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LEO SYSTEMS PROGRAM OFFICE

U.S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)

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PREFACE

~~(S/B)~~ Mission [redacted] has included [redacted] of satellites: POPPY, which was operational from 1962-77; [redacted] present. A progenitor, GRAB, preceded the NRP and was operational from 1960-62. GRAB and POPPY were ELINT search and technical intelligence collectors, directed against Soviet air and ballistic missile defense systems. POPPY Mission [redacted] was used in 1968-69 to demonstrate the potential for [redacted] by means of low earth orbit satellites. In 1970, the USIB added EOB production and ocean surveillance to POPPY mission guidance. [redacted]

~~(S/B)~~ A record of POPPY (Missions [redacted] is given in the *History of the Poppy Satellite System* (1978). The format was suggested by topics specified by the DNRO:

> ... program objectives, costs, contractors, mission launch and termination dates, significant problems and anomalies and their mission impacts, significant intelligence contributions, an overview of mission successes and failures, ground stations, key personnel, etc. [redacted] Cite 1354, 30 Sep 1977)

The 96-page report was prepared at [redacted] in a period of weeks, and it complied with the task, literally. Each topic was addressed in turn, beginning to end. The report records technology and techniques and their evolution. No particular effort was made to make the report lively or readable. Those significantly involved in conceiving, implementing, and supporting POPPY are mentioned only in an appendix, titled "Key Contributors."

~~(S/B)~~ In October 1996, Capt (now RAdm) Rand H. Fisher (then the LEO systems program manger) commissioned the history of [redacted] (Missions [redacted]. He suggested a chronological, event-driven narrative. What happens in the world, affects design. What is developed, affects operations. Key players should be identified and credited with their contributions as the narrative proceeds. Nor should the history gloss over pitfalls and false starts that are part of every real system development. We should tell about near misses and failures, as well as successes; disagreements, as well as agreements and compromises; losses and gains. The objectives were to satisfy the NRO requirement for a [redacted] history and edify those who get the chance to read it. The document was to be written for the men and women who work in our laboratories, industrial facilities, and ground stations and who want to know more about roots of systems they make happen and perform operationally.

~~(S/B)~~ While research and writing were underway, the scope changed — as a consequence of decisions, within the NRO and NSA, to accelerate consideration of POPPY for declassification and potential public disclosure. The operational systems [redacted] program management office of the LEO SPO, under the late [redacted] was tasked by the joint POPPY declassification integrated process team (IPT) to provide materials, including text, historical references, and artifacts. Accordingly, greater emphasis was placed on [redacted] precursors, particularly GRAB, which had been treated only cursorily in the 1978 POPPY history, and on identifying documents of potential interest to historians. The story of [redacted] turned into a story of [redacted] and predecessors and a supporting historical archive.

~~(S/B)~~ *U. S. Navy/NRO Program C Electronic Intelligence Satellites (1958-1977)*, a history of GRAB and POPPY, is provided herewith to support the POPPY declassification IPT. The first six chapters — distributed by the LEO SPO in January as *U.S. Navy Electronic Intelligence Satellites (1958-1962)* — have received minor corrections and additions resulting from further research. Some additional paragraphs are now unclassified, consistently with DCI approval, on 30 April 1998, of the SIGINT Committee's request to declassify specific aspects of GRAB for public disclosure as part of the Naval Research Laboratory's 75th anniversary celebration in June 1998.

EXECUTIVE OVERVIEW

(U) A U.S. Navy ELINT satellite system became operational in July 1960 and was operated until August 1962. The mission was to obtain information on Soviet air defense radars that could not be observed by Air Force and Navy ferret aircraft flying ELINT missions along accessible borders in Europe and the western Pacific.

(U) The system was proposed by the Naval Research Laboratory in the spring of 1958. In parallel with exploratory development by the NRL, the Office of Naval Intelligence obtained endorsements of Project Tattletale from elements of the executive and legislative branches. With positive recommendations from State, Defense, and CIA, President Eisenhower approved full development on 24 August 1959. By then, the project had been placed under a limited distribution security control system (Canes) with access limited to fewer than two hundred people in the Washington D.C. area. Development and interagency coordination proceeded as the GRAB (Galactic Radiation and Background) experiment.

(U) After NRL completed development of the GRAB satellite and a network of overseas ground collection sites, a first launch was approved by Eisenhower on 5 May 1960, just four days after a CIA U-2 aircraft was lost on a reconnaissance mission over Soviet territory. The GRAB satellite got a free ride into space on 22 June 1960 with Navy's third Transit navigation satellite. GRAB carried two electronic payloads, the classified ELINT package and instrumentation to measure solar radiation. The SolRad experiment was publicly disclosed in DoD press releases on this and subsequent launches. The cost to achieve an initial operating capability was [redacted] Four more launches were attempted, one of them successfully on 29 June 1961. Total cost of the program was [redacted]

(U) The Director of Naval Intelligence exercised overall control. Field sites were operated by elements of the Army, Navy, Air Force, and CIA. Data recorded on magnetic tape was couriered back to the NRL. Tapes were evaluated, duplicated, and forwarded to the NSA at Army Fort Meade, Maryland, and the Strategic Air Command at Offut Air Force Base Omaha, Nebraska, for analysis and processing. In searching the tapes for new and unusual signals, NSA found that the Soviets were already operating a radar that supported a capability to destroy ballistic missiles. The [redacted] SAC's processing was aimed at building the SIOP (single integrated operations plan), a responsibility of the Joint Strategic Targeting Staff at Offut AFB.

~~(S/B)~~ Shortly after the NRO was officially established as an operating agency of the DoD, the Navy ELINT satellite project and its multi-agency infrastructure were assimilated in the NRP as Program C (Navy) in July 1962. The GRAB successor, two-ball POPPY 1/Mission [redacted] was launched five months later and was followed, in the next nine years, by six more launches of three or four POPPY satellites at a time. Starting as an ELINT general search system, the POPPY mission gradually expanded, as capabilities improved, to encompass: general search, ABM search, technical intelligence, EOB production, and ocean surveillance.

~~(S/B)~~ Growing concern in the U.S. defense establishment about demonstrated abilities of Soviet fleets to project military power across seas and oceans, was registered in 1970 by the USIB's designation of ocean surveillance as a national intelligence objective. Pursuant to a study conducted by the Defense Science Board, POPPY was upgraded by NRO and Navy to become an interim ocean surveillance system. Meanwhile, NRO, Navy, and NSA conducted broader studies to determine an optimum system and concluded in 1972 that the POPPY technology, infrastructure, and operational concept should evolve to [redacted] POPPY operations continued at [redacted] MGSs until 1977, when [redacted]

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(U) *Antecedents to surveillance from space in the 1950s were well publicized American and Russian participation in an international space program and parallel, covert U.S. efforts to gain more knowledge of new Soviet weapons and defenses. The Naval Research Laboratory participated in both endeavors.*

Vanguard

(U) In October 1954, planners of the International Geophysical Year, meeting in Rome, Italy, adopted an American proposition that artificial satellites could be placed in orbit above the Earth's atmosphere to observe extra-terrestrial radiation and geophysical phenomena. Proposals from the U.S. armed services circulated in the spring of 1955, and the U.S. National Security Council consented to the idea of a space program with a peaceful purpose, if it would not interrupt ballistic missile programs — a particular concern of Secretary of Defense Charles E. Wilson. An advisory panel of eminent scientists was formed by Donald A. Quarles, assistant secretary of defense for research and development (R&D), to evaluate the several proposals to achieve earth-circling satellites. In midsummer, the White House and Kremlin separately announced intentions to put satellites into orbit during the 18-month scientific program, to start in two years. International participation, down to the grass roots level, would be enabled by coordinated efforts to track the small, manmade objects in outer space, using both radio and optical equipment. The U.S. Department of Defense (DoD) committed technical skills, equipment, and facilities of the Army, Navy, and Air Force to build, launch, and operate a scientific satellite for the National Academy of Sciences. American universities and government laboratories submitted ideas for experiments to the U.S. national committee for the International Geophysical Year. Those selected were funded by the National Science Foundation.

(U) The Naval Research Laboratory (NRL) in southwest Washington, D.C., was selected by Assistant Secretary Quarles' advisory panel in late summer to develop the scientific satellite and a passive tracking system. Administrated by the Department of the Navy (DoN) through the Office of Naval Research, the Navy Lab had a solid track record, extending back to 1946, in investigating physical phenomena and properties of the upper atmosphere by means of sounding rockets that telemetered scientific measurements back to earth. SecDef Charles Wilson formally assigned overall technical responsibility for the National Academy satellite to the Navy on 9 September 1955. The Air Force would provide a launch site and support from the Patrick Air Force Base ballistic missile test center at Cape

Canaveral, Florida. The Army would build tracking stations and provide communication circuits. The Glenn L. Martin Company in Baltimore, Maryland, won a competed contract to develop a rocket, built to NRL's specification of major characteristics and required performance. Martin had previously manufactured for NRL the Viking sounding rocket, first fired in 1949. The Viking would be adapted as the first stage of a nonmilitary three-stage launch vehicle for scientific Project Vanguard. NRL's contract with Martin called for six test vehicles and six satellite launch vehicles, the expectation being that one in six attempts to orbit a satellite would succeed. In the same time frame, under a higher DoD priority, Martin undertook developmental work as prime contractor for the Air Force Titan intercontinental ballistic missile (ICBM). The first Vanguard test vehicle, a single-stage refurbished Viking, was launched in December 1956.

(U) The Russians were first in space. The Kremlin announced, on 26 August 1957, successful firing of an ICBM. Sputnik was launched on a modified ICBM from Tyuratam on 4 October carrying a scientific payload that transmitted for 23 days. On 3 November, Sputnik 2 went into orbit, with a live dog as a passenger, and transmitted for seven days. Plans were announced to begin lunar flights in two years. The space feats boosted Russian national pride and benefited the U.S.S.R. economically and politically, while the U.S. debated national priorities and capabilities in the news media and on Capitol Hill in Washington, D.C.

(U) Vanguard had completed three successful test vehicle firings, and the first launch of three live stages with a minimal four-pound spherical test payload was scheduled for December. As backup to Vanguard, ordered by President Eisenhower after Sputnik 1's triumph, the new secretary of defense, Neil H. McElroy, approved on 8 November an updated proposal from the U.S. Army Ballistic Missile Agency in Huntsville, Alabama, for two attempts to orbit a satellite using a modified Jupiter C intermediate range ballistic missile (IRBM). A 20-pound cylindrical Vanguard instrumentation package, designed to measure cosmic radiation and meteoric impact, was transferred from NRL to the Jet Propulsion Laboratory in Pasadena, California, for adaptation to a 31-pound, bullet-shaped satellite named 'Explorer'.

(U) While the U.S. scientific program was being augmented in response to Sputnik, the responsibility of DoD's director of guided missiles was expanded to include military space programs. Military operational requirements for satellites were under review by the Armed Forces Policy Council. The council was chaired by SecDef Neil McElroy and included the deputy secretary of defense, service secretaries, and service chiefs. Council member Adm Arleigh A. Burke, chief of naval operations (CNO), designated RAdm John E. Clark, director of the guided missiles division in the office of CNO, to speak for the Navy. Clark stated the Navy's operational requirements for reconnaissance/surveillance (most urgent), navigation, communication, and anti-submarine warfare detection satellites. He listed as common to all three services, requirements for a weather satellite, an electronic countermeasure satellite, and a nuclear armed missile space platform (Nov 57).

(U) At midday on the 6th of December, the U.S. failed its first attempt to orbit a test payload when the new Vanguard rocket lost thrust, tipped, and exploded seconds after liftoff from its launch stand at Cape Canaveral — to the dismay of millions of Americans tuned to live broadcasts. [The damaged 6.4-inch sphere is on exhibit at the Smithsonian Air and Space Museum near a full-scale Vanguard launch vehicle.]

(U) Undaunted by the Vanguard failure, NRL distributed 200 copies of an updated 121-page secret report of its collective vision for America's space program beyond Vanguard (10 Dec 57). Forty NRL contributors were guided by John P. Hagen, who directed Project Vanguard. Included among military, operational, and scientific satellites were systems designed for radio navigation, nuclear weapons test reconnaissance, electronic intelligence reconnaissance, communication, geophysics, solar physics, interplanetary and cosmic research, manned flight and biological experiments, lunar vehicles, and satellite launching vehicles and facilities. The report showed that most needs could be met by 300-pound satellites launched by an IRBM for the first stage (either Air Force Thor or Army Jupiter) and Vanguard hardware for upper stages. The post-Vanguard program was included as part of Navy recommendations, compiled by the Bureau of Ordnance, for the national satellite and space vehicle program (24 Dec 57). A month later, Capt Peter H. Horn, NRL's military director, forwarded a copy of the entire report directly to CNO Arleigh Burke (22 Jan 58).

(U) The Army delivered the birth of outer space exploration for the U.S. by its launch of Juno, a hastily modified Jupiter C, on 31 January 1958, carrying battery-powered Explorer into elliptical orbit. Anomalous scientific data, transmitted to the Vanguard Minitrack stations for nearly four months, contributed to James A. Van Allen's later discovery of the Earth's inner radiation belt, which interfered with his cosmic ray experiment at high altitudes. A second Vanguard attempt to orbit a minimal payload on 5 February again disappointed America, due to a control system failure a minute after liftoff.

(U) Military and intelligence potential of space-based systems quickly gained widespread appreciation in the DoD. Study efforts became projects. SecDef Neil McElroy formally established the Advanced Research Projects Agency (ARPA) to replace an ad hoc (guided missiles) group and oversee space-related research and development within the military departments (7 Feb 58). Under Roy W. Johnson, recruited from General Electric, ARPA was quickly staffed by civilians from the office of the secretary of defense (OSD) and military officers from the Army, Navy, Marine Corps, and Air Force. RAdm John Clark was reassigned from duty as OpNav's director of guided missiles to become ARPA's deputy director. ARPA backed a continuation of the Army Explorer project and funded full-scale development of an Air Force advanced reconnaissance system (Sentry).

(U) Among the needs for a satellite to support naval warfare was an electronic countermeasure satellite, an operational requirement that Navy shared with Army

and Air Force. The avionics division of the Navy Bureau of Aeronautics, which answered to ECM-related requirements other than shipborne configurations, requested by confidential letter that the NRL establish a new priority B problem: "To design, develop, and fabricate an Electronic Countermeasures Intercept System, subminiaturized, lightweight, for supersonic vehicles" (5 Mar 58). The ECM intercept system of the future was intended to cover 1000 to 10000 MHz (50 MHz to 50 GHz desired), be compatible with tri-service efforts in ECM and supersonic vehicle fields, be installed on either manned or unmanned vehicles, and automatically retransmit intercepted data to existing naval receiving stations. Equipment for evaluation was wanted by 1 January 1959. The new problem would supersede a long-standing project to develop wide open radar intercept systems for naval early warning aircraft (NRL Problem 54R06-17). On that same day, 5 March, the Army Explorer team's second satellite failed to attain orbit when the fourth stage did not ignite.

(U) The Vanguard team's third try with a test payload, on 17 March 1958, went according to plan. Solar powered Vanguard 1 was deployed in an elliptical orbit, transmitted its signal for seven years, and permitted the first long term observation of orbital dynamics, resulting in discovery of the Earth's oblateness and initiation of mathematical modeling of the Earth's gravitational field.

Electronic Countermeasures

(U) The confidential ECM task from BuAer was intended for (and had been invited by) NRL's third-echelon countermeasures branch, which developed equipment for conventional collection platforms to gather intelligence on signals from threat weapons systems. The branch had developed systems for use on naval ships, transportable equipment huts for deployments to friendly military installations adjacent to Communist-bloc borders, and miniaturized equipment for use on aircraft and submarines. ECM technology advanced by the branch included electronic signals intercept, direction finding, jamming, and deception techniques, including chaff and decoys. The countermeasures branch provided equipment, technical support, and technology transfer for various surveillance and reconnaissance platforms, via the Navy Bureaus of Ships and Aeronautics, the Air Force ECM wing in Biloxi, Mississippi, and the Central Intelligence Agency (CIA). Intercept equipment developed by the branch included antennas and receivers, recorders, and analysis devices. These equipments were often upgraded to exploit new technology and keep pace with the threat signal environment as it spread into higher regions of the radio frequency spectrum. Several generations of signal direction finding (DF) equipment had been developed for shore stations, ships, and aircraft, including long-range patrol planes and electronic signal ferrets.

[redacted]

(U) Howard O. Lorenzen, countermeasures branch head since 1950, had arranged after World War II, through wartime contacts in the British Admiralty, to borrow some captured German electronic equipment stored at the Admiralty's Signal and Radar Establishment in Portsmouth, England. Two devices were to prove especially fruitful: the Wullenweber goniometer and the Athos system's crystal video receiver.

(U) In 1957, at the back end of the Hybla Valley Coast Guard Communication Station in northern Virginia, the branch's DF section had erected a wide-aperture radio DF antenna, consisting of a 400-foot diameter ring of broadband sleeve antennas and an inner vertical reflector screen. The German goniometer, located in a small building in the center of the array, was used to accurately measure bearings of radio signals transmitted at high frequency (HF) from ships at sea. The Wullenweber technology was the basis for a collaboration between Howard Lorenzen and the new head of the Naval Security Group, Capt Bernard F. Roeder, a line officer with a sub-specialty in communications. Navy-funded project [redacted] would enable NavSecGru to intercept and determine the direction of HF radio signals, then fix a transmitter's position by correlating bearings reported from a net of [redacted] stations. A very small experimental remote array was being built about a mile east of the 400-foot array and would be connected to equipment in the same Wullenweber operations building. [In years to come, circularly disposed antenna [redacted]

(U) Research engineer Reid D. Mayo had been advancing wide-open crystal video receiver technology for shipborne and airborne ECM applications since 1949, based at the outset on the Athos warning system. Athos had been used by lookouts on German submarines to detect enemy airborne radar operating at ten-centimeter and three-centimeter wavelengths. The latest advance by Mayo's unit was the design of a [redacted] antenna/detector, sponsored by BuAer's avionics division for the Navy's two airborne early warning squadrons (NRL Problem 54R06-20). The [redacted] antenna would be used with airborne crystal video receivers to search for possible new radar signals from Soviet aircraft.

(U) Sputnik 1 temporarily diverted several members of the DF section, including Reid Mayo, to track its 20 MHz signal and help determine its orbit, using both bearing and Doppler measurements generated by the Wullenweber system at Hybla Valley. Mayo and his assistant, Vincent S. Rose, shifted in early December to a crash project, sponsored by the BuShips countermeasures branch, to develop a periscope-mounted spiral antenna, [redacted] that would be connected to crystal video receivers for collection of [redacted] radar signals within the periscope's line of sight. The systems section of Lorenzen's branch developed a similar configuration, with a vertical sleeve monopole antenna, to cover low to very high communication frequencies (15 KHz to 265 MHz). Following integration and testing at Kolmorgen Optical, Inc. in North Hampton,

Maine, Kolmorgen's modified periscope (type 8A) and NRL's intercept equipment were installed on the [redacted] to support its mid-January deployment to the [redacted] Reid Mayo and William Edgar (Ed) Withrow, also from the DF section, observed the installation, tested the ECM system, and participated in sea trials. They did the same, in February and March, for a second system on the [redacted] would operate in the [redacted].

(U) While Reid Mayo engineered the undersea project, his superiors were promoting applications of crystal video receiver technology in outer space. Howard Lorenzen, countermeasures branch head, and Louis A. Gebhard, superintendent of the radio division, had collaborated on a description of an electronic intelligence reconnaissance satellite, which was incorporated as a seven-page section in NRL's 10 December report to BuOrd on the post-Vanguard program. The system would be targeted on one radar employed in the Moscow defense complex, which was "out of range for ground-based sites and conventional airborne platforms," and utilize "a microwave antenna, a bandpass filter, a crystal detector, a simple video amplifier, a pulse stretcher circuit, a modulator, a tiny transmitter, and a telemetering antenna" (10 Dec 57, section 2.1.3.2). A four-pound battery would provide about 100-milliwatt average power for three weeks of intermittently operating a payload weighing about 27 ounces. Payload characteristics were compatible with the powerful [redacted]. The payload would be activated by radio command when above Moscow's radio horizon and would telemeter information to existing receiving stations within line of sight. Missions and payloads would expand as "as the load-carrying capacity increased." They had discussed the project in detail with cognizant personnel in the Office of Naval Intelligence and expected to be ready for launch "within about a year, assuming that appropriate priorities would be assigned." Since then, Lorenzen had encouraged Marion B. Pickett, his counterpart in BuAer's avionics division (AV-42), to support NRL's exploratory research, resulting in the 5 March priority B ECM problem request.

National ELINT Program

(U) ECM equipment was designed for tactical warfare and used to support operational commanders. Howard Lorenzen had been among the pioneers of after-the-fact analysis of countermeasures intercept data, and, to further this effort, he had helped organize an ELINT component of the joint communication and electronics committee in 1948 and chaired the ELINT sub-panel during the Korean War. By 1955, magnetic drum and magnetic tape recording technology and protocol had advanced to a point that electromagnetic signals of interest could be preserved on tape and then analyzed elsewhere in detail after the collection event. Recorders provided a technical means to support an urgent Air Force need to develop a Soviet radar order of battle. Accordingly, the National Security Council had directed and the DoD had implemented a loosely coupled national electronic intelligence (ELINT) program under the secretary of the Air Force (SAF) to fund and manage a

second tier of signals exploitation. SecDef Charles Wilson had assigned responsibility to the SAF and delegated to him authority to direct and supervise consolidated processing, analysis, and dissemination of ELINT data and to guide and coordinate ELINT activities of all agencies of the DoD (13 Jul 55). In his new office as SAF the following month, Donald Quarles had the responsibility to implement a national ELINT program.

(U) Pursuant to national and defense directives, the Army & Navy Electronic Evaluation Group, collocated with NavSecGru headquarters in northwest Washington, D.C., had been redesignated as the National Technical Processing Center (NTPC). The NTPC was administered by an ELINT coordinating group in the office of the assistant chief of staff for intelligence USAF (AFCIN-Z), jointly staffed by about a hundred personnel from the three military departments and CIA, and commanded by an Air Force lieutenant colonel. The services and CIA's office of ELINT were represented in AFCIN-Z's ELINT advisory board. U.S. ELINT objectives and general intelligence requirements were prepared by the AFCIN-Z, submitted by the SAF, and approved by the Joint Chiefs of Staff (JCS) as guidance for signals collection (recording) to operational forces equipped with ECM equipment. Operational commanders retained unabridged authority over integral ECM resources and freedom to exchange ELINT for mutual support. Recordings were couriered, as expeditiously as possible, to the NTPC.

(U) NRL's countermeasures branch participated in and supported the national ELINT program by serving on technical committees; developing intercept equipment; evaluating data acquired from ECM configurations installed on Navy, Air Force, and CIA platforms; and technically supporting the NTPC through the Office of Naval Intelligence. Within the DoN, developmental requirements came from elements of the office of CNO, sponsorship from material bureaus. In both cases, cognizance corresponded with the platform: shipborne, airborne, or shore-based. Development coordination across platforms and military departments was provided by the Office of Naval Research (ONR) in the Pentagon.

Chapter 1 References

13 Jul 55 SecDef (S) DoD Directive S-3115.2
Subj: National ELINT Program
Ref: NSCID 17, 16 May 55

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10 Dec 57 NRL (S/restricted data) Report 5097, Ser 00808/RD (Rev. 2)
Subj: A Satellite and Space Vehicle Program for the Next Steps Beyond the Present VANGUARD Program (U)

24 Dec 57 BuOrd (S) letter to CNO, Ser 005029
Subj: [Navy's recommendations for the national satellite and space vehicle program]

22 Jan 58 DirNRL (S/restricted data) letter to CNO, 4140-16:JWS:eb, NRL Prob A02-88, Ser: 00821/RD
Subj: "A Satellite and Space Vehicle Program for the Next Steps Beyond the Present

VANGUARD Program"; transmittal of
Encl: NRL Report 5097, dated 10 Dec 57

7 Feb 58 SecDef (U) DoD Directive 5105.15
Subj: [Advanced Research Projects Agency]

5 Mar 58 BuAer (C) letter to DirNRL, Aer-AV-4212, 02982
Subj: Establishment of a Problem at the Naval Research Laboratory; Request for
Encl: (1) Confidential Problem Details [for TED Project Number NRL-AV-42004]