A Brief History of the LEO Program
(file dated 8/13/91)

INTRODUCTION

In the years following World War II, it was strongly suspected that Soviet strategic weapon developments were accelerating, but our knowledge of these new threats deep within the USSR was desperately weak. There was growing concern regarding the status of Soviet 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 on these new threats and were unable to meet all of our 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 balloons to carry photographic and SIGINT payloads, were largely unsuccessful. In 1953, the RAF overflew the Soviet ballistic missile test range head at Kapustin Yar and brought back photographic evidence confirming our fears about ICBM developments. However, such flights were politically inflammatory, not to mention highly dangerous. Less obtrusive, more survivable means were required.

THE ESTABLISHMENT OF THE NRO

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 practicality of flight operations and the relatively small field of view even from 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. space effort was initiated, on September 9, 1955, when the Naval Research Laboratory (NRL) was commissioned to develop Project Vanguard. While the launch of Vanguard I was unsuccessful, Vanguard II successfully placed a scientific satellite into earth orbit.

Our formative space program was spurred ahead by the surprise launching of SPUTNIK 1 on October 4, 1957, followed by the stunning announcement of a SPUTNIK 2 launch, 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, called TATTLETALE.

Directed at mainbeams of Soviet radar signals in the [redacted] the 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 [redacted] 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, six DYNO ground readout stations were established around the world. On June 22 of that year, 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 and 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 the 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. The payloads consisted of black boxes designed to collect specific signals or classes of signals associated with the rapidly developing Soviet strategic capability and 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).

A major element in the early LEO SIGINT system was Program 770 which was a nose-down, three axis stabilized, store & dump system that initially provided ELINT pulse data words and coarse geolocation for selected bands. Program 770 was assigned Mission 7150 and eventually provided 5-6 MHz analog data recording. Later, payloads designated Mission 7200 such as BIRD DOG, SETTER, and REAPER added a very accurate geolocation capability. Other Agena payloads include SOCTOP and TOPSOC flown between 1960 and 1963 which detected Soviet attempts to skin track Missions 7400 and 7800, while other receivers intercepted Soviet [redacted] and BMEW (WILD BILL series) radars. The STOPPER and BIT payloads were launched to detect skin tracking of the Agena missions. Another 7300 mission called PLYMOUTH ROCK, flown in early 1963 to replace lost U-2 coverage, typified the early 7300 mission emphasis of general and directed search by surveying the 2 to 4 GHz ELINT spectrum for [redacted] By May 1963, the SAC 544th RTG, which had processing responsibility for the PLYMOUTH ROCK mission, had geolocated hundreds of [redacted] and located six new sites as well as new equipment at known sites. Other Agena missions, such as SQUARE TWENTY and DONKEY which were flown in the late 1960's, intercepted Soviet [redacted]

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 upon. 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 manage the NRP. 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. Program C assumed responsibility for the DYNO program. The National Security Agency (NSA) was assigned responsibility for processing and dissemination of the collected data.

POPPY Development (1962 - 1967)

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, including multiple cooperative spacecraft techniques. 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. Improving 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 August 1. 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 the systems on orbit was improving.

With the fundamentals of launch, operation, and signal processing established, attention turned to improvement and expansion of capabilities. In December, 1966, a POPPY upgrade was approved to provide [redacted] of Soviet ABM radars. [redacted] In May of that year, th[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 modern SIGINT capabilities.

Mission 7300 Beginnings (1963 - 1973)

During this period, while Program C evolved POPPY from DYNO, Program A was successfully launching and operating a variety of special purpose satellites, culminating with the development of a simple spacecraft that could be launched piggyback with other payloads on the Atlas booster. Once in space, this smaller satellite separated from the host vehicle and operated as an independent spacecraft. It also provided 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. Program A and the NSA developed strong working relationships over this period to develop collection and processing concepts to meet these rapidly emerging threats.

The early Mission 7300 payloads, like the POPPY system, 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 first's which occurred and the innovative use of new technologies to accomplish the mission. Examples of this include the first use of spinning interferometers for geolocation on VAMPAN in 1968 and the first use of monopulse [redacted] on ARROYO in 1971.

In October 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.

The first P-11 spacecraft (PUNDITs I-IV) intercepted Soviet telemetry data and were followed in 1964 by NOAH's ARK, STEP-13, and PLYMOUTH ROCK-1 which served in ABM search and general search roles. The first P-11 with a single spacecraft, scan independent, geolocaction capability was FANION-1/TRIPOS-1, launched in June 1965. The spacecraft operated for 22 months and provide[redacted] of hundreds of C and E model [redacted] radars as well as general search in the 4 to 8 GHz range.

A family of spinning pencil beam P-11 vehicles evolved during the 1966 to 1970 time frame targeted for the emerging Soviet ABM threat and consisted of a set of six vehicles whcih consisted of 2 LAMPAN/SAMPAN, 2 TRIPOS/SOUSEA, 1 VAMPAN, and 1 MABELI. These vehicles were preceded by a QRC search system called FACADE which went from chalkboard to orbit in less than 3 months and has been crediteds with the first intercept of DOG HOUSE. The LAMPAN, SAMPAN, TRIPOS, and SOUSEA vehicles covered the L, S, C, and X bands while VAMPAN provided 100 MHz to 1 GHz sidelobe intercept coverage, wide-area search, and geolocation. Technical Intelligence (TI) on HEN HOUSE and other Soviet ABM emitters was provided first by MAGNUM in 1965, SLEW-TO in 1967, and later by three TIVOLI vehicles beginning in 1968. TIVOLI I, II, and III had mission lifetimes of 15, 19, and 20 months respectively and provided pre-detection recordings for fine grain TI analysis of command frequencies between 50 MHz and 4 GHz.

The success of the VAMPAN program inspired two rotating interferometers for COMINT mapping called TOPHAT I and II. Launched on November 18, 1971, TOPHAT I operated for 45 months and collected [redacted]

[redacted] while TOPHAT II, launched on April 10, 1974 operated for 72 months and also provided Rutley coverage. The MABELI spacecraft, launched on January 20, 1972, operated for 88 months and provided detailed TI on the Soviet ABM family of HEN HOUSE, DOG HOUSE, TRYADD, and BIG SCREEN radars. MABELI had the first spaceborne polarimeter which provided accurate measurements of radar power levels and main beam patterns for ABM treaty verification and also provided an on-board tape recorder to store pre-detection and digitized measurements.

[redacted]

MISSION 7300 URSALA/RAQUEL ERA (1973-1979)

While Program C was concentrating on ocean surveillance, Program A was evolving two additional distinct payload classes. URSALA for general search targets, and RAQUEL for directed search/technical intelligence. The impetus for these missions was heavily influenced by the development of the [redacted] which were detected in imagery but had not been detected through SIGINT. 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 the [redacted] was also required, as was a capability to measure technical parameters precisely and to sample waveforms. The URSALA and RAQUEL classes of vehicles were developed in direct response to this combination of requirements generated by the [redacted]

URSALA and RAQUEL represented an increase in capabilities and covered wide frequency ranges. The URSALA vehicle was optimized for a general search mission while the RAQUEL vehicle was optimized for directed search and TI missions. 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. The URSALA feed was designed to produce an independent geolocation for each pulse intercepted, thus allowing characterization of signals independent of their agility, modulation, or motion. 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 receiver on RAQUEL allowed predetection sampling of intercepted waveforms and was automatically cued from the search receivers to perform the TI functions.

With the addition of URSALA and RAQUEL, the NRO had complementary low earth orbit collection systems: [redacted] URSALA/RAQUEL for sidelobe radar and communication signals. The URSLA and RAQUEL satellites used an upgraded version of the P-11 bus which was procured in block buys and stored as assembly kits pending payload development to reduce satellite unit costs. These spacecraft were also upgraded for longer design lives of 18 to 24 months. During the period of 1972-1979, four URSALAs and two RAQUELs were successfully developed and launched with an average mission lifetime of over 88 months. RAQUEL IA still operates in a transpond mode today more than 13 years after her launch in 1978.

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 further van developments which have evolved into today's EPDS(ARMY) and TEP (AIR FORCE) support vans deployed around the world receiving transponds of Mission 7300 raw data in near-real time. The increased OPELINT role of Mission 7300 also resulted in subsequent encryption of the downlink data on URSALA IV and prompted the [redacted] to initiate development of faster 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 OPELINT capabilities than they were in improved Technical Intelligence from RAQUEL. The program office studied the possibility of combining the URSALA and RAQUEL capabilities 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 for the program. This led to the subsequent definition and approval of the Mission 7300 FARRAH series of satellites in 1977.

[redacted]

[redacted]

MISSION 7300 FARRAH PROGRAM

In 1982, the first FARRAH satellite was launched "piggyback" on a KH-9 imagery satellite. Although cost effective from a launch point of view, the principal disadvantage of launching FARRAH as a secondary capability on the KH-9 host was that optimum phasing of FARRAH I and II could not be achieved. Like earlier 7300 series vehicles, the first two FARRAH satellites were designed around the basic P-11 structure. However, the FARRAH vehicles were more capable and complex than previous P-11's as a result of combining the URSALA and RAQUEL payloads into a single spacecraft and meeting the volume constraints of the KH-9 platform. They covered the full frequency range of 2-18 GHz with a monopulse DF capability for sidelobe intercept and an omnidirectional capability for mainbeam TI intercept. A TI receiver provided predetection sampling of the intercepted waveforms via either the high gain DF or omni antennas. Each satellite weighed approximately 750 lbs. Also, the basic P-11 bus was upgraded for longer life and increased power capability to support more payload.

FARRAH I (launched in May, 1982) and FARRAH II (launched in June, 1984) took longer to develop than the URSALA and RAQUEL spacecraft for several reasons, the majority of which resulted from design changes to the baseline FARRAH configuration after contract start. In addition to P-11 bus upgrades, there were ECP's to increase payload life, improve ground processing, and update test equipment. There were also some unexpected development problems stemming from the high packing density of the satellite. Both FARRAH I and II far surpassed their 3 year design life and are still operating today. Since only two FARRAH (P-11 class) satellites were ever built, the anticipated cost savings from combining the two spacecraft was much smaller than expected because the nonrecurring costs associated with the satellite block change were only amortized over two vehicles. However, considering the reduced launch integration and CC&C costs of two (versus four) satellites and the two fold increase in mean mission duration, a substantial cost benefit was realized in the long run.

As with other space systems, overhead SIGINT ground segments had to keep pace with the growing capabilities and technologies of the spacecraft. During the 1970's, the 7300 [redacted] transitioned to digital mainframe computers to keep pace with the advanced digital payload outputs. On October 1, 1984 [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 [redacted] improving emitter geolocation accuracy and allowing more comprehensive fusion and analysis of collected data.

In 1980, a policy decision was made 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. Mission 7300 was a logical candidate to transition to the Shuttle since the "host" launch opportunity disappeared with the cancellation of the KH-9 program.

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 system. As a result of these studies a decision was made to transition the [redacted] and 7300 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 [redacted] on the Shuttle. However, in the mid-80's excess Titan II 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. In the end, the switch to the shuttle and then back again to expendable launch vehicles (ELVs) proved to be extremely costly for both Mission [redacted] and 7300. [redacted] When the decision was made to return to ELV's, the Titan IV was the only existing booster that could support the weight growth. Unfortunately, the Titan IV is also the most expensive launch vehicle made. [redacted]

FARRAH III, [redacted]

While expanding the roles and capabilities of the FARRAH series of spacecraft, Mission 7300 also began developing lightweight satellites for specialized missions. The first of these was GLORIA I. [redacted] Also under development is the COMINT and Rapid Reporting Interferometry Experiment (CARRIE) with a planned 1992 launch aboard the first TAURUS booster being developed for DARPA by Orbital Sciences Corporation. CARRIE will detect, characterize, and map COMINT emitters on-board for rapid dissemination to tactical EPDS vans.

[redacted]

[redacted]

CONCLUSION: LOOKING AHEAD

With the world situation changing rapidly, new collection challenges will continue to arise. Emphasis on surveillance of Soviet activities is decreasing, while coverage of Second and 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.

The intelligence community is re-examining the low earth orbiting 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 SIGINT 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 [redacted] 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.