4 The Air Force WS-117L-Derived Projects

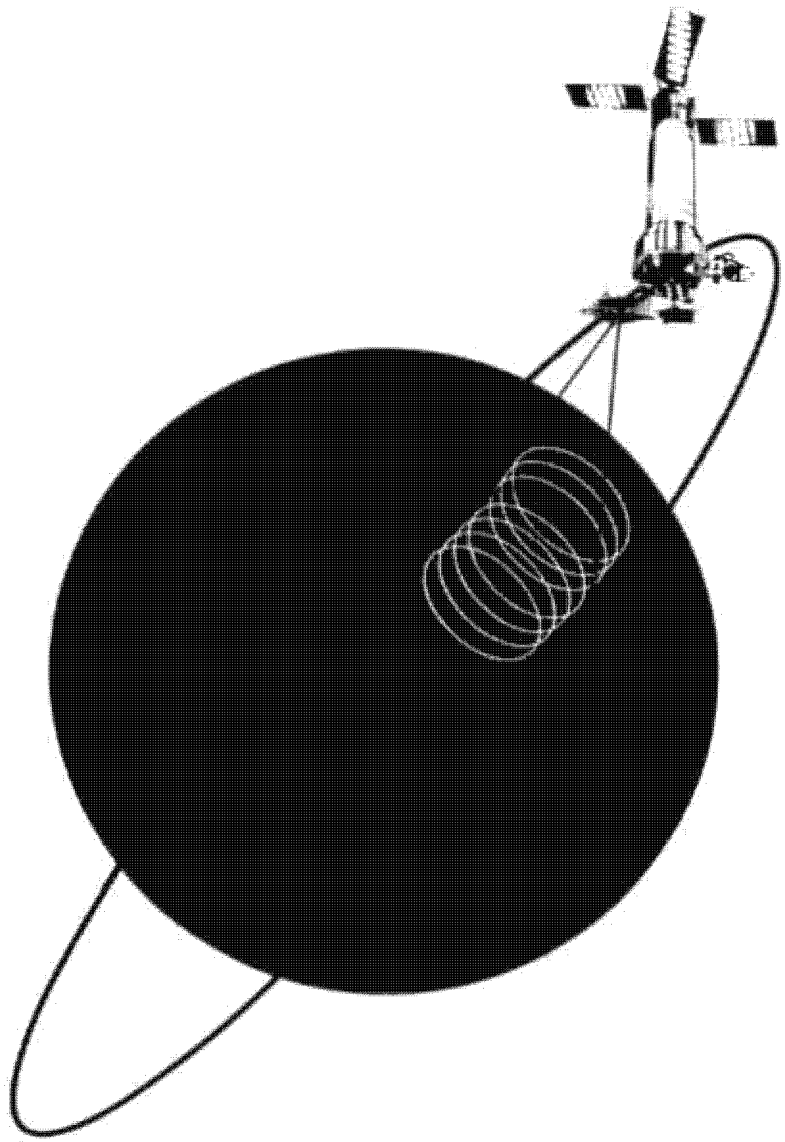
SAMOS E-1/F-1 (WS-117L and Project 102)

The requirements for the Advanced Reconnaissance System, Weapon System 117L (WS-117L), were incorporated in System Requirement No. 5, published by Headquarters, Air Research and Development Command (ARDC), on 29 November 1954, and were validated in General Operational Requirement 80-2, issued by Headquarters, US Air Force, on 15 March 1955. At that time ELINT was the responsibility of the US Air Force, as spelled out in DOD Directive S-3115.2 issued on 13 July 1955. Intelligence requirements for the ELINT satellites of WS-117L were developed under guidance from Air Force Assistant Chief of Staff for Intelligence (AFCIN), MGen James Walsh. On 29 October 1956 the Air Force awarded contract AF 04 (647)-94 to Lockheed Missiles and Space Division (LMSD) in Sunnyvale, California, for initial system development studies on WS-117L. In June 1957 LMSD awarded the first contract for US ELINT satellite payloads to the Airborne Instruments Laboratory (AIL) at Mineola, Long Island, New York. The work on contract was Subsystem F (S/S F), the ELINT payload of WS-117L.

Because the US did not have radar data from the interior of the Soviet Union at that time, the requirements for WS-117L were stated in very general terms. Consequently, the S/S F ELINT payload designs were based on various national estimates of the Soviet radar environment. These estimates were contained in the RAND Corporation's Report 280, "Signal Density Study," published 1 September 1955; the Air Force Technical Intelligence Center (ATIC) report, "Handbook of Soviet and Satellites RADAR Equipment," 9 November 1955; and in estimates by the Planning Research Corporation, a subcontractor to Ramo-Wooldridge, Inc., under contract to the Air Force for development of the WS-117L Intelligence Data Processing Subsystem I (S/S I). These estimates relied on peripheral intercepts from ground sites, airplanes (including limited U-2 collection), and ships. Radar data collected by the early satellite ELINT payloads (Navy GRAB/DYNO in 1960 and Air Force ferret systems in 1961) showed that the actual density of radar data collected over the Soviet interior was many times greater than anticipated. Accommodating this large volume of data slowed the development of data processing systems, changed payload-tasking plans, and resulted in some payload modifications.

The first true source of national requirements for satellite reconnaissance systems was published by the US Intelligence Board (USIB) in USIB-D-33.6/8, "Intelligence Requirements for a Satellite

STRAWMAN operational concept



Program A: Projects 102, 698BK, & 770 (STRAWMAN satellite shown)	
Orbital inclination:	67° - 75°
Orbital altitude:	275 miles
Orbital shape:	Circular
Ground coverage:	100-mile-diameter circle
Collection technique:	Read-in over denied area, record, and read-out to SCF remote tracking stations.
Collection antennas:	Circular horns for high frequency. Logarithmic conical spiral for VHF/UHF

Approved for Release: 2021/09/01 C05134315

Reconnaissance System of which SAMOS is an Example," 5 July 1960. It stated, in part, "There are important problems toward which electronic reconnaissance could contribute critical information during the research and development phase . . . One of the most important of these is the search for emissions associated with an ABM system." Paragraph 1c. stated, "Additional types of directed coverage may be required. Provision should be made to procure such equipment by Quick Reaction Capabilities (QRC)." Also " . . . a close working relationship between the R&D organization and the intelligence community is required."[1]

Col John O. Copley

Prior to the publication of USIB-D-33.6/8, Maj (later Col) John O. Copley, the Air Force WS-117L Project Officer for S/S F at the Air Force Ballistic Missile Division (AFBMD), Inglewood, California, had worked with LtCol John Poe of the AFCIN staff, Capt John Marks of the Headquarters SAC Intelligence staff, and Jim Foreman and Art Thom, who were senior analysts at ATIC, Wright-Patterson AFB, Ohio, to determine collection requirements for the S/S F payloads. They decided that the urgent requirement of SAC for an electronic order of battle (EOB) was the most important factor guiding payload design. These data were essential to SAC in planning bomber penetration routes. Next in order of importance were the detailed technical characteristics of these radars, especially for the early warning and ground-to-air missile systems. The F-1 and F-2 ELINT payloads, with their compressed digital description of the radar intercepts, were designed for the EOB and general-search missions, while the F-3 payloads, with their wideband (6 MHz) analog output, provided the fine grain technical characteristics of selected radars.

The 5 July 1960 USIB guidance appeared to validate the design of the S/S F payloads, if a QRC effort were included. The QRC requirement was met by a separate series of relatively simple, single-mission payloads that could be developed rapidly and mounted on the aft rack of the Lockheed Agena spacecraft.

The S/S F payloads were mounted on the front rack of the nose-down, vertically stabilized Agena, which was continuously Earth-oriented when in orbit. The three-axis stability of the vehicle was provided by control moment gyros supplementing the natural gravity-gradient force that tended to orient the vehicle vertically. Nickel-cadmium batteries supplied the power, limiting average spacecraft life to five or six days, depending on the weight of batteries that could be carried.

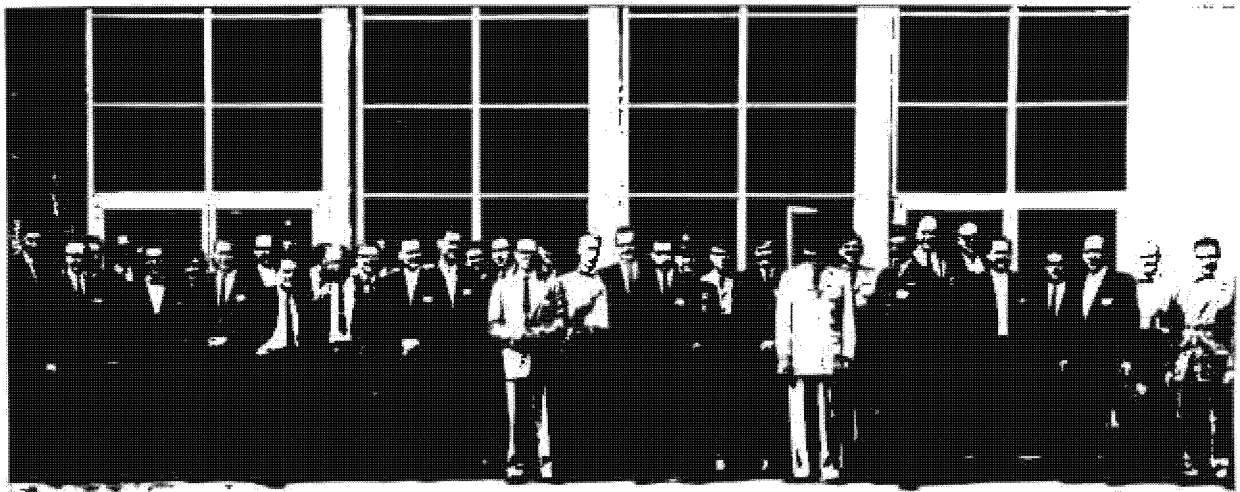
The S/S F-1 payload covered the frequency range of 2.5 to 3.2 and 9.0 to 10.0 GHz. These frequency bands were the popular World War II S-band and X-band in which most of the area search, air-to-air, and ground-to-air missile radars were still operating. One additional frequency band, from 100 to 400 MHz, was used by the higher power, ground-based early warning radars, but the F-1 vehicle was incapable of carrying an antenna of sufficient size to be effective in that radio-frequency range. This was remedied in the follow-on F-2 payloads by extending frequency coverage down to 59 MHz.

The F-1 superheterodyne receiver scanned the radio frequency bands, measuring two pulse repetition intervals (PRIs), pulsewidth (PW), radio frequency (RF), and time for each signal intercepted. This information formed a digital word for each intercept that was then transmitted at a 10-kilobit rate via a very high frequency (VHF) down-link to the tracking stations. The data could be transmitted in realtime or stored on a magnetic-tape recorder over the target area and played back when the satellite was in contact with a tracking station. Spacecraft and payload status data were transmitted on a second VHF telemetry link using pulse amplitude modulation of various tones to frequency-modulate the down-link (PAM/FM). Commands were sent to the vehicle via a 3,200-MHz transponder on the Agena vehicle, which was also used for tracking.

The payload intercept antennas were nadir-pointing directional arrays, with a coverage circle on the ground about 100 miles in diameter at the center frequency of each band.* Additional nondirectional antennas performed an inhibit function, preventing signals originating outside the coverage circle of the directional antennas from reaching the payload via the sidelobes of the directional antennas. The system was known as a "sidelobe" intercepter because it intercepted the sidelobes of the ground radar antennas using its own main beam while, at the same time, it rejected signals (mostly main beams) from other ground radars that entered its sidelobes. The payload intercept antenna main beam looked only at the zenith lobes (sidelobes) of the ground radar, thereby eliminating the scan rate of the ground radar main beam as an influence on the probability of intercepting the radar. This system was the reverse of the Navy DYNO payloads, which depended on seeing the main beams of the ground radars. In both systems the sensitivity of the system was adjusted very carefully to assure reception of only the portion of the ground radar antenna power that was desired (sidelobes for S/S F and main beams for DYNO).

The S/S F and follow-on payloads were built by the AIL at Mineola and Deer Park, Long Island, New York, under the direction of Win Fromm. The F-1 payload used components of a vacuum-tube-type ELINT receiver, the AN/APR-9, which AIL had developed for the Air Force in 1948. This equipment was extensively modified to operate in the space environment and was unique in being the only vacuum-tube-type ELINT payload ever flown in space by the United States. F-1 used motor-driven mechanical CAMS for frequency scanning, which was also unique to satellite-borne ELINT systems.

* For a fixed antenna size, the diameter of the coverage circle is an inverse function of frequency.



Participants in the dedication ceremony of the Airborne Instruments Laboratories, Inc., facility at Melville, Long Island, New York, where Subsystem F and subsequent 698BK payloads were built, 13 October 1959

(Partial listing from left): Don Clark, Phil D. Doersam (third), George P. Minalga (fourth), Pete Sielman (sixth), Maj Walt H. Spindler (eighth), John L. Hyrne (ninth), Eugene Fubini (11th), Maj Bill Bean (12th), Sid Hassin (13th), George W. Price (14th), George Heiniger (15th), Bob Hunter (20th), William M. Harris (24th), James J. Foreman (26th), Col Will Ray (27th), Capt Don Wipperman (28th), LtCol Robert Yundt (29th), LtCol John F. Poe (30th), Maj John O. Copley (31st), Maj Donald Farr (32nd), Winfield E. Fromm (33rd), Ken Knopf (34th), Jim Stevenson (35th), Jack Wieland (37th), and Gregg Stevenson (38th).

To translate the 10-kilobit data stream received at the ground tracking site at Vandenberg AFB, California, into the actual PRI, PW, and RF of the individual intercepts, an F-1 ground data handler was furnished by AIL. This equipment used logic circuits constructed of hardware components to interpret the data stream and produce an output that listed PRI, PW, RF, and time of each intercept for each readout of the payload. This information was used at the tracking station to determine the payload status, particularly on realtime readouts, that contained data from special LMSC-operated calibration vans and known local radars. A second F-1 ground data handler unit was located at the Satellite Test Center (STC) at Sunnyvale, California, to provide input data for the CDC-1604 computer. The readout data, recorded on magnetic tape at the Vandenberg tracking station, were transported by courier to the STC. There the data were translated by the F-1 ground data handler in the same manner as at Vandenberg and were processed on the CDC-1604 computer. The computer contained acceptance criteria to validate the individual intercepts and, using the spacecraft ephemeris, translated the time of intercept into the location of each valid intercept. These data were then manually checked against the characteristics and location of known ground radars and the

[redacted]

calibration van transmitters to evaluate the accuracy of the output data. It was planned that readout data played back from the vehicle recorder, consisting of data intercepted over the Soviet Union or other areas outside the coverage circle of the ground tracking station, would be recorded at the tracking station and furnished to the processors at the Strategic Air Command (SAC) Headquarters at Omaha, Nebraska. There, functions similar to those used at the STC would be performed using the WS-117L Subsystem I Data Management System to develop finished intelligence data.

When the SAMOS Program Office (SAFSP) was formed at Los Angeles Air Force Station, California, on 30 August 1960, two development areas were defined. Program I included the readout projects of Subsystems E and F. The E-1, E-2, and E-3 photo payloads (in increasing order of ground resolution) became Project 101, while the F-1, F-2, and F-3 ELINT payloads became Project 102. Program II was reserved for the photo recovery projects. In Program I, the SAMOS 1 payload was unique, combining as it did the F-1 ferret and E-1 photo readout payloads. This arrangement was developed during the regime of the Advanced Research Projects Agency (ARPA) as a cost-saving measure. The F-1 was mounted in front of the E-1 lens; that lens looked Earthward through a hole cut in the S-band horn antenna of the F-1. This novel arrangement severely vignetted the view of the E-1 camera. The problem was solved by installation of a squib which, when fired on orbit 21, detached the F-1, thereby providing the E-1 a full field of view.

To determine the accuracy of the PRI, PW, and RF measurements made by the payload it was necessary to use the real-time mode to collect radar signals with known parameters and then check the payload measurements against the signals being transmitted. The S/S F Project Officer, Maj John Copley, remembered that in his previous assignment as the QRC Officer at Rome Air Development Center, New York, he was responsible for the modification of several AN/GPQ-T1 training sets, which were van-mounted radar receivers and simulated radar transmitters used by SAC for training electronic warfare officers. Since the radar transmitters could simulate known radars, they seemed an excellent choice for calibration vans, or "cal vans," to transmit radar signals to the satellite receivers. Copley located three vans in Air Force inventory and they were provided to LMSC to modify for this use. These vans were used for several years until requirements for radar simulation became too sophisticated for this relatively ancient equipment, originally built for the Korean War. In 1965 they were replaced with more modern equipment mounted in modified tour buses.

The SAMOS 1 used an Atlas booster to lift the Agena vehicle into a low Earth orbit. The first ignition of the Agena main engine placed it in an eccentric transfer orbit with an apogee of 275 miles. A second ignition at apogee circularized the orbit at 275 miles. Polar inclination of the orbit assured coverage of the entire Soviet land mass.

[redacted]

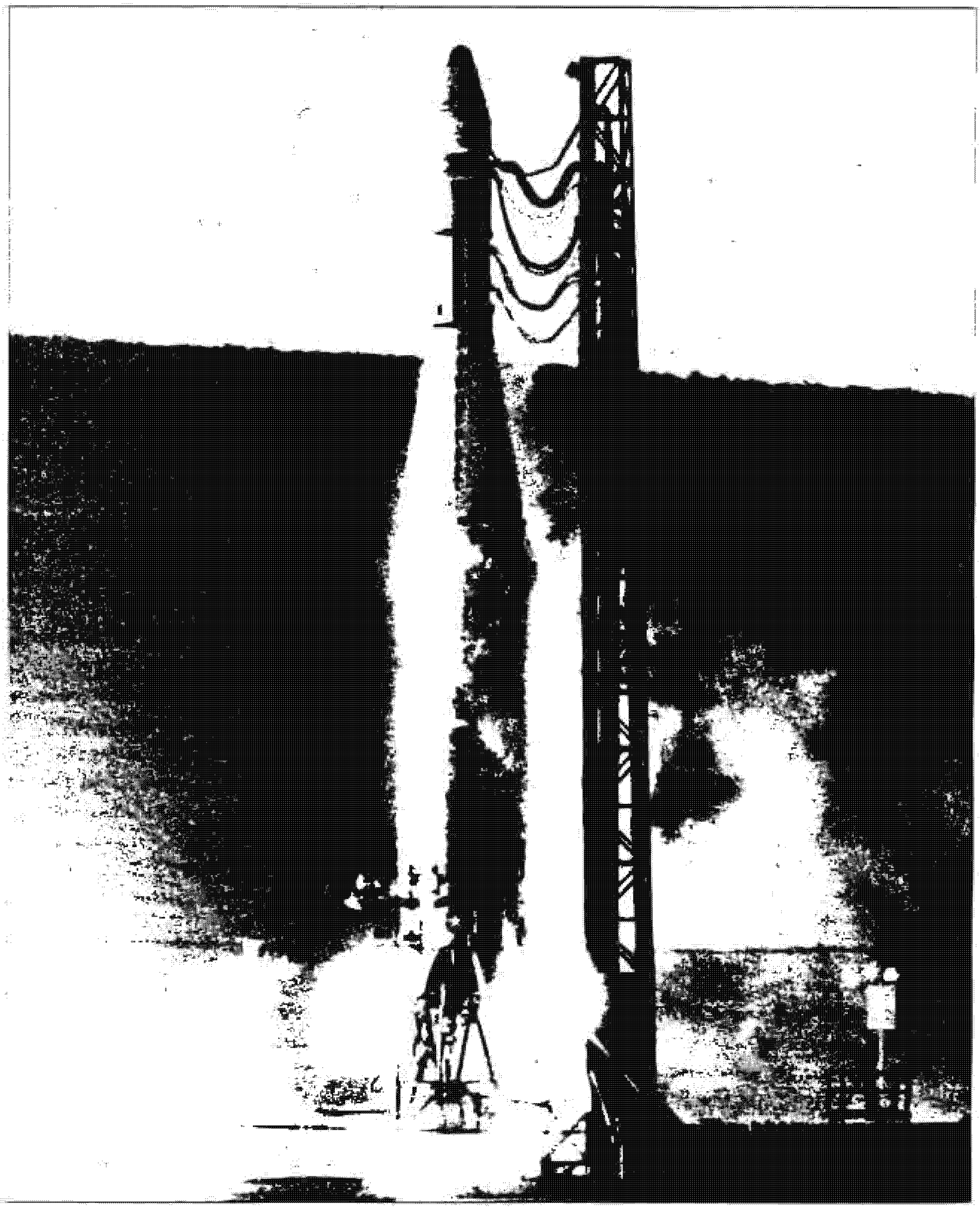
Despite all obstacles, on a clear, crisp day on 11 October 1960, Copley, George Price (the LMSC payload manager), Vince Henry (the AIL F-1 specialist), and the rest of their crew stood in the Vandenberg tracking station parking lot looking out over the launch base. The great day had arrived and SAMOS 1 was on the pad, ready to launch. They watched it rise out of a plume of white smoke in a picture-perfect launch until it was out of sight. Jubilation reigned momentarily until they reentered the tracking station control room and discovered that, during the launch, the umbilical connector had stuck to the cold-gas bottle connection, thereby releasing all the attitude-control gas. Because this gas was needed to control the vehicle during the burning of the orbital engine, the Agena did not attain orbit.

The launch of SAMOS 2 a few months later was somewhat different. It was a gray, rainy day on 31 January 1961 and the launch pad was not even visible from the tracking station. This did not deter the launch crew, and vehicle 2102 was launched into the desired orbit with both the E-1 and F-1 payloads working as expected. On orbit 8 a realtime readout at the Vandenberg tracking station produced the first orbital intercept data from the F-1 system. These data were processed on the F-1 ground data handling equipment, which transformed the 10-kilobit data stream into individual intercepts. This was done at Vandenberg and the STC in Sunnyvale. Output of the F-1 ground data handler at the STC was processed on the 1604 computer, producing 69 identifiable intercepts of signals from US West Coast radars and the cal vans. This verified beyond doubt that the AIL concept had produced a working system. The 2-kilocycle inverter in the payload power supply failed shortly thereafter and no more intercepts, friendly or otherwise, were made.

In the meantime the E-1 photo payload was collecting pictures through the hole in the S-band horn and there was great elation at the tracking station as the E-1 ground processing system produced 100-foot-resolution pictures on many orbits, even though they were rather vignetted. There was great anticipation of bigger and better pictures when the squib was fired on orbit 21 to remove the F-1 payload, but the results suggest that a catastrophe had occurred. The spacecraft was never heard from again.

This proved to be the only successful SAMOS Atlas/Agena readout program launch, and it was only a partial success. The third E-1/F-1 was cancelled to save money for the E-2 launch the following spring. Unfortunately, in April 1961 the Atlas booster for that vehicle blew up on the pad; consequently, shortly thereafter, the photo readout program was cancelled in favor of the more promising photo recovery programs (the already successful CORONA, and GAMBIT, approved for development). The third E-1/F-1 payload was placed in storage until the F-1 was resurrected and used as the Group 0 payload in the upcoming Project 102 missions.

The F-1 payload worked long enough to produce 69 intercept words, but that was not the whole story. Just as importantly, under the leadership of Frank



SAMOS 2/Atlas/Agena launch, Vandenberg Air Force Base, 31 January 1962

..uing, the LMSC crew at the STC processed the data on the CDC 1604 computer. Using known West Coast radars and the cal van signals for verification, they proved that a workable system had been developed. Not only could the data be collected, but the data could also be processed and a useful output produced. The approval of the follow-on SAMOS Project 102 ELINT missions on 9 March 1961 by the Under Secretary of the Air Force, Joseph V. Charyk, was very strongly influenced by these factors.[2]

BGen William G. King, Jr.

The F-2 and F-3 Thor-Boosted Projects: 102, 698BK, and 770

On 23 December 1960, even prior to the successful E-1/F-1 launch of January 1961, Under Secretary of the Air Force ...k directed modification of the ...IOS ELINT Project 102, as follows: "The use of Atlas boosters in the flight test program for subsystem F-2 will be terminated. Subsystem F-2 and F-3 flight test will utilize Thor boosters in combination with the Agena vehicle, and will be conducted as an integral part of the SAMOS Program. The initial F-2 flight test should be scheduled at the earliest practical date. In planning for the F-3 development and flight test, consideration should be given to include provisions for secure transmission of analog readout data through encryption or other techniques."*[3]

* During the SIGINT Satellite History peer review in March 1994, BGen William G. King, Jr., who played a prominent role in this history, said, "The curt nature of Dr Charyk's direction to redirect Project 102 was typical of the explicit and direct instructions we received in the field. Suggest you highlight this fact. It probably was basic to the DNRO management approach."

The switch from Atlas intercontinental ballistic missile (ICBM) to Thor intermediate-range ballistic missile (IRBM) boosters was a logical step in light of the rapid developments in solid-state electronics and digital circuitry. Use of these techniques, plus new lightweight materials, resulted in an F-2 payload less than two-thirds the weight of the F-1. The F-2 covered more of the radio frequency spectrum using three frequency bands, as compared to the two on F-1. Nonetheless, Col (later BGen) William G. King, Jr., the Project 102 director, recommended four F-2 and four F-3 launches, using an Agena vehicle patterned after the Agena of the DISCOVERER/Thor program. Having first-hand knowledge of the failures that the DISCOVERER program had overcome, he felt that four launches of each payload would provide adequate assurance that at least one of each would be successful (DISCOVERER had finally been successful on the 13th launch). This philosophy, along with the success of F-1, was convincing enough to gain Charyk's approval of an eight-launch program, with the first launch in February 1962.

On 9 March 1961, Charyk allocated $35 million in FY62 funds as an initial increment for Project 102, scheduled to launch four F-2s in 1962 and four F-3s in 1963.[4]

The new Project 102 required names for each payload more specific than F-2 and F-3. To accomplish this, Copley and his counterpart, LtCol Edwin J. Istvan of the Air Force Office of Missiles and Space (SAFMS) staff, devised a system that identified payloads by the type of output data they produced (a digital data stream or a wide-bandwidth analog signal) and by the radio frequency bands that they intercepted. The frequency band configurations were numbered 1, 2, or 3, and the term "digital" was adopted for payloads with digital output and "analog" for those with analog output. For example, Group 2D provided radio frequency coverage from 0.059 to 0.130, 2.5 to 3.2, and 8.2 to 12.4 GHz and produced a digital data stream as the output, whereas Group 2A provided a wide-bandwidth analog output covering the same frequency bands. Payloads with digital output were EOB and general search (GS) collectors. Their output was a 10-kilobit digital data stream. Payloads with wideband analog output collected technical intelligence (TI) to determine the fine-grain characteristics of radars of the highest priority. Their output bandwidth was 6 MHz and they utilized the analog magnetic instrumentation equipment (AMIE) wideband helical scan video recorder developed by RCA for on-orbit recording.

As a further cost-saving measure, the third SAMOS E-1/F-1 Agena vehicle, 2103, with the E-1 photo components removed, was redesignated 2301 and reconfigured for launch on a Thor booster. The F-1 payload became Group 0, the first of the Project 102 Thor-boosted launches.

Although it was conducted as part of the SAMOS Program, Project 102 had much more in common with DISCOVERER, which was the cover name for the "black" CORONA photo recovery project. They both used the same Thor/Agena launch configuration and had many common subsystems, they were both under contract to LMSC, and administration of the "white" elements of DISCOVERER had been transferred to the SAMOS office on 9 September 1960.

It soon became clear that operating Project 102 as part of the SAMOS office required duplication of most functions of the DISCOVERER office except for payload operation. As a result, in April 1961 BGen Robert E. Greer moved Project 102 from SAFSP to the nearby DISCOVERER office, both of them located at the Air Force El Segundo complex. This essentially meant that Maj Copley and his secretary Katherine Holt moved in with Col Lee Battle and the DISCOVERER development team. The arrangement worked out very well with Copley handling the SIGINT payloads and Capt Bill Johnson handling the photo payloads. Most other subsystems were common to both programs, and from external observation it was impossible to tell the difference between a SIGINT and a photo launch. There was a difference in the security classification of the payloads. The photo payloads were developed and operated using the CIA's covert ("black") CORONA security system, whereas SIGINT payloads were DOD SECRET, with strict "need-to-know" enforced.

That this combination of the two programs worked well was proven when, instead of the minimum two-out-of-eight successes King had predicted, by the end of 1965 the SIGINT program had grown to nine launches, all of which had been successful. Lee Battle believed that one manager per subsystem or element was more than adequate and steadfastly refused to fill extra billets that were made available to him. The success of the DISCOVERER and 102 projects certainly validated this position.

When the joint CIA/DOD agreement was signed on 6 September 1961, forming the National Reconnaissance Program, the administrative bond between the photo and SIGINT sections of the DISCOVERER Project Office was strengthened further.[5] The most notable effect was that the CIA CORONA payload was now procured and operated under the new joint-agency covert DOD-CIA BYEMAN system, which included both the CIA's CORONA compartment and the Air Force "black" compartments (GAMBIT for the photo recovery system and EARDROP for SIGINT projects). The Air Force ELINT payloads in Project 102 remained DOD SECRET, with a strict "need to know," and were assigned "mission numbers" in the TALENT-KEYHOLE intelligence product protection security system, starting with 7151 for the Group 0 launch of January 1962.

By December 1961 Project 102 was settling into its new environment. Due to funding limitations, every effort was made to simplify the configuration and the project was cut back to seven flights, four in 1962 and three in 1963. There would be no Group 2 analog payload and no flexible on-orbit programmer for the analog missions. Encryption for the wideband analog down-link was still required. A project ceiling of $33.4 million for FY62 was imposed.[6] To meet this ceiling, Copley worked closely with George Price, the LMSC payload director, to assure that the Project 102 payload designers were imbued with a "no-frills" attitude. Digital Group 0 was not a problem since it used the last F-1 payload and was compatible with the subsystems of the Agena vehicle.

The new digital payloads used many of the F-1 techniques including frequency-sweeping superheterodyne receivers, but with lightweight solid-state components that provided improved versatility and reliability. Electronic frequency scan and switching were a great improvement over the former electromechanical methods employed for these functions by the F-1 payloads. The digital output continued to be a 10-kilobit data stream similar to that of F-1. The frequency range from 59 to 12,500 MHz was covered in three configurations (Groups 1 through 3). To provide the wide-bandwidth TI needed to understand the operation of new Soviet ABM and ground-to-air radars, operation of the analog payloads was necessarily more complex. Recording of radar intercepts was accomplished by the AMIE recorder developed for this task by RCA in Camden, New Jersey. To obtain the 4-MHz bandwidth of the early models, a helical scan machine was developed using four recording heads scanning sequentially in exactly the way present-day video cassette recorders (VCRs) operate. To obtain maximum utilization of the wideband recording capability of the AMIE recorder, it was necessary to stop the frequency scan of the receivers and dwell on the frequency of interest while making the recording. The receiver had to either recognize a signal of interest (at least, the presence of a signal) or be pretuned to suspected frequencies of interest. Because the AMIE recorded only when the receiver "recognized" a specific signal, the recording time per orbit was frequently very short and used a small fraction of the tape available. To avoid wearing out the tape by constantly using the first few minutes of tape recording time, it was necessary to allow the analog payloads to collect for many orbits before reading out the data. This often caused the analyst processing the data great difficulty in identifying the segment he was looking at, particularly when (sometimes inadvertently) another read-in occurred before all the previous data had been read-out. To ease this problem, in later payloads the digital data word describing the signal characteristics, in addition to time, was recorded on the AMIE recorder tape along with each intercept.

The Agena support systems were very similar for all DISCOVERER flights except that the photo-mission spacecraft were horizontally stabilized, while the SIGINT missions were vertically stabilized, with the front rack of the Agena vehicle nadir-oriented. The Agena spacecraft would naturally assume a vertical position with respect to Earth while in orbit due to the gravity-gradient effect. This made the attitude control for the SIGINT spacecraft much less complex than for the photo systems, which had to make constant adjustments. The command and control systems were very similar except that the SIGINT vehicles had two encrypted 10-kilobit down-link transmitters on the digital missions and an encrypted 10-megabit down-link for the analog system. Actually, it was not technically feasible to encrypt the full 4-MHz bandwidth of the analog recorder at that time (it would have required at least a 40-megabit down-link), so the first analog mission returned 750-kHz bandwidth of analog data via the 10-megabit down-link. This system was flown on the first analog mission, 7156, on 27 February 1964. Afterward, the Director of NSA reviewed the situation and determined that, due to the complexity of wideband analog data, encryption would not be necessary for future analog down-link data.

Both the digital and analog payload commands were transmitted via the S-band (3.2 GHz) transponder used for tracking the Agena. The command instructions for each orbit were generated by the Mission Control Center (MCC) in the STC for the F-1 and Project 102, Group 0. Only off/on commands were available at this time and the normal commanding was to turn the payload on as it came within sight of the Soviet-Sino Bloc and turn it off as it exited the area. Command instructions became more complex for the Project 102 payloads, starting with the Group 2-D launch on 18 June 1962.

On 2 May 1962, the National Reconnaissance Office (NRO) was formally created and in July 1962 the Director of the NRO (DNRO), Joseph V. Charyk, defined his support staff, known as the Office of Space Systems, Office of the Secretary of the Air Force (SAFSS). An operations staff, SS-4, headed by Col Tom Herron, was responsible for working with the appropriate committees of the USIB to translate their requirements to specific payload operations and to advise these boards of present and planned capabilities of the NRO. By this time, the SAMOS Program Office at Los Angeles Air Force Station had been renamed the Office of Special Projects, Office of the Secretary of the Air Force (SAFSP), and was still headed by BGen Robert E. Greer, who reported directly to Charyk. Greer gave his operations staff at SAFSP the office symbol [redacted]

DNRO Charyk proposed and received an approval from the President's Foreign Intelligence Advisory Board (PFIAB) in 1962 that, ". . . all satellite projects of the National Reconnaissance Program (NRP) should be handled in the same manner by a single operations unit of the NRO Staff."[7] A Satellite Operations Center (SOC) was created as part of SS-4, an office in SAFSS, and was located in Room BD-944 in the Pentagon. Initially, the SOC was concerned primarily with tasking the CORONA and GAMBIT photo programs and exercised minimal control over the SIGINT satellites, which, like the photo satellites, were controlled from the Satellite Test Center (STC) in Sunnyvale. In the SIGINT arena, the initial function of SOC was to translate USIB requirements into mission requirements for specific payloads. The National Security Agency (NSA) representative, Hank DeCourt, who had joined the NRO staff as part of the 1962 DNRO agreements, became increasingly involved in this process. In 1964, as the SIGINT satellite payloads, and consequently their commanding or "tasking" (planning and controlling their collection operations) became more complex [redacted] of NSA was added to the SOC staff to oversee the SIGINT tasking requirements. These requirements were transmitted to [redacted] in Los Angeles where, in conjunction with the MCC personnel at the STC, they were translated into specific tasking for each mission. Lockheed technical personnel at the STC ensured that operation of the satellite vehicle support subsystems was optimized.

The lifetimes of the early vehicles were limited to between six and 20 days depending on the weight of the batteries that could be carried. In late 1962 the "standard" Agena D satellite development was initiated at AFBMD, basically to control cost. This vehicle made it possible for each project to choose "accessories" to customize the standard Agena bus. This improvement, plus the thrust augmented Thor (TAT) program, which added three solid rockets to the Thor booster, increased the available on-orbit weight and flexibility of the Agena. Lockheed incorporated solar arrays starting with vehicle 2702, launched on 19 July 1965. ELINT payload life gradually increased from 51 days for 2702 to over one year for the follow-on MULTIGROUP and STRAWMAN payloads.

The Group 0 digital mission, vehicle 2301, mission 7151, was launched on 21 February 1962 from Vandenberg AFB, California. The tube-type F-1 receiver operated successfully for six days in orbit until the spacecraft batteries were depleted and the mission was terminated. It became the first Project 102 mission to collect data from the Soviet Union and read-out data at the New Hampshire and Hawaii remote tracking stations (RTSs) as well as at the Vandenberg RTS. Data were processed in essentially the same way that the F-1 data had been handled. The output from the F-1 ground data handling equipment in the STC was processed on the CDC 1604 computer to validate each intercept and, based on the vehicle ephemeris, translate time of intercept into geoposition.

Development of the data handling subsystem, S/S I of WS-117L, was under way prior to the formation of SAFSP. It was designed to process the data from the wideband photo readout (RF down-linked) surveillance system on film and the data from the ELINT readout systems as they were recorded on magnetic tape at the tracking stations. When Acting Secretary of the Air Force Joseph V. Charyk directed the change of program emphasis from readout to recovery on 4 November 1960, he also cancelled Subsystem I.[8] This left the S/S F ELINT data users with no system to process the S/S F data. The LMSC data processing of realtime readouts in the STC for engineering evaluation was the only capability available to produce validated and geopositioned intercepts from the Group 0 payload. By applying the LMSC processing system to all of the data (rather than just the realtime readouts), it was possible to provide both the NSA and SAC with verified intercepts containing emitter parameters and locations.

During 1961, increasing emphasis was placed on protecting the security of Project 102 data and mission operations. John G. Schaub, the Lockheed Project 102 manager, recognized the difficulty of protecting both the hardware and the data in building 104, the heart of the Lockheed building complex at Sunnyvale, California, which was surrounded by a myriad of unclassified activities. To provide a facility where good security could be maintained, he convinced Lockheed management that an isolated location was required. This led to the construction of buildings 523 and 524 in an isolated area of Sunnyvale formerly occupied by tomato fields. For many years this area was known as the "tomato patch." Building 523 housed the unclassified spacecraft development and test activities, and building 524 provided a secure area to conduct the classified development program, check out the payload, and process the reconnaissance data.

The buildings were completed in January 1962, shortly before the launch of vehicle 2301, and included an F-1 ground data handler and CDC 1604 computer for processing the data. The original plans for buildings 523 and 524, which were each two stories, called for a single stairway at one end of each building. Realizing the inconvenience this could cause when an individual on the stairless end wanted to go from floor to floor, Schaub insisted that there be stairways on both ends of the buildings. When he won this battle, the second stairway in building 524 was dubbed "The John G. Schaub Memorial Stairway," a name it presumably retains to this day.

The data from mission 7151, Group 0, was checked in building 524 by comparing the computer output with manually processed data from the calibration vans. The STC capability was used primarily for realtime data evaluation for mission control purposes. Preprocessing of mission 7151 data at both the STC and building 524 produced 4,800 intercept words of high-quality corrected data, which were sent to NSA on IBM 727 digital tape for processing at their operations building at Fort Meade, Maryland. Initial processing was done on the IBM 7090 computer and later on the IBM 7094. Each intercept [redacted] from mission 7151 data, which were provided to the Defense Intelligence Agency (DIA) for EOB listings and to other customers for their direct use.

But early location accuracy produced by the overlapping circles was generally poor, with a circular error probable (CEP) as great as [redacted]* By the conclusion of mission 7152, in June 1962, the LMSC team in building 524 had refined selected data to a [redacted] and concluded that this was about the limit of the system as then constituted. The preprocessed ELINT data were also sent to the 544th RTG at SAC Headquarters, Offutt AFB, Omaha, Nebraska, for further processing on their Finder (AN/GSQ-1) computer system. The output of this processing was added to the Single Integrated Operations Plan (SIOP), which SAC used to control all their bombing missions.

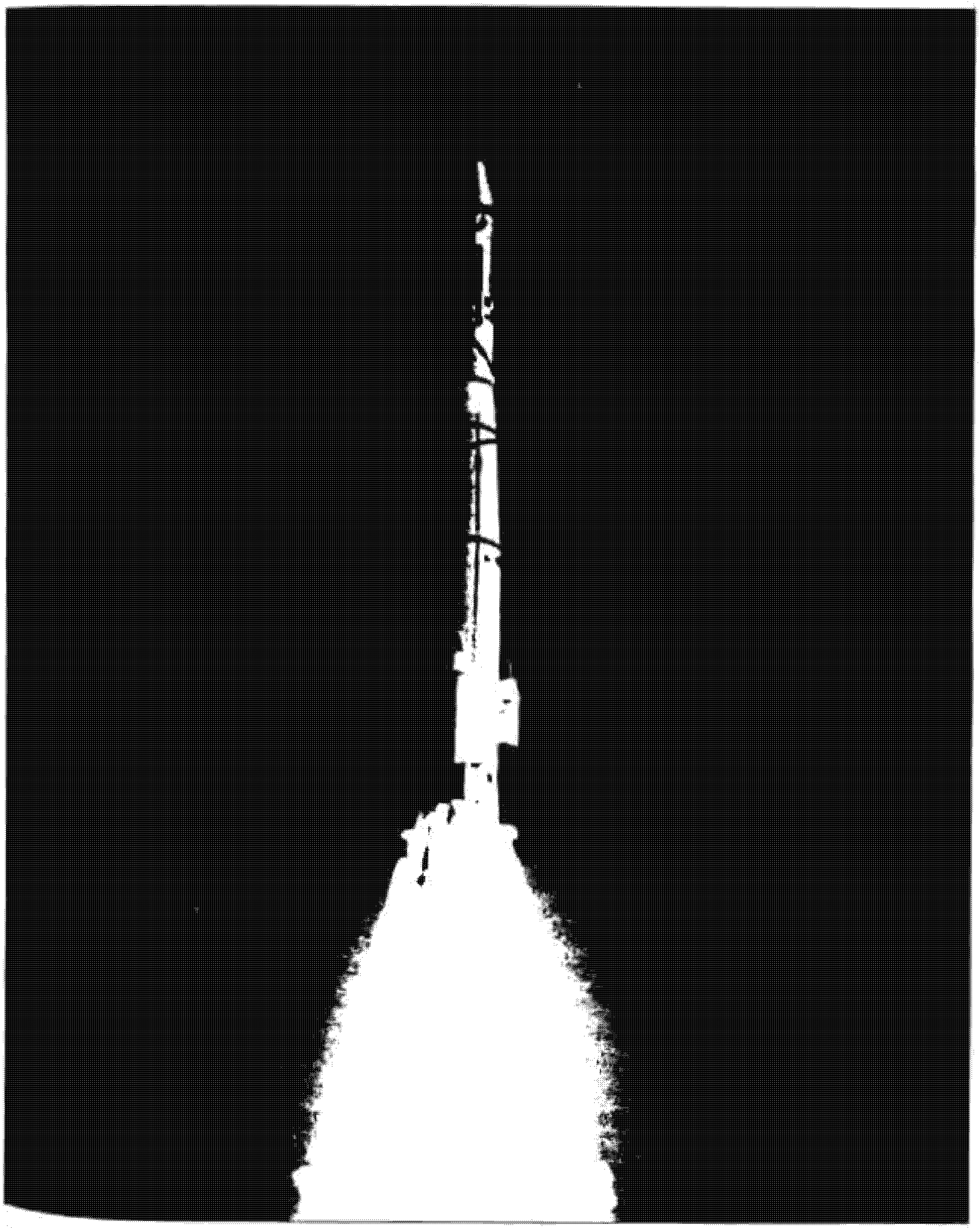
Ed Stillman, one of the early LMSC processing team members, recalled that his first assignment at Lockheed was in building 524 working with Jack Shepherd, also of Lockheed, to handle the ground segment of this mission and also mission 7152, flown in June 1962. To verify the accuracy of the data, Stillman used locations of known radars in Alaska (such as the MSQ-1) to correct the biases in the ELINT reconnaissance data. The first thing that Stillman discovered in the data from vehicle 2301 (mission 7151) was that the arithmetic signs of spacecraft pitch and roll had been entered into the computer reversed. Once this was corrected, Stillman was able to correlate the data. He discovered this error through manual analysis and has since come to believe that manually checking computer data (at least the initial and unusual data) is really mandatory.[9]

* Circular error probable (CEP) is a term for accuracy. It means that 50 percent of all the locations reported will be within this distance of the correct location.

Vehicle 2312, mission 7152, was launched on 18 June 1962 carrying the first Project 102 digital payload, Group 2-D. This first all-solid-state system had many advantages over the vacuum tubes and mechanical scanners of the Group 0 (F-1) payload. In addition to extended frequency coverage, this system was much lighter, more reliable, and used considerably less power. Expectations for a long, useful life, however, were dashed on the second evening of operation (at about four a.m.). In those days program office personnel felt obligated to be in the Mission Control Center (MCC) of the Satellite Test Center (STC) to supervise the conduct of all orbital operations until everything was checked out and became routine. When the satellite was "acquired" on orbit 26, it appeared that the tape recorder would not read-out during the pass. What actually happened was that a "read-in" command had been sent by mistake. So, when the program office decision to send another read-out command was executed, the tape recorder tried to operate in forward and reverse simultaneously. This ended the mission and caused an immediate redesign of the recorder command system. It also terminated the continuous presence of program office personnel in the MCC (without, at least, some occasional sleep).

The Douglas Corporation, which manufactured the Thor booster, invented a method of increasing the booster's thrust by strapping three XLR-81 solid rockets to its base. Lee Battle of the DISCOVERER team decided that vehicle 2313 would be a good one to use for testing the new booster, which was called the thrust-augmented Thor (TAT). Unfortunately, George Price and his Lockheed payload engineers could not deliver the Group 1D payload by the November 1962 launch availability of the new Thor, so Battle substituted a photo bird. When it was launched on 16 November 1962, one of the solids failed to fire, promptly dumping the payload into the Pacific Ocean. The next flight, vehicle 2313, mission 7153, with a Group 1 digital payload, launched on 16 January 1963 using a Thor, was successful. However, the mission lasted only two days due to a battery failure. It collected [redacted] new and updated radar sites in the Soviet Union. Some months before, shortly after he was designated DNRO, Joseph Charyk changed the project identifier from 102 to 698BK. This made vehicle 2313 the first launch under the new program number and changed the security classification to DOD SECRET, SPECIAL HANDLING.

Vehicle 2314, mission 7154, a Group 1 digital payload, was launched on 29 June 1963 using a TAT booster, as did all subsequent 698BK launches. It established a program record of 10 days of orbital operations and produced approximately 140,000 good intercept words. The first wideband analog mission, 7156, was launched on vehicle 2316, 27 February 1964, with a mission life of 12 days. The value of the data was degraded by erratic operation of the wideband AMIE helical-scan tape recorder, mostly caused by tape "gunking" of the recording heads, resulting in frequent loss of data from one or two of the four recording heads. The down-link data [redacted]



698BK/TAT/Agena launch, Vandenberg Air Force Base, 29 June 1963 limited the analog data bandwidth to about 750 MHz and further degraded the data. A previous payload named HAYLOFT, mission 7210, had been orbited as an auxiliary payload on the POPPY Program launch of 11 January 1964 as a test bed for the AMIE recorder and KW-26 encryptor. [redacted] (mistaken) that the 7156 mission would be successful. Very few radars were intercepted by HAYLOFT; those results provided additional evidence that signals previously intercepted by ground intercept sites in this frequency band were not from [redacted]

Project 698BK, vehicle 2316, also carried an auxiliary payload that was to become an integral part of future Project 770 missions. The story of this payload began in Garland, Texas, a little over two years earlier, at the Electronic Systems Division of Ling-Temco-Vought (LTV). By the summer of 1962, Maj Copley had instituted regular monthly meetings to review the status of all the Program A SIGINT projects. Frequently these meetings would be held at the facility of a payload contractor. Organizations and representatives typically attending, in addition to Copley and/or his newly assigned assistant, Capt John O'Connell, would be [redacted] from the Office of ELINT (OEL) at CIA (who was assigned to assist Copley in interpreting requirements and evaluating payload configurations), [redacted] from NSA, Eldon Sasser from SAC, Don Wipperman from the US Air Force Security Service

[redacted]

(AFSS), and on occasion, representatives from other government organizations, plus LMSC and the payload subcontractors. George Price, Bill Harris, and Vince Henry of LMSC would present the project status, which would be followed by a discussion of problems or changes necessary. It was not unusual for new payload ideas to be presented at these meetings, followed by discussion of their merits.

Introduction of the new auxiliary payload came about in exactly this way. Gene Kieffer, President of LTV Electronic Systems Division (later E-Systems) in Dallas, Texas, had approached both Price and Copley about an interferometer-type payload that promised to obtain 5-mile location accuracy from a 275-mile-high orbit. At a meeting in October 1962 at the LTV E-Systems facility, Kieffer presented the results of an [redacted] aircraft test that supported this accuracy prediction when translated to a [redacted] space payload targeted against the new [redacted] version of the S-band system that shot down F. Gary Powers' U-2). The payload idea gained wide acceptance and was named BIRD DOG for its pointing accuracy. Despite some concern for sensi- [redacted] BIRD DOG was included as an auxiliary payload on 2316 and the following three vehicles, 2315 and 2317 of the 698BK Project and 2702 of the 770 Project.

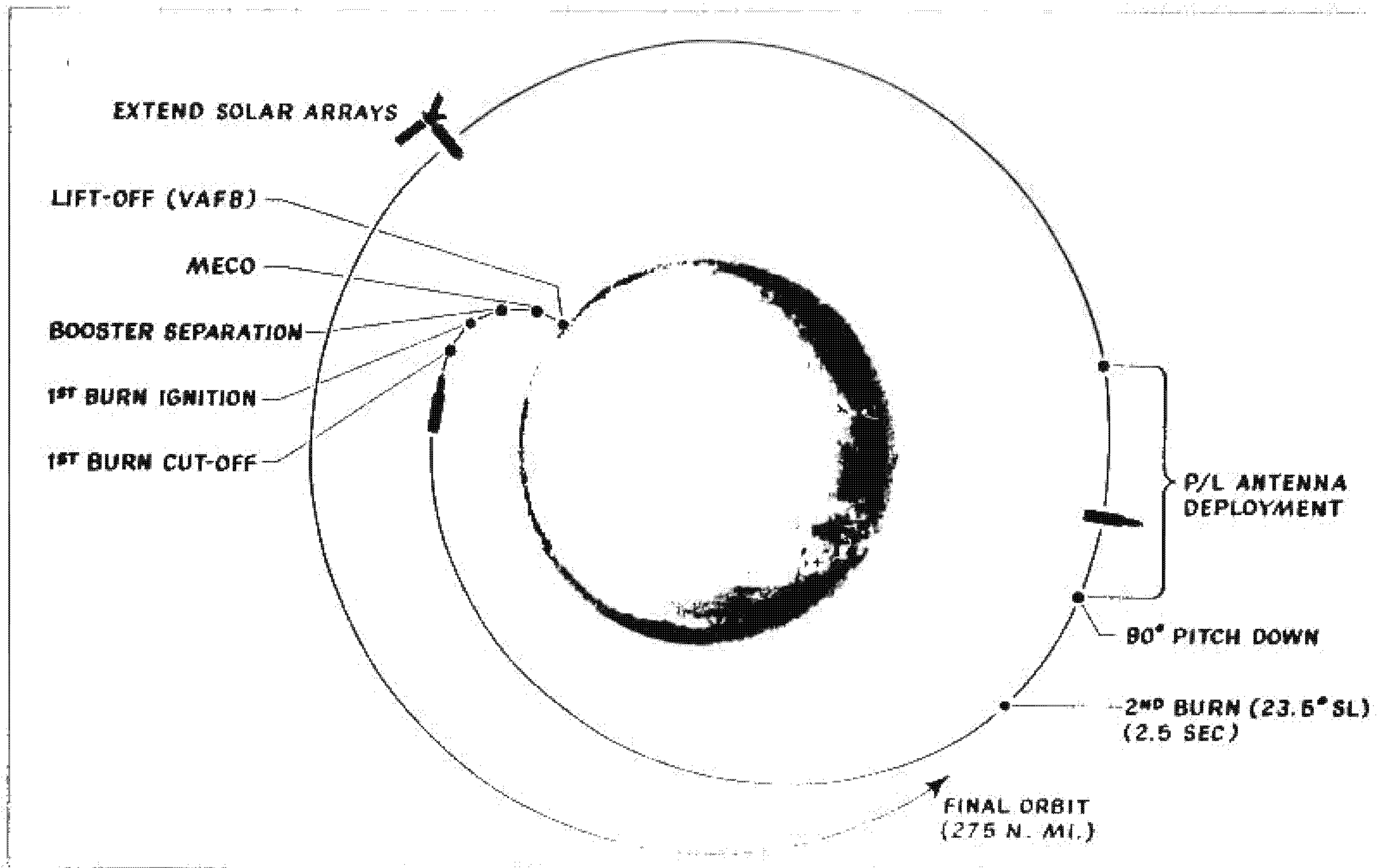
The interferometer used phase measurements to describe the angle-of-arrival of a signal based on intercept of a single pulse. A digital word was formed in the payload, identifying the location cell by the phase measurements of the intercept. New digital words were formed for each of the multiple hits on the same radar while the emitter was in the spacecraft field-of-view. Digital words that described the same signal parameters and whose cells were in an approximate straight line parallel with the flight path of the spacecraft were combined to produce more accurate locations than was possible with a single direction-finding hit. The digital payload output was preprocessed at LMSC to correct for vehicle attitude and receiver and antenna calibration. These data were sent to NSA, where intercepts were combined and emitters identified. SAC also received and processed the same data for direct entry into the SIOP. BIRD DOG produced the first high volume locations with accuracies better than [redacted] Accuracies were often as good as [redacted]

Vehicle 2315, mission 7155, a Group 2 digital payload, was launched on 3 July 1964. It operated for 17 days and produced [redacted]

The last Project 698BK digital payload, 2317, mission 7157, carrying a Group 3 digital payload, was launched on 3 November 1964 and operated for four days. In addition to the digital output, to supplement the technical intelligence (TI) output of the wideband analog missions, the detected video output from the receivers was recorded in analog format on a 100-kHz bandwidth Leach magnetic recorder. The analog data proved to have limited value since the radar pulses had to be "stretched" to fit the 100-kHz bandwidth of the recorder, thus preventing effective analysis of the "fine grain" characteristics of the radar pulses needed for the TI mission. The location accuracy of the 698BK digital data provided to SAC and NSA had improved to approximately [redacted] by the launch of mission 7157, and some locations were reduced to [redacted]

Also launched on vehicle 2317 was the auxiliary payload BIRD DOG 3. This version used an inflatable antenna system to cover the lower frequency range of 521 to 648 MHz. The mylar used to construct the antenna proved to be incapable of withstanding orbital conditions and collapsed, completely ending thoughts of low-frequency BIRD DOGs. A powerful ground camera snapped a picture of this subsidiary payload in orbit and it was an ugly, wrinkled sight!

~~Top Secret~~
BYE-9197/94



Typical injection trajectory, Project 698BK and 770

After the earlier June 1962 launch of the Group 2 digital payload, mission 7152, all of the Project 102/698BK digital data were preprocessed by Lockheed in building 524 using their CDC 1604 computer. In preparation for the processing of 7152 digital data, it was necessary to update the previously used F-1 processing capability to match the new payload format. The F-1 ground data handler was not useable without major changes in hardware logic, and it was recognized that, with the advances in data processing technology, writing computer software was much more effective than constantly rebuilding hardware logic circuits to match new formats. A program was written for the CDC 1604 computer to translate the 10-kilobit F-2 down-link data into radio frequency, pulse-width, pulse repetition rate, and time data for each intercept. A second program validated this data and translated time into geolocation using the vehicle ephemeris.

Since the project number was still 102 at that time, given the contemporary popularity of a St. Louis beer known as Brew 102, it wasn't strange that these computer software programs became known as BREW 1 and BREW 2. In the summer of 1962 when the CDC 1604 computers were upgraded to much more capable CDC 3200s and the project name was changed to 698BK, it seemed only logical to change these program names to the more conventional ferret system terms, ROOK and [redacted]

The validated ELINT output of these software programs was sent to both NSA and SAC. Once NSA had assumed the responsibility for processing ELINT data in the fall of 1961, NSA and SAC had become parallel processors. A Memorandum of Understanding between NSA and SAC was signed on 11 September 1962 that clarified these ELINT processing arrangements. SAC would process certain space vehicle ELINT signals data in response to the operational intelligence need and in satisfaction of tasking instructions provided by NSA. NSA would provide planning and technical support and guidance.[11]

Maj Eldon Sasser

A practical demonstration of this cooperation occurred late in 1962, when Raymond B. Potts of NSA Research and Development (R&D) met with Maj Eldon Sasser and Capt Donald Wagner, SAC 544th Reconnaissance Technical Group (RTG), at NSA, Fort Meade, Maryland, to discuss a SAC requirement for a special-purpose signal deinterleaver and photographic output to process U-2 and satellite data collected in dense signal environments. The deinterleaver consisted of special-purpose equipment that accepted analog signals on magnetic tape and used digital

Mitford M. Mathews

counters and hardware logic to separate overlapping signals (deinterleaving them) of the same pulse repetition interval (PRI) before filming the analog data for analysis. Mitford Mathews, Assistant Director for NSA R&D, approved the development of the special-purpose deinterleaver and proposed to develop an analog-to-digital converter and the necessary computer software to provide an automated analysis system for SAC. Mathews personally developed the software and Potts directed the development of the analog-to-digital converter in-house at NSA, Fort Meade. Potts also obtained a five-channel photographic strip film unit to photograph the output from the special-purpose deinterleaver from Space Technology Laboratories (STL) in El Segundo, California. The work at STL was under the direction of Douglas Royal. This equipment was installed at SAC headquarters in Omaha, Nebraska, in early 1965.*[12]

* The special-purpose deinterleaver was a hardware logic device that would open logic gates or windows so that all the analog pulses from a particular radar would be available for filming on one channel or track on the film. This system would separate up to five signals from five different radars with the same PRI. The filming device would present five parallel tracks of data—one from each deinterleaver output.

Since the initiation of the 698BK Project in June 1962, the project had been operating under the security of SECRET, SPECIAL HANDLING, even though the balance of the NRO projects by now were all operating under the BYEMAN security system, including the POPPY project. In order to achieve uniformity, 698BK was brought under the BYEMAN system in November 1963 and the program number was changed to 770. Since the contracting was switched from Air Force SECRET, SPECIAL HANDLING to SECRET/BYEMAN, it was necessary to change the vehicle numbering system to disguise the connection between 698BK and 770. The first 770 Agena vehicle became 2701, which was a POPPY Project launch in March 1965.

As a consequence of these changes, Copley had been moved from the DISCOVERER Program Office back to the nearby Air Force Special Projects Office (SAFSP) in El Segundo in November 1962. Within SAFSP, all the SIGINT projects were assigned to the SIGINT Project Office [redacted] with Col Robert Yundt as chief. Copley became Chief of the Payload Section [redacted] In July 1964 Copley was transferred from Los Angeles to Andrews AFB, Maryland, and Capt John O'Connell, who had joined Copley during the DISCOVERER days, took charge of [redacted] To provide O'Connell with adequate support, in the summer of 1964 Yundt requested technical assistance from The Aerospace Corporation, similar to the support that firm was providing the photo programs. An Aerospace group under Sandy Evans was formed for this purpose. He assigned

Col Robert W. Yundt

Daymond Speece to support software developments. Maj John G. Kulpa was assigned as Chief of [redacted] shortly thereafter.

To further improve relationships between the NRO and the NSA in their collection and processing activities, the DNSA proposed on 28 January 1964 to establish an NSA position at the STC in Sunnyvale.[13] In the summer of 1964, following several months of negotiation, the first West Coast NSA representative to the NRO [redacted] was assigned to work with the project office, [redacted] at El Segundo, California, with duties primarily in the payload-development area. Apparently, Yundt preferred to have the NSA representative close by where he could keep an eye on him! Shortly afterward, LtCol George Barthel, USAF, was assigned to the Sunnyvale area as the SAC representative to the STC and building 524. Also at this time, [redacted] US Army, who had been recently assigned to NSA from the CIA intercept site at [redacted] was assigned to the satellite data processing area. In October 1965, following a series of monthly trips to Sunnyvale, California, [redacted] was assigned to represent NSA at the STC and building 524. Yundt was unsure of [redacted] NSA motives and required that he call [redacted] every time he visited 524 and to log in and out when he did so. Eventually, [redacted] convinced Yundt that [redacted] efforts were desirable and this unnecessary prohibition was lifted.

The first Project 770 mission was vehicle 2702, mission 7158, launched on 16 July 1965, the legacy of vehicle 2316, mission 7156, which had been the first wideband analog payload (it was launched on 27 February 1964). It was a Group 3 configuration covering 640 MHz to 8.28 GHz. It operated for 51 days and marked the first effective use of solar arrays on a SIGINT vehicle (vehicles starting with 2316 had solar arrays, but battery problems prevented effective use or very long life). NSA had been planning to process these data since late in 1962, when NSA's Ray Potts responded to a requirement from NSA operations and conducted a study of the analog-to-digital conversion needs to process the analog data that would be collected by the 698BK analog system. A special high-speed analog-to-digital converter, BEERMAN, was proposed and subsequently developed in-house in 1963 by NSA R&D.

The BEERMAN equipment had been operated in the R&D spaces at NSA to support the mission 7156 and 7210 launches in 1964, and it used the R&D CDC 1604 computer as the buffer tape controller to provide temporary digital-data storage and control for the digital-tape recorders.

The BEERMAN analog-to-digital converter [redacted] into a digital format for computer processing. BEERMAN [redacted] These operations served a useful R&D function, but due to the short life of the missions and relatively narrow 750 kHz bandwidth of the unencrypted data, very little useful product was collected. BEERMAN was installed in operational spaces at NSA in late 1964 after the specially designed buffer tape controller was delivered by Control Data Corporation. Potts, meanwhile, moved from NSA R&D to NSA Operations as Chief of Special Projects (K-4/SP) in May 1965 and was responsible for processing, analysis, and reporting of data collected by SIGINT satellites.

Everything was in place to support mission 7158, the first mission whose output data would record predetection in 6-MHz bandwidth analog form and transmit to the ground without encryption. Computer programs had been written by NSA to process this data and to produce locations and identifications. The computer printouts were also used to scan the data for signals analysis. Considerable manual analysis of the analog data and the computer output was required to produce useable results from this first wideband analog mission. Experience gained in processing and analyzing the data from this mission in 1965 provided valuable design information for follow-on systems.[15]

The last F-2 type payload was mission 7160, carried on vehicle 2703, a Group 3-D payload launched on 9 February 1966. It also carried a 100-kHz bandwidth Leach magnetic-tape recorder of the same type used on mission 7157 for analog-signal detection. Altogether, 736 readouts of digital and 429 readouts of analog data were collected during the seven-month lifetime of the payload. Several thousand updates to the EOB data were furnished to DIA and SAC, but the analog data suffered from the same bandwidth restrictions that plagued the mission 7157 data, and little technical intelligence (TI) was produced.

Vehicle 2703 also carried an auxiliary payload proposed by LTV E-Systems as a follow-on to the BIRD DOG series. This version, known as SETTER, was designed [redacted] expected that SETTER would intercept many other tracking and early warning radars as well. The SETTER 1 payload, mission 7228, was integrated onto the front rack of Agena vehicle 2703 along with the Project 770 Group 3-D. All of the SETTER (and its follow-on, REAPER) payloads were given mission numbers in the AFTRACK series (7200-7299), following the BIRD DOG tradition, even though they were integrated with the other Project 770 payloads, which carried 7100 series mission numbers. SETTER 1 operated for 40 days and although the frequency coverage was limited to 2.68 to 2.936 GHz, [redacted] the best achieved to that date. A byproduct of this best-ever accuracy was the discovery by Ed Stillman of LMSC that the vehicle was yawing in response to the interaction of the vehicle's magnetic field with the magnetic field of the Earth. Duane Scott of the guidance department was able to calculate these forces and compensate for them by placing magnets appropriately on the vehicle structure to counteract the natural forces. This procedure was used to damp unwanted oscillations on the following MULTIGROUP and STRAWMAN missions with great success.

By the end of 1965 it was becoming increasingly obvious that building 524 was bursting at the seams. Moreover, building 524 was not designed to provide the electronic security required, particularly for personnel involved in data analysis at the product level and for the COMINT payloads, where testing and processing of sensitive data were very difficult. The need for a more secure facility, adequate to support expanded testing and processing requirements, became obvious to contractor and government personnel alike. Bill Harris and Bill Troetschel, LMSC, responsible for the AFTRACK packages; George Price, LMSC, in the 698BK area; Jerry Christiansen, LMSC, in processing; [redacted] US Army, representing NSA; and LtCol George Barthel, US Air Force, representing SAC, all lobbied John Schaub, LMSC Program Manager, to press for a new building adequate for all their activities. Schaub listened and with the backing of Fritz Oder, LMSC Vice President for Programs, and Jim Plummer, also an LMSC Vice President, convinced Dan Haughton, LMSC Chairman of the Board, to invest in an appropriate facility. Thus, construction of [redacted] was initiated in the LMSC complex at Sunnyvale, California, and was completed just in time to process the output of the first of the new MULTIGROUP payloads, launched 28 December 1966.

MULTIGROUP Launches

By the summer of 1962 it was becoming clear to many on the 698BK development team that improvements could be made in the design of the 698BK payloads, which had a set of fixed frequency combinations labeled Group 1, 2, or 3 and covering 59 to 12,500 MHz that had to be selected long before launch. No other frequency coverage was possible without major payload modification. This was primarily because the antenna configurations were very difficult to change without major redesign and testing. Additionally, the command and control support systems were limited in flexibility by the small number of commands available.

To develop a payload more responsive to changing requirements, LMSC and AIL initiated proposal activity to develop a new payload configuration to be called MULTIGROUP. It would have eight frequency bands, each with a matched antenna. Any four bands could be flown on any given mission with minimal turnaround time. It also would be capable of both digital and wide band predetection (6 MHz) analog recording of all bands. A 32-command ultrahigh frequency (UHF) system and an on-orbit programmer would also improve system flexibility.

In June 1963, LtCol John Copley, along with George Price, Chief of the LMSC Payload Office, briefed the members of the Washington NRO staff (SAFSS) on details of the new payload project. In November 1963, approval to initiate development of the MULTIGROUP project was received from Brockway McMillan, who had replaced Joseph V. Charyk as the DNRO in April 1963. In April 1964 McMillan approved launch of the first MULTIGROUP for April 1966, plus three additional launches in FY67. This was later reduced to three total launches when the successor STRAWMAN project was approved in September 1966.

The configuration of the first Project 770 MULTIGROUP vehicle 2731, mission 7161, was similar to the previous Project 770 Agena launch vehicle 2703 with the exception of the new payload and improved UHF command system. It was the last Project 770 mission to use the TAT booster of the former 698BK project. The launch date slipped to 28 December 1966, mostly because of changes caused by concerns over the technical characteristics of the payload. The numbers and density of Soviet radars were increasing rapidly, and signal overlapping and interference were becoming difficult to deal with. Additionally, the presence of high-power continuous-wave (CW) signals (such as television and high-power point-to-point communications) had made processing of 698BK payload data even more complex. These signals tended to overpower the antenna's sidelobe inhibit system, reducing the reliability of the location-finding and analog signal-processing programs. To address these technical problems, the bandwidth of the receiver system and the overall gain of the payload receivers was reduced. Also, a special [redacted] recognizer was added, making it possible for the data processors to, at a minimum, detect the presence of interference.

MGen John L. Martin, Jr.

BGen (later MGen) John L. Martin, Jr., named Director of Special Projects at El Segundo, California, on 1 July 1965, became concerned about the efficacy of performing a system test of the integrated payload and vehicle system in building 524 at Sunnyvale and then disassembling it for shipment to Vandenberg AFB for launch. This required reassembly of the system at the Vandenberg vehicle assembly building and retest prior to launch. Not only did this process cause excessive wear and tear on the system, but it also made very attractive the option of shipping the payload and Agena from Sunnyvale with problems ("open items") that presumably would be solved or fixed at Vandenberg. After considerable study, a new, more rapid factory-to-pad system of processing the payload and vehicle as a unit was initiated for

Agena vehicle 2731. Named FASTBALL, it set as a goal 17 days from receipt of the payload at Vandenberg AFB to launch.

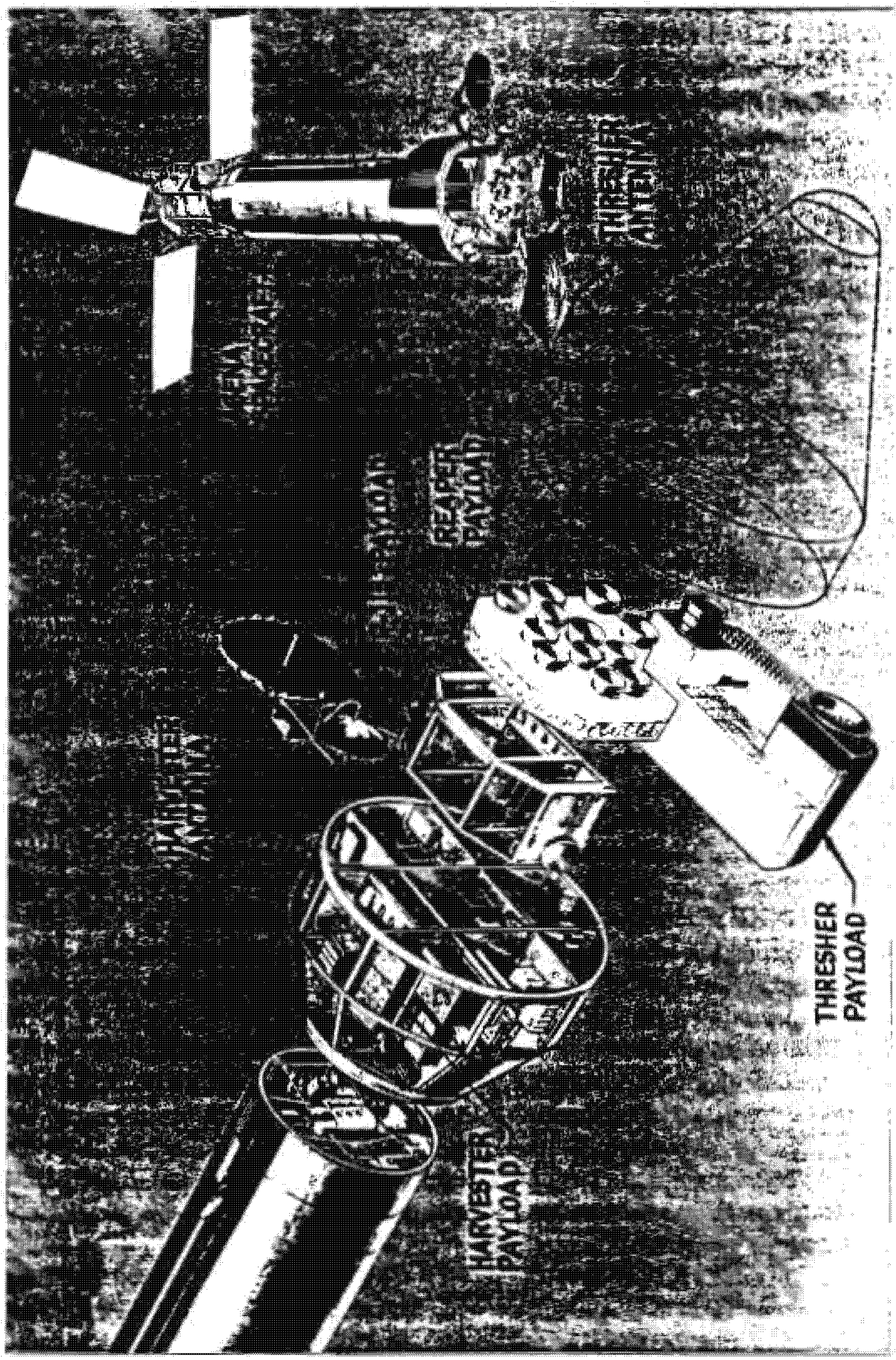
LtCol Jack Sides, who had replaced Yundt as the [redacted] Project Director, felt confident enough to direct the launch on 29 December 1966, just 25 working days after 2731 had arrived at the base. Despite the misgivings of many of the contractors and launch crew, and much to the delight of Sides, the launch was perfect and the spacecraft operated with no problems on orbit. Sides, who was retiring from the Air Force at the end of December, considered this an excellent Christmas present! His successor, Col David D. Bradburn, presided over the remaining two MULTIGROUP launches with equal success.

Project 770 MULTIGROUP Agena Vehicles 2732 and 2733 were boosted into orbit by an improved Thor booster using CASTOR solid rocket motors replacing the former XLR-81s. The extra thrust made it possible for vehicle 2732 to carry an add-on payload called DONKEY, which used a 6-foot parabolic "wrapped rib" dish antenna that deployed on orbit, in addition to the originally scheduled SETTER 1A and MULTIGROUP 2 payloads. MULTIGROUP set new records for length of on-orbit operation. Vehicle 2731 lasted over five months, the DONKEY payload on 2732 went a few days longer, and 2733 produced data for almost 15 months! A great deal of this success is attributable to improved solar arrays and batteries developed for the Agena D vehicle.

The more sophisticated commanding and programming capability of these payloads, which permitted many different adjustments of the payloads during each orbital collection pass, stimulated an effort to use the collection system in the most effective way. In July 1964 [redacted] of NSA joined the staff at the Satellite Operations Center (SOC) at SAFSS and became a part of the effort to translate USIB guidance into vehicle operations responsive to this direction. NSA tasking messages were sent to the STC from the SOC, providing both long-term and immediate operating direction. These "ITEMY" messages, as they were called, combined NSA and NRO interpretation of USIB guidance. Alerts to upcoming Soviet activities were provided by NSA through their Defense Special Missile and Astronautics Center (DEFSMAC) so that payload tasking could be responsive.

In the late summer of 1966, the Director, NSA, LGen Marshall S. Carter, US Army, and Ray Potts visited the SAFSP contractor facility at LMSC while [redacted] was under construction. The possibility of expanding NSA's participation with the Air Force and its contractor was discussed with the local SAFSP representative and with [redacted] the NSA representative at LMSC. On 28 October 1966 NSA forwarded to the Director SAFSP a concept paper regarding the establishment of an NSA Support Detachment (NSD) at Sunnyvale, California.[16]

Completed in December 1966 [redacted] was put to immediate use. Vince Henry of LMSC, now manager of the P-11 payload program, had established a need



STRAWMAN payload vehicle

for a secure test and checkout area. This need dovetailed well with the government need for a secure data-analysis facility. The DNSA forwarded a letter to the Director, SAFSP, on 14 February 1967 describing the scope and nature of a West Coast NSD at [redacted] and advising that SAC had agreed to participate in the detachment to support NSA processing and to serve as the SAC liaison officer.[17] The NSA Assistant Director for Production, Oliver Kirby, subsequently forwarded a memorandum to DNRO Alexander H. Flax on 29 February 1967, informing him of the plans and rationale for the detachment.[18] On 15 March 1967 the Director SAFSP concurred with the objectives and functions outlined for the NSD and agreed to arrange for contractor support by LMSC.[19]

The NSD was established in July 1967 at LMSC [redacted] with [redacted] as Chief. [redacted] had resigned from the Army in March 1967 and converted to civilian status with NSA, reporting to Potts (K4/SP). Assigned to [redacted] were four analysts: [redacted] was also assigned as an NSA intelligence information research technician. Also working for [redacted] were Maj Bob Jackson, US Air Force, and Maj Billy Thornton, US Air Force, of Operating Location 65 (OL65), SAC. Two analyst positions (operating stations) were quickly set up using Mincom 1-MHz recorders that [redacted] "obtained," although the recorders were originally intended for George Cotter, already a senior official at NSA! Later they were replaced by properly ordered recorders, and Cotter got his Mincoms back. This

[redacted]

capability was augmented by signals analysis support from LMSC that was later expanded by the establishment of an LMSC Special Signals Analysis Team (SSAT), headed by John Riley, which did in-depth analysis of new and unusual intercepts. The initial mission for the NSD was to prescan data and do preliminary analysis on signals of interest. In addition, the detachment was to support all West Coast NSA operations and interfaces with the SAFSP and their contractors located on the West Coast. To do this, the detachment had direct communications with K4/SP at NSA using a dedicated secure teletype link known as the "SUNCOM."

The NSA Support Detachment (NSD) activities pretty well filled up one side of [redacted] was built essentially in the form of two mirror images, with space between the two halves of the building to park and check out the calibration vans. On the processing side, the new building made it possible for NSA to delegate certain ELINT data processing

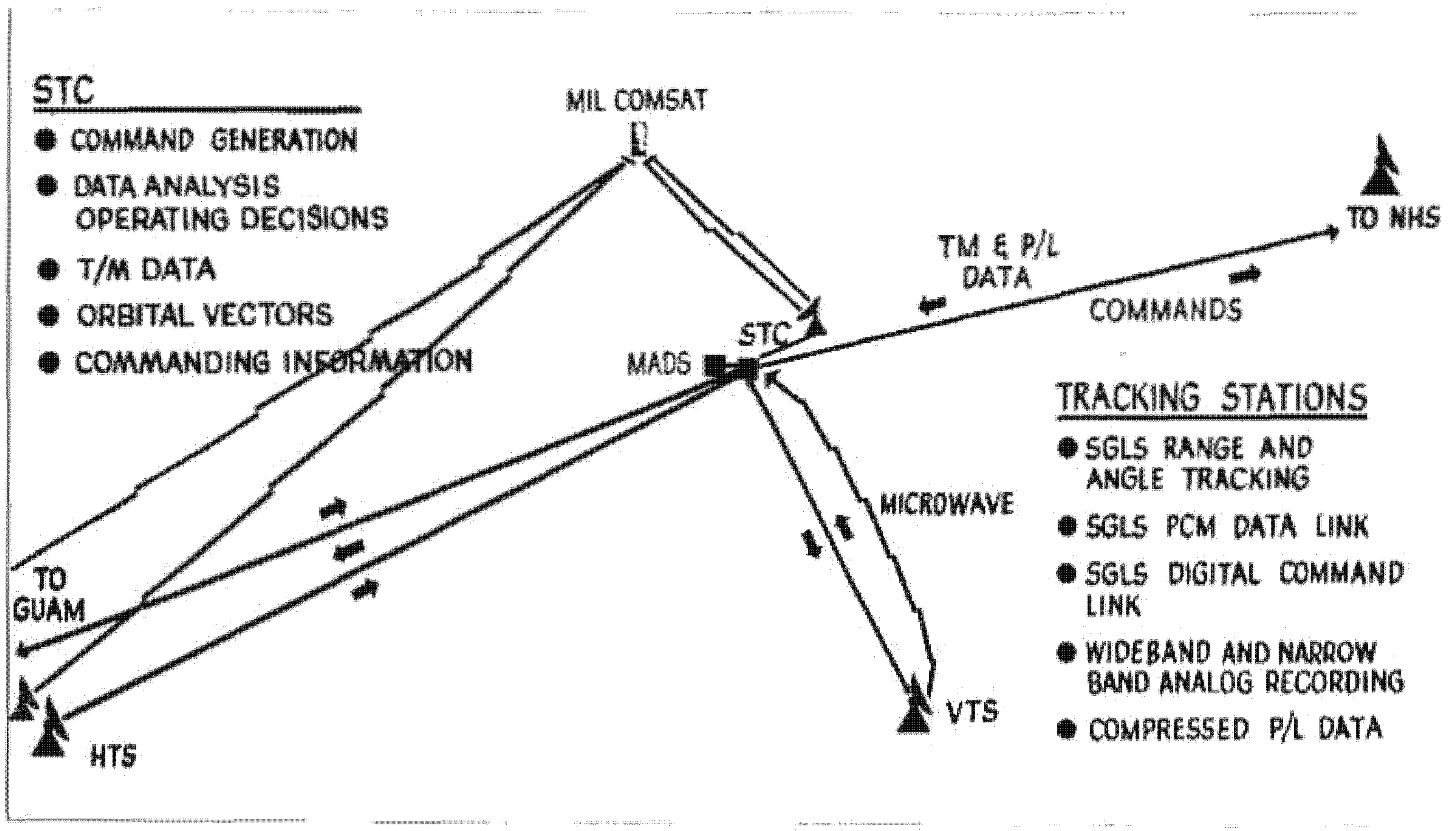
[redacted]

and analysis activities to LMSC personnel, under NSD direction. In December 1966 LtCol Jack Sides, [redacted] and Potts agreed to place an NSA engineer as an integrated member of the SAFSP staff in El Segundo to manage the SAFSP processing operation at LMSC in Sunnyvale (both NRO and NSA responsibilities). [redacted] was assigned from NSA, K4/SP, and arrived at [redacted] in February 1967. He was welcomed by Col David D. Bradburn, who by then had succeeded Sides as head of [redacted] This action coincided with the implementation of the Mission and Data Services (MADS) contract with LMSC to support processing activities in [redacted] and also to support analysis activities of the NSD. [redacted]

An action occurred on 29 September 1967 that illustrates the spirit of cooperation engendered by the close working relationship of Bradburn, [redacted] and Potts. NSA K4/SP was notified by message from [redacted] that the Air Force budget would not permit their support of NSA processing operations at LMSC. Three and a half hours later Potts sent a message to [redacted] coordinated through all appropriate senior officials and NSA Deputy Director Tordella, transferring $370,000 to fund a compatible computer facility in [redacted] to process data for NSA.[20] This led to the negotiation of a formal agreement between Bradburn, [redacted] and Potts entitled "SAFSP SUPPORT FOR NSA PROCESSING OPERATIONS." It provided for a compatible Data Processing Facility implemented as a joint NRO/NSA activity at [redacted] which was essentially parallel to the satellite data processing capability within NSA.

This combined payload development and processing facility in [redacted] provided the flexibility necessary to make maximum and effective use of personnel and equipment on a mission-by-mission basis. Additional benefits included improved timeliness in processing, improved feedback for tasking operations, optimized interaction of processing considerations in the design of SIGINT payloads, and significant economies by having an integrated approach to collection and processing operations. This effort was provided by the SAFSP MADS contract with LMSC. The individual task orders under the contract were defined either as NRO or NSA data-processing functions.

NRO processing included payload support and preprocessing. NSA, through the [redacted] MADS contract, provided technical direction and selected processing and analysis by LMSC. This was the first use



Data collection network, Air Force Satellite Control Facility (AFSCF)

[redacted]

of contractor processing by NSA. Contractor signals analysis support had previously been established and used by NSD in early 1967.[31] NSA arranged for special funding and transferred funds t[redacted]for the NSA share of the costs. Within[redacted] was responsible for technical surveillance of the MADS contract. Potts was responsible for the NSA participation in the program.

Within[redacted]the SAFSP Assistant Deputy for Field Operations, Lt Col Rich Gray, was responsible to[redacted] for all data-processing operations performed on-site. The detachment chief,[redacted] and other NSA representatives as appropriate, provided the technical guidance for the NSA data processing and were technically responsible for contractor performance and acceptability of the final product. A Data Handling and Operations Plan (DAHOPS) identified responsibilities, milestones, effort, and equipment required. Software that had been developed by NSA was provided to the MADS contract. NSA sent knowledgeable personnel to assist the contractor in getting the system operational and in training personnel for the particular job.[32] The establishment of the joint processing facility in LMSC[redacted] with the Air Force, NSA, and the contractor working closely together soon removed most, if not all, the suspicions and distrust that had previously existed.

On the digital processing side, NSA provided a CDC-6400 computer, initially to handle MULTIGROUP digital data (Ray Potts intervened with CDC President Bill Norris to secure the computer on time). The CDC-6400 computer was installed in [redacted]in the fall of 1967. NSA sent the software developed to process MULTIGROUP/SETTER, and[redacted] Computer Processing Group (C Group) spent many long hours at[redacted] helping Jerry Christiansen and his LMSC crew to get this software installed and modified for the 17 January 1968 launch of MULTIGROUP-3. The MULTIGROUP/SETTER data were the first to be completely contractor-processed at LMSC under the[redacted]MADS contract under NSA technical direction. The results were sent directly via secure communications links to NSA's Operational ELINT Organization, then headed by[redacted]who had replaced[redacted]for reporting to the Intelligence Community and to SAC for integration into the SIOP. DIA received the radar identification and location data from NSA for inclusion in the DIA EOB database.

To handle the wideband analog, RCA model TR-22 CVR predetection recorders were used at the ground sites and processing centers. The TR-22 recorders were commercial television recorders modified for continuous video recording (CVR), with improved technical characteristics to meet the requirements for predetection instrumentation recording. NSA specified the recorders to be used and a combined purchase was made for all recorders by[redacted] Special processing and analysis equipment was developed jointly by NSA and[redacted] NSA, through[redacted]acquired a special RCA one-tenth-speed TR-22 CVR recorder to be used for detailed signal analysis.

The predetection analog data, along with other payload digital data from MULTIGROUP, were filmed at [redacted] using a continuous strip of photographic film. NSD and LMSC (under detachment direction) selectively analyzed the film using the Analog Processing Equipment (APE) developed by Ben Gardner of Gardner Associates, San Diego, California. The original analog tapes were sent to NSA for technical analysis. At NSA the analog tapes were processed through the BEERMAN analog-to-digital converter, which was modified to accept the payload time and receiver data, which were merged to provide a digital tape output for computer processing. The computer printouts were used to produce radar locations and to scan the data for signal analysis. Considerable manual analysis of the analog data and the computer printouts was required to produce useable results.

The technical analysis efforts at NSA and at [redacted] were very closely coordinated. The large volume of data required the combined efforts of all the technical analysis people available. Both analysis groups screened the data for signals of interest. NSA used tip-off from other sources or data and the results of intercepts from POPPY and the P-11s to identify dates and times of particular interest to be examined. Duplicate analysis was generally avoided except in those cases where the combined expertise of all the analysts and the payload designers was required to resolve analysis problems presented by unusual signals.

[redacted]

Improvements to the digital EOB payloads resulted in significantly more accurate radar locations. Back in 1960-61, the original SAMOS collected three successive pulses from the cone of coverage. Processing of the data from each three-pulse group using overlapping circles produced locations with accuracies of about

Flight summary: Program A, Agena-based low-orbit SIGINT satellites

MISSION NUMBER	PROJECT and PAYLOAD	MISSION (All payloads are ELINT)	OPERATIONAL LIFETIME 1960	1961	1962	1963	1964	1965	LIFETIME Days
N/A	SAMOS 1 (F-1 PAYLOAD)	GS	10/11						Booster failure
N/A	SAMOS 2 (F-1 PAYLOAD)	GS		1/31 2/1					1
7151	102 Group 0-D	EOB			2/21 2/27				6
7152	102 Group 2-D	EOB			6/18				1
7153	698BK Group 1-D	EOB				1/16 1/18			2
7154	698BK Group 1-D	EOB				6/29 7/9			10
7156	698BK Group 1-A	DC/TI					2/27 3/11		12
7212	BIRD DOG 2	EOB					2/27 3/13		15
7155	698BK Group 2-D	EOB					7/2 7/7		5
7211	BIRD DOG 1	EOB					7/3 7/8		5
7157	698BK Group 3-D	EOB					11/3 11/7		4
7213	BIRD DOG 3	VHF EOB					11/3		Antenna failure
7158	770 Group 1	DC/TI						7/16 9/5	51
7226	BIRD DOG 4	C EOB						7/16	Power supply failure

GS = General Search
TI = Technical Intelligence
EOB = Electronic Order of Battle
ABM = Antiballistic Missile
DC = Directed Coverage
VHF = Very High Frequency

Flight summary: Program A, Agena-based low-orbit SIGINT satellites *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION (All payloads are ELINT)	OPERATIONAL LIFETIME					LIFETIME
			1966	1967	1968	1969	1970	Days/ mos
7160	770 Group 3-D	EOB	2/9 9/6					7 mos
7228	SETTER 1	S-BAND EOB	2/9 3/22					40 days
7161	770 MULTI-GROUP 1	GS/DC/TI EOB	12/28	6/17				5 mos
7229	SETTER 2A	S-BAND EOB	12/28	6/19				5 mos
7162	770 MULTI-GROUP 2	GS/DC/TI EOB		7/24 12/28				5 mos
7230	SETTER 1B	S-BAND EOB		7/24 12/28				5 mos
7163	770 MULTI - GROUP 3	GS/DC/TI EOB			1/17	4/3		14 mos
7232	SETTER 1B	S-BAND EOB			1/17	4/3		14 mos
7164	STRAWMAN 1; THRESHER 2	GS/DC/TI EOB			10/5	9/27		12 mos
7233	REAPER 1	GS/DC/TI EOB			10/5	9/27		12 mos
7238	CONVOY1	ABM DC/TI			10/5	9/27		12 mos
7165	STRAWMAN 2; THRESHER 2	GS/DC/TI EOB				7/31	9/27	13 mos
7234	REAPER 2	GS/DC/TI EOB				7/31	9/27	13 mos
7239	CONVOY 2	ABM DC/TI				7/31 8/30		31 days

GS = General Search EOB = Electronic Order of Battle DC = Directed Coverage
TI = Technical Intelligence ABM = Antiballistic Missile

[redacted]

Flight summary: Program A, Agena-based low-orbit SIGINT satellites *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION (All payloads are ELINT)	OPERATIONAL LIFETIME 1970	1971	1972	1973	LIFETIME Months
7166	STRAWMAN 3; THRESHER 3	GS/DC/TI EOB	8/26		2/1		17
7235	REAPER 3	GS/DC/TI EOB	8/26		2/1		17
7167	STRAWMAN 4; THRESHER 6	GS/DC/TI EOB		7/16		3/23	17
7236	REAPER 4	GS/DC/TI EOB		7/16		3/23	16
7240	HARVESTER	GS		7/16 12/16			5
7168	STRAWMAN 5; THRESHER 5	PROGRAM CANCELLED – NO FLIGHTS					
7237	REAPER 5	PROGRAM CANCELLED – NO FLIGHTS					

GS = General Search
TI = Technical Intelligence
EOB = Electronic Order of Battle
ABM = Antiballistic Missile Radar
DC = Directed Coverage

[redacted] CEP in 1962. The MULTIGROUP missions starting in December 1966 collected [redacted] These technical improvements in the MULTIGROUP collection system made it possible to identify radar locations with [redacted]

The technical capability provided by MULTIGROUP wide band predetection collection and the combined analysis by NSA headquarters, the NSD detachment, and LMSC of the collected data resolved [redacted] MULTIGROUP/SETTER payloads launched in 1967 and 1968 provided additional fine-grain technical measurements [redacted]

An important development occurred in the spring of 1968 when data on SA-2 surface-to-air missiles and other defensive radars in Vietnam became a high priority. Fortunately, the orbit of MULTIGROUP/SETTER allowed readout of data to the Vandenberg RTS on the orbital pass following [redacted] Through the MADS contract, facilities were set up to courier the tapes from Vandenberg to [redacted] This capability has since been expanded and developed to operate in crisis situations in many different areas of the world. The software techniques developed to make MULTIGROUP/SETTER responsive to crisis operations were further refined for the follow-on STRAWMAN project, and they provide the basis for support to tactical operations to this day.

STRAWMAN Launches

Even before the first MULTIGROUP launch in December 1966, the payload and its support systems had been outdated by the rapidly changing electronics technology and collection requirements of the 1960s. The expectation that interchangeable receiver and antenna modules would give MULTIGROUP more flexibility did not hold up when the realities of preparing the spacecraft for launch were confronted. A testing program at both the subsystem and system level was absolutely required to qualify any payload for launch. Once the system had been subjected to vacuum, thermal, mechanical, and electrical qualification testing, there was no way a receiver and antenna module could be changed (for different frequency coverage) without repeating the entire test process. Although MULTIGROUP did have different configurations on each mission, the configuration had to be determined six to eight months in advance. In the case of Agena vehicle 2733, the last MULTIGROUP, there was time to change the configuration to make the payload collection more responsive to the ABM/AES threat. It would have been desirable to change 2732 also, but the necessary six- to eight-month slip in schedule was unacceptable.

In the summer of 1964 [redacted] from NSA joined [redacted] as an integrated member of the payload staff, and at approximately the same time Bob Yundt requested technical support from The Aerospace Corporation. By the summer of 1965 [redacted] along with Sandy Evans of Aerospace, through both an in-house effort and contractor studies, began defining an improved payload that would combine the capabilities of the MULTIGROUP payload, built by Airborne Instruments Laboratory at Deer Park, New York, and the SETTER payload, built by E-Systems at Dallas, Texas. Although these payloads flew together on all the MULTIGROUP missions, they operated independently, thereby requiring considerable duplication of support-system functions. The SETTER payload provided excellent emitter location accuracy (+/- 5 miles), but it could not operate at frequencies lower than 2 GHz due to excessive size of the multiple antennas required for an interferometer-type payload. MULTIGROUP used single spiral antennas that divided the target area into sectors and used single-pulse phase comparisons to achieve geolocation. Though not as accurate as SETTER, it was capable of determining location within +/- 20 miles at frequencies as low as 59 MHz. Using improved versions of these payloads sharing a new solid-state core memory for the digital data and an improved tape recorder called a data storage unit, for the wideband analog data, the proposed STRAWMAN payload offered increased flexibility combined with improved payload performance. Moreover, room would be available for one additional payload that could share the recorders and other new support systems.

Improvements in the support systems now included adoption of the new S-band Space-Ground Link System (SGLS) developed for the Satellite Control Facilities. This provided a pulse code modulation down-link operating at 128 kilobits per second (kbps) and an inflight-loadable programmer capable of 1,021 commands. There was also a backup command link with 32 discrete commands. For the first time it would be possible to encrypt these links using NSA-provided KGR-29 and KGT-28 equipment. The 6-MHz wideband down-link remained unencrypted.

An improved booster, the THORAD, allowed an increased on-orbit weight of the Agena spacecraft and ELINT payloads of 3,850 pounds, and a new battery/solar array system provided 270 ampere-hours per day. Because it was subject to quick revision if necessary, the new configuration was called STRAWMAN. The payloads, named THRESHER (AIL) and REAPER (E-Systems), covered 125 to 3,300 MHz in five bands. LtCol Jack Sides, the [redacted] Project Director at the time, briefed the STRAWMAN concept to DNRO Flax on 1 April 1966. On 6 June 1966 Flax gave his approval to protect long-lead-time items. In September 1966 Flax approved the project and [redacted] initiated project contractual action with LMSC. The project was to consist of five flights, with the first launch in October 1968. There would be one flight per year thereafter through 1972.

The first two STRAWMAN missions carried an auxiliary payload designed to determine detailed characteristics of ABM radars. The first was called CONVOY and was targeted at [redacted] of these payloads were built by Bill Perry's Electronic Systems Laboratories (ESL) in Sunnyvale, California. The fourth mission carried the HARVESTER payload, also built by ESL, with a capability to intercept [redacted]

The first STRAWMAN launch, another in the Project 770 series, was Agena vehicle 2734 on 5 October 1968. All of the payloads and support systems operated

Key accomplishments, Agena-based prime payloads

- First scanning superheterodyne receiver and on-orbit radar signal digital processing of RF and pulsewidth and interval measurements with location information, all aboard a three-axis stable ELINT platform, in 1961.

- First wide band magnetic-tape recorder on-orbit, in 1964, provided a technical ELINT capability, which led to the following accomplishments.

  — First wideband predetected radar signal data, recorded in 1965, yielding unprecedented details on the USSR's several ABM systems, including their sophisticated [redacted]

  — Intercepted many new, unique radar signals other than ABMs.

  — First very accurate location-finding (less than [redacted] processed on-board, in 1966; for SAMs in Vietnam (with less than [redacted] data were provided in near-realtime (hours) to US field commanders in 1968.

  — Auxiliary payloads in 1968-71 collected even more detailed ABM and SAM radar data, such as CW capability and measured power.

for a little over a year, twice the planned lifetime of six months. Agena 2735, launched on 31 July 1969, operated for over 13 months, resulting in a projection of at least a nine-month lifetime for the following launches. Agena 2736 continued the record by lasting for almost 18 months after a launch on 26 August 1970. The final vehicle, Agena 2737, was launched on 16 July 1971 and lasted over 20 months. On this mission the antenna connector to the lower band antenna of HARVESTER failed, thereby eliminating any chance to intercept the SA-5 signals at 5 GHz. This was the only major failure of any of the four vehicles, making STRAWMAN by far the most successful ELINT system to date.

By 1970 NSA had expanded the processing facility at Fort Meade for satellite-collected SIGINT to three CDC 6600 computers, in order to handle the greatly increased volume of data from the POPPY and P-11 missions. Concentration on these programs at Fort Meade was possible because of the resources available at [redacted] All STRAWMAN, THRESHER, and REAPER digital data were processed for NSA by LMSC under the [redacted] MADS contract in [redacted] using the same arrangements that were established for MULTIGROUP and SETTER. The necessary software modifications to take advantage of collection system improvements to provide more accurate locations were developed under the MADS contract for NSA as a joint NSA and LMSC technical development effort.

In 1970 a CDC 6600 computer replaced the CDC 6400 computer at LMSC to provide the needed three-times increase in processing capacity and speed to handle the increased volume of data being collected by the new satellite systems. At the same time, a new MADS contract was negotiated b[redacted] the NSA integrated member of the [redacted] staff. This contract provided the needed flexibility to cover premature failure or the extended life of a payload being processed. It also provided for the addition of a new payload to be processed. The funding for the computer and the MADS contract was split between [redacted] and NSA based on cost-sharing agreements worked out for each mission.

The THRESHER digital EOB collection and processing system produced radar locations with a 15-mile accuracy. The processing of data from THRESHER 2, launched 31 July 1969, produced 9,444 radar locations, including 183 radar locations reported electrically to US forces in Vietnam within hours of intercept. THRESHER 3, launched 26 August 1970, produced 11,519 radar locations with 15-mile accuracy in the first four months of operation. During this same four-month period, REAPER 3, a part of the same STRAWMAN mission, produced 33,915 locations with a 5-mile accuracy.[25]

All ELINT payloads that were a part of the STRAWMAN collection system—THRESHER, REAPER, CONVOY, and HARVESTER—were connected to the predetection analog recorder in the prime payload. The predetection analog data analysis was split between NSA and the LMSC Special Signal Analysis Team (SSAT), which was working for the NSA detachment (NSD) to make efficient use of the limited number of technical analysts. The signal analysis efforts were complementary except for combined efforts on special signals of interest. The all-source and multiple-satellite-source technical analysis was generally done by analysts at NSA.

By 1968 the Grab Bag data system was developed by Joyce Warnkassel of LMSC to store all "left over" satellite data. This included all intercepts that were geolocated but did not meet NSA reporting criteria as valid emitters. This provided a very valuable database for comparison with other data and intercepts to find new high-interest signals for technical analysis. For example, Grab Bag made it possible to identify and correlate data from a frequency agile radar that transmitted signals at different radio frequencies but never stayed on one frequency long enough for the payload to make a pulse repetition interval (PRI) measurement.

Technical intelligence produced by STRAWMAN included ABM radar details [redacted] scan variations as seen by the THRESHER payload. THRESHER, with REAPER, intercepted "signals in the 250 to 500 MHz and 2,000 to 3,000 MHz bands that may be [redacted] CONVOY 1 (also known as P69TH) provided simultaneous predetection recordings [redacted] CONVOY 2 provided simultaneous predetection recordings of two separate beams [redacted] The HARVESTER payload, targeted against the Soviet [redacted] from the Soviet Union.[32] HARVESTER also collected unidentified 8- to 10-GHz signals [redacted][33] HARVESTER also made other intercepts at the same time as mission 7333 (SOUSEA, 8 to 12 GHz).[34] These are but a few highlights of the technical contributions of STRAWMAN. The data processing experience gained from the STRAWMAN predetection data analysis provided the basis upon which the [redacted] data analysis system was developed.

The extensive QRC reporting from THRESHER/REAPER to military forces in Vietnam and Europe continued the project PENDULUM effort initiated with MULTIGROUP/SETTER. All QRC reporting was in less than 24 hours from time of intercept, with the average time from collection to reporting being about 5 1/2 hours. During 1969 there were 41 project PENDULUM reports and 183 in 1970.

In the spring of 1970, DNRO John L. McLucas reassessed the SIGINT satellite programs in view of budgetary constraints. Considering the design capabilities of [redacted] the capabilities of other low-orbiting ELINT satellites (POPPY and P-11), the STRAWMAN capability seemed redundant. He therefore directed the cancellation of vehicle 2738 and all further development work. Under this plan, the STRAWMAN system continued operations through July 1972.

STRAWMAN represented the culmination of a development effort that started before the first spacecraft was launched and incorporated many pioneering concepts. STRAWMAN's legacy could be seen not only in the development of spaceborne equipment but, even more importantly, in the development of ELINT predetection technical analysis techniques and equipment used by practically every follow-on system.

Chapter 4 References

1. USIB-D-33.6/8, "Intelligence Requirements for a Satellite Reconnaissance System of which SAMOS is an Example" 5 July 1960.

2. MSG SECRET/SAFMS SEN-61-29, Part I, Program I. Project 102, 9 March 1961.

3. MSG SECRET/SAFMS PHOTO 60-68, 23 December 1960.

4. MSG SECRET/SAFMS SEN-61-29, Part 1, Program I, Project 102, 9 March 1961.

5. Letter from Roswell L. Gilpatric, Deputy Secretary of Defense, to Allen W. Dulles, Director of Central Intelligence, "Management of the National Reconnaissance Program," 6 September 1961.

6. S/MSG to LMSC, Sunnyvale, CA, fm HQ SSD, SSZDK-12-12-15, "Program 102 Reorientation," signed [redacted] Contracting Officer, 27 December 1961.

7. Memo from Col Henry C. Howard, USAF, "A Cursory Review of the Evolution of the SOC," July 1968.

8. TWX (S) SAFMS-INS-60-31, quoting memo from Joseph V. Charyk to Chief of Staff, USAF, "Memoranda Relating to the Disposition of Sub System I," 4 November 1960.

9. Ed Stillman interview, 28 February 1991.

10. LMSC Data from 770 History, BIF003/2-021054-69, 22 July 1969.

11. *NSA in Space*, April 1975, (BYE-19385-75) p. 71.

12. Raymond Potts' personal notes (hereafter Potts' notes).

13. NSA-BYE-17835-4.

14. Potts' notes.

15. Potts' notes.

16. MARGO 1535-6 (TS/B/TK).

17. NSA-BYE-60000-67, and *NSA in Space*, p. 33.

18. NSA-BYE-60051-67, and *NSA in Space*, p. 34.

19. *NSA in Space*, p.34.

21. Potts' notes.

22. SAFSP SUPPORT FOR NSA PROCESSING OPERATIONS (BYE-70872-67)(S/B); Appendix 4.

23. Stillman interview, 28 February 1991.

24. Stillman interview, 28 February 1991.

25. K4SP Status Board, 20 December 1970.

26. [redacted]

27.

28.

29.

30.
and

31.

32.

33.

34.

Approved for Release: 2021/09/01 C05134315

5 The Air Force AFTRACK and 989 Projects

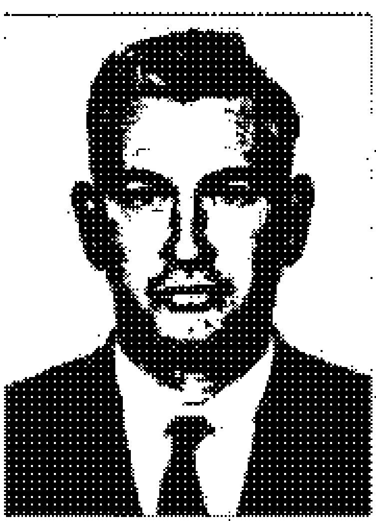
The Origins of Quick Reaction SIGINT in Space

In the summer of 1957, Col Frederic C. E. "Fritz" Oder, Director of the WS-117L Project Office at the Air Force Ballistic Missile Division (AFBMD), Inglewood, California, struggled with a very difficult budgetary crisis. Funds for missile and space activity had fallen victim to an austere DOD budget, providing only $10 million for FY57, with promise of little more in FY58. Oder and BGen Osmond J. Ritland, the Deputy Commander of AFBMD, decided a new approach was required to obtain effective support for the project. Their previous associations with the CIA on the U-2 project led them to the belief that a covert approach would be more palatable and effective, particularly in view of President Eisenhower's desire to secure "Open Skies." The plan would involve the concept of covert overflight from orbit, participation of the CIA, and a definite project acceleration. Oder's secretary Betty Hawkins called it the "second story" because she was required to keep the details in a file separate from the WS-117L documentation.

Col Frederic C. E. Oder

The centerpiece of the plan was a covert photo payload with a recoverable film capsule, to be launched on Thor boosters, earlier than the already planned Atlas launches. On 7 February 1958 President Eisenhower, in a meeting with James Killian, approved the plan. Eisenhower's decision was prompted in part by the launch of Sputnik I in October 1957. Richard Bissell, Assistant Director of the CIA and the U-2 Project Director, had agreed to head the CIA effort that would be responsible for the covert security system and procurement of the photo payload. Also in February 1958, President Eisenhower established the Advanced Research Projects Agency (ARPA) to consolidate all military space systems development. Since ARPA would be responsible for the "white" development of the reconnaissance spacecraft, booster, and all support systems, Oder arranged for his assistant on WS-117L, Capt Bob Truax, US Navy, to be assigned to ARPA to assure adequate coordination between the white support systems and the "black" CORONA payload. ARPA named the cover for the capsule recovery project DISCOVERER and assigned to it biomedical and other scientific activities to disguise its real mission.

In November 1959 the DISCOVERER project was reassigned from ARPA to the Air Force as an "operational" project. When BGen Robert E. Greer became Director of the SAMOS Project in August 1960, he used the authority of his "second hat" as Deputy Commander of AFBMD to incorporate Col Lee Battle and the DISCOVERER Project Office into his organization. To the unwitting ("white") Air Force and to the world at large it appeared that DISCOVERER was an AFBMD scientific project.


Harold Willis

These events set the stage for the invention of the Agena AFTRACK Project. Harold Willis, who worked for George Miller in the Office of ELINT (OEL) at CIA Headquarters in Langley, Virginia, was briefed on the CORONA project in 1959 because of concern in the Intelligence Community about the electronic security of the DISCOVERER Agena spacecraft's commanding and tracking subsystems. It was thought that the Soviets might be constructing antiballistic missile (ABM) or anti-Earth-satellite (AES) radars that could be used to track or even interfere with the US tracking of DISCOVERER satellites.

Willis was aware of the role of the Lockheed Missile and Space Company (LMSC), not only as the system engineer for development of the DISCOVERER Project, but also for the Air Force SAMOS Project, which included an ELINT capability called Subsystem F (S/S F). If a Soviet radio frequency (RF) transmission or interference threat existed, there was a good chance that in several years S/S F would be capable of detecting it. But Willis felt the Soviet RF threat could develop much sooner and that waiting several years to detect it was a very risky proposition. In discussions with Bill Harris of the LMSC S/S F payload staff and Maj John Copley, the Air Force S/S F SAMOS payload manager, Willis concluded that a small, self-contained electronic payload permanently attached to the aft rack of the DISCOVERER Agena vehicle would be capable of detecting any Soviet tracking or interference with the S-band beacon used on the Agena vehicle. This critical beacon was used for tracking and commanding the vehicle through US Verlort ground radars. Copley obtained approval and the minimal funding necessary for the payload development, test, and incorporation on the aft rack of the Agena. Willis briefed Bissell and obtained CIA approval of the scheme in November 1959. The small AFTRACK project was underway.

Although S/S F procurement was done in the white world at the DOD SECRET level, there was general agreement that, in keeping with the covert nature of the CORONA payload, activities associated with the AFTRACK project should be handled on a strict need-to-know basis. In the same way they had provided the Hiller Aircraft Building as a cover for the CORONA development, LMSC arranged office space on Hanover Street in Palo Alto, California, for Bill Harris to conduct payload development and integration activities. Only those people directly associated with the project were made aware of its existence.

From this modest beginning, the concept of a quick reaction capability (QRC) payload that was small, simple, and required minimal development time caught on rapidly. QRC developmental activities for intercept of ELINT had a history in the Air Force dating back to the Korean War, when radar technology was advancing at a rapid rate and collection systems that required years of normal development time were hard pressed to keep up. The plan was to build systems that could be developed in less than nine months, did not necessarily conform to all military standards (even commercial parts were allowed), but could operate reliably for a long enough period to answer urgent questions and provide inputs to the Intelligence Community and to the design of collection systems then under development. The program had started at Wright-Patterson AFB, Ohio, at the Wright Air Development Center (WADC) in the early 1950s for airborne equipment (primarily in the area of electronic warfare). The ground QRC program was initiated at Rome Air Development Center in 1955, and Copley was chosen as the first ground QRC officer. This background provided the necessary basis for the concept of simple, rapidly developed, and effective AFTRACK payloads fixed to the DISCOVERER Agena vehicle.

The aft rack of the Agena vehicle was well suited to this application. There was considerable vacant space available; the real problems were power and weight. Small, simple, lightweight payloads requiring minimal power were ideally suited to this application. A few extra telemetry points were always available for narrowband data to be down-linked and a simple on/off command did not overtax the command system. The Agena vehicle developers had only one mandatory requirement: there must be a fuse in the power line of the SIGINT payload so that there was no way the primary payload power system could be jeopardized. Since the DISCOVERER Agena vehicle flew with its major axis perpendicular to nadir (so that the CORONA camera, mounted at right angles to the long axis of the Agena, would always point toward the Earth), it was no problem to install Earth-pointing antennas on the aft rack.

Initially the DISCOVERER vehicle had a lifetime limited to five or six days, owing to complete reliance on battery power. This limited the collection time for the AFTRACK payloads but it was long enough to collect useful data. When the CORONA Program developed a capability to return two recovery capsules, a system called [redacted] The AFTRACK payloads took advantage of this capability to extend their lifetime by operating during the [redacted] For this it was necessary to add an independent programmer and data link. This was done and many later AFTRACK payloads did operate during the [redacted] Very early in the AFTRACK program, recorders had been added (where the telemetry recorder was not adequate) so the payload could collect data over the Soviet Union and return it to the remote tracking stations (RTSs) of the US Satellite Control Facility (SCF) in Sunnyvale.

Security was a serious concern, as mentioned earlier; not only because of the CORONA payload on the same vehicle, but also to avoid providing the Soviets with ammunition to attack President Eisenhower's "Open Skies" efforts in space. Initially the project was handled at the DOD SECRET level and strict need-to-know was enforced. The initial DOD/CIA partnership agreement to participate in a National Reconnaissance Program (NRP) in September 1961 required stricter security. The SAMOS Program Office in El Segundo became the Office of Special Projects (SAFSP). LtCol Ed Istvan, who had been assigned responsibility for Space SIGINT Systems on the SAFSS staff in Washington, was tasked with developing a more secure system-access control. After struggling mightily with Air Force Security Regulation 205-1 (the SIGINT program was still under DOD security control), he came up with the codeword "EARDROP" to protect AFTRACK payloads. This required all personnel requiring access to sign an EARDROP security agreement, and a list of cleared personnel was maintained. Documents were stamped "SPECIAL HANDLING," in the same manner as the Air Force black GAMBIT photo project. The National Reconnaissance Office (NRO) was formed on 2 May 1962. In December 1962 the BYEMAN system was applied to all SIGINT Programs except 698BK, which remained "SPECIAL HANDLING" until November 1962. A new codeword, EARPOP, replaced the Air Force EARDROP and Navy POPPY designators. From that time on all space reconnaissance programs have been conducted by the NRO under security control of the BYEMAN system.

In December 1962 Copley was transferred from the DISCOVERER Program Office to the newly formed SIGINT Project Office of SAFSP as Chief, [redacted] Division, responsible for payload development. In November 1963, a new program number, 770, was assigned to disassociate the new BYEMAN effort from the previous DOD 698BK program. Boosters, Agenas, and associated support equipment continued to be procured in the white world, but since that time all payloads have been procured through black BYEMAN contracts.

Five days prior to the launch of the first AFTRACK payload on DISCOVERER 13, 10 August 1960, the US Intelligence

Board (USIB) issued the first national-level SIGINT requirements document, USIB-D-33.6/8, "Intelligence Requirements for a Satellite Reconnaissance System of Which SAMOS is an Example," 5 July 1960. Paragraph 1c. stated: " . . . additional types of directed coverage may be required. Provision should be made to procure such equipment by Quick Reaction Capabilities (QRC)." Also " . . . a close working relationship between the R&D organization and the Intelligence Community is required." The AFTRACK project personnel felt that the program followed this direction very closely!

Following the STARFISH high-altitude nuclear tests launched from Johnston Island in 1961, LMSC, in response to a new requirement published by ARPA to investigate the effect of these nuclear explosions on the ionosphere, developed a subsatellite called the P-11. This was a small spin-stabilized satellite, a free-flier, weighing a little over 200 pounds. It was first carried into orbit on the aft rack of the Agena vehicle and then separated and boosted into its own orbit, higher than the host vehicle, to carry out its mission.

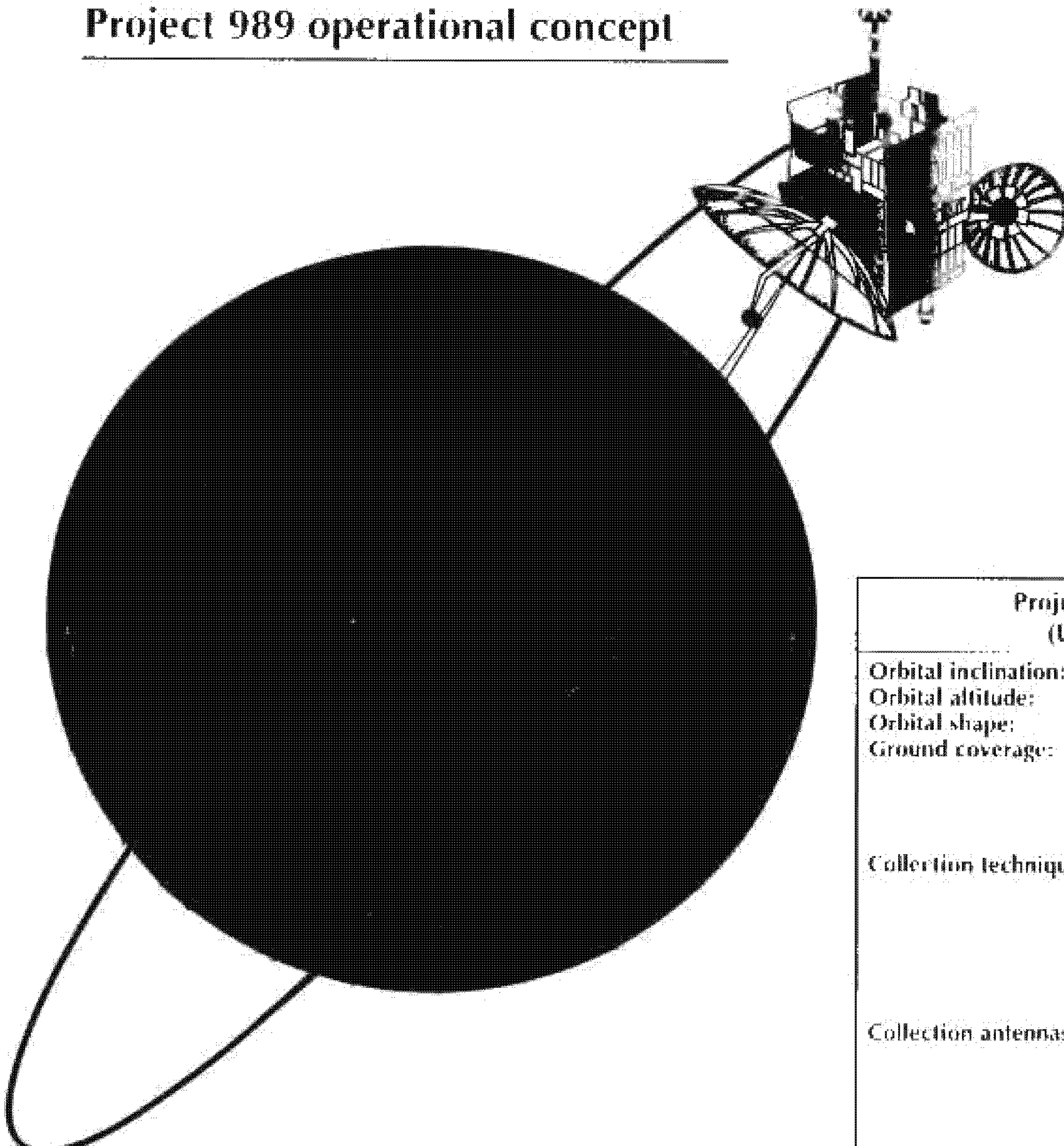
Work started on the first ARPA P-11, called HITCHHIKER, in the spring of 1962. It was to be launched from the aft rack of the DISCOVERER vehicle, once in orbit. Col Lee Battle and his staff at the DISCOVERER Project Office brought it to the attention of Maj John Copley, who sponsored the fixed AFTRACK payloads. They pointed out to Copley that a subsatellite, free of the Agena vehicle, would allow selection of a choice of orbital altitudes plus a potential of much longer life. The orbital inclination would have to be the same as the host vehicle, but this was no problem since the host photo missions used the same polar orbits desired by the SIGINT missions for coverage of the Soviet-Sino Bloc.

Shortly thereafter Copley briefed MGen Greer, Director of Special Projects, on the possibilities of the P-11. With Greer's approval, Copley briefed the Director of the NRO (DNRO), Joseph V. Charyk, in the summer of 1962 and got Charyk's approval to start the project. The first launch of what was to be Project 989 occurred in the summer of 1963. This development eventually led to the phasing out of the fixed aft rack payloads on the Agena vehicle except for the "vulnerability payloads," which were continued on the aft rack of all photo missions to detect hostile radar tracking of the vehicle. The last of the SIGINT AFTRACK payloads, mission 7225, SQUARE TWENTY, was launched 28 October 1965 on vehicle 1620. Although the 72XX series of mission numbers was continued after this time for secondary payloads, none were mounted on the aft rack during the time frame covered by this history.

The AFTRACK Program

In early 1960, concern was growing in the US Intelligence Community that the Soviet Union was building not only missile systems but also systems to counter US missiles and satellites. U-2 photography had shown that large ground radar sites were under construction at the Soviet Sary

Project 989 operational concept



Project 989 – P-11 Subsatellites (URSALA satellite shown)	
Orbital inclination:	67° - 105° (host vehicle determines)
Orbital altitude:	275 miles
Orbital shape:	Circular
Ground coverage:	(a) Hemispheric for Technical Intelligence (b) Narrow swath for direction finders
Collection technique:	Spin-stabilized vehicle with omnidirectional intelligence missions and spinning-pencil-beam antennas for direction finding.
Collection antennas:	Flat or conical spirals for Technical Intelligence missions. Parabolic dishes or waveguide horns for direction finding.

Shagan R&D test site in the vicinity of the missile launch pads. The Soviets also had several ships and trawlers equipped with large radomes whose purpose was not known. In February 1960, Harold Willis of the CIA Office of ELINT (OEL), having recently been briefed on the CORONA photo satellite program, contacted Maj Copley and told him of these concerns. He expressed the national-level fears that the Soviets might in some way interfere with the operation of the CORONA command and tracking subsystems.

Copley was responsible for the contract with LMSD to develop the ELINT subsystem, S/S F of the SAMOS System, for the Air Force with the Airborne Instruments Laboratory (AIL) at Mineola, Long Island, New York, as the subcontractor. Willis had discussed with Bill Harris of the LMSD S/S F office the possibility that support might be available on the aft rack of the CORONA Agena spacecraft for a small electronic "black box" that could detect any electronic interference to the mission. Willis had also discussed the problem with Gene Fubini of AIL, who became an enthusiastic supporter of the AFTRACK concept and suggested a small payload called SOCTOP, which received signals in the 2.5- to 3.2-MHz frequency band in which the Agena S-band beacon operated. It required only an on/off command and a few telemetry points to encode its output. Copley was able to obtain the minimal funding required, and Willis arranged for authority to mount SOCTOP on the aft rack of the DISCOVERER 13 Agena vehicle. The presence of SOCTOP created very little notice when DISCOVERER 13 was launched on 10 August 1960. Most of the attention was focused on the recovery capsule that attained fame as the first object to be recovered intact from an orbiting spacecraft (something the Soviet Union had not yet achieved).

The immediate analysis of the SOCTOP data was almost as remarkable as the capsule recovery. It showed what appeared to be Soviet tracking of the CORONA spacecraft on almost every readout by a US-operated tracking station (there was no recorder, so data could be received only when the spacecraft was in view of the tracking stations). That Soviet tracking was so extensive worldwide was a surprising and alarming discovery; Willis quickly passed the "tracking" story on to the Intelligence Community. However, further analysis of the data revealed that SOCTOP actually was receiving signals from US Verlort radars at the remote tracking stations (RTSs) as they tracked the spacecraft. Despite the embarrassment to Willis and others caused when the error was discovered, the small AFTRACK payload for QRC response to urgent ELINT questions did catch on!

SOCTOP was the first of a long series of "vulnerability" payloads, so called because of their part in an NRO program to determine susceptibility of reconnaissance satellites to hostile Soviet (or other) activities. Eventually this type of payload flew on almost every Program A low-altitude reconnaissance satellite launched. The objective was to determine if Soviet or other hostile radars were actually tracking or trying to interfere with the electronics on the vehicle and the degree of success they achieved. A byproduct of this activity was verification of the tracking radar characteristics or discovery of new variations in their patterns not seen previously. The payload configuration changed as new and improved tracking radars appeared and as collection payload technology improved.

In early 1963, following a series of SOCTOP launches, a competition was held by the Special Projects Office to design a more sophisticated payload capable of receiving and returning characteristics of signals in the [redacted] frequency range. A recorder was to be included, [redacted] Pitsenbarger and his team at Electronics Defense Laboratory (EDL)-Sylvania in Mountain View, California, won the competition and produced the new version, known as STOPPER. This initiated an era, continuing through 1975, in which EDL produced all of the electronic vulnerability payloads that were installed on most photo and SIGINT satellites.

[redacted] to this frequency range. By this time the NRO had been formed and the SAFSP in El Segundo, California, had been given responsibility for the development of a survivability program for all NRO vehicles. Accordingly, sponsorship of these "BIT boxes" was transferred from the SAFSP ELINT office to the SAFSP vulnerability office.

Maj Murray J. Sherline developed the concept of tailoring the frequency coverage of the BIT boxes to the known radar threats, rather than duplicating the mission of the ELINT satellites of looking for new threats. The data from the STOPPER missions was processed at the EDL-Sylvania plant at Mountain View, California. No foreign attempts to probe (unlock) the beacon or to skin-track the US space vehicle were discovered.

Many versions of the BIT boxes were developed as new radar data were received and as payload construction techniques improved. BIT I through IX versions were built as more data on [redacted] collected. In 1968 the BIT boxes were consolidated under the title [redacted] with configurations tailored to the individual launches.

[redacted]

[redacted]

The BIT box output was distributed to NSA and other interested agencies and was also used to program the operation of, and sometimes to aid in the design of, other SIGINT satellite payloads. NSA had no responsibility for processing the vulnerability payloads but did benefit from the results. Many reports were issued showing the capability of the [redacted]

Following the first AFTRACK payload (SOCTOP 1), flown in August 1960, Gene Fubini and his AIL team came up with a simplified version of the forward rack SAMOS Project 102 payload (F-2) that would simply scan the 0.4- to 1.5-GHz band to detect radar activity in the Soviet Union, including suspected ABM/AES radars. Its mission was almost the reverse of SOCTOP (detection of ground radars rather than radar tracking of the satellite) so, naturally, it was named TOPSOC. It used the F-2 high-gain super-heterodyne receivers and, essentially, omnidirectional antennas. Since TOPSOC lacked the directional antenna of the F-2 payload, but still retained the sensitivity, it scooped up a large number of interleaved signals, horizon to horizon, including sidelobes and main beams! Although an RF band had been chosen that was thought to be relatively quiet (400 to 1,600 MHz), the first TOPSOC, launched on 12 September 1961, encountered a signal environment in the Soviet Union that proved far too populated and active to be successfully processed by any automatic or manual techniques available at that time. The first lesson in matching the collection system to the processing system had been learned! It was also clear that, in the 1960s, there were many more radars in the Soviet Union than previously thought. Another thing learned was that unless the intercept is unique and of very high priority, an intercept without a location has very little value (at the same time, Navy POPPY satellites were proving this same axiom).

The TOPSOC launches occurred in the summer and fall of 1961, but sometime before this another approach to the QRC AFTRACK payloads had developed. In those days, the Air Force sponsored an annual review at the Stanford Electronics Laboratories (SEL) in Palo Alto, California, of SEL's activities in support of ELINT, or more precisely, the electronic warfare community. These were called the Technical Advisory Committee (TAC) meetings. Almost all contractors and government agencies involved in the development or use of electronic warfare systems attended regularly, making it one of the premier

ELINT events of the year. Until this time, of course, ground, sea, and airborne platforms were the extent of the discussions.

Bill Harris, the LMSC AFTRACK payload manager; Phil Doersam, LMSC S/S F manager; and Maj Copley attended the TAC meeting in August 1960 in search of concepts for AFTRACK payloads. At the meeting, Jim DeBroekert of SEL demonstrated a newly developed miniaturized receiver. With the receiver connected to a power meter, he had been flying it in his Cessna airplane around the San Francisco Bay area to demonstrate radar-location techniques. Harris asked DeBroekert if his receiver could be adapted to an AFTRACK application. The result was TAKI (named after the [redacted] it was intended to intercept), and it used [redacted] included a tape recorder, making it the first AFTRACK payload with this capability. Bill Rambo, in charge of SEL at the time, was intrigued with the simplicity of the concept and even made a short 8-mm movie to illustrate it. This was the beginning of a long association between SEL, LMSD, and SAFSP that ended only when pacifists protested SEL's involvement with the military during the Vietnam war.

Don Grace, who became the SEL manager for AFTRACK payloads, set up a small lab in the basement of their building on the Stanford campus where Don Eslinger built (essentially single-handed) all the SEL payloads (10 total). Other very capable members of their staff were John Hunter, Tony Taussig, Tom Miles, and Chuck Schoens. DeBroekert, Miles, and Hunter went on to form ARGO Systems when the university gave in to protesters in the spring of 1967 and closed SEL. Eslinger went to Georgia Tech, Schoens to Stanford Research Laboratories (SRI), and [redacted] by way of Applied Technology, Inc (ATI).

The SEL policy was to design and build the first of a new series and then turn production over to industry. Following TAKI, WILD BILL was invented in the spring of 1961. (Neither Grace nor DeBroekert would admit which Bill—Harris or Rambo—it was named after!) WILD BILL's mission was to search for signals from the [redacted] SEL built two WILD BILL payloads that covered the frequency range of 50 to 150 MHz, calculated to be the most probable band that [redacted] would utilize. The first WILD BILL was launched on 7 July 1961 and operated for two days with no important intercepts. The second, designated WILD BILL 1, was launched on 27 February 1962 and operated for only two orbits with no significant results. Later versions of WILD BILL were built by ATI, which had been formed in the Palo Alto area by John Grigsby.

another former SEL engineer. LMSC had contracted with Grigsby to build the follow-on versions of SEL payloads.

[redacted] For this reason, WILD BILL 2, Grigsby's first copy, launched on 12 December 1962, covered the frequency range of 550 to 620 MHz. Once again the results were nil. Since another signal collected from the reflection [redacted] WILD BILL 3 was designed for 150 to 230 MHz. This worked. WILD BILL 3, launched on 12 June 1963, collecting in the 150- to 230-MHz frequency range, made the first confirmed satellite intercept of the Soviet [redacted] on 26 June 1963. POPPY also made intercepts of [redacted] radar in the same time period.

The WILD BILL 3 intercept was the first time that the [redacted] signal had been collected since its first ground intercept in October 1962. The first [redacted] structure was seen in U-2 photography in April 1960 and the [redacted] This was confirmed shortly thereafter by an intercept by POPPY mission 7102, launched on 15 June 1963, plus additional intercepts by WILD BILL 4, which was launched piggyback on the POPPY launch vehicle.

Following the WILD BILL missions, John Grigsby (who was quite tall) proposed a payload that would define the center frequency of the [redacted] The payload was given the name of LONG JOHN and was flown on three very successful missions between 27 November 1963 and 13 June 1964. A fourth LONG JOHN (this was actually LONG JOHN 3, launched on 15 February 1964) suffered a recorder failure immediately after launch. All of the LONG JOHN payloads were launched on [redacted]

The last AFTRACK payload designed and built by Don Grace and his SEL team was PLYMOUTH ROCK. It covered the frequency range of 2.0 to 4.0 GHz and was built at the request of SAC. SAC had an urgent electronic order of battle (EOB) requirement to identify and locate as many [redacted] as possible in the interim prior to the launch of the Project 698BK and POPPY missions designed for this coverage. The intent was to provide an output compatible with the ELINT processing system called FINDER, which had been designed to process data from the U-2 and other airborne collection systems. PLYMOUTH ROCK 1 was launched on 24 November 1962 and achieved at least two firsts: it was the first AFTRACK payload to receive a mission number, 7201, in accordance with the new BYEMAN procedures, and it was also the first space payload to use a sweeping yttrium-iron-garnet (YIG) filter for frequency discrimination. Two more PLYMOUTH ROCKs were built by ATI, the last of which had the further distinction of being the only AFTRACK payload also carried by the new P-11 program.

The outputs from the AFTRACK payloads included commutated data from selected points on the primary mission telemetry commutator and also, at times, recorder output from the AFTRACK payload. Each payload was unique and produced different processing and analysis challenges. LMSC processed the data to evaluate payload performance and assisted NSA and SAC in their processing and analysis effort.

Data from TAKI, WILD BILL, TOPSOC, PLYMOUTH ROCK, and LONG JOHN were processed at NSA on an electronic machine complex known as HOPECHEST. HOPECHEST was a combination of an analog-to-digital converter and a CDC 160A computer (replaced with a CDC 3300 computer in the mid- to late 1960s). The differences in data format for each mission required extensive programming effort to write and extensive machine-time to check out the computer programs for each individual package. Frequently more time was spent in developing the processing than was required to process the data. For example, once the basic computer programs for a TAKI mission were written and checked out, it took a relatively small amount of time to process all the formatted data from that TAKI mission and any subsequent identical TAKI mission. Unfortunately, most missions were not identical because the AFTRACK payloads had to compete for points on the primary mission telemetry commutator, so data formats changed frequently. Analysis of the data still required extensive manual effort after or in parallel with the machine processing.

SAC processing and analysis of data from the AFTRACK payloads were frequently done by LMSC in building 524, Sunnyvale, for SAC with SAC participation. LMSC provided space and equipment for SAC analysts. NSA analysis of the limited data from the five TAKI flights revealed a high density of [redacted] Soviet early warning radar signals and provided [redacted] signal parameters. This was important at that time since the [redacted] radar was thought by some elements of the US Intelligence Community to function as a part of the Soviet ABM system.

The PLYMOUTH ROCK data were processed at LMSC, NSA, and SAC. SAC, [redacted]

While the AFTRACK ELINT story was unfolding, other parallel efforts were underway in the COMINT area. Interest in COMINT had surfaced in several [redacted] which he suggested some elements of S/S F of WS-117L might be adapted to COMINT collection, but he felt that feasibility needed to be demonstrated.

It was Capt Don Wipperman and his associates at Air Force Security Service (AFSS), San Antonio, Texas, who came up with the first COMINT satellite concept. Together with the AIL team, they presented an idea for an AFTRACK payload capable of intercepting [redacted] communications signal that was then thought to be from the prevalent air/ground (A/G) communications system in the Soviet Union. This resulted in the TEXAS PINT (AFSS was in Texas). Its only drawback was that when launched on 30 August 1961, it showed that [redacted] had been superseded by more advanced [redacted] communications systems. It did provide a good look at the VHF environment over the Soviet Union. These data were used extensively in later payload designs. In the summer of 1961, Sanders Associates at Nashua, New Hampshire, teamed with [redacted] Their two NEW JERSEY payloads (the original idea came from ITT in Nutley, New Jersey), launched on 27 July 1962 and 7 January 1963, intercepted and located several [redacted] The follow-on NEW HAMPSHIRE payload (built by Sanders Associates, Nashua, New Hampshire) never flew, due to contractual difficulties.

In another area of the COMINT scene, Wayne Burnett of HRB-Singer at State College, Pennsylvania, came up with a concept to intercept, encode, and record [redacted] It was necessary to encrypt this COMINT information on the down-link to safeguard it from Soviet knowledge. This was accomplished by use of NSA-furnished [redacted] encryption equipment, utilized during readout to US tracking stations. The intercept electronics, invented by HRB engineer Conrad Welch, resulted in three GRAPE JUICE payloads, launched on 12 December 1961, 17 April 1962, and 17 September 1962. They brought back [redacted] payload launched on 4 December 1962 had pretty much the same results. A final version, OPPORKNOCKITY ("it tunes but once"), was launched on 21 August 1964. [redacted]

Two more payloads, SQUARE TWENTY and DONKEY, launched in 1965 and 1967, completed the story of AFTRACK COMINT collection. With the experience to date, the concept of copying content from low orbiters was losing its attraction, and accurate location was becoming a more important consideration. SQUARE TWENTY, designed to locate the Soviet [redacted] communications links, was launched on 28 October 1965. It had a mission lifetime of 11 days and produced many [redacted] It also had a copy capability but could not lock on for periods long enough to be useful.

One other AFTRACK payload that was actually integrated into the front rack along with MULTIGROUP 2 and SETTER 1B was DONKEY, launched on 24 July 1967. This payload was part of a program initiated by Col John Copley, who was then assigned to the Manned Orbiting Laboratory (MOL) staff at US Air Force Headquarters. The payload activities were handled under the BYEMAN program, but through a unique management arrangement, the overall effort was managed by the Air Force. Back in February 1965, Copley had been assigned to determine if there were any SIGINT applications that might be enhanced by the manned aspect of the MOL. Several ELINT applications were examined, but in the area of COMINT, the intercept of the [redacted] could also be collected from the sidelobes, however, intercept times could be lengthened appreciably and might permit intercept of adjacent emitters on the same link, thereby providing the necessary continuity. This is what DONKEY attempted to demonstrate.

A program developed by the team of E-Systems in Garland, Texas, and EDL-Sylvania, using Soviet [redacted] transmitter specifications [redacted] involved airborne testing against a simulated [redacted] terminal installed at the E-Systems facility. An Air Force helicopter was used to fly a payload in an intercept pattern through the main beam and sidelobes of the microwave antenna. Phil Fyre and a team of analysts at EDL analyzed the data and made recommendations for mission profiles. The results were sufficiently encouraging to convince the team that a satellite test should be performed to verify the flight-test data. Use of a spinning P-11 satellite was considered, but the need for a three-axis-stable platform indicated the Agena vehicle was the appropriate carrier. Vince Henry, the AFTRACK and P-11

Flight summary: Program A, Project AFTRACK SIGINT payloads

MISSION* NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME									LIFETIME
			3rd Quarter 1960	4th Quarter 1960	1st Quarter 1961	2nd Quarter 1961	3rd Quarter 1961	4th Quarter 1961	1st Quarter 1962	2nd Quarter 1962	3rd Quarter 1962	Days
N/A	SOCTOP 1**	VULNERABILITY DETECT HOSTILE JAMMING OR TRACKING	08/10-11									1
N/A	TAKI 1	ELINT-GS [redacted]				06/16-17						2
N/A	WILD BILL	ELINT-GS ABM					7/7-8					2
N/A	TEXAS PINT	COMINT COPY [redacted]					8/30-9/1					2
N/A	TOPSOC 1	ELINT-GS ABM					9/12-9/19					5
N/A	TOPSOC 2	ELINT-GS ABM					9/17-9/21					4
N/A	TOPSOC 3	ELINT-GS ABM						10/13-10/15				2
N/A	TOPSOC 4	ELINT-GS ABM						11/5-11/7				2
N/A	GRAPE-JUICE 1	COMINT COPY [redacted]						12/12-12/13				1
N/A	WILD BILL 2	ELINT-GS ABM							2/27			2 orbits; 0.15
N/A	GRAPE-JUICE 2	COMINT COPY [redacted]								4/18-4/22		5
N/A	TAKI 2	ELINT-GS [redacted]								6/28-7/5		7
N/A	NEW JERSEY 1	COMINT COPY [redacted]									7/27-8/2	5
N/A	GRAPE JUICE 3	COMINT COPY [redacted]									9/17-9/22	5

GS = General Search ABM = Antiballistic Missile COPY = Lock-on Copy Content

* Mission number not assigned to AFTRACK payloads until November 1962

** Follow-on vulnerability payloads listed on separate table

Top Secret

[redacted]

Approved for Release: 2021/09/01 C05134315

Flight summary: Program A, Project AFTRACK SIGINT payloads *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME 4th Quarter 1962	1st Quarter 1963	2nd Quarter 1963	3rd Quarter 1963	4th Quarter 1963	1st Quarter 1964	2nd Quarter 1964	LIFETIME Days
7201	PLYMOUTH ROCK 1	ELINT GS	11/24-12/01							5
7202	WILD BILL 2	ELINT-GS [redacted]	12/12-12/15							3
7203	VINO 1	COMINT COPY [redacted]	12/4-12/7							3
7204	TAKI 3	ELINT-GS [redacted]	12/4-12/7							6
7205	NEW JERSEY 2	COMINT COPY [redacted]		1/7-1/14						6
7206	VINO 2	COMINT COPY [redacted]		2/28	(Failed to orbit)					0
7207	WILD BILL 3	ELINT-GS [redacted]			6/12 6/26					13
7216	WILD BILL 4	ELINT-GS [redacted]			6/15	7/20				35
7208	PLYMOUTH ROCK 2	ELINT GS			6/29	7/11				12
7219	LONG JOHN 2	ELINT DC/TI [redacted]					11/27 12/12			15
7218	LONG JOHN 1	ELINT DC/TI [redacted]					12/21	1/10		20
7210	HAYLOFT	ELINT-GS ABM						1/11 1/30		19
7222	LONG JOHN 3	ELINT DC/TI [redacted]						2/15 3/9		23
7224	LONG JOHN 4	ELINT DC/TI [redacted]							6/13 6/26	13

[redacted] = Directed Coverage
GS = General Search
TI = Technical Intelligence
ABM = Antiballistic Missile
COPY = Lock-on Copy Content

Flight summary: Program A, Project AFTRACK SIGINT payloads *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME											LIFETIME
			3rd Quarter 1964	[illegible] 1964	[illegible] 1965	[illegible] 1965	[illegible] 1965	[illegible] 1965	[illegible]	3rd Quarter 1967	4th Quarter 1967	1st Quarter 1968		Days
7215	OPPOR-KNOCKITY	COMINT COPY	8/21	10/23										53
7223	NEW HAMPSHIRE	COMINT COPY	Cancelled due to technical problems											0
7225	SQUARE TWENTY	COMINT COPY/LOC					10/28	11/8						20
7231	DONKEY	COMINT COPY/LOC								7/24		1/28		190

Note: 7200 Series BIRD DOG, SETTER, CONVOY, and HARVESTER were classified as secondary payloads on 698BK,770, andSTRAWMAN Projects, and were listed with them.

COPY = Lock-on Copy Content
LOC = Locate < 15 miles

Top Secret

[redacted]

Approved for Release: 2021/09/01 C05134315

manager at LMSC, determined that a location on the forward rack was the only practical place to mount the 6-foot expandable parabolic antenna required for the mission. Agena vehicle 2732, scheduled to launch the MULTIGROUP 2 and SETTER 1B payloads in July 1967, would have new, more powerful CASTOR II solid rockets, providing greater thrust than the previously used thrust-augmented Thor (TAT) booster. This made it a logical choice for the addition of DONKEY. Installation of all three payloads (including three outboard expandable antennas) required very innovative engineering. This may have been the point at which the payload was named DONKEY (for lack of a better explanation). In any case DONKEY boasted an independent down-link and when launched on 24 July 1967 operated 30 days longer (for a total of 182 days) than the other payloads following the failure of their data link transmitter.

DONKEY was unable to perform the sidelobe intelligibility mission on orbit due to the failure of the pointing mechanism on the 6-foot dish antenna. This did not prevent mapping of the [redacted] emitter locations, resulting in the development of a grid involving a large majority of the [redacted] emitters in the Soviet Union. These preliminary COMINT data were valuable in mission planning for the [redacted] In fact, the initial airborne intelligibility program convinced Gene Pitsenbarger of EDL and Vince Henry (and his boss, George Minalga) of LMSC [redacted] emitter as the low-orbiting MOL flew swiftly over the Soviet Union (this may be another explanation for the name of the DONKEY COMINT AFTRACK payload). [redacted]" The locations produced by SQUARE TWENTY, DONKEY, and the later ARROYO P-11 payload furnished a wealth of information in planning the [redacted]

All of the data from the COMINT payloads were analyzed at the contractor facilities and at NSA, mostly by rather laborious manual processing. The information gained from the early TEXAS PINT, NEW JERSEY, GRAPE JUICE, and VINO payloads was minimal except for the development of a healthy respect for the interference environment over eastern Russia. OPPORKNOCKITY made 12,000 intercepts of recognized [redacted] signals that contained several teletype and some voice modes. These [redacted]

SQUARE TWENTY made 1,290 intercepts of the Soviet [redacted]

50 miles on single hits. Poke-throughs (ground antenna main beams hitting sidelobes of the payload antenna) were minimized by the payload's ability to measure power levels of incoming signals. Unique information was obtained on the Soviet [redacted]

SQUARE TWENTY achieved its primary objectives and yielded substantial evidence to support further efforts targeting microwave communications, using satellites for collection.[3]

DONKEY mapped [redacted] locations much like SQUARE TWENTY mapped [redacted] During the DONKEY payload's five-month life starting 24 July 1967, it detected Soviet [redacted] signals on over 1,000 tasked orbits. Tasking included command selection of various RFs corresponding to known trunks of the [redacted] The high sensitivity of the system resulted in false readings due to the main beam of the [redacted] transmitter being received in the sidelobes of the DONKEY antenna. However, other data, such as long-intercept durations and amplitude-versus-time profile, were used to validate the true target location.[5]

AFTRACK payloads such as OPPORKNOCKITY, VINO, SQUARE TWENTY, and DONKEY required extensive, time-consuming manual analysis. Typically the NSA analyst would go to LMSC when the payload was launched and work with the payload designers and operators for a week or more to validate the data and methods for analysis. Data would then be [redacted] The time information with ephemeris data was used to plot the position of the satellite at the time of intercept. It was then possible to use all the manually derived data and make determinations about the location and pointing angle of the transmitting antenna, its signal type, and probable user. These efforts were so time-consuming that it took two years to manually analyze 11 days of SQUARE TWENTY collection. Five months of DONKEY collection also took about two years to analyze, even with additional analyst assistance. Most of these data was analyzed by [redacted] of the NSA [redacted] with the able assistance of other members of his group, including [redacted] his chief analyst.

The AFTRACK payloads had run their course by the time of the SQUARE TWENTY launch in 1965. The much more capable spinning subsatellites, called P-11s by LMSC, took over the original QRC-type missions of the AFTRACKs, and went on to greater capability, utility, and inevitably, the accompanying and ever-increasing cost.

Project 989, the P-11 Spinning Subsatellites

The P-11 subsatellite project, approved by DNRO Charyk in the summer of 1962, was to become the mainstay of the Air Force (Program A) SIGINT low orbiters by the end of the decade. After the cancellation of the STRAWMAN project in 1970, the Air Force P-11s and the Navy POPPY [redacted] comprised the low-orbit SIGINT satellite program.

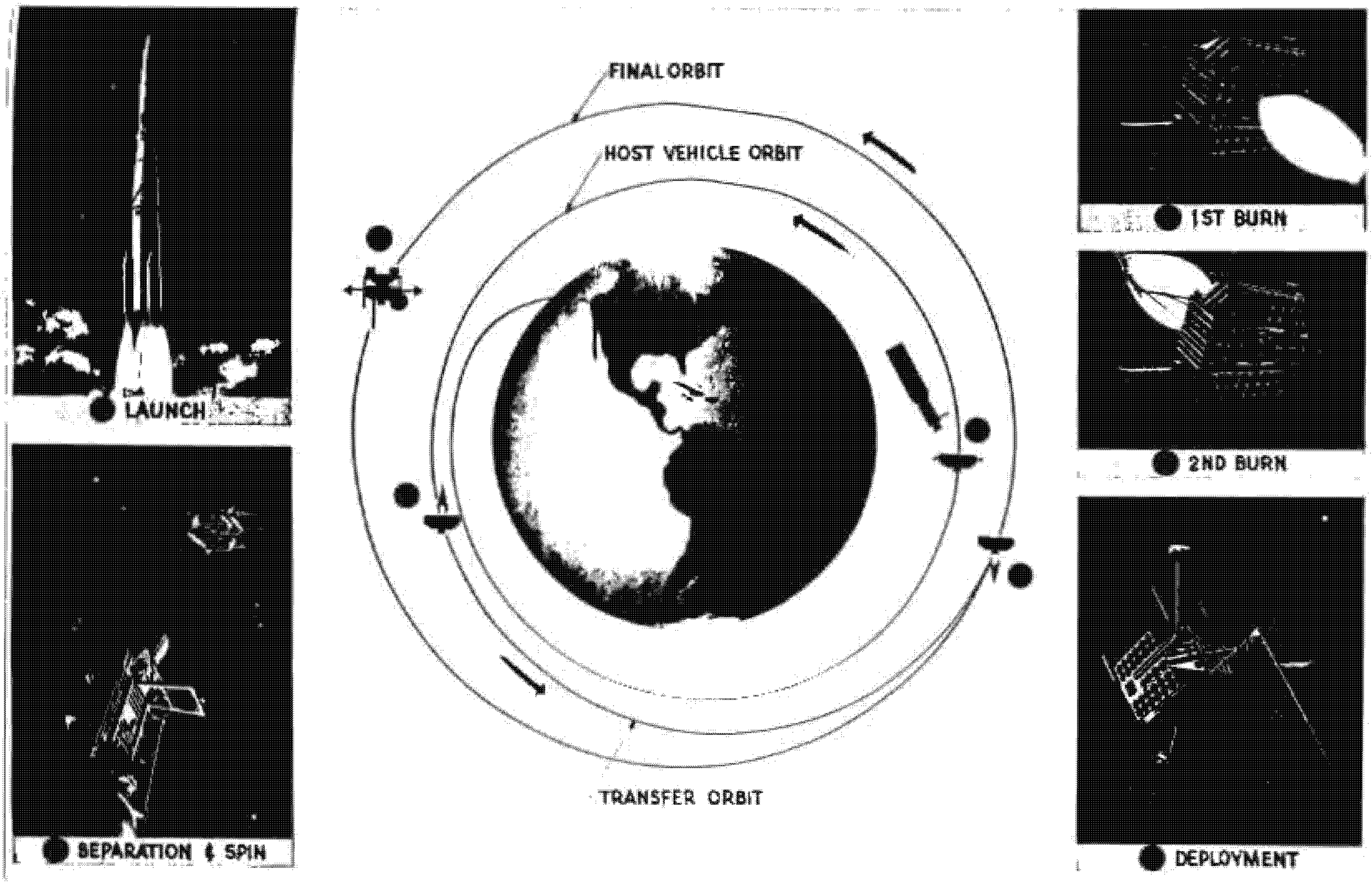
The ARPA-sponsored development of HITCHHIKER, the first LMSC P-11, showed the way to overcoming the many limitations of the SIGINT AFTRACK payloads. Because the P-11 was launched from the DISCOVERER Agena after it was in orbit, minimal energy was required to boost the P-11 to the new, higher orbit needed to provide the longer lifetime desired for SIGINT missions. In addition to long life, a major advantage was the manyfold increase in available payload weight, providing greater capability and versatility.

Following on-orbit release from the Agena, the satellite was spun up to approximately one revolution per second by small solid rocket motors firing perpendicularly to the line of flight. On the ARPA version, HITCHHIKER, a large solid rocket motor mounted on the spin axis was then fired to obtain the desired eccentric Earth orbit. On the SIGINT mission satellites a smaller rocket was used to boost the satellite to a new orbit with a 275-mile apogee. Firing a second rocket engine at apogee circularized the orbit at an altitude of 275 miles, providing years of potential lifetime.

The first P-11s were hexagonally shaped and about 40 inches in diameter, weighed 240 pounds, used solar arrays attached to the vehicle that charged a battery for power, and contained a command receiver and telemetry transmitter.

Key accomplishments, Agena AFTRACK payloads

- Revealed high density of Soviet radars for early warning of aircraft, in 1961.
- Proved intercept of low-power, low-VHF communications from space, including automatic recognition of active signals on Soviet [redacted] communications, in 1961.
- Produced locations of Soviet communications transmitters for intelligence database, in 1965, that was later used for [redacted]
- Monitored Soviet radar tracking of US reconnaissance satellites.



Project 989 sequence of launch events

[redacted]

The power system was upgraded with the launch of vehicle 4401, PUNDIT 4, on 28 April 1965, by the addition of a set of erectable solar arrays that were unfolded on orbit. As weight and payload capabilities expanded, additional erectable solar arrays were added to match the power capacity to the mission requirements. The spinning-pencil-beam missions, starting with vehicle 4402, FANION/TRIPOS, launched 25 June 1965, introduced a sun sensor and a horizon sensor to support their direction-finding capability. For more accurate spin axis determination, three sun sensors were incorporated in the later direction-finding missions, starting with vehicle 4423, TOPHAT, launched 18 November 1970. Vehicle 4427, ARROYO, launched 10 September 1971, was the first vehicle with the electrical axis of its parabolic direction-finding antenna parallel to the spin axis of the vehicle; it used a magnetic attitude-control system to maintain the spacecraft axis within a few degrees of the orbit plane at 55 degrees north latitude. Commandable spin-rate control had been incorporated first in vehicle 4422, TIVOLI 3, launched 4 March 1970. Almost every P-11 vehicle added one or more new features. These capabilities did not come without an accompanying increase in weight that saw the 240 pounds for PUNDIT 1 grow to 380 pounds for MABELI, the first P-11 launched on the new HEXAGON program, which used a Titan launch vehicle. The additional weight-carrying capacity of the HEXAGON vehicle made it possible to build the 565-pound vehicle 4429, RAQUEL 1, launched 29 October 1974.

The SIGINT P-11s were initially assigned project number 770A, but in 1965, because of an NRO administrative change, the number became 989. This number stuck and the project has since been Project 989.

As the project developed, additional payload capabilities were added. The first P-11s had essentially nondirectional antennas and were intended to collect specific emitters, primarily to obtain textual content of the intercept data. These were directed-coverage missions, which included PUNDIT and SAVANT for on-pad and launch telemetry and WESTON for radio teletype and voice content of the Soviet VHF and UHF point-to-point communication systems [redacted] and [redacted] As the advantage of COMINT mapping over copying content from low-orbit became more obvious (primarily because of the interference environment and limited time to copy content), direction-finding techniques were incorporated in the directed coverage P-11 payloads in addition to the content copy function. In the COMINT area, these techniques were used by ARROYO for [redacted] microwave communications and TOPHAT for Soviet [redacted] communications.

The first ELINT payloads were also directed-coverage missions, with no direction-finding capability but with increasingly capable technical intelligence (TI) capabilities. These included NOAH'S ARK, STEP 13, SLEW-TO, MAGNUM, FACADE, TIVOLI, and MABELI. These were followed by the general search (GS) and electronic order of battle (EOB) missions that used spinning-pencil-beam antennas for direction finding. These included FANION, TRIPOS, SOUSEA, and SAMPAN. The one exception, PLYMOUTH ROCK, was the first and only GS P-11 payload with no direction-finding capability. A combination of these payloads, plus LAMPAN and VAMPAN (to extend the search range of SAMPAN), was used to attack the ABM problem when it became a vital concern in late 1966. These were SAMPAN, LAMPAN, VAMPAN, FACADE, TIVOLI, MABELI, TRIPOS, and SOUSEA. The last phase of the program saw the development of spinning-pencil-beam, monopulse payloads with all digital output, capable of providing direction-finding information on a pulse-by-pulse basis. These were URSALA, RAQUEL, and FARRAH, with GS, EOB, and directed-coverage capabilities.

By 1962, the long-standing requirement to intercept telemetry transmissions from Soviet missile launches had become a major problem for intelligence analysts. These data carried needed information about the missile operation and launch profile. The CIA, NSA, and armed services intercept sites strung around the periphery of the Soviet Union could not [redacted] By this time, most of the critical missile staging and thrust measurements had already been transmitted to the Soviet ground station.

[redacted]

Henry, P-11 payload manager at LMSC, were impressed with the importance of intercepting on-pad and liftoff missile telemetry. EDL-Sylvania was chosen to build a payload for the P-11 that could accomplish this task in the low VHF region between 61 and 76 MHz. Bill Perry,* the EDL payload engineer, knew from the experience of previous AFTRACK missions that the payload would encounter severe electromagnetic interference. To counter this threat, he incorporated interference-reduction circuitry designed to permit payload operation in the presence of strong TV and FM broadcast signals. To increase the flexibility of the payload, the down-link used an NSA-furnished [redacted]

This first P-11 payload, called PUNDIT (relating in some tortured way to Charlie Tevis), was launched from ARGON vehicle 1601 on 29 October 1963. The payload operated for 19 months, but the interference problem everyone had feared minimized the payload's ability to extract telemetry data from the intercepts. The probability of receiving launch pad test telemetry appeared to be good, but, of course, the probability that PUNDIT would arrive over the launch site just as a missile was being launched was very low. Three more PUNDITS were launched over the next

* William J. Perry was Director of Sylvania/General Telephone Electronic Defense Laboratories in 1963, and in 1965 he founded ESL, Inc. Later, he served as Under Secretary of Defense for Research and Engineering (1977-1981), as Deputy Secretary of Defense (1993-1994), and as Secretary of Defense (beginning in 1994).

year and a half with rather marginal results (PUNDIT 3 suffered a launch-vehicle failure).

In 1965 Bill Perry left EDL to form his own company, Electronic Systems Laboratories (ESL), in Sunnyvale, California. He proposed an advanced version of the PUNDIT payload that would have the added capability to cover the Soviet's newly developed UHF telemetry frequency bands that should be relatively free from high-power radio broadcast and TV interference. This payload, SAVANT, featured electronic recognizers to assist in collecting [redacted] telemetry used by the UHF telemetry transmitters. It also featured advanced FM and TV interference cancellation. There were two successful launches of SAVANT, on 16 June 1967 and 22 September 1969. Both missions operated for well over a year and produced greatly improved telemetry data.

PUNDIT 1 collected VHF missile telemetry in the 60- to 80-MHz frequency range on 24 orbits; some of the telemetry [redacted] PUNDIT 2 operated for three months and PUNDIT 4 operated for 21 months with similar results. The data collected by the PUNDIT satellites were processed at NSA and con- [redacted]

PUNDIT provided the first real volume of data on the signal density in the Soviet telemetry bands at satellite altitudes. The signal-density data were analyzed at ESL in Sunnyvale to develop environmental data necessary for the design [redacted]

SAVANT 1 and 2 provided 1-MHz bandwidth predetection data that were processed and analyzed at NSA. [redacted]

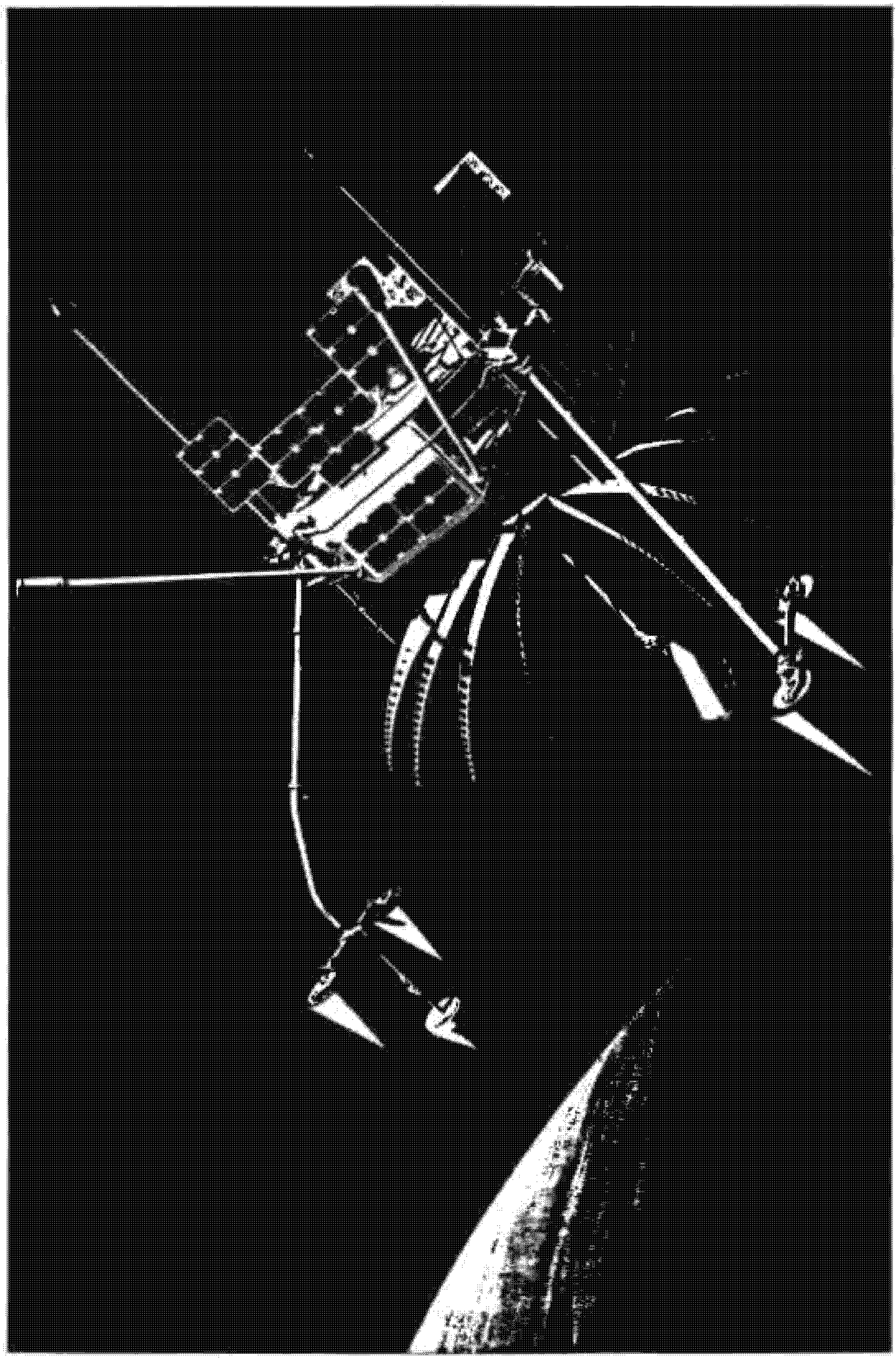
WESTON was the only directed-coverage P-11 COMINT satellite with no direction-finding capability. It was designed by Wayne Burnett and his team at HRB-Singer in State College, Pennsylvania, as a follow-on to their OPPORKNOCKITY AFTRACK payload. WESTON was designed to collect the content of [redacted] It had a 100-kbps down-link using a [redacted] encrypter furnished by NSA. The launch was delayed for more than two years by a combination of trouble in passing the system test and the overwhelming priority of the ABM-intercept P-11s. WESTON was finally launched on 30 September 1969 and operated for 11 months on orbit. Nominal results were achieved primarily because of the same interference environment that had pestered its predecessors.

WESTON data were manually analyzed at NSA. The data analysis confirmed [redacted] the interior of the Soviet Union, first detected by OPPORKNOCKITY in 1964. WESTON further demonstrated the severe European FM broadcast interference problem in space. The heavy interference and signal-density environments made data analysis very difficult and limited the value of the collected data. WESTON discovered VHF links subordinate to Soviet [redacted] WESTON also produced data on the ELINT signals from [redacted] Soviet ABM radars.[8] WESTON [redacted] with mission 7335, TIVOLI 3, intercepted [redacted] and [redacted] radars, revealing additional signal data.[9]

The P-11 COMINT mappers included ARROYO and TOPHAT. ARROYO [redacted] was approved in 1966 almost simultaneously with the [redacted] It was built by AIL to map microwave towers operating over the 1,200- to 2,200-MHz and 3,400- to 3,900-MHz frequency ranges. Launch was delayed until 10 September 1971, primarily because of the high priority assigned to the P-11 ABM payloads. ARROYO featured a 6-foot expandable parabolic dish antenna pointing in the direction of the P-11 spin axis, which used conical scan [redacted] plus fast RF search with signal recognition lock-on and sidelobe-inhibit antennas. It was also capable of precision power measurements and accurate RF determination. Orbital lifetime ended after one month due to a massive payload failure.

The ARROYO data from the analog magnetic tapes were recorded on roles of [redacted] ARROYO showed [redacted]

TOPHAT, built by E-Systems in Garland, Texas, featured a spinning interferometer with back-to-back pairs of conical spiral antennas (first pneumatic deployment) and had the mission of locating and recording selected voice, tone, and teletype channels of Soviet troposcatter communications emitters in the frequency



ARROYO COMINT P-11 spacecraft

range of 450 to 1,000 MHz. The output data were digitized at a 1-Mbps rate and transmitted on the down-link using an NSA-furnished [redacted] There were two launches, one on 18 November 1970 and one on 10 April 1974. Very successful orbital lives of almost four and six years, respectively, were achieved.

The TOPHAT P-11 down-link was recorded at the remote tracking stations (RTSs) in its encrypted form. The data were then forwarded to NSA for decryption and processing [redacted] wrote the software at NSA to process the data. TOPHAT data analyzed by [redacted] and his team provided the complete structure of the Soviet [redacted] emitters. TOPHAT also provided support to the [redacted] system in its COMINT mission. As a bonus, TOPHAT aided in identifying users of the Soviet [redacted]

The first directed-coverage P-11 ELINT payload was NOAH'S ARK built by Applied Technology, Inc. (ATI), Palo Alto, California. The system engineer was Tony Taussig (whose first name was really Noah) and the mission was to intercept [redacted] and other high-power radars in the 154- to 550-MHz frequency range. Launched on 6 July 1964, the mission collected data for 35 days. All analog data were analyzed manually at NSA. There were no significant results.

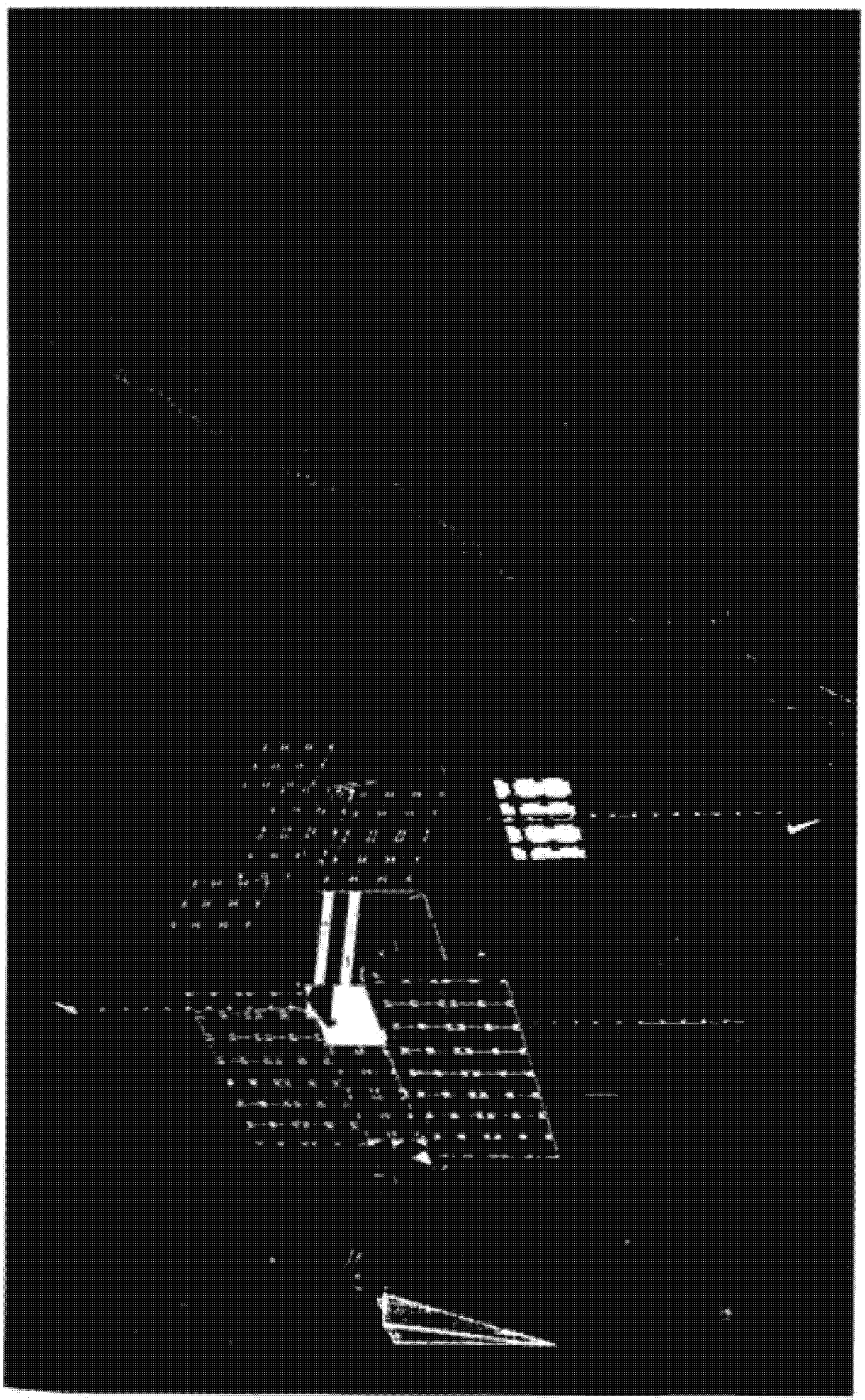
Next in the series was STEP-13, built by HRB-Singer, which had an ABM search mission covering 150 to 230 MHz. The coverage was selected based on 13 unidentified signals intercepted by a CIA peripheral intercept site and believed to be ABM-related. STEP-13 was launched on 23 October 1964 and operated for four months. The data were manually analyzed at NSA, SAC, and LMSC and provided several unusual signals, including a Soviet [redacted]-like radar signal.

The third P-11 payload in this series was MAGNUM, built by ATI to collect further data on [redacted] and other possible high-power search or ABM radars. It covered the 100- to 250-MHz frequency range and featured a recognizer plus sample-and-hold circuitry to preserve [redacted] It was launched on 3 August 1965, had a mission lifetime of 19 months, and made a major contribution to the early understanding of the Soviet [redacted] ABM radar. MAGNUM produced both wide- and narrowband data for analysis. Wideband data were received through a filter with a bandwidth of 154 to 162 MHz. Narrowband data were received through a 1-MHz filter centered about 158 MHz, which permitted an estimate of scan time as the signal swept through the filter.[11] The MAGNUM tapes were screened by analysts at NSA, and those containing signals of interest were analyzed at either NSA [redacted] presentation. Analysis of the MAGNUM data determined the [redacted] of the [redacted] radar signal.[12] MAGNUM intercepted the [redacted] radar at [redacted]

SLEW-TO, built by Bill Perry's new ESL in Sunnyvale, California, was the first payload to feature predetection recording and a recognizer and delay line to track the [redacted] radar. It covered the frequency range of 154 to 163 MHz and used a new 1-MHz bandwidth magnetic tape recorder. SLEW-TO was launched on 9 May 1967 and had an orbital lifetime of three months. The payload split the [redacted] SLEW-TO's wideband down-link failed after four days, but the narrowband (150 kHz) predetection recorder and unique [redacted]

The FACADE P-11 payload was actually the first in the series of high-priority ABM search missions authorized as a result of the Harry Davis Committee recommendations in late 1966. It was launched on 2 November 1967, just nine months from

[redacted]



TIVOLI technical intelligence P-11 spacecraft the time Vince Henry at LMSC was given a go-ahead. To cover all suspected ABM frequencies, it covered 250 to 2,250 MHz in [redacted]

The TIVOLI P-11 payload was in development when FACADE was authorized but, due to its more sophisticated circuitry, could not be readied on the desired time scale. It was built by ESL and had a more capable technical intelligence (TI) design that covered the frequency range of 100 to 4,020 MHz. [redacted] It was launched on 24 January 1968 and had an orbital lifetime of 15 months. There were two additional TIVOLI launches, on 19 March 1969 and 4 March 1970; orbital lifetimes were 18 and 20 months, respectively. The 1-MHz bandwidth predetection data [redacted]

TIVOLI 1 produced detailed signal-modulation data on numerous Soviet ABM radars, [redacted] These data were either new data or confirmations of the data produced earlier by POPPY and MULTIGROUP. In addition, TIVOLI 1 identified a possible mode [redacted] TIVOLI 1 also produced data on a number of new and unidentified radars.

TIVOLI 2 collected a number of additional new and unusual signals, as well as confirming results from TIVOLI 1 and other satellite intercepts. TIVOLI 2 found [redacted]

[redacted]

Analysis of data from the TIVOLI 3 flight refined the technical details of the Soviet [redacted] TIVOLI 3 also developed information on the [redacted][27] New signals were detected in the Soviet Union and China.

The last of the directed-coverage TI payloads was MABELI manufactured by ESL to provide technical intelligence on and measure the effective radiated power (ERP) of the ABM radars [redacted] Launch was on 20 January 1972 and the orbital lifetime was more than seven years. The MABELI data were screened by the [redacted]

MABELI made precision main-beam radiated power and polarization measurements on volumes of radars, including all of the Soviet ABM transmitters [redacted] all analyzed in unprecedented detail from MABELI data, and many technical reports were published by NSA. Some specific results included the following: [redacted] Chinese radars were also intercepted.[31]

The next series of P-11s were the spinning-pencil-beam general search (GS) and electronic order of battle (EOB) collectors. The first of these, PLYMOUTH ROCK, was an exception in that it did not have a spinning-pencil-beam antenna. It had been an AFTRACK payload and SAC had developed a capability to process the data. In order to provide a longer life and consequently more data, the last PLYMOUTH ROCK payload was mounted on a P-11, but there was no way to add a direction-finding capability without major modifications. Additionally, payloads with direction-finding capability were in the planning stage and the primary mission of PLYMOUTH ROCK was to obtain data that SAC could process for its ELINT EOB files on an expedited basis. It was launched with STEP-13 on 23 October 1964 and had a orbital lifetime of 134 days.

FANION was built by Jim DeBroekert and the Stanford Electronics Laboratories (SEL) team. It used a Mills Cross antenna to provide an in-track and cross-track intercept, the intersection of which was the location of the target. It was designed to collect [redacted]

[redacted] even though the BIRD DOG payload that had the same mission was in the design stage. DeBroekert was convinced that the BIRD DOG would miss [redacted] due to lack of sensitivity.

FANION 1, mission 7307, was launched on 25 June 1965 and operated for 21 months. This mission collected the target-tracking signal from the Soviet [redacted]

FANION 2, mission 7317, launched 16 September 1966, operated for three months. FANION 3 (PENNON), mission 7319, launched on 9 May 1967, operated for 80 days. SAC processed the data from both of these missions for NSA as described above and produced a large volume of useful EOB data. Manual signal analysis at NSA found [redacted] 33

TRIPOS 1, the first true spinning-pencil-beam system, built by ATI, was launched as a companion mission on the same P-11 as FANION 1 on 25 June 1965. TRIPOS was a search system collecting signals in the 4- to 8-GHz range, with a location capability provided by a 3-foot directional antenna that scanned Earth's surface with a pattern resembling a pencil beam. TRIPOS 1 operated for 21 months. TRIPOS 2 was launched with FANION 2 on 16 September 1966 and operated for three months. The analog data from these systems were processed and analyzed at NSA. The software used for each mission was modified as necessary to take advantage of experience gained on previous missions and to account for individual differences or problems associated with each mission.[34] TRIPOS produced [redacted] described earlier in the FANION processing. The technical signal analysis of the TRIPOS analog data produced reports on a number of new and unusual signals.[35]

The last P-11 payload developed by SEL was SAMPAN. It covered 2 to 4 GHz, used a 3-foot parabolic dish antenna and had an inhibit function, similar to that used on the MULTIGROUP payloads built by AIL, to prevent interference from main beams of ground emitters. (Two omnidirectional antennas received main beams on signals seen in the sidelobes of the pencil-beam antenna. A comparator determined if the signal in the omni channel was stronger than that in the pencil-beam channel and, if so, inhibited it so that it would not be present in the output.) It [redacted] from blocking out the ABM-associated radar intercepts that were the primary target of SAMPAN 2 and 3.

SAMPAN 1 was launched along with SOUSEA 1 built by AIL, Mineola, Long Island, New York. SOUSEA covered the 8- to 12-GHz range using a 3-foot dish and a sidelobe inhibit antenna similar to that on the SAMPAN system to prevent the poke-through problems seen on the earlier FANION/TRIPOS missions. SAMPAN 1/SOUSEA 1 were launched on P-11 vehicle 4405, 16 August 1966, and had an orbital lifetime of 14 months.

[redacted]

[redacted]

SOUSEA 1 analog data were manually analyzed at NSA. SOUSEA 1 provided data on the Soviet target-tracking radar, [redacted]

[redacted]

SAMPAN marked the swan song for SEL. When militant students surrounded and picketed the Stanford building during the Vietnam war in 1966, Jim DeBroekert gained undying fame by remaining inside the building to guard the BYEMAN safes. Fortunately the students chose to ignore him but he gained the novel distinction of being blacklisted in the Students for Democratic Society (SDS) "Pig Book." During a break in the picketing, Jim, with Air Force assistance, smuggled the SAMPAN payload through Moffett Naval Air Station to [redacted] at LMSC. With the Stanford decision to close SEL as a result of the student action, SAMPAN 1 was completed at LMSC and SAMPAN 2 was built there.

In the summer of 1966, great concern developed in the Intelligence Community that emissions from ABM installations [redacted] were not being intercepted by the SIGINT satellites. The President's Scientific Advisory Committee (PSAC) asked DNRO Alexander H. Flax to form a committee to investigate the problem. Flax appointed Harry Davis, the former Director of the Rome Air Development Center in Rome, New York, and a member of Flax's staff, to chair the committee. In December 1966 Charlie Jarrett and Daymond Speece of The Aerospace Corporation briefed the Davis Committee. Speece and Jarrett showed probability data indicating that if these radars were active and radiating, a combination of P-11s would intercept the signals. On this basis, DNRO Flax approved and expedited the P-11 program, with a first launch nine months following. This short time from approval to launch was accomplished by those dedicated workers on the FACADE payload mentioned earlier. Additional ABM payloads in this series were TIVOLI, VAMPAN, LAMPAN, SAMPAN, TRIPOS, SOUSEA, and MABELI. By 1970, this series, plus the POPPY and STRAWMAN satellites, had identified all of the ABM radar installations.

SAMPAN 2 was launched with LAMPAN 1 on 14 March 1968 and operated for 12 months. These general search (GS) missions were specifically designed to address the Soviet ABM and SAM problems. At this time P-11 data were being processed and analyzed at NSA, [redacted] direction, depending on the availability of resources. SAMPAN 2 provided data on several unidentified signals, such [redacted]

SAMPAN 3 was launched with LAMPAN 2 on 1 May 1969 and operated for 10 months. Both missions had problems that required special manual processing efforts. The spin axis was 20 degrees off nominal and there was [redacted] that corrupted the radar data. SAMPAN 3 [redacted] after the software was modified to account for the spin axis problem.[40]

LAMPAN data were analyzed at NSA, [redacted] depending on the availability of resources. LAMPAN intercepted several high-interest and unidentified signals. LAMPAN 1 provided data on a possible [redacted]

SOUSEA 2 was launched with TRIPOS 3 on 20 June 1968 and operated for 18 months. The data were processed at [redacted] NSA under the Air Force MADS contract. Technical analysis of SOUSEA 2 data provided some new [redacted] signals and, with TRIPOS 3, provided data [redacted]

SOUSEA 3 was launched with TRIPOS 4 on 20 May 1970 and operated for 32 months. The data were also processed at [redacted] NSA. SOUSEA 3 processing produced [redacted] 20 December 1970, which were reported in hardcopy reports.[43] Technical analysis of the SOUSEA 3 data provided additional new [redacted] SOUSEA 3 data, combined with data collected by the HARVESTER satellite payload (described in Chapter 4), provided a number of reports on an unidentified 8- to 10-GHz signal.[44]

The two flat window-shade, log-spiral collection antennas on VAMPAN provided a phase interferometer system, permitting single angle-of-arrival measurements to be

Flight summary: Project 989 P-11 subsatellites

MISSION NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME 1963	1964	1965	1966	1967	LIFETIME Months
N/A*	HITCH-HIKER 1	MAP VAN ALLEN BELT	7/1 9/15					2
7301	PUNDIT 1	TELINT COPY (MISSILE & SPACE)	10/30		5/22			19
7302	PUNDIT 2	ELINT COPY (MISSILE & SPACE)	12/19	3/9				3
7304**	NOAH'S ARK	ELINT ABM GS/TI		7/6 8/11				1
N/A*	HITCH-HIKER 2	MAP VAN ALLEN BELT		8/4	11-1			15
7305 7306	STEP-13 PLYMOUTH ROCK	ELINT - DC ELINT - GS		10/23	2/23			4
7309	PUNDIT 4	TELINT COPY (MISSILE & SPACE)			4/28		1/25	21
7307 7308	FANION 1 TRIPOS 1	ELINT C-BAND- [redacted] C-BAND GS			6/27		3/16	21
7312	MAGNUM	ELINT ABM [redacted] GS/TI			8/3		3/9	19
7310 7311	LIEGE PLICAT	ELINT [redacted]			Recorders failed on first orbit	5/14		0
7314 7315	SOUSEA 1 SAMPAN 1	ELINT X-BAND GS S-BAND GS				8/16	10/15	14
7317 7318	FANION 2 TRIPOS 2	C-BAND [redacted] EOB C-BAND GS				9/16	12/7	3

GS = General Search
TI = Technical Intelligence
EOB = Electronic Order of Battle
ABM = Antiballistic Missile
DC = Directed Coverage
COPY = Lock-on Copy Content

* No mission number (not part of Project 989)
** 7303 4102 PUNDIT 3: Failed on launch

Flight summary: Project 989 P-11 subsatellites *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME 1967	1968	1969	1970	1971	LIFETIME Months
7316 7319	SLEW-TO FANION 3	ELINT DC/TI [redacted] EOB (C-BAND)	5/9 8/11					3
7320	SAVANT 1	TELINT COPY (MISSILE & SPACE)	6/16	10/22				16
7321	FACADE	GS/TI ABM	11/2	2/9				3
7324	TIVOLI 1	ABM DC/TI		1/24	4/10			15
7322 7323	LAMPAN 1 SAMPAN 2	ABM GS		3/14	3/7			12
7326 7327	TRIPOS 3 SOUSEA 2	ABM GS		6/20		1/13		18
7325	VAMPAN 1	ABM GS		9/18	9/28			12
7330	TIVOLI 2	ABM CHICOM TELINT DC/TI			3/19	9/24		18
7328 7329	LAMPAN 2 SAMPAN 3	ABM GS			5/1	2/16		10
7336	SAVANT 2	TELINT COPY (MISSILE & SPACE)			9/22		5/16	20
7313	WESTON	VHF COMINT COPY				9/30	8/17	11

DC = Directed Coverage
GS = General Search
TI = Technical Intelligence
EOB = Electronic Order of Battle
ABM = Antiballistic Missile
VHF = Very High Frequency
COPY = Lock-on Copy Content

Flight summary: Project 989 P-11 subsatellites *(continued)*

MISSION NUMBER	PROJECT and PAYLOAD	MISSION	OPERATIONAL LIFETIME 1970	1971	1972	1973	1974	1975	LIFETIME Months
7335	TIVOLI 3	ABM DC/TI	3/4	10/04					20
7332 7333	TRIPOS 4 SOUSEA 3	ABM GS	5/20			1/9			32
7334	TOPHAT 1	COMINT TROPOSCATTER LOC/COPY	11/18				6/21		43
7337	ARROYO	COMINT MICROWAVE LOC/COPY		9/10 10/10					1
7339	MABELI	ABM DC/TI			1/20			4/17/79	87
7338	URSALA 1	ELINT GS/EOB			7/7			5/6/78	69
7342	URSALA 2	ELINT GS/EOB				11/10		12/26/78	62
7340	TOPHAT 2	COMINT TROPOSCATTER LOC/COPY					4/10	2/24/80	71
7341	RAQUEL 1	ELINT [redacted] TI/EOB					10/29	1/23/80	62

DC = Directed Coverage
GS = General Search
TI = Technical Intelligence
EOB = Electronic Order of Battle
ABM = Antiballistic Missile
CW = Continuous Wave
COPY = Lock-on Copy Content
LOC = Locate < 15 miles

made. [redacted] of NSA worked very closely with Vince Henry, the LMSC payload designer, to ensure that the payload design would provide sufficient signal measurements to resolve phase ambiguity in the processing. [redacted] developed the algorithms for processing the VAMPAN collected data. The data from this GS mission were processed manually with computer assistance both at NSA and for NSA [redacted] spent much time at LMSC before and after the launch, evaluating the payload and data.[45] VAMPAN provided information on a [redacted] VAMPAN also provided information on other non-ABM-associated radars such as [redacted]

Manual analysis of the FACADE data from the 2 November 1967 launch by the Special Signals Analysis Team (SSAT) at [redacted] NSD direction found the first intercept, on 4 November 1967, of the Soviet [redacted] ABM target-tracking radar, [redacted] representing a significant new Soviet radar design.[46] FACADE also intercepted a possible [redacted] ABM radar associated with the [redacted].

The data from all the TIVOLI missions were manually analyzed by NSA and by the team at [redacted] NSD direction. TIVOLI, with its 1-MHz bandwidth predetection recording capability, produced detailed signal modulation data on numerous Soviet ABM radars such as [redacted]

Selected MABELI data were analyzed by NSA at Fort Meade after tapes containing signals of interest were selected and forwarded by LMSC. Analysis of MABELI data provided detailed technical information [redacted]

The mission of the TRIPOS 3/SOUSEA 2 and TRIPOS 4/SOUSEA 3 missions was GS and technical intelligence (TI) against the Soviet ABM/SAM problem. The dual payload, TRIPOS/ SOUSEA P-11, was launched on 20 June 1968, operated for 18 months, and successfully merged analog and digital readout. The data were processed [redacted] as the first major P-11 processing effort for NSA under the Air Force MADS contract. NSA transferred the software developed and used at NSA, Fort Meade, Maryland, [redacted] for processing of the data. NSA also sent [redacted] from K4SP, the personnel who had developed the NSA software, to [redacted] and [redacted] crew in modifying and improving the software and establishing the operations on the new compatible processing system located in building [redacted] The data were processed by [redacted] NSD technical and operational control, with the results of the processing sent by secure data link to NSA/K4SP for release to the Intelligence Community and military consumers. TRIPOS 3 provided excellent EOB and discovered new deployments, such as the [redacted]

Approved for Release: 2021/09/01 C05134315

Many new, unusual, and unidentified emitters were found and reported by TRIPOS 3, including technical information [redacted]

TRIPOS 4 was launched with SOUSEA 3 on 20 May 1970 and operated for 32 months. The data were processed at [redacted] NSA under the Air Force MADS contract as a follow-on to the previous TRIPOS 3/SOUSEA 2 missions. [redacted] from NSA/K4SP, had replaced [redacted] as chief of the NSA detachment in the summer of 1969. The CDC 6400 computer [redacted] was replaced by a CDC 6600 computer to raise the processing capacity by a factor of three to handle the great volume of data produced by the increasing number of P-11 missions and the large volume of digital data being produced by the STRAWMAN missions (described in Chapter 4). By 1970, NSA had upgraded the processing system at Fort Meade to three CDC 6600 computers, providing nine times the capacity that existed in 1966 to process the increased volume of data from POPPY, STRAWMAN, and the P-11 missions.

TRIPOS 4 processing [redacted] reported in hard-copy by 20 December 1970.[47] Technical analysis of TRIPOS 4 data provided a number of new and unusual signals. The analysis showed that the Soviets were apparently expanding the use of the RF spectrum into the 4- to 8-GHz band.[48] TRIPOS 4 made a number of intercepts of [redacted] was one of the highest-priority ELINT requirements. After [redacted]"[51] All the ABM-related radar signals were found and considerable technical information about their capabilities and operations was developed from data collected by the P-11s, POPPY, and the MULTIGROUP/STRAWMAN satellite systems, with one possible exception. The signals from the [redacted]

URSALA spinning-pencil-beam P-11 spacecraft in TRIPOS 4 data.[52] Much of the [redacted]

In early 1971 TRIPOS 4/SOUSEA 3 was used in several crisis-monitoring situations and was extremely effective in supporting a Navy ocean-surveillance exercise [redacted]

The final series of P-11s were the all-digital, pencil-beam EOB payloads, URSALA and RAQUEL, launched between 1972 and 1979. URSALA introduced the Motorola payload team from Scottsdale, Arizona, to the P-11 team. URSALA covered 2 to 12 GHz and returned the data in digital format at 254 kbps. RAQUEL marked the return to the project of E-Systems in Dallas. It covered the range of 4 to 18 GHz and had both an electronic order of battle (EOB) and technical intelligence (TI) capability; it featured digital 256-kbps data output for the EOB mission and 750-kHz analog data for the TI mission. There were two URSALA launches, on 7 July 1972 and 10 November 1973. (The last two URSALAs were launched on 8 July 1976 and 16 March 1979.) All of the missions had an orbital life of over five years, with URSALA 1 operating for almost six. RAQUEL 1 was launched on 29 October 1974 and operated on orbit for over five years (62 months). A slightly modified RAQUEL 1A was launched on 16 March 1978.

The URSALA missions featured all-digital output data designed to perform general search (GS) and provide EOB on [redacted] of NSA wrote the signal-processing algorithms for the URSALA monopulse system and developed the processing software for the first launch on 7 July 1972. [redacted] operation. The [redacted] software was checked out at NSA and later sent [redacted] in 1973 to process the URSALA data at [redacted] under NSA detachment (NSD) supervision. Smith was assigned to NSD at the time the URSALA processing was transferred to guide [redacted] processing. The original URSALA processing required considerable computer time. Smith led [redacted] effort to significantly improve the timeliness of the processing. At this time NSA was pushing for near-realtime processing and reporting.[54]

URSALA produced large quantities of radar locations with accuracies better [redacted] area.[56] URSALA 1 analysis also found signals from the Soviet [redacted] In addition to producing locations and technical information on radars, URSALA 1 also provided valuable information on communications transmitters such as the Soviet [redacted]

Launched on 10 November 1973, URSALA 2 added to the accomplishments of URSALA 1, making the first intercepts of the [redacted] URSALA 2 identified a signal from the Soviet [redacted] URSALA 2 also identified and located a Soviet [redacted] In 1974 URSALAs 1 and 2 participated in several time critical reporting (TCR) operations around the USS Kitty Hawk during its transit to a station off the coast of Iran.[58]

[redacted] the Chief of NSD from 1969 to 1977, characterized the URSALA payloads with their monopulse direction-finding (DF) capability as the backbone of the EOB program.[59] [redacted] who replaced [redacted] as Chief of NSD in 1977, characterized URSALA as the culmination of the evolution of spinning-pencil-beam all-digital collectors.[60]

[redacted]

RAQUEL 1 produced ELINT TI and EOB. The processing and analysis of RAQUEL data were done by [redacted] NSA at the [redacted] RAQUEL 1 was the first SIGINT satellite to collect and geoposition in the 12- to 18-GHz frequency range. The onboard recorder provided predetection recording of new and unusual signals. The payload provided data from both the omni and DF antennas. The omni data were very dense, so dense that only limited use could be made of the data. A major problem was relating the DF and omni data to the same emitter. Both channels of data were machine processed and the signals of interest were analyzed [redacted] under NSA direction. The volume of data was more than could be handled by the CDC 6600 computer at Sunnyvale. A CDC Cyber 74 computer replaced the 6600 computer in 1974 providing a 1.2 times increase in capacity. The Cyber 74 mass storage was expanded to add another 1:3 increase in capacity in 1975. Processing of the RAQUEL 1 data for radar EOB produced location accuracies of better than [redacted] The absence of a monopulse capability on the payload limited the location accuracy. Analysis of the RAQUEL predetection data provided technical information on new and unusual signals, such as [redacted]

By 1977 the TI and search missions of the low-orbit ELINT programs were in full operation. Much progress had been made in the operational ELINT mission. NSA quick reaction capability (QRC) reporting of selected threat emitters had started in 1965, with results reported to the military commands in the field in five to 12 hours after intercept. In 1977 routine reporting began providing specified threat signals and their locations directly to the National SIGINT Operations Center (NSOC) at NSA, where they were reformatted and sent to the Pacific ELINT Center (PACELINT) and in turn to tactical and other service commands. What had started years before as special QRC reporting of threat emitters had now become routine and was a part of regular processing. By 1979, ELINT emitters were not only identified to an EOB pin number (location) but also were identified to a specific unit user of the radar. ELINT and COMINT were routinely combined, and by 1980 NSA reports were identifying the movement of target units by their unit identification, not by just the fact that a specific radar had moved. The Army was putting interim tactical ELINT processing (ITEP) vans in the field to process satellite-collected ELINT for direct use by field commanders. In 1981 NSA personnel [redacted] Operational ELINT, and Raymond Potts, D/Chief A1, Operations and Control) convinced the Director of NSA, Adm Bobby Inman, to approve narrative reporting of radar locations from the [redacted] directly to the military commands. This was a major policy change, providing

Key accomplishments, Project 989

- Proved intercept of low-power, low-VHF Soviet telemetry signals from space in 1963. Provided first real data on VHF signal density over the Soviet Union. First on-pad telemetry intercept from space in 1967.
- Provided technical data on Soviet ABM radars in 1964, including the [redacted] radar.
- Began producing EOB, in 1965; fast reporting, direct to field, in 1972.
- High volumes of technical ELINT, including refinements on Soviet ABM radar parameters in 1968 [redacted]
- Located troposcatter communications transmitters in 1970 and Soviet microwave communications in 1971.
- [redacted]

intelligence data to the military forces sooner and in a more understandable and useful form.[62]

The FARRAH payload, developed in the late 1970s and still operating today, was the ultimate culmination of the P-11 project. It combined the monopulse D/F of URSALA with the TI capability of RAQUEL. It also included an onboard digital processor providing [redacted] geopositioning to allow intercept of the most sophisticated radars, including those using a [redacted]

In 1978, anticipating the launch of FARRAH 1, NSA and NRO personnel both pushed for near-realtime processing. The SIGINT Overhead Requirements Subcommittee (SORS) of the US Intelligence Board (USIB), recognizing the potential of the FARRAH system, established a six-hour requirement for combined processing and reporting of FARRAH 1 data. Convinced of the feasibility of this requirement, [redacted] rewrite of the FARRAH software for the Cyber 175 computer at the [redacted] in late 1978 and early 1979. The continuing [redacted] The old FARRAH processing system was replaced and near-realtime processing was now established.[63]

FARRAH was the only SIGINT satellite collector capable of collecting data in both the northern and southern hemispheres. This capability was used very effectively to provide the only SIGINT satellite support [redacted]

The P-11 program "grew" from simple, single-purpose payloads intended to solve specific problems to an all-encompassing payload supporting ground forces with essential "battleground" information in very close to realtime. It also provided the technical data to keep up with worldwide radar developments. It gave all those involved in the development a tremendous feeling of achievement and promises to be a major contributor of SIGINT support to the US military forces for many years to come.

Chapter 5 References

1. NSA-BYE-20850-65 and [redacted]

2. *NSA in Space*, April 1975, BYE-19385-75, pp. 13-14.

3. *SQUARE TWENTY Final Report*, 1 May 1968, BYE-19347-68.

4. *Intercept/Results of Mission 7231 Targeting Against* [redacted] *Complex*, 9 July 1969, BYE-18741-69.

5. *NSA in Space*, pp. 14-15.

6. [redacted]

7. [redacted]

8. *NSA in Space*.

9. Reports AM41, 17 June 1970, and AM78, 30 October 1970, TK/WC-W205/47-71 (TS/B/TK/COMINT).

10. *NSA in Space*, p. 29.

11. [redacted]

12. [redacted]

13. [redacted]

14. [redacted]

15. [redacted]

16. [redacted]

17. [redacted]

18. [redacted]

19. [redacted]

20. [redacted]

21. [redacted]

22. [redacted]

23. [redacted]

24. [redacted]

25. Report 004, 16 January 1970.

26. TCS 58527-71, 13 October 1971; Report AM63, 28 September 1970; Report AM81, 24 November 1970; Report AM07, 23 February 1971; Report AM16, 15 April 1971; Report AM29, 5 August 1970; Report AM09, 28 January 1972.

27. Report 29, 1 and 12 May 1970; Report 32, 15 May 1970; Report 25, 29 June 1971; Report 27, 2 August 1971; Report 51, 4 November and 8 December 1971; Report 43, 7 October 1971; Report 28, 5 May 1972; [redacted]

28. [redacted]

29. [redacted]

~~Top Secret~~

30. [redacted]
31. [redacted]
32. Raymond Potts' personal notes (hereafter Potts' notes).
33. TK/WC-W205/47-71 (TS/B/TK).
34. Potts' notes.
35. TK/WC-W205/47-71.
36. TK/WC-W205/47-71.
37. [redacted]
38. [redacted]
39. Report # R19, 21 March 1969.
40. Photo of the K4SP Status Board, 20 December 1970.
41. [redacted]
42. TK/WC-W205/43-71.
43. K4SP Status Board photo.
44. [redacted]
45. [redacted] interview, 11 August 1992.
46. [redacted]
47. K4SP Status Board photo.
48. Report 72, 20 October 1970.
49. [redacted]
50. Report 45, 8 October 1971.
51. Report 61, 29 December 1971.
52. [redacted]
53. QR, 31 March 1971.
54. Interviews with [redacted] 24 June 1992, and [redacted] 26 June 1992.
55. [redacted]
56. [redacted]
57. *NSA in Space*, p. 30.
58. QR, 31 March 1974.
59. [redacted] interview, 25 July 1990.
60. [redacted] interview, 27 February 1991.
61. *NSA in Space*.
62. Interviews with [redacted] 27 February 1991; [redacted] 24 June 1992; and [redacted], 24 June 1992.
63. [redacted] interview, 24 June 1992.

Reverse side blank