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Chapter 10

Vela—A Space System Success Story[*]

John R. London III[†]

Introduction

In 1958, technical advisors supporting the Geneva negotiations for discontinuance of nuclear testing conceived of a unique application for artificial satellites. Thus began the Vela program—an orbital network of space sensors deployed by the United States in the 1960s, that would monitor compliance with the limited nuclear test ban treaty, successfully, for 21 years. Vela's legacy was one of meeting requirements quickly, reliably and inexpensively. The first pair of satellites launched in 1963 reached orbit only six days after the test ban treaty went into effect. By 1984, the twelve satellites launched as part of the Vela program had traveled over three billion orbital miles and had recovered data from about 40 events. Operating at altitudes between 16 and 17 Earth radii, every satellite in the Vela system exceeded its design life by many times. Vela also provided natural radiation monitoring for the Apollo program and broke new ground in the field of X-ray astronomy. The Vela program was a success story from start to finish, and it represented an outstanding example of a reliable, affordable space system, providing useful data for a variety of applications.

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[†] Space Systems Division, El Segundo, California, U.S.A. Fellow, BIS; Associate Fellow, AIAA.

In support of the Geneva negotiations for the discontinuance of nuclear testing, several U.S. *ad hoc* committees made scientific estimates of various space-based techniques for detecting nuclear detonations occurring outside the Earth's atmosphere, and they investigated possible operational satellite systems for implementing this concept. One of these committees, the Panofsky Panel on High Altitude Detection, made a number of recommendations to the President's Scientific Advisory Committee pertaining to research and development, which was needed to increase the basic understanding of the physical mechanisms involved. These recommendations formed the basis for the space-based element of a new program designed to increase understanding of the complex technical problems associated with monitoring a moratorium on nuclear tests.

On September 2, 1959, the Director of Defense, Research and Engineering in the U.S. Department of Defense (DoD) directed the DoD's Advanced Research Projects Agency (ARPA) to undertake a research and development program to define technical requirements for monitoring a nuclear test ban. ARPA, in collaboration with the Atomic Energy Commission (AEC), the National Aeronautics and Space Administration (NASA), the Departments of Commerce and Interior, and the Department of the Air Force, created a program called Project Vela. Vela, the Spanish work for watchman, was subdivided into three principal phases or sub-programs which related to the various technical systems being addressed. The standard phonetic words Uniform, Sierra, and Hotel were selected as the code names for these phases, and these corresponded to the first letters of underground, surface, and high-altitude detection systems, respectively. Vela Uniform was research and development, primarily targeted at improving seismic capabilities to detect and characterize underground nuclear explosions. Vela Sierra encompassed ground-based systems to detect nuclear explosions at extreme altitudes in the atmosphere and space. Vela Hotel focused on the technologies required for satellite-based detection of nuclear tests in space.

The primary objective of the Vela Hotel program was to conduct space-based studies to verify the feasibility of using X-ray, gamma ray, and neutron detectors in satellite-borne radiation detection systems. These detection systems were intended to detect and gather data on high altitude nuclear explosions. Efforts were directed toward accumulating a maximum of experimental data and gaining a broad understanding of the principles that were key to detecting nuclear explosions in space. The studies were conducted in a way that allowed an early attainment of operational capability, if such a capability proved to be feasible and desirable. In retrospect, this foresight proved to be invaluable, because the program ultimately evolved away from a research program and toward an operational program.

The need for a functional system to detect nuclear tests in space was extremely important in the late 1950s and early 1960s, because of the growing interest in antiballistic missile (ABM) systems. ABM system concepts in those days depended on nuclear-tipped ballistic missile interceptors. The interceptors detonated their warheads in space to achieve a high probability of a successful intercept. Thus, space testing of nuclear weapons became a critical aspect of the ABM system development. Exact effects of interceptor warhead detonations on target warheads were unknown. Effects of a nuclear fireball in space on radar tracking systems needed to be quantified. An explosion in the Earth's magnetic field generated a tremendous electromagnetic pulse, causing potential problems with satellite circuitry. No country could be allowed to conduct clandestine nuclear tests in space, or they might gain an advantage in ABM development, and the U.S. deterrent would be diminished. Vela Hotel was intended, ultimately, to ensure no test in space would go undetected.

In mid-1959, the U.S. DoD assumed overall responsibility for Project Vela Hotel, with support from the AEC. The AEC undertook laboratory development of the nuclear detection instrumentation. Management responsibility for Vela Hotel within the DoD was officially assigned to ARPA on September 2, 1959. The agency issued ARPA Order 102-60 on September 18, 1959, to the Air Research and Development Command, for study and evaluation of the technical and operational factors associated with detecting high altitude nuclear detonations.

A development and funding plan for a $100 million program was submitted and subsequently rejected because of a shortage of funds. ARPA issued guidance for a reduced scope program and authorized a $10 million budget on December 8, 1960. An additional $5 million was provided for the program on January 13, 1961.

Early in the study phase of the program it became necessary to establish the Joint Technical Group (JTG), a team that could represent the technical views of the DoD and the AEC. Its members included scientists and engineers from Los Alamos Scientific Laboratory, Lawrence Radiation Laboratory, and Sandia Corporation. DoD members included a representative from ARPA and the Vela Satellite Program Director at Air Force Ballistic Missile Division (BMD) in Los Angeles, California. The Vela program director at BMD in the early 1960s, Colonel Lonnie Q. Westmoreland, served as chairman for the JTG. The JTG proved invaluable in facilitating the efficient integration of the DoD spacecraft with the AEC-developed payload. The Group was the focal point for overall planning and management of the Vela satellite program. Its members were intimately familiar with the satellite and detector system details. The Group's small size allowed quick reaction to policy decisions, redirection and guidance.

The management structure for the Vela Hotel Program was unique, because the Department of Defense and the Atomic Energy Commission had separate top-level management chains that came together with the JTG. The DoD delegated executive management and funding responsibility to ARPA. ARPA worked through Headquarters United States Air Force and the Air Research and Development Command (renamed Air Force Systems Command in 1961) to delegate the detailed program management responsibility to BMD (renamed Space Systems Division in 1961). The AEC delegated detailed development responsibility of the detection payloads to the Los Alamos, Sandia, and Lawrence Radiation Laboratories.

Program Start-Up

Vela Hotel was originally organized as a two-phase program. The first phase consisted of various hitchhiker and probe experiments conducted by Los Alamos Scientific Laboratory, Lawrence Radiation Laboratory, the Air Force Special Weapons Center, NASA, Space Systems Division, and Sandia Corporation. Hitchhiker launches with equipment aboard Discoverer vehicles were conducted in 1961 and 1962. Lawrence Radiation Laboratory designed and fabricated the instrumentation, and Lockheed Missiles and Space Company integrated the equipment with the engine access doors of the Discoverer vehicles. Lockheed also provided the telemetry systems and collected the data. These experiments flew on the Discoverer 29 and 31 satellites from Vandenberg Air Force Base, California, and the experiments used three types of payloads. The first type consisted of a solid-state electron spectrometer and a pair of scintillation X-ray detectors incorporating guard rings; the second included the same X-ray detectors, plus a neutron gamma ray detector; the third contained two open-ended photomultiplier X-ray detectors and a combination proton/electron/neutron/gamma ray detector.

Los Alamos Scientific Laboratory and Sandia conducted experiments designed to characterize the various types of X-rays in space. These experiments were flown on balloon-borne background surveys and Air Force Blue Scout launch vehicles.

The second phase of the Vela Hotel program involved the design, fabrication, and planned launch of tandem pairs of spacecraft on five Atlas-D/Agena-B vehicles from Cape Canaveral Air Force Station, Florida. All of these launches were originally planned to occur in the 1963-1964 time-frame. Each of the satellites was planned to be placed in an 80,000 kilometer-plus altitude orbit. Mission goals included observing the radiation background in space and monitoring the on-board X-ray, gamma ray, and neutron detectors' ability to obtain signals from nuclear tests. ARPA intended for the second phase of the program to gather significant knowledge of the space radiation background, to allow an operational detection system to be fully defined. The first ten experimental satellites were not explicitly intended to perform an operational nuclear burst detection role. The second phase of the program was also referred to as Program 823 early on, but the numerical program designator was dropped in early 1963 by direction of Joseph V. Charyk, Under Secretary of the Air Force.

On November 24, 1961, the Air Force announced that it had selected Space Technology Laboratories Inc., of Los Angeles, California, as the spacecraft contractor for the Vela Hotel Program. Space Technology Laboratories, later renamed TRW Systems Group, was tasked to build the ten Vela spacecraft under what was then a relatively unique contractual arrangement. The Air Force Space Systems Division used a cost-plus-incentive fee contract with incentive features based on cost and performance. To provide a strong profit motive for the contractor to turn in an outstanding performance along with good cost control, the program office established a maximum fee of 14.95 percent (almost to the 15 percent legal limit) along with a minimum fee of 0.55 percent. The amount of the initial basic contract was $15 million then-year dollars, so the target median fee of 7.75 percent equated to a little over $1 million. Emphasis was placed on the performance portion of the fee by making the performance incentive approximately twice the cost incentive. To spread the performance incentive out over the life of the contract and provide meaningful incentives, the areas selected for contract performance evaluation were a 168 hour reliability test, controllable error, early demonstration, and lifetime in orbit. The Air Force placed the most emphasis on lifetime in orbit.

The contract put Space Technology Laboratories (STL) on a tight schedule to design, produce, integrate AEC-developed payloads, and to launch ten spacecraft. In fact, the first tandem launch of two spacecraft on a single Atlas Agena occurred less than two years after the November 1961 contract announcement, and the STL (TRW Systems Group)-developed spacecraft achieved all major technical objectives of the program on the first launch. Accomplishment of such an extraordinarily challenging schedule was attributed to a small government-industry project management team, simplified research and development management and reporting schemes, early establishment of well-defined program goals, and distinct lines of authority without duplicate management channels. The Vela team was goal-oriented and highly communicative, and they consistently demonstrated a highly flexible approach to problem solving.

Space System Description

The original contract with STL (TRW) called for ten Vela satellites to be delivered, but only six of these ten were ever launched. The six were launched in pairs on three different Atlas-Agenas, and the missions were so successful that the final two launches were canceled. An advanced Vela spacecraft program was approved in March 1965, requiring advanced versions of the original Vela spacecraft configuration to be developed and launched on Titan IIIC launch vehicles. The follow-on contract for the advanced Velas was also given to TRW Systems Group, and the Air Force used a firm fixed-price incentive fee contractual instrument. Six advanced Velas were successfully launched on three Titan IIIC's from the renamed Cape Kennedy Air Force Station. The Air Force placed a total of twelve Vela satellites into orbit over the life of the program, but a maximum of only eight were operated at any given time.

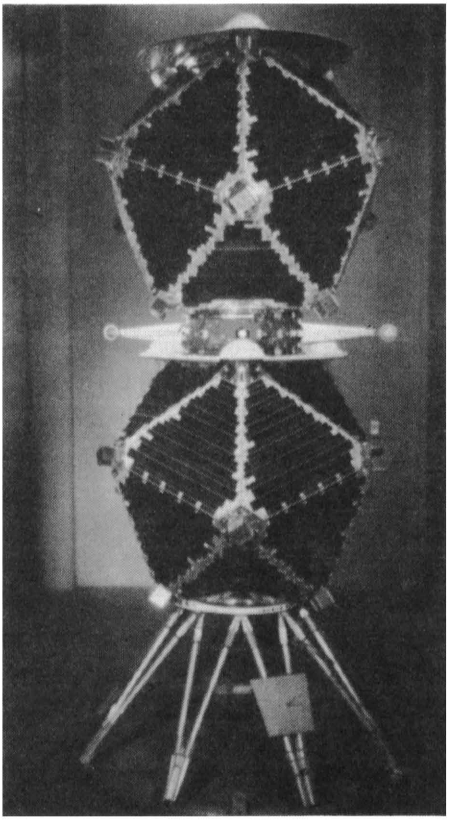

Figure 1 Original Vela satellites in launch configuration.

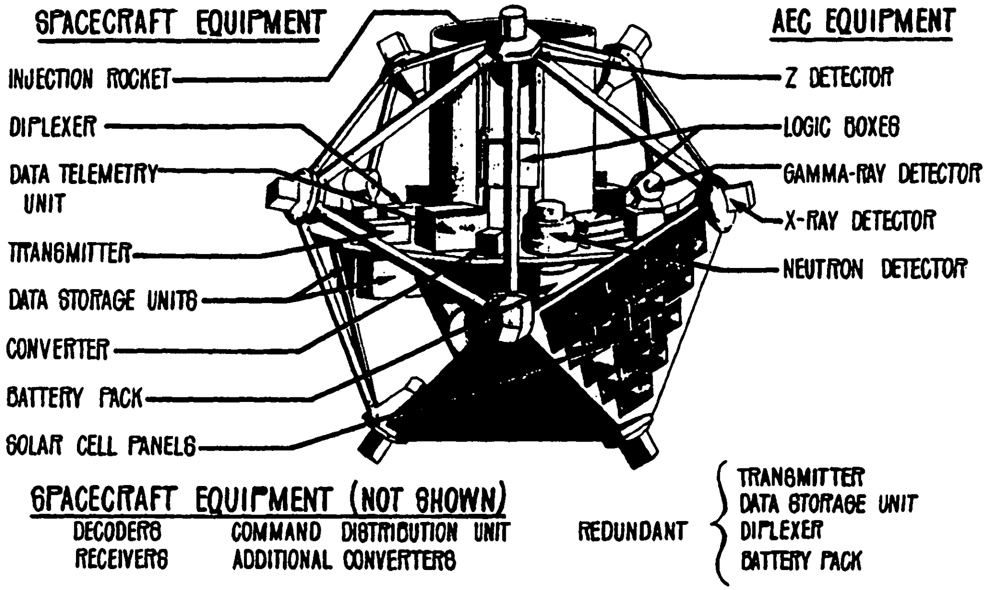

Figure 2 Vela spacecraft. Cutaway view.

The original Vela satellite (Figures 1 and 2) was in the geometric shape of an icosahedron (a regular polyhedron with 20 sides). Each side was in the shape of a triangle, and 18 of the 20 sides were covered with solar cells for electrical power production. The remaining two sides were on opposite ends of the satellite and accommodated the apogee kick motor and its cylindrical housing. There was a total of 14,000 solar cells covering each spacecraft. Each satellite was 1.4 meters in diameter. Two four-stud antennas were located at opposite ends of the central magnesium cylinder which housed the apogee motor and supported the satellite's aluminum structure. The central cylinder corresponded to the spacecraft spin axis. The original Vela satellites were spin-stabilized.

A passive thermal control system, using honeycomb structure and fiberglass and aluminum sheets and struts, combined with a continuous spin for stabilization provided thermal control. The propulsion subsystem used a modified Ranger BE-3 solid propellant motor (called a BE-3-A) manufactured by the Hercules Powder Company. This kick motor added velocity as the apogee of the ascent transfer ellipse and thereby circularized the orbit of the spacecraft. A heat shield was used to protect the payload detectors and solar cells from excessive heat and exhaust products during the motor's burn. It was ejected shortly after completion of the motor firing.

Space Technology Laboratories did not provide an attitude control and orientation system for the first four Vela spacecraft. The third pair of original Velas, however, did contain a vernier velocity and attitude reorientation system

(ARS). This was an electrically heated gas propulsion system. The ARS consisted of a sun sensor, thrust nozzle, solenoid valve, and control box.

The power subsystem converted solar energy to electrical, controlled and regulated this energy by means of voltage converters, and supplied the various regulated voltages needed to operate the on-board equipment. Two redundant battery packs were included to store power for use during solar eclipses and when spacecraft inclination to the ecliptic caused reduced solar cell output.

The communication subsystem performed three major functions. First, it received a carrier from ground tracking stations and transmitted a carrier which was coherent with the receiver carrier. Second, the communications subsystem received and processed commands into useable signals that operated relays in the command distribution unit. Lastly, it accepted any one of four modulated inputs from the telemetry subsystem to transmit payload data or spacecraft status data. The output power was sufficient to be received by the world-wide Air Force tracking net.

The telemetry subsystem accepted data from the payload and processed the data for application to a modulator which modulated the communication subsystem transmitter. The payload data could be transmitted real time or stored. The storage unit handled about 30,000 bits of payload data for later transmission to the ground. The telemetry subsystem also accepted spacecraft status data in the form of analog inputs. The inputs were processed serially and sent to the modulator for transmission to the ground. There were two redundant data storage units and two digital telemetry units.

Each spacecraft pair of original Velas was tacked one on top of the other with a nitrogen gas spin-up interstage between the two spacecraft. The spin-up system provided a spin stabilization rate of 120 revolutions per minute. The spacecraft pair were mounted for launch on a booster interface truss assembly inside the payload fairing.

The AEC's laboratories provided the basic payloads for the original Vela spacecraft. The payloads were arrays of X-ray, gamma ray, and neutron detectors. These types of radiation and particle detectors were deemed best suited for the Vela goal of deep-space detection of nuclear explosions occurring at extreme altitudes and in space. On the first Vela spacecraft, ten square X-ray detectors were placed at vertices of the exterior triangular faces. In these locations, each detector had a field of view greater than a hemisphere. Two additional diagnostic detectors were also placed at triangle vertices to measure the electron and proton background. Since the X-ray and gamma ray detectors were sensitive to charged particles, these diagnostic detectors were needed to provide correlation data to correct X-ray and gamma ray readings. Six gamma ray detectors and a neutron detector were also mounted on the interior of the first Vela spacecraft.

As the program progressed, small changes were made to the spacecraft and payload configuration. Notably, the gamma ray detectors were moved to be contiguous with the external X-ray detectors by the third flight of the original Vela satellites.

After the outstanding success of the first three Vela launches, a new, advanced Vela satellite system was defined (Figure 3). Also built by TRW, the new spacecraft were similar to, but had some significant differences from, the original Vela satellites. These spacecraft incorporated lessons learned from the first development program and the first flights, and they also reflected the change in program orientation and the new capabilities defined for the advanced Vela.

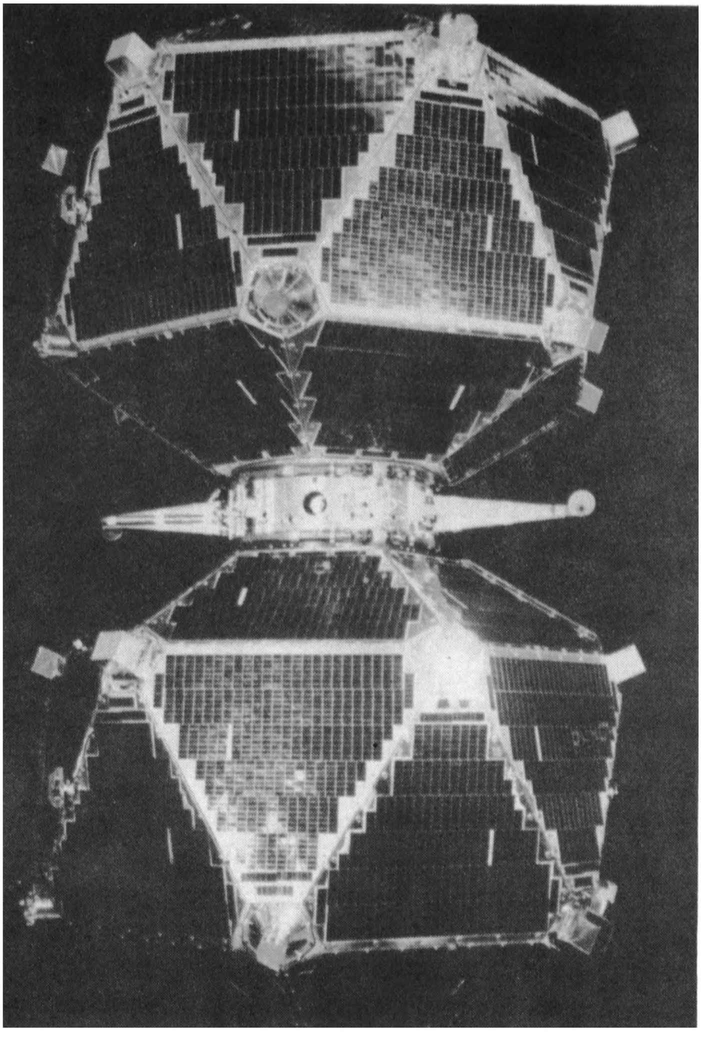

Figure 3 Advanced Vela satellites in launch configuration.

The advanced Vela spacecraft were designed to detect nuclear weapon tests in space and in the Earth's atmosphere. The spacecraft contained a pair of optical flash detectors, called Bhangmeters, to measure a nuclear explosion based on the brightness of its flash. To keep the Bhangmeters always pointed at the Earth, the spacecraft had to be three-axis-stabilized instead of spin-stabilized. It did rotate at one revolution per minute for thermal control. In addition to the two flash detectors, the advanced Velas contained eight X-ray detectors, four gamma ray detectors, an electron-proton spectrometer, one neutron detector, two heavy-particle detectors, one X-ray analyzer, a solid state spectrometer, two Geiger counters, an extreme ultraviolet radiation detector, and electro-magnetic pulse detectors. The additional detectors and three-axis stabilization system meant the advanced Velas were significantly heavier than the original Vela spacecraft. This added weight required a more powerful launch vehicle, and the Titan IIIC became the booster for the advanced Vela satellites.

Six advanced Velas were launched in pairs on three Titan IIIC rockets. The first pair of advanced Velas launched (and the fourth pair launched overall) were notably different from the second and third pair of advanced Velas launched. A major redesign was done between the first and last two pairs of advanced Velas. The last two pairs were almost identical, and the last pair was a back-up set of spacecraft launched as contingency spares.

The first pair of advanced Velas were 28-sided polygons, 1.42 meters in diameter and 1.17 meters in height. Twelve triangular panels girdled the spacecraft equator, and twelve trapezoidal and two hexagonal panels were placed above and below. The panels were covered with 22,500 solar cells producing 120 Watts. The second and third pair of advanced Velas were similar in configuration, but they had an overall diameter of 1.27 meters.

All of the advanced Velas had apogee kick motors for orbital circularization. The first pair used the BE-3-B1 motor, and the last two pairs used the more powerful BE-3-A7 motor. Although the spacecraft were three-axis stabilized, they were spin-stabilized for apogee motor firing and then de-spun after the final orbit was achieved. The spacecraft were stacked one on top of the other like the original Vela spacecraft, and they were connected by a spin-up interstage. The spacecraft stack was mounted to the Titan IIIC transtage using a truss structure.

The three-axis stabilized system included in all the advanced Velas added a number of new components to each spacecraft. The stabilization system included a reaction wheel, reaction electronics, control electronics assembly, rate assembly, valve driver assembly, Earth sensors, Sun sensor assembly, and a pneumatics assembly.

The first pair of advanced Velas included two four-stub antenna arrays mounted on opposite ends of the central structural and motor mount cylinder. These arrays were similar to those on the original Vela spacecraft. However, six antennas projecting from the spacecraft midsection were added. The last two pairs of advanced Velas deleted the two four-stub arrays and used eight whip antennas evenly distributed around the spacecraft midsection.

Mission Description

The general orbits selected for all the Vela satellites were extremely high in altitude—ranging from 95,000 to 120,000 kilometers. The primary purpose for operating at these altitudes was to insure that the satellites would be above the Van Allen radiation belts. The trapped radiation belts could have provided an intolerably high background radiation count for the detectors, and they might have produced fatigue in the detector systems. Also, high energy protons in the belts could have degraded solar cell efficiency and induced radioactivity in spacecraft components, which would have provided high background radiation for some hours after the spacecraft had passed through the belts. Finally, high altitude avoided the denser regions of micrometeorites.

The Vela orbits were inclined anywhere from 32 degrees to 41 degrees. This was to insure good coverage of all areas around the Earth, and it was a relatively efficient inclination to launch into from Cape Canaveral's 28.5 degree latitude.

The initial launch vehicle considered for the Vela program was a Thor/Ablestar/30KS8000 booster launching a single Vela satellite. The Atlas D/Agena B booster (Figure 4) quickly became the launch vehicle of choice, because of its ability to carry two Velas into the required transfer orbit. Because of the orbital inclination and altitude required, and the designation of the Atlas as the satellite booster, Cape Canaveral (later to be renamed Cape Kennedy and subsequently revert back to Cape Canaveral) Air Force Station, Florida, was the only launch site considered. Launch Complex 13 at the Cape was the pad used for the Vela launches. Advanced Vela launches, using the Titan IIIC, flew from Launch Complex 41 at the Cape.

The launch and orbital injection profiles for the original Vela satellites were similar to the profile used for the advanced Velas (Figure 5). For the original Velas, the Atlas launch vehicle burned out at approximately 174 kilometers and separated from the Agena vehicle. Just prior to separation, the nose fairing around the tandem spacecraft was jettisoned. The Agena added velocity using two burns separated by a coast period. Moments before the second burn was terminated, the spacecraft stack was spun up. After thrust was terminated and spin-up was achieved, the spacecraft separated from the Agena and each other. The two separated spacecraft and the spent Agena then coasted toward apogee in a 320 by 97,000 kilometer elliptical transfer orbit. After reaching apogee about 17 hours later, and using standard Hohmann transfer techniques, the lead spacecraft fired its apogee motor upon ground command and was injected into its final orbit. The trailing spacecraft continued in the transfer ellipse for one full orbit, and then it fired its apogee motor for orbit circularization. This resulted in a 140 degree separation between the two spacecraft. This kind of angular separation ensured that the Earth could not block the detection of a nuclear event from both spacecraft.

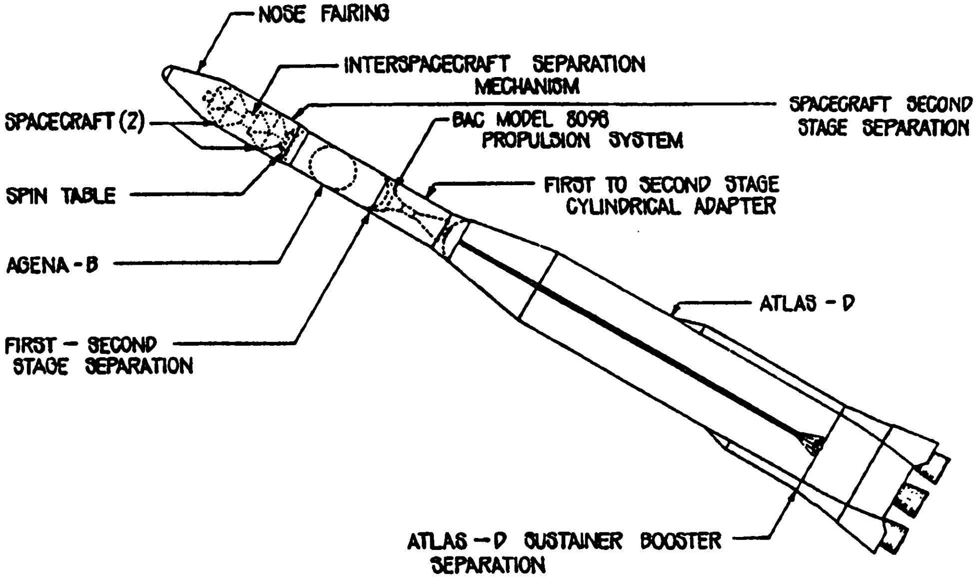

Figure 4 General vehicle and spacecraft configuration.

The launch of the advanced Velas on the Titan IIIC (Figure 6) depended on two burns by the Transtage upper stage. The first Transtage burn placed the Transtage and satellites in a 185 by 70,000 kilometer elliptical orbit. The vehicle coasted toward apogee for 3.8 hours and fired the Transtage engines a second time at an altitude of 45,000 kilometers. The second Transtage burn resulted in an elliptical transfer orbit of 9,300 by 110,000 kilometers. Fifteen minutes after the second burn, the Vela satellites separated as a single unit from the Transtage and were spin stabilized by the spin interstage unit. After spin up, the satellites separated from each other and coasted toward orbit apogee for 20 hours. At apogee, the trailing spacecraft fired its injection motor and circularized its orbit at 110,000 kilometers. The lead spacecraft continued in the transfer ellipse for one full revolution and then fired its motor and was circularized 140 degrees from the other spacecraft. Since a 180 degree separation was desired, the exact position for injecting the second spacecraft was selected to ensure a relative drift rate between the satellites. After the 180 degree separation was achieved, onboard station keeping maintained proper spacing.

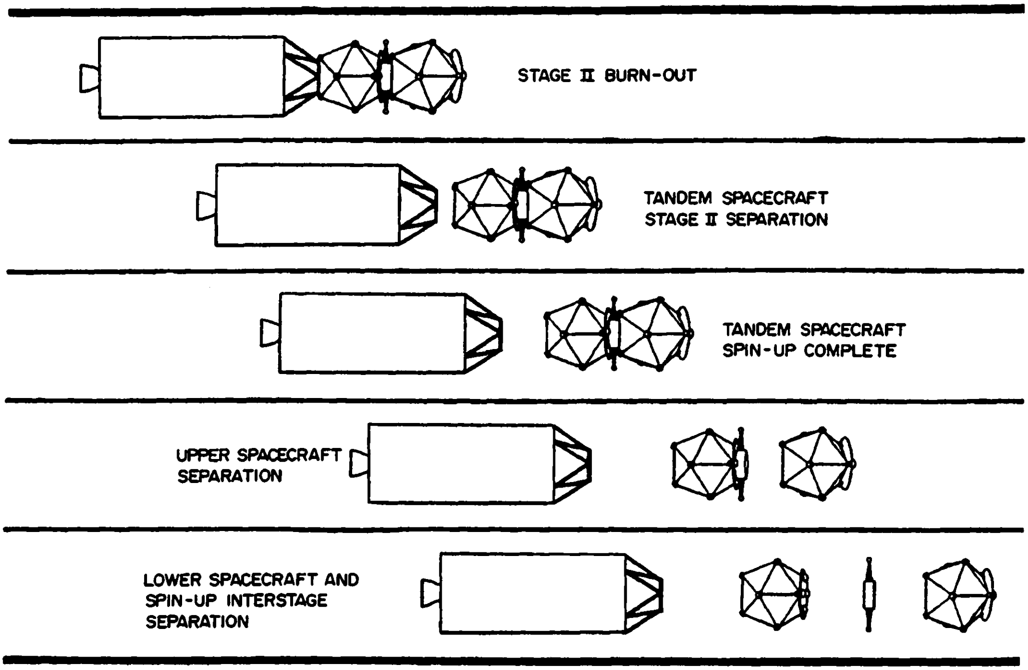

Figure 5 Separation and spin-up sequence.

Launch operations at the Cape were under the direction of the 6555th Aerospace Test Wing, a component of Space Systems Division (SSD). Command and control of satellite injection and orbital operations were under the 6594th Aerospace Test Wing, Satellite Test Center, Sunnyvale, California. The 6594th directed use of the worldwide Air Force satellite control network to operate the Vela spacecraft. The Indian Ocean Tracking Station was added at the beginning of the program because of support requirements for Vela.

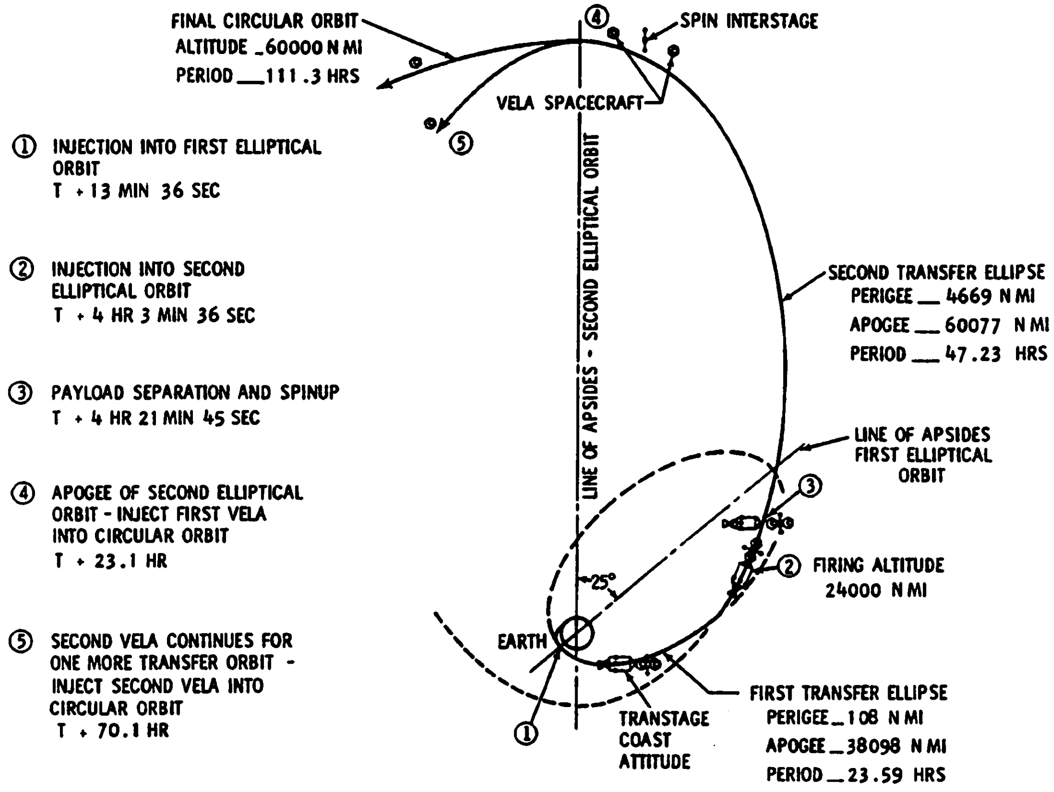

Figure 6 Titan II C/Vela flight plan.

Program Launch and Mission History (Figures 7 and 8)

The first launch of the Vela program occurred on October 16, 1963, only six days after the limited test ban treaty had gone into effect. The launch was designated Launch I, and it carried Vela satellites #1801 and #1851 into 38 degree inclination orbits. The spacecraft weighed 135 kilograms after orbital insertion. Orbital support was limited to both spacecraft in August 1968.

The second Vela launch took place on July 17, 1964, as an Atlas Agena roared aloft from the Cape's Complex 13. Spacecraft #3662 and #3674 reached their approximately 40 degree-inclined orbits, despite a small mishap during flight. After the satellites separated, the Agena continued to burn briefly, and it bumped one of the spacecraft. Damage was minor, and the mission was able to proceed. The spacecraft weighed 145 kilograms each on-orbit. Support to the satellites was limited in December, 1969.

Figure 7 Colonel Stephen H. Sherrill, Jr. (seated), Vela program director at SSD in the mid-1960s, with his deputy program director, Lieutenant Colonel Homer Howell.

Vela Launch III occurred on July 20, 1965, a calendar day that later would see two major U.S. space accomplishments. Spacecraft #6564 and #6577 achieved their 35 degree inclination orbits without incident. The 152 kilogram spacecraft operated until support was limited on #6564 in July 1970, and on #6577 in October 1970.

The first pair of advanced Velas lifted off on April 28, 1967. The heavier 231 kilogram spacecraft were placed in 32 degree inclination orbits. Spacecraft #6638 and #6679 were the first Velas launched by the powerful Titan IIIC.

Launch V (later Va) took place on May 23, 1969. Two redesigned advanced Velas (#6909 and 6911) achieved 32.8 inclination orbits. The spacecraft weighed 259 kilograms each.

The last Vela launch, designated Launch Vb, boosted two 261 kilogram advanced Velas into orbit. Spacecraft #7033 and #7044 went into 33.5 degree inclination orbits.

Many hitchhiker spacecraft were launched along with Vela spacecraft during the course of the program. The hitchhiker spacecraft were injected into the elliptical transfer orbit, where they routinely passed in and out of the Van Allen radiation belts. A number of these tiny spacecraft were designed to study the background radiation environment at various altitudes.

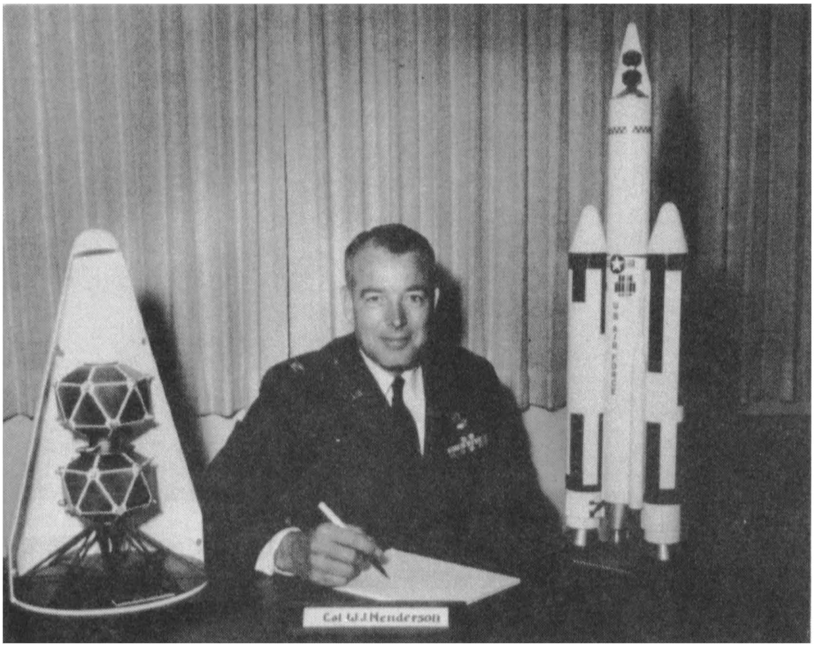

Figure 8 Colonel W. J. Henderson, Vela program director at SSD in the late 1960s.

After the first Vela launch, the program was redirected to provide interim operational deep space nuclear weapon detection capability. This came as a result of the significant operational utility demonstrated by the first two spacecraft. It is interesting to note that all of the original Vela spacecraft were designed to study the natural and man-made space radiation environment, but they performed so well, that an interim operational detection capability was available.

The program's goals for the third launch were redirected to provide continued interim operational deep space detection capability, along with exploring the feasibility of nuclear detection in the Earth's atmosphere from a space platform. The program goals were redirected for Launches IV, Va and Vb, to provide interim operational deep space and world-wide atmospheric radiation monitoring capability.

Despite the Vela program's primary focus on nuclear test detection from space, it provided extremely valuable collateral capabilities in two significant areas. First, Vela was a pathfinder in several areas of space science, including X-ray astronomy. Vela #6911 provided years of data on the X-ray double star Cygnus X-1. Vela also provided information on extremely powerful, brief radiation waves, known as X-ray and gamma ray Bursters. Vela provided detailed data on lightning bolt characteristics.

The second area of important collateral capability was in support of NASA's radiation warning network for the Apollo program. Since manned lunar missions meant that human beings would be exposed for days at a time to the cislunar space environment, and that they would not have the radiation protection of Earth's magnetic field, radiation monitoring of the space environment became very important. Vela satellites faithfully provided detailed data on radiation between the Earth and Moon, allowing NASA to have a clear and continuous view of the space environment during Apollo missions. Data was also provided in conjunction with space walks during the Gemini program.

In 1975, the Air Force Technical Applications Center at Patrick Air Force Base, Florida, assumed program management responsibilities for Vela. The Air Force Satellite Control Facility at Sunnyvale continued to provide orbital support throughout the life of the program. At 11:57 a.m., Pacific Daylight Time, on September 27, 1984, the Vela program came to an end. Colonel Thomas Niquette, Director of Operations for the Air Force Technical Applications Center sent the command terminating operation of spacecraft #6909.

During the years of operations, Air Force personnel at Sunnyvale supported about 200,000 Vela passes. Despite short design lives, the satellites operated for many years because of TRW's good design and careful application of redundant systems, along with the Satellite Control Facility's professional management of orbital operations.

Summary

The Vela satellite program began as a relatively small budget research program. It ended as a dramatically successful, cost-effective space system that provided invaluable operational data to many users. Vela successfully monitored the critically important test ban treaty, supported many NASA manned missions, and provided a wealth of information in several important disciplines of space science. Vela was truly a success story, and it provides an important case study to help program managers, engineers, and space scientists achieve maximum benefit, despite limited budgets from current and future space systems.

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