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## **EXPLORERS 1-7**

**Dates:** January 31, 1958, to July 24, 1961

**Type of satellite:** Scientific

**Country:** The United States

*In the aftermath of Sputniks 1 and 2, the United States was compelled to launch a manmade satellite into Earth orbit quickly. After the failures of some early Vanguard launch vehicles and subsequent launchpad explosions, research for what became the Explorer program was approved. Although only five of the first seven Explorers reached Earth orbit, the program was a major success.*

### **Principal Personages:**

WERNHER VON BRAUN, Technical Director, Army Ballistic Missile Agency (ABMA)

JAMES A. VAN ALLEN, Professor of Physics, University of Iowa

JOHN B. MEDARIS, Commander, ABMA Ordnance Corps

JAMES M. GAVIN, Chief of Research and Development, U.S. Army

WILLIAM H. PICKERING, Director, Jet Propulsion Laboratory

NEIL H. McELPoy, U.S. Secretary of Defense

ALAN WATERMAN, Director, National Science Foundation

THOMAS KEITH GLENNAN, Administrator, National Aeronautics and Space Administration

### **Summary of the Satellites**

The Explorer program began with the United States' first orbital satellite, Explorer 1, launched in the International Geophysical Year (an eighteen-month period during 1957-1958 designated as a time of intense geophysical study). Explorers 1 through 7 were hastily launched by the U.S. Army and the Jet Propulsion Laboratory (JPL) when Project Vanguard showed signs of faltering in the shadow of the Soviet Union's Sputniks 1 and 2.

The technological advances leading up to the launch of Explorer 1 had begun some fifteen years before. In May 1945, with the sound of Soviet artillery in the distance, the German rocket scientists based at Peenemünde, Germany, surrendered to American forces. The effective design and awesome striking power of German offensive missiles had impressed the Allies during the V-2 London bombings. Allied commanders were quick to realize the value of roughly one hundred V-2 rockets for experimentation and the value of securing one hundred German rocket scientists, who were most willing to emigrate and advance the science of rocketry in the United States. The leader of the German group was Wernher von Braun, who, before his death in 1977, would prove himself invaluable in all phases of U.S. space efforts.

Building on significant advances in rocketry made by the Army, Air Force, Navy, and JPL in the 1940's, the U.S. Army Ordnance Guided Missile Center - later named the Army Ballistic Missile Agency (ABMA) - was formed at the Redstone Arsenal in Huntsville, Alabama,

in 1950. There, with the assistance of JPL and, later, von Braun's colleagues, the Redstone rocket was developed from the V-2 for predominantly military purposes. With the Korean War in progress, military ballistic research was well funded and highly successful. By mid-1955, in direct competition with Project Vanguard of the Naval Research Laboratory (NRL), the Army-JPL team submitted a proposal for Project Orbiter to the Department of Defense to fulfill the satellite launch scheduled for the International Geophysical Year. The Navy plan was ultimately accepted in September 1955. Clearly, morale at the Redstone Arsenal was low after the Navy won their proposal to launch the United States' (and at that time, perhaps the world's) first manmade orbital satellite. Department of Defense funding was not available for nonmilitary research. The Army argued, in vain, for additional research and development support for Project Orbiter, but none was granted. Thus, ABMA and JPL rocket research continued in the shadow of NRL's Project Vanguard.

The Jupiter series evolved from the Redstone ballistic missile, which, in turn, was the direct descendant of the German V-2. Jupiter A was the first modified Redstone and between September 1955 and June 1958, twenty-five Jupiter tests were conducted. Jupiter C was designed as a vehicle to test nose-cone materials for reentry. Standing 17.7 meters high and measuring 2.7 meters in diameter, the missile weighed roughly 50,000 kilograms. The Jupiter C was configured with a lengthened Redstone first stage fueled with hydyne (a mixture of unsymmetrical dimethylhydrazine and diethylene triamine). A cluster of eleven solid-propellant Sargeant rockets comprised the second stage, and the third stage was made up of three Sargeants. Different from contemporary rockets, before launch the third stage of Jupiter C was set into rotation (for stability and added ballistic accuracy), thus creating an unusual "spinning top" effect on the prelaunch rocket.

Various staging combinations and propulsion systems were tested. By September 20 1956 the ABMA-JPL team had launched a prototype Jupiter C with a dummy last stage. By the summer of 1957, a suborbital Jupiter C had reached its target area and was recovered. These launches, and government funding, allowed the Army-JPL team to produce the four-stage Juno 1 (nearly identical to the three-stage Jupiter C).

Finally, on November 8, 1957, amid the failure of Vanguard missiles and the success of Sputnik 1, the ABMA received authorization from the Department of Defense to revive Project Orbiter and attempt to launch a satellite into low Earth orbit sometime during the remainder of the International Geophysical Year. The Jupiter C rocket was reasonably well tested, and confidence in the launch system ran high. Because of previous losses in funding, however, a suitable satellite needed to be designed from scratch. In addition, launch schedules, refitting of launch pads and tracking systems at Cape Canaveral needed to be organized. The Juno 1 was created from a stock Jupiter C missile, with an added solid-propellant Sargeant fourth stage as a satellite carrier. On January 31, 1958, some three months after the directive and through an intense concerted effort, the Army-JPL team's Juno 1 rocket successfully launched Explorer 1 from Cape Canaveral, Florida.

The roles of the ABMA and JPL were paramount in the rapid production of the satellite Explorer 1. Acting in concert with physicist James A. Van Allen, researchers had assembled the instrument payload for Explorer I and prepared it for launch. Tracking and telemetry systems

(known as Microlock) had been tested, and a late January 1958, launch window at Cape Canaveral had been secured before the next scheduled Vanguard mission (February 5, 1958).

Of the first seven Explorer missions, only five (Explorers 1, 3, 4, 6, and 7) achieved orbit. Explorer 1 was hurled into an orbit with a revolution period of 114 minutes, an initial apogee (farthest distance from Earth) of 2,531 kilometers, and an initial perigee (nearest distance to Earth) of 360 kilometers. Explorer 1, a cylindrical satellite 2 meters long and 15.2 centimeters in diameter, was mounted atop the fourth-stage Sargeant. With a total weight of 13.97 kilograms, it contained an 8.22-kilogram instrument payload with antennae and included radio transmitters and power necessary to reach Earth-based monitoring stations. The instruments included a cosmic-ray detector, micrometeorite sensors, and temperature sensors to measure both inside and outside temperature changes.

Explorer 2, a satellite similar to Explorer 1, failed to reach orbit on March 5, 1958 because the fourth stage failed to ignite. Three weeks later, on 26 March, Explorer 3 was launched into an orbit with a 2,800-kilometer apogee and a 191.5-kilometer perigee; the orbit decayed and forced reentry after three and a half months, on 28 June. The Explorer 3 instrument payload was nearly identical to that of Explorer 1, helping to reproduce and therefore verify earlier measurements. On July 26, 1958, Explorer 4 was placed in orbit with an initial apogee of 2,209 kilometers, an initial perigee of 262 kilometers, and a 110-minute orbital period. With a larger payload than its predecessors (11.7 kilograms) Explorer 4 contained radiation and scintillation counters, as well as internal temperature sensors. Explorer 5 failed to reach orbit on August 24, 1958, because of damages incurred during first-stage separation. It plummeted to Earth after 11 minutes.

The National Aeronautics and Space Administration (NASA), created in October 1958, took control of US. space activities, including the Explorer and Vanguard programs. Hence, the next Explorer mission occurred under the new agency's auspices. Explorer 6 was a 4.20-kilogram, 3.65-meter-diameter inflatable satellite (it resembled a balloon) designed to offer high visibility for Earth-based trackers, allow radar targeting, and provide atmospheric density data. Fired atop a Juno 1 (Jupiter C) with an experimental "apogee kick" fifth stage, Explorer 6 (aka Beacon 1) failed to reach orbit on October 22, 1958 because of some vibration resulting from third-stage cluster rotation.

During a research and development period at NASA lasting roughly one year, researchers attempted to correct problems found during the previous launch failure. The newer rocket design, named Juno 2, suffered an initial failure on July 16, 1959. To launch a multiple-experiment payload (identical to the future Explorer 7) the rocket experienced rapid attitude variations and exploded in the fifth second after lift-off. A second Explorer 6 attempt, with identical instrument payload, was launched successfully on August 7, 1959, atop a Thor-Able 3 rocket. A Juno 2 did successfully orbit the Explorer 7 on October 13, 1959, with an initial period of 101.3 minutes, an apogee of 1,096 kilometers, and a perigee of 555 kilometers. Instruments on board the 41.5-kilogram satellite were designed to measure energetic particles and radiation and micrometeorite bombardment. Explorer 7 returned data on Earth's magnetic field and solar flares until July 24, 1961.

## Knowledge Gained

Throughout the last half of the 1940s many sounding rockets (short-duration subvertical launches to measure physical atmospheric conditions) were fired to perform measurements in the upper atmosphere. By the mid-1950s, prevailing expert opinion supported the necessity of orbital satellites to provide long-duration measurement of atmospheric change rather than the momentary data provided by spot-fired sounding rockets. Destined to set a design precedent for many future classes of spacecraft, the Explorer missions in the late 1950's fulfilled the United States' obligation to participate in the International Geophysical Year, restored pride in the American space effort and covered altitudes and latitudes far in excess of contemporary Vanguard missions. In combination, the Explorer and Vanguard programs provided new data on Earth's near-space environment, a body of knowledge to be refined and expanded to the solar system and beyond with more sophisticated spacecraft.

Upon orbit, Explorer 1 measured unexpectedly high radiation levels roughly 1,100 kilometers above Earth's surface. Corroborated by Explorer 3 and confirmed by Sputnik 3, the region was named the Van Allen radiation belt, an area high above Earth where cosmic radiation is trapped along the magnetic field lines of Earth.

Micrometeorite sensors detected diurnal variation in meteorite flux and showed that particles between 4 and 9 micrometers in diameter were ten times more likely to strike the sensors than were larger particles. After twelve days of operation, the mass of material striking Earth daily was estimated at 10 million kilograms. Temperature fluctuations were measured both inside and outside the Explorer 1 satellite which confirmed the success of methods employed to control internal temperature.

Unlike its earlier counterpart, Explorer 3 contained a tape recorder which allowed for more complete data transmission. Only 15 percent of the telemetry from Explorer 1 was received by ground stations, while the improved methods of Explorer 3 allowed transmission of 80 percent of its data. The mission added more data to those collected by Explorer 1. Explorer 4 measured, within a wider range of altitude and latitude, cosmic rays and trapped radiation of the Van Allen radiation belt. As confirmed later by Pioneer spacecraft, Explorer 4 discovered two subdivisions density distribution data, measured the radiation belt and micrometeorite bombardment, and served as a radar target for ongoing tracking and geodetic research. The instrument package of Explorer 7 suffered from intense saturation of radiation electrons, thus limiting results. One of three micrometeorite sensors was damaged during launch and produced erroneous data. Still, Explorer 7 returned so much useful information that processing it all required more than six years. The spacecraft measured heat and radiation variation in Earth's atmosphere and meteorological changes resulting from such variation. In addition, correlations were documented between auroral activity and trapping of charged particles along Earth's magnetic field lines.

## Context

The early Explorer program, developed during a period of pioneering rocket research, greatly affected the future of unmanned and manned spaceflight. The Explorer program advanced the art and science of American rocketry. Expanded growth in the fields of space vehicle engineering, construction, propulsion, and launch technique were predictable outcomes of the Explorer program. It provided a needed boost in morale with the launch of Explorer 1 and in interfacing with Project Vanguard, added to the strength of both programs. Major advancements in electronic circuitry design and miniaturization, missile guidance, tracking, telemetry, and antennae systems were accomplished by the ABMA-JPL team during the formative stages of the Explorer program. The Redstone, Jupiter C, and Juno 1 rockets were progenitors of the Juno 2, Juno 5 and Saturn missile systems, a series of successful rockets destined to take men to the Moon.

In terms of satellite technology, the Explorer 1 led the way for a legacy of long-lasting interplanetary Explorer-class spacecraft and the future development of Ranger, Surveyor, Lunar Orbiter, Mariner, Pioneer, and Voyager spacecraft. The combined data from such missions embraced and developed the science of planetology. Earth-directed investigations heightened environmental awareness and allowed a new view of Earth to be globally shared.

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*Charles Merguerian*

### **Cross-References**

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