THE RETURN TO MERCURY: AN OVERVIEW OF MESSENGER'S FIRST MERCURY FLYBY. Sean C. Solomon[1], Ralph L. McNutt, Jr. [2], Peter D. Bedini[2], Eric J. Finnegan[2], David G. Grant[2], and the MESSENGER Team, [1]Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Road, N.W., Washington, DC 20015, scs@dtm.ciw.edu; [2]Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, Ralph.McNutt@jhuapl.edu, Peter.Bedini@jhuapl.edu, Eric.Finnegan@jhuapl.edu, David.Grant@jhuapl.edu.

Introduction: The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft, under NASA's Discovery Program, will be the first probe to orbit the planet Mercury. Launched in August 2004, MESSENGER is midway through a complex interplanetary cruise phase that involves six planetary flybys. The first of three flybys of Mercury will occur on 14 January 2008, an event that marks the first spacecraft visit to the innermost planet since Mariner 10 last did so nearly 33 years ago. Here we give an overview of the observations made during the flyby and their scientific implications for Mercury.

MESSENGER Objectives and Payload: The MESSENGER mission [1] was designed to answer six questions: (1) What planetary formational processes led to Mercury's high ratio of metal to silicate? (2) What is the geological history of Mercury? (3) What are the nature and origin of Mercury's magnetic field? (4) What are the structure and state of Mercury's core? (5) What are the radar-reflective materials at Mercury's poles? (6) What are the important volatile species and their sources and sinks near Mercury?

Those questions, of broad importance to all the inner planets, led to the mission scientific objectives: to map globally the major element chemistry and mineralogy of the planet's surface; to image globally the surface at a horizontal resolution of hundreds of meters and make spectral measurements of major geologic units at visible and near-infrared wavelengths; to measure the vector magnetic field both near the planet and throughout the planet's magnetosphere; to measure Mercury's obliquity, the amplitude of Mercury's physical libration, and Mercury's long-wavelength gravity field; to carry out geochemical remote sensing of Mercury's polar surface and exosphere; and to assay the major neutral species in the exosphere and major charged species in the magnetosphere [1].

The measurement objectives for MESSENGER are met by a payload consisting of seven instruments plus radio science. The instruments (Fig. 1) include the Mercury Dual Imaging System (MDIS) [2], the Gamma-Ray and Neutron Spectrometer (GRNS) [3], the X-Ray Spectrometer (XRS) [4], the Magnetometer (MAG) [5], the Mercury Laser Altimeter (MLA) [6], the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [7], and the Energetic Particle and Plasma Spectrometer (EPPS) [8].

First Mercury Flyby: The January flyby is one of three successive Mercury encounters, each followed by a propulsive maneuver near the next aphelion, needed to reduce the arrival speed at Mercury to the point that orbit insertion can be accomplished at the fourth encounter in March 2011 [9]. The Mercury flybys and subsequent maneuvers yield successive orbits having Mercury:spacecraft orbital-period ratios of about 2:3, 3:4, and 5:6. For all three flybys the closest approach altitude will be about 200 km.

MESSENGER will approach Mercury from the night side and will cross the dawn terminator shortly after closest approach (Fig. 2). MESSENGER will view the sunlit side of Mercury, including about half of the hemisphere not imaged by Mariner 10, primarily on departure. Because MESSENGER's second Mercury flyby in October 2008 is approximately 1.5 Mercury solar days after the first, the opposite hemisphere will be sunlit. MESSENGER will thus have the opportunity to view almost the entire surface of Mercury in the course of the first two flybys.

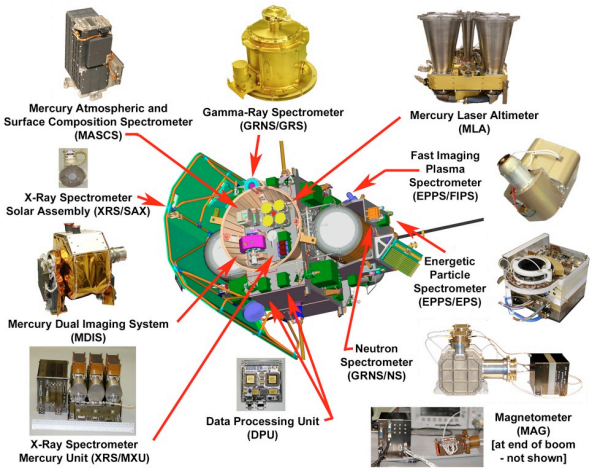

Fig. 1. MESSENGER flight instruments and their positions on the spacecraft.

Flyby Observations: All payload instruments will be operating during the flyby. MDIS will acquire an 11-color mosaic of part of the hemisphere not seen by Mariner 10 [10], including the entire Caloris basin; several large monochrome mosaics at a range of resolutions, several of which will provide an opportunity for stereo analysis; a series of color frames designed

for photometric analysis [11]; and inbound and outbound movies. MASCS will obtain the first high-resolution spectral reflectance measurements (at ultraviolet to near-infrared wavelengths) of surface composition [12], conduct night-side and day-side limb scans of exospheric species [13], and map the composition and structure of the tail region [14]. MAG will measure Mercury's near-equatorial internal field and document the major plasma boundaries of Mercury's magnetosphere [15]. EPPS will characterize high-energy ions and electrons [16], and make the first measurements of low-energy ions [17], in Mercury's magnetosphere and its heliopsheric environment. MLA will carry out the first laser altimetric profile of the planet [18], and GRNS and XRS will provide a first look at surface elemental composition [19]. The radio science experiment will yield new information on Mercury's long-wavelength gravity field [20].

Together, the MESSENGER flyby observations will serve to optimize the measurements to be made during the mission orbital phase and, more importantly, substantially advance our understanding of Mercury's geology [21-27], surface chemistry and mineralogy [28-31], geophysics [32], exosphere [33-35], and magnetosphere [36].

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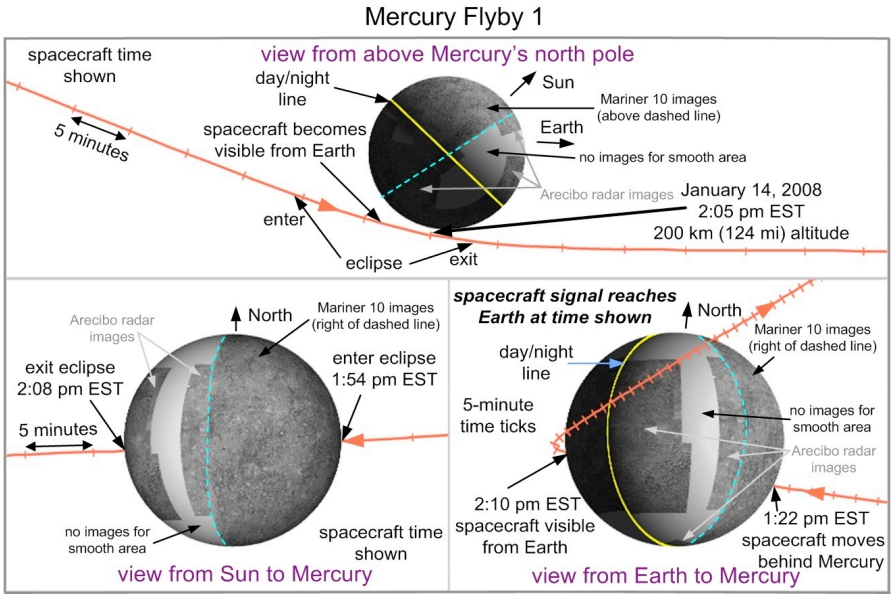

Fig. 2. Three perspectives on the geometry and timing of MESSENGER's first Mercury flyby. Superimposed on the planet are mosaics of Mariner 10 images, where available, and Arecibo radar images [37] of the opposite hemisphere.