# Checking In:
## Vela Hotel and Early Nuclear Accountability in Space

By: Madeline Whitacre

### Introduction

In 1963 the United States, United Kingdom, and the Union of Soviet Socialist Republics signed and ratified the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and Under Water. The treaty was negotiated amid the distrust and political tensions of the Cold War, yet the United States was willing to enter into a legally binding agreement with the Soviet Union. This was made possible because of technological advancements that enabled government officials to feel confident in US independent monitoring and verification capabilities. In particular, the satellite detection system developed as the Vela Hotel program allowed the US to monitor for nuclear events from orbit. Once established, the Vela satellites successfully performed their mission of treaty monitoring and event detection but also contributed significantly to our understanding of various astrophysical phenomena.

A robust space-based monitoring system remains an important facet of US assurance and deterrence capabilities today. Satellite monitoring programs ensure treaty violations and nuclear proliferation are detectable. This deters non-nuclear nations from proliferating due to the international political ramifications that come with being a known proliferator and warns the United States and our allies of any emerging threats. This type of assurance strengthens trust between nations that are under the umbrella of US nuclear deterrence, such as Japan and South Korea, and limits proliferation of nuclear weapons to those nations which might otherwise pursue their development in pursuit of national security.

As the United States' first space-based nuclear event detection program, Vela's success laid the groundwork for the monitoring programs that are ongoing today.

### Need for Nuclear Event Detection

Since the early days of nuclear weapons science, scientists and US government officials alike have recognized the importance of monitoring for nuclear weapons development and testing. During World War II when the United States was secretly developing the world's first nuclear weapons under the Manhattan Project, the project's chief of foreign intelligence Major Robert Furman was responsible for gathering information on potential Nazi atomic research projects.

Corresponding with Furman, Manhattan Project physicist Luis Alvarez suggested the following plan for obtaining samples of water from near suspected German production sites to analyze:

> A fishing trip in a boat would probably give the best disguise, as the fisherman could carry a water bottle in his lunch basket, and fill it after drinking the original contents. The water should be collected from the center of the river, to get the swiftest flowing water, so that the holdup would be minimized. In the lake, the water should be collected as near to the suspected site as possible, or as near to each of the inlet rivers as can be done. Speed in getting from the collection point to the counting room is of great importance, as you are no doubt, aware.[1]

The need to monitor other countries for nuclear weapons development and testing continued to expand throughout the Cold War. By the 1950s, there was a clear growing need to expand nuclear weapons monitoring capabilities by utilizing and developing new detection technologies—a fishing boat and water bottle were no longer going be adequate.

By the mid-1950s, public opinion was turning against atmospheric nuclear weapons testing. There was a growing concern about the effects of fallout on public health. In particular, the 1954 Castle Bravo test sparked a great deal of controversy. As the highest yield test the United States ever conducted, Bravo detonated at 15 megatons, which was significantly higher than its designers had anticipated. The unexpectedly large yield contributed to high levels of fallout which led to significant radiation exposures for nearby Marshall Islanders as well as a Japanese fishing boat.[2] Eventually one of the boat's crew members died following the incident due to complications related to his medical treatment.[3] Concerned for their health following the Bravo test, the Marshall Islanders petitioned the United Nations to put an end to nuclear testing.[4] The impact of Bravo brought widespread attention to the fallout produced by atmospheric nuclear testing and its health impacts. The push to end testing that was initiated by Bravo would continue to grow.

As pressure for a test ban continued to mount, negotiations began between the US, Britain, and USSR, working toward the goal of a comprehensive ban on nuclear testing. But for any potential ban to be ratified as a treaty, the United States insisted there must be a detection system in place that could monitor for treaty violations.

From July 1 to August 21 of 1958, experts from the US, UK, and USSR, gathered in Geneva to discuss different systems of treaty verification that could be used to help enforce a test ban.[5] They explored several different detection methods for use in atmospheric, underground, and underwater environments. These included methods that had been studied for decades, such as the use of acoustic waves, radioactive debris, seismic waves, and radio signals. The scientists also explored various high-altitude detection methods.[6]

In examining possible high-altitude detection methods, the conference attendees concluded that there was a very high possibility that nuclear detonations could be detected via satellite.[7] This was a significant finding considering that the first ever artificial Earth satellite, Sputnik, was launched just a year prior, in 1957. They suggested that detectors for neutrons as well as prompt and delayed gamma-rays could be used to monitor for nuclear detonations in space and at high altitudes. However, before a satellite's detection range could be established, more data on the background cosmic radiation in its orbiting path was needed.[8]

The conference concluded with a recommendation to set up a series of 160 to 170 control posts and 10 ships outfitted with equipment to detect radioactive debris, radio-signals, seismic, acoustic, and hydroacoustic waves. On-site inspections would be carried out if, based on the data from the detectors, a nuclear detonation was suspected.[9] The detection methods recommended in 1958 were based on the technology that was immediately available at the time. Although satellite-based detection seemed promising, more work needed to be done before it could be implemented.

On August 23, 1958, just after the conference of experts concluded, President Eisenhower announced that the United States was going to refrain from testing and enter a voluntary moratorium lasting at least a year. This moratorium would coincide with a proposed series of negotiations between the United States, Soviet Union, and Britain during which the nations would work towards a test ban treaty.[10] The report of the conference of experts had generally been positive, so a complete ban on testing seemed feasible in the not-so-distant future. On October 31, the nuclear powers met in Geneva to begin negotiations towards a test ban. The voluntary testing moratorium would last until September of 1961.[11]

Despite the implication that reliable nuclear event detection and verification could be achieved relatively quickly, issues with developing underground detection systems started to arise, bringing into question the functionality and practicality of the proposed Geneva System.[12] However, as underground detection efforts were facing technical problems, work to develop satellite-based systems moved forward.

## Research and Development of Vela Hotel Satellites

The Vela program officially began on September 2, 1959, and responsibility for detecting nuclear detonations via seismic, high altitude, and surface detection methods was assigned to the Advanced Research Projects Agency (ARPA) with the Department of Defense (DOD) taking final responsibility for developing the program with support from the National Aeronautics and Space Administration (NASA) and the Atomic Energy Commission (AEC).[13] The program was organized into three areas of research and development. The Vela Uniform branch of the program would investigate underground detection, Vela Sierra surface-based detection, and Vela Hotel high-altitude detection.[14] The name Vela was derived from the Spanish word velar, meaning "to keep vigil", or velador, meaning "watchman".[15] The code names Uniform, Sierra, and Hotel were selected to correspond with the first letter of the detection method that they represented; "u" for underground, "s" for surface, and "h" for high-altitude.[16] Research for Vela Sierra focused on detection via air fluorescence. The Vela Uniform program worked on developing better underground detection capabilities by incorporating experiments into underground nuclear tests.[17]

The AEC, a US federal agency responsible for promoting and controlling nuclear science (and predecessor to today's Department of Energy), was responsible for providing the detectors and logics system for the Vela Hotel program.[18] Two AEC-managed laboratories contributed to the program. Sandia Laboratories developed the logics system and the Los Alamos Scientific Laboratory (LASL) designed and built the satellite's various detectors.[19]

By July 1961, several different options had been considered for the Hotel portion of the Vela program: an Argus satellite, near-earth satellites, and far-earth satellites. An Argus satellite would orbit the earth at around 400 miles above the surface and could detect electrons from nuclear detonations trapped in the earth's magnetic field.[20] The Argus satellite was not pursued because its detection range was limited by the structure of earth's magnetic field and its use would leave large areas of space, particularly near the poles, unmonitored.[21] Designers also wanted to avoid orbits in the Van Allen belts because they thought fluctuations in natural radiation might negatively impact the satellite's detection capability.[22] Designers also considered near-earth satellites with orbits between 350 and 1,000 miles. These satellites would use neutron, gamma-ray, and thermal x-ray detectors to monitor for clandestine nuclear detonations. However, at this height of orbit scientists believed they would need a system of 40 satellites to fully monitor the planet. Therefore, this system wasn't pursued due to the cost implication of the high number of spacecraft required.[23]

Instead, the Vela Hotel program focused its efforts on the development of far-earth satellites, orbiting between 50,000 and 75,000 miles around the planet and be equipped with neutron, gamma-ray, and thermal x-ray detectors. Because the satellites were so far from Earth's surface, they could monitor large swaths of the planet at once. Initial concepts for this system would use a series of six satellites.[24] By the time the project's personnel were ready to deploy the Vela system, they had decided that only two spacecraft would be required to keep nearly the entire Earth, upper atmosphere, and intervening space in the satellites' field of view.[25] They also considered expanding the far-earth satellite system to include solar-orbiting satellites to ensure no violations were taking place behind the moon or in deep space. However, solar-orbiting satellites would likely experience communication and range issues and, ultimately, the focus remained on far-earth satellite development. To develop this system, scientists identified four main areas of research:

> (a) The nature of the radiation signals observed at a detector which might result from a nuclear explosion;
>
> (b) The natural radiation background which might result in a false alarm in the system;
>
> (c) Development of reliable satellite-borne detectors and associated electronic instrumentation; and
>
> (d) Countermeasures, for example, shielding of a nuclear explosion, which might be employed by a violator to conceal the detonation.[26]

Initial research on background radiation sources was done by mounting instrumentation onboard other DOD and NASA satellites and by attaching experimental sensors to high altitude balloons. Despite this initial research, very little was known about pulse phenomena and the fluctuation of natural background radiation.[27] Therefore, scientists identified the need to include sensors designed to monitor for natural radiations sources in addition to sensors to monitor for traces of nuclear detonations on the Vela satellites so they could better understand how to distinguish between the two.

In August of 1961, Sandia completed the initial development of the logics system, the onboard electronics system responsible for collecting and telemetering satellite data. However, the logics system still needed to be tested, refined, and adapted to the Los Alamos designed detection instrumentation before it could be used in lengthy space missions.[28]

As research to develop a monitoring system was ongoing, a major political hurdle to a test ban treaty loomed on the horizon. On August 30, 1961, the USSR announced it would resume nuclear testing. The nation detonated its first post-moratorium test on

September 1, ending the voluntary moratorium.[29] In response, on September 5 President Kennedy publicly announced that the US would also resume testing.[30]

Despite the resumption of testing, development of the Vela satellite systems continued to move forward. At LASL, staff from the P-4 (High Altitude Physics) and P-1 (Electronics) groups were the main contributors to the satellite program.[31] The P-4 group at Los Alamos worked to develop x-ray, gamma-ray, and neutron detectors, and by October of 1961 it reached a point where development could not progress without consulting the spacecraft contractor who had not yet been selected.[32] By December, Space Technology Laboratories TRW became the program's spacecraft contractor, and fabrication was ready to begin on the nearly-finalized neutron counter. LASL planned to provide wooden mock-ups of the satellite's detectors to TRW, and Sandia would provide corresponding logics boxes so the contractor could start planning cabling layout.[33] By this time, key personnel in the development of the Vela satellites were starting to join P-4, including some of the primary and co-investigators of the various LASL detectors.[34]

Early in 1962 scientists started designing ground-based equipment to calibrate and test the satellite's detectors.[35] The x-ray, gamma-ray, and neutron detectors underwent various tests to determine how they would react to the extreme environmental changes in altitude and temperature they would experience in orbit, as well as vibration testing to see how they would react during launch.[36] By August, scientists and engineers successfully completed an electrical systems test of engineering models for the Vela detectors at Sandia, and development of flight proof models was underway.[37]

LASL detectors developed for the Vela system were also incorporated into instrumented rockets to gather data during atmospheric nuclear tests. In 1962 the US conducted a series of nuclear tests, Operation Fishbowl, near Johnston Island in the Pacific.[38] The x-ray, gamma-ray, and neutron detectors developed for Vela collected data for three of the operation's tests: Checkmate, Kingfish, and Starfish Prime.[39] Technicians mounted the detectors to rockets and launched them from the Hawaiian Islands at the time the tests were detonated.[40] Information collected from these high-altitude nuclear tests helped provide some concrete data to the Vela program. The effort contributed to the baseline understanding of what signals the instruments would observe from a nuclear detonation conducted at high altitude.

To successfully meet the scheduled launch date of September 26, 1963, LASL needed to finish producing all the detectors that needed to be incorporated with the Sandia-designed logics payload and the actual body of the spacecraft, all of which then needed to be tested as a complete system.[41]

## Developments Towards Successful Treaty Negotiations

Comprehensive test ban negotiations continued throughout the voluntary testing moratorium from 1958 – 1961. However, the United States and Soviet Union could not come to an agreement regarding the verification system for underground tests, including the number of control stations and inspections. The Soviets wanted control posts in its territory to be manned primarily by its own citizens and to strictly limit the number of annual inspections conducted by outsiders. The US did not believe this would be enough to verify that treaty violations were not taking place. These disagreements, in conjunction with deteriorating political relations between Soviets and the US, led to the end of the Geneva negotiations in January 1962.[42]

Despite the conclusion of the moratorium and the failure of the Geneva negotiations, both nations still wanted to come to an agreement to limit nuclear testing. In March of 1962 the United Nations Eighteen-Nation Disarmament Conference met with the same goal of negotiating a test ban treaty. Two bans were proposed by the British and US representatives: a comprehensive test ban and a ban limited to atmospheric, underwater, and outer space tests.[43] Both proposals were rejected by the Soviet Union. They opposed the comprehensive ban's requirement for on-site inspection and the limited ban because it would continue to allow underground testing, citing the potential military significance of such tests.[44]

Undeterred by continued setbacks, President Kennedy and UK Prime Minister Macmillan drafted a joint letter to Soviet Premier Khrushchev in spring of 1963 proposing that high level representatives from the US and U.K. travel directly to Moscow to discuss a test ban.[45] Khrushchev agreed to the talks and Soviet representatives met with US Ambassador Averell Harriman and British delegate Lord Hailsham in July of that year. The Soviets continued to oppose on-site inspections, believing it would lead to espionage, and the US still saw inspections as a requirement for verification for an underground test ban. These conflicting stances meant that a comprehensive test

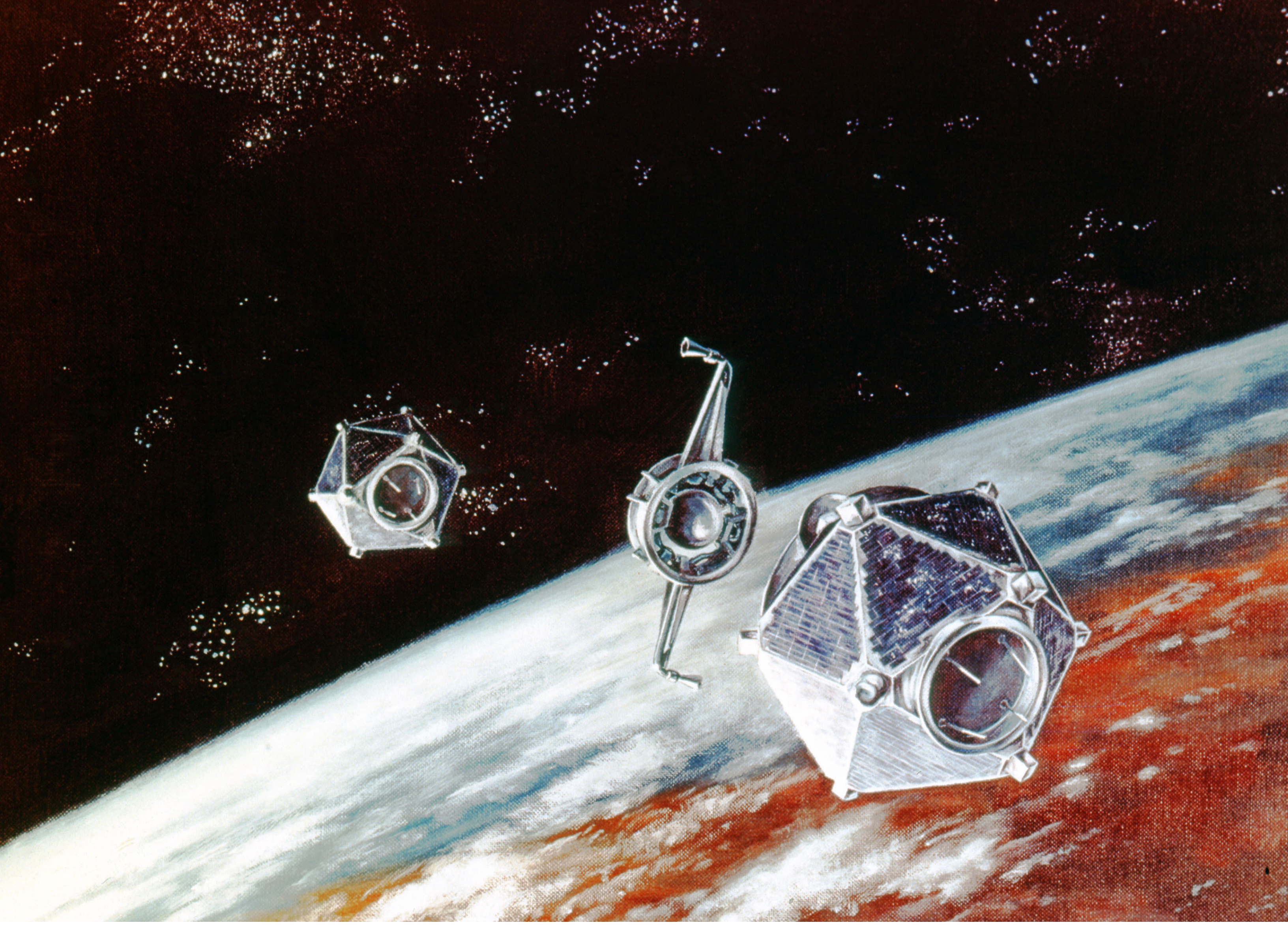

**FIGURE 1.** Artist's conception of a Vela satellite in orbit. Source: CN64-302, (Los Alamos, LANL NSRC Archive, 1964).

ban would not be pursued, leaving the delegation to negotiate a limited test ban.[46] Removing underground tests from the equation, the British, Soviets, and US agreed that the nations could independently monitor to verify compliance to a treaty addressing nuclear testing underwater, in the atmosphere, and in space.[47] In previous negotiations the Soviets opposed a partial test ban. However, their position changed following the Cuban Missile Crisis in October of 1962 and the ongoing deterioration of the USSR's relationship with China.[48] An unrestricted arms race and unrestricted nuclear testing no longer seemed beneficial. On August 5, 1963, the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space, and Under Water was signed in Moscow. The treaty, more commonly called the Limited Test Ban Treaty, or LTBT, was ratified by the US Senate on September 24, 1963 and entered into force on October 10, 1963.[49]

## Launch of Detection Instruments

Throughout these ongoing political developments, scientists working on the Vela Hotel program continued to push forward with the development and deployment of the satellite system. The initial scheduled launch date for the first pair of Vela satellites was September 26, 1963. Although the satellites and their payload were delivered to Cape Canaveral the week of August 19, a myriad of small issues kept pushing the launch date back—a contractor had wired one of the cables wrong, oil had been spilled onto some of the surfaces during testing, and one of the detectors had to be replaced.[50]

Despite the setbacks, the first launch of the Vela satellites took place on October 17, 1963—just one week after the LTBT entered into force. The pair of satellites, 1A and 1B, were launched from Cape Canaveral on an Atlas-Agena D rocket and

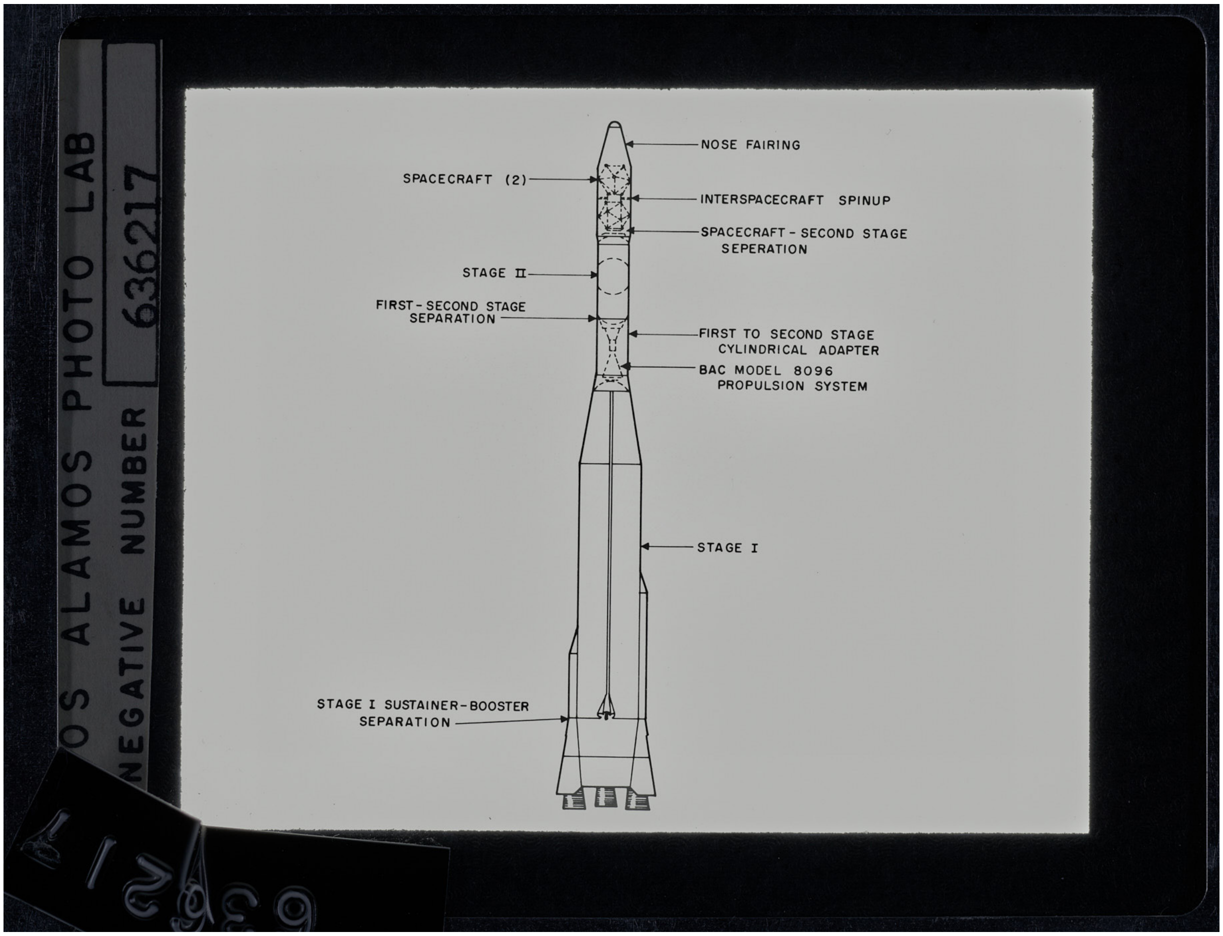


**FIGURE 2.** Cutaway line drawing of rocket carrying twin Vela satellites.
Source: A-1992-056 (1), (Los Alamos, LANL NSRC Archive, n.d.).

placed into a very far orbit of about 17 earth radii, or approximately 63,000 miles away from the surface of the earth.[51] Early on, the satellite program was meant to be a proof-of-concept effort rather than as a fully functional detection system.[52] However, the success of the instruments contributed to the programs transition from an R&D project to a programmatic effort. Additionally, these first satellites were only meant to monitor for nuclear explosions at high altitudes and in outer space. It would not be until the third anniversary of the launch of Vela 1A and 1B that it was publicly announced that the satellites had become sophisticated enough that they could also detect nuclear detonations that took place on Earth's surface.[53]

Each of the Vela launches consisted of one pair of satellites launched in tandem. The launch profile remained consistent across all six satellite launches. During the launch the two satellites were mounted together inside the nose cone, which fell away after the vehicle left the atmosphere. Jets of gas were used to set the pair spinning at two revolutions per second, and the two satellites then separated from each other. Then, as described in a 1964 LASL article, "a solid-fuel rocket inside one of the spinning spacecraft was ignited to push it into orbit. The second capsule was allowed to fall into a natural elliptical orbit that carried to about 200 miles from earth and out to apogee a second time, when it was injected into orbit, circular like the first but trailing by about 140 degrees."[54] This process meant that the satellites were nearly opposite each other as they orbited the earth so that working together they could monitor most of the planet and surrounding area at all times.

The Vela satellites relied primarily on instruments that could detect x-rays, gamma-rays, and neutron radiation to monitor for nuclear detonations. When a nuclear device is detonated, the reaction immediately emits gamma-rays and neutrons; these are the

| Vela Satellite Launch Details | | | | | | |
|---|---|---|---|---|---|---|
| Satellite Pair | 1A/B | 2A/B | 3A/B | 4A/B | 5A/B | 6A/B |
| Launch Date | 10-17-1963 | 7-17-1964 | 7-20-1965 | 4-28-1967 | 5-23-1969 | 4-8-1970 |
| Launch Vehicle | Atlas Agena D | Atlas Agena D | Atlas | Titan III-C | Titan III-C | Titan |
| Launch Site | Cape Canaveral | Cape Canaveral | Cape Canaveral | Cape Canaveral | Vandenberg AFB | Cape Canaveral |
| Mass | 150 kg each | 150 kg each | 150 kg each | 231 kg each | 259 kg each | 261 kg each |

**TABLE 1.** The Vela program consisted of a total six total launches, each sending one pair of satellites into orbit. Source: NASA Space Science Data Coordinated Archive, accessed March 21, 2023, https://nssdc.gsfc.nasa.gov/nmc/SpacecraftQuery.jsp

"prompt" emissions. The fission products produced by the reaction also emit gamma-rays and neutrons; the "delayed" emissions. Large quantities of thermal radiation are also emitted in the form of x-rays.[55]

The Vela satellite system included both prompt and delayed gamma-ray detectors. From the onset the Geneva conference of experts was concerned that a country might detonate a test behind the moon as a means of evading detection. The delayed gamma-ray detectors helped to alleviate that concern.[56] Detonating a nuclear device behind a large object in space such as the moon would, in principle, reduce the prompt gamma-rays, neutrons, and x-rays that could be detected by the satellite system. However, the delayed gamma-rays released by the debris from the detonation would continue to expand out from behind the shield, merely postponing detection by Vela's programmatic delayed gamma detectors. Based on the estimated expansion rate of the debris from a test, Los Alamos scientist Jim Coon, the P-4 group leader, calculated that delayed gamma signals from a detonation behind the moon would expand past the edges of moon and be detectable within 4 seconds of the detonation.[57]

Unlike many of the other detectors that were placed on the outside of the spacecraft, Vela's neutron detectors were located on the platform inside the satellite because neutrons could easily travel through its skin.[58] The satellite's x-ray detectors were mounted on the external surface of the satellite because the x-ray signals would be blocked by the skin of the spacecraft. These detectors were equipped with in-flight calibration capability as well as a "guard" detector that could help to differentiate between cosmic x-ray sources and those from potential nuclear events.[59]

After the launch of the third pair of Vela satellites, LASL scientists published a series of papers in the *Proceedings of the IEEE* (Institute of Electrical and Electronics Engineers) journal, detailing the numbers and types of detectors aboard the satellites. These included diagrams illustrating how the different detection instruments worked.[60] The information was primarily published for political reasons. US scientists wanted the Soviet Union to be aware of the detection capabilities that had been developed with the Vela satellites, and to know that the US would detect any violations of the LTBT.[61]

Later iterations of Vela, beginning with the launch of Vela 3A and 3B, included bhangmeters which measure optical signals, in particular the characteristic double-peaked curve of light intensity from a nuclear detonation. The first iteration of the bhangmeter was used in Operation Sandstone in 1948.[62] By the time bhangmeters were incorporated into the Vela system, they had been consistently used as part of the US's testing program and were well understood. Onboard Vela, the bhangmeters monitored for clandestine nuclear tests, the presence of which would be indicated by a double-peaked light intensity curve. The bhangmeters that were incorporated into the Vela satellites were developed by Sandia.[63]

Vela's orbit also passed through the magnetosphere, a region of plasma around the earth. This provided scientists an opportunity to study the region and its phenomena. Beginning with the launch of Vela 3A and 3B, plasma and energetic particle sensors were developed and incorporated into the satellites.[64] From the fourth Vela launch onwards, the satellites included instruments to monitor and study lightning and solar activity.[65]

The instruments used on the satellites continued to be improved as the Vela program progressed. Advancements were made to the programmatic instrumentation as well as the background and basic science detectors.

In addition to the detectors, the satellite required a logics system that was responsible for collecting and telemetering data from the detectors back to earth for analysis. The detection instruments collected vast amounts of data, and Sandia's logics system would help to identify the data that was most relevant to nuclear event detection. The logics system was a computer that had to be designed to survive launch and the environment of space. A 1988 Sandia news article reflected on the how challenging the requirements were:

> Build a highly complex electronic system. It needs the capabilities of a room-sized IBM 704 computer. Even though computer components can fail in an office with a constant temperature, put the system atop a powerful rocket and blast it into space where it must work perfectly in extreme temperatures. It must distinguish natural radiation from nuclear-blast radiation, produce reliable data, reduce that data down to a meaningful package, and transmit it back to earth where it can be deciphered easily. The satellite can't weigh more than about 500 pounds or be more than five feet in diameter. And, by the way, it has to have an on-board, self-sustaining power system.[66]

With this combination of LASL detectors and Sandia logics, the Vela satellites were well equipped for their mission.

## Contributions to Basic Science

Several important contributions to the understanding of astrophysics came out of the Vela satellite program because the Vela systems were equipped to detect background phenomena as well as monitor for nuclear events.

Using the Vela data from the cosmic x-ray detectors, unique cosmic x-ray sources were observed and studied. In July of 1969, Richard Belian first noticed a new cosmic x-ray source. He and his co-workers in P-4, Doyle Evans and Jerry Conner (the primary investigator for the satellite's cosmic x-ray detector), began monitoring changes to the source as the Vela 5A and 5B satellites collected data with each orbit. The source had a much higher intensity than any of the other known cosmic x-ray sources and was visible until September 24 of that year.[67] This source, the analysis of which was published in The Astrophysical Journal in 1970, was one of the early observations of what would later be identified as x-ray bursts.[68]

The plasma and energetic-particle detectors onboard Vela collected a myriad of early data on plasma physics phenomena.[69] Between 1965 and 1967, the satellite instruments compiled information on the proton density, flow speed, flow direction, and proton temperature of the solar winds.[70] Scientists analyzing Vela data also made significant contributions to the understanding of the magnetosphere's plasma sheet, including various studies of how it responded to magnetospheric substorms.[71]

In the mid-1970s, the Vela satellites also contributed to geophysical research, particularly relating to lightning. The satellite's optical systems first identified what scientists termed "superbolts"—lightning discharges whose "radiated energy is over 100 times that measured from typical lightning."[72]

Perhaps the most well-known of Vela's contributions to astrophysics was the discovery of gamma-ray bursts, which was first publicly announced in 1973 in The Astrophysical Journal.[73] Ray Klebesadel, who was the primary investigator for the programmatic x-ray and gamma-ray instruments, first noticed signals from gamma-ray bursts in the Vela data in 1969.[74] Contemporary researchers using other satellites had noticed these signals as well. But the advantage Los Alamos scientists had was that they had access to data from multiple different satellites. By mid-1969, the program had had five successful Vela launches. Without multiple satellite measurements, other researchers could not eliminate the possibility that these signals were just particle disturbances (electrons or protons interacting with the detectors and causing a false signal). Because the signals that Klebesadel found in the Vela gamma-ray data were nearly simultaneous across multiple Vela satellites, it seemed clear that there was more to the signals than coincidental particle disturbances.[75]

Gamma-ray bursts are short bursts of gamma-ray light, which is the most energetic form of light. These bursts, lasting between a few milliseconds to a few minutes, are several hundred times brighter than a typical supernova and about a million trillion times brighter than the sun.[76] They are also the largest explosions in the universe since the big bang.[77]

The discovery of gamma-ray bursts could not be announced immediately following the initial observation of the signals in 1959. At first, scientists did not have enough data to eliminate the sun as a possible source of the gamma-ray signals. In 1970, a sixth pair of Vela satellites were launched with more advanced gamma instrumentation. With these improved data sets available, scientists were able to identify 16 gamma-ray events that were of cosmic, not solar, origin. With the identification of these 16 events supporting the discovery, Los Alamos researchers were able to publish their results.[78]

The discovery of gamma-ray bursts is probably the most significant of Vela's contributions to basic science. It has been fifty years since the paper announcing the discovery was published, and gamma-ray burst research is still a dynamic field of astrophysics. It was not until 24 years after the initial discovery that scientists came to a consensus on the cause of gamma ray-bursts.[79] Short duration bursts are associated with colliding neutron stars, and long duration bursts are associated with supernovae, although not every supernova causes gamma-ray bursts.[80]

The Vela Hotel program was cancelled in September of 1984 when the sixth and final pair of Vela satellites was deactivated. These had been launched on April 8, 1970, collecting data for 14 years.[81] The instruments that Los Alamos had developed for Vela continued to be incorporated into Defense Support Program satellites and GPS satellites, which took over Vela's mission of nuclear detonation detection.[82] According to Los Alamos National Laboratory (LANL) scientist William Priedhorsky, the Vela satellites are "widely considered to have seen every aboveground nuclear explosion that was within their field of view,"[83] successfully fulfilling their mission.

Even after the Vela program ended, the data that the satellites had collected over the years continued to be useful for scientific research. One example of later research done with the Vela data was the analysis of the various x-ray sources recorded by the Vela 5B satellite. The x-ray detector on this satellite collected information for a decade—from its launch on May 23, 1969, until June 19, 1979. The long-term consistent data collected from the detector provided a unique opportunity to analyze changes in the x-ray sky.[84] Analysis of Vela data contributed not only to treaty verification, but also to our understanding of these astrophysical concepts.

## The Impact of Vela

In July 1963, President Kennedy addressed the nation and shared his sentiments regarding the LTBT:

> According to the ancient Chinese proverb, A journey of a thousand miles must begin with a single step. My fellow Americans, let us take that first step. Let us, if we can, step back from the shadows of war and seek out the way of peace. And if that journey is a thousand miles, or even more, let history record that we, in this land, at this time, took the first step.[85]

Although the LTBT did not end all nuclear testing, it brought about the end of the era of atmospheric testing and reduced global fallout, helping alleviate the public's concerns over its effects. The treaty's success also helped to lay the groundwork for future work on nuclear arms control and served as an early step towards détente.

In 1964, Bill Ogle, the test director at Los Alamos, gave a talk about the impact of detection on international policy and politics. He emphasized that the detection capabilities developed with the implementation of the Vela satellites opened new possibilities in the realm of international relations and treaty negotiation:

> the concept of inspection and detection is a new and important contribution in international relations. If accepted it essentially means that international agreements would become possible and practical without requiring international trust … the tremendous gain to be achieved is in establishing a method by which we can advance national and international aims in dealing with a nation that we do not trust.[86]

The success of the Vela satellites gave the United States confidence in its ability to detect violations of the LTBT. Development of this capability provided the technical framework that enabled the negotiation and ratification of the LTBT.

Although the Vela program ended in 1984, it laid the groundwork for the nuclear event detection programs that are in place today. Since the first Vela launch in 1963, the United States has had a nuclear event detection capability in space enabling treaty monitoring, expanding and improving on much of the technology developed for use on Vela. Development of this space-based monitoring technology has bolstered confidence among the US and our allies in the ability to detect and deter testing and proliferation.

Vela also significantly contributed to the understanding of the nature of the universe. These satellites were launched at a time when scientists believed space was fairly static.[87] Data gathered from the Vela satellites relating to gamma-ray bursts, solar wind, x-ray phenomena, and plasma physics helped change this perception of space. ■


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