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The Early Explorers

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Introduction

In the chaos that swept the United States after the launching of the first Soviet Sputniks, a variety of satellite programs was sponsored by the Department of Defense (DoD) to supplement (and in some cases supplant) the country's flagging "official" satellite program, Vanguard. One of the stronger programs was sponsored by the ABMA (Army Ballistic Missile Agency) with its engineering team lead by the German rocket expert, Wernher von Braun. Using the Juno I launch vehicle, the ABMA team launched America's first satellite, Explorer 1, which was built by Caltech's Jet Propulsion Laboratory (JPL) (see **Explorer: America's First Satellite** in the February 1998 issue of *SpaceViews*).

While these first satellites returned a wealth of new data, they were limited by the tiny 11 kilogram (25 pound) payload capability of the Juno I. In order to orbit larger payloads carrying a larger range of instrumentation, von Braun's team developed the Juno II. While the Juno I upper stage cluster of solid rocket motors was retained, the Juno II used a modified Jupiter IRBM instead of the smaller modified Redstone as a first stage. This new combination was first used to launch the Pioneer 3 and 4 lunar probes in December 1958 and March 1959 (see **Shooting for the Moon** in the January 1, 1999 issue of *SpaceViews*).

ABMA planners started working with JPL under the aegis of ARPA (Advanced Research Projects Agency) to develop new and larger satellites to fly on the Juno II. But long before the first of these new satellites was even launched, political decisions changed the landscape of America's fledging space program. With the formation of NASA in October of 1958, all ARPA-sponsored space science satellite programs were transferred to the new space agency. Among these programs were the next generation of Explorer satellites the ABMA was planning.

The First New Explorers

The first of the new series of larger Explorer satellites was the 39.7 kilogram (87.5 pound) satellite NASA designated as S-1. Built by JPL, the spin stabilized S-1 consisted of a pair of fiberglass cones joined at their bases with a diameter and height of 76 centimeters each. The scientific payload consisted of instruments to study cosmic rays, solar X-ray and ultraviolet emissions, micrometeorites, as well as the globe's heat balance. This was all powered by a bank of 15 nickel-cadmium batteries recharged by 3,000 solar cells mounted on the satellite's exterior. This advanced payload was equipped with a timer to turn itself off after a year in orbit.

Explorer S-1 was launched from Cape Canaveral on July 16, 1959 on Juno II Round AM-16. Immediately upon launch an electrical problem in the Jupiter first stage doomed the mission to failure. In one of the Cape's more spectacular early launch failures, the Range Safety Officer detonated the rocket's destruct package 5.5 seconds after launch after the rocket had pitched over towards the ground.

But as the ABMA team was preparing their next Juno II for launch, another unrelated Explorer satellite would attempt to reach orbit. This satellite, called S-2, was originally a joint USAF-ARPA project to launch a sophisticated probe into a very elongated orbit to study the Earth's newly discovered Van Allen radiation belts. S-2 would study this region in more detail than the Pioneer probes that first traversed it. Like the USAF-ARPA lunar Pioneer program, S-2 was transferred to NASA shortly after it was founded with the USAF officially relegated to an advisory role.

The S-2 payload was arguably one of the most advanced satellites ever constructed up to that time. Built by STL (Space Technology Laboratory) like the USAF Pioneer orbiters (see **Operation Mona: America's First Moon Program** in the April 1998 issue of *SpaceViews*), the satellite was a 64 kilogram (142 pound) spheroid with a diameter of 66 centimeters (26 inches) and a height of 74 centimeters (29 inches). The spin stabilized satellite used four extendable solar "paddles" to power its array of onboard equipment.

The impressive array of instruments was designed to study various types of trapped radiation, galactic cosmic rays, geomagnetism, radio propagation and micrometeorites. Also carried was a TV line scanner similar to that flown on the USAF Pioneers designed to produce crude images of the Earth from orbit. These TV signals were transmitted back to Earth along with digital data from other instruments using a UHF transmitter that operated for a few hours a day. A pair of continuously operating VHF transmitters returned a constant stream of analog instrument data. The S-2 payload would be sent into its elongated 12-hour hour orbit using the USAF Thor-Able - the same launch vehicle unsuccessfully used to send the USAF Pioneers to the Moon.

Thankfully, S-2 would have better luck than the Pioneers orbiters. On August 7, 1959 (40 years ago this month) Thor-Able 3 successfully placed S-2, now officially designated Explorer 6, into a 245 kilometer (152 miles) by 42,400 kilometer (26,343 mile) orbit inclined 47 degrees to the equator. The only major problem occurred when one of the four solar paddles failed to fully extend resulting in the new satellite generating only 63% of nominal power. This amount gradually decreased through the mission and affected the quality of the transmitted signal especially near apogee.

Despite its initial problems, Explorer 6 was a spectacular success. It returned the first crude images of the Earth from orbit. It also supplied a wealth of fresh data on the radiation and magnetic environment of near-Earth space. On September 11 one of the two VHF transmitters failed and contact was finally lost on October 6 when the power levels fell below the minimum the satellite needed to operate. In total, Explorer 6 returned 23 hours of digital data and 827 hours of data in analog form. Experience from the design of the successful and innovative Explorer 6 would be used by STL engineers for later Pioneer lunar and interplanetary probes.

A crude scanner image of a crescent Earth taken by Explorer 6 on August 14, 1959 from an altitude of 27,000 km. (NASA)

Success for ABMA

With Explorer 6 in orbit, the ABMA team was ready for another launch attempt. Juno II Round AM-19B carried a USAF-developed payload called Beacon. This was a 12 kilogram (26 pound) balloon designed to inflate to 3.7 meters (12 feet) across once in orbit. It was meant to study the properties of the upper atmosphere from orbit. A malfunction in the rocket's guidance system shortly after launch on August 14, 1959 (40 years ago this month) prevented Beacon from reaching orbit.

Undeterred, von Braun's team studied the causes of the Juno II failures and made corrections for the launch of the next satellite designated S-1a on Round AM-19A. Payload S-1a weighed 41.9 kilograms (92.3 pounds) and was a slightly improved version of the ill fated S-1. But unlike S-1, S-1a was successfully launched into a 557 kilometer (346 mile) by 1,069 kilometer (664 mile) orbit inclined 50.3 degrees to officially become Explorer 7. NASA's newest Explorer returned much new information on the spatial and temporal structure of the inner edge of the Van Allen radiation belts that complimented earlier data and that taken concurrently by later satellites. Explorer 7 returned continuous real-time data through February 1961 and then intermittently until August 24 of that year.

Next up was payload S-46. This 10.2 kilogram (22.5 pound) cylindrical satellite was 18 centimeters (7 inches) in diameter and 53 centimeters (21 inches) long. Similar in design and mission to the earlier Explorer satellites launched by the Juno I, S-46 carried instruments to study the Earth's radiation belts. But unlike its earlier siblings, S-46 also carried four banks of solar cells mounted on a rectangular box to recharge its batteries for up to one year. By using the more powerful Juno II, this new payload could survey the Van Allen belts from a more highly elongated orbit that was designed to survey its breadth. The new payload mounted atop of Juno II Round AM-19C was launched on March 23, 1960 but all telemetry was lost shortly after first stage burn out. The Juno II had failed again.

Launch of Explorer 7 on October 13, 1959. (NASA)

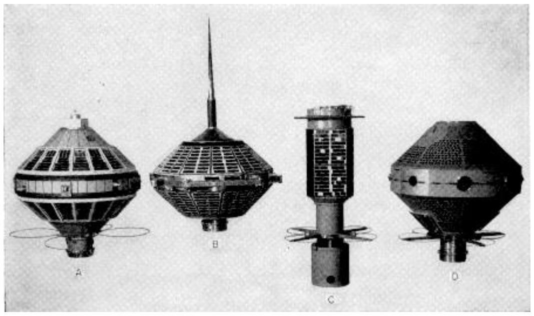
The next attempt by ABMA to launch a JPL-built Explorer came later that year. Payload S-30 was similar in shape and design to the earlier S-46-series satellites except it did not carry solar cells and had a life of only 1.5 months. Weighing in at 40.26 kilogram (88.65 pounds), this satellite was designed to make in situ measurements of upper atmospheric properties such as electron density, temperature, composition and how they vary with time and altitude. The solar cells were excluded from this payload because asymmetric charging on the cell surfaces would produce electric fields that could affect experiment results. Three different sensors to measure micrometeorites were also carried.

This new payload was successfully launched into a 459 by 2,289 kilometers (285 by 1,423 mile) orbit on Juno II Round AM-19D on November 3, 1960. As expected, Explorer 8 operated until December 28 when its batteries were finally exhausted. During its useful life, Explorer 8 returned a large volume of data but unfortunately there were problems processing the raw telemetry into usable measurements. Because of these problems, most of the data had to be processed by hand. Nonetheless many important new observations were made including the discovery of a helium layer in the ionosphere.

The Last Flights of the Juno II

From the start NASA policymakers knew that the Juno II was only a stopgap measure. Kludged together from a variety of preexisting hardware, the Juno II was hardly an optimum design for the task of satellite launches. And its high failure rate only underscored the need for a replacement. By the end of 1960, the all solid-rocket motor Scout had already started test flights. Promising lower costs and better reliability, the Scout was designed to launch small Explorer-class payloads into low orbits and would gradually replace Juno II in that role during 1961. Larger payloads to be launched into distant Earth orbits would use a highly upgraded version of the Thor Able called the Thor Delta (later know as just Delta). But in the mean time the remaining Juno II rounds had payloads to launch.

The next payload ready for launch was S-45. It was similar to the proven design of Explorers 7 and 8 and weighed 34.1 kilograms (75.0 pounds). This solar-powered satellite would transmit low power, phase-coherent signals at six different frequencies between 20 and 960 MHz which would be monitored by ground stations. This allowed scientists to determine many key parameters of Earth's ionosphere. On February 24, 1961 what would have become Explorer 10 (Explorer 9 was successfully launched on a Scout eight days earlier) was launched on Round AM-19F. Unfortunately a malfunction prevented the last two stages from igniting and S-45 failed to reach orbit.



From left to right, S-1a (Explorer 7), S-45, S-15 (Explorer 11) and S-30 (Explorer 8).

Unlike the earlier Explorers, payload S-15 observed the heavens making it the first astronomical satellite. This satellite consisted of an octagonal box 31 centimeters (12 inches) across and 59 centimeters (23 inches) long mounted on top of a 52 centimeter (20 inches) long cylinder with a diameter of 15 centimeters (6 inches). The principle instrument was designed to detect gamma rays with an energy greater than 50 Mev over a field of view of five degrees. The spin of the satellite in orbit would allow this directional detector to scan most of the celestial sphere with emphasis along the galactic plane. The satellite would also measure the Earth's reflectivity to gamma rays. This 43.2 kilogram (95.1 pound) satellite had a life expectancy of four months due to the deleterious effects of radiation on the solar cells mounted on the exterior of the box.

Launched on April 27, 1961, S-15 became Explorer 11 when Round AM-19E sent it into a 497 by 1,793 kilometer (309 by 1,114 mile) orbit. Despite the loss of its tape recorder, Explorer 11 was able to return a large amount of real-time data during its unexpectedly long 224 day life. One of the more important findings was the lack of evidence to support steady state cosmology. This theory proposed that new matter was being continuously created to fill the expanding Universe. This process should have generated a gamma ray signature that Explorer 11 could detect. Their absence was a boost for the popular alternative theory called the Big Bang.

The last payload that Juno II launched was S-45a. Essentially a duplicate of the unsuccessful S-45, the last ABMA-JPL Explorer lifted off on Round AM-19G on May 24, 1961. But failure struck again when a malfunction during second stage ignition doomed the mission. With this anticlimactic finale, the Juno II was quietly retired after ten launches. While the Juno II had its problems, it did successfully launch three satellites and one lunar probe that added immensely to the first steps in the exploration of space.

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