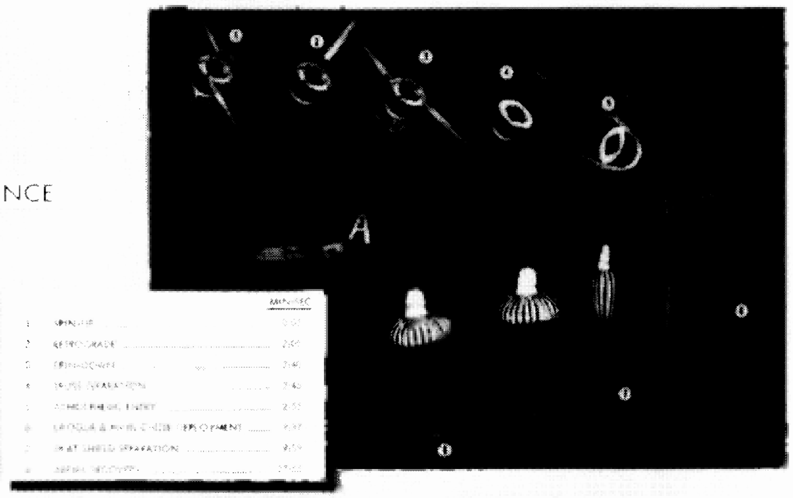
At 15,000 feet, the rate of descent is from 1200 to 1650 feet per minute, which is suitable for aerial recovery by USAF JC130 aircraft.

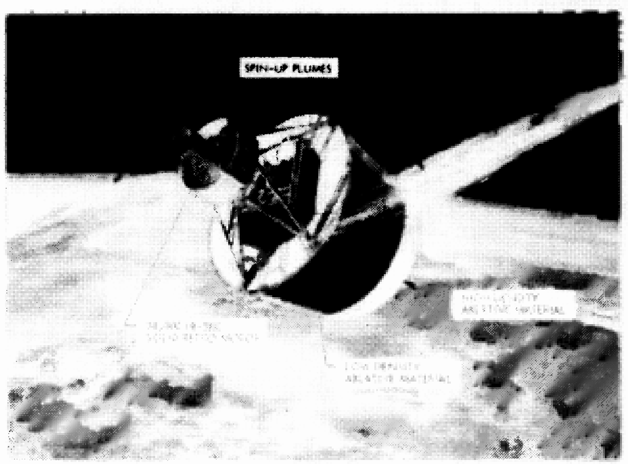
Each RV has a base diameter of 57-1/2 inches and is 85 inches from the heatshield nose to the retro motor nozzle. Maximum total weight of the RV and film is 1695 pounds. This consists of 956 pounds of RV and equipment, 239 pounds for film take-ups, and 500 pounds of film.

The heatshield when removed shows the gold tape covered canister which is part of a passive on-orbit thermal control system which, together with electrical heaters, maintains the desired canister temperature. The propulsion truss assembly and SV attachment fittings are shown.

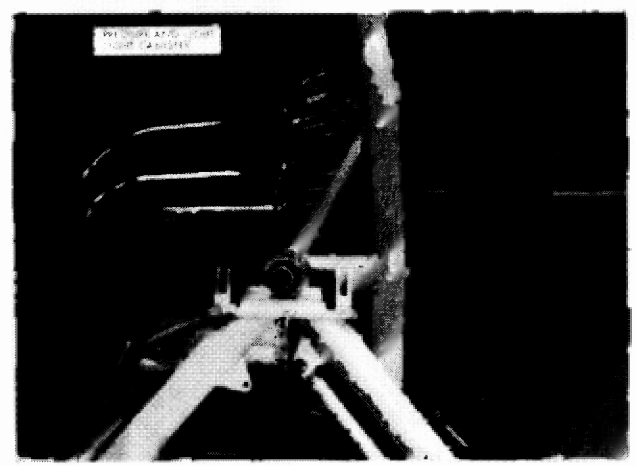
MARK 8 REENTRY VEHICLE

RECOVERY SEQUENCE





SPIN-UP EVENT



RV WITHOUT HEAT SHIELD

DATA RECOVERY OPERATIONS

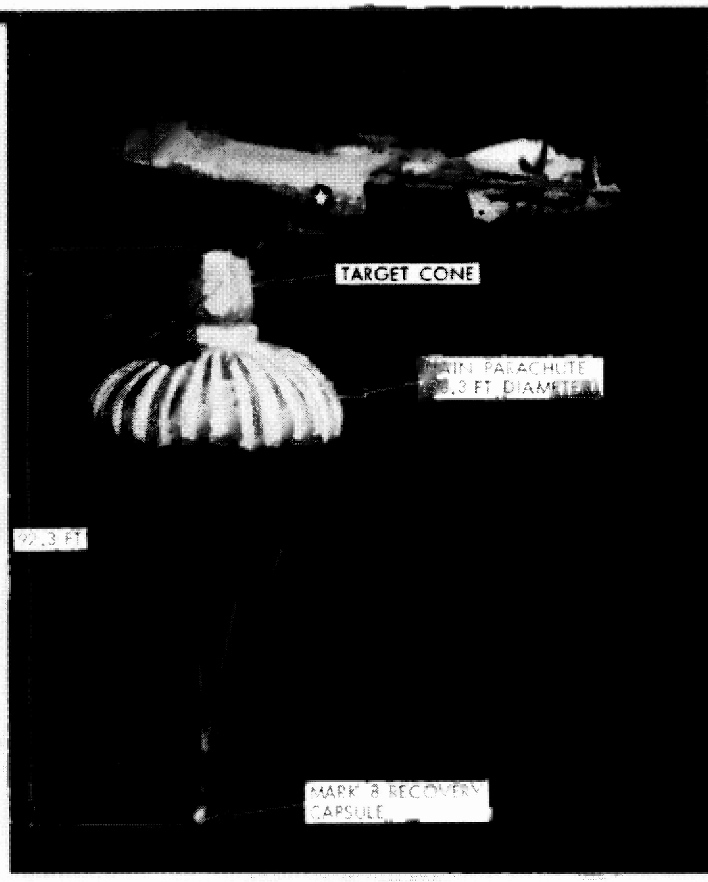
The target cone is 10 feet in diameter and 15 feet high. It contains the nylon load lines which are engaged by hooks on the retrieval line loops deployed by the retrieval aircraft.

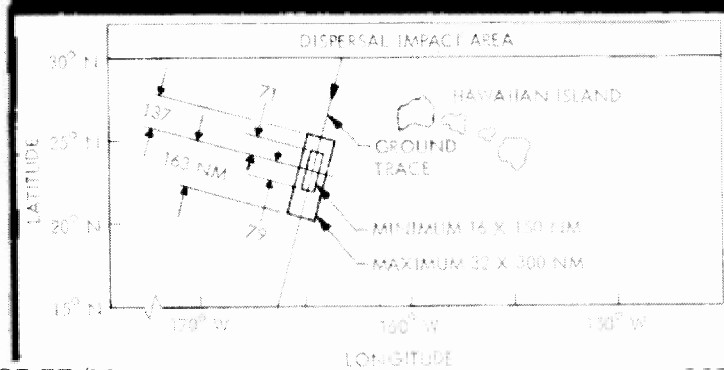
The minimum dispersal impact area applies to all normal film load with the maximum dispersal area applicable to a maximum unbalanced film load. In an emergency, recoveries may be required outside this designated area toward Midway Island or the California Coast.

If aerial retrieval is not accomplished, water recovery becomes a backup phase. When sea water contacts a sensor, a relay closes the film canister vent valve and transfers vehicle power to the water recovery beacon. A salt water corrosion plug will sink the recovery capsule in 48 to 60 hours after water impact. This allows a reasonable time for location and pickup by Air Force and Navy forces.

If the RV significantly overshoots the specified impact point, it will be destroyed. This is accomplished by ejecting the heatshield and deploying the drogue chute if aero drag has not produced 0.003 g by a given time after RV separation. This results in the RV burning up when the atmosphere is encountered. This provision has not been utilized on the HEXAGON program to date.

DATA RECOVERY OPERATIONS





MARK 8 EQUIPMENT

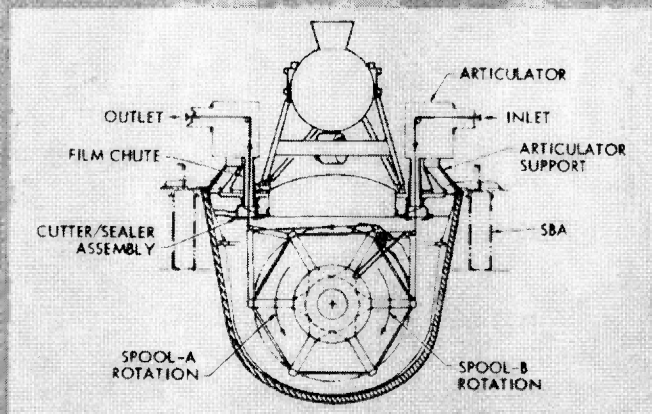
The film is shown passing through the RV. Transfer of film to this RV consists of transferring take-up power, wrapping film on this take-up, cutting and sealing the film path on the exit side, followed by cutting and sealing the inlet film path on the forward RV.

The RV base ablative cover consists of panels of ultra low density material. The base panel structures are of fiberglass honeycomb sandwich construction. A laminate of graphite blankets over glass fiber blankets covers the main parachute compartment. The circuit interrupter switch and wire bundles are mechanically separated near the ablative surface by a guillotine prior to physical separation of the RV from the SV.

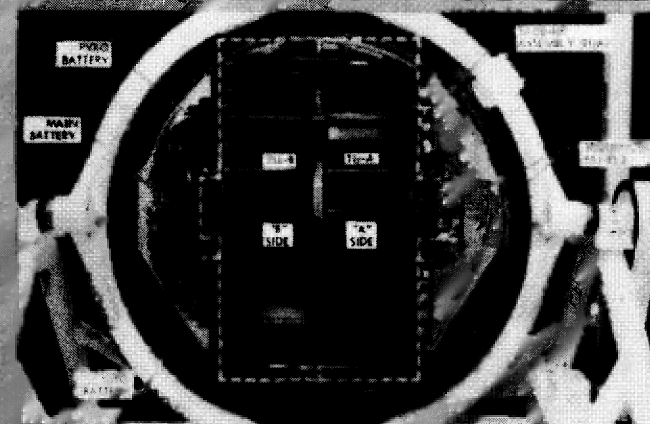
The bottom view shows the film on take-up A and B. The take-up drive motor and control electronics are contained mainly within the take-up hub. The canister is shown removed for access to the take-up and the RV equipment. This access greatly enhances film tracking alignments and testing during SV factory testing.

The RV assembly shows the structural frames within the RV which provide mechanical support for the take-up assembly and RV equipment. Of the encapsulated volume inside the RV, 18 ft^3 is for the take-up assembly and 13 ft^3 is used by the RV equipment. The film stack diameter can be up to 35 inches. RV power distribution and event sequence control is provided by relays. Time delay relays are used to control sequence timing. Instrumentation is provided for monitoring the deorbit-reentry events and temperature. This data is processed through the PCM commutator to the tracking and telemetry transmitter.

MARK 8 RV EQUIPMENT



FILM THROUGH RV



FILM ON RV TAKE UPS

RV BASE ABLATIVE COVER

RV ASSEMBLY

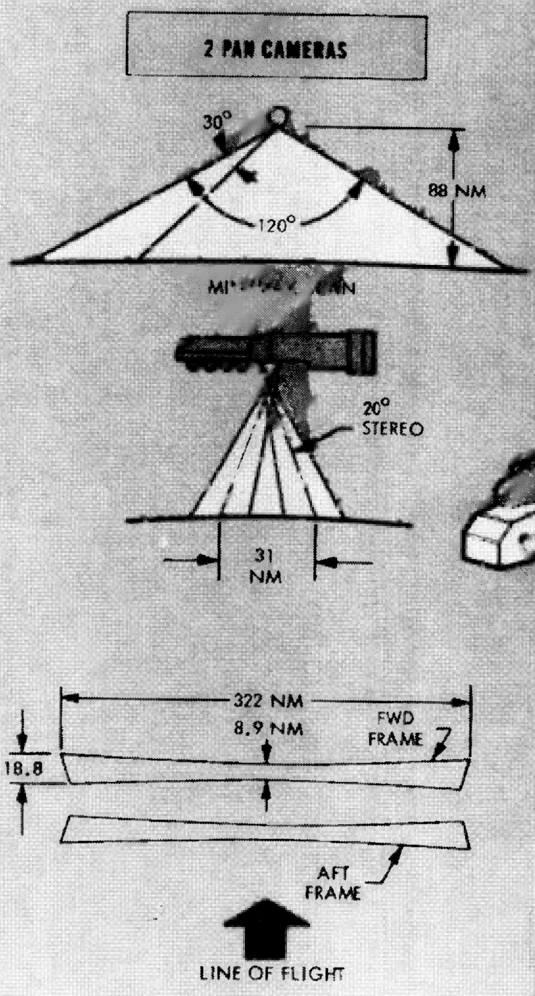
SEARCH CAPABILITY

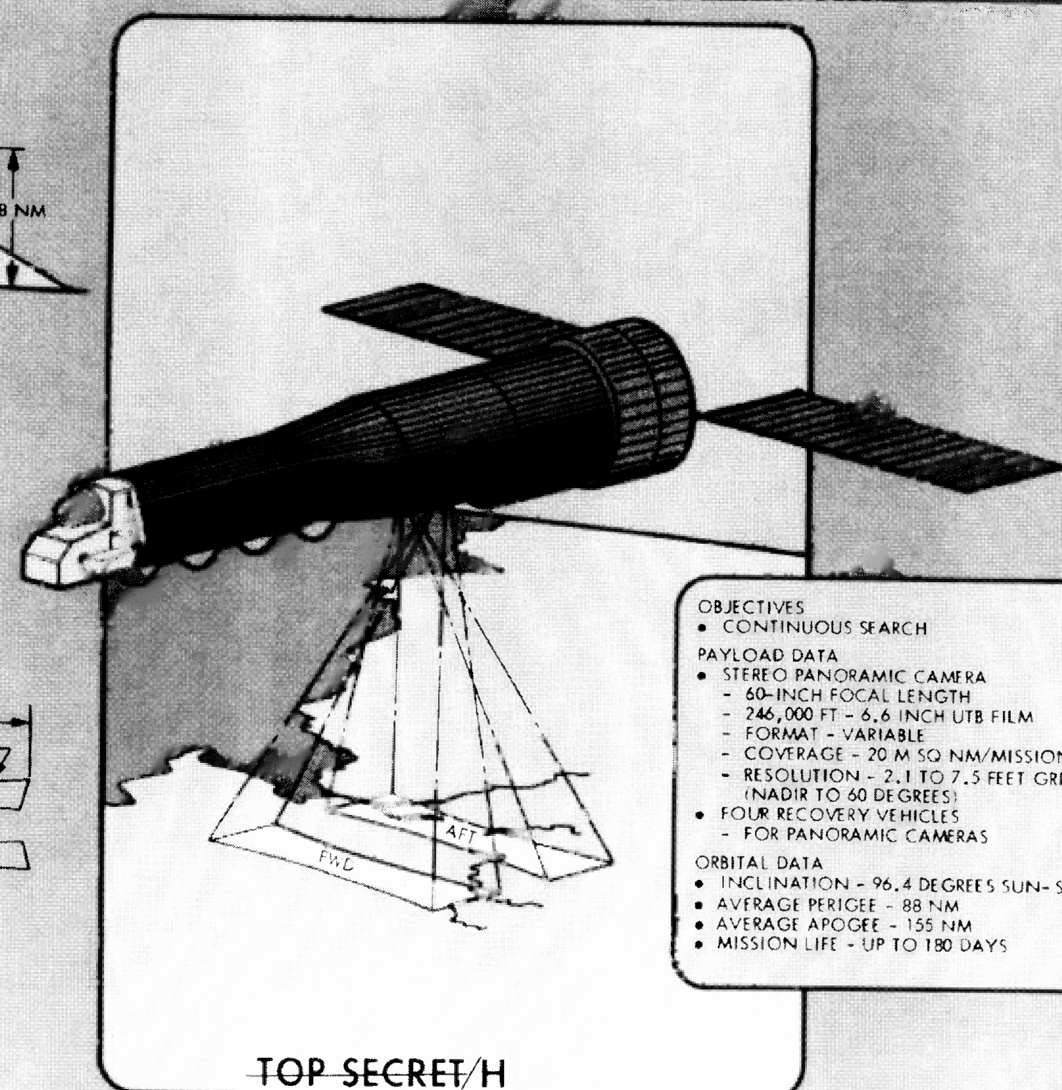
SEARCH/SURVEILLANCE OPERATIONS

Scanning is accomplished by continuous rotation of the optical bars at a rate to produce a nominal three percent frame-to-frame overlap allowance at nadir. The minimum scan sector is 30 degrees, the maximum 120 degrees. To achieve stereoscopic coverage the port camera (camera-A) looks forward 10 degrees and the starboard camera (camera-B) looks aft 10 degrees. At 88 nm altitude the interval of the forward to the aft frame is 31 nm. Since camera-B lags camera-A with respect to ground cover at nadir, the shutter of camera-B is inhibited for the first three frames and camera-A for the last three frames of each operation. Either camera can be operated separately in a mono mode.

The ground format varies with altitude, scan sector, and scan center. With the optical bars counter-rotating the ground formats for the two camera are not the same. The area of coverage per mission also varies with the average scan sector of acquisitions. At ±45 degrees average scan with the maximum supply of 1414 black and white film, gross stereo coverage of 20 million square nautical miles (M sq. nm) can be achieved at an average acquisition altitude of 88 nm with the current film transport system. At an average scan of ±30 degrees, this coverage would be reduced to 16 M sq. nm.

SEARCH/SURVEILLANCE OPERATIONS





OBJECTIVES
- CONTINUOUS SEARCH

PAYLOAD DATA
- STEREO PANORAMIC CAMERA
  - 60-INCH FOCAL LENGTH
  - 246,000 FT - 6.6 INCH UTB FILM
  - FORMAT - VARIABLE
  - COVERAGE - 20 M SQ NM/MISSION STEREO
  - RESOLUTION - 2.1 TO 7.5 FEET GRD (NADIR TO 60 DEGREES)
- FOUR RECOVERY VEHICLES
  - FOR PANORAMIC CAMERAS

ORBITAL DATA
- INCLINATION - 96.4 DEGREES SUN-SYNCHRONOUS
- AVERAGE PERIGEE - 88 NM
- AVERAGE APOGEE - 155 NM
- MISSION LIFE - UP TO 180 DAYS

BIF003W/2-093945-77

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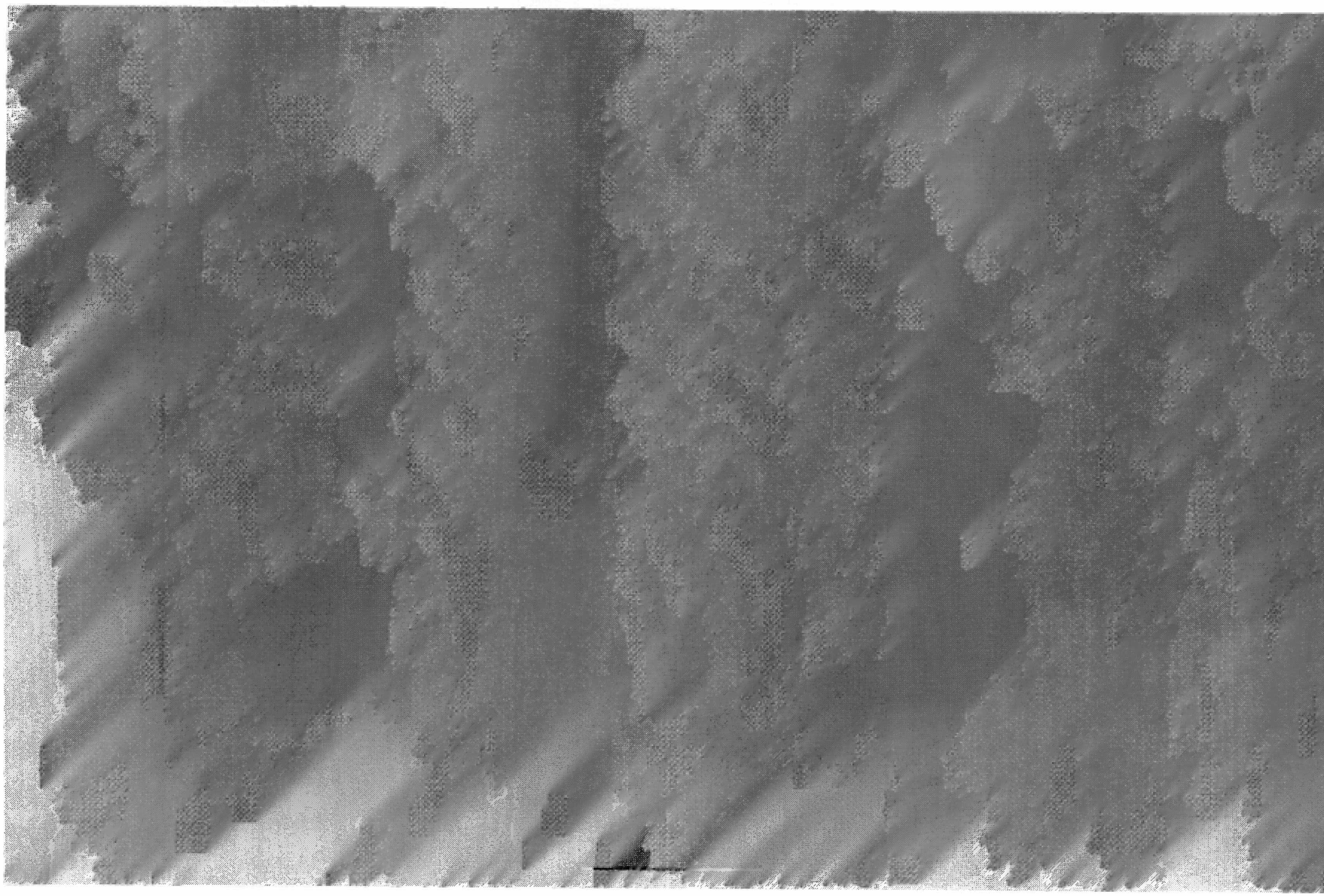
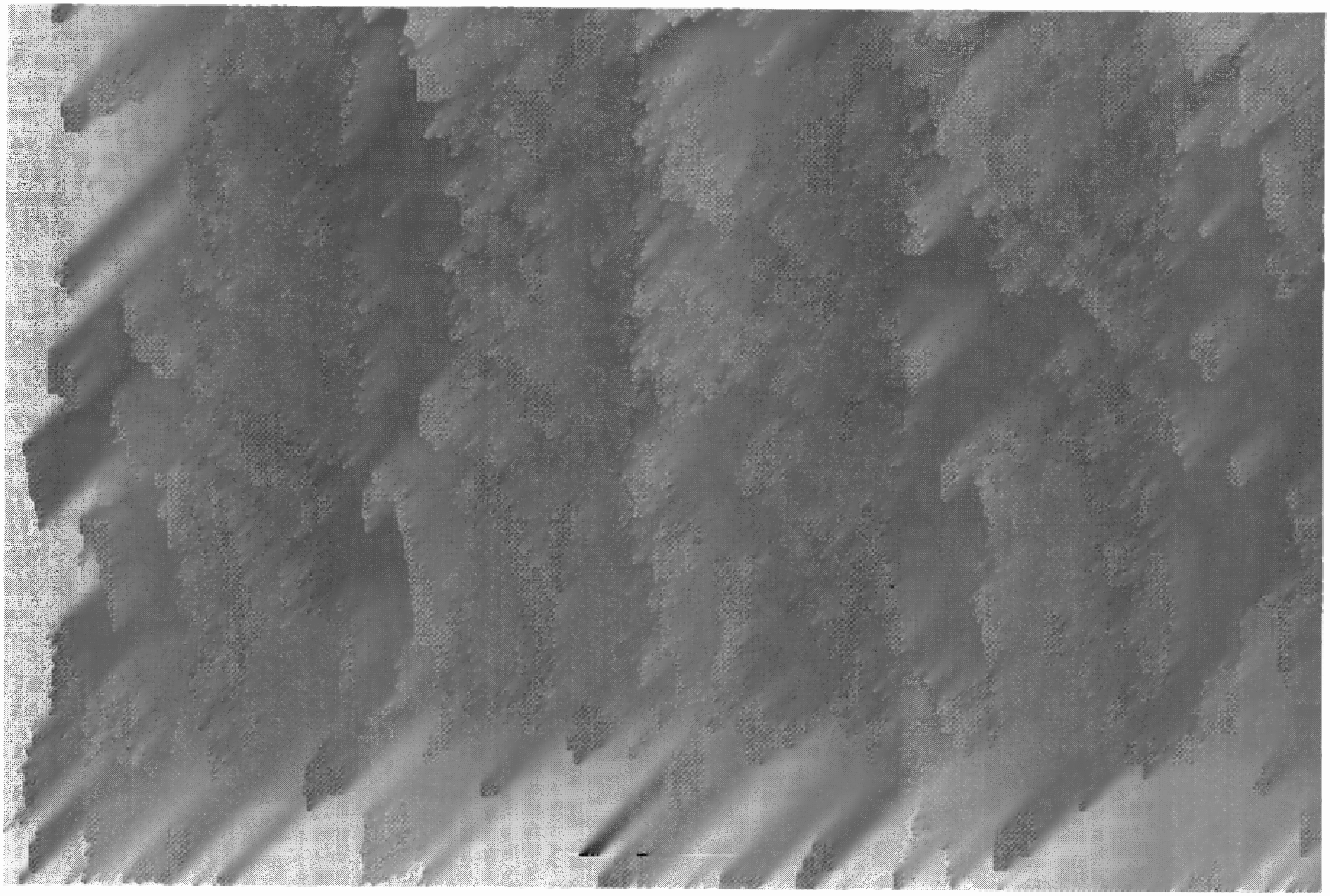
PENTAGON



TOP SECRET/H

SAMSO IN LOS ANGELES



THE CAPITOL

Conditions for this photograph are: Mission 1212-3, op 723, frame 002 forward, 002 aft, -24^{o} scan, 15 October 1976, stereo, 20X magnification of the Capital, Washington, D. C.

The ability of the HEXAGON camera to photograph targets in stereo greatly increase its capability as an intelligence gathering tool. All subjects reveal more information in three dimensions because they assume all the spatial dimension we are used to seeing. This allows determination of structure height, seeing the real shape of unusual objects and separation of items from confusing background.

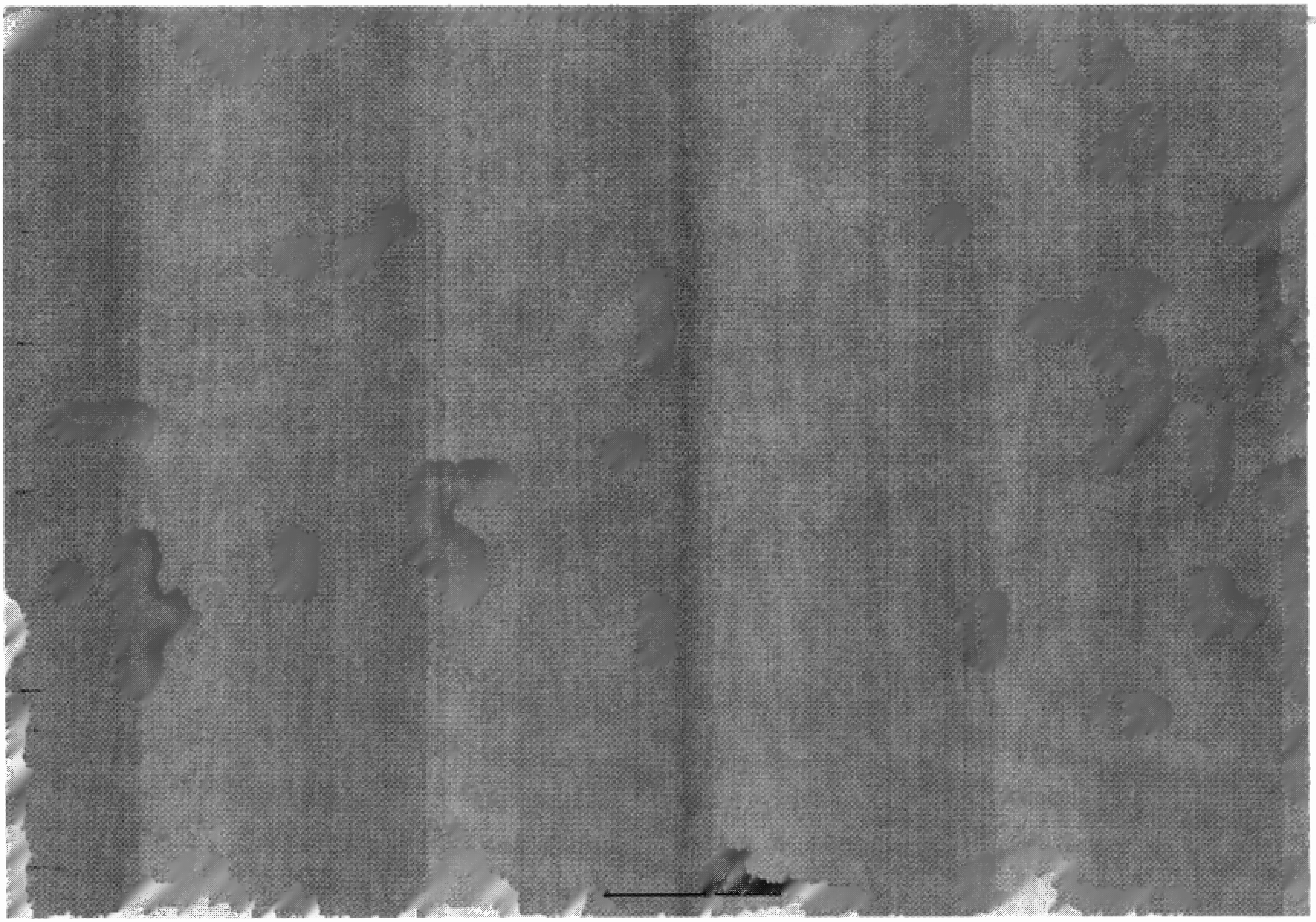
The item at (A) is the press box for the last presidential inauguration. It was still under construction. The relief of the trees at (B) shows how cover for troops and vehicles can be interpreted and targets located.

During the time between exposures, vehicles (C) moved to new locations. The scale of the photograph and time interval are known so their speed can be calculated.

Stereo imagery generally increases the information content of a target area and provides for a more complete and accurate intelligence reporting.

~~TOP SECRET~~/H

THE CAPITOL

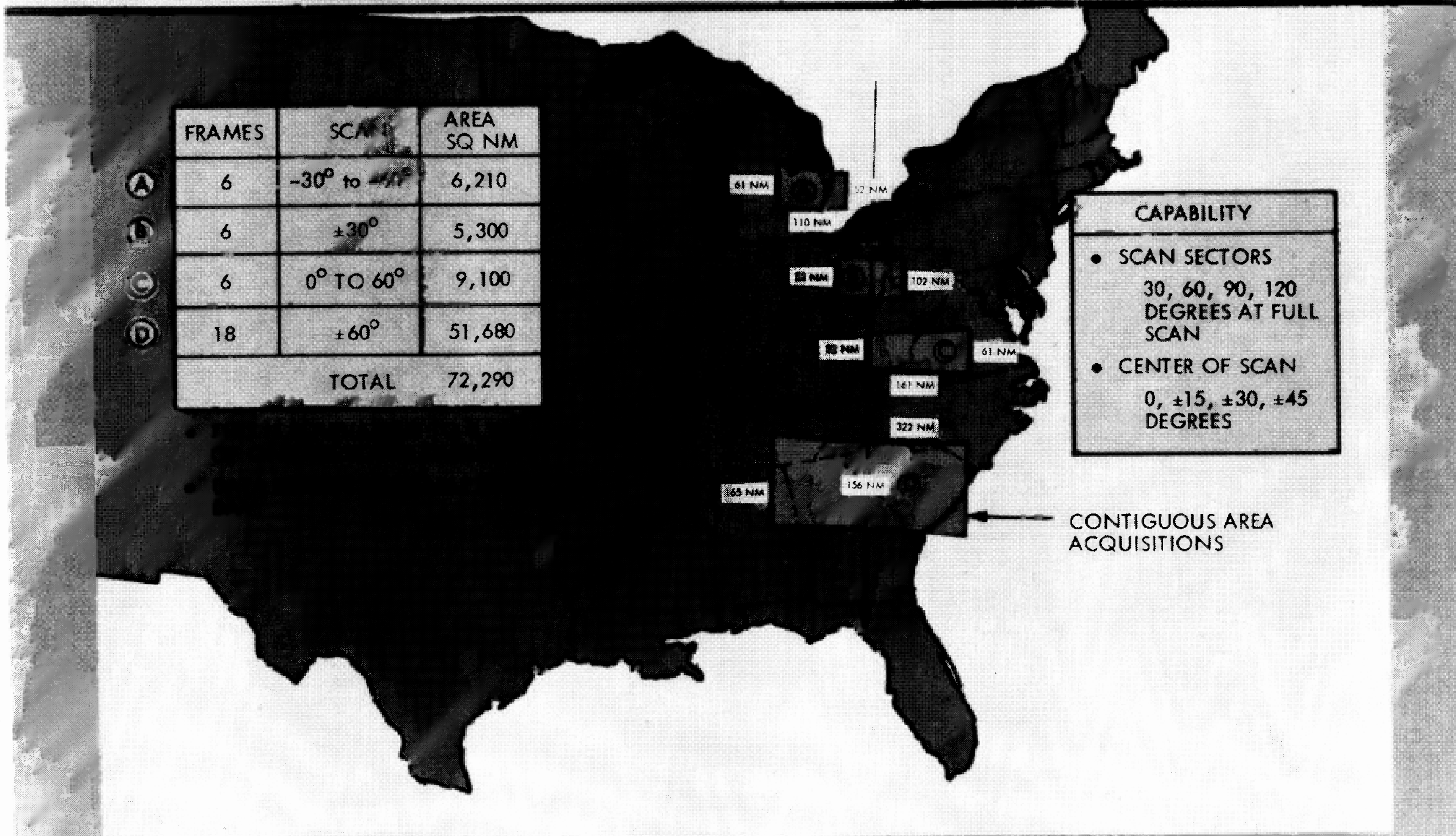


PANORAMIC SYSTEM FLEXIBILITY

HEXAGON has considerable flexibility in area search because of the selectability of scan sectors, scan centers, mono/stereo modes, and the number of frames for contiguous area acquisition. Using the United States as a familiar target objective, the four operations shown in the accompanying illustration range from a ±30 degree scan sector with 6 frames totaling 5300 sq nm mono to a ±60 degree scan sector with 18 frames totaling 51,680 sq nm mono. The example illustrates acquisitions along the flight path and on either side of it in a variety of modes, all during a single orbit rev. Acquisitions could be either mono or stereo operations.

Data return at Hawaii is available in [redacted] from this particular pass if timeliness is a factor. In its capability to perform world-wide search, data return of any acquisition is achievable within a one-day period.

PANORAMIC SYSTEM FLEXIBILITY

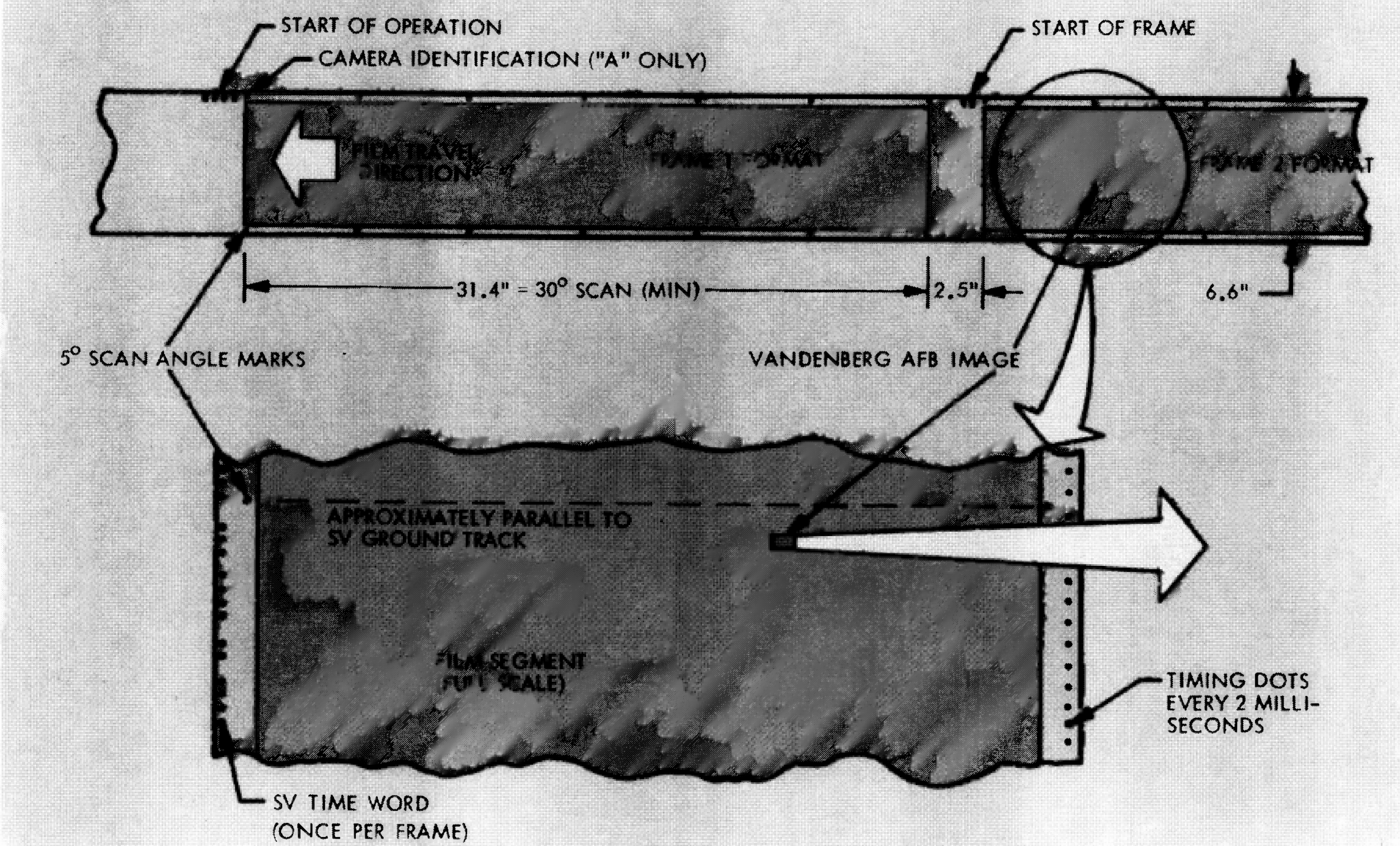


	FRAMES	SCAN	AREA SQ NM
A	6	-30° to [illegible]	6,210
B	6	±30°	5,300
C	6	0° TO 60°	9,100
D	18	±60°	51,680
		TOTAL	72,290

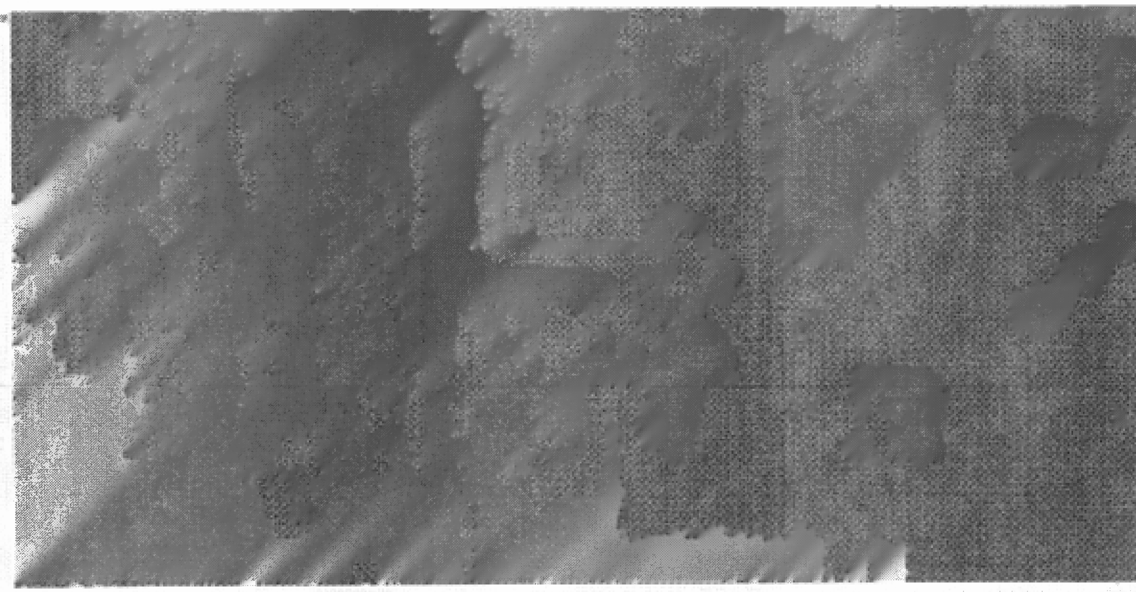
CAPABILITY

- SCAN SECTORS
  30, 60, 90, 120 DEGREES AT FULL SCAN
- CENTER OF SCAN
  0, ±15, ±30, ±45 DEGREES

CONTIGUOUS WIDE AREA COVERAGE



CONTIGUOUS WIDE AREA COVERAGE



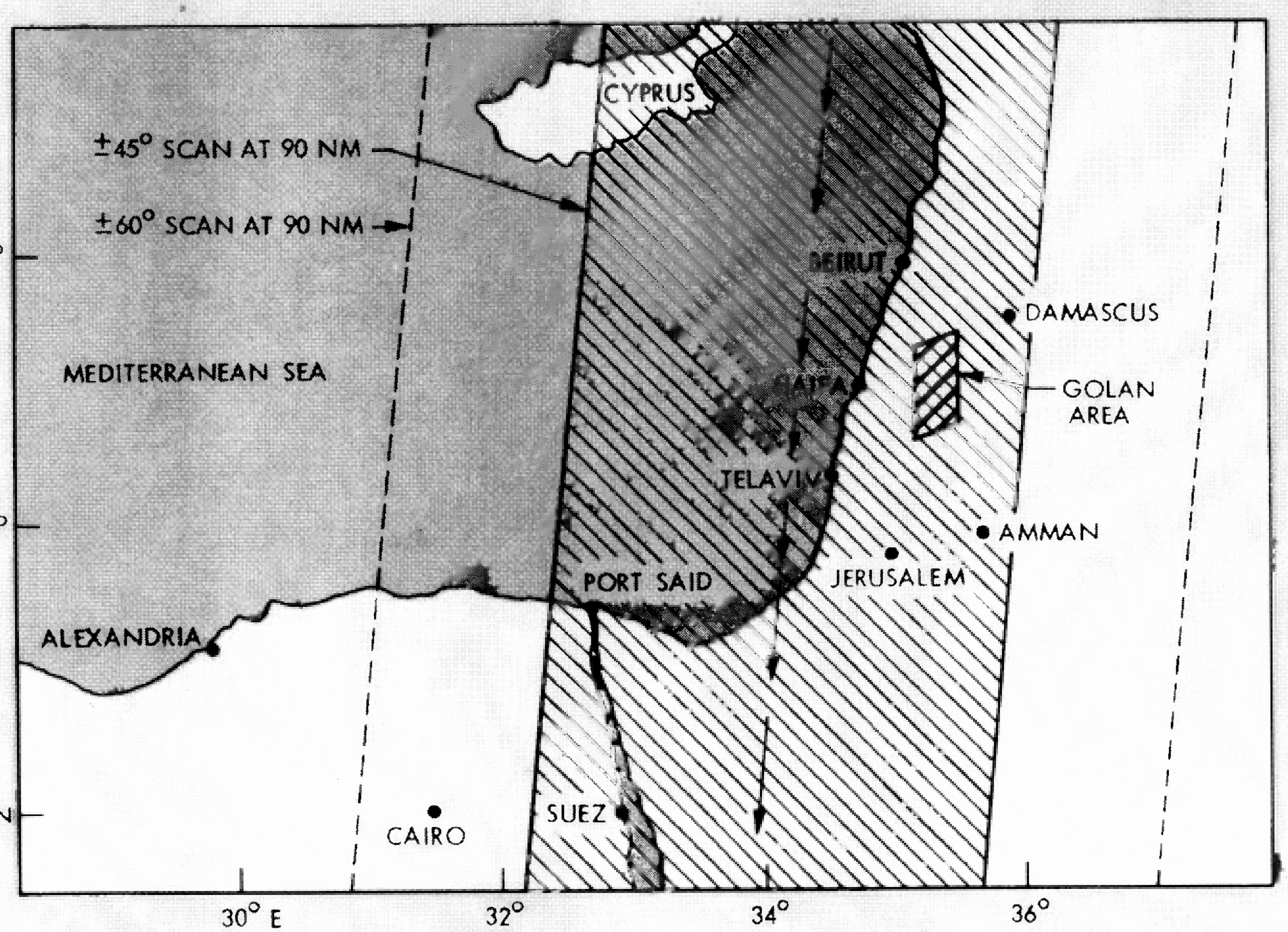
VANDENBERG AFB (HEXAGON LAUNCH SITE ON RIGHT)
VIA MISSION 1209-1 AT 40 TIMES MAGNIFICATION

THE KEY UNIQUE FEATURE OF HEXAGON IS ITS ABILITY TO CAPTURE LARGE AREAS ON FILM WITHIN A FEW MINUTES. A "FREEZING" OF THE ENTIRE AREA ALLOWS FOR IDENTIFICATION AND ENLARGEMENT OF ANY POINT OF POSSIBLE INTEREST AS ILLUSTRATED ABOVE. THIS IS A VALUABLE CAPABILITY WHEN CONDUCTING SEARCH FOR SPECIFIC TARGETS OF UNCERTAIN LOCATIONS.

MID EAST COVERAGE

A typical area search acquisition by HEXAGON is the coverage of the Eastern Mediterranean. This is a single two-minute stereo operation. At 90 nm altitude and a cross track scan of ±45 degrees, the primary areas of interest in Western Syria, Lebanon, Israel, Western Jordan, part of the Sinai Peninsula, and part of Cyprus are acquired as a contiguous area. At ±60 degrees scan, the additional width permits a greater tolerance in the longitudinal position of the flight path in addition to a wider area searched. In an extreme crisis, through the control of the orbit, a daily report of the acquisition of these areas is achievable.

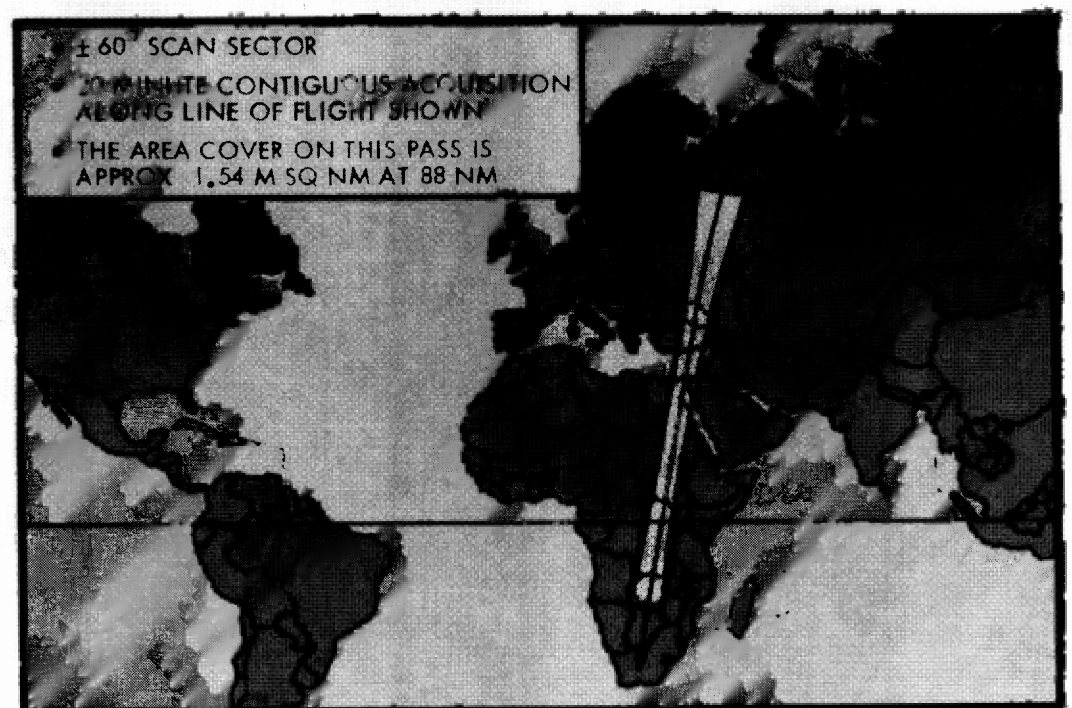
MID EAST COVERAGE



BROAD AREA ACQUISITION

The HEXAGON system can provide broad area acquisition with a contiguous area acquisition of considerable magnitude along the line of flight using any of the selectable scan sector and scan center combinations. The maximum 120 degree swath width is illustrated for a 20 minute contiguous operation acquiring a 4800 nm long area, 322 nm wide, extending from Western Russia, through the Eastern Mediterranean, down into Southern Africa. The total area approximates 1.54 M sq nm with an average altitude of 88 nm.

BROAD AREA ACQUISITION



COVERAGE ACHIEVEMENTS

The magnitude of the total world-wide imagery accomplished by HEXAGON can be compared with a familiar geographic area equivalent. As examples, the cloud-free total worldwide imagery of the fourth mission is equivalent to sixty acquisitions of Texas, or mission three equivalent to eight times the United States. The total area of Communist and free-world is 52.2 million square nautical miles which could be covered within two to three missions. The reduced coverage on mission 1201 was due to the loss of RV-3.

The percent of cloud-free acquisitions are dependent on several factors. The geographic locations of selected targets, the time of year, the time of day, and satellite weather information determine basic weather expectancy. The probability of cloud-free acquisitions is improved by longer missions, permitting more selectivity of operations within longer intervals of time between RV returns. The need to acquire certain high priority targets on every access reduces the probability of cloud-free acquisitions. The cloud-free unique imagery from mission 1212 consisted of: USSR [redacted] square nautical miles, Eastern Europe [redacted] China [redacted] other [redacted] and Middle East [redacted] Egypt, Syria, Jordan, Iraq, Lebanon and Israel) for a total of [redacted] square nautical miles.

The unique COMIREX targets shown in the table for each mission were read out by NPIC out of a total COMIREX target population that has ranged from about [redacted] in the earlier missions to about [redacted] on the most recent missions.

COVERAGE ACHIEVEMENTS

MISSION NUMBER	AREA COVERAGE (MILLION SQUARE NAUTICAL MILES)					UNIQUE COMIREX TARGETS IMAGED
	WORLD-WIDE		COMMUNIST COUNTRIES AND MIDDLE EAST			
	TOTAL IMAGERY	PERCENT CLOUD FREE	TOTAL IMAGERY	CLOUD-FREE		
				GROSS	UNIQUE	
1201	15.9	[redacted]	11.2	[redacted]	[redacted]	[redacted]
1202	21.1	[redacted]	16.1	[redacted]	[redacted]	[redacted]
1203	26.4	[redacted]	22.5	[redacted]	[redacted]	[redacted]
1204	18.8	[redacted]	14.2	[redacted]	[redacted]	[redacted]
1205	17.5	[redacted]	12.7	[redacted]	[redacted]	[redacted]
1206	18.9	[redacted]	15.1	[redacted]	[redacted]	[redacted]
1207	18.0	[redacted]	13.9	[redacted]	[redacted]	[redacted]
1208	16.6	[redacted]	13.0	[redacted]	[redacted]	[redacted]
1209	18.6	[redacted]	14.1	[redacted]	[redacted]	[redacted]
1210	17.4	[redacted]	13.6	[redacted]	[redacted]	[redacted]
1211	23.1	[redacted]	17.6	[redacted]	[redacted]	[redacted]
1212	17.9	[redacted]	12.6	[redacted]	[redacted]	[redacted]
1213	14.2 (1)	[redacted]				

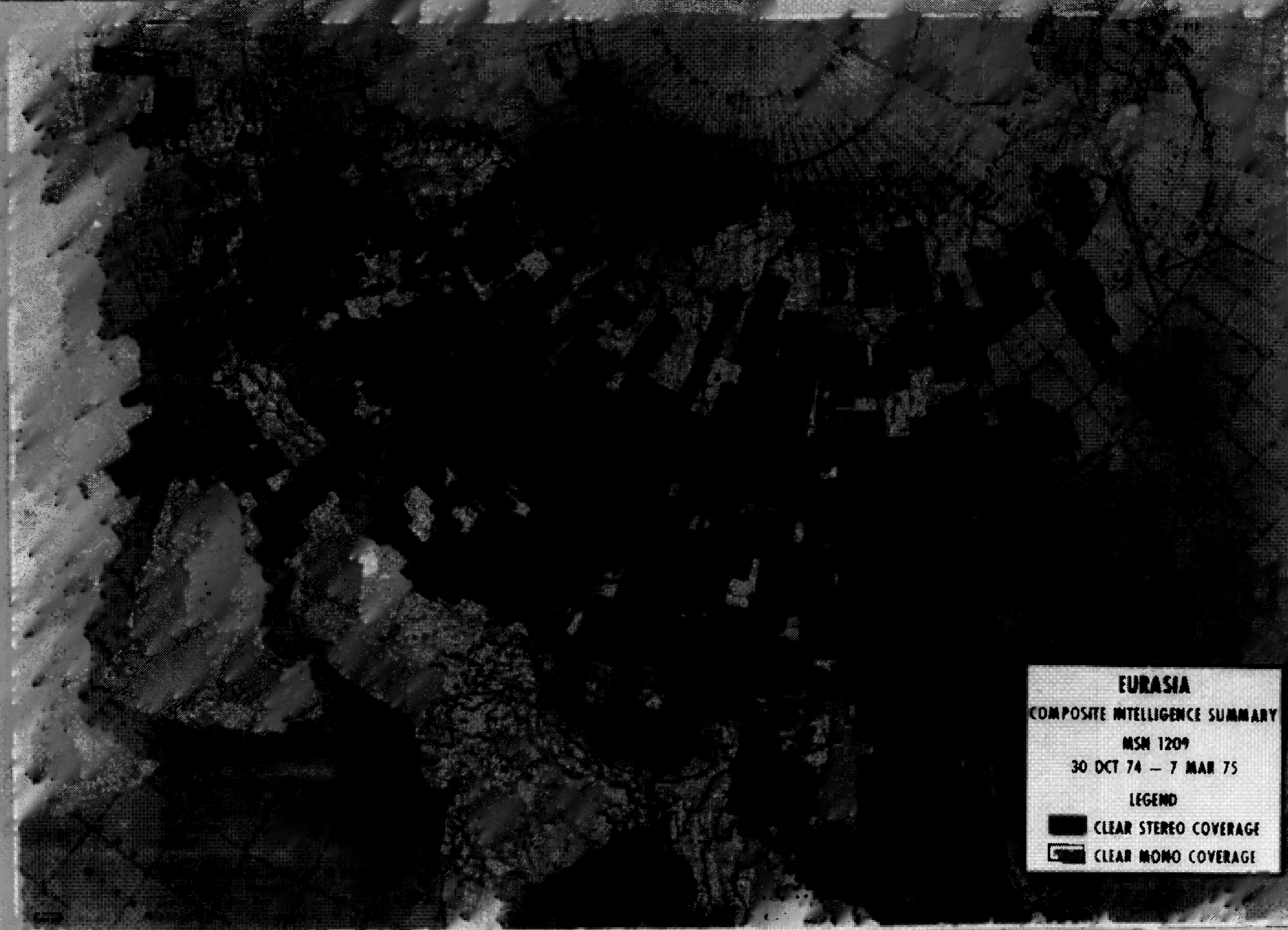
(1) THROUGH RV #3

SEARCH GLOBAL COVERAGE

This is a representative coverage of the Europe, Asia, and surrounding countries. The enclosed block or cell areas taken but not cloud-free are also shown. High priority targets were taken several times to ensure a cloud-free take and to note ground activity changes throughout the four-month life of Mission 1209.

These geographic areas of interest total 10.9 million square nautical miles and consist of: USSR 6.87, Eastern Europe 0.4, China 2.82, other Communist countries 0.56, and Middle East 0.25. The free-world area, including the United States, comprises a total of 41.3 million square nautical miles.

SEARCH GLOBAL COVERAGE

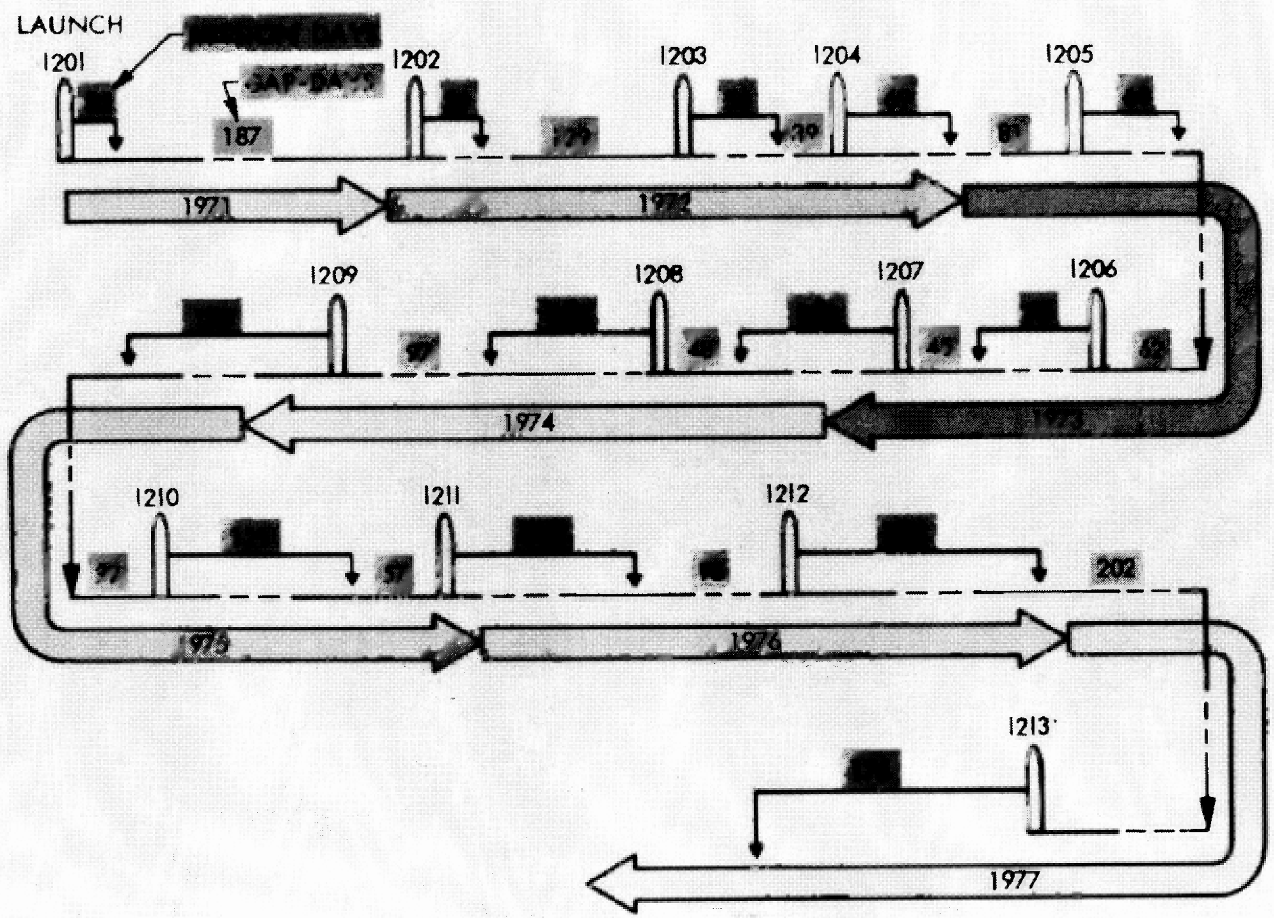


COVERAGE HISTORY

The initial contract for HEXAGON was to fly each vehicle for thirty days every 60 days for a 50% search coverage. The highly successful on-orbit performance, higher altitude, and design improvements of HEXAGON has allowed longer mission durations. This has resulted in extending search and surveillance operations up to 176 days.

The gap in continuity (RV #4 recovery to next vehicle launch) of HEXAGON coverage has varied widely. These gaps for the 13 flights to date have ranged from a low of 39 days to a high of more than 200 days. Under the accomplished schedule of the 13 launches, operational coverage with the acquisition and subsequent return of imagery data was available approximately half the time.

COVERAGE HISTORY



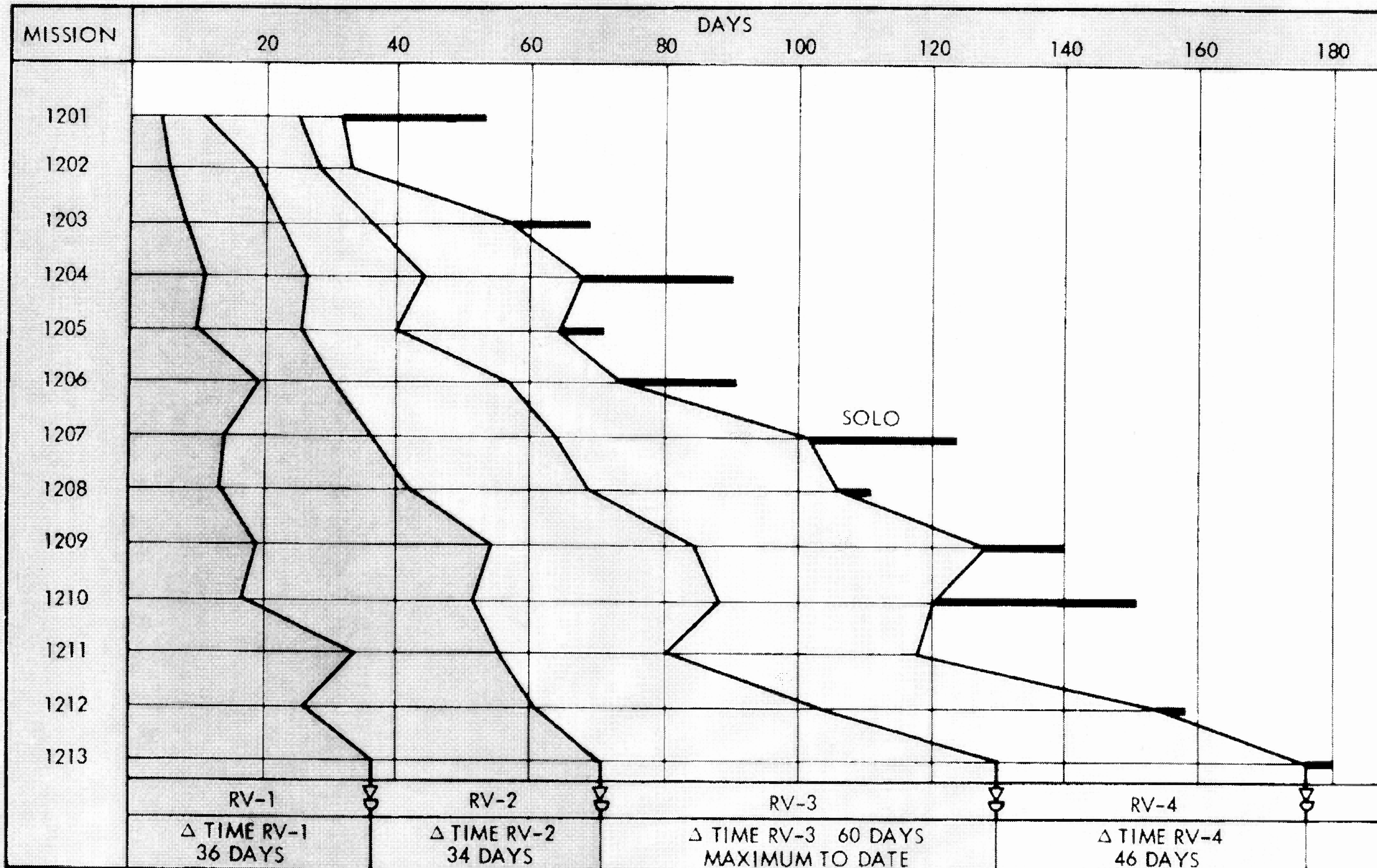
INCREASING DURATION BETWEEN RECOVERIES

Since the first launch on 15 June 1971 the increasing mission life (from 32 to 176 days) has resulted in an increasing number of operating days between recoveries. Starting with a low of 5 days, it has increased to intervals of 36, 34, 60, and 46 days on the thirteenth flight. On each of 11 flights, the shortest operating days per RV preceded the recovery of RV-1. On each of eight flights the longest time period preceded RV-4 recovery. Future increases in mission life to utilize the potential of the SV will produce on the average as many as 60 days of operations preceding the recovery of each RV.

Under crisis condition it is [redacted]possible to make a non-full RV recovery after the critical target is photographed; however, this option has not been selected to date.

Solo operations have been used to exploit the SV capabilities without risk to RV recovery. Solo tests have been instrumental in successfully increasing mission durations.

INCREASING DURATION BETWEEN RECOVERIES



SO-255 COLOR FILM

Conditions for this photo are: Mission 1208-4, OP 733, Frame 006, Aft, Scan Angle -2°, 15 July 1974, 40X magnification of San Francisco, California.

Color photography contributes an additional dimension to search and surveillance photography. It removes the image from the abstraction of black-and-white and places it in a context we understand more readily.

We see the world as a collection of shapes with size, texture, and color. A photograph lacking color is lacking one element in relation to reality.

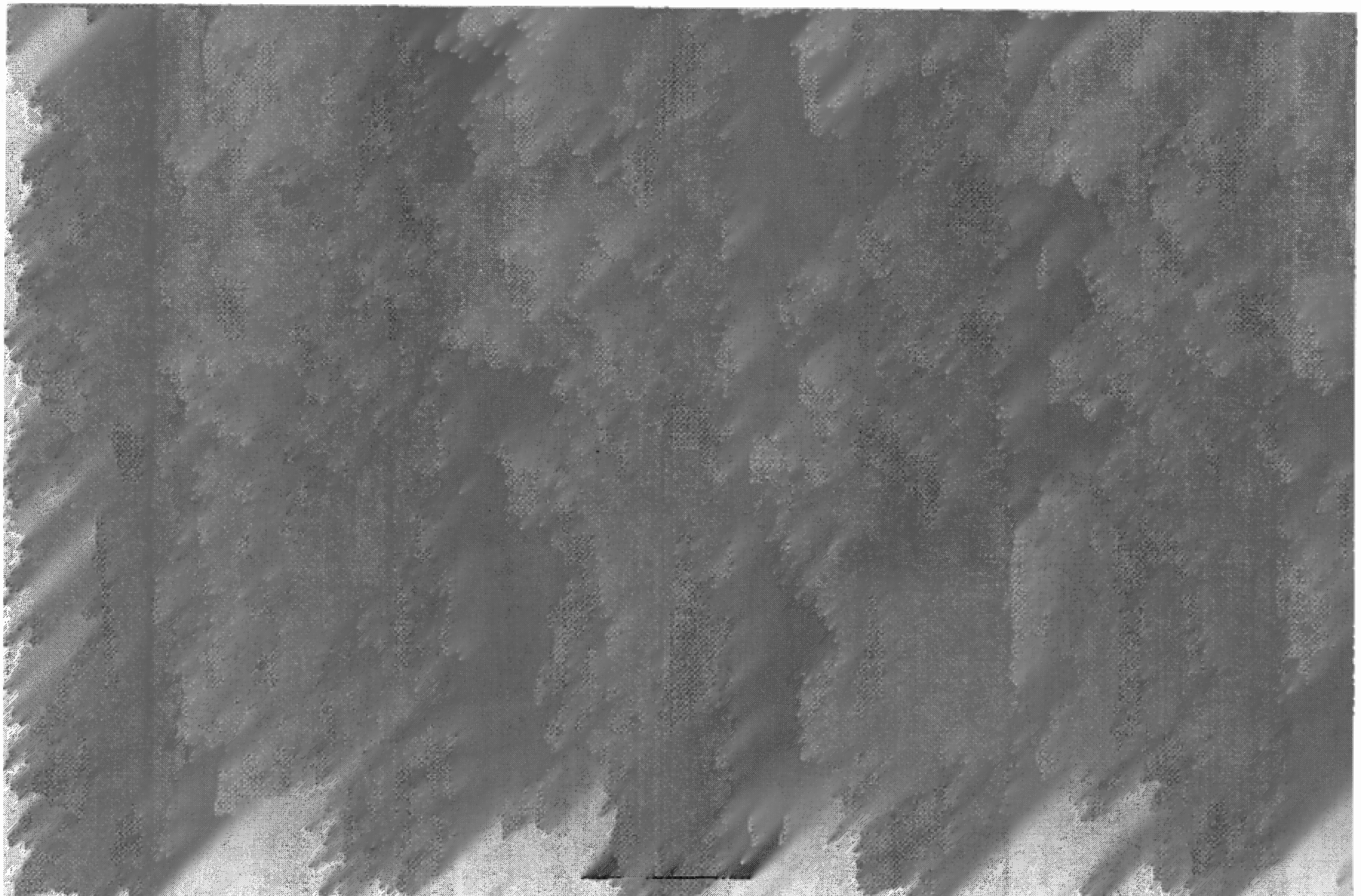
This scene is photographed in natural color and many items are readily identifiable because of color cues. The school buses at (A) could be interpreted as such in black-and-white by their proximity to the school complex. However, the distinctive yellow hue that we associate with school buses signals their use immediately.

The blue color traditionally found in swimming pools is easily located in several residential areas (B). Black and white coverage would require a detailed search because their geometric shapes would be lost among the buildings. The competition pool at (C) shows varying depth by the transition from lighter to darker blue as the water deepens. This same signature is seen at (D) indicating an expensive, in-ground pool. Numerous other items will be apparent to the viewer because of its association with object color in everyday experience.

Military, industrial, and transportation items also have distinctive color coding signatures and are separated from the enormous amount of photo detail in the same manner as the items cited above.

TOP SECRET H

SO-255 COLOR FILM



SO-130 INFRARED COLOR FILM

Conditions for this photo are: Mission 1213-3, OP 713, Frame 006, aft, scan angle 0^{o}, Oct 14, 1976, 5X magnification near Santa Fe, New Mexico.

Infrared color films were originally designed as a camouflage detection film. They have the capability of separating man-made, hidden objects from natural vegetation because of special characteristics of infrared radiation. Resolution is quite low compared to the black-and-white films used as the primary payload.

Vegetation containing living chlorophyl reflects a large percentage of the infra-red component of natural sunlight. Plants under stress (having insufficient water, diseased, etc.) will have a breakdown in their chlorophyl structure and consequently reflect less infrared. This type of color film shows infrared reflectance as a magenta colored image. Healthy vegetation will appear as bright magenta and will change in either color or brightness as the plants degrade.

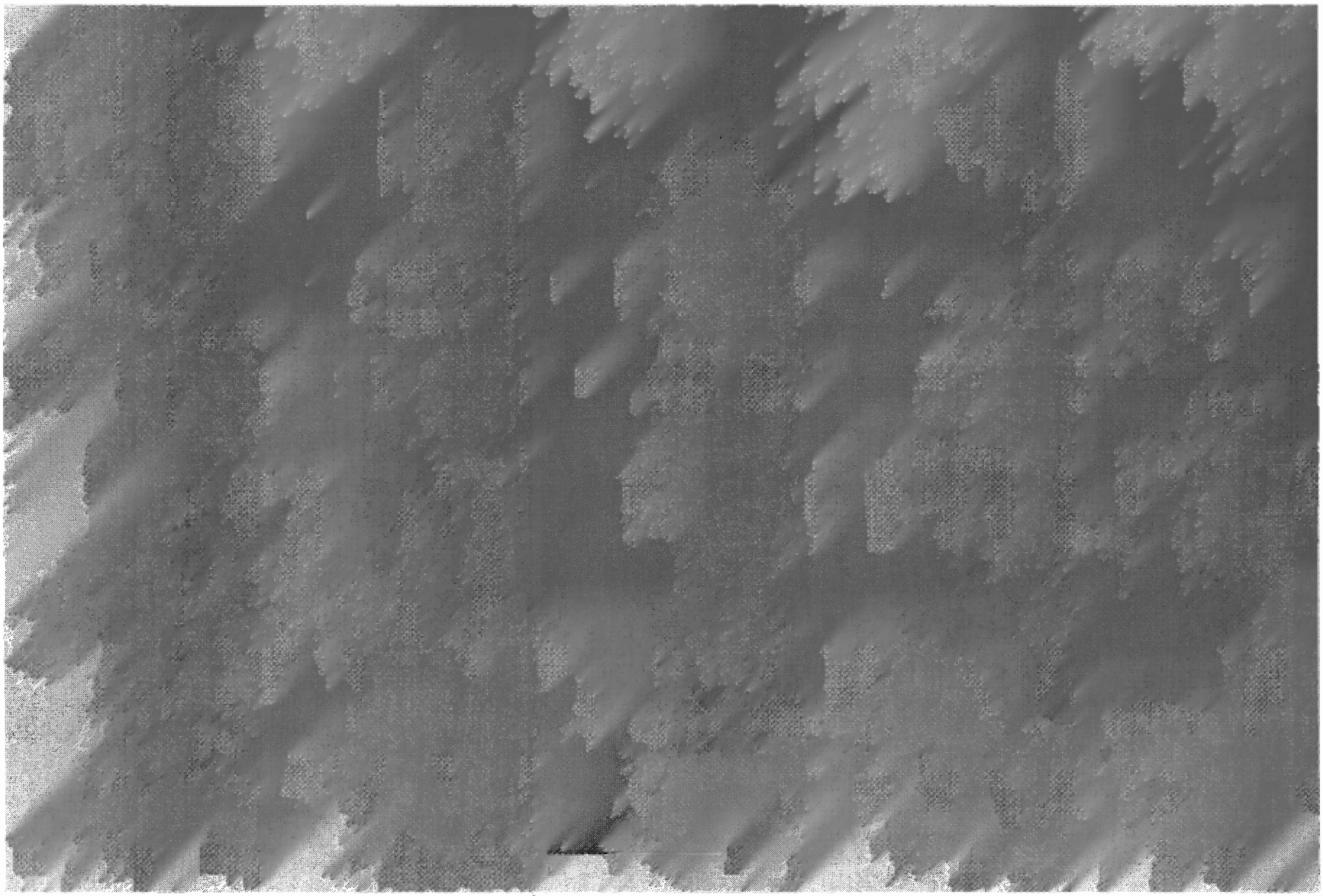
As a result of this characteristic, SO-130 is an ideal film for monitoring crop vigor and potential yield giving very basic intelligence data on the food supply and import/export requirements of a country.

In the accompanying photo varying degrees of vegetation vigor and distribution are indicated. The plantings at (A) are well advanced and show local irregularities in water supply and/or soil capability. Pasture land is seen as healthy at (B) and fallow fields are obvious at (C). The natural ground cover for the area is indicated as arid area, low chlorophyl cover by the response indicated by (D).

There are also notable color differences in the ponds that cross the format diagonally. As suspended sediments increase in volume, the color shifts toward the light blue and into the green portion of the spectrum. This is an indicator of the erosion and retention of valuable soils. Though marginally useful as a comouflage detection film at this scale, SO-130 is outstanding as a crop monitoring tool.

~~TOP SECRET~~/H

SO-130 INFRARED COLOR FILM



FILM TYPES FLOWN

CONVENTIONAL BLACK AND WHITE FILMS ARE:

- 1414 – The standard fine grain high resolution B & W film flown on HEXAGON Missions through Mission 1213. This film has an extended red sensitivity, is approximately 2 mils thick (0.5 mil emulsion coated on a 1.5 mil base), and has an Aerial Film Speed (AFS) of 15.0.
- SO-208 – This film is identical to 1414 except that it is coated on an ultra-thin 1.2 mil base. This will allow approximately 20,000 additional feet of film to be utilized in the HEXAGON system and is the standard material for missions 1214 and up.

HIGHER RESOLUTION BLACK AND WHITE FILMS ARE:

- SO-124 – A panchromatic B & W film flown experimentally on Mission 1210. This film has higher low-contrast resolution than the conventional B & W films. It is coated on a 1.5 mil base and has an AFS of 6.0 requiring longer exposure times than the conventional B & W films.
- SO-460 – This film is essentially identical to SO-124 except that it is coated on the ultra-thin 1.2 mil base. The AFS is 6.0.
- SO-464 – This film is essentially SO-460 with the yellow AH dye removed. This results in an increase of emulsion speed to an AFS of 10.0. This emulsion is also coated on the ultra-thin 1.2 mil base.
- Aerial 15 – This is one of the new "Mono Dispersed Cubic" emulsions sometimes also referred to as "J" coatings. These emulsions exhibit extremely fine grain, high resolution, and very slow emulsion speeds. This film has an AFS of 6.6 and is coated on the ultra-thin 1.2 mil base.

COLOR FILMS ARE:

- SO-255 – This is a conventionally sensitized, fine grain, high-definition color reversal film. The emulsion is coated on a 1.5 mil base with the film having an AFS of 9.5.
- SO-130 – This is a "False Color" infrared sensitive color reversal film on a 1.5 mil base with an AFS of 7.5. This film is used extensively for economic intelligence evaluation.

FILM TYPES FLOWN

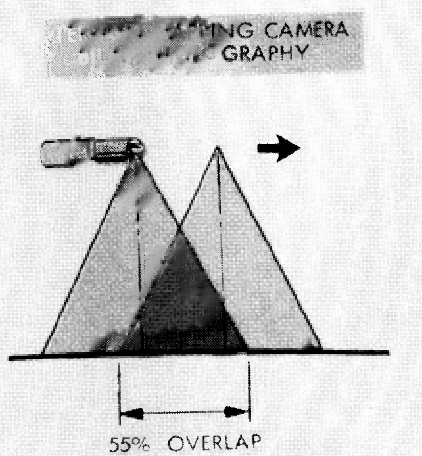
MISSION	FILM TYPES							
	1414	SO-255	SO-130	SO-208	SO-124	SO-460	SO-464	AERIAL 15
	Film Footage – Feet							
1201	172,640							
1202	156,115							
1203	185,325							
1204	208,454	10,000						
1205	216,010	2,000						
1206	191,017	21,000	500					
1207	207,832	4,984	500					
1208	210,069	2,588	3,000					
1209	217,338	8,150	3,400					
1210	210,156	9,150	3,150		3,750			
1211	153,942	4,500	4,500	4,500				
1212	231,450	4,500	4,500					
1213	198,536	3,500	5,500	20,000		7,000	8,000	2,000
TOTALS	2,558,884	70,372	25,050	24,500	3,750	7,000	8,000	2,000

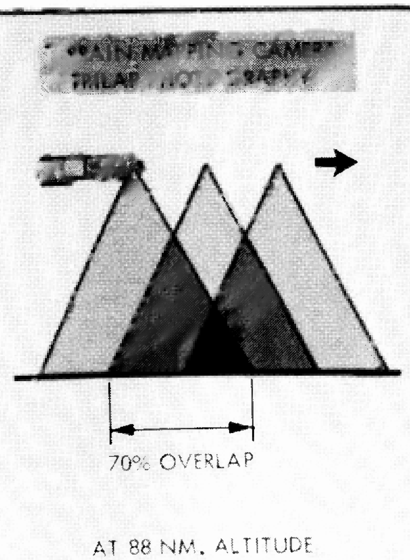
MAPPING SYSTEM

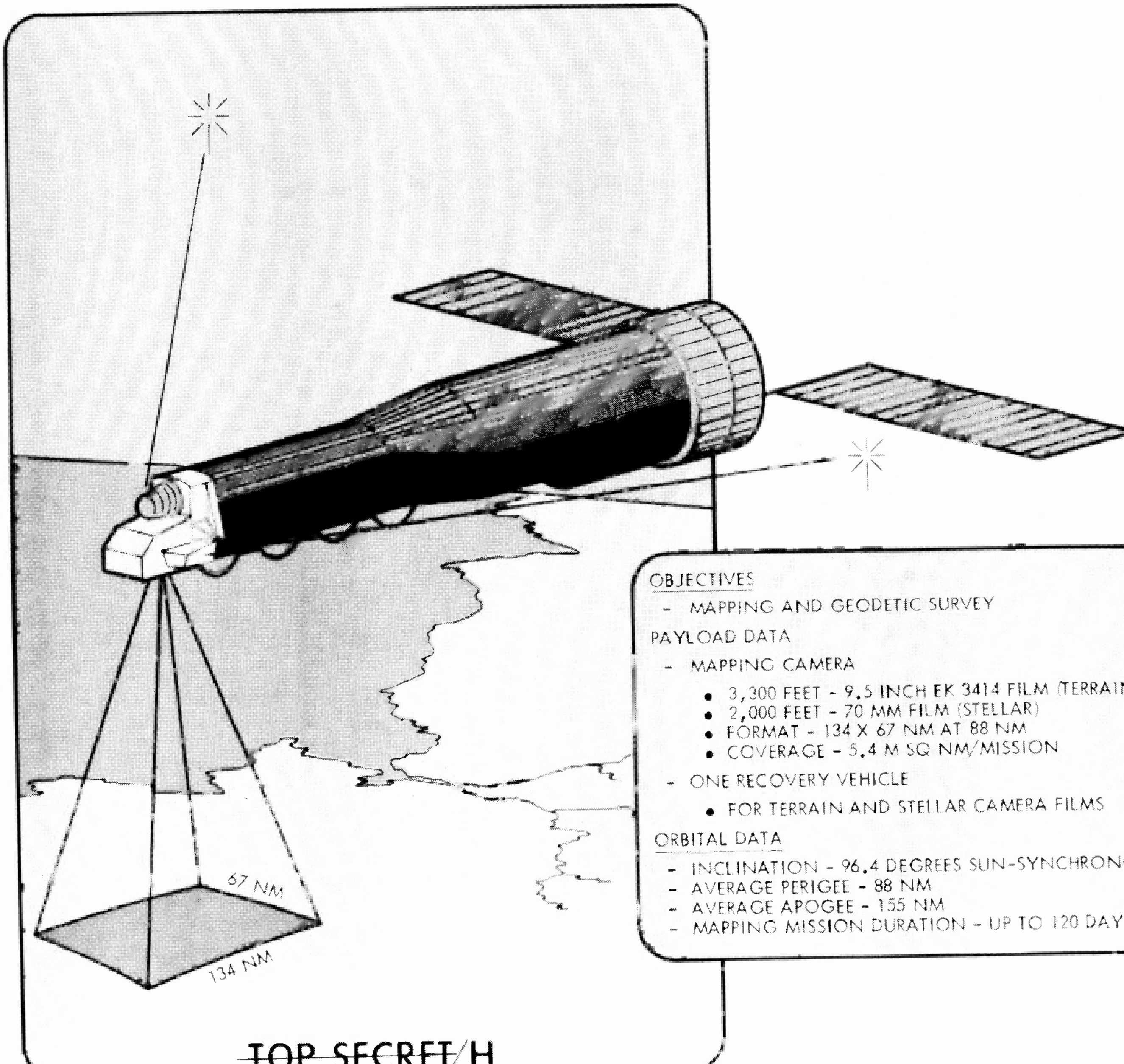
MAPPING CAMERA OPERATION

The mapping camera system (MCS) is utilized to provide cartographic control for compilation of 1:50,000 scale maps. Photogrametric data is achieved by simultaneously acquiring overlapping terrain and star field photographs through three precisely calibrated lens systems. Control points are established by measurements of prominent imagery on overlapping pairs of terrain photography. Measurements of star image locations on stellar frames provide an accurate orientation of the terrain camera axis in space at the time of each photograph. Stereo photography, necessary for vertical measurements of terrain imagery, is acquired in two stereo modes providing 70% or 55% overlap. A third mode is used to provide mono photography with 10% overlap. The high resolution and wide coverage (70 X 140 nm) of the terrain camera provide a useful tool in searching for primary targets of interest and earth survey objectives. On completion of the MCS mission, the terrain and stellar films are returned in a single Mark V recovery vehicle. The doppler beacon system and NAVPAC system provides ephemeral information which accurately establishes camera/vehicle position in space. These data are needed to support mensuration of MCS imagery.

MAPPING CAMERA OPERATIONS







OBJECTIVES

- MAPPING AND GEODETIC SURVEY

PAYLOAD DATA

- MAPPING CAMERA
  - 3,300 FEET - 9.5 INCH EK 3414 FILM (TERRAIN)
  - 2,000 FEET - 70 MM FILM (STELLAR)
  - FORMAT - 134 X 67 NM AT 88 NM
  - COVERAGE - 5.4 M SQ NM/MISSION
- ONE RECOVERY VEHICLE
  - FOR TERRAIN AND STELLAR CAMERA FILMS

ORBITAL DATA

- INCLINATION - 96.4 DEGREES SUN-SYNCHRONOUS
- AVERAGE PERIGEE - 88 NM
- AVERAGE APOGEE - 155 NM
- MAPPING MISSION DURATION - UP TO 120 DAYS

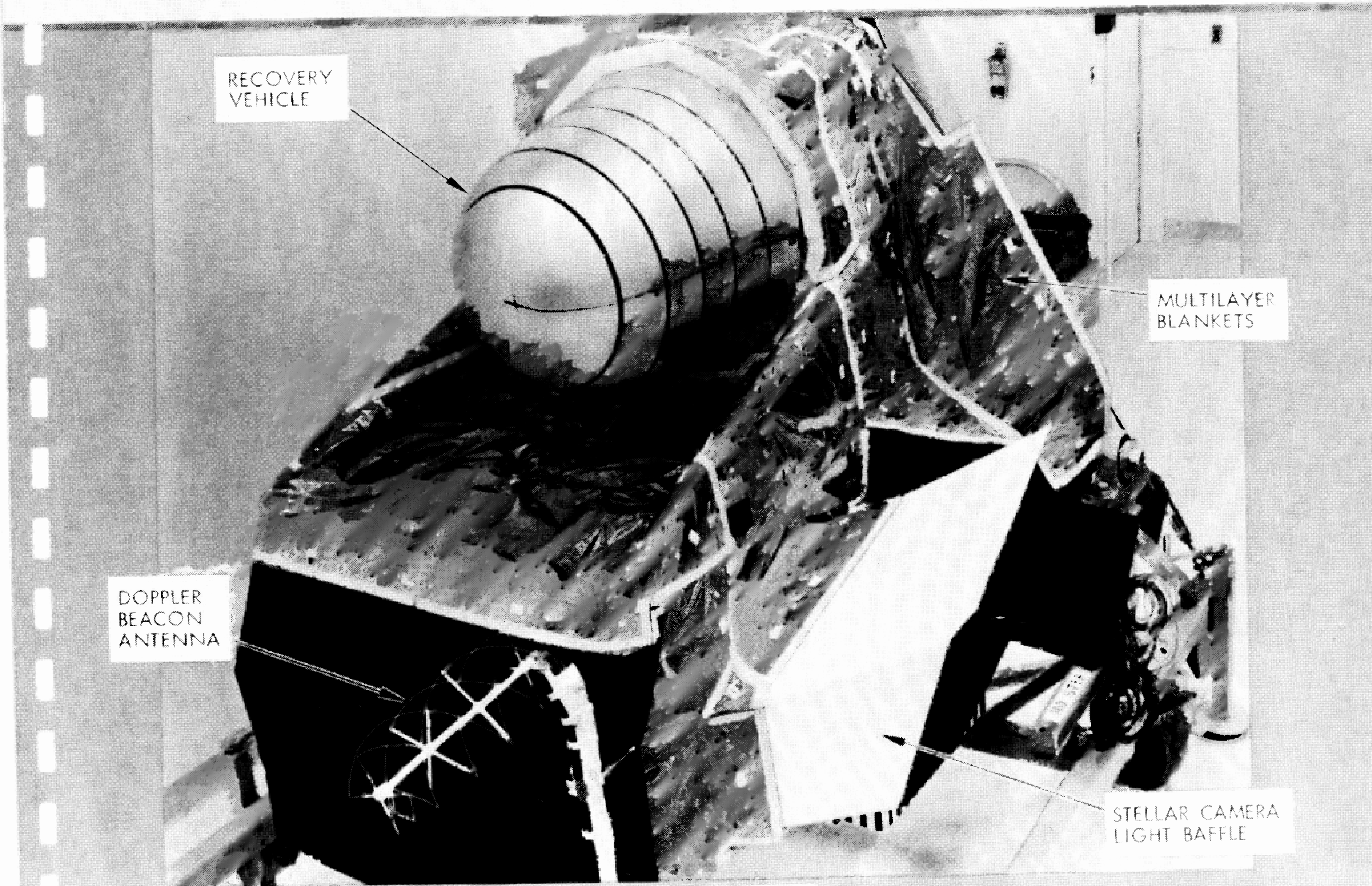
MAPPING CAMERA SYSTEM

The Mapping Camera System (MCS) structure supports and positions the individual subsystems with respect to each other and within the space constraints of the SV shroud. The loads are transmitted to six structural attach points on the vehicle bulkhead. Pitch and yaw alignment of the structure to the SV attitude reference module is achieved by shimming the attach points.

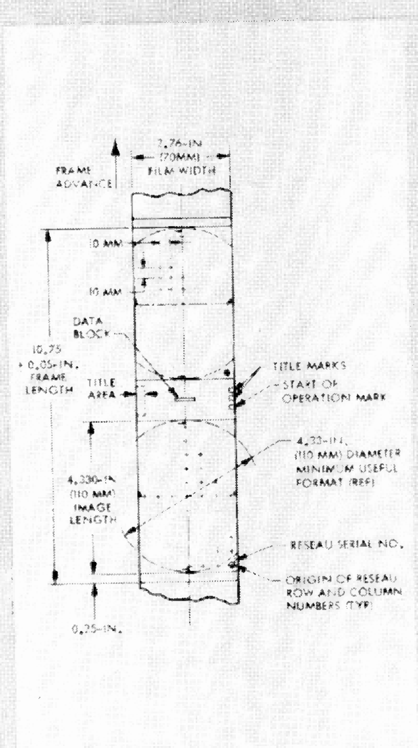
Temperature control is achieved by passive means (paint, tape, multilayer blankets and thin metal sheets, i.e., cocoons) for all but the precise temperature requirements of the lens system, which employs heaters for their accurate control.

Electrical interfaces between the SV and the MCS are at the bulkhead. All command, telemetry, timing and power are provided by the SV.

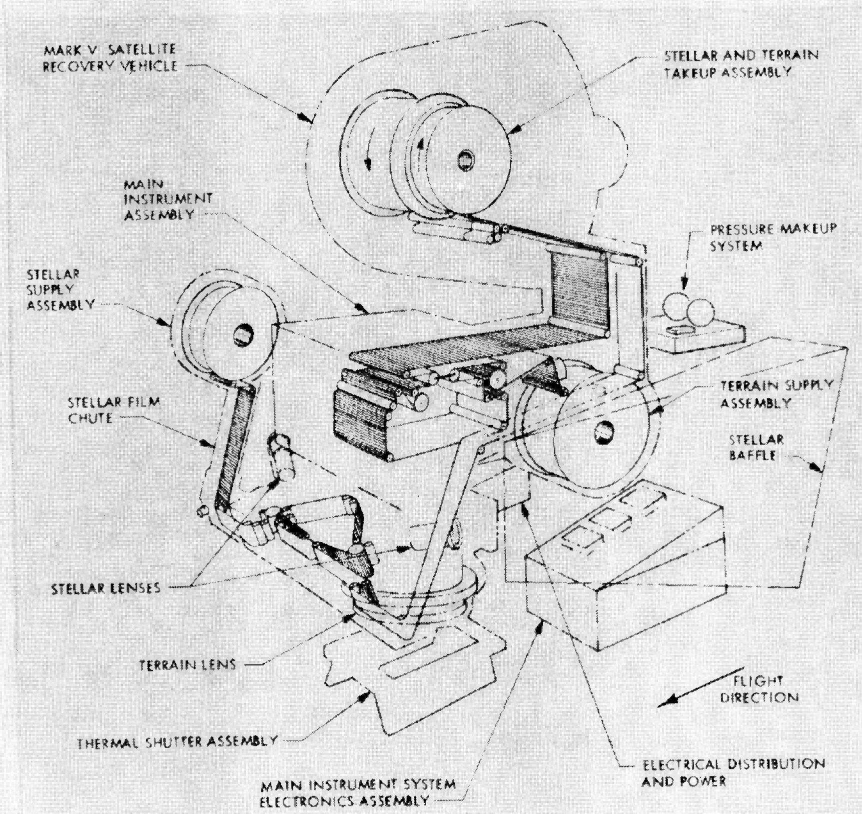
MAPPING CAMERA SYSTEM

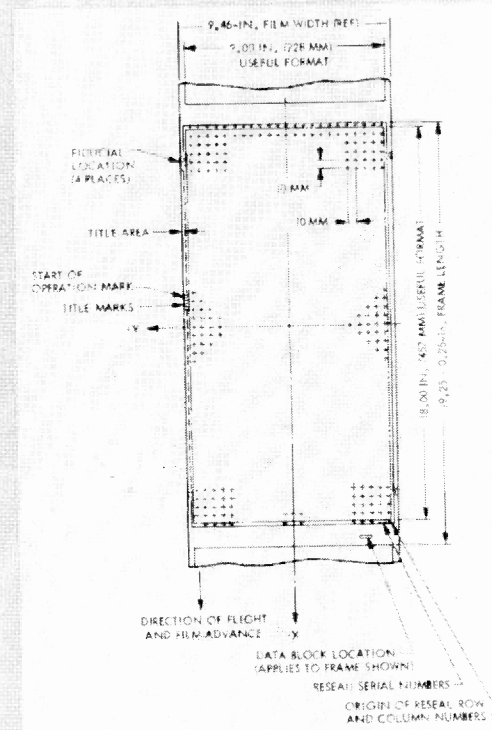


MAPPING CAMERA DESCRIPTION



STELLAR FORMAT

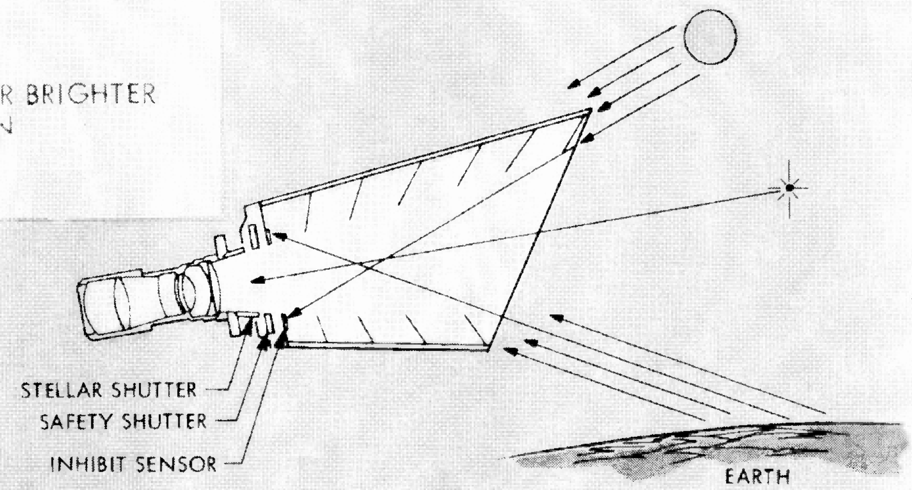




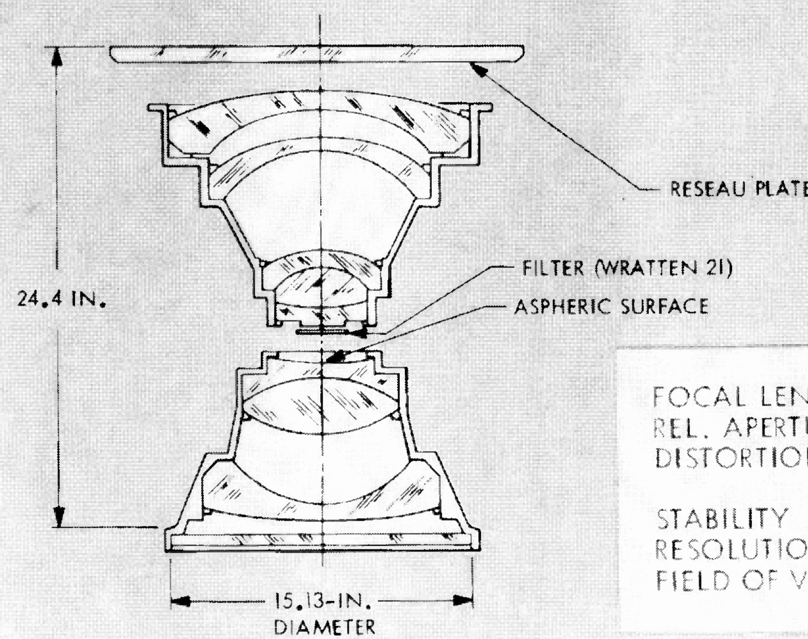
TERRAIN FORMAT

MAPPING CAMERA LENSES

LENS FOCAL LENGTH	10.0 INCHES
RELATIVE APERTURE	f/2.0
SENSITIVITY	6th MAGNITUDE STARS OR BRIGHTER
BORESIGHT STABILITY	2 ARC-SEC IN OPERATION
FIELD OF VIEW	16 BY 25 DEGREES



STELLAR LENS AND BAFFLE

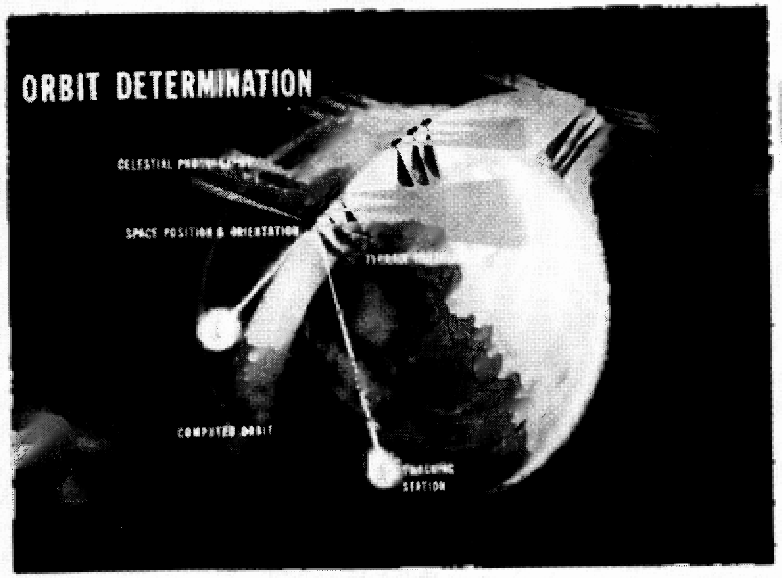


TERRAIN LENS

FOCAL LENGTH	12.0 IN.
REL. APERTURE	f/6, T/14
DISTORTION	100 MICRONS MAX RADIAL 20 MICRONS MAX TANGENTIAL
STABILITY	2 MICRONS IN OPERATION
RESOLUTION	95 L/MM AWAR (VEM ON 3414 FILM)
FIELD OF VIEW	38 BY 72 DEGREES

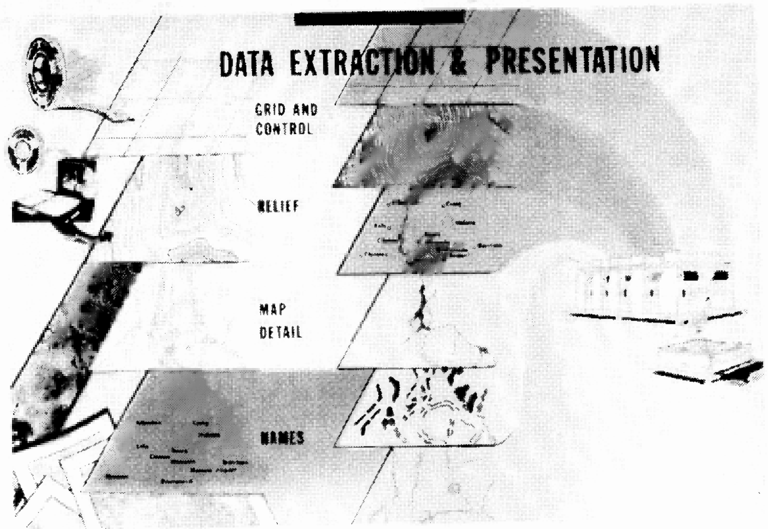
NRO APPROVED FOR
RELEASE 17 September 2011

MAPPING PROCESS



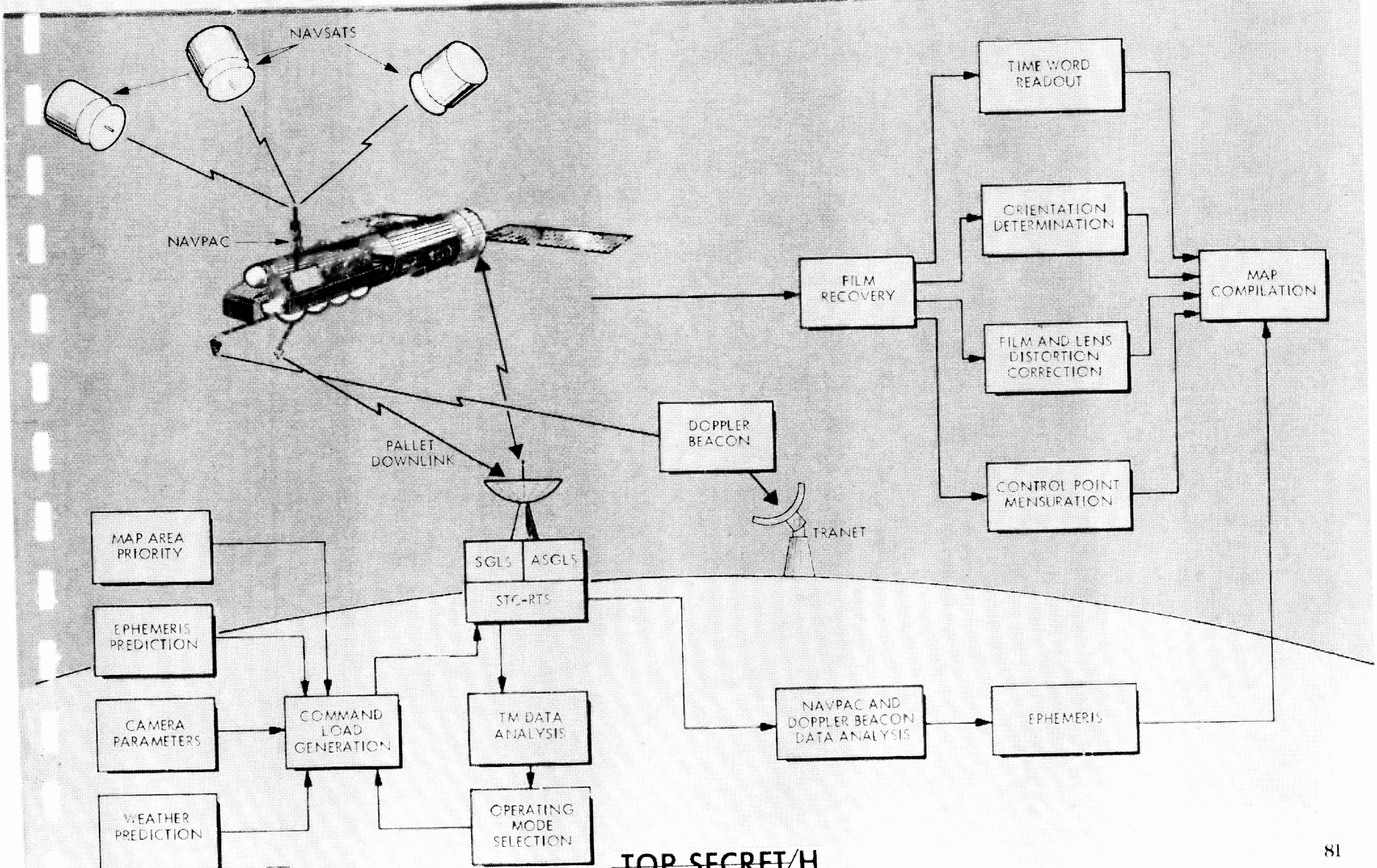
ACQUISITION

EXPLOITATION



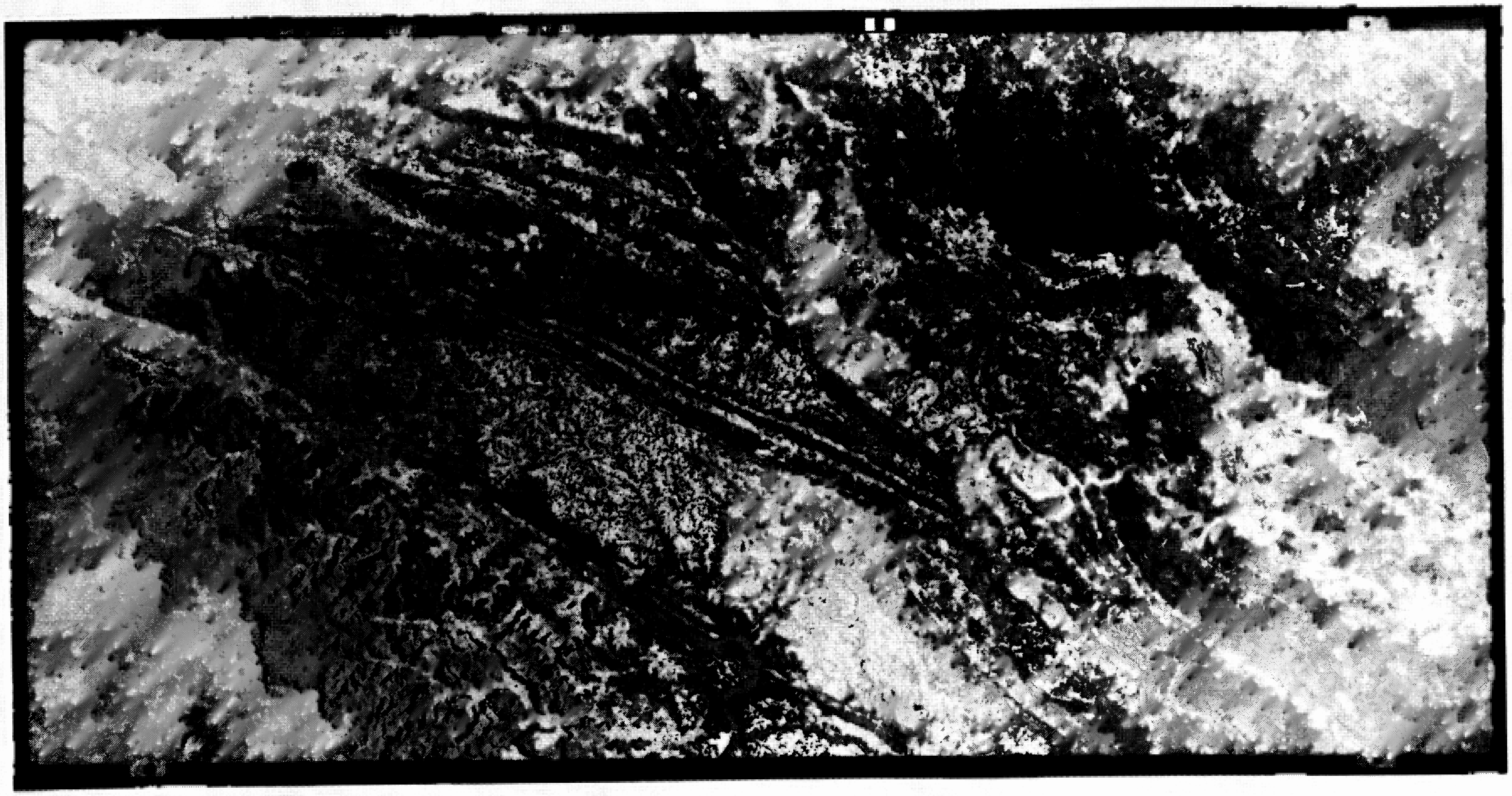
PUBLICATION

MAPPING CAMERA DATA FLOW

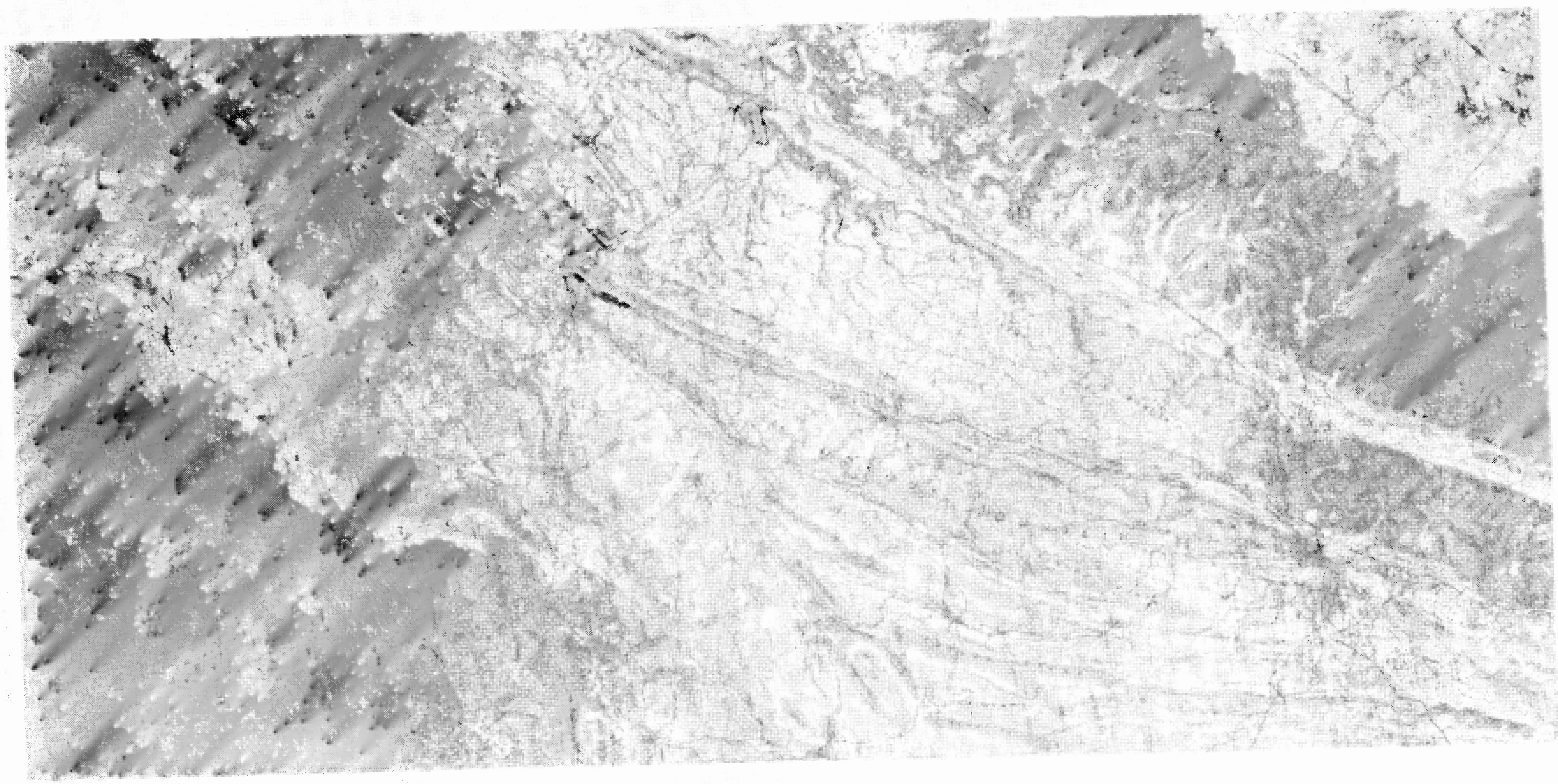


TERRAIN FRAME

50% REDUCTION OF FULL (9 × 18 INCH) TERRAIN FRAME



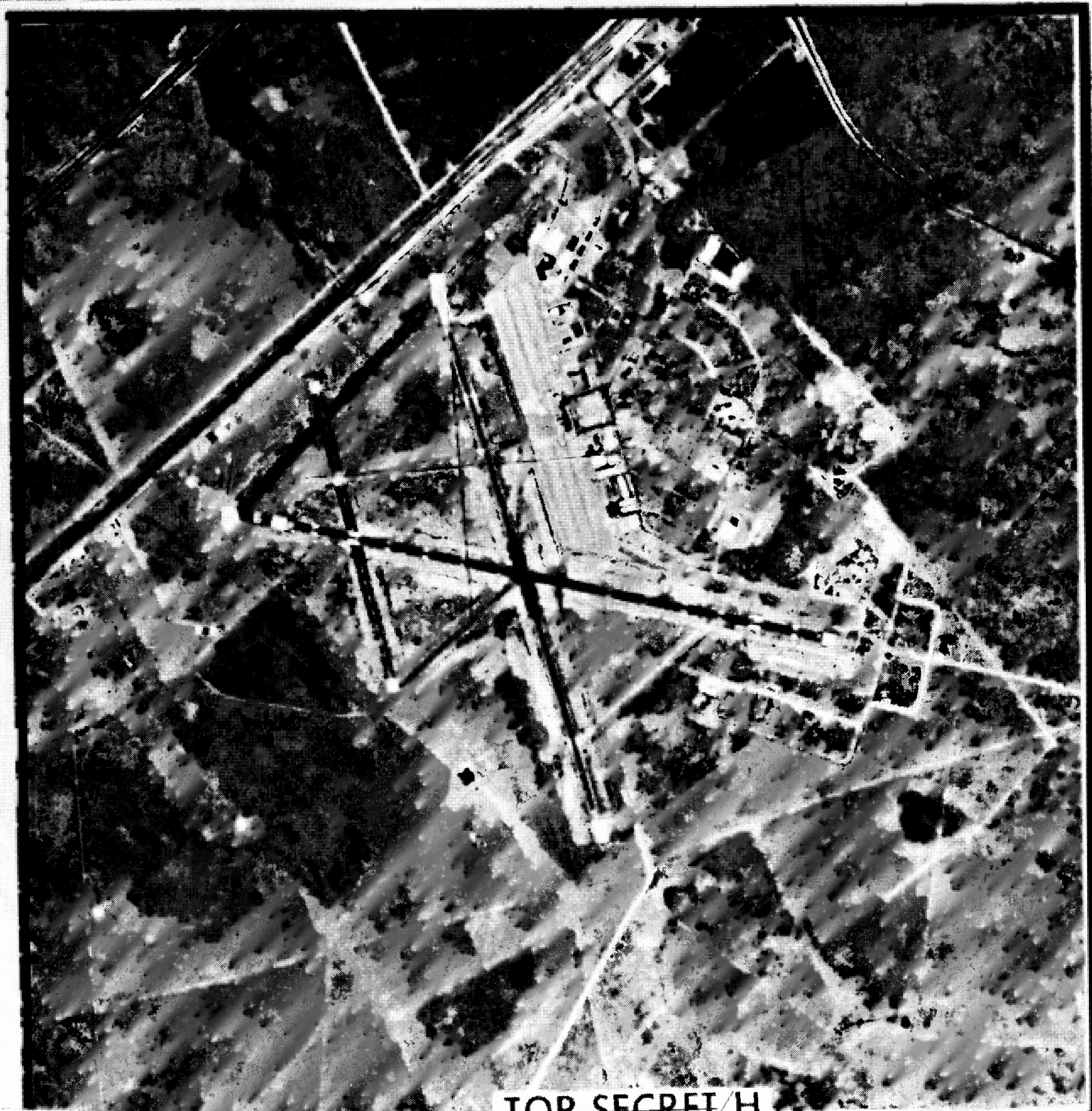
IDENTIFICATION OF FULL FRAME COVERAGE



ORIGINAL DESIGN PHOTO

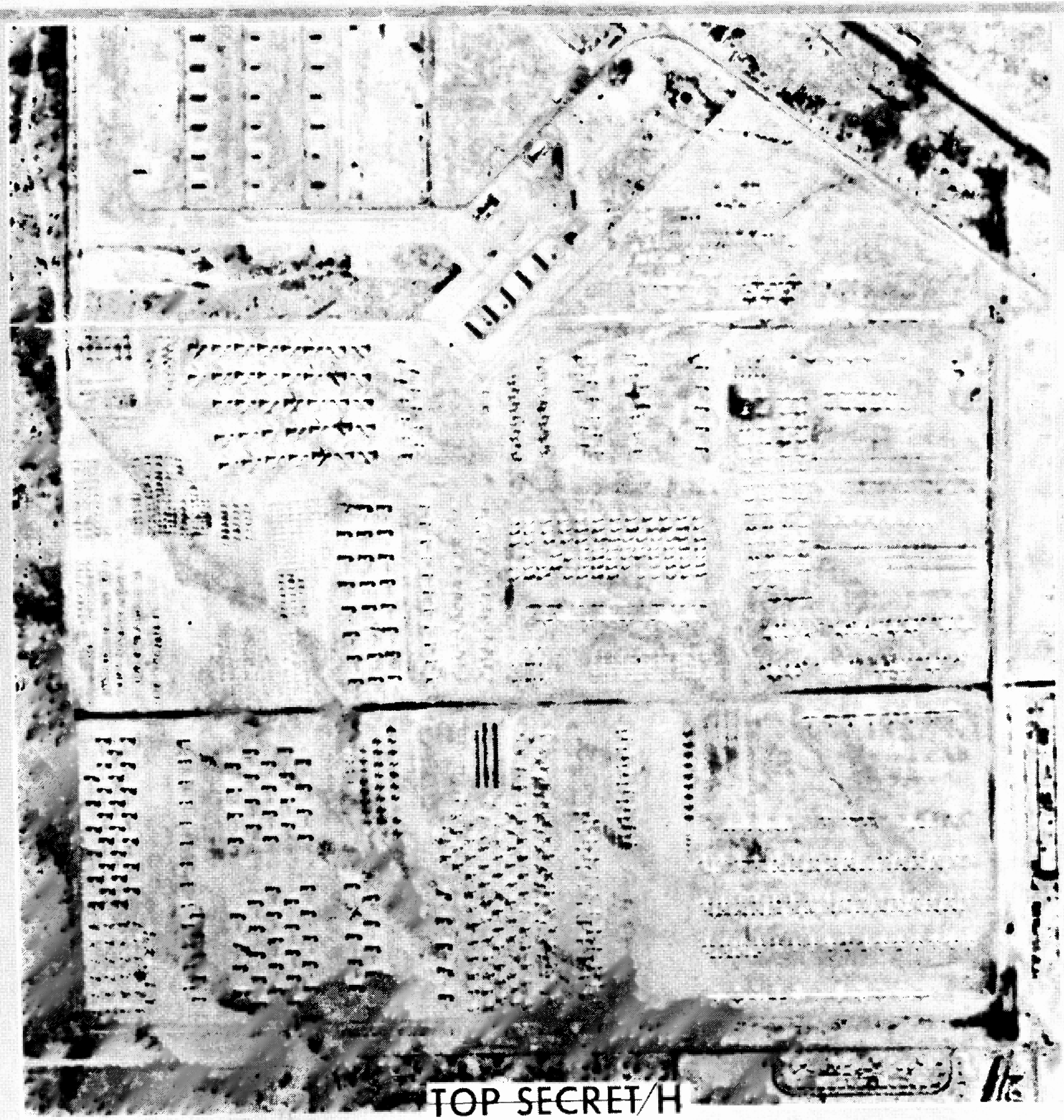
- WILLIAMS AFB
(20 X)
- EK 3400 FILM
(MISSIONS 1205 - 1208)

PRODUCT IMPROVEMENT



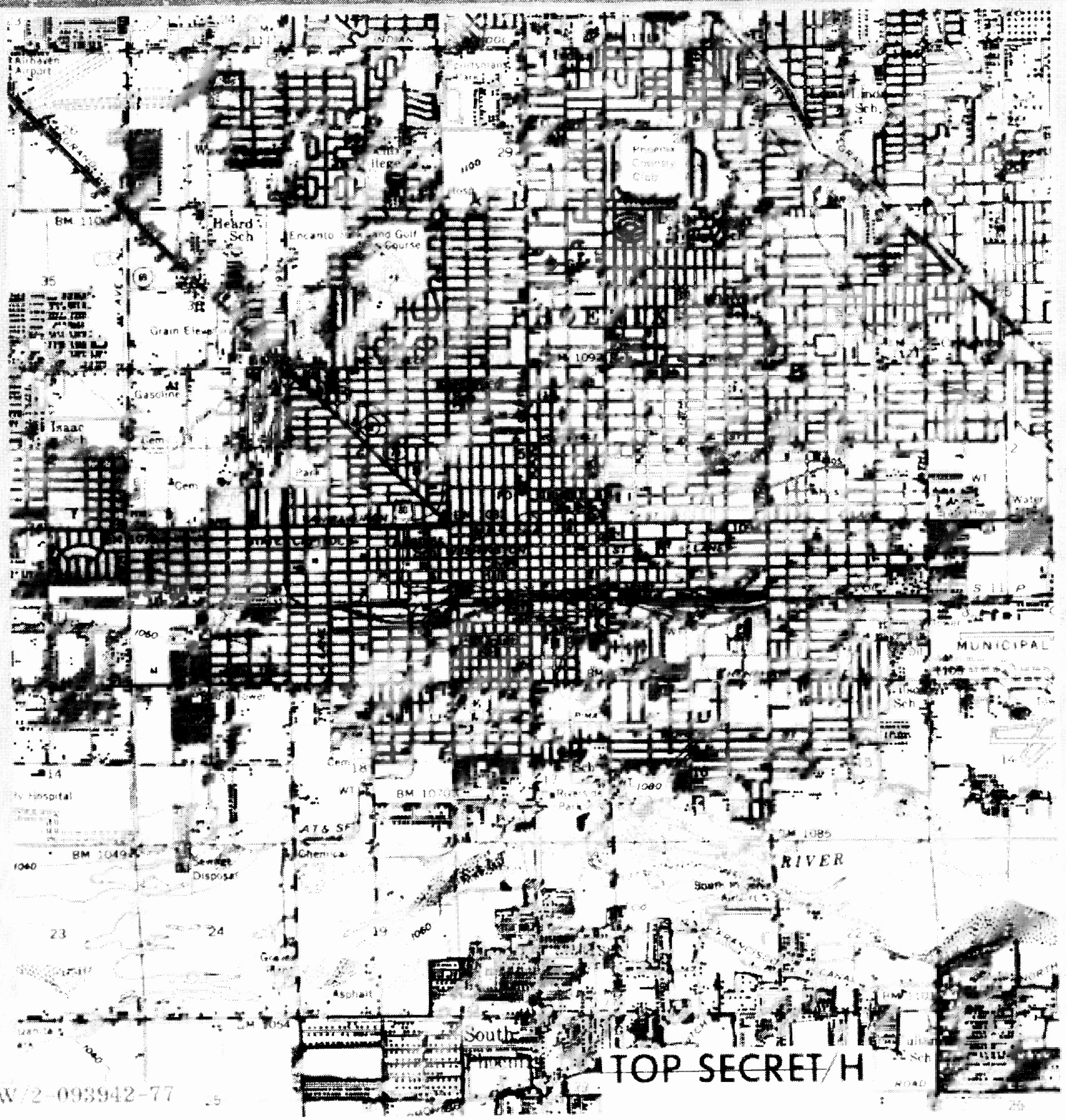
- MIDLAND TEXAS AIR TERMINAL (20 X)
- EK 3414 FILM (MISSIONS 1209 AND UP)

STORAGE SITE



- DAVIS MONTHAN AFB (40X)
- MISSION 1211 EK 3414 FILM

TERRAIN PHOTO OVERLAY 1211



- UNITED STATES GEOLOGICAL SURVEY 1:62,000 MAP PUBLISHED 1959
- TERRAIN PHOTO OVERLAY MISSION 1211 1976

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TERRAIN PHOTO OVERLAY 1211

- UNITED STATES GEOLOGICAL SURVEY 1:62,000 MAP PUBLISHED 1959
- TERRAIN PHOTO OVERLAY MISSION 1211 1976

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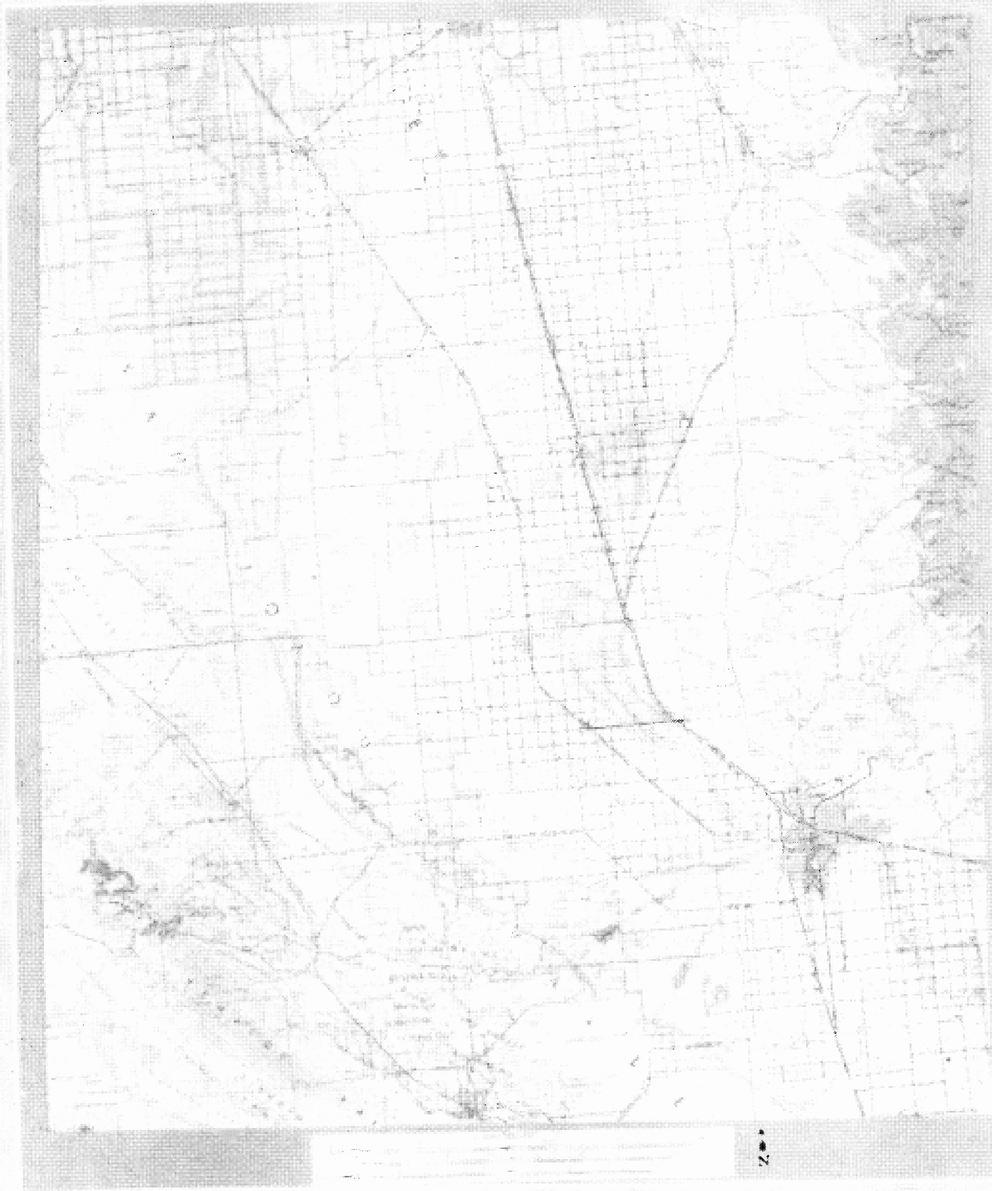
EXPERIMENTAL PHOTOGRAPHY

- SAN JOAQUIN VALLEY
- MISSION 1206
  CONTACT PRINT
  S0131 FILM
  (IR FALSE COLOR)

SAN JOAQUIN VALLEY

- US GS MAP OF
  SAN JOAQUIN VALLEY



AREA ACCESSED PER MISSION

ACTUAL TERRAIN COVERAGE

MISSION (NUMBER)	MISSION LENGTH (DAYS)	TOTAL AREA ACCESSED (THOUSAND SQ NM)	EQUIVALENT AREA ACCESSED (SQ NM)		
			CONUS (2.26 M)	S. AMERICA (5.20 M)	AFRICA (8.95 M)
1205	40	5894	2.6 X	1.1 X	0.6 X
1206	42	6282	2.8 X	1.2 X	0.7 X
1207	58	6671	3.0 X	1.3 X	0.7 X
1208	60	6487	2.9 X	1.3 X	0.7 X
1209	59	6773	3.0 X	1.3 X	0.8 X
1210	52	6668	3.0 X	1.3 X	0.7 X
1211	60	6919	3.1 X	1.3 X	0.8 X
1212	62	7363	3.3 X	1.4 X	0.8 X
1213	112	8099	3.6 X	1.6 X	0.9 X

GLOBAL COVERAGE 1212

METRIC PAN CAMERA SYSTEM-ATTITUDE DETERMINATION

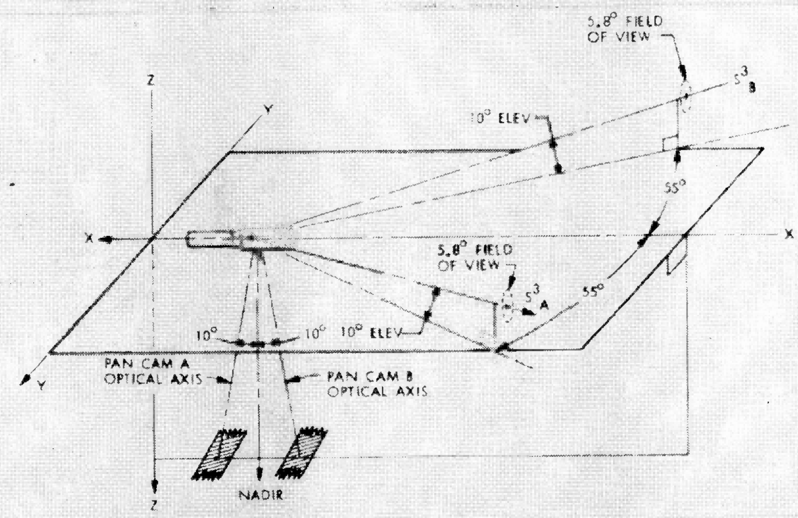
The metric pan camera attitude determination provides accurate coordinates of selected geographic points to be used as control points for compiling maps. It derives image space angles from measured space coordinates and requires auxiliary data to establish absolute coordinates and base distances; e.g., accurate ephemeris data and time of exposure, the angular orientation of the stellar relative to the pan terrain camera (interlock), the stellar angular orientation and camera angular motion history are the required data.

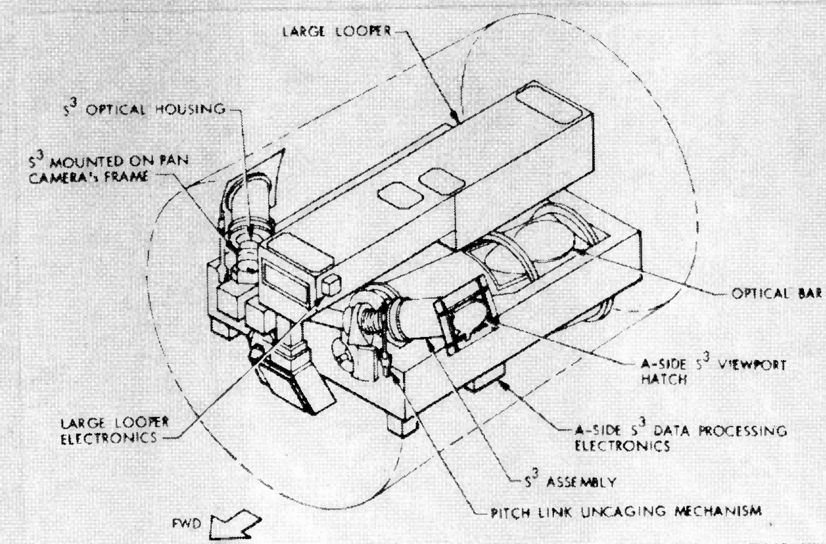
Stellar orientation data is acquired by a solid state electronic camera system accurate enough to determine pan camera line-of-sight pointing to within 5 arc seconds (1σ). Two stellar cameras will be mounted on the TCA frame, one on each side of the SV, with line-of-sight elevation of 10 degrees up from horizontal and 55 degrees aft in azimuth. Data of star image detections will be processed and stored in existing on-board recorder. This data will be read out to supporting tracking stations and will be processed off-line. Film markings will be provided correlating stellar camera star image detections and pan photography time.

SV rigid body motion history during photography is obtained from the current ARM rate gyros through the existing telemetry system. Vibration and thermal distortion motions are accounted for in on-ground data processing. Implementation is scheduled for SV-17 and up superseding the Mapping Camera System (MCS) previously described.

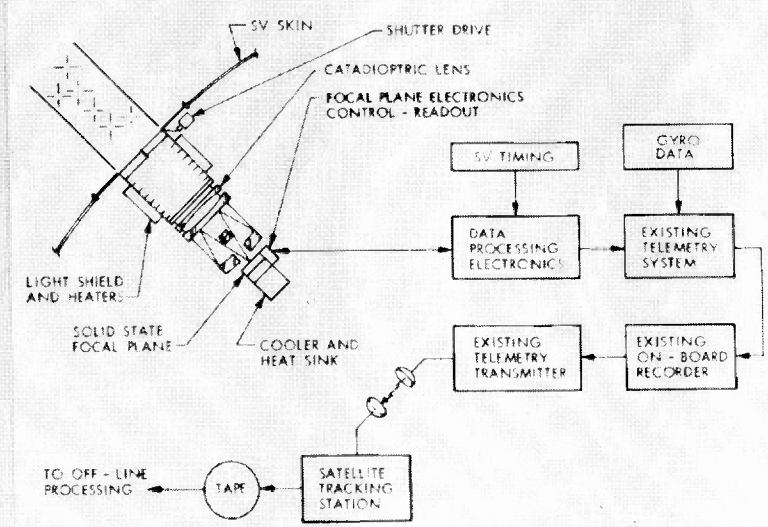
METRIC PAN CAMERA SYSTEM

ATTITUDE DETERMINATION





STELLAR SOLID STATE (S^3) CAMERA ASSEMBLY



STELLAR CAMERA DATA FLOW

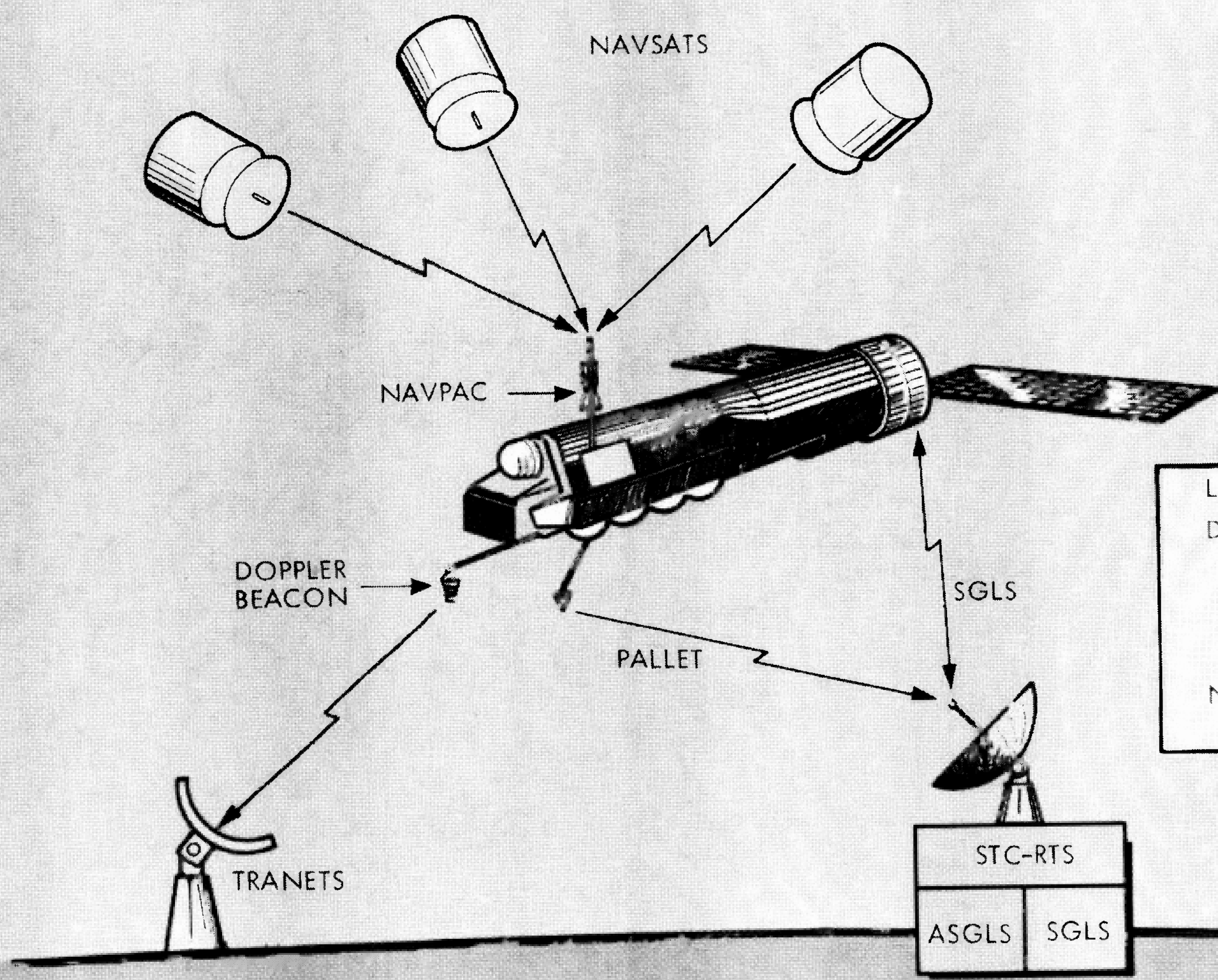
METRIC PAN CAMERA SYSTEM-LOCATION DETERMINATION

The primary tracking system for the reconstruction of an accurate ephemeris has been the Doppler Beacon System (DBS) using a worldwide network of geoceivers. This subsystem is a dual oscillator of ultra high stability which provides a method for the accurate tracking of the Satellite Vehicle by the supporting station network. The electronics and the antenna are currently mounted on the mapping camera system. The plan is to install the antenna on the forward bulkhead starting with SV-17, which will be configured without a mapping camera system.

The DBS will be redundant to the Navigational Package (NAVPAC), which will be the primary means by which a precision ephemeris can be reconstructed for mapping. NAVPAC consists of two sensing systems plus associated control and data processing hardware. The antenna/receiver system can acquire up to three Navy Navigation Satellites (NAVSATS) simultaneously and track the doppler and refraction frequencies. The miniature electrostatic accelerometer (MESA) provides data on all non-gravitational accelerations sensed. The delta processing unit collects, sorts, and time annotates all the data, recording NAVPAC times at which NAVSAT time marks are received, thus calibrating the NAVPAC clock. Timing accuracy is expected to be 1.2 microseconds.

NAVPAC is mounted on the -Y pallet with the antenna erected vertically above.

METRIC PAN CAMERA SYSTEM



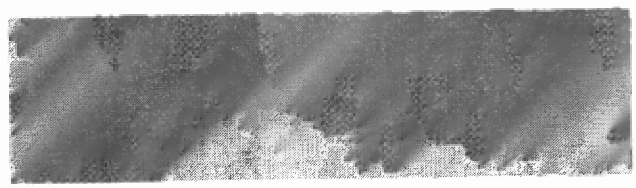
LOCATION DETERMINATION

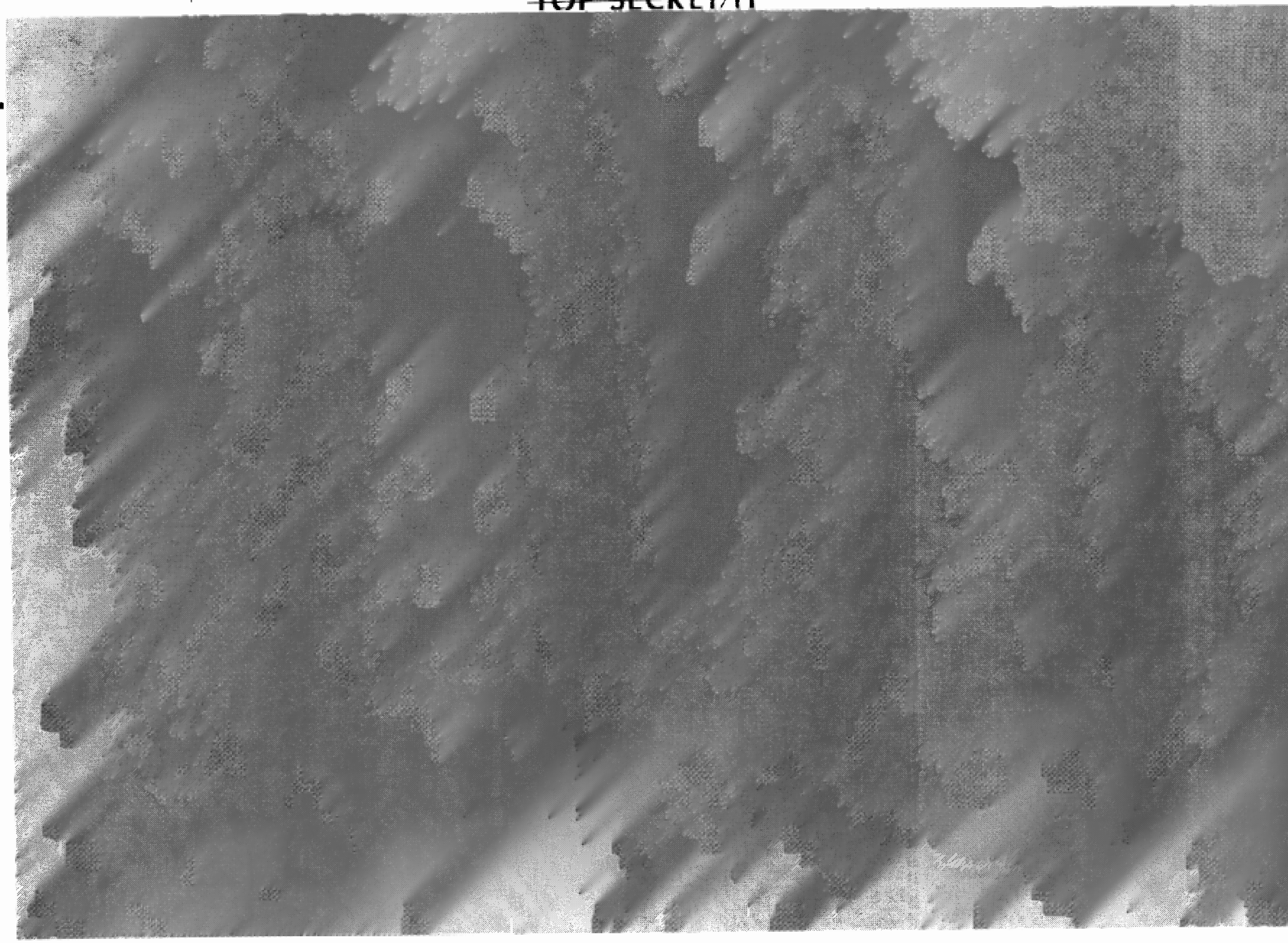
DBS ACCURACY

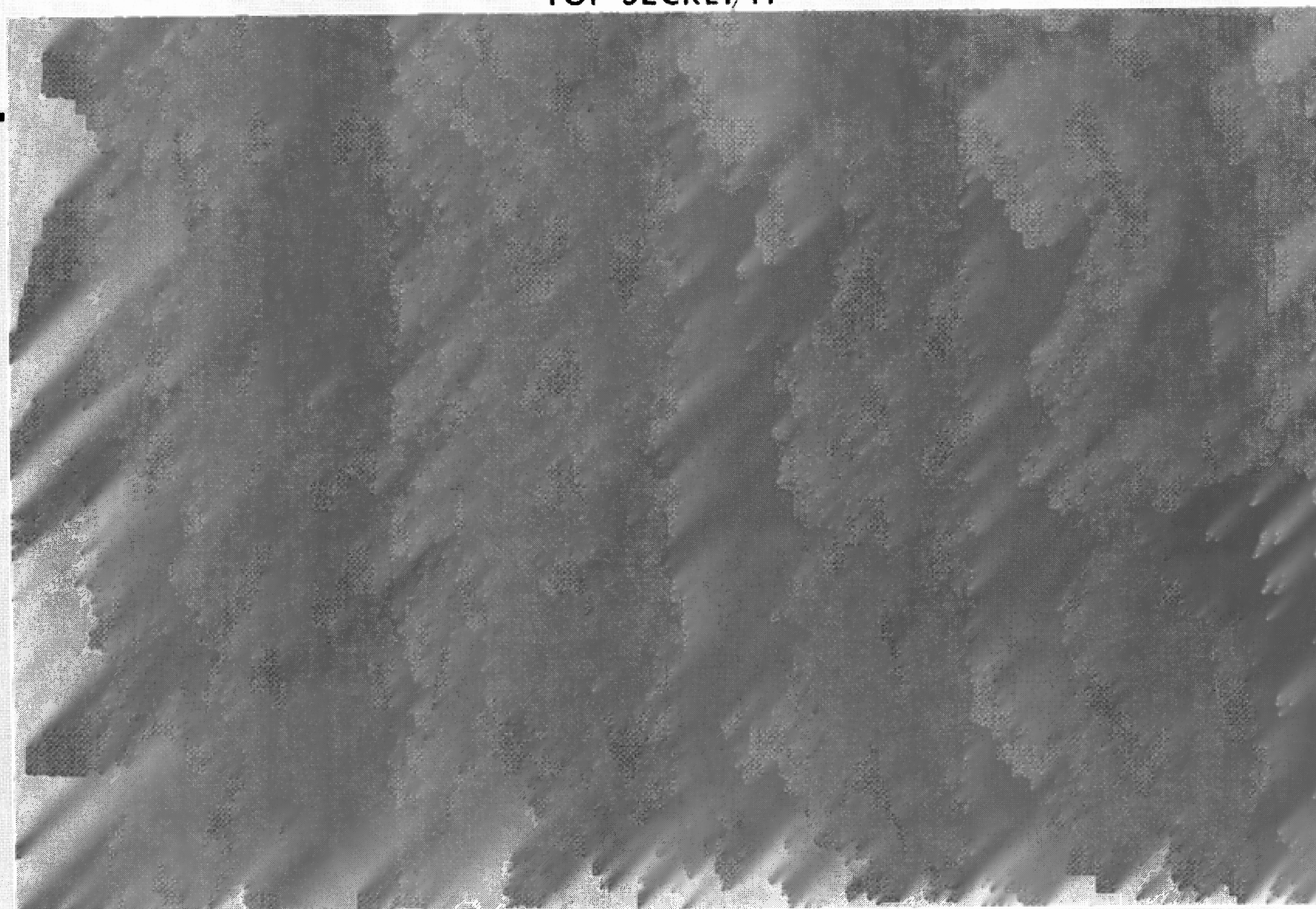
±200 FT IN-TRACK
±175 FT CROSS-TRACK
±100 FT RADIAL
ORBITAL VELOCITY ±0.12 FT/SEC

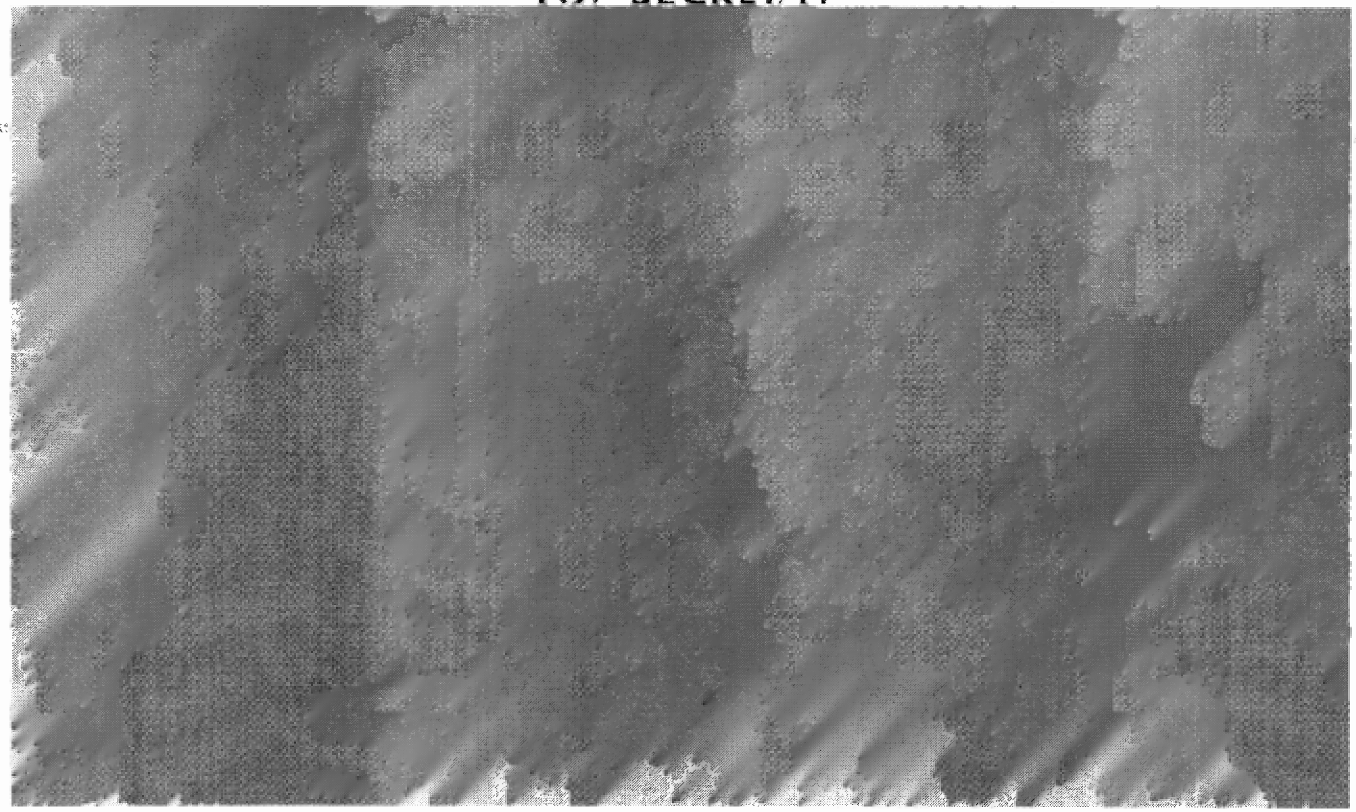
NAVPAC ACCURACY

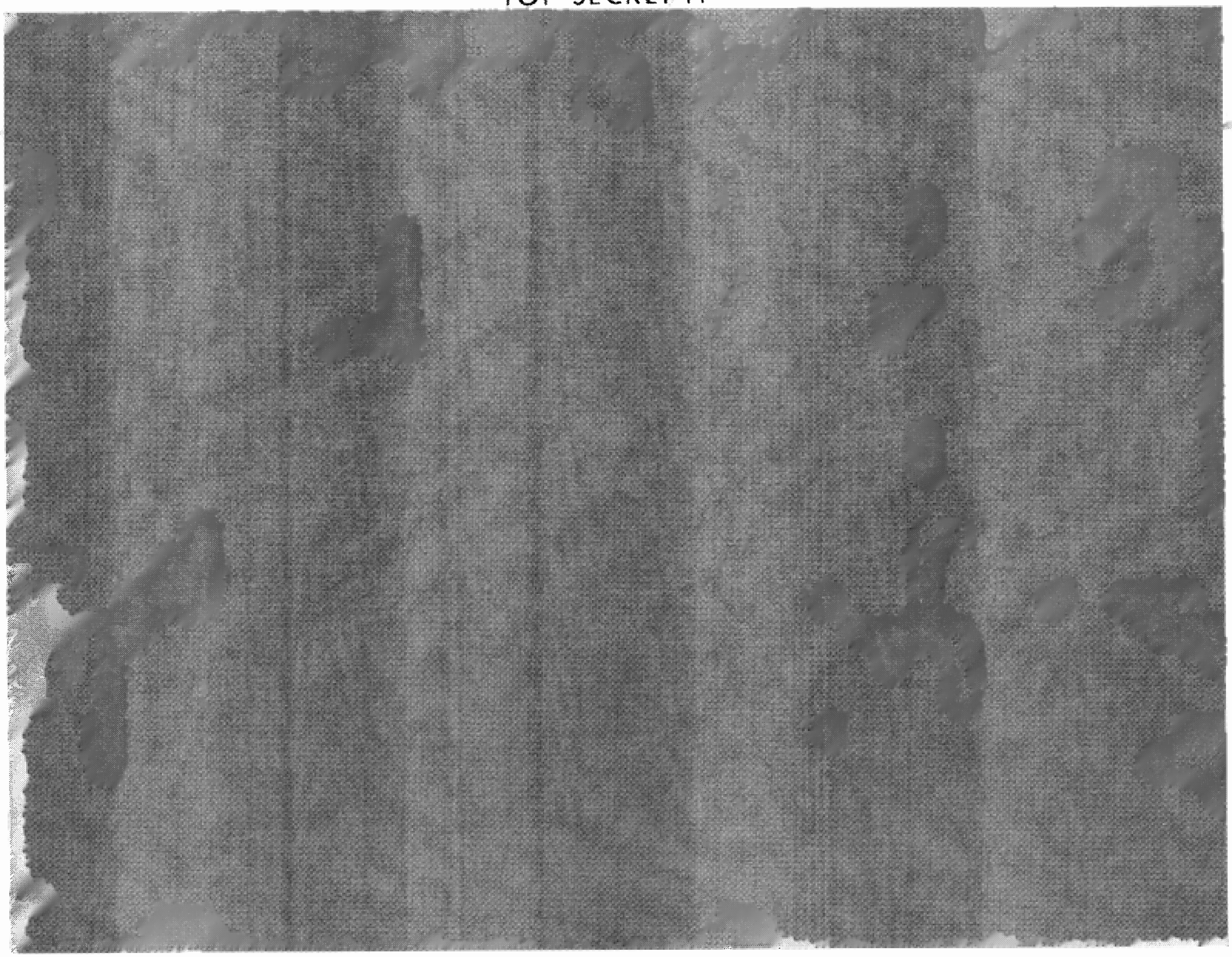
≤ 30 FT ALL 3 AXIS

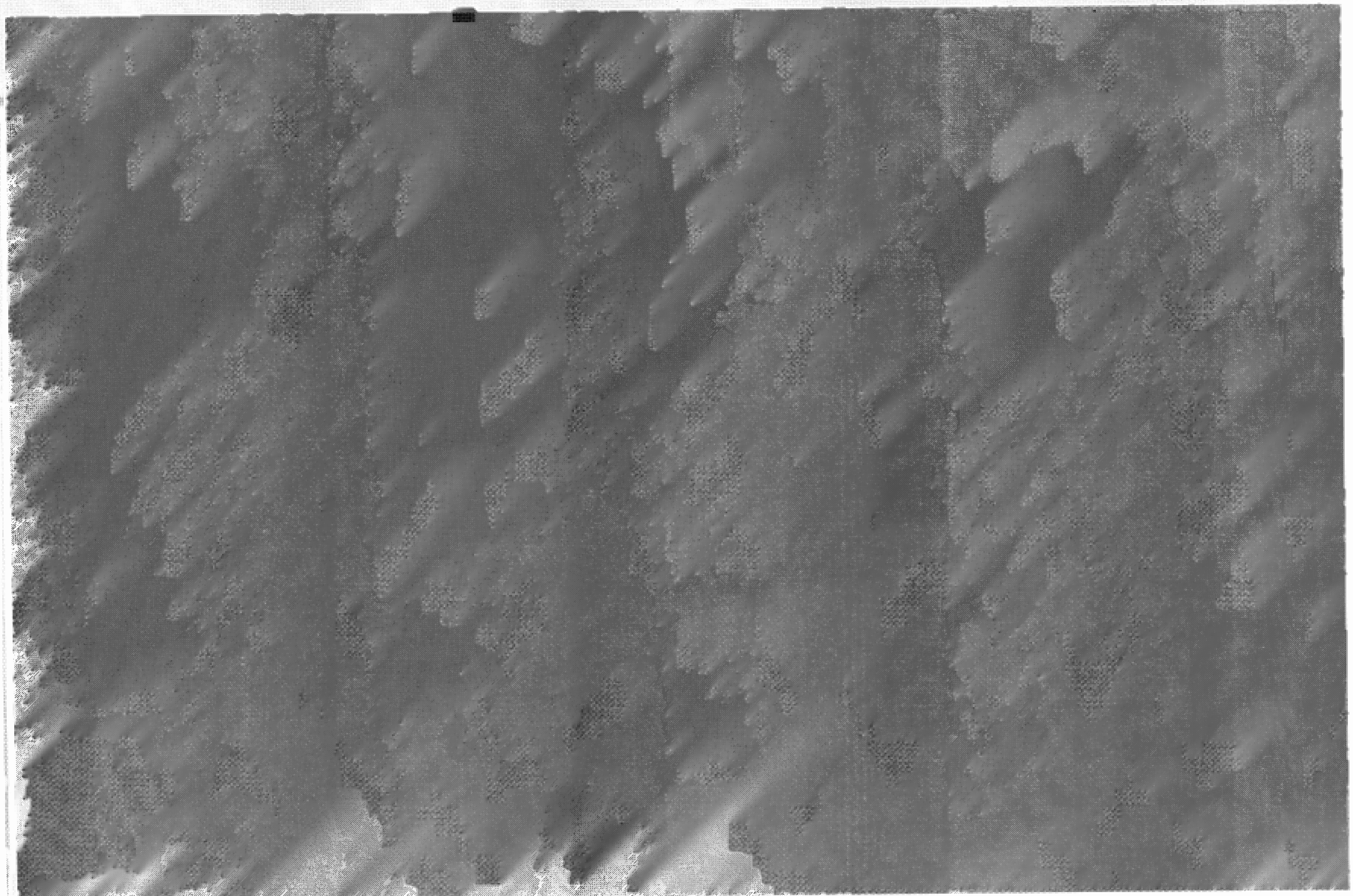












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SATELLITE BASIC ASSEMBLY

SHROUD CONFIGURATION

The shroud provides a protective enclosure for the payload on the launch pad and during ascent. It is a corrugated monocoque aluminum cylinder 52 ft long and 10 ft in diameter. Through air conditioning umbilicals and ducting the temperature and humidity are maintained at the desired values while on the launch pad.

Twenty-four removable doors provide access for servicing reentry vehicle igniters, sub-satellite trickle charge and arming, alignment checks of attitude reference to two-camera assembly reference axes, shroud thruster spring cocking, and shroud final pyro arming.

The shroud separates from the Satellite Vehicle after the pyrotechnic agent, Mild Detonating Fuse (MDF), breaks the magnesium longitudinal and beryllium circumferential breakstrips. Springs initiate the shell separation and then the acceleration from the booster Stage II cause the halves to fall away from the SV. No single failure in the pyrotechnic or electrical system will prevent shroud separation.

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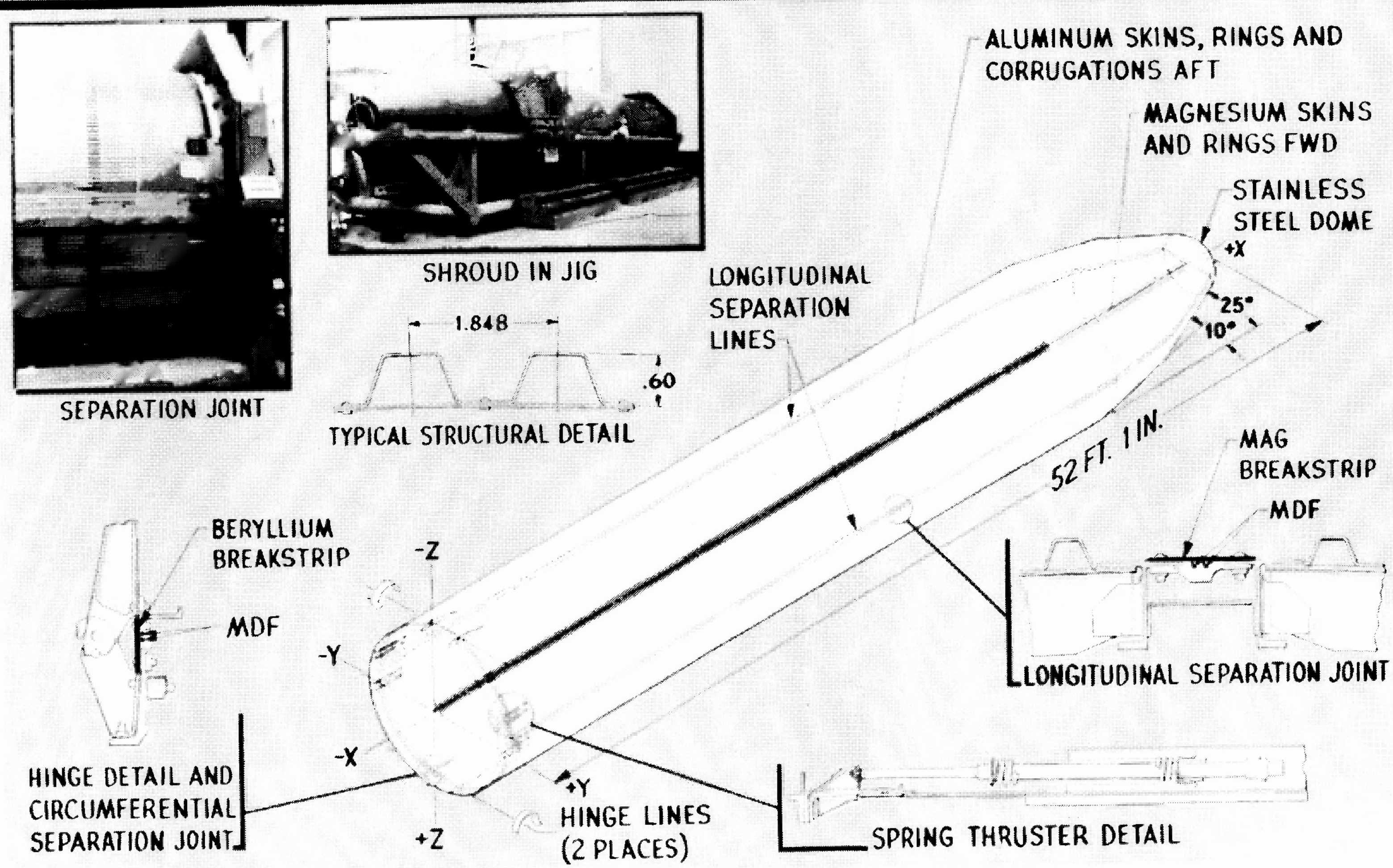
SHROUD CONFIGURATION



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THERMAL CONTROL

Temperature control is maintained primarily by passive design techniques, with augmentation by electric heaters as required for special control and thermal uncertainties. The two-camera assembly is passively maintained within 70 $\pm 23^{O}$F and the film supply within 70 $\pm 30^{O}$F by isolating them from the earth-facing environment and coupling to the upper-vehicle surfaces (cocoons). The temperature gradient requirement along the film path is 5^{O}F or less and cannot be met with a passive design; temperature sensors, heaters and control logic are required.

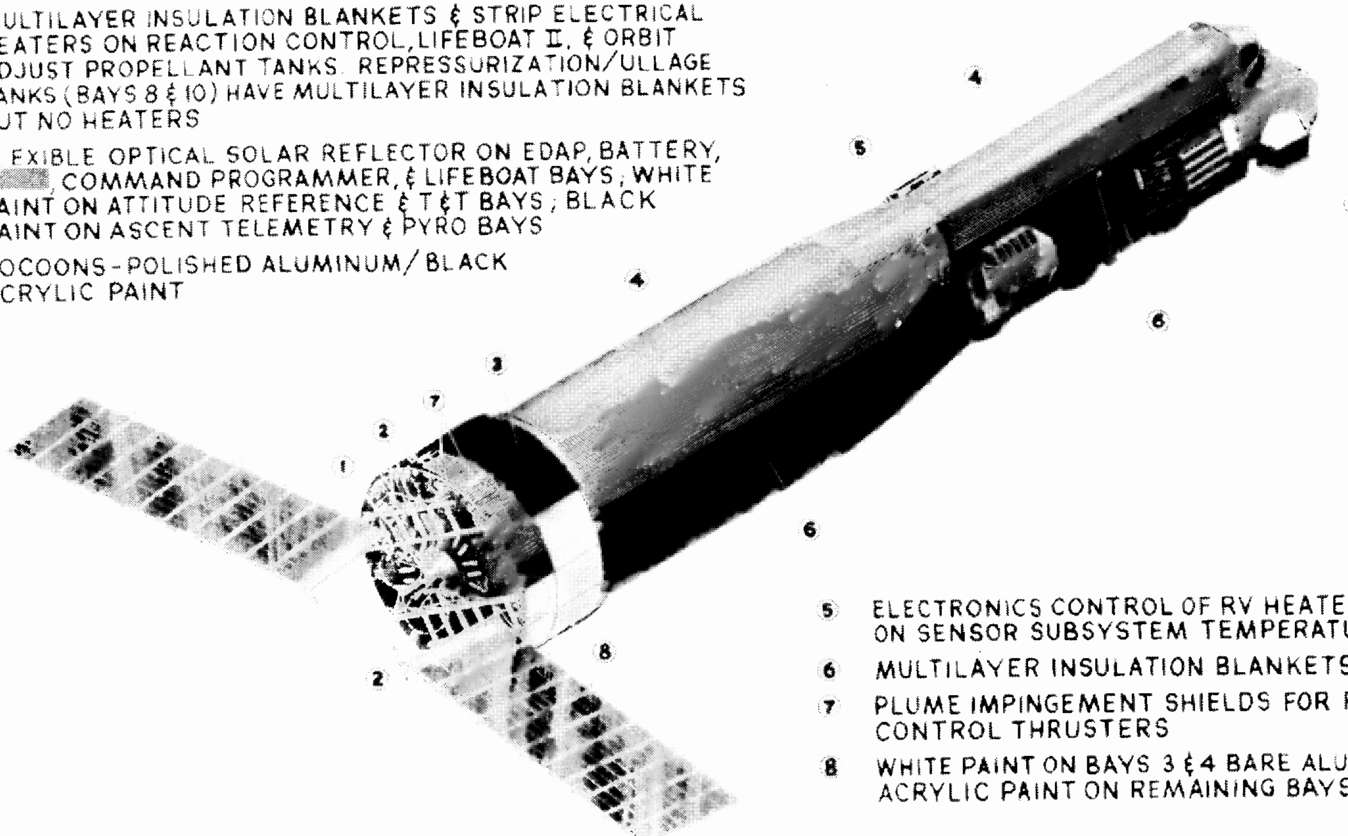
In the Aft Section, the conflicting requirements of keeping the electronic equipment temperature down and the propellant and thruster temperatures up cannot be met passively. Heaters are provided to keep the OAS propellant above 70^{O}F, to heat the OAS engine to 70^{O}F before starting, to keep the RCS engines above 100^{O}F, and to prevent hydrazine from freezing in the RCS tanks and OAS valves. However, these heaters are usually not required for nominal conditions.

Rechargeable (type-40) batteries are provided with heaters because the 30^{O}F to 70^{O}F temperature limits are tighter than the passive design uncertainties allow. The Lifeboat tanks can be heated to increase their impulse capacity.

The thermal design provides required temperature control over a beta angle range of -8 to +60 degrees for the complete range of vehicle activity level and resulting power dissipation with a single paint pattern. Larger negative beta angles are not permitted since the contamination of the thermal control surface by the booster causes the batteries to run at too high a temperature. When [redacted] metric pan camera stellar sensors are flown, the beta angle is limited to +30 degrees.

THERMAL CONTROL

1. ORBIT ADJUST VALVE SHIELD & HEATER
2. MULTILAYER INSULATION BLANKETS & STRIP ELECTRICAL HEATERS ON REACTION CONTROL, LIFEBOAT II, & ORBIT ADJUST PROPELLANT TANKS. REPRESSURIZATION/ULLAGE TANKS (BAYS 8 & 10) HAVE MULTILAYER INSULATION BLANKETS BUT NO HEATERS
3. FLEXIBLE OPTICAL SOLAR REFLECTOR ON EDAP, BATTERY, , COMMAND PROGRAMMER, & LIFEBOAT BAYS; WHITE PAINT ON ATTITUDE REFERENCE & T&T BAYS; BLACK PAINT ON ASCENT TELEMETRY & PYRO BAYS
4. COCOONS - POLISHED ALUMINUM/BLACK ACRYLIC PAINT



5. ELECTRONICS CONTROL OF RV HEATERS - BASED ON SENSOR SUBSYSTEM TEMPERATURE
6. MULTILAYER INSULATION BLANKETS
7. PLUME IMPINGEMENT SHIELDS FOR REACTION CONTROL THRUSTERS
8. WHITE PAINT ON BAYS 3 & 4 BARE ALUMINUM/BLACK ACRYLIC PAINT ON REMAINING BAYS

SATELLITE BASIC ASSEMBLY STRUCTURE

The SBA structure, shown in the cut-away drawing, is of semimonocoque construction. The booster adapter section has aluminum skin, rings, and stringers. This section contains the booster separation joint, which uses 2-1/2 grain/ft of mild detonating fuse to break a circumferential beryllium strip.

The OAM/RCM section has corrugation-reinforced aluminum skin with aluminum and magnesium internal structure. This section contains the propulsion elements and the solar array modules.

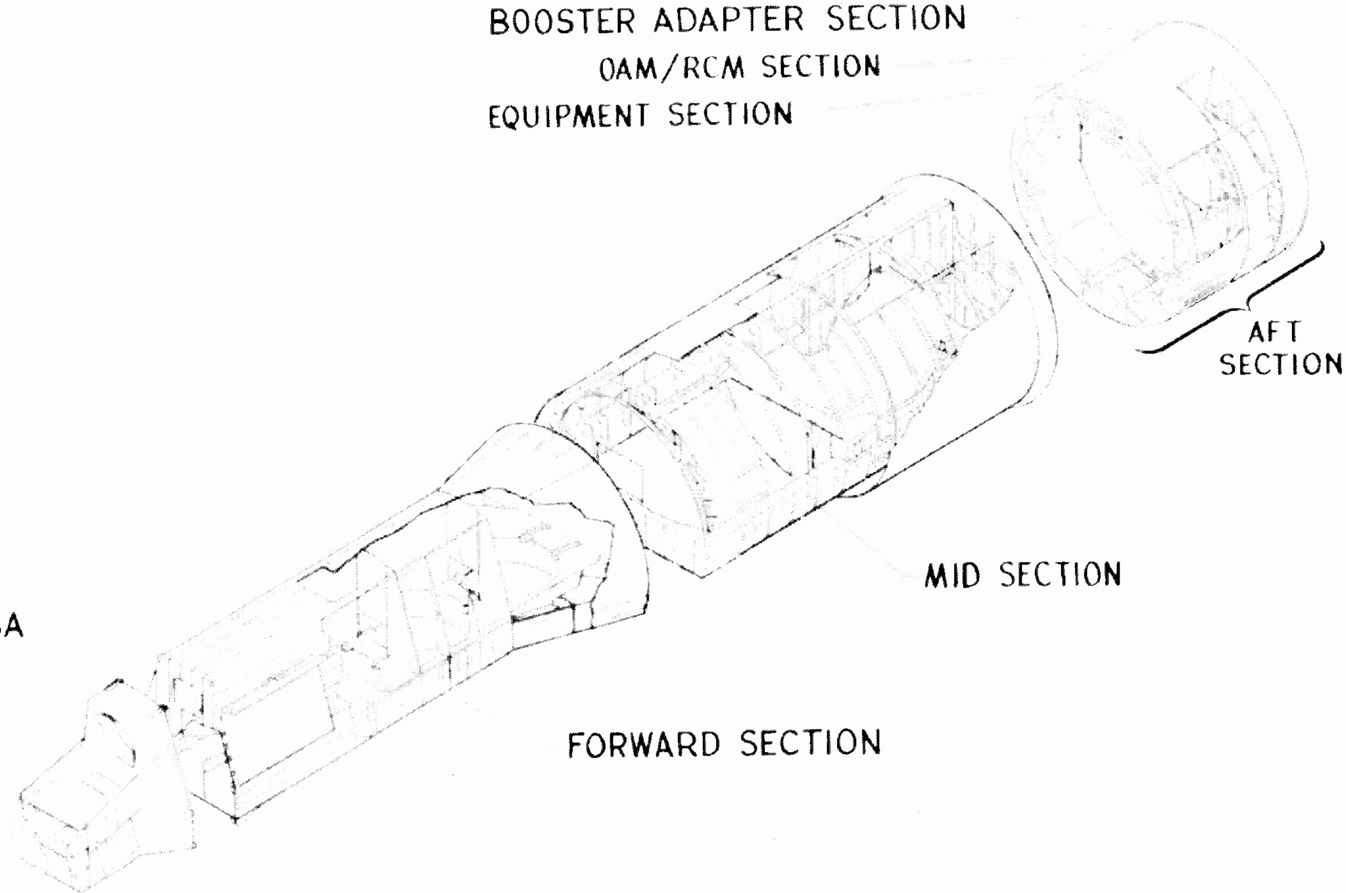
The equipment section has twelve removable corrugation reinforced aluminum skin panels bolted to an aluminum tubular internal structure which supports honeycomb equipment panels. Guidance, communication, command, and power components are mounted on these panels as subsystem modules.

The Mid-Section has a short titanium conical section and a cylindrical section of magnesium skin, with magnesium hat-section longitudinal stiffeners. Magnesium and titanium internal structure supports the primary payload.

The Forward Section has aluminum and magnesium skin with magnesium hat-section longitudinal stiffeners. The internal magnesium and aluminum structure with titanium fittings supports the four (4) reentry vehicles. The Mapping Camera System, [redacted] are supported on the external surfaces of the Forward Section.

The Mapping Camera System is supported in the Auxiliary Payload Structure Assembly (APSA).

SATELLITE BASIC ASSEMBLY STRUCTURE



SATELLITE BASIC ASSEMBLY-AFT SECTION

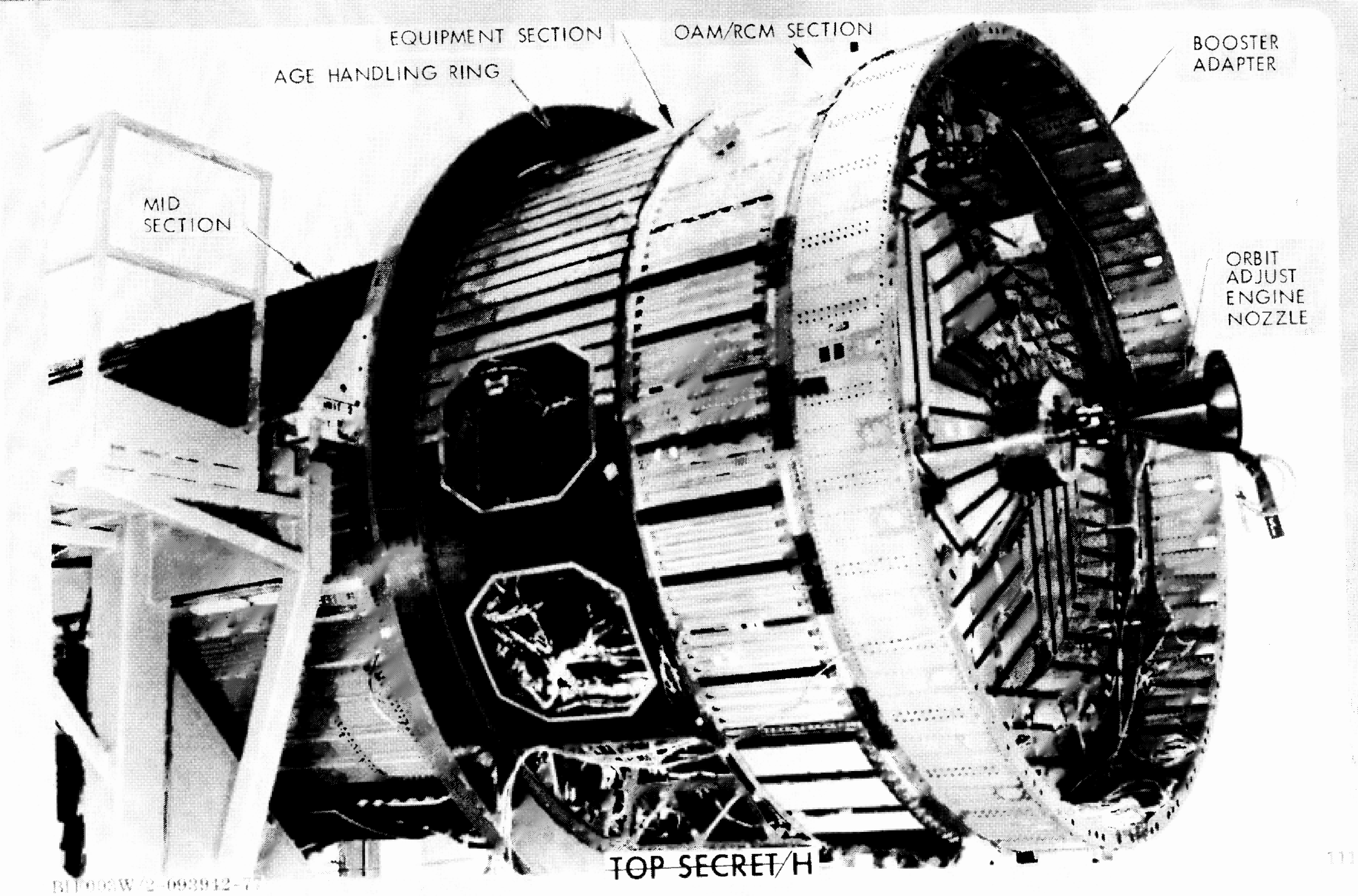
The Aft Section consists of an equipment module, a booster adapter section, and an Orbit Adjust Module/Reaction Control Module (OAM/RCM). It is 10 ft in diameter and 5 ft long. This section is a semimonocoque structure with a corrugated aluminum external skin. It weighs approximately 3500 pounds, including all equipment, less expendables. The Aft Section provides environmental protection and thermal control during ground, ascent, and orbital operations. The structure is capable of withstanding the dynamic and static conditions imposed during all phases of ground handling, launch, ascent, and orbit. The Aft Section interfaces with the booster, Mid Section, ground AGE, main electrical umbilical, pressurization and propellant loading lines, and the battery cooling lines.

The booster adapter section mates the Satellite Vehicle to the Titan IIID booster. The adapter is equipped with 70 square inches of vent area. The separation joint with a redundant pyrotechnic system is a part of this section.

The OAM/RCM section houses and supports the OAS/RCS hydrazine systems which provide orbit and attitude control, the independent lifeboat freon gas system which provides emergency attitude control, and the solar array modules which generate power. This section interfaces with ground pressurization and propellant loading lines. The solar array modules which mount on the aft bulkhead adjacent to the OA engine nozzle are not shown in the photograph.

The equipment section consists of 12 equally spaced, equally sized bays, each capable of supporting up to 500 pounds of equipment on individual trays. Two bays are presently unused and are available for growth items. Each equipment bay provides sufficient access to allow complete module installation and removal at the factory and pad as shown in the lower completely open bay. The other bays as shown have non-flight panels with ground access doors used in factory assembly and test. This section interfaces with the main electrical umbilical and the Mid Section.

SATELLITE BASIC ASSEMBLY-AFT SECTION



ATTITUDE CONTROL

The Attitude Control System (ACS) provides earth-oriented attitude reference and rate sensing. It develops RCS thruster firing signals to bring the vehicle to a commanded attitude and to maintain attitude and rate within the accuracies shown below. The ACS also provides measurements of vehicle attitude and rate during search/surveillance operation to the accuracy shown.

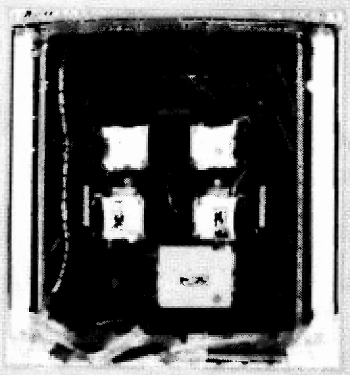
The ACS is a three-axis rate gyro-integrator system with updating in pitch and roll by horizon sensor and in yaw by gyro-compassing. Error signals generated by the gyros and horizon sensor are combined in the flight control electronics, and modulated by pseudo-rate circuits in each axis to provide thruster firing commands with the impulse bit control necessary to meet the tight rate control and short settling-time requirements.

All elements are redundant for malfunction correction. Cross-strapping between redundant and primary ACS components (horizon sensors, gyros, flight control electronics assembly) is possible to permit selection of non-failed components to drive the RCS thruster.

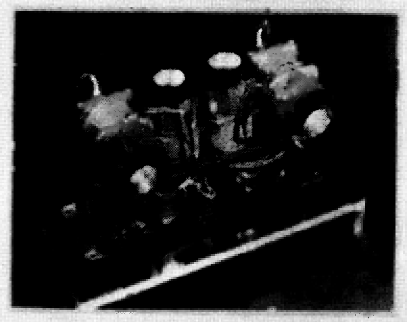
	Control Requirements			Measurement Requirements		
	Pitch	Roll	Yaw	Pitch	Roll	Yaw
For search/surveillance operations						
Attitude accuracy (deg)	0.7	0.7	0.64	0.4	0.4	0.5
Rate accuracy (deg/sec)	0.014	0.021	0.014	0.001	0.001	0.001
During non-horizontal operations						
Attitude accuracy (deg)	3	1	1			
Rate accuracy (deg/sec)	0.15	0.15	0.15			

Setting time from search/surveillance disturbances: Stereo 0.2 seconds, Mono 6 seconds

ATTITUDE CONTROL



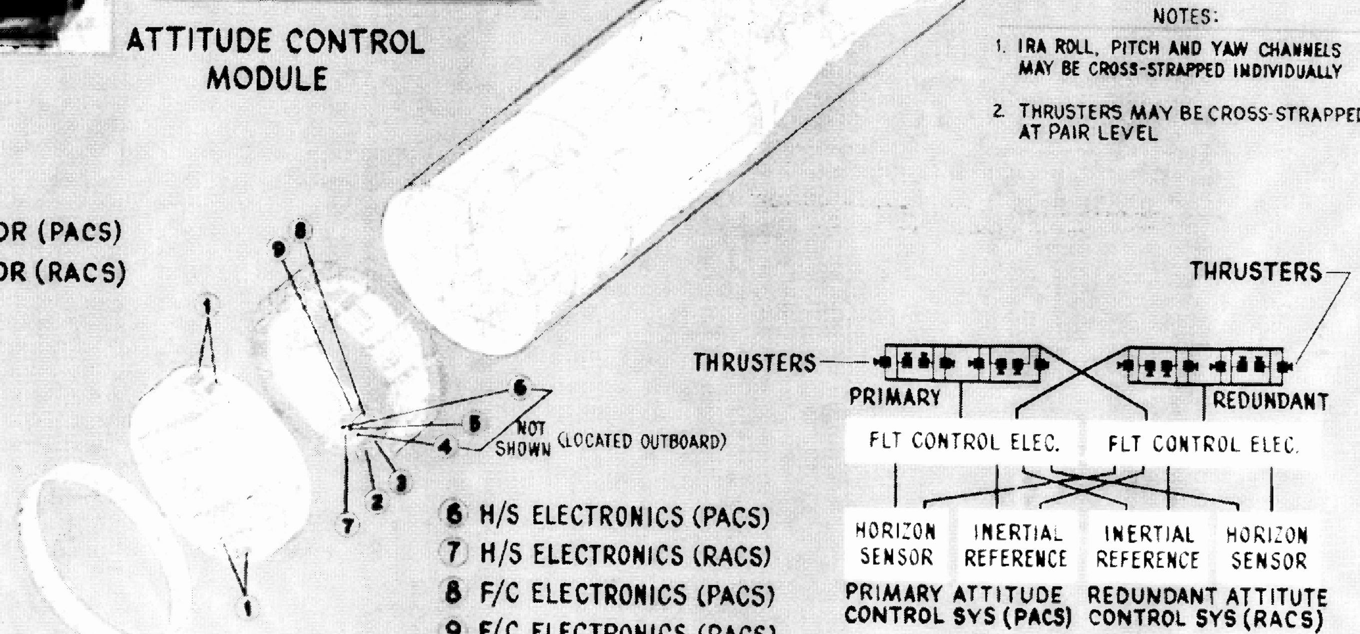
ATTITUDE CONTROL MODULE



THRUSTERS

1 THRUSTERS
2 HORIZON SENSOR (PACS)
3 HORIZON SENSOR (RACS)
4 IRA (PACS)
5 IRA (RACS)

NOTES:
1. IRA ROLL, PITCH AND YAW CHANNELS MAY BE CROSS-STRAPPED INDIVIDUALLY
2. THRUSTERS MAY BE CROSS-STRAPPED AT PAIR LEVEL



6 H/S ELECTRONICS (PACS)
7 H/S ELECTRONICS (RACS)
8 F/C ELECTRONICS (PACS)
9 F/C ELECTRONICS (RACS)

ORBIT ADJUST AND REACTION CONTROL

An Orbit Adjust System (OAS) and Reaction Control System (RCS) provide the forces necessary to control the vehicle orbit and the vehicle attitude in orbit, respectively. The OAS provides injection error correction (if required), drag and perigee rotation makeup, and deorbit of the Satellite Vehicle at the end of the mission. The RCS provides pitch, yaw, and roll control via 8 thrusters.

OAS and RCS both use catalytic decomposition of monopropellant hydrazine to generate thrust. For reliability, the systems are pressure-fed, with the pressurizing gas enclosed in the propellant tank with the hydrazine. This results in declining or blowdown pressure characteristics: the thrust level of the OAS engine declines from 250 to 100 pounds and that of the RCS engines from 6 to 2 pounds. A quad-redundant valve operated by the command system controls flow to the OAS engine. The ACS generates signals that control the firing of the RCS engines.

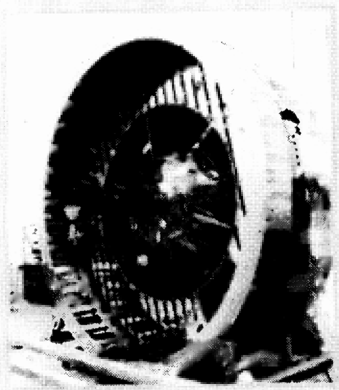
On SV-15 the 62-inch diameter OAS tank can be loaded with up to 4000 pounds of propellant with two spheres containing high pressure nitrogen (isolated by pyro valves and admitted into the OA tank at times selected during the mission) to maintain the pressure within the desired operating range. This propellant can be utilized in OA burns to provide velocity increments of 2 ft/sec to 400 ft/sec. A passive (surface tension) propellant management device maintains propellant at the tank outlet at all times, permitting engine firings in any attitude.

On Vehicles SV-13 and SV-14 the two nitrogen tanks are manifolded directly with the OA tank and provide enough ullage space to permit 3700 pounds of propellant to be loaded within the operating pressure range.

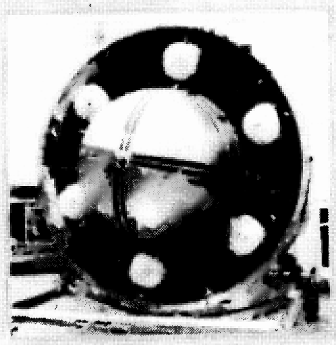
The four 22-in. diameter RCS tanks provided capacity for 450 to 540 pounds of propellant. Propellant orientation is maintained by diaphragms. The thruster impulse bit (0.15 lb-sec or less, depending on blowdown status) is compatible with the tight rate-control requirements. A complete redundant set of thrusters is provided for malfunction protection; either set can be supplied by the four tanks and each pair of thrusters can be driven by the primary or redundant ACS valve drivers.

A transfer line is provided between the OAS and RCS tanks to permit propellant exchange to optimize the use of on-board propellant for each mission.

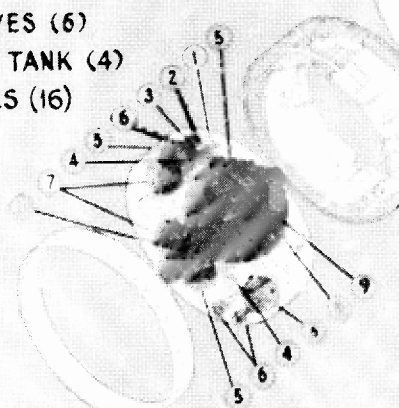
ORBIT ADJUST & REACTION CONTROL



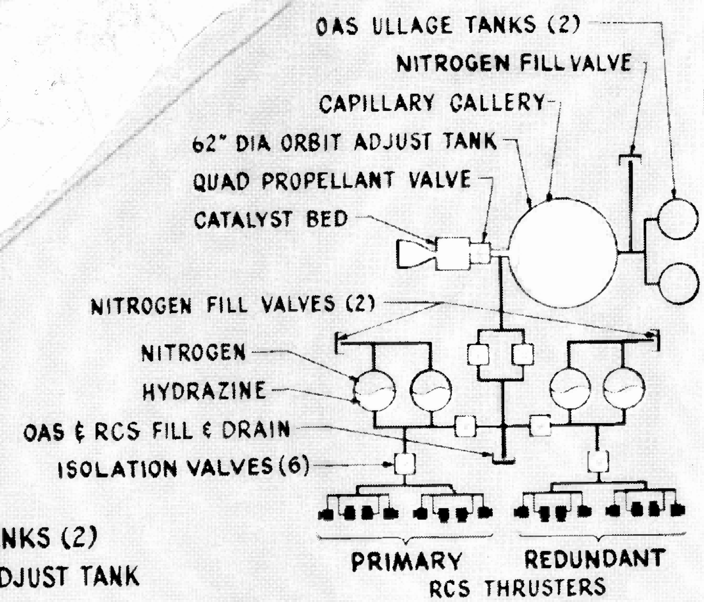
VIEW LOOKING FORWARD



VIEW LOOKING AFT



1 OAS FILL VALVE
2 RCS GAS FILL VALVES (2)
3 RCS PROPELLANT FILL VALVE
4 ISOLATION VALVES (6)
5 RCS GAS/PROP TANK (4)
6 RCS THRUSTERS (16)
7 OAS ULLAGE TANKS (2)
8 62" DIA. ORBIT ADJUST TANK
9 OA/RCM J-BOX
10 ORBIT ADJUST ENGINE



ELECTRICAL DISTRIBUTION AND POWER

Power to operate the Satellite Vehicle is provided by solar arrays deployed from the Aft Section following separation from the booster. Rechargeable NiCd batteries (type-40) provide energy storage to meet dark-side-earth and peak power requirements. Unregulated power is distributed throughout the vehicle to using equipment within a 24 to 33 vdc range.

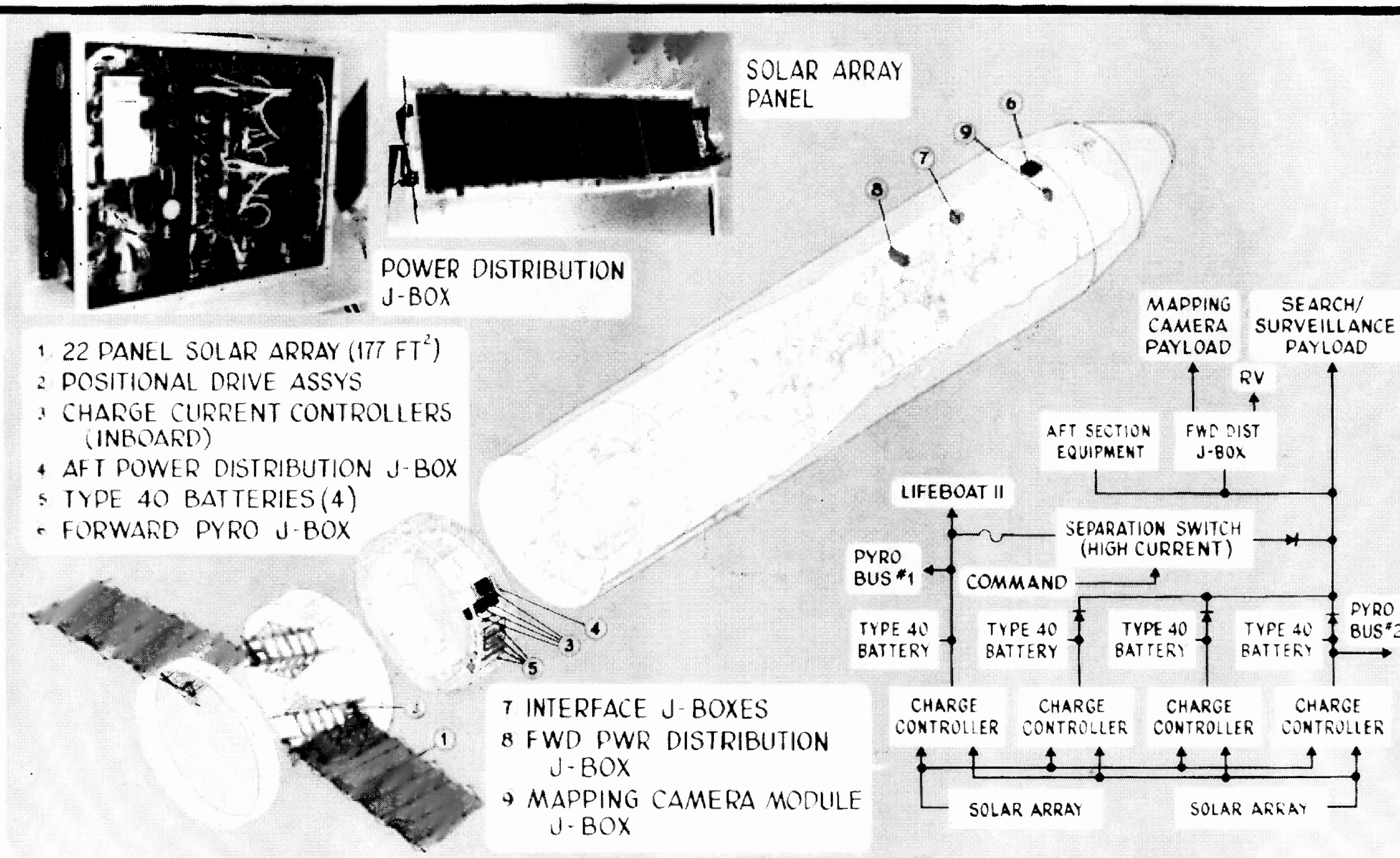
The power generation and storage system comprises four parallel segments, with an array section, charge controller, and battery in each to reduce the effect of a failure; a single malfunction will not terminate the mission. Fusing of equipment, limiting minimum wire size, and isolating voltage-critical circuits add to the reliability.

The power system is capable of providing approximately 11,000 watt-hours/day of usable power over a beta angle range of -8 to +60 deg by adjusting the array angle about the vehicle roll axis. This will support at least 52 minutes per day of search/surveillance and mapping camera system operation.

Power for the lifeboat system is provided by one type-40 battery from the main power system. Equipment necessary for recovery vehicle and Satellite Vehicle deorbit can be switched to this battery for emergency operations. Depletion of the batteries below 55 percent or an excessive load on the main power system will automatically isolate the lifeboat system and its battery. This assures adequate power for the emergency operations. The lifeboat system can be re-connected to the main system by command if the anomaly can be corrected.

Pyro power is provided by either of two type-40 batteries from the main power system and distributed by redundant circuits.

ELECTRICAL DISTRIBUTION & POWER

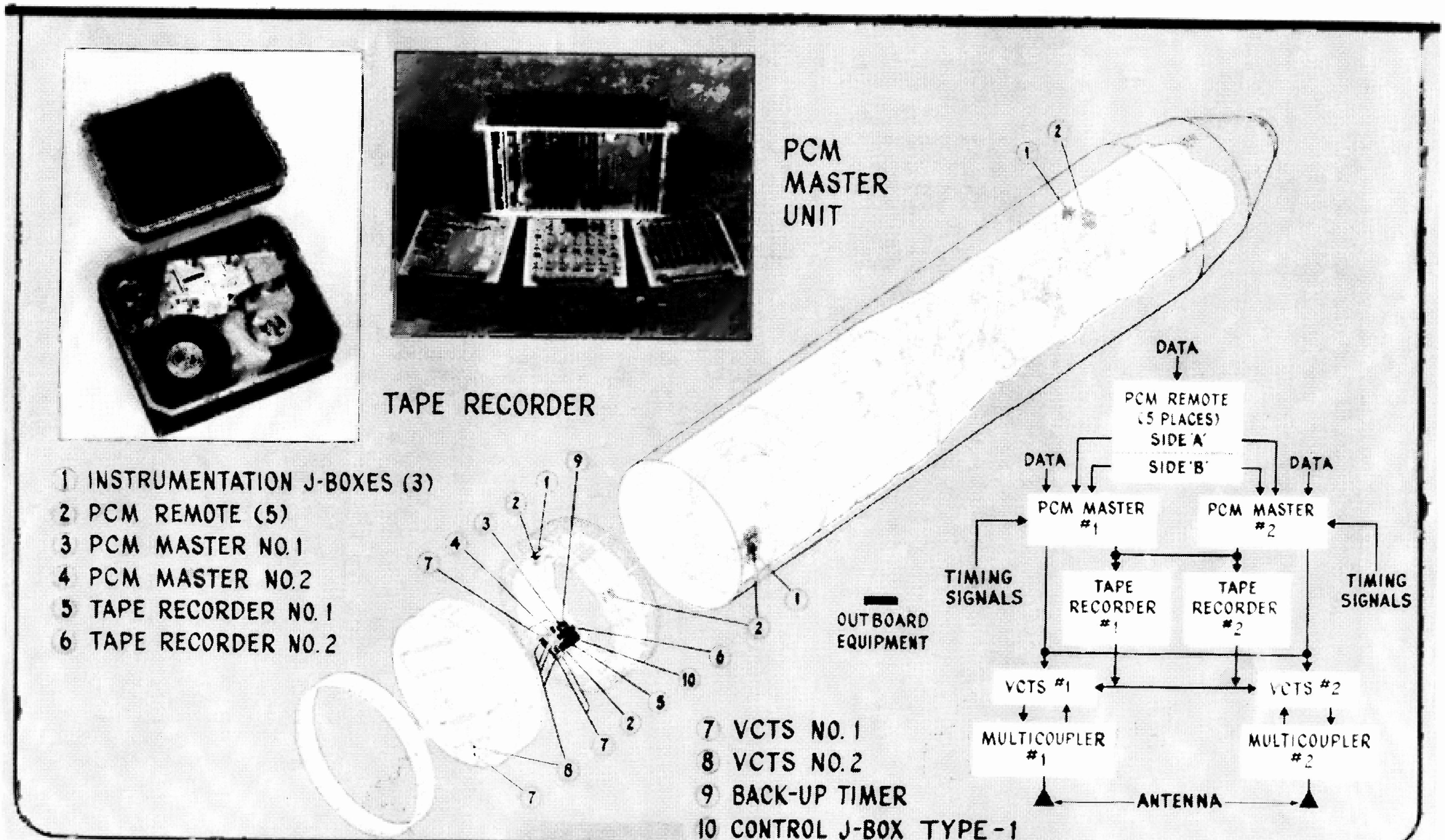


TELEMETRY AND TRACKING

The SGLS-compatible telemetry subsystem provides PCM real-time data (ascent at 48 kbps, engineering analysis at 128 kbps, and orbit at 64 kbps), and PCM tape recorded data (48 kbps played back at 256 kbps). The PCM telemeter provides status data for normal mission operation, test operations and evaluation, command acceptance confirmation, and postflight evaluation. Each tape recorder storage allows the monitoring of the SV temperature profile by periodic sampling. Over 1500 data sources are monitored – some at up to 500 samples per second.

The SGLS-compatible tracking subsystem provides range measurement information, including slant range (50 ft maximum 1σ bias error and 60 ft rms maximum noise error), range rate (0.2 ft/sec maximum 1σ error), and angle-of-arrival (1.0 milliradian maximum 1σ bias error and 1.0 milliradian rms maximum noise error).

TELEMETRY & TRACKING



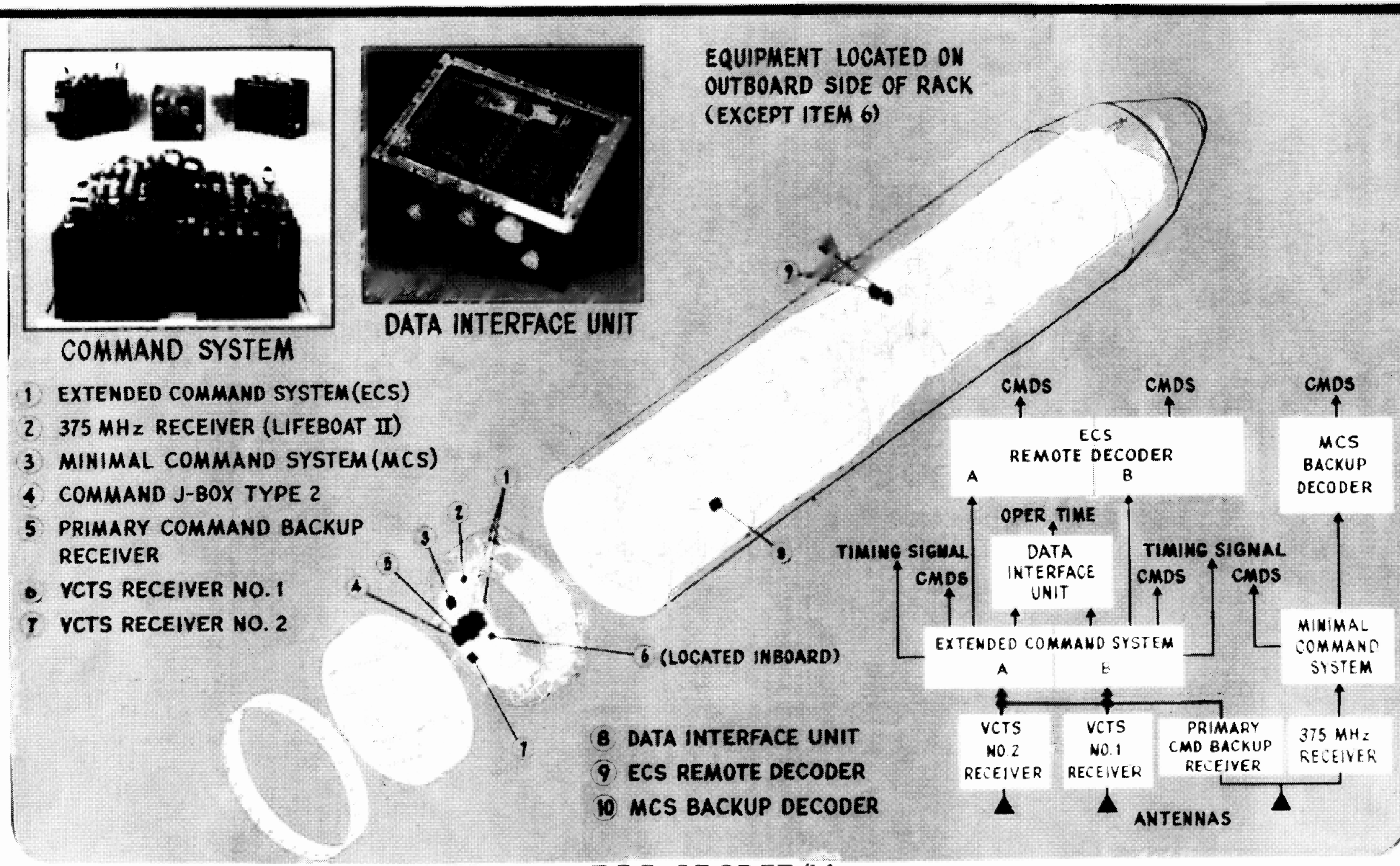
COMMAND AND TIMING

The Extended Command System (ECS) provides real-time and stored-program command capability. The SGLS compatible ECS system with complete redundancy provides 64 real-time and 626 stored-program commands with a memory capability of 1152 commands. Ninety-six secure command operations are possible. On SV-15 and up the number of secure command operations will be increased to 192. The ECS provides operational commands to perform primary and secondary missions, the capability to configure the vehicle into various operational modes, a pre-flight test and checkout capability, security for critical functions, and a time signal to the PCM and the payload.

The Minimal Command System (MCS) provides 28 real-time and 66 stored-program commands with a memory capability of 53 commands. Ten secure command operations are available. The MCS provides lifeboat commands for an independent capability of recovery RVs and initiating SV deboost and the capability to obtain real-time and recorded telemetry data.

The Data Interface Unit (DIU) provides for the generation, storage and transfer of time information to the search/surveillance camera, mapping camera, telemetry, [redacted] The DIU also provides the mapping camera system and pan camera time request pulse to the NAVPAC experiment.

COMMAND & TIMING



LIFEBOAT II

The lifeboat system provides emergency capability to initiate separation of two Reentry Vehicles (RV) and to deorbit the Satellite Vehicle in the event of a complete failure of the main power system, the attitude control system, or the extended command system.

Emergency operational control is provided by the 375 MHz receiver and minimal command system, with capability for real-time, stored-program, and secure commands.

Attitude control for RV releases and SV deorbit is provided by earth-field sensing magnetometers, rate gyros, and a cold gas (freon 14) control force system. Lifeboat is capable of RV releases and SV deorbit operations on both south-to-north and north-to-south passes.

Power to keep the system ready for use, and for the emergency operations is provided by a type-40 battery and 1/4 of the solar arrays from the main power system. The OAS engine and the redundant SGLS, PCM, tape recorder, and other equipment necessary for RV release, SV deorbit, and recovery of vehicle diagnostic data are switched from the main power system to the lifeboat bus for the emergency operations. In a nominal tumbling mode, enough power is generated to keep this emergency mode operating until the vehicle reenters.

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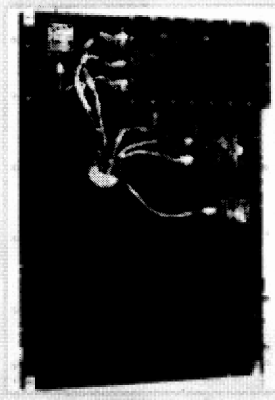
LIFEBOAT II

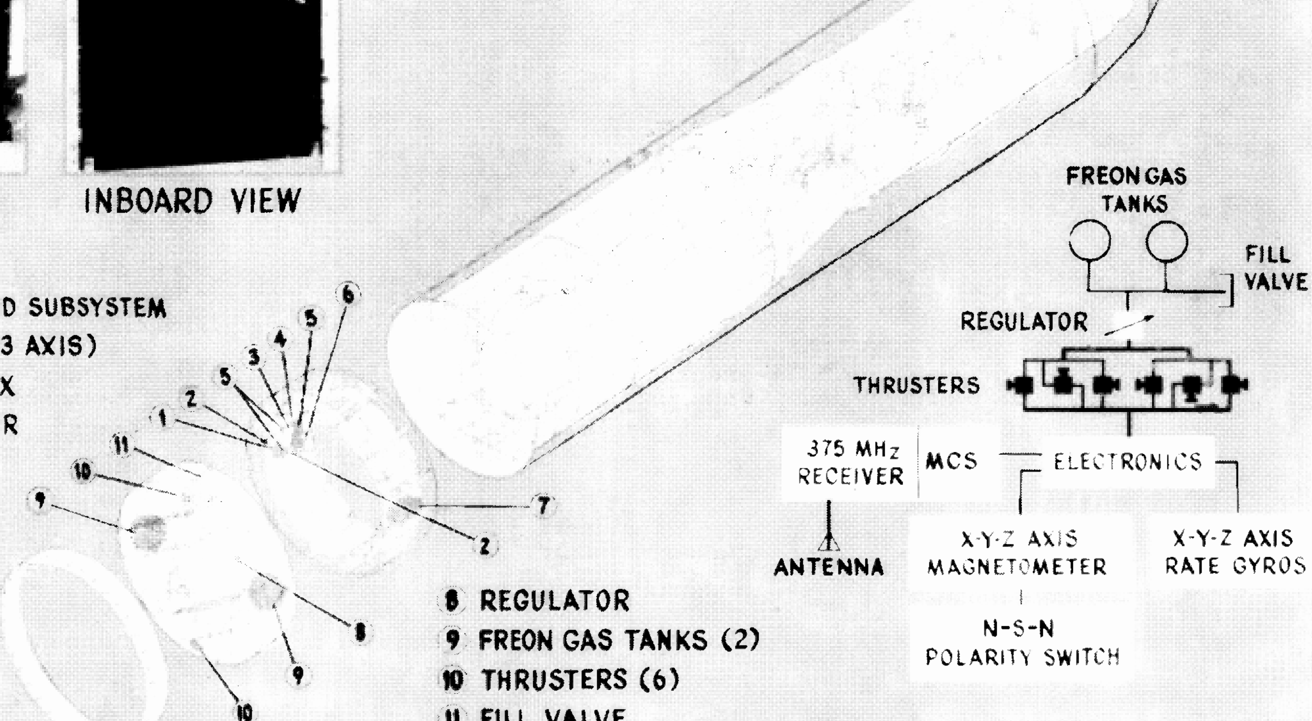
OUTBOARD VIEW



INBOARD VIEW

1 MINIMAL COMMAND SUBSYSTEM
2 MAGNETOMETER (3 AXIS)
3 LIFEBOAT II J-BOX
4 375 MHz RECEIVER

5 RATE GYRO (3)
6 ELECTRONICS
7 TYPE 40 BATTERY



8 REGULATOR
9 FREON GAS TANKS (2)
10 THRUSTERS (6)
11 FILL VALVE

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HARDWARE FLOW

The HEXAGON integrated test program begins at the piece-part level and continues through component, module and vehicle levels of assembly. Testing at progressive levels of assembly permits workmanship faults to be identified and eliminated early in the test program.

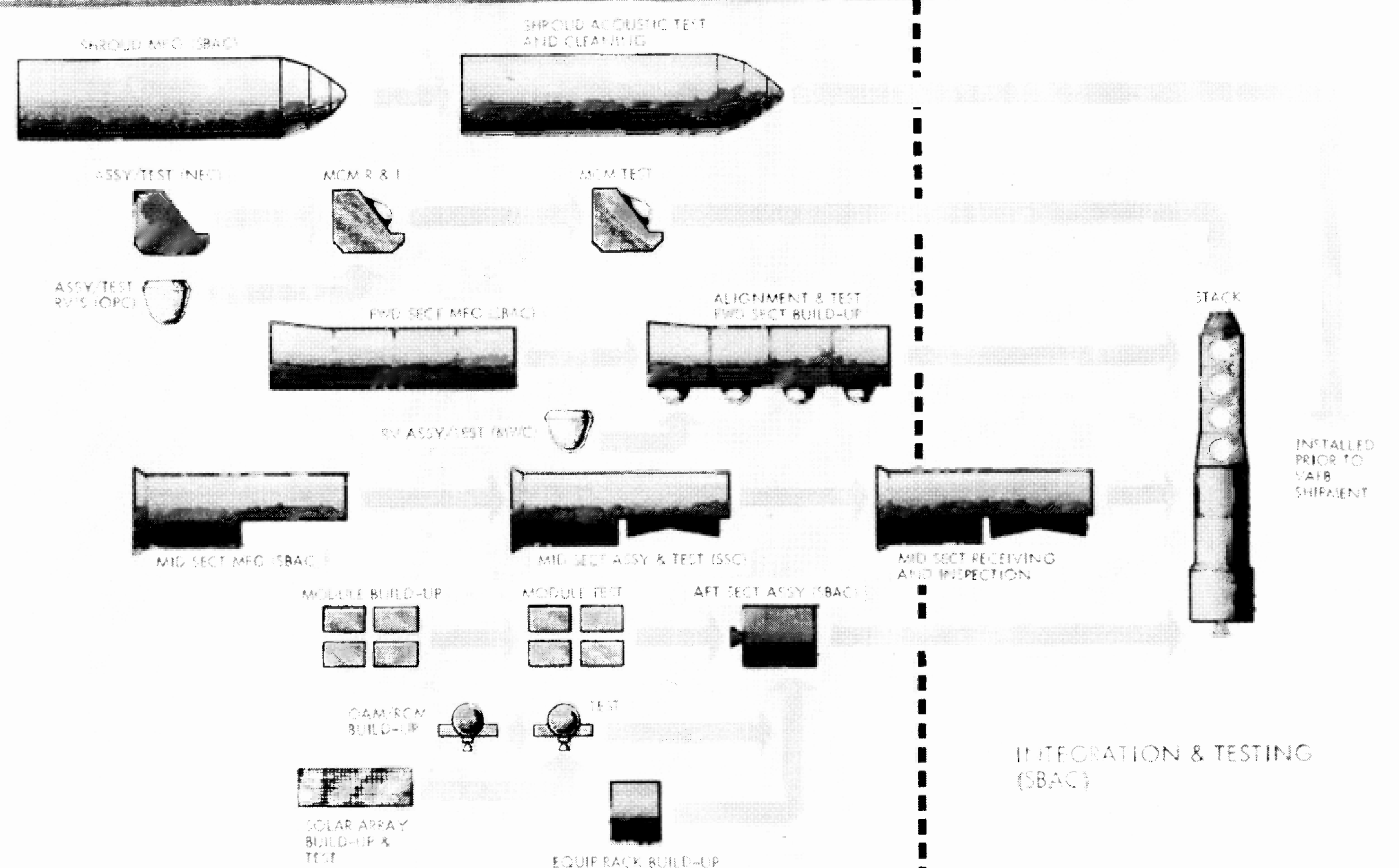
The SBA piece-parts are subjected to electrical and environmental stress and visual inspection tests to verify piece-part specification. The SBA components are subjected to ambient, random vibration, temperature-vacuum and burn-in acceptance tests for early detection and correction of design, parts and manufacturing defects. The components are then assembled into the aft section modules or installed in the forward and mid-sections. The aft section electronic modules are subjected to ambient, acoustic and thermal vacuum tests. The propulsion module and solar array modules are subjected to ambient and acoustic tests.

The sections are then mated to form the Satellite Vehicle which is then ready for the system level tests prior to VAFB shipment.

The nomenclature shown on the accompanying illustration indicates the contractor where manufacturing or testing occurs:

SBAC – Satellite Basic Assembly Contractor (Lockheed)
MWC – Midwest Contractor (McDonnell Douglas)
NEC – Northeast Contractor (Itek)
OPC – Our Philadelphia Contractor (General Electric)
SSC – Sensor Subsystem Contractor (Perkin-Elmer)

HARDWARE FLOW



HARDWARE FLOW

The objective of the factory-to-pad test program is to demonstrate flight readiness of each vehicle at the factory and to perform vehicle checkout and launch preparations at the launch complex.

The assembled vehicle is tested as a system with payload electrical simulators to verify compatibility of the SBA equipment with the payload interfaces. The payloads are then electrically connected to the Satellite Basic Assembly (SBA) and the vehicle is tested to verify performance and compatibility.

The vehicle is subjected to an acoustic test and is monitored during the exposure to verify proper SV health and status. The vehicle is then tested to verify that it survived the acoustic environment. The vehicle is next subjected to a thermal vacuum test with the aft section subjected to two thermal cycles and the payloads subjected to one thermal cycle. Aft section performance tests are conducted at low and high temperatures and typical mission profile tests are performed on the payloads including film transfers to each reentry vehicle.

A collimation test of the Two Camera Assembly (TCA) is performed at vacuum to verify optical performance and to determine the flight focus setting for the camera system. The mapping camera flatness is verified and the flight setting for the film path pressure makeup is determined.

The vehicle is then prepared for shipment which includes flight film loading [redacted] A systems test is then performed to verify systems performance. Final shipping preparations are performed and the shround is installed. The vehicle is then transported to the launch base.

The vehicle is mated to the booster and an Aerospace Vehicle (AV) systems test is performed to verify that the SV operates properly and to verify compatibility between the AV and the Vandenberg tracking station and the Satellite Test Center. Final flight preparations consisting of propellant loading and pyrotechnic installation is performed. The countdown is initiated and consists of the final SV functional test and launch configuring for lift-off, roll back of the Mobile Service Tower, flight command loading, performing terminal count and launching the Aerospace Vehicle.

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HARDWARE FLOW