A BRIEF HISTORY OF

THE U.S. LOW EARTH ORBIT RECONNAISSANCE PROGRAMS

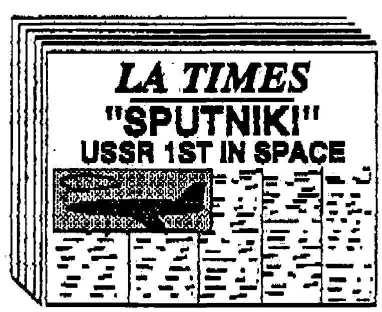
In the years following World War II, it was strongly suspected that Soviet strategic weapon developments were accelerating, but our knowledge of what was going on deep within the USSR was desperately weak. There was growing concern regarding Soviet status of ICBMs, ABM radars, long range bombers, and atomic bomb developments and their resultant impacts on the US/USSR balance of power.

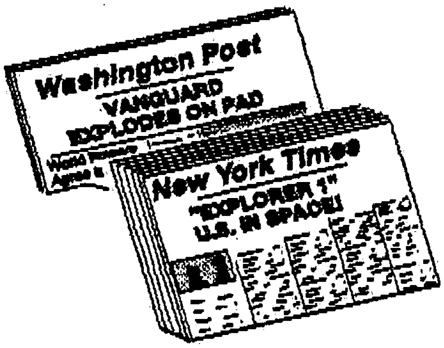
HUMINT and ship-borne/land-based listening posts around the periphery of the Soviet Union were providing a mere trickle of data and were unable to meet our many intelligence needs. The vast inaccessible areas of the USSR had to be overflown if strategic threats were to be detected and assessed. Early attempts, using ballons to carry photographic and SIGINT payloads, were largely unsuccessful. In 1953, the RAF overflew the Soviet ballistic missile test range head at Kasputin Yar and brought back photographic evidence confirming our fears about ICBM developments. However, such flights were politically inflamatory, not to mention highly dangerous. Less obtrusive, more survivable means were required.

In 1954, a project was authorized to develop a spy plane capable of overflying the Soviet Union above the effective altitude of their air defenses. In July of 1956, only 24 months later, the first operational U-2 overflight of the USSR was accomplished. These flights continued over the next four years, bringing back valuable photo and electronic reconnaissance on a wide variety of targets. However, the practicalilties of flight operations and the field of view from even U-2 altitudes limited the frequency of revisits to any one area, as well as the total area of coverage in any time period.

Coincident with the U-2 development, the U.S. military space effort was initiated, on September 9, 1955, when the Naval Research Laboratory (NRL) was commissioned to develop Project Vanguard. The objective was to orbit a scientific earth satellite and establish a satellite tracking network.

Our formative space program was spurred ahead by the surprise launching of SPUTNIK 1 on October 4, 1957, followed by the stunning announcement of SPUTNIK 2, carrying a live dog, on November 3rd. The threat of Soviet technical achievements was easily projected to potential military capabilities, while the international prestige associated with spectacular space accomplishments swung heavily toward the Soviet side of the Cold War.





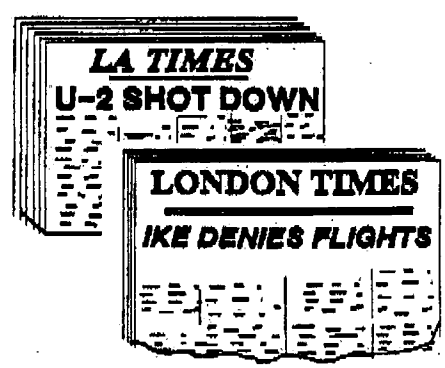
On January 31, 1958, the U.S. entered the earth satellite arena with the successful launch of the Army's Jupiter missile, carrying Explorer 1 into orbit. This was a scientific mission.

The military and intelligence potential of space was quickly recognized, and on June 20, 1958, only five months after our first satellite went into orbit, DARPA asked the NRL to begin development of a space surveillance system. The Navy's Vanguard team assumed the task, and in 1959 proposed the first U.S. ELINT satellite.

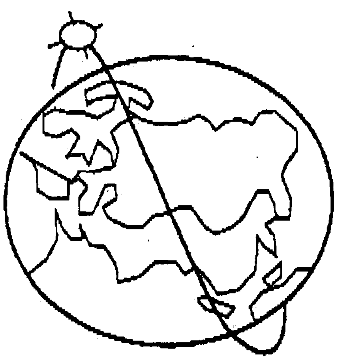
Directed at Soviet radar main beam signals in the [redacted] MHz range, this TATTLETALE system was to have a very narrow mission objective by today's standards. The 1950's ELINT technology, the limited capacity of our first launch vehicles, and the formative status of our understanding of the threat and space collection processes restricted this and subsequent other early collection satellites to single-objective missions.

In August of 1959, President Eisenhower approved the TATTLETALE Project, only to cancel it shortly thereafter due to security leaks publicizing the effort. Ike called for tighter security measures to surround our space intelligence programs, and the Navy immediately began a follow-on program, the DYNO ELINT satellite. It was the forerunner to today's Mission 7100 Program, and soon added a solar radiation experiment to its payload, providing a useful "cover" story for the mission. The project was renamed SOLRAD for public dissemination.

In 1960 [redacted] DYNO ground readout stations were established around the world. On June 22, a month after Francis Gary Powers' U-2 was shot down over the Soviet Union, SOLRAD1/DYNO1, the first U.S. ELINT reconnaissance satellite was successfully placed into low earth orbit. Weighing only 42 lbs, its mission was to conduct main beam collection of Soviet radars. It operated for two and one-half months. After two subsequent unsuccessful U.S. satellite launch attempts, SOLRAD3/DYNO2 was orbited on June 29, 1961. It operated for two months.



During this same period, the exploratory phase of what would later become Mission 7300 was initiated with the launch of Discoverer 13 in August of 1960. The launch carried with it the first of a series of 23 highly specialized payloads on the aft rack of the Agena launch vehicle. These payloads consisted of black boxes designed to collect specific signals or classes of signals associated with the rapidly developing Soviet strategic capability. The payloads were characterized by their relatively small size and weight (50-100 lbs?), very special purpose nature, very short lifetimes (limited by the life of the host vehicle), relatively low cost, and very short development spans (typically less than 6 months).

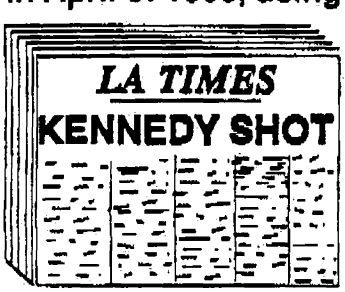


In August of 1961, with multiple space reconnaissance systems and missions developing, an organization and staffing plan for a National Reconnaissance Program (NRP) was agreed to. The program was to include streamlined management and procurement procedures in response to the growing urgency for a robust U.S. space intelligence capability, brought about by increasing concern over suspected Soviet technical developments and their effective denial of our access to vast areas following the loss of our U-2 the previous year.

On June 14, 1962, the SECDEF formally established the National Reconnaissance Organization (NRO) to head the NRP. Program C was established within the NRO, and assumed responsibility for the DYNO program. Program A was responsible for booster/satellite integration and launch as well as for a number of programs, one of which would evolve into the Mission 7300 program. The National Security Agency (NSA) was assigned responsibility for processing and dissemination of data.

Technology advances, along with increasing efforts to define and implement more capable space collection concepts, led to more sophisticated collection systems and functions. Approaches to improved area coverage and location of signal sources were developed, [redacted] The DYNO team applied these advances to their next generation of spacecraft, and on December 13, 1962, the first pair of POPPY satellites was successfully launched into low earth orbit. These were the first to carry the Mission 7100 series of designations, and were identified as Mission 7101. With significant improvements in system reliability, Mission 7101 continued operating for two and one-half years.

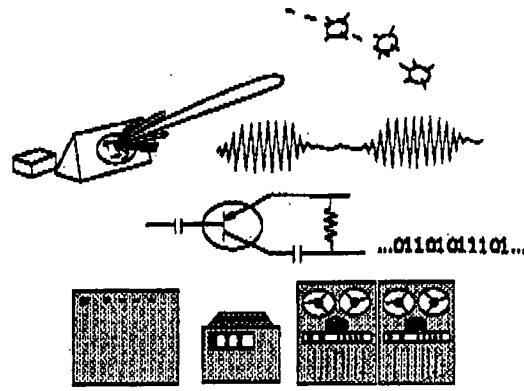
In April of 1963, using the new POPPY system, operators began searching for, detecting, and reporting new and unusual signals from the Soviet Union. The signal analysis process was performed manually with analog equipment at the ground sites.



On June 15, 1963, the first triplet of POPPY satellites (Mission 7102) was launched, but only remained operational until [redacted] Another triplet was launched on January 1, 1964

(Mission 7103), remaining active for four years, and the Mission 7104 cluster of four POPPY satellites, launched in March of 1965, also operated for four years. It was clear that the reliability of our systems on orbit was improving.

With the fundamentals of launch, operation, and signal processing established, attention turned to improvement and expansion of our capabilities. In December, 1966, a POPPY upgrade was approved, to provide [redacted] geolocation of Soviet ABM radars. In 1967, several Mission Ground Stations (MGSs) were relocated to their own dedicated, permanent buildings, allowing expansion of processing functions and capacity and stability of operation. In May of that year, the POPPY [redacted] implemented an analog-to-digital data conversion capability and began digital processing of collected signals. Advanced digital processing techniques of today are at the core of our modern SIGINT capabilities.



Meanwhile, the special purpose Agena payloads had proven very successful. This led to the desire in the late 1960's to develop a simple spacecraft system capable of being launched piggyback with another payload on an Atlas. Once in space, this smaller satellite would separate from the host vehicle and operate as an independent spacecraft. It would also provide longer mission durations and the capacity to carry larger and more capable SIGINT payloads. This desire was heavily motivated by concern over the lack of knowledge on the rapidly emerging Soviet ASAT capability.

In August of 1963, the pioneering phase of the Mission 7300 Program began, with the piggyback launch of a simple spinning spacecraft bus known as the P-11 on the side of an Atlas Agena. This phase spanned nearly a decade, with 37 separate missions, beginning with PUNDIT-I and ending with MABELI. The pioneering phase continued the use of carefully specialized payloads with very specific missions, often targeted against specific signals or classes of signals. A variety of types of missions were flown including Directed Search, FIS, COMINT Mapping, and Technical Intelligence (TI). Payloads were obtained from nine different suppliers in order to obtain a range of ideas and encourage innovation.

Typical early Mission 7300 payloads covered a limited intercept frequency range (4 GHz or less) and were functionally relatively simple. The satellites during this phase weighed 250 to 300 lbs and were designed to last nine months nominally, but typical on-orbit lives averaged 15 months. Development spans were relatively short, typically less than one year. The pioneering nature of this phase of Mission 7300 was evidenced by the numerous firsts which occurred and the innovative use of new technologies to accomplish the mission. Examples of this include the first use of [redacted] in space on VAMPAN in 1968 and the first use of monopulse [redacted] techniques on ARROYO in 1971.

As the new technologies, system architectures, and techniques gave rise to new capabilities, the potential value of space collection was being more widely recognized, and the scope of the user community and their requests for data grew. In August of 1967, the POPPY MGSs were tasked to report intercepts and signal parameters from ship-borne emitters, and [redacted] began reporting such data in March, 1968. The application of digital technology and methods spread to other MGSs, and in February of 1969, [redacted] published a comprehensive operations manual for the POPPY system. The space reconnaissance programs were entering the realm of modern, stable, well structured systems, in response to growing demands and increased user dependence on their output.

As the collection satellite community matured, so did their approaches to defining requirements, deriving system concepts, and controlling the development and procurement process while maintaining the flexibility to respond to changing needs. In April of 1969, the Chief of the Naval Security Group (CNSG) proposed an ocean surveillance constellation with innovative orbital configurations, expanded technical capabilities, and payloads optimized for collection of Soviet shipborne emitters. [redacted]

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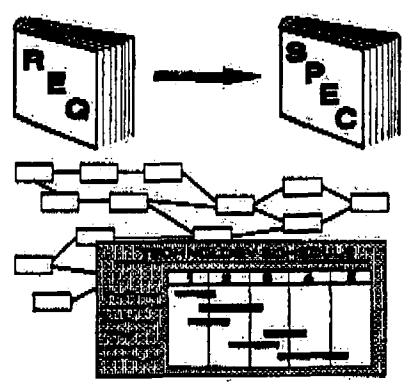


The last of the POPPY satellites, a cluster of four spacecraft launched on December 14, 1971, operated for nearly six years as Mission 7107. The POPPY program, now surpassed by improved technologies and capabilities, was shut down on September 30, 1977. [redacted]

[redacted]

Mission 7300 was also entering a new phase in the 70's characterized by the emergence of two distinct payload classes designed for general search (URSALA) and directed search/technical intelligence (RAQUEL). The impetus for these missions was heavily influenced by the development of [redacted] a new generation of Soviet SAMs which were detected in imagery but had not been detected by available SIGINT collection techniques. The lack of specific knowledge about these high-threat signals led to a set of requirements which could not be satisfied by a single system using the technology available at that time. Since the frequency of the signals was not known, it was necessary to develop a collection system capable of searching a wide frequency range. A means of associating the signals definitely with [redacted] was also required, as was a capability to measure technical parameters precisely and to [redacted] The URSALA and RAQUEL classes of vehicles were developed in direct response to this combination of requirements generated [redacted]

Representing a significant increase in capabilities, the URSALA and RAQUEL covered relatively wide frequency ranges and were optimized for the general search and directed search/TI missions, respectively. The URSALA design included 2 to 12 GHz coverage, spinning pencil beam antennas with monopulse feeds for sidelobe intercept and location of targets, and a wide instantaneous bandwidth of 2 GHz. RAQUEL provided 4-18 GHz coverage, high gain antennas for sidelobe intercept, omni antennas for mainbeam intercept, and emitter location capability using a centroiding technique. A TI receiver on RAQUEL [redacted]

Both satellites used an upgraded version of the P-11 bus which was procured as a block of common "cast iron" spacecrafts to reduce satellite unit costs. These spacecraft were also upgraded for longer design lives of 18 to 24 months. The satellites required considerably more time to develop then their predecessors due to the increased complexity of the payloads and the accompanying longer times required for system integration and test. However, during the period of 1972-1979, four URSALAs and two RAQUELs were successfully developed and launched.

In 1973, the Mid-East war prompted use of Mission 7300 and other systems principally designed for Technical Intelligence and search to support operational ELINT. The operational intelligence value of URSALA, with its relatively accurate sidelobe intercept and geolocation capability, was quickly recognized and stimulated the development of techniques for more rapid data processing to enhance its usefulness to tactical users. The successful use of vans to process URSALA data led to subsequent encryption of the downlink data on URSALA IV and prompted the [redacted] to initiate development of near real-time processing techniques.

In 1976, the continuation of the Mission 7300 program was threatened by the decision not to procure a new block of RAQUEL satellites. The cost of the new block (RAQUEL 2) was judged to be excessive, based on the perceived intelligence value of improved mainbeam technical intelligence. The services, particularly ASPO, were more interested in the URSALA [redacted] capabilities than they were in improved Technical Intelligence from RAQUEL. The program office studied the possibility of combining the URSALA and RAQUEL capabilties into a single, general purpose satellite in order to reduce the total program cost, address a broad range of intelligence needs, and consolidate user support fro the program. This led to the subsequent definition and approval of the Mission 7300 FARRAH series of satellites in 1977.

User awareness and demands for SIGINT continued to increase broadly, and the overhead intelligence community responded. [redacted]

[redacted]

[redacted]

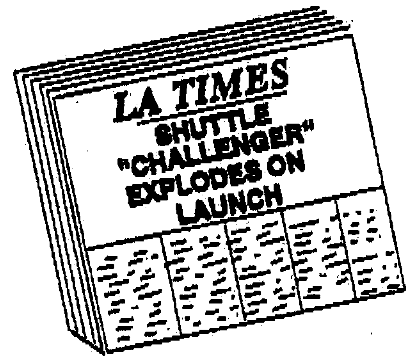
In 1982, the first of two FARRAH satellites which were designed using the basic P-11 bus was launched piggyback on the KH-9 imagery satellite. These satellites represented a relatively significant increase in complexity due to the combination of the URSALA and RAQUEL capabilities within the constrained volume available using the KH-9 as a host vehicle. They covered the full frequency range of 2-18 GHz with a monopulse DF capability for sidelobe intercept and a capability for mainbeam TI intercept. A TI receiver provided [redacted] via either the high gain DF or omni antennas. Each satellite weighed approximately 750 lbs and required upgrading of the P-11 bus for longer life and increased power capability to support the more complex payload.

Both the FARRAH I and II satellites required significantly longer development times and were plagued by problems stemming from the high packing density of the satellite. The second FARRAH satellite actually required longer to develop than the first due to the iterative redesign of the payload based on problems uncovered during the testing and on orbit operation of FARRAH I. In spite of the development problems both satellites provided successful mission capabilities once on orbit.

However, it is doubtful that the objective of replicating the capabilities of URSALA and RAQUEL at less total program cost was met. The mission scope, complexity, and technical challenges of collection requirements in a modern signal environment had manifested themselves in the design and development process of increasingly sophisticated collection satellites. The realities of the complexity and cost of the process of combing several designs and missions into one, unrecognized at the start of the FARRAH phase of M7300, offered a hard but valuable lesson for future architecture considerations.

As with other space systems, overhead collection ground segments had to keep pace with the growing capabilities and technologies of the spacecraft. On October 1, 1984 the M7100 [redacted] started using the GPS system to synchronize all of their clocks with U.S. Naval Observatory time. This allowed much improved correlation of events among the ground stations, improving emitter geolocation accuracy and allowing more comprehensive correlation and analysis of collected data. Operator skills had to increase along with the technologies, too, and in 1986 ten new specialty codes were established, in association with the Classic Wizard program.

In 1980, the DNRO made a policy decision to transition existing and future programs to the Space Shuttle as a standard launch vehicle. This led to a systematic review of all programs to determine which would be retained and transitioned to the Shuttle. Early on, it was decided not to transition the KH-9 which meant that if Mission 7300 were transitioned to the Shuttle it would need to develop a new means of getting on orbit.



The ELINT Mix Study and related studies were performed to examine the issue of whether to transition existing low altitude SIGINT programs to the Shuttle, combine the low altitude SIGINT programs into a single program, or to attempt to replace selected low altitude capabilities with a more capable high altitude capability. As a result of these studies it was decided to transition the current low altitude programs to the Shuttle with improved capabilities in areas where these programs had historically proven to be most effective, i.e., missions requiring periodic high probability of intercept and geolocation over very large geographic areas, and main beam technical intelligence missions.

The Mission 7300 FARRAH satellites were originally planned to ride share with the improved Mission 7100 on the Shuttle. However, in the mid-80's excess Titan 2 launch vehicles became available, and plans and designs were changed to make use of those vehicles. This change would provide more flexibility in optimizing the orbits while retaining a relatively inexpensive launch capability. Thus, in 1988 the first of a new block of FARRAH vehicles was launched on a dedicated Titan 2 launch vehicle. This block of vehicles used a new bus designed to be compatible with several launch vehicles.

The new block of FARRAHs were significantly larger and heavier (over 3000 lbs) then the predecessors which used the P-11 bus. This increase in size and weight was motivated primarily by the desire to alleviate previous constraints imposed by the restricted volume available. The increased size and weight allowed incorporation of improved payload capabilities including [redacted]

At the same time that the larger FARRAH vehicles were being developed, [redacted]

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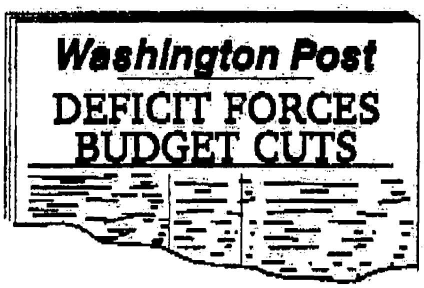
With the world situation changing rapidly, new collection challenges will continue to arise. Emphasis on surveillance of Soviet and PRC activities is decreasing, while coverage of Third World areas and crises is expanding. Intelligence users with new missions in new geographic areas will generate new requirements. Changing mission priorities and objectives will translate into new technical and operational demands on collection systems. Budget constraints will impose new limitations and lead to technology and architecture innovations.



The low earth orbit reconnaissance programs are currently re-examining their missions, capabilities, architectures, and priorities, investigating alternative configurations with an eye toward significant cost reductions. Throughout this process, the critical role of our low earth orbit reconnaissance systems will continue to be updated, and the unique contributions they make to our national intelligence programs will continue to evolve. Preserving the best and unique capabilities of Missions 7100 and 7300, our programs will draw upon the 30 years of experience, hard lessons learned, and knowledge gained since the launch of the 42-pound DYNO1 in 1960.