# SAMPLE

## Solar System Missions: Messenger

Mercury at Last

Aira Astralis

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# Introduction

MESSENGER was a NASA robotic space probe that orbited the planet Mercury between 2011 and 2015, studying Mercury's chemical composition, geology, and magnetic field. The name is a backronym for Mercury Surface, Space Environment, Geochemistry, and Ranging, and a reference to the messenger god Mercury from Roman mythology. MESSENGER was launched aboard a Delta II rocket in August 2004.

Its path involved a complex series of flybys - the spacecraft flew by Earth once, Venus twice, and Mercury itself three times, allowing it to decelerate relative to Mercury using minimal fuel. During its first flyby of Mercury in

January 2008, MESSENGER became the second mission, after Mariner 10 in 1975, to reach Mercury. MESSENGER entered orbit around Mercury on March 18, 2011, becoming the first spacecraft to do so. It successfully completed its primary mission in 2012.

Following two mission extensions, the spacecraft used the last of its maneuvering propellant to deorbit, impacting the surface of Mercury on April 30, 2015. MESSENGER's formal data collection mission began on April 4, 2011. The primary mission was completed on March 17, 2012, having collected close to 100,000 images. MESSENGER achieved 100% mapping of Mercury on March 6, 2013, and completed its first year-long extended mission on March 17, 2013.

The probe's second extended mission lasted for over two years, but as its low orbit degraded, it required reboosts to avoid impact. It conducted its final reboost burns on October 24, 2014, and January 21, 2015, before crashing into Mercury on April 30, 2015.

# Chapter 1: The Discovery of Messenger

No subsequent close-range observations of the planet would take place for more than 30 years. In 1998, a study detailed a proposed mission to send an orbiting spacecraft to Mercury, as the planet was at that point the least-explored of the inner planets. In the years following the Mariner 10 mission, subsequent mission proposals to revisit Mercury had appeared too costly, requiring large quantities of propellant and a heavy lift launch vehicle.

Moreover, inserting a spacecraft into orbit around Mercury is difficult, because a probe approaching on a direct path from Earth would be accelerated by the Sun's gravity and pass Mercury far too quickly to orbit it.

However, using a trajectory designed by Chen-wan Yen in 1985, the study showed it was possible to execute a Discovery-class mission by using multiple, consecutive gravity assist, 'swingby' maneuvers around Venus and Mercury, in combination with minor propulsive trajectory corrections, to gradually slow the spacecraft and thereby minimize propellant needs. The MESSENGER mission was designed to study the characteristics and environment of Mercury from orbit. The scientific objectives of the mission were: to characterize the chemical composition of Mercury's surface.

The MESSENGER spacecraft was designed and built at Johns Hopkins University's Applied Physics Laboratory. Science operations were managed by Sean Solomon as principal investigator, and mission operations were also conducted at JHU/APL.

The MESSENGER bus measured 1.85 meters (73 in) tall, 1.42 m (56 in) wide, and 1.27 m (50 in) deep. The bus was primarily constructed with four graphite fiber / cyanate ester composite panels that supported the propellant tanks, the large velocity adjust (LVA) thruster, attitude monitors and correction thrusters, the antennas, the instrument pallet, and a large ceramic-cloth sunshade, measuring 2.5 m (8.2 ft) tall and 2 m (6.6 ft) wide, for passive thermal control.

At launch, the spacecraft weighed approximately 1,100 kilograms (2,400 lb) with its full load of propellant. MESSENGER's total mission cost, including the cost of the spacecraft's construction, was estimated at under US$450 million. Main propulsion was provided by the 645 N, 317 sec. Isp bipropellant (hydrazine and nitrogen tetroxide) large velocity assist (LVA) thruster. The model used was the LEROS 1b, developed and manufactured at AMPAC?ISP's Westcott works, in the United Kingdom.

The spacecraft was designed to carry 607.8 kilograms (1,340 lb) of propellant and helium pressurizer for the LVA. Four 22 N (4.9 lbf) monopropellant

thrusters provided spacecraft steering during main thruster burns, and twelve 4.4 N (1.0 lbf) monopropellant thrusters were used for attitude control. For precision attitude control, a reaction wheel attitude control system was also included. Information for attitude control was provided by star trackers, an inertial measurement unit and six Sun sensors.

The probe included two small deep space transponders for communications with the Deep Space Network and three kinds of antennas: a high gain phased array whose main beam could be electronically steered in one plane, a medium-gain "fan-beam" antenna and a low gain horn with a broad pattern.

The high gain antenna was used as transmit-only at 8.4 GHz, the medium-gain and low gain antennas transmit at 8.4 GHz and receive at 7.2 GHz, and all three antennas operate with right-hand circularly polarized (RHCP) radiation.

One of each of these antennas was mounted on the front of the probe facing the Sun, and one of each was mounted to the back of the probe facing away from the Sun. The space probe was powered by a two-panel gallium arsenide/ germanium solar array providing an average of 450 watts while in Mercury orbit. Each panel was rotatable and included optical solar reflectors to balance the temperature of the array.

Power was stored in a common-pressure-vessel, 23-ampere-hour nickel-hydrogen battery, with 11 vessels and two cells per vessel. The spacecraft's onboard computer system was contained in an Integrated Electronics Module (IEM), a device that combined core avionics into a single box. The computer featured two radiation-hardened IBM RAD6000s, a 25 megahertz main processor, and a 10 MHz fault protection processor. For redundancy, the spacecraft carried a pair of identical IEMs.

For data storage, the spacecraft carried two solid-state recorders able to store up to one gigabyte each. The IBM RAD6000 main processor collected, compressed, and stored data from MESSENGER's instruments for later playback to Earth.

MESSENGER used a software suite called SciBox to simulate its orbit and instruments, in order to "choreograph the complicated process of maximizing the scientific return from the mission and minimizing conflicts between instrument observations, while at the same time meeting all spacecraft constraints on pointing, data downlink rates, and onboard data storage capacity." Included two CCD cameras, a narrow-angle camera (NAC) and a wide-angle camera (WAC) mounted to a pivoting platform.

During its stay in Mercury orbit, the probe's instruments yielded significant data, including a characterization of Mercury's magnetic field and the

discovery of water ice at the planet's north pole, which had long been suspected on the basis of Earth-based radar data. In 1973, Mariner 10 was launched by NASA to make multiple flyby encounters of Venus and Mercury. Mariner 10 provided the first detailed data of Mercury, mapping 40-45% of the surface.

Mariner 10's final flyby of Mercury occurred on March 16, 1975.

End of free sample. The full book is available at putrabooks.github.io

# ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.