NATIONAL RECONNAISSANCE OFFICE
14675 Lee Road
Chantilly, VA 20151-1715

31 January 2019

Mr. John Greenewald, Jr.
27305 W. Live Oak Road, Suite #1203
Castaic, CA 91384

John@greenewald.com

Dear Mr. Greenewald:

This is in response to your request dated and received on 2 January 2019 at the National Reconnaissance Office (NRO). Pursuant to Executive Order 13526, Section 3.6, you requested a Mandatory Declassification Review (MDR) of the previously released *"History of the Poppy Satellite System."*

We completed our review of this document and determined that additional information can be released. However, some information remains withheld; this information qualifies for continued classification under Executive Order 13526, Sections 3.3 (b)(1) and 3.5(c).

You have the right to appeal this determination to the NRO Appellate Authority, 14675 Lee Road, Chantilly, VA 20151-1715, within 90 days of the above date. You may also submit an appeal electronically through the National FOIA Portal at www.foia.gov or via email to FOIA@nro.mil. Please include an explanation of the reason(s) for your appeal as part of your submission.

If you have any questions, please call the Requester Service Center at (703)227-9326 and reference case number EOM-2019-00033.

Sincerely,

for Cynthia Allman
FOIA Public Liaison

Enclosure:
1 Document

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HISTORY OF THE
POPPY SATELLITE SYSTEM

Approved for Release: 2019/01/30 C05096560

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HISTORY OF THE POPPY SATELLITE SYSTEM

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FOREWORD

This report describes the history of the POPPY project from its concept in 1958 through its termination on 30 September 1977. This history was compiled at the request of the Director, National Reconnaissance Office to the Director, Program C. Included in this report are the significant events during the nineteen years of the POPPY project, including the development and refinement of POPPY satellites, mission ground stations, ground readout equipment, analog analysis, and data processing. The impact of failures, problems and anomalies are evaluated. Successes of the POPPY project are measured against program objectives. Technical data, cost history, key contributions, a glossary of terms related to the POPPY project, and a bibliography are contained in annexes to the report.

Each of the chapters in the report is intended to be somewhat self-contained. Annex 1 contains a summary of mission characteristics and merges some information from the third through the seventh chapters in order to provide a chronological summary of the technological innovations in the order of the launches.

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I. CONCEPTION

During the second world war, lookouts on German submarines used a hand-held crystal video type radar receiver named ATHOSS to detect pulses emitted from search radar on allied warships and airplanes. This simple passive electronic countermeasure receiver enabled evasion before range had closed sufficiently for returning radar echoes to indicate the presence of the submarine to the searching warship or airplane. After the war, crystal video receiver technology was applied in the direction finding systems for use on American warships and airplanes because of its simplicity, its small size and wide open frequency detection characteristics. By the late fifties, a crystal video receiver was being fitted to type 8-A submarine periscope; the first three receiver prototypes were developed by the Naval Research Laboratory (NRL) in late 1957.

On 4 October 1957, the Union of Soviet Socialist Republics (U.S.S.R.) launched the first artificial satellite as part of the thirty-month International Geophysical Year. Thirty days later, the second Sputnik was launched with a live dog as a passenger.

About one month later on 6 December 1957, with the whole nation watching on National television, the United States (U.S.) attempted its first satellite launch on a totally new sophisticated Vanguard missile. The payload was the grapefruit sized Vanguard satellite - weighing three pounds. The missile lost thrust after 2 seconds and crashed in a huge ball of flames. The tiny satellite fell out of the nose fairing and rolled away. Its antennas were bent and broken and charred black from the fire - yet it was still transmitting its signal. This national embarrassment triggered a number of things. The immediate results were a presidential decision to task the Army team, under Dr. Wernher von Braun at the Redstone Arsenal, to launch a satellite on the existing ICBM called Jupiter C. Fortunately, these efforts did meet with success and on 31 January 1958, the U.S. placed its first satellite, Explorer I, in orbit. This satellite discovered the Van Allen belt. The Navy Vanguard team succeeded on Saint Patrick's Day, 17 March 1958, by placing Vanguard I in a highly elliptical orbit. This satellite, powered by solar cells, transmitted its signal for over six years. This stable orbit with constant transmission from the satellite permitted the first long term observation of orbital dynamics. This resulted in the discovery of the "pear-shaped earth" and initiated a series of sophisticated modeling efforts of the earth's gravity field which is so important for predicting satellite positions vs time and for ballistic missile accuracy.

But the Vanguard initial failure also had other longer range effects. It caused the nation to re-evaluate its position in the newly arrived space age. We felt threatened in that we seemed to be falling behind in this new high technology area. A frantic call went out to better educate more engineers and scientists in our colleges and universities. The gauntlet had been laid down and America would

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respond with a tremendous effort and close that gap. In retrospect the Vanguard program with its spectacular failure but subsequent success and its tremendous technology advances may have been the best thing that could have happened to the infant U.S. space program.

Also, of much more specific value to the Navy was the fact that Vanguard had developed a technology base in satellite design at NRL which formed the foundation for the subsequent POPPY program.

These first space exploration successes stimulated the Advanced Research Projects Agency (ARPA) to solicit other DOD elements for proposals for space related projects. The Chief of Naval Operations (CNO) relayed the query to Navy scientific and technical organizations by asking, "All hands to consider how they could use space in their design ideas for the Navy."

NRL responded to the CNO query with the proposal to launch a satellite into a 500 NM circular orbit. The satellite would be equipped with an S band crystal-video receiver to detect signals of sufficient power density and would use an uncoded radar beacon to transpond them (pulse-for-pulse) down to cooperative ground stations for recording and subsequent analysis. The proposal was reviewed and approved through the Navy and DOD and was approved by the President in August 1959 as Project TATTLETALE.

[redacted] Project TATTLETALE in the New York Times lead [redacted] by the President and to a presidential order to tighten security. A special security system was then established by the Office of Naval Intelligence (ONI). Access was limited to individuals with a strict need-to-know and required the approval of ONI, ARPA, or the Office of the Special Assistant to the Secretary of Defense (Special Operations). Those individuals granted access were required to execute a project secrecy agreement.

NRL developed the concept and designed the ELINT satellite and ground readout equipment which was continued as the top secret Project Walnut. Additional security was provided by adding an NRL scientific cover experiment designed to telemeter measurements of solar activity in X-ray, Lyman-Alpha, and ultraviolet radiations above the earth's atmosphere. This cover experiment became the first of a series of SOLRAD satellite experiments designed and exploited by the Naval Research Laboratory. The cover name GRAB (Galactic Radiation and Background) was used for the intelligence and scientific satellite.

With the first launch pending, new importance was added to the project after the crash of a U-2 high-altitude reconnaissance aircraft in the U.S.S.R. on 1 May 1960. Subsequent cancellation of routine U-2 overflights ended the capability for deep interior surveillance of the U.S.S.R. Future overhead surveillance missions would require presidential approval.

The first U.S. and reconnaissance satellite (photo or SIGINT) to become operational was successfully launched on 22 June 1960 from Cape Canaveral, Florida aboard a Thor-Able-Star. GRAB/Dyno 1, as this ELINT satellite was named, shared the launch vehicle with Transit 2A, the Navy's second navigation satellite. The purpose of the ELINT package, designated Dyno 1, was to collect ELINT data from the interior and infrequently covered maritime regions of the U.S.S.R. ELINT data is transponded by the Dyno 1 for a forty-minute period after interrogation. The mission ground station equipment was operated only when Dyno satellites were transmitting above their radio horizon; recorded data from the down link(s) on magnetic tape; and forwarded data recordings with collection logs to NSA via the Armed Forces Courier Service (ARFCOS).

The ELINT capability of Dyno 1 was successfully tested on 4 July 1960 at Wahiawa, Hawaii, well out of Soviet range. Tense political climate following the U-2 incident dictated that this satellite would be tasked only by specific presidential authority. Thus only 22 data collection passes across the SINO Soviet bloc were collected and processed during the three month useful lifetime of the GRAB/Dyno 1 satellite.

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II. ORGANIZATION

Throughout its lifetime the POPPY project was managed, operated and supported by a number of DOD elements under overall Navy leadership. There were two distinct phases of organization, pre-NRO and the reorganization following establishment of the NRO in 1962. During both of these phases, multi-agency activities were coordinated by means of a Technical Operations Group (TOG).

A. PRE-NRO

Directorship of Project GRAB/Dyno (see Annex 3) was assigned to the Director of Naval Intelligence (DNI). The TOG acted as the steering committee or staff of the project director. The TOG members were drawn from designated DOD organizations and the National Security Agency (NSA). The participating organizations, their responsibilities, and the staff responsibilities of their representatives to the TOG were specified by the DNI.

1. The NRL developed the overall system concept; designed, constructed, deployed, and logistically supported electronic receiving, recording, and timing equipment at mission ground stations; designed, fabricated, tested, and calibrated the satellite systems from concept through launch injection into orbit, and provided engineering and technical direction through the operational exploitation phase; trained mission ground station personnel; controlled the satellite prior to launch; monitored the launch; and monitored on-orbit performance of the satellite. The NRL member of the TOG was designated as the project technical representative/project manager until January 1971.

2. The Naval Security Group (NSG) directed and coordinated all mission ground station operations; acted as the focal point for all electrical communications associated with the operations of the project; provided sites, support facilities and operating and maintenance personnel at the [redacted] NSG mission ground stations. The NSG member of the TOG was designated as the project operational representative. 3.3(b)(1) 3.5(c)

3. The NSA authorized the allocation of service cryptologic personnel to man and operate the mission ground stations; processed all ELINT data recordings and disseminated the ELINT product; interpreted national intelligence collection and processing requirements and made tasking recommendations; and furnished the magnetic tapes for recording data at the mission ground stations. The NSA representative to the TOG was designated as an advisor to the staff.

4. The DNI had the authority to review and approve all aspects of the project. The Scientific and Technical Intelligence Center of ONI (STIC) provided intelligence requirements to the director; provided signal analysis support to NSA; monitored the signal analysis

program; and disseminated quality control technical data to mission ground stations. The STIC member of the TOG was designated as the product control representative.

[redacted]

6. As of 1962, the Army Security Agency (ASA) provided a site, support facilities and operating and maintenance personnel at the ASA mission ground station.

7. The sites where dedicated GRAB/Dyno collection and processing and spacecraft commanding systems were installed in the pre-NRO period are as follows:

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SITE	FUNCTION
[redacted]	[redacted]
ADAK, ALASKA	[redacted]
HYBLA VALLEY VIRGINIA (Engineering Ground Station).	[redacted]
WAHIAWA, HAWAII	[redacted]

B. NRO PROGRAM C

Upon consolidation of all U.S. overhead reconnaissance projects into a National Reconnaissance Program (NRP) in 1962, DNRO established NRO Program C as the organizational component to continue operation and management of the Dyno satellites. By December 1962, the Byeman

Control System was implemented throughout the project to govern security procedures. Byeman Project EARPOP replaced the Project Walnut security clearance. The satellites became designated as POPPY satellites, and subsequent launches would receive NRO mission numbers in the 7100 series. The DNRO reviewed the organization and responsibilities within Program C as proposed by the DNI in the time frame July 1962 through January 1963. The following changes and additions to organizational responsibilities were implemented:

1. The NRO provided funding to support Program C based on annual program budget submissions by NRL beginning with fiscal year 1963. The Consolidated Cryptologic Program (CCP) continued to support mission ground station personnel, magnetic tape, and data processing.

2. The DNI became designated as Director, Program C. The CNI provided a POPPY project director responsible for supervising and administering all aspects of the project subject to the approval of Director, Program C.

3. The NRO Deputy Director for Operations prepared routine tasking schedules for the operational control of POPPY satellites with technical support from the TOG. Routine tasking was directed by the NRO Satellite Operations Center (SOC) through NSG. NSA directed quick reaction tasking of POPPY satellites through NSG following tip-off of Soviet space or missile activity.

4. Program A of the NRP provided the launch vehicle, launch vehicle/satellite integration, and launch services. The NRO separately funded this support.

5. The Naval Research Laboratory was designated the technical director responsible for design, development, and operational support.

C. LATER CHANGES

Program C and the POPPY project organization functioned in the same general manner as established under the NRO for the next fourteen years. Changes subsequent to 1963 were the result of realignments within the Navy, changes in capabilities leading to added responsibilities, and changes in participation. Significant changes and associated factors were the following:

1. Starting in April 1963, the requirement for detecting, electrically reporting and logging new and unusual signals was added to the responsibility of mission ground stations. The resulting on-line manual analysis produced the earliest possible recognition of [redacted] tion resources for exploitation. [redacted] 3.3(b)(1)
[redacted] after it was couriered 3.5(c)
back to CONUS for processing. Various site facilities were upgraded

and changes made to the satellite designs in order to enhance the detection and recognition of the new emitters as they were added to the Soviet radar inventory during their rapid build-up during the 1960's. These Soviet radar changes started with original designs in the landbased early warning and surface to air systems and expanded to all types of systems from land, sea, air and later space platforms, almost all of which were initially detected and parametrically categorized by this intelligence gained from POPPY.

2. In 1967, ONI became redesignated as the Naval Intelligence Command (NIC). COMNAVINTCOM retained the responsibility of Director, Program C.

3. In response to the 1966 Presidents Scientific Advisory panel's urgent request to expoit overhead reconnaissance to determine if the Soviet Union was developing an antiballistic missile radar system the program site in [redacted] was equipped with analog-to-digital data conversion and a small data processing computer. This on-site computer-aided manual analysis system was installed in [redacted] and Adak, Alaska in late 1970. [redacted]

4. AFSS participation ended in October 1969 with the closure of its last POPPY mission ground station at [redacted]

5. ASA participation ended in August 1970 with the closure of its POPPY mission ground station at [redacted] 3.3(b)(1) 3.5(c)

6. On 14 January 1971, the Navy Space Project Office was established as PM-16 of the Naval Material Command. The Manager, Navy Space Project (PM-16) was designated as the Director, Program C. POPPY project director functions were performed within the System Project Office (SPO) of PM-16. Liaison with NIC continued.

7. In June 1973, PM-16 was redesignated as PME-106 of the Naval Electronic Systems Command with its manager continuing as Director, Program C.

8. [redacted]

9. On 2 August 1977, the Director, Program C directed cessation of the POPPY Mission 7107 operations. However, the Engineering ground station at [redacted], continues to perform power management activities to sustain spacecraft operational capability.

10. On 30 September 1977, DNRO directed termination of the POPPY program as the [redacted]

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III. SATELLITES

All of the GRAB/Dyno ELINT satellites contained scientific cover experiments of the SOLRAD type. Engineering evolution and innovative refinement of the spacecraft and ground station subsystems were continued by NRL in the POPPY program following the transition from GRAB/Dyno to POPPY. The satellites were designed for long-life high-duty cycle operation. All satellites were designed for full utilization any time a satellite was in view of a ground station. Eight satellites provided useful intelligence for periods in excess of five years. This combination provided a very efficient low-cost satellite system which continuously had from two to eight operating satellites on-orbit from 1963 until 1977 when the program was terminated.

A. CLUSTER SIZE

The GRAB/Dyno satellites were launched pickaback with other scientific and navigation satellites. Two of the five attempts to orbit Dyno satellites were successful. The first POPPY launch Mission 7101 orbited a pair of ELINT satellites. The next two launches orbited POPPY triplets. Each of the final four launches carried four POPPY satellites [redacted]

B. ORBITAL CHARACTERISTICS

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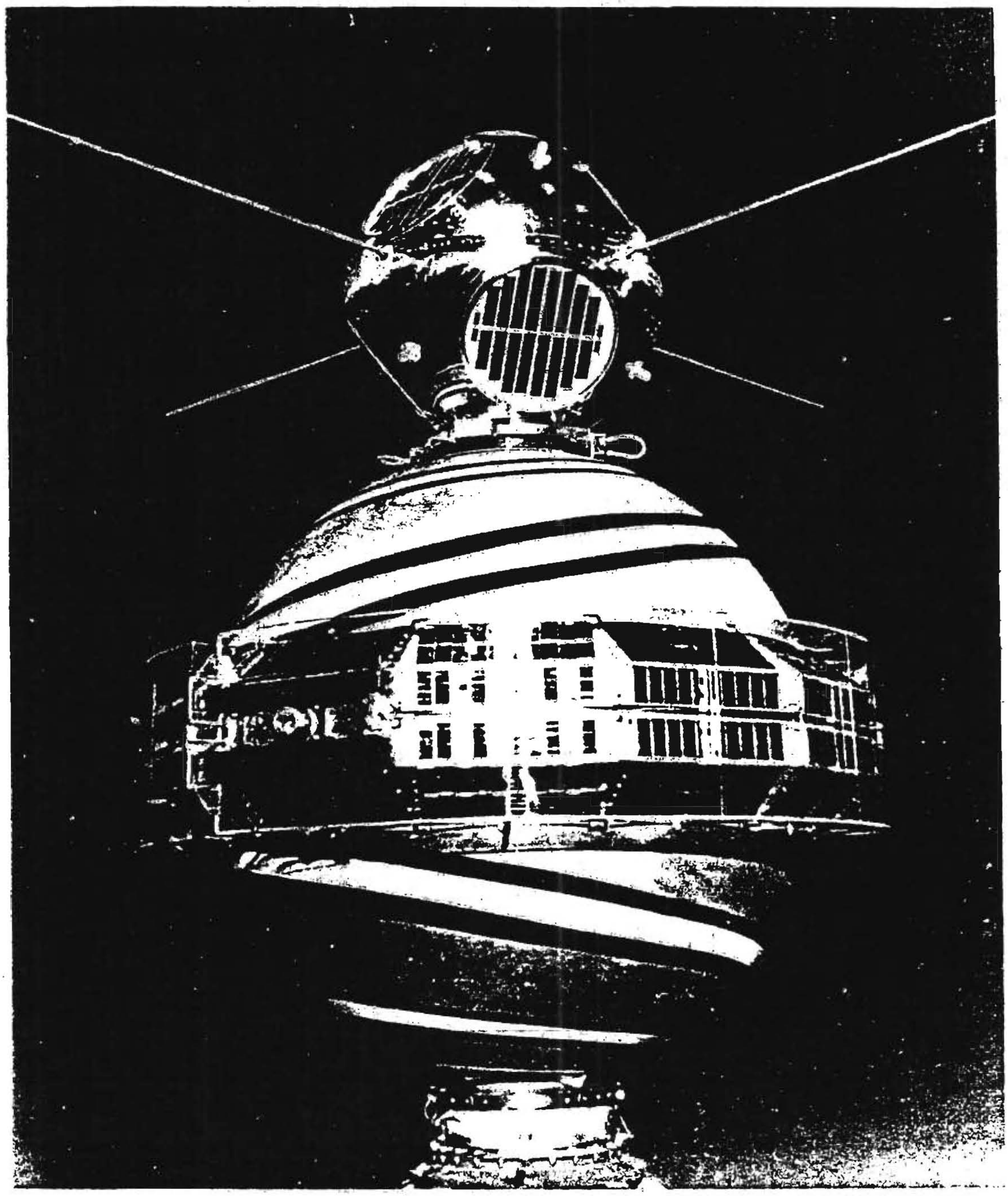
The satellites were intended to achieve nearly circular orbits at an altitude of 500 nautical miles with an inclination of 67 degrees. Of the four successful launches before 1964, two orbits were elliptical, and two orbits were highly elliptical. Each of the five launches from 1964 through 1971 achieved nearly circular orbits at altitudes near 500 nautical miles and inclinations near 70 degrees.

C. PHYSICAL CHARACTERISTICS

The GRAB/Dyno satellites were of spherical configuration with a diameter of 20 inches. The first Dyno spacecraft weighed 42 pounds; later Dyno spacecraft weighed up to 55 pounds.

In the first POPPY launch, both of the satellites were composed of two 20-inch diameter hemispheres joined by a 4-inch wide equatorial band. The stretched sphere design was used for all satellites in the next three launches, either with 20-inch or 24-inch diameter configurations. These satellites weighed between 55 and 130 pounds.

The multiface design was first used on Mission 7105 in 1967, three of the four satellites being multiface. The fourth was a



First U.S. SIGINT Satellite,
GRAB/Dyno 1 mounted above TRANSIT 2A

stretched sphere with a 9-inch equatorial band. The multiface satellite measured 27-inch diameter across flats at its 12-sided equator. Spacecraft equatorial bands varied in size to accommodate the increase in size and number of electronic and mechanical components necessary to satisfy the increasing mission requirements. The basic multiface structure was utilized on all POPPY satellites after Mission 7105. The weights of the multiface satellites ranged from 162 to 282 pounds.

D. POWER

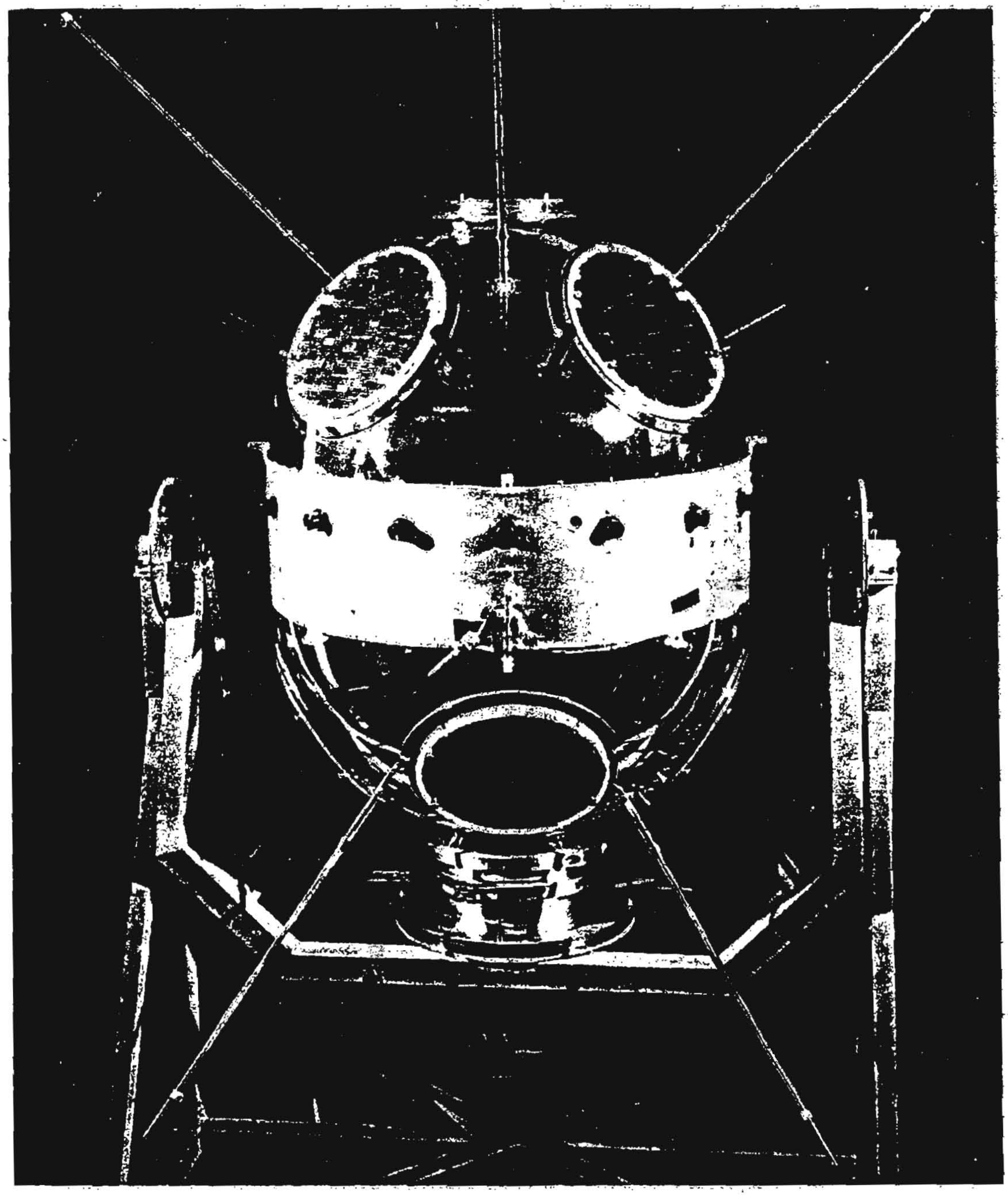
The first Dyno satellite was powered from a 12-volt storage battery consisting of nine D size cells in series. The battery was charged by silicon solar cells and was designed to provide useful life of one year in orbit. Six 9-inch diameter round patches of 156 cells were symmetrically located on the surface of the sphere so that approximately one watt of power would be available for any orientation of the satellite. In full sun, a single patch could provide about two watts of charging power to the chemical storage battery. From Dyno 2 onward, +12-volt and -12-volt storage batteries were included.

In the 24-inch diameter satellites, more solar cells of smaller size were placed on 11-inch diameter panels. The six symmetrically placed panels provided about four watts of charging power to an 18-cell, nickel-cadmium battery pack. (NOTE: 9-inch diameter solar panels were used with the 20-inch diameter satellite and 11-inch diameters with the 24-inch satellite.)

E. TELEMETRY

The satellites continuously telemetered engineering data on the housekeeping condition of the satellite and state of the command of the ELINT collection receivers and options. [redacted] Satellite engineering data such as battery voltage, temperatures, etc. were sampled by the [redacted] commutator. Discrete or command status indicators were binarily encoded and monitored by the [redacted] commutator. 3.3(b)(1) 3.5(c)

From 1969 onward, the satellites were equipped with a digital [redacted] telemetry subsystem in order to improve the speed and reliability of telemetry readout using a [redacted] display at the mission ground stations.



Typical 24" Diameter Spherical Satellite
with 9" high Equatorial Band

The first GRAB/Dyno satellites transmitted telemetry signals at 108 MHz. In later years, frequencies in the neighborhood of 137 MHz were used to avoid interfering signals.

In the spheres and stretched spheres, the power output of both the telemetry transmitter and the ELINT data transmitter(s) was fed into a single omni-directional, 4-element turnstile array. The same antenna served for reception of the command signals. The multifaces used two such turnstile arrays, one for command reception and telemetry transmission, the second for ELINT data transmissions.

F. COMMAND

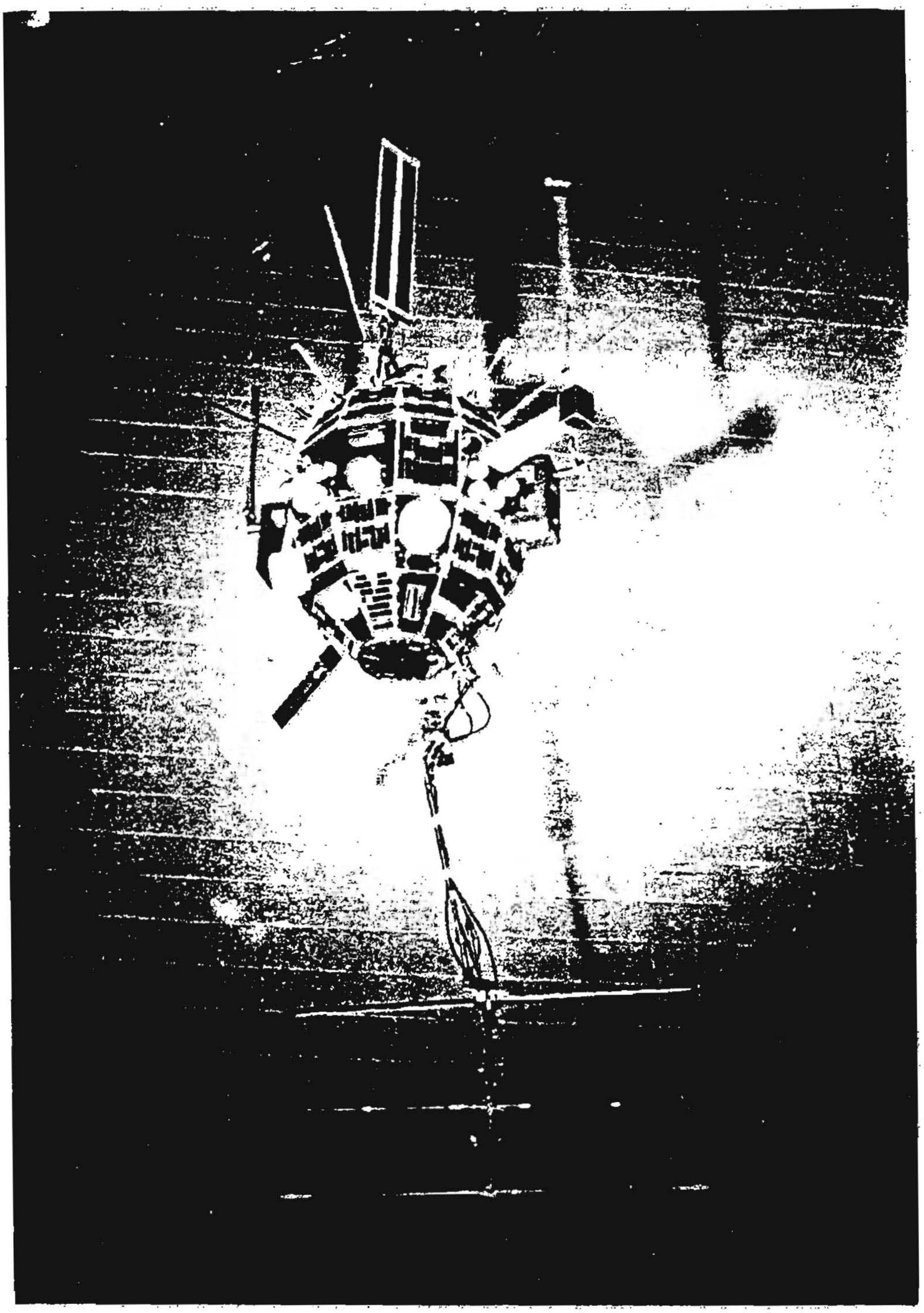
The command receiver in the GRAB/Dyno satellite was adapted from the system used with Vanguard. [redacted] The receiver was a double superheterodyne with crystal control on both the first and second oscillators to provide stability. Audio amplification of the proper tone activated the corresponding relay switches to turn on the data link transmitter and one of the two timers and to turn off telemetry at the end of useful life.

As command options increased to include more data receivers, data links, experiments, station keeping devices, etc. the basic command system was expanded from a simple tone system to a tone digital system utilizing ten frequency tones allowing over a hundred commands.

G. ELINT COLLECTION

The crystal video receiver was used during the entire history of POPPY because of its high probability of intercept, wide-open RF characteristic, stability over wide temperature and voltage fluctuations, low power requirements, and demonstrated long life reliability. 3.3(b)(1) 3.5(c)

[redacted]



Typical 27" Multiface Satellite
Mission 7107

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H. ATTITUDE STABILIZATION AND STATION KEEPING

With refinements in the employment and placement of new directional antenna types, the orientation of the vertical axis of the satellites became a factor affecting performance. Satellites which tumbled or orbited upside down or sideways did not orient their ELINT antennas to produce optimum coverage in azimuth. To overcome this problem, a Gravity Gradient Stabilization Experiment (GGSE) was implemented in the eighth launch (Mission 7103). One satellite was fitted with an extendable 28-foot beryllium-copper boom. A tip mass at the end of the boom contained a magnet floating in viscous fluid. When the boom was extended, the magnet would align itself with the earth's magnetic field. Torque exerted by the gradient of the earth's gravity field caused the axis of the satellite/boom system to align itself with the local vertical. Libration of the satellite/boom assembly would be gradually dampened as the viscous fluid in the sphere dissipated energy from the relative motion of the magnet. This 2-axis gravity gradient stabilization experiment succeeded in aligning the satellite's axis to within 8 degrees of the local vertical and consumed no on-board power.

Gravity Gradient Stabilization was also implemented in Mission 7104, including 2-axis gravity gradient and 3-axis gravity gradient 3.3(b)(1)
with two additional booms to provide yaw stabilization. In Mission 3.5(c)
7105 two satellites were equipped with 2-axis gravity gradient stabilization, and two were equipped with the 3-axis system. One of the 3-axis stabilized satellites used additional booms; the other used a flywheel to provide active stabilization of the yaw axis. All satellites launched thereafter used the 3-axis, active system employing a single boom and flywheel.

Anhydrous ammonia was successfully used as the microthruster gas in one satellite in 1967 and in all satellites launched thereafter.

Three axis stabilization was a necessary prerequisite to the station keeping capability.

IV. MISSION GROUND STATIONS

[redacted] In addition, NRL operated an engineering data readout and interrogation site at Hybla Valley, Virginia until July 1967, when it was relocated to [redacted]

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[redacted]

The [redacted] operation was relocated to Adak Island after Dyno 1 due to local interference from a [redacted] in 1962 to preserve operational security. Due to the scheduled closure of the SIGINT station at [redacted] a mission ground station was established at [redacted] in 1962.

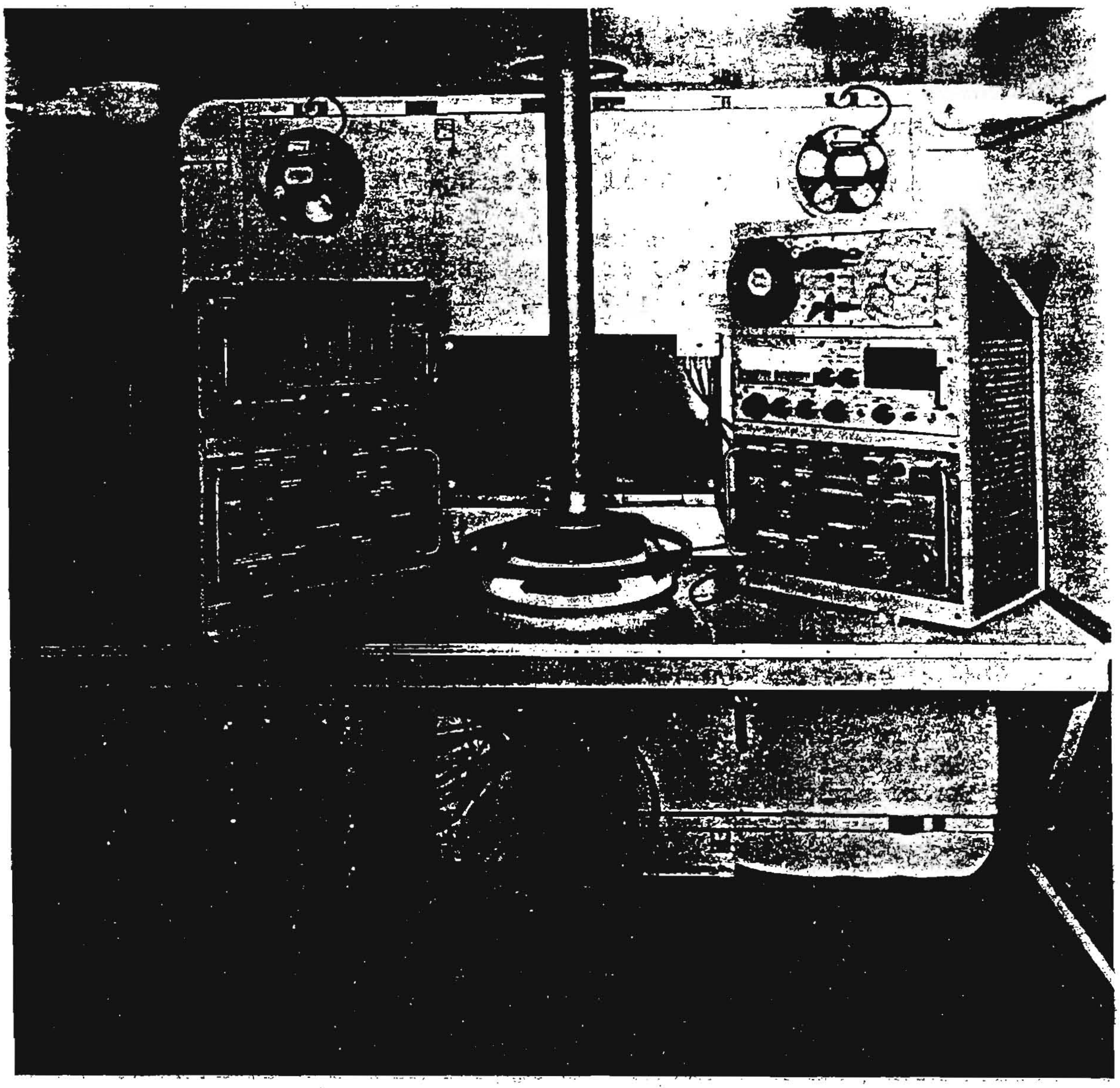
[redacted]

Adak was the only one of the GRAB stations to continue POPPY operations until project termination. Adak [redacted] ceased POPPY operations in August 1977.

During the initial operations collections were conducted in Earth Satellite Vehicle (ESV) shelter huts. After the system stabilized in the sixties, the transition was made to permanent buildings.

A. ESV HUTS

The ESV huts were procured from Craig Systems, Inc. of Lawrence, Massachusetts. These lightweight, aluminum shelters, designed for



First Generation GRAB/Dyno 1
Receiving, Timing, and Recording Position inside ESV Hut

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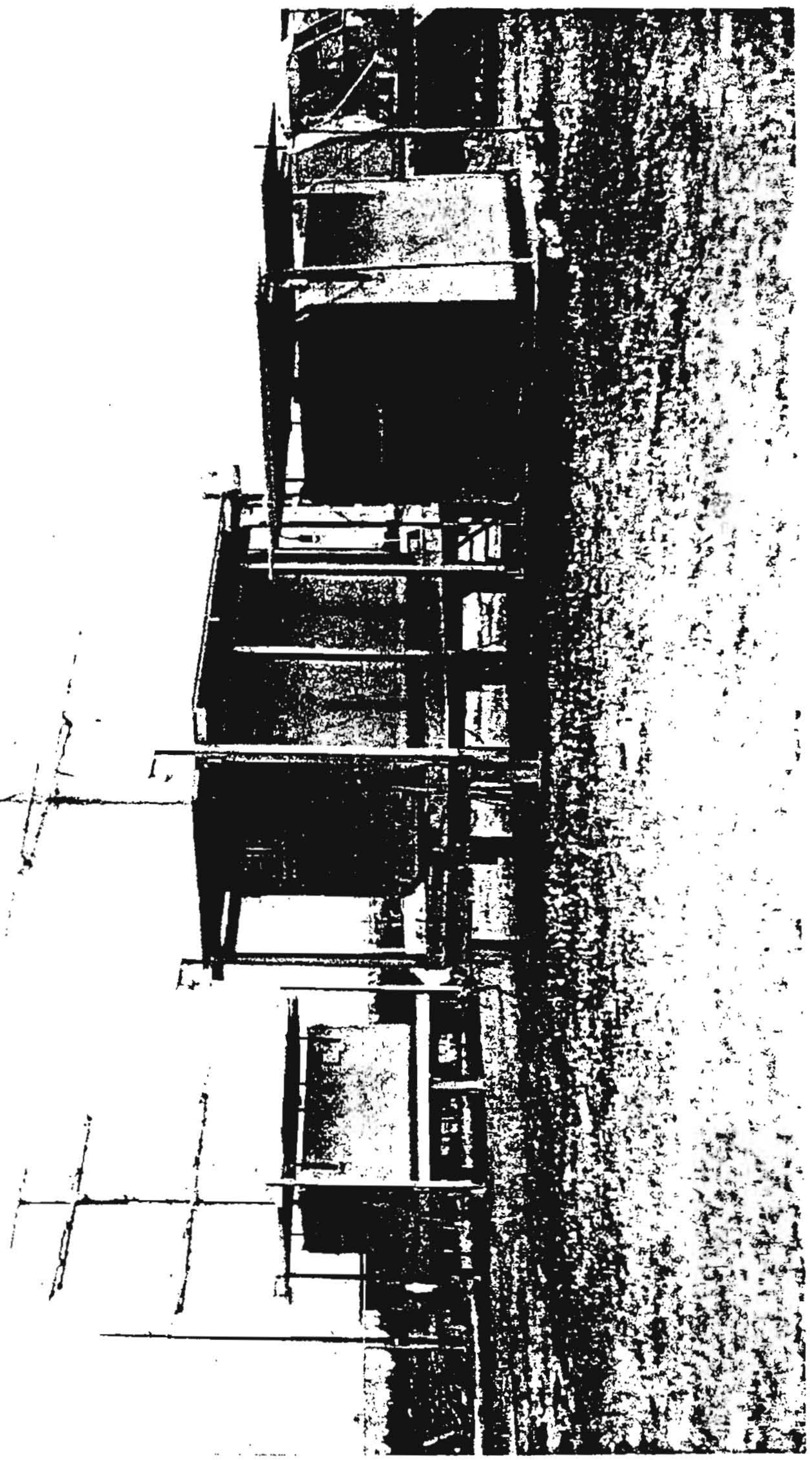
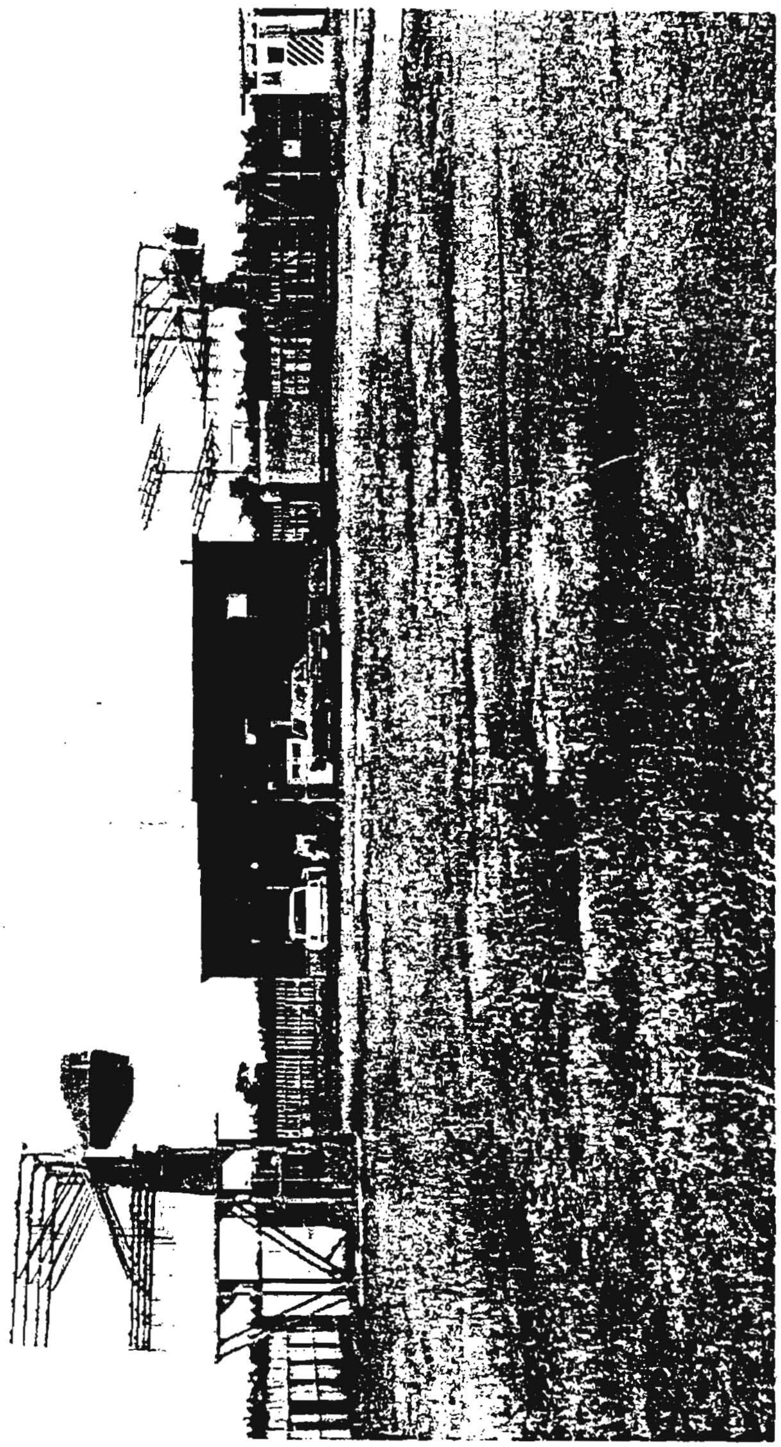


POPPY Mission Ground Station [redacted]
Typical Earth Satellite Vehicle (ESV Hut Installation)



POPPY Mission Ground Station Permanent Building [redacted]

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worldwide service conditions, could be transported by helicopter, large aircraft, truck, rail, or ship. They were described as all-weather shelters constructed of lightweight rigid floor, roof, side-wall and end panels secured by two lifting-band assemblies. The panels were fire resistant and water proof. The ESV huts came equipped with two work benches, a spare parts cabinet, exhaust fans, a filtered air inlet, incandescent lighting, a power entrance and distribution cabinet, and an electric heater.

At NRL the ESV huts were fitted out for operations prior to deployment. NRL installed sheet-metal supporting racks to hold the electronic equipment, the necessary electronic equipment, an antenna mast, antennas, an antenna steering mechanism and brake assembly, and an air conditioner. The ESV huts were shipped as stand-alone assemblies requiring only minimal site support. At the mission ground stations, the ESV huts were placed on concrete pedestals, on pavement, or on elevated platforms equipped with carport-type canopy roof, provided with electrical power and they were ready to conduct operations. The ESV huts were only manned to prepare for and conduct scheduled collection operations. By 1962, in preparation for the first dual-satellite launch, each collection site was provided with two of the fully equipped ESV huts.

B. PERMANENT BUILDINGS

As the expanded exploitation and data collection roles placed increasing burdens on the site personnel, a move into permanent buildings was started in the early sixties when buildings housing the phased-out GRD-6 direction finding systems became available at [redacted] Adak. These wooden buildings were adequate to replace the ESV huts and provided the necessary space to install the growing number of bays of electronic equipment.

At other sites different buildings or parts of buildings were made available for the POPPY installation. By 1967, the [redacted] installations were in permanent buildings. [redacted] 3.3(b)(1) 3.5(c)

The first permanent building designed specifically for POPPY operations was completed as a military construction project at [redacted]

V. GROUND READOUT EQUIPMENT

Mission ground station functions related to ELINT data collection included telemetry readout, satellite interrogation, and ELINT data monitoring and recording. All mission ground stations performed the telemetry readout and monitored and recorded ELINT data. Capability to interrogate the satellites was located at the NRL engineering field station in Hybla Valley [redacted]

A. TELEMETRY READOUT

[redacted]

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After the change of frequency for telemetry transmission, the interrogation antenna was also used to receive telemetry.

B. INTERROGATION

All satellites in 500 nautical mile orbits which came within 1750 nautical miles of an interrogation site could be commanded or interrogated upon acquisition and readout of the telemetry signal. The output of a command tone generator was fed into a transmitter with a 250-watt power output and propagated directionally on an array of four 10-element Yagi antennas fitted on the same mast as the telemetry antenna array. The satellite ELINT receiver(s) and data link transmitter(s) would be powered-up or activated when interrogated by the command signal from the ground station. The interrogation would be verified by interpreting state of command data in the telemetry stream.

With the move into permanent buildings, the manually steered antennas were replaced by remotely steerable, pedestal-mounted arrays consisting of two rows of four cross-polarized Yagi antennas. These antennas could be trained in both azimuth and elevation, permitting

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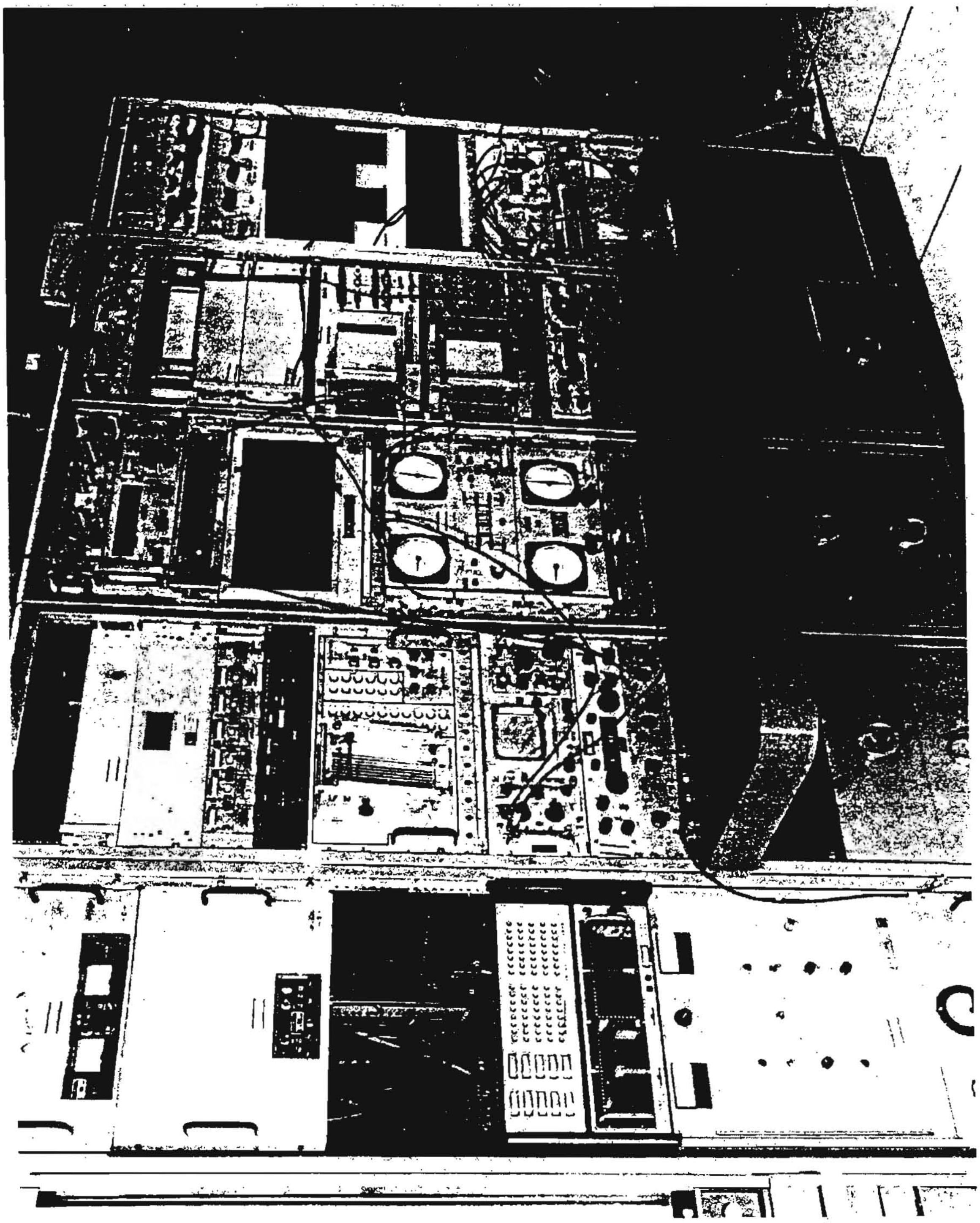

POPPY MGS Interrogation Position - 1972

uninterrupted telemetry and data collection as the satellites passed at high elevation angles. These antennas were fed by 5Ø-watt output command transmitters.

The interrogation position expanded into five bays of equipment manned by one operator. By 1967, the position included programmed command tone generators which read pre-punched cards prepared to implement the specific collection task groups authorized by the NRO Satellite Operations Center (SOC). The position also included an R-39ØA/URR receiver connected to a 25-foot whip antenna for the reception of the local standard time broadcast used to set the digital time generator. Solid state receivers replaced the R-39ØA/URR receivers used to copy telemetry.

All satellite interrogation except for ELINT data collection operations, (such as thrusting and power/attitude management, etc.) was performed at the NRL engineering ground station in Hybla Valley, Virginia [redacted]

C. ELINT COLLECTION

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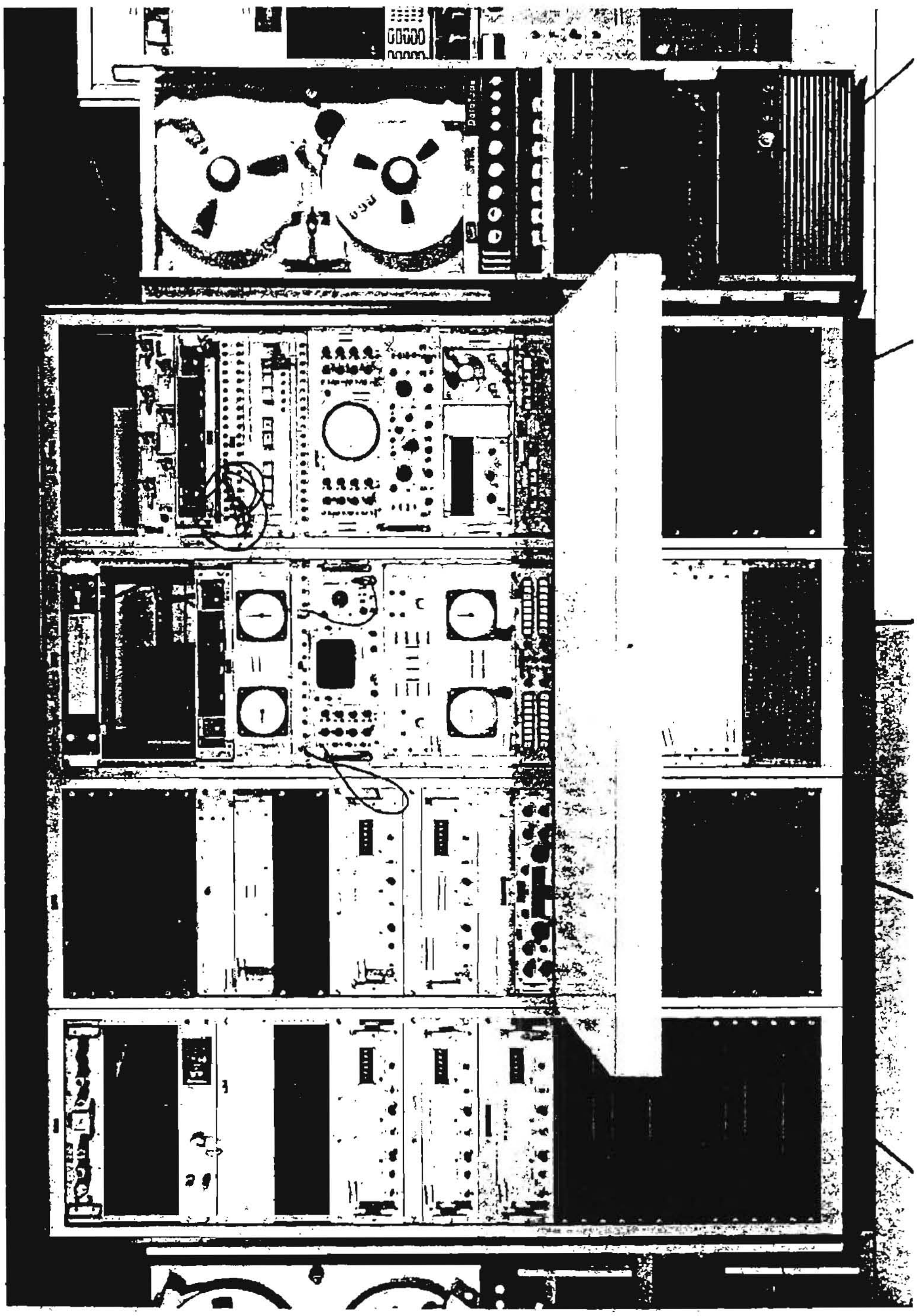


POPPY MGS Collection Position - 1972

In the early seventies, the collection systems incorporated a mini-computer for automatic satellite tracking and automatic equipment for checking, comparing and selecting the optimum receiver polarization. These additions made it possible for a collection system to be manned by one operator.

With the standard POPPY orbit, there were nearly fourteen revolutions per day. The equator crossing of each revolution was about 26 degrees to the west of its predecessor. The northern mission ground stations were able to collect an average of seven passes per day with an average duration of about 15 minutes/pass. The pace of collection operations depended on the number of missions active at any one time, the maximum being three in the 1967 time frame.

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

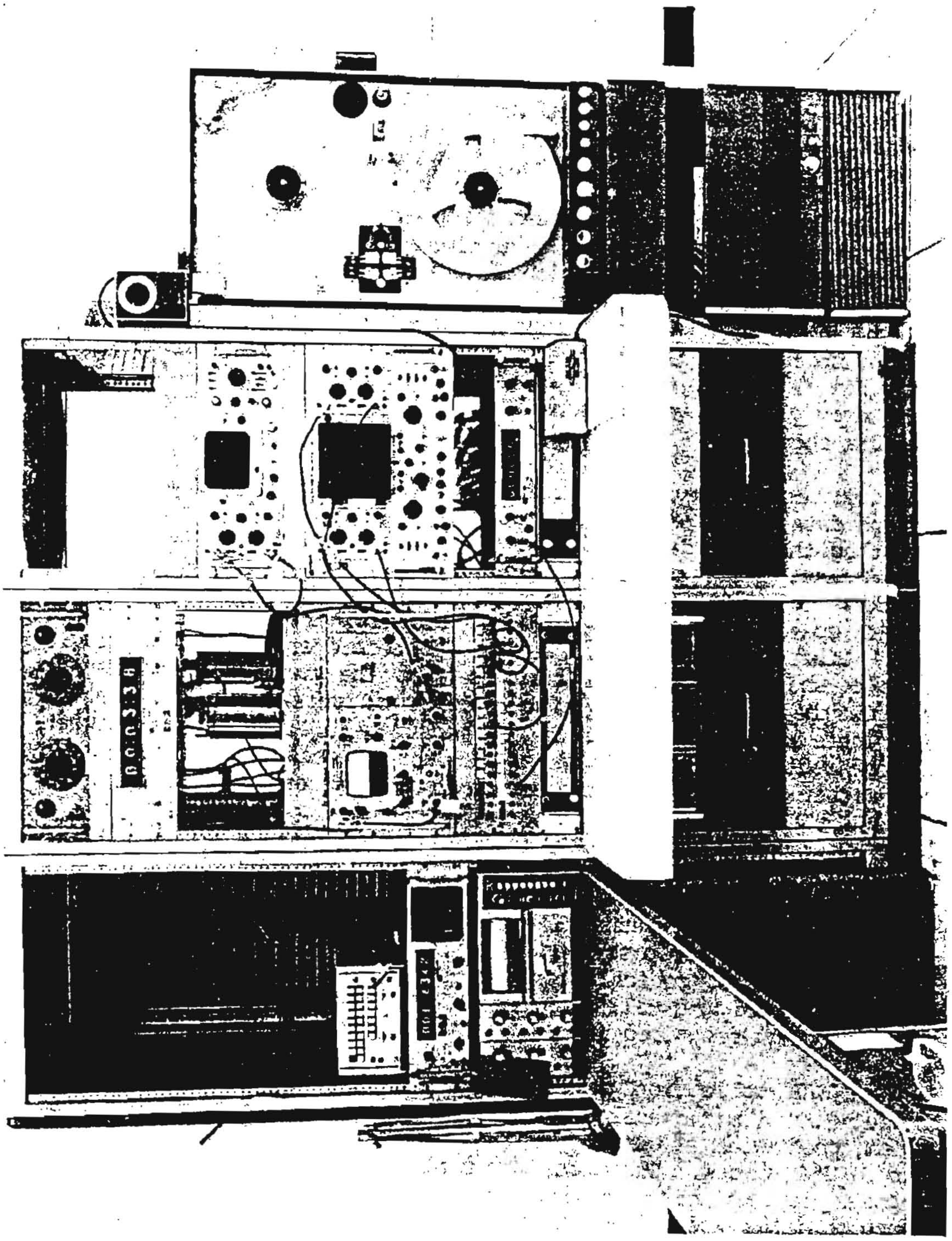
VI. ANALOG ANALYSIS

Analog analysis of the GRAB and POPPY data was performed at NSA with some analytic support from NRL and STIC. A [redacted]

The GRAB collection positions in the ESV huts had a playback capability but limited analysis equipment. Some of the sites had also been equipped with a quality-control position installed indoors in secure SIGINT spaces. These quality control positions were used for a post-pass playback of recordings to verify verbal annotations, the presence of data, and correspondence with collection logs.

With the aid of training tapes sent by NSA, collection operators were trained to aurally recognize signals with the desired characteristics. The results stimulated the upgrade of the collection systems and the provision of analog analysis positions.

3.3(b)(1)
3.5(c)



POPPY MGS - Analog Analysis Position for Off-Line QC Function

[redacted]

3.3(b)(1)
3.5(c)

Collection operators noted in their logs occurrences of NSA specified signals of high interest as well as new, unique or unidentified signals. After a pass, analog analysts played back the tapes at their analysis and quality-control positions and performed aural and visual scans of each of the recorded data links. Parameters of these signals of interest and unidentified signals were measured and tabulated. After verification of the parameters of unidentified signals, leading analysts prepared a daily signal of interest tipoff report for transmission to NSA and to other POPPY sites.

In the early seventies, pulse width selectors were added to the analog analysis positions to isolate and display the data collected from a single RF band in the satellite(s).

As the reliability in detecting and reporting signals of interest at the mission ground stations became established, the requirement for forwarding all analog tapes to NSA diminished to a requirement to forward only those tapes containing unidentified signals or tapes specifically requested by NSA. Recordings not forwarded were retained for a specified period, then degaussed and recycled.

VII. DATA PROCESSING

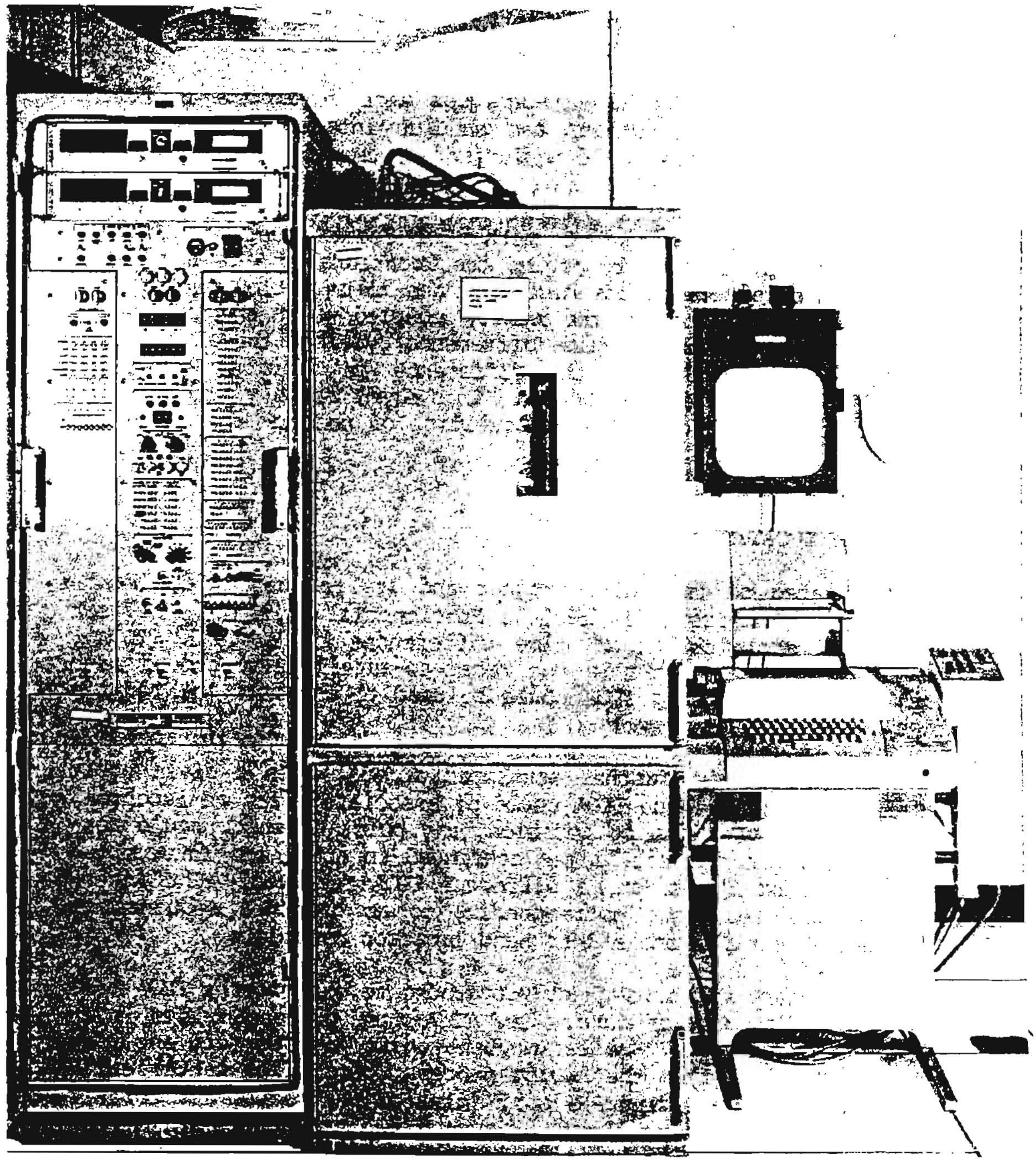
Already in 1960, computers were used at NSA and at NRL to help cope with the large volume of collected data. The emphasis at NSA was the production of ELINT. NRL analyzed the data in order to advance the satellite data collection technology. During the seventeen years of data processing, there were four distinct phases. During the first phase, GRAB data processing techniques were developed and radar locations were approximated by means of intercept geometry. The second phase grew out of the capabilities of the first dual-satellite launch in 1962. In the third phase, computer-aided manual data processing was performed at mission ground stations. Finally in the fourth phase POPPY automatic data processing system (PAPS) was developed and deployed to POPPY sites.

A. GRAB DATA PROCESSING

[redacted]

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)



3.3(b)(1)
3.5(c)

POPPY MGS - Buffered Digital Tape System - 1972

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

POPPY MGS - SEL- 810 CPU Digital Data Processor - 1972

BYE-56105-78

3.3(b)(1)
3.5(c)

BYE-56105-78

3.3(b)(1)
3.5(c)

[redacted]

D. POPPY AUTOMATED PROCESSING SYSTEM (PAPS)

The goal of achieving timely production of a high volume of radar locations was achieved by the NRL/HRB development of PAPS. In September 1972, an SEL 86 computer and peripherals were installed at [redacted] and loaded with the PAPS software*. PAPS was derived from CAMS, but the larger computer and its peripheral devices permitted processing in a continuous stream. Manual intervention was still an option, and detailed listings of the output of software routines could be produced on demand. 3.3(b)(1) 3.5(c)

PAPS was fed by either digital tapes for off-line processing or by on-line data from a Priority Data Extractor (PDE). The priority data extractor performed a front-end hardware type sort of the pulse data by channel and PRI, thus accelerating the processing and timely locations of signals of interest.

[redacted]

*The computer was delivered from SEL four months prior to site deployment, with a seven-month software development having started three months earlier on a machine loaned by NSA. This system became operational two weeks after receipt at the site. Approximately two months later DNRO, Dr. John L. McLucas, personally used PAPS to locate and report two Soviet Naval combatants [redacted] five minutes after the end of the satellite pass. This illustrated the speed and ease of PAPS operations.

3.3(b)(1)
3.5(c)

VIII. IMPACT OF PROBLEMS AND ANOMALIES

Most project problems and anomalies lead to technical innovations and have been mentioned in preceding chapters. A brief summary of other obstacles is provided in the following paragraphs in the launch chronology.

A. FIRST LAUNCH - GRAB/DYNO 1, 22 JUNE 1960

This mission was useful for ELINT collection for just ninety days. In addition to the short life, the need for Presidential authorization to interrogate the satellite was a constraint on the amount of data that was collected. The actual impact of these two factors was not overly important since stateside analog analysis and budding data processing capabilities were saturated by the amount of data collected. No anomalies were observed in the intercepted data. No problems were encountered in the interrogation of the satellite or in collection and forwarding of data tapes. Scientific cover experiment SOLRAD 1 was operational for 10 months and highly successful.

B. SECOND LAUNCH, 30 NOVEMBER 1960

The Thor rocket burned out 12 seconds early and was destroyed by Range Safety. Fragments landed in Cuba. The incident resulted in the prohibition of launch trajectories ideal for the desired 70-degree inclination and forced a dogleg injection effort on subsequent launches from Cape Canaveral, Florida. This failure resulted in a nine-month lapse in GRAB collection.

C. THIRD LAUNCH - DYNO 2, 29 JUNE 1961

This launch vehicle had three spacecraft stacked one on top of the other. Failure of separation system between the topmost pair caused Dyno 2 and State University of Iowa Dr. Van Allen's INJUN satellites to remain attached in orbit. Thus Dyno 2 was used on the odd days and INJUN used on the even days during the fourteen month Dyno 2 operational lifetime. The constraint of Presidential approval of interrogations was removed. The lower of the two RF bands, 550-610 MHz, gradually reduced its collection sensitivity until after fourteen months no signals could be detected in this band. Time-sharing the satellite with INJUN precluded interrogation GRAB/Dyno 2 on half the potentially lucrative passes over the U.S.S.R.

D. FOURTH LAUNCH, 24 JANUARY 1962

The attempt was made to orbit a third ELINT satellite with the cover experiment SOLRAD 4A along with four other satellites. The

3.3(b)(1)
3.5(c)

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Thor-Able-Star launch vehicle exploded during launch due to a crack in the second stage engine. The impact of the loss of the satellite was a postponement of project intelligence collection activity.

E. FIFTH LAUNCH, 26 APRIL 1962

Another launch failure occurred in the program's first attempt from the Western Test Range at Vandenberg AFB, California. The ELINT package was the same type of configuration used on the prior attempt and SOLRAD 4B provided a cover experiment. The Scout rocket rose for slightly over two minutes and landed in the ocean within sight of the launch pad.

F. SIXTH LAUNCH - MISSION 7101, 13 DECEMBER 1962

The two satellites of Mission 7101 were injected into a highly elliptical orbit of 124 by 1500 nautical miles because the Agena D continued to burn after its programmed turn-off time. This elliptical orbit made it difficult to detect and track the telemetry signal with the fixed elevation antennas used at the collection sites.

Near perigee, the field of view of the satellites was considerably reduced to a radius as low as 900 nautical miles, about half the radius of the field of view for the intended orbit. At apogee, the radius of the field of view was approximately 2700 nautical miles.

There were some occurrences of cross-talk between the 192-237 MHz band and the 380-480 MHz band of 7101B. The possibility of erroneously assigning an RF to a signal of interest was countered by not activating both receivers for collection at the same time. The impact was not great since there was a relative scarcity of data in the higher of these bands.

Tasking of Mission 7101 was suspended on 4 May 1965, by which time two newer missions were being regularly collected with more extensive RF coverage and in nearly circular orbits.

G. SEVENTH LAUNCH - MISSION 7102, 15 JUNE 1963

The attempt to place the first POPPY triplet into a circular orbit was not entirely successful when the second-stage Agena D failed to ignite on its second circularizing burn. The resulting orbit of 95 by 495 nautical miles decayed within seven weeks. The impact was the postponement of new RF coverage for seven months.

H. EIGHTH LAUNCH - MISSION 7103, 11 JANUARY 1964

Launched into a nearly circular orbit, the three satellites of Mission 7103 were relatively free of problems until natural degradation of their storage batteries ended their useful lives. Two of these satellites lasted over a year. The third satellite (the first to use a Gravity Stabilization system) achieved a new endurance record by lasting for slightly over four years.

[redacted]

I. NINTH LAUNCH - MISSION 7104, 9 MARCH 1965

The four satellites of Mission 7104 were deployed as separated [redacted] The first 3-axis gravity gradient stabilization experiment did not perform as planned and the satellite flew sideways. Consequently, the first attempt to use a microthruster for stationkeeping could not be evaluated on this satellite.

Deterioration of the storage batteries of [redacted] caused their tasking suspensions after about sixteen months of operation. The impact was a loss of some [redacted] Low voltages created a problem with the third satellite after 42 months of useful life, leaving several months of sporadic operations when high sunlight conditions prevailed. The fourth satellite lasted for 52 months.

3.3(b)(1)
3.5(c)

J. TENTH LAUNCH - MISSION 7105, 31 MAY 1967

The thermal design of the Mission 7105 multifaced satellites favored the cold end of the thermal specification range and led to high battery voltages. The impact was negligible since the satellites could be activated to reduce the voltages even when not used for ELINT collection. Such activations were easily implemented by the 50-minute activation period and the capabilities for delayed activation and recycled activations at 100-minute intervals.

7105A, a stretched sphere with conservative solar cell power system design using four solar cell patches on each hemisphere, experienced power system low voltages during periods of low sunlight and had to be conservatively tasked thereafter.

In late 1969, as the [redacted] orientation of 7105D precluded the use of its microthruster until the [redacted] When aspect monitoring again indicated a favorable orientation, the microthruster was activated. 7105D caught up with, then went ahead of 7105C before the microthruster could again be used to eliminate the small velocity difference and restore proper spacing.

There were a number of instances of cross-talk between receivers on these satellites, resulting in inhibitions on certain tasking combinations. Many of the cross-talk situations eventually disappeared as battery voltages fell.

[redacted]

Each of the satellites eventually succumbed to deteriorating storage batteries but not until attainment of over four and one-half years of useful life.

K. ELEVENTH LAUNCH - MISSION 7106, 30 SEPTEMBER 1969

[redacted]

Tasking for the initial orbit was loaded in the satellites prior to launch to enable assessment of the initial reaction to the launch by Soviet space surveillance radars. However, nothing out of the ordinary was observed in the initial data.

3.3(b)(1)
3.5(c)

On the fourth day after launch, the Agena D apparently exploded, but no immediate adverse consequences to the satellites were observed. The resulting orbit was nearly circular, and all satellites were predicted to be within a 240 nautical mile envelope by late November. All subsystems operated as desired. No constraints were imposed on ELINT collection. Operational tasking commenced on schedule in late October 1969.

On 25 February 1970, 7106D failed to respond to interrogation by a mission ground station. Thirty minutes later, 7106B also failed to respond. [redacted]

Routine tasking of 7106A/C ceased on 28 January 1972. Intermittent collection tasking for special purposes was conducted through October 1972.

L. TWELFTH LAUNCH - MISSION 7107, 14 DECEMBER 1971 3.3(b)(1) 3.5(c)

There were some occurrences of cross-talk in receivers of Mission 7107 satellites, which very slightly constrained tasking combinations. Eventual degradation of storage batteries, starting with 7107A in April 1973, lead to power management procedures that slightly restricted tasking. Thus conserved, the satellites remain useful to date.

IX. PERFORMANCE VERSUS OBJECTIVES

Program objectives changed over the years, both in response to new intelligence requirements and as a consequence of the project's proven capabilities. [redacted]

A. GRAB/DYNO 1

In response to the requirement to collect ELINT from the U.S.S.R., Dyno 1 was activated for twenty-two 40-minute collection periods over the U.S.S.R. The chief result of this mission was the successful demonstration of the collection technology in the satellite and mission ground stations. ELINT results included the following: 3.3(b)(1) 3.5(c)

1. E band density over the European land mass was over four times that anticipated. [redacted] Both the U.S.S.R. and western Europe were found to have more equipment active in E band than the U.S.

[redacted]

5. The lack of a significant number of unidentified Soviet radar types indicated that the U.S. intelligence was quite accurate concerning Soviet E band radars with significant power. [redacted] A total of 612 Soviet emitters were identified, 42 of which were approximately located and correlated to known installations.

B. GRAB/DYNO 2

[redacted]

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3.3(b)(1)
3.5(c)

[redacted]

BYE-56105-78

[redacted]

ELINT production from Mission 7105 data was somewhat overwhelming compared to previous POPPY contributions. The technology in space and on the ground had come of age. Highlights of this production are summarized in the following items:

1. Initial detections, parametric determinations and locations were made of various ABM-associated signals:

3.3(b)(1)
3.5(c)

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3.3(b)(1)
3.5(c)

[redacted]

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

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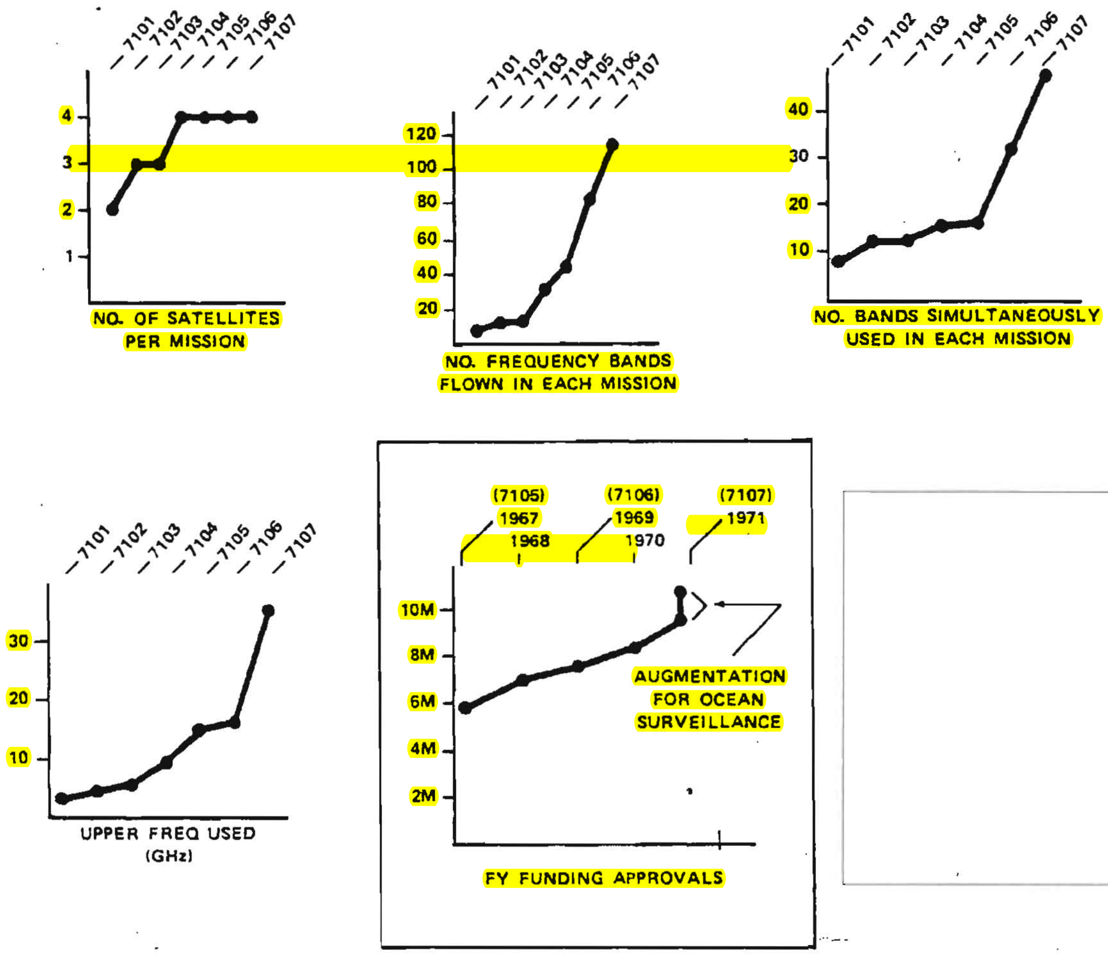
3.3(b)(1)
3.5(c)

3.3(b)(1)
3.5(c)

POPPY GROWTH



NO. OF SATELLITES PER MISSION

NO. FREQUENCY BANDS FLOWN IN EACH MISSION

NO. BANDS SIMULTANEOUSLY USED IN EACH MISSION

UPPER FREQ USED (GHz)

FY FUNDING APPROVALS

ANNEX 1

MISSION CHARACTERISTICS

BYE-56105-78

FIRST LAUNCH

PROJECT NAME:	GRAB (Walnut security clearance)
NRL MISSION:	Pre-NRO Launch: Thor-Able-Star from Cape Canaveral, Florida on 22 June 1960
ORBIT:	Elliptical with 330 by 565 nautical mile altitude, 66.7 degrees inclination, and period of 101.6 minutes.
REMARKS:	This was the first operational overhead intelligence satellite for the U.S.
GROUND STATIONS:	[redacted]
SATELLITES:	Dyno 1 Transit 2A (APL)
DIAMETER INCHES:	20
WEIGHT POUNDS:	42
NUMBER RF BANDS:	1
RF COVERAGE MHZ:	2500-3250
END OF LIFE:	9 September 1960
USEFUL LIFE:	90 days
INNOVATIONS:	First U.S. satellite with an ELINT mission and first successfully launched U.S. intelligence satellite. First U.S. pickaback launch. Fixed tuned crystal video receiver with six monopole antennas for omni-directional ELINT data reception. ELINT receiver active for 40 minutes upon interrogation from the ground.

3.3(b)(1)
3.5(c)

BYE-56105-78

Intercepted pulses transponded at [redacted] on 150 MHz omni-directional data down link.

[redacted] 3.3(b)(1) 3.5(c)

BYE-56105-78

SECOND LAUNCH

PROJECT NAME:	GRAB (Walnut security clearance)
NRO MISSION:	Pre-NRO
LAUNCH:	Thor-Able-Star from Cape Canaveral, Florida on 30 November 1960
ORBIT:	Not achieved
REMARKS:	Booster vehicle malfunctioned and was destroyed. Impacted in Cuba causing an international incident. Resulted in restrictions on all future launches from Cape Canaveral relative to acceptable launch azimuths.
SATELLITES:	Dyno Transit 3A (APL)
DIAMETER INCHES:	20
WEIGHT POUNDS:	40
NUMBER RF BANDS:	1
RF COVERAGE MHZ:	2500-3250
INNOVATIONS:	None

BYE-56105-78

3.3(b)(1)
3.5(c)

THIRD LAUNCH

PROJECT NAME: GRAB (Walnut security clearance)

NRO MISSION: Pre-NRO

LAUNCH: Thor-Able-Star from Cape Canaveral, Florida on 29 June 1961

ORBIT: Elliptical with 475 by 540 nautical mile altitude, 66.8 degrees inclination, and period of 103.8 minutes.

REMARKS: Pickaback with INJUN - failed to separate. This was the second separation failure of NRL Satellites. Design of these separation systems had not been an NRL responsibility but on all future launches NRL took the responsibility for separating their own satellites. There have been no subsequent separation failures over the last 70 satellites.

GROUND STATIONS: [redacted]

USN-13 Adak, Alaska [redacted]

[redacted]

3.3(b)(1)
3.5(c)

SATELLITES: Dyno 2, INJUN (SUI) and Transit IIIB (APL)

DIAMETER INCHES: 20

WEIGHT POUNDS: 55

NUMBER RF BANDS: 2

RF COVERAGE MHZ: 550-610
810-910

END OF LIFE: August 1962

USEFUL LIFE: 14 months

INNOVATIONS: RF coverage extended to two portions of the spectrum.

[redacted]

BYE-56105-78

FOURTH LAUNCH

PROJECT NAME:	GRAB (Walnut security clearance)
NRO MISSION:	Pre-NRO
LAUNCH:	Thor-Able-Star from Cape Canaveral, Florida on 24 January 1962
ORBIT:	Not achieved
REMARKS:	No guidance on Able-Star stage
SATELLITES:	Dyno + 4
DIAMETER INCHES:	20
WEIGHT POUNDS:	55
NUMBER RF BANDS:	2
RF COVERAGE MHZ:	165-185 2600-3250
INNOVATIONS:	Attempt to place five satellites into orbit using a single launch vehicle.

3.3(b)(1)
3.5(c)

BYE-56105-78

FIFTH LAUNCH

PROJECT:	GRAB (Walnut security clearance)
NRO MISSION:	Pre-NRO
LAUNCH:	Scout from Vandenberg AFB, California on 26 April 1962
ORBIT:	Not achieved
REMARKS:	Scout was launched with no attitude control gas in the fourth stage.
SATELLITES:	Dyno
DIAMETER INCHES:	20
WEIGHT POUNDS:	55
NUMBER RF BANDS:	2
RF COVERAGE MHZ:	165-185 2600-3250
INNOVATIONS:	First project launch from Western Test Range.

3.3(b)(1)
3.5(c)

BYE-56105-78

SIXTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7101

LAUNCH: Thor-Agena D from Vandenberg AFB, California on 13 December 1962

ORBIT: Highly elliptical with 124 by 1500 nautical mile apogee, 70.3 degrees inclination, and period of 116.0 minutes.

REMARKS: First burn in second stage continued until fuel was depleted.

GROUND STATIONS:

3.3(b)(1)
3.5(c)

SATELLITES:	Alfa	Bravo	INJUN + 2 scientific satellites,
DIAMETER INCHES:	20	20	
WEIGHT POUNDS:	55	55	
NUMBER RF BANDS:	4	4	
RF COVERAGE MHZ:	165-200 320-390 510-610 2000-2750	192-237 380-480 570-710 2600-3250	
END OF LIFE:	4 May 65	4 May 65	
USEFUL LIFE:	28 months	28 months	
INNOVATIONS:	First dual-satellite POPPY launch.		

BYE-56105-78

Use of stretched 2Ø-inch diameter sphere design on 71Ø1A/B.

3.3(b)(1)
3.5(c)

First program launch without accompanying unclassified SOLRAD scientific cover experiment.

BYE-561Ø5-78

SEVENTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7102

LAUNCH: Thor-Agena D from Vandenberg AFB, California on 15 June 1963

ORBIT: Highly elliptical with 95 by 495 nautical mile altitude rapidly decaying, 69.9 degrees inclination, and period of 94.1 minutes.

REMARKS: No Agena second burn - failed to circularize.

GROUND STATIONS: [redacted]

SATELLITES:	Alfa	Bravo	Charlie - two scientific satellites
DIAMETER INCHES:	24	24	20
WEIGHT POUNDS:	85	85	65
NUMBER RF BANDS:	4	4	4
RF COVERAGE MHZ:	260-320 450-550 830-1080 2500-3120	230-290 480-580 665-855 3000-3650	90-105 170-205 1300-1750 3250-4100
END OF LIFE:	1 Aug 63	30 Jul 63	27 Jul 63
USEFUL LIFE:	47 days	45 days	42 days

3.3(b)(1)
3.5(c)

INNOVATIONS: First launch of a POPPY triplet.

[redacted]

BYE-56105-78

EIGHTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7103

LAUNCH: TAT-Agena D from Vandenberg AFB, California on 11 January 1964

ORBIT: Nearly circular with 490 by 506 nautical mile apogee, 69.9 degrees inclination, and period of 103.41 minutes.

REMARKS: (TAT) thrust augmented Thor. Three solid rockets strapped to booster.

GROUND STATIONS:

3.3(b)(1)
3.5(c)

SATELLITES:	Alfa	Bravo	Charlie
DIAMETER INCHES:	20	24	20
WEIGHT POUNDS:	65	89	84
NUMBER RF BANDS:	4	4	4
RF COVERAGE MHZ:	170-205 575-720 820-1080 3800-4800	156-180 482-610 660-865 2500-3120	105-125 1050-1360 1580-2020 4650-5150
END OF LIFE:	27 Mar 65	28 Jul 65	20 Jan 68
USEFUL LIFE:	13 months	18 months	48 months

INNOVATIONS: Axis of 7103C aligned to within 8 degrees of vertical using 2-axis gravity gradient stabilization with sphere at end of 28-foot boom with tip mass containing magnetic anchor in viscous fluid. Satellite was designed to generate either boom up or boom down by use of omni-directional antennas.

BYE-56105-78

3.3(b)(1)
3.5(c)

BYE-56105-78

NINTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7104

LAUNCH: Thor-Agena D from Vandenberg AFB, California on 9 March 1965

ORBIT: Nearly circular with 490 nautical mile perigee by 506 nautical mile apogee, 70.1 degrees inclination, and period of 103.6 minutes.

GROUND STATIONS:

SATELLITES:	Alfa	Bravo	Charlie	Delta - 4 scientific satellites
DIAMETER INCHES:	24	24	24	24
WEIGHT POUNDS:	103	106	130	130
NUMBER RF BANDS:	8	8	8	8
RF COVERAGE MHZ:	165-202 230-292 550-1080 2650-3090 3180-4180	165-245 440-655 815-1085 1820-2900 2940-3320	155-184 275-455 1070-1860 3800-5900	100-1000 4850-5550 5850-8400 9050-9500
END OF LIFE:	1 Aug 69	5 Jul 66	29 Oct 68	30 Aug 66
USEFUL LIFE:	52 months	16 months	42 months	18 months

3.3(b)(1)
3.5(c)

INNOVATIONS: RF coverage extended to X band, without a gap from 155 to 9500 MHz.

First launch of four POPPY satellites.

Three-axis gravity gradient stabilization implemented with 7104D

BYE-56105-78

Approved for Release: 2019/01/30 C05096560

Used Eddy current damper to control librations.

Use of microthrusters for stationkeeping [redacted]

[redacted]

First eight payload launch.

3.3(b)(1)
3.5(c)

BYE-56105-78

TENTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7105

LAUNCH: Thor-Agena D from Vandenberg AFB, California on 31 May 1967

ORBIT: Nearly circular with 500 by 508 nautical mile altitude, 70.0 degrees inclination, and period of 103.3 minutes.

GROUND STATIONS: [redacted]

SATELLITES:	Alfa	Bravo	Charlie	Delta
DIAMETER INCHES:	24	27	27	27
WEIGHT POUNDS:	109	182	162	222
NUMBER RF BANDS:	10	10	12	12
RF COVERAGE MHZ:	153-200 550-1108 2560-3315	153-200 550-922 2560-3615	100-124 195-550 920-2520 3600-4055 4910-5080 6460-6710	196-553 920-2520 4920-5080 6450-9515 14500-14800
END OF LIFE:	3 Mar 72	3 Mar 72	Dec 71	3 Mar 72
USEFUL LIFE:	57 months	57 months	54 months	57 months

3.3(b)(1)
3.5(c)

INNOVATIONS: Aspect monitoring systems on all satellites.

RF coverage extended to J band.

[redacted]

BYE-56105-78

[redacted]

3.3(b)(1)
3.5(c)

BYE-56105-78

Approved for Release: 2019/01/30 C05096560

ELEVENTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7106

LAUNCH: Thorad-Agena D from Vandenberg AFB, California on 30 September 1969

ORBIT: Nearly circular with 491 nautical miles perigee and 506 nautical mile apogee, 70.0 degrees inclination, and period of 103.5 minutes.

REMARKS: Thorad-stretched fuel tank on booster

GROUND STATIONS: [redacted]

SATELLITES:	Alfa	Bravo	Charlie	Delta - 5 space available scientific sat.
DIAMETER INCHES:	27	27	27	27
WEIGHT POUNDS:	235	228	247	236
NUMBER RF BANDS:	20	20	21	21
RF COVERAGE MHZ:	154-242 350-1093 1790-3315 5220-6790 8580-10040	154-242 347-1092 1790-3315 5235-6720 8560-10070	154-200 240-450 548-652 836-9971 1082-2595 2680-5260 6690-8600 14750-15110	154-200 242-452 548-652 836-971 1080-2590 2675-5250 6675-8620 14595-14970
END OF LIFE:	28 Jan 72	25 Feb 70	28 Jan 72	25 Feb 70
USEFUL LIFE:	28 months	5 months	28 months	5 months

3.3(b)(1)
3.5(c)

INNOVATIONS: [redacted]

BYE-56105-78

3.3(b)(1)
3.5(c)

[redacted]

BYE-56105-78

TWELFTH LAUNCH

PROJECT NAME: POPPY (Byeman EARPOP)

NRO MISSION: 7107

LAUNCH: Thorad-Agena D from Vandenberg AFB, California on 14 Decembeer 1971

ORBIT: Nearly circular with 530 nautical miles perigee and 540 nautical mile apogee, 70.0 degrees inclination, and period of 104.9 minutes.

GROUND STATIONS: [redacted]

3.3(b)(1)
3.5(c)

SATELLITES:	Alfa	Bravo	Charlie	Delta
DIAMETER INCHES:	27	27	27	27
WEIGHT POUNDS:	270	270	282	282
NUMBER RF BANDS:	16	16	21	21
RF COVERAGE MHZ:	154-200 545-970 1785-4857 5227-6785 9200-9600 16980-18040	154-200 550-975 1800-4862 5200-6755 9200-9600 12570-14520	202-551 813-1813 2082-2596 2682-2928 4837-5265 6410-10550 14465-16070 34680-35000	204-550 814-1810 2182-2590 2682-2931 4825-5268 6398-10545 14438-15155 15950-17060 34680-34980
END OF LIFE:	2 Aug 77	2 Aug 77	2 Aug 77	2 Aug 77
USEFUL LIFE:	68 months	68 months	68 months	68 months

INNOVATIONS: Wave polarization measurement experiment.

Coverage extended to EHF region.

[redacted]

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ANNEX 2

COST DATA

FUNDING AUTHORIZED IN $MILLIONS

FISCAL YEAR	MISSIONS	ARPA/ NAVY	NRP[1]	CCP[2]	TOTAL
1958	NONE	0.2			
1959	NONE	0.225			
1960	DYNO 1	0.79			
1961	DYNO 2 AND ABORT	3.025			
1962	TWO FAILURES	1.5			
1963	7101A/B 7102A/B/C		7.343		
1964	7103A/B/C		6.0		
1965	7105A/B/C/D		6.0		
1966	NONE		6.0		
1967	7105A/B/C/D		5.847		
1968	NONE		7.031		
1969	NONE		7.54		
1970	7106A/B/C/D	1.550[3]	8.42		
1971	NONE	0.750[3]	10.899		
1972	7107A/B/C/D		0.768		
1973	NONE		1.658		
1974	NONE		1.526		
1975	NONE		1.382		
1976&TQ	NONE		1.804		
1977	NONE		0.787		
1978	NONE		0		
TOTALS:[4]	11 LAUNCHES	$8.04	$73.005		

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FOOTNOTES ON FUNDING

1 NRP funding authorizations do not include funding to Program A for costs of launch vehicles and for launch vehicle/satellite integration.

2 CCP costs are not available. CCP funding would include the costs of analysis and data processing at NSA, the costs of magnetic and digital tapes provided to the mission ground stations for recording data, and costs of military personnel and facilities support at the mission ground stations. All other ground station costs from antennas and receivers to computer and software are included however.

[redacted]

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4 Cumulative program costs for 14 launches (11 successful) and 29 satellites, as well as building, deploying, maintaining [redacted] dedicated ground stations for an 18 year period was approximately <u>$81 Million</u> dollars, excluding Program A costs for launch vehicles.

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ANNEX 3

KEY CONTRIBUTORS

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~~[illegible] VIA TALENT-KEYHOLE/COMINT CONTROL SYSTEMS JOINTLY~~

KEY MANAGEMENT POSITIONS/INCUMBENTS

Director, Naval Intelligence/Director, Project GRAB:

RADM L. H. Frost USN . . . . August 1959 to September 1960
RADM V. L. Lowrance USN . . . . September 1960 to July 1962

Director, Program C:

RADM V. L. Lowrance USN . . . . July 1962 to June 1963
RADM R. L. Taylor USN . . . . June 1963 to May 1966
CAPT M. H. Rindskopf USN . . . . May 1966 to July 1966
RADM E. B. Fluckey USN . . . . July 1966 to June 1968
CAPT F. Murphy USN . . . . June 1968 to August 1968
RADM F. J. Harlfinger USN . . . . August 1968 to July 1971
RADM R. K. Geiger USN . . . . January 1971 to July 1975
CAPT R. T. Darcy USN . . . . July 1975 to July 1977
RADM G. M. Yowell . . . . July 1977 to Present

Director, Naval Security Group:

CAPT L. R. Shulz USN . . . . June 1960 to July 1961
RADM T. R. Kurtz USN . . . . July 1961 to December 1961
CAPT L. R. Shulz USN . . . . December 1961 to January 1962
RADM T. R. Kurtz USN . . . . January 1962 to August 1963
RADM R. E. Cook USN . . . . August 1963 to July 1968

Commander, Naval Security Group Command:

RADM R. E. Cook USN . . . . July 1968 to June 1971
RADM C. G. Phillips USN . . . . June 1971 to August 1974
RADM G. P. March USN . . . . August 1974 to September 1978

Naval Research Laboratory GRAB/POPPY Project Manager:

Mr. H. O. Lorenzen . . . . August 1959 to February 1973
Mr. R. D. Mayo . . . . February 1973 to Present

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~~TOP SECRET~~ [redacted]

SIGNIFICANT EVENTS/INNOVATIONS AND KEY CONTRIBUTORS

INITIAL CONCEPT/SYSTEM PERFORMANCE REQUIREMENTS (NRL)

Mr. R. D. Mayo originated the concept of the Dyno ELINT satellite in early 1958. Messrs. H. O. Lorenzen and J. H. Trexler expanded the concept and coordinated with other organizations to provided for multi-agency participation, the use of SIGINT stations for data collection, and forwarding of data to NSA for processing and product dissemination. RADM Reed of ONI advanced the NRL Proposal through the Navy, ARPA, DOD elements, and the executive branch to secure presidential approval.

SATELLITE DESIGN (NRL)

Mr. M. J. Votaw adapted the Vanguard design to accommodate Dyno and the Solar Radiation cover experiment. He also established the interface between Dyno 1 and Transit 2A for the first dual-satellite launch. Subsequently, Mr. E. L. Dix was the chief design engineer for the satellites. Mr. P. G. Wilhelm became responsible for the satellite technology from 1965 to present.

SATELLITE POWER SUBSYSTEM AND THERMAL DESIGN (NRL)

Mr. F. W. Raymond supervised the overall design of the power subsystem with the solar cell array designed by Mr. J. Yuen and the power subsystem conditioning package designed by Mr. J. G. Winkler. Mr. R. S. Rovinski designed the thermal subsystem for all of the Dyno and POPPY satellites.

COMMAND AND TELEMETRY (NRL)

The command and telemetry subsystems for the first Dyno and the early POPPY satellites were implemented by Messrs. Dix and Wilhelm. Later refinements were made under the supervision of Mr. Wilhelm. These included improved telemetry and data link transmitters by Mr. L. E. Hearton; command and telemetry subsystem expansions and refinements by Mr. Winkler; on-board storage memory for engineering measurements and timed command activation by Mr. R. E. Eisenhauer; and development of the PCM telemetry subsystem by Mr. Eisenhauer and Mr. R. O. Wilson.

The original interrogation and telemetry readout subsystems for the ESV huts were designed and implemented by Mr. Dix. These subsystems were later expanded and refined by Messrs. W. E. Withrow and A. Q. Tool as the transition was made into permanent buildings.

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ELINT COLLECTION (NRL)

Mr. Mayo established the overall performance requirements for the ELINT subsystems in the succession of satellites based on [redacted] (STIC) derivation of suitable collection requirements from the current national intelligence requirements. The chief designer of the ELINT payloads was Mr. V. S. Rose. These designs were implemented, tested, and installed in the Dyno and POPPY satellites by Messrs. V. S. Rose, E. G. Becke, and L. E. Earl. 3.5(c)

Mr. Mayo designed the original collection system for the ESV huts and supervised implementation. Later refinements and expansions of the collection system inside permanent buildings were supervised by Mr. Mayo with designs and implementation and testing by Messrs. F. V. Hellrich and W. M. McDavit of NRL and by Messrs. L. M. Hammarstrom, M. J. Van de Walle, and J. N. O'Connor of HRB-Singer, Inc.

SATELLITE STATIONKEEPING (NRL)

Mr. R. T. Beal designed and implemented the 2-axis gravity gradient stabilization used in the POPPY satellites. Mr. Beal also designed and implemented the passive tip mast yaw stabilization concept to provide 3-axis stabilization. The active, electronic flywheel yaw stabilization method was adapted from Nimbus satellites for POPPY by Mr. G. E. Flach. Mr. F. Raymond developed the specifications for injecting multiple satellites into their desired orbits and [redacted] The microthruster subsystems were designed by Mr. Wilhelm and implemented by Mr. P. Carey. Satellite aspect monitoring and control methods were developed by Messrs. Wilhelm, Beal, Raymond, and Rovinski. Mr. Raymond determined the timing and degree of thrusting necessary for stationkeeping. Actual thrusting manuevers were conducted by Messrs. Wilhelm, Carey, and Beal. 3.3(b)(1) 3.5(c)

LAUNCH VEHICLE/SPACECRAFT INTEGRATION

Mr. Dix coordinated integration efforts for the launches from Cape Canaveral. After 1962, the Director, Program A had the responsibility for booster/spacecraft integration. During later POPPY launch preparations, CAPT G. Geyer USAF supervised contractor functions and coordinated with NRL representatives from Mr. Wilhelm's organization.

SIGNAL LEVEL [redacted] (NRL)

Mr. Eisenhauer conceived and designed the signal level [redacted] measurement experiments used in POPPY. These designs were implemented and refined by Messrs. B. W. Ryon and J. W. Phillips.

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MISSION GROUND STATION FACILITIES (NRL)

Mr. C. W. Price adapted the ESV huts for Dyno and POPPY interrogation and collection functions, including the ESV hut layouts and installations of equipment. Later, Mr. Price coordinated the moves into permanent buildings and equipment installations with cognizant personnel at SIGINT stations. He developed the preliminary building design and facility concept as well as provided the layout of the operational equipment for the receiving recording and data processing for the three MILCON projects.

MISSION GROUND STATION OPERATIONS MANAGEMENT (NSG)

CDR F. Hitz chaired the first TOG steering committee and supervised the development of the GRAB/POPPY operations management system. Key focal point managers during the project's coming-of-age were Commanders L. McGraw and R. W. Olson. Among the POPPY project officers at mission ground stations making significant contributions to management and data exploitation were Lieutenants R. L. Potts, R. E. Lentz, B. F. Booth, and R. L. Kellogg. CPO R. B. Kargle was foremost among the senior enlisted men who managed personnel and day-to-day operations and propagated their knowledge of ELINT in the field. LCDR J. Morgan of NSG headquarters coordinated operations with POPPY project officers during the early seventies and organized the POCG at NSA in 1975.

NSA DATA PROCESSING

[redacted]

ANALOG ANALYSIS

[redacted]

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[redacted]

FIELD DIGITIZATION

Mr. F. V. Hellrich of NRL and Mr. L. M. Hammarstrom of HRB were the architects of the system to digitize POPPY data in the field in 1967. Mr. M. J. Van de Walle of HRB developed the first linear phase receiving system and the RS-1A solid-state receivers. Mr. M. Sheets of NRL conceived of and specified the adaptive thresholding technique. Mr. T. W. Fisher and Mr. J. R. Lindley of NRL designed and implemented the buffered memory digital recording system for the ADDS/digital tape interface.

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1971 OCEAN SURVEILLANCE AUGMENTATION

CAPT L. Moffit and [redacted] of the staff of Director, Program C managed the validation process for employing Missions 7105 and 7106 to provide ocean surveillance information to U.S. Navy fleet commanders. 3.5(c)

[redacted]

Lieutenants R. E. Lentz and B. F. Booth supervised the development of the PAPS operating capability at [redacted] in 1972-1973.

SYSTEM ENGINEERING AND INTEGRATION

Mr. L. M. Hammarstrom of HRB and, subsequently, NRL provided overall spacecraft/ground station engineering, integration, and testing functions 1964 through 1976.

3.3(b)(1)
3.5(c)

GENERAL

The above names and contributions are representative of generations of talented and dedicated individuals from NRL, NSA, NSG, AFSS, ASA, CIA, HRB, ONI, Program C staff, Program A, NRO staff, and NAVSPASUR who developed, operated, supported and exploited the POPPY System.

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ANNEX 4

GLOSSARY OF POPPY-RELATED TERMS

TERM	EXPLANATION
Athos	- German-developed crystal video receiveer of WWII. Probably named after Mount Athos in northeastern Greece, home of celibate monks inhabiting 20 monastaries. One thousandth anniversary of founding of first monstary, Great Lavra, in 1963. Book on Athos monastaries published in Germany in 1943 (Moenchsland Athos by F. Doelger).
[redacted]	
GRAB	- Galactic Radiation and Background. Covername for Project Dyno ELINT satellites.
GREB	- Galactic Radiation Energy Balance.
[redacted]	- NRO SOC title for Mission 7100 series Reports Control Manual.
Reptile	- Unclassified name used at NSA for POPPY project.
[redacted]	
SISS ZULU	- Unclassified name used within the Naval Security Group to refer to the POPPY project.
SOLRAD	- Solar Radiation measurement packages carried along with ELINT payloads. This legitimate scientific payload formed excellent "cover story" for the Dyno ELINT payloads through the pre NRO period.
[redacted]	
Transit 2A	- Second Navy navigation satellite, shared launch vehicle with Dyno 1 on 22 June 1960. First successful dual-satellite launch.
Transit 4A	- Navy navigation satellite was the primary payload on the launch vehicle with Dyno 2 on 29 June 1961.
Walnut	- Name of security project for safeguarding details of the Dyno ELINT satellites. CANIS security oath.
[redacted]	

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ANNEX 5

BIBLIOGRAPHY

[redacted]

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NSA product reports

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LT R. L. Kellogg USN: binders of source material, notes

NRL technical satff

LCDR R. L. Potts USN: original draft dated 15 June 1978 TS BYEMAN/TK/ COMINT Jointly

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