Chapter 2

PAST AND PLANNED MISSIONS TO MERCURY

2.1 NASA'S SUCCESSFUL MARINER 10 MISSION TO MERCURY

Although acquiring ground-based astronomical observations of Mercury is difficult, visiting the planet via spacecraft to acquire observations in-situ is even more challenging. Its close proximity to the sun creates high thermal radiation and high gravity environments.

At this time, only one space mission to Mercury, NASA's Mariner 10 (Clark, 2004) has actually rendezvoused with the planet. Three encounters by Mariner 10 (M10) in 1974 and 1975 provided the first in-situ observations of one hemisphere. An especially important discovery was that Mercury has an intrinsic magnetic field, implying that the planet has a partially molten, iron-rich core and, thus, a history of extensive geochemical differentiation. However, lack of global coverage (only 45% of the surface was imaged), and the limited nature of many onboard measurements, has lead to largely unconstrained theories of Mercury's origin and history.

Table 2-1. **Mariner10 Details**

Launch	Flight
Mission Management: JPL Launch: November 3, '73: 5:45 UTC Launch Site: Cape Canaveral, USA Launch Vehicle: Atlas Centaur 34 Spacecraft Mass: 503 kg	Arrivals: Venus: February 2, '74 (5768 km) Mercury 1: March 29, '74 (703 km) Mercury 2: September 21, '74 (48069 km) Mercury 3: March 16, '75 (327 km) End of Mission: March 24, '75

The Mariner 10 Mission **(Figure 2-1, Table 2-1)** was launched on November 3, 1973, the first day of its scheduled launch period. The

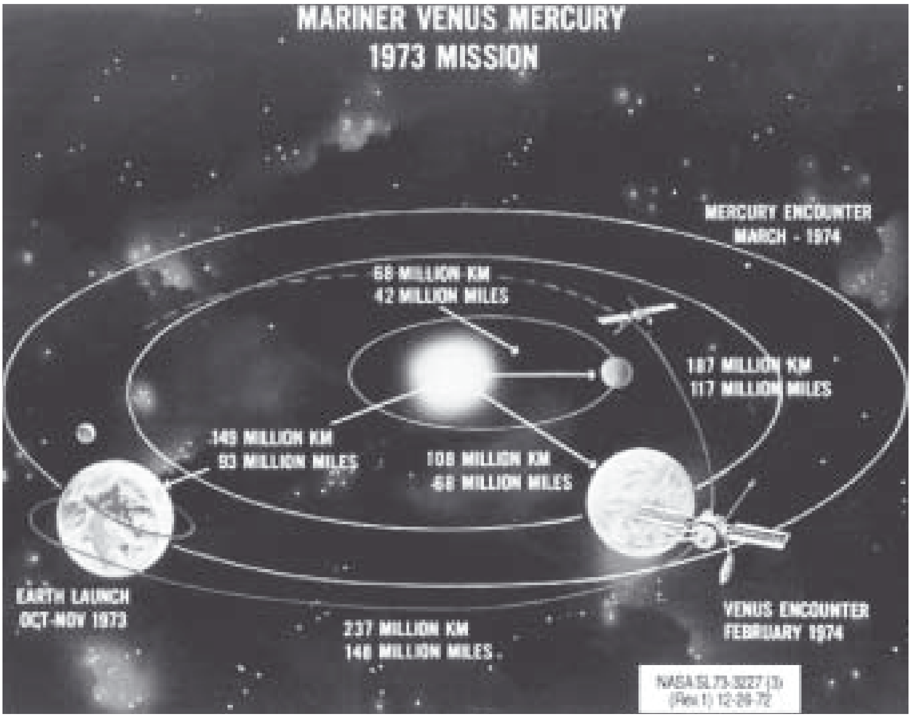

Figure 2-1. Mariner 10 mission scenario, showing the 'firsts' that are necessarily associated with every mission to Mercury: Here, these include the first encounters with the planet Mercury and the first use of the gravitational assist technique. (Found at http://www.hrw.com/science/si-science/physical/astronomy/ss/mercury/img/marinertraject.gif.)

spacecraft encountered Venus in early 1974, when it provided the first close-range measurements of this planet while also executing a gravity-assist maneuver that enabled it to later reach Mercury. Historically, Mariner 10 was the first mission to utilize a gravitational-assist trajectory, as well as the first to visit, at close range, more than one planetary target. The spacecraft was then transferred into a retrograde orbit around the sun. In this orbit, the spacecraft encountered Mercury three times. **Tables 2-1 and 2-2** list the mission firsts and details.

***Table 2-2*. Mariner 10 Payload**

Instrument	PI, PI Institute
TVTab System	B. Murray, Cal Tech
IR Radiometer	C. Chase, Santa Barbara Research
UV Airglow and Occultation Spectrometers	A. Broadfoot, Kitt Peak
Radio Science and Celestial Mechanics Package	H. Howard, Stanford University
Magnetometer	N. Ness, Goddard Space Flight Center
Charged Particle Telescope	J. Simpson, U. Chicago
Plasma Analyzer	H. Bridge, MIT

The first flyby (variously described in the literature as Mercury I or M1) which was characterized by a dark-side periapsis, occurred in March 1973, 146 days after launch. At closest approach, the spacecraft was 700 kilometers above the unilluminated hemisphere. A search for a tenuous neutral atmosphere was conducted during this pass by monitoring the extinction of solar EUV radiation and by observing thermal infra-red emission from a favorable (dark) ground-track. Mariner-10 passed through a region in which the Earth is occulted by Mercury (as viewed from the spacecraft) and this permitted use of a dual-frequency (X- and S-band) radio occultation probe to search for an ionosphere and to measure the radius of the planet. A global magnetic field was unexpectedly discovered in the course of the encounter.

Following a 176 day solar orbit, a second flyby (Mercury II/M2) featured a southern hemisphere passage with a periapsis of ~50,000 kilometers. This trajectory filled a gap in the photographic coverage obtained inbound and outbound during the first encounter. In Section 2.5 is a discussion of the overall coverage achieved and the resolution of the photographs obtained.

During the third, and closest, flyby (Mercury III/M3), the spacecraft flew to within 330 kilometers of the surface, with the primary objective of defining the source of the magnetic field discovered during the first encounter. For this reason M3 like M1 was a dark-side flyby. Because of its closeness to the planet and the absence of an Earth occultation, this pass yielded the most accurate celestial mechanics data obtained during the mission. Partial-frame pictures at the highest resolution (up to 90 m), were acquired near the terminator in areas previously photographed at relatively low resolution during M1.

Data taking continued until March 24, 1975, when, with the supply of attitude-control gas exhausted, the 506 day mission was terminated. The spacecraft was, thereafter, transferred into a retrograde orbit around the Sun, which it still orbits. The total research, development, launch, and support costs for the Mariner series of spacecraft (Mariners 1 through 10) was approximately $554 million and, thus, averaged only $55 million per mission.

2.2 THE MARINER 10 SPACECRAFT

The Mariner 10 bus structure **(Figure 2-2)** was eight-sided and measured approximately 1.4 meters across and 0.5 meters in depth. The weight of the spacecraft was 504 kg, including 80 kg of scientific instrumentation (see Table 2.1) and 20 kg of hydrazine. With its two 2.7 meter by 1 meter solar panels deployed, the span of the spacecraft was 8.0 m. Each panel supported an area of 2.5 m^2 of solar cells attached to the top of the octagonal bus.

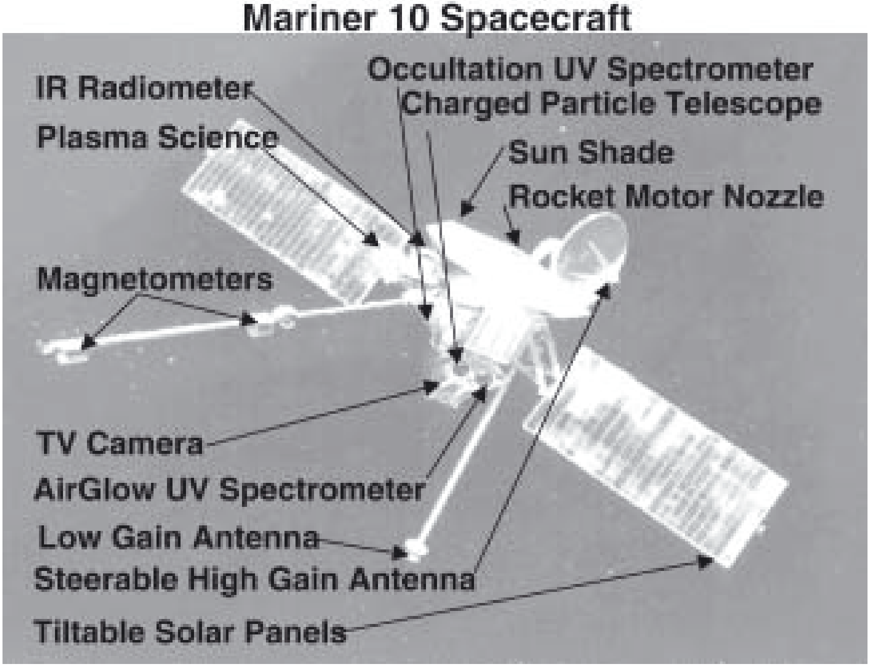

Figure 2-2. Mariner 10 spacecraft, illustrating the spacecraft design described in the text: The instrument package, including cameras boom mounted instruments, including the magnetometer, can be seen, along with the solar panels, later used in the first demonstration of 'solar sailing'.

The spacecraft measured 3.7 m from the top of its low-gain antenna to the bottom of the thrust vector control assembly of its propulsion subsystem. In addition, the high-gain antenna, magnetometer boom, and a boom for the plasma science experiment were attached to the bus. The two degrees-of-freedom scan platform supported two television cameras and the ultraviolet air-glow experiment. A two-channel radiometer was also onboard.

The rocket engine was liquid-fueled and two sets of reaction jets were used to provide 3-axis stabilization. Mariner 10 carried a low-gain omni-directional antenna composed of a 1.4 m wide, honeycomb-disk, parabolic reflector. The antenna was attached to a deployable support boom and driven by two degrees-of-freedom actuators to provide optimum pointing toward the Earth. The spacecraft could transmit at S and X-band frequencies. A Canopus star tracker was located on the upper ring structure of the octagonal satellite and acquisition sun sensors were mounted on the tips of the solar panels.

Simple thermal protection strategies involved: insulating the interior of the spacecraft, top and bottom, using multi-layer thermal blankets and deploying a sunshade after launch to protect the spacecraft on that side which was oriented to the sun.

2.3 THE MARINER 10 SCIENTIFIC PAYLOAD

Table 2-2 lists the instruments and instrument providers for the scientific payload of Mariner 10. The television science and infrared radiometry experiments provided planetary surface data. The plasma science, charged particles, and magnetic field experiments supplied measurements of the interplanetary medium and of the environment close to the planet. The dual-frequency radio science and ultraviolet spectroscopy experiments were designed to detect and measure Mercury's neutral atmosphere and ionosphere. The celestial mechanics experiment provided measurements of the mass characteristics of the planet as well as tests of the theory of General Relativity.

2.4 OVERVIEW OF MARINER 10 OBSERVATIONS

The onboard cameras were equipped with 1500-mm focal length lenses to enable high-resolution pictures to be taken during both the approach and post encounter phases. During the first flyby **(Figure 2-3)**, the closest approach of Mariner 10 to Mercury occurred when the cameras could not photograph its sunlit surface. The imaging sequence was initiated 7 days before the encounter with Mercury when about half of the illuminated disk was visible and the resolution was better than that achievable with Earth-based telescopes. Photography of the planet continued until some 30 min before closest approach, thereby providing a smoothly varying sequence of pictures of increasing resolution. Pictures with resolutions on the order of 2 to 4 km were obtained for both quadratures during M1. Resolution varied greatly, ranging from several hundred kilometers to approximately 100 m. Large-scale features observed at high resolution were used to extrapolate coverage over broad areas photographed at lower resolution. The highest resolution photographs were obtained approximately 30 min prior to and following the darkside periapsis during the first and third encounters. Pictures were taken in a number of spectral bands enabling the determination of regional color differences.

The second (bright side) Mercury encounter provided a more favorable viewing geometry than the first. In order to permit a third encounter it was necessary to target M2 along a south polar trajectory. This allowed unforeshortened views of the south polar region, an area which had not

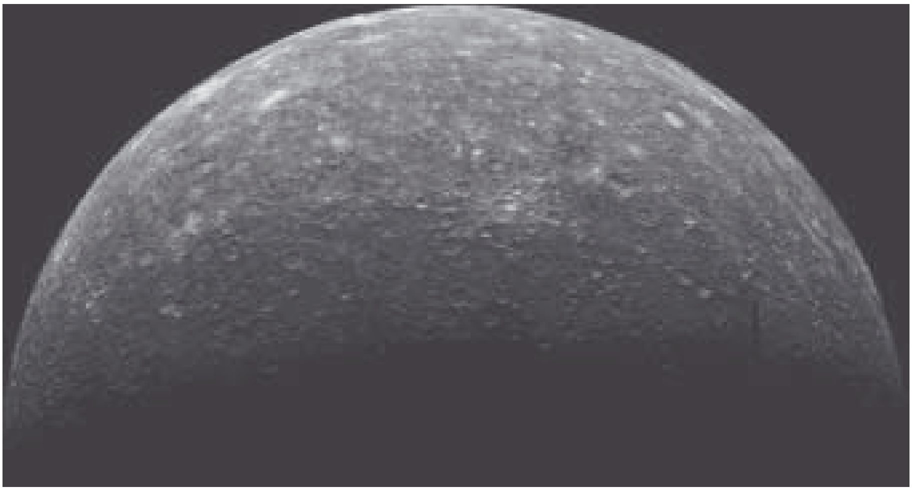

Figure 2-3. Mariner 10 incoming view during the first encounter. (NASA Atlas of Mercury SP432.)

Figure 2-4. Mariner 10 departing view during the third and final encounter. (NASA Atlas of Mercury SP432.)

previously been accessible for study. Images from this region provide a geological and cartographic link between the two sides of Mercury photographed during M1. Stereoscopic coverage of the southern hemisphere was also achieved. Because of the small field of view resulting from the long focal length optics employed, it was necessary to increase the periapsis altitude to about 48,000 km to ensure sufficient overlapping coverage between consecutive images. The resolution of the photographs taken during closest approach ranged from 1 to 3 km.

The third Mercury encounter **(Figure 2-4)** was targeted to optimize the acquisition of magnetic and solar wind data, so that the viewing geometry and hemispheric coverage employed were very similar to those utilized during the first encounter. However, M3 presented an opportunity to provide high-resolution coverage of areas of interest that were previously seen only at relatively low resolution. Because of ground communication problems, the latter pictures were acquired as quarter frames.

Overall, Mariner 10 photographed about 45% of Mercury's surface with a resolution that varied from about 2 km to 100 m (the latter in extremely limited areas).

2.5 MARINER 10 MISSION OBJECTIVES

What was actually accomplished by Mariner 10? The stated objectives of the mission were: (1) primarily, to measure the surface, atmospheric and physical characteristics of Mercury and (2) to measure the atmospheric, surface and physical characteristics of Venus, thereby (3) to complete the survey of the inner planets, as well as (4) to validate the gravity assist trajectory technique, (5) to test the experimental X-band transmitter, and (6) to perform tests of General Relativity theory. We'll describe how well Mariner 10 realized those objectives pertaining to Mercury and advanced the study of that planet in the next four chapters.

2.6 NASA'S ONGOING MESSENGER MISSION

MESSENGER, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging Mission, is a NASA Discovery Mission developed by the Applied Physics Laboratory of the Johns Hopkins University (Gold et al, 2001; Solomon et al, 2001). It was actually launched in August 2004 with modifications to the original scenario **(Figure 2-5)**. After a long seven year cruise, with six challenging gravitational assists (a technique pioneered on the Mariner 10 mission!), including one at the Earth,

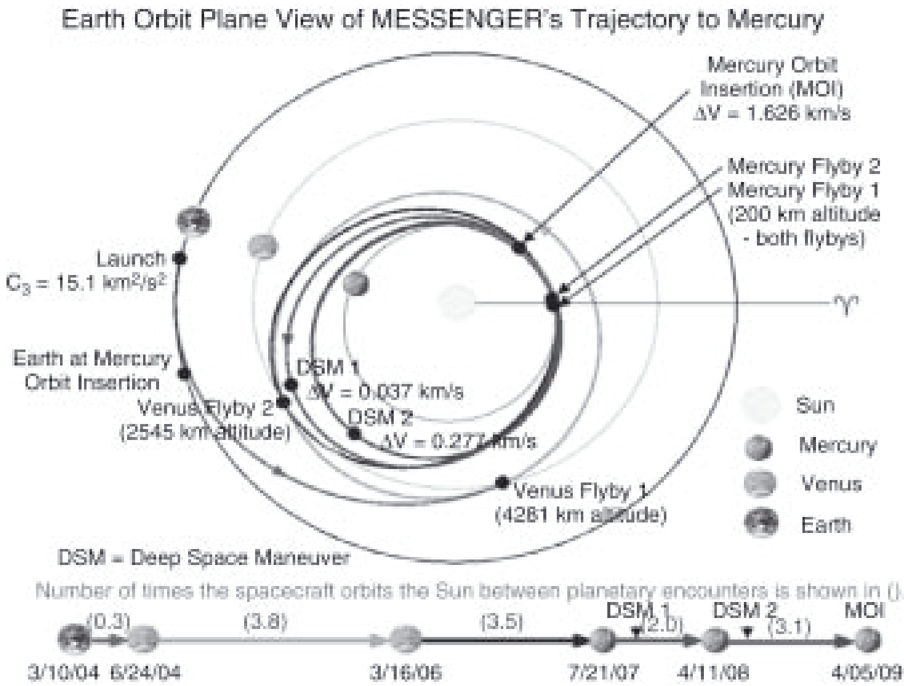

Figure 2-5. Messenger Mission Scenario for original March 2004 launch showing the mission timeline, with extensive use of the gravitational assist technique developed for Mariner 10 during the five year cruise, and the first orbiting of Mercury during the nominal one year orbital mission. (Found at MESSENGER website courtesy of APL.)

two at Venus, and three at Mercury, the spacecraft will undergo orbital insertion, during its fourth encounter with Mercury, in 2011.

The, nearly polar, twelve-hour orbit planned has a high northern latitude periapsis near the terminator. It is highly elliptical, with an altitude that ranges from 200 to 400 km at periapsis to 11,000 km at apoapsis (**Figure 2-5**). Although this configuration will allow 360 degree coverage in the northern hemisphere over the course of the mission, Messenger's orbit, with its high ellipticity and poor illumination at periapsis, is not ideal for spectrometers, which require solar illumination, and will thus provide only low resolution coverage of the southern hemisphere. However, this is the compromise required to enable this state-of-the-art orbital mission to survive in the severe radiation environment of Mercury. The total duration of the mission, four Mercury years, should allow ample opportunity to measure dynamic figure parameters (such as the amplitude of libration) essential in ascertaining the structure of the planet. It is anticipated that 15 Gb of data will be collected during the course of the mission.

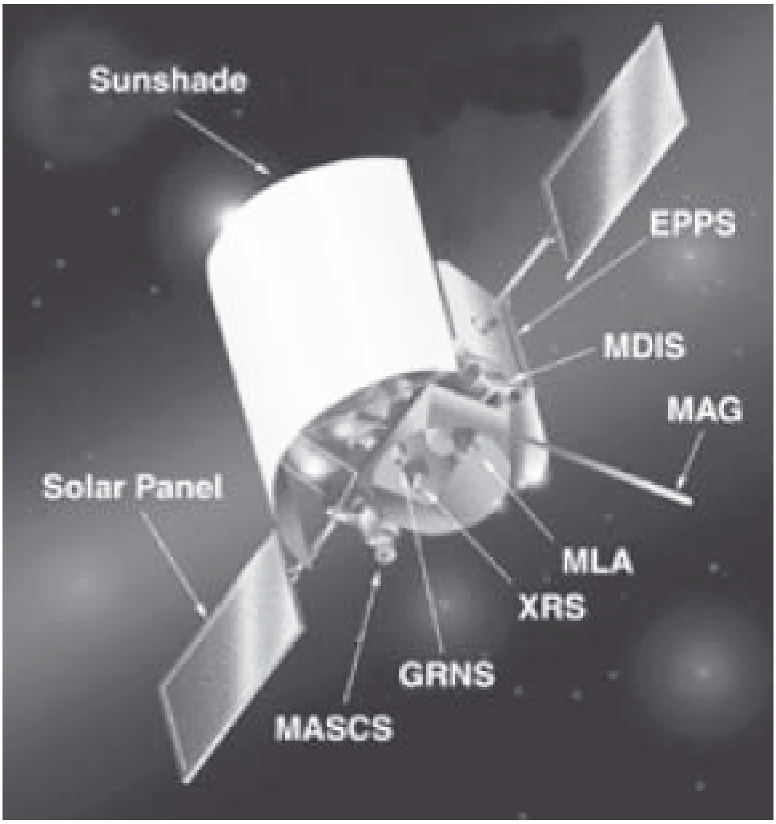

Figure 2-6. MESSENGER spacecraft, illustrating the spacecraft design with the solar panels and sunshade described in the text: The instrument package, including the boom mounted magnetometer, are labeled. The spacecraft is based on a modified NEAR spacecraft design and will use a similar chemical propulsion system. (Found at NSSDC Web site courtesy of NSSDC.)

2.7 THE MESSENGER SPACECRAFT AND PAYLOAD

Messenger (Gold *et al*, 2001) is a fixed body, 3-axis, momentum-controlled spacecraft with chemical propulsion provided by aerojets **(Figure 2-6)**. This design minimizes risk both by eliminating moving parts, thus obviating the chance of mechanical failure, and by exploiting heritage from the NEAR mission. The basic design of NEAR is, however, modified to suit the severe thermal environment at Mercury. The modifications include a

Table 2.3. **Payload Flown on Messenger Mission (Gold *et al,* 2001)**

MESSENGER Mission, NASA Discovery Mission, Launched August 2004 Fixed body S/C, 200-440x12000 km, periapsis 60-70N, near terminator, 15 Gb data					
Instrument	Range Spec Res	Mss kg	Pwr W	Measurement Spatial Res	BW kbs
NarrowAngleCamera WideAngle Camera	450-1050 nm 8 color filters	5.5	10	125-250m/pixel B&W >250m BW,>1km color	.4
1 Gamma-ray and 2 Neutron Spctrmtrs	0.1-10 MeV .14 @.6MeV	9	4.5	K,Th,U,Fe,Ti,O ,volatiles Conc to 1m depth, 100's-1000's km/pixel	.1
X-ray Spectrometer	0.7-10 keV 350 ev	4	8	Mg,Al,Si,S,Ca,Fe surface conc, 40-1000's km/pixel	.05
Magnetometer	1024 nT 40 Hz <1-300 sec	3.5	2	Magnetic field, anomalies	.014
Laser Altimeter		5	20	Topo map, 10-50 m spot 100-300 m spacing	.05
UV/Vis Spctrmtr	115-600 nm @<1nm	1.5	1.5	Atmosphere comp,25 km	.9
Vis/IR Spectrograph	300-1450 nm @4nm	1	1.5	Mineralogy maps, 5 km	.9
Energetic Particle and Plasma Spectrometer 1) FIPS and 2) EPS	1)0-10 keV/q 2).01-5MeV/n	2.25	2	High E particles, plasma distribution 1) 360 x 70 2) 160 x 12	.1
Transponder	X-band	5	18	Gravity, interior structure 100's km	.01

lightweight sunshade deployed on the sun-facing side at periapsis, a solar array with optical reflectors, and lighter weight materials.

The Messenger Payload **(Table 2-3)** includes all the instruments that would be expected on a planetary mapping mission, as well as a couple of additional instruments to provide some environmental context. The wide angle camera provides black and white images of the surface with higher average resolutions than Mariner 10 images, as well as far more color information at comparable resolution. The narrow angle camera provides far higher resolution for selected features. The infrared spectrometer provides the first detailed measurements of surface mineral abundances. X-ray, Gamma-ray, and Neutron spectrometers acquire the very first elemental abundance data, for major elements, radioactive elements, and protons (from which water abundance may be inferred) to varying depths in the regolith. The radio science package and altimeter will allow quantitative characterization of the surface and interior morphology. A magnetometer will allow the first comprehensive study of the magnetic field, presumably confirming the presence of the magnetic dipole. Two additional instruments allow characterization of the external environment, including the UV spectrometer to determine the character of the exosphere, and a high energy particle and plasma detector to provide some information on the charged particle environment.

2.8 THE MESSENGER MISSION OBJECTIVES

The relatively poorly constrained yet often surprising results from Mercury have created major controversies about the processes that formed not only that planet but the early solar system itself. Messenger's objectives involve understanding those processes (Solomon et al, 2001). Surface constituent abundances from near IR, X-ray, and Gamma-ray spectrometers on scales ranging from global (bulk) to regional (geochemical province) and occasionally local (stratigraphic unit) will provide insight on solar system formation and Mercury's origin. The high resolution imaging for selected features, combined with comprehensive coverage of the northern hemisphere at higher spectral and spatial resolution than available previously should provide a far greater understanding of Mercury's geological history, and the nature of impact activity in the early solar system. Magnetometer, energetic plasma and particle detector, radio science, and ranging observations should provide insight on the formation and state of Mercury's magnetic core and internal structure. The UV spectrometer and neutron spectrometers should provide measurements which can be used to assess the processes by which Mercury acquired volatiles and an exosphere.

2.9 THE ESA/ISAS PLANNED BEPI COLOMBO MISSION

Bepi Colombo **(Figure 2.7)** is a Cornerstone Mission Concept of the European and Japanese (ESA/ISAS) Space Agencies (Grard et al, 2000; Anselm and Scoon, 2001). At the time of writing, launch is planned for 2014.

Two spacecraft, namely the **Mercury Planetary Orbiter** (MPO) and the **Mercury Magnetospheric Orbiter** (MMO), will be launched, in either split, or single, launch mode. Various options for propulsion are still under consideration. A Solar Electric Propulsion System (SEP) is the likely choice in light of the validation of this technology during the SMART 1 mission (to the Moon). With SEP, both spacecraft will arrive at approximately the same time for capture by Mercury, that is in either less than 2.5 years if they both

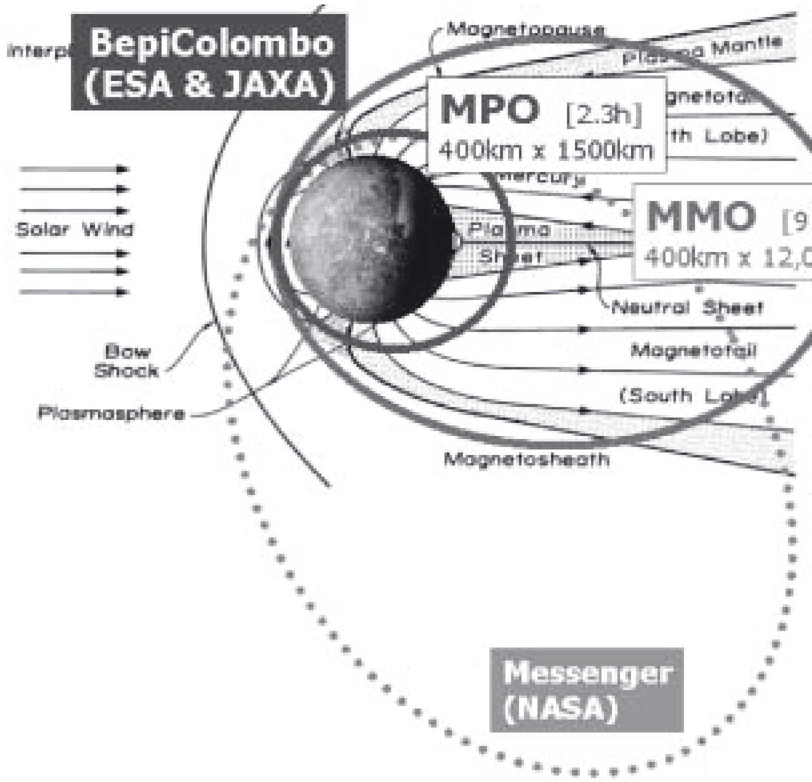

Figure 2-7. Bepi Colombo Mission Scenario for both spacecraft (Grard et al, 2000, ESA Bulletin). This low thurst propulsion system trajectory will require a 2.5 to 3.5 year cruise. Mercury will then be studied from orbit over a one year period. (Courtesy of ESA)

go directly to the planet or in 3.5 years if a gravitational assist strategy is used. The plan is to insert both spacecraft, probably using chemical propulsion systems, into nearly polar orbits and have equatorial periapses, thereby allowing 360^0 coverage of the entire planet to be achieved during the lifetime of the mission, which is nominally one year, as in the case of Messenger. Initially, both MPO and MMO will be inserted into an anti-solar, equatorial periapsis, and an elliptical 400 x 1,500 km orbit. The selection of periapsis in the anti-solar hemisphere is a strategy adopted to deal with the extreme radiation environment, but the trade off will be lowering the best available spatial resolution. Gradually, the MMO will be inserted into a resonant orbit, while maintaining an anti-solar, equatorial periapsis, to attain an ellipticity of 400 x 12,000 km (which is desirable for a magnetospheric mission). The MPO is expected to collect over 1500 Gb of data and the MMO 1.5 Gb of data during the nominal mission.

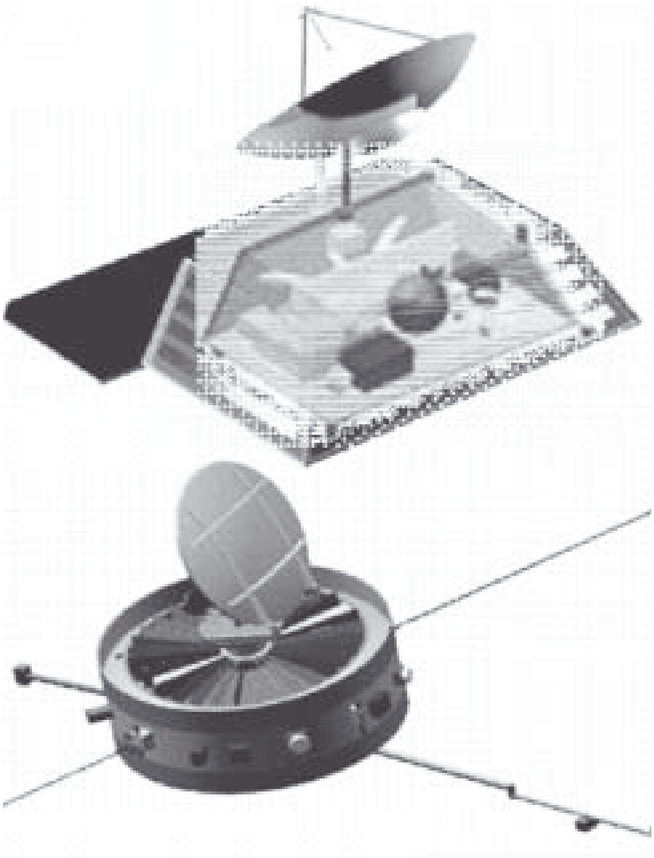

Figure 2-8. Bepi Colombo ESA MPO and ISAS MMO (Grard et al, 2000, ESA Bulletin). These views illustrate the spacecraft design concept, with solar panels and sunshade incorporated into the design. The MPO (Mercury Planetary Orbiter) (above with cutaway insert) is a 3-axis stabilized, nadir pointing spacecraft. The MMO (Mercury Magnetospheric Orbiter) (below) is a spin stabilized spacecraft with spin axis perpendicular to the ecliptic plane. Both spacecraft use solar electric propulsion to get to Mercury, and a chemical propulsion system for orbital insertion and all activities which follow. (Courtesy of ESA)

2.10 THE BEPI COLOMBO SPACECRAFT AND PAYLOAD

Bepi Colombo is a dual platform mission **(Figure 2.8)**. The MPO, to be provided by ESA, features a nadir-pointing, 3-axis stabilized design, which is optimal for a mapping mission. It is designed to provide close range studies of the surface and, from its measurements, the internal state and dynamic figure properties of Mercury can be derived. The MMO, to be provided by ISAS, features the spin stabilization and 15 rpm spin rate optimal for a magnetospheric mission. It is designed to provide information on the wave and particle environment surrounding Mercury. The two payloads **(Table 2.4)** are configured to provide complementary measurements of the planet in the context of its external environment.

The MPO will include a traditional planetology instrument suite. Wide and narrow angle cameras provide average 200 m/pixel resolution for the entire surface and 20 m/pixel resolution for selected features, This is comparable to what is provided by Messenger but, in the case of Bepi Colombo, coverage of the southern hemisphere is additionally available. The infrared spectrometer provides significant improvements with respect to spectral coverage and spatial resolution relative to MM, thereby allowing a more detailed study to be made of local variations, particularly in the southern hemisphere. The Gamma-ray and Neutron spectrometers have comparable performances to MM. The CIXS X-ray spectrometer, however, will be capable of higher sensitivity, as well as of higher spectral and spatial resolution than is provided by the proportional counters used on Messenger. This performance will greatly facilitate the direct comparison of mineralogical and major elemental abundances of elements including iron, for features on the scale of 1 to 2 km in size. The Ultraviolet spectrometer is comparable to the one flown on Messenger and should allow a study to be made of temporal variations in atmospheric constituents, and atmospheric dynamics in the southern hemisphere. Also, the radio science package and laser altimeter are comparable to the ones flown on Messenger, but, again, coverage of the southern hemisphere should result in better global modeling of Mercury's interior structure.

The MMO will include a traditional magnetospheric instrument suite. The magnetometer is comparable to the Messenger instrument. The combined charged particle detectors will provide a more comprehensive survey than is available from Messenger of the nature of charged particle behavior in the magnetosphere. The search coil and electric antenna will allow detection of local emission sources. The camera will provide both additional and complementary imaging information.

2.11 THE BEPI COLOMBO MISSION OBJECTIVES

The objectives of Bepi Colombo focus on obtaining the kind of coverage necessary to fill in particular gaps in our knowledge of planet Mercury (Grard *et al*, 2000). Determining the nature of the unimaged hemisphere and polar deposits as well as composition of the entire surface

Table 2-4. **Proposed Payload for Bepi Colombo**

ESA Mercury Planetary Orbiter (MPO) http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=36098 as of 1/1/2005 3axis, nadir pointing S/C, orbit 400x1500 km, periapsis anti-solar point, 1500 Gb data					
Instrument	Range	Mass kg	Pwr W	Measurement	Bw kbs
HiRes Stereo Cameras Vis/IR Spectrometers (SIMBIO-SYS)	350-1050 nm	12	16	20m/pixel narrow 200m/pixel wide	40
IR Spectrometer (MERTIS-TIS)	.8-2.8 u 128 channels	6	10	Mineralogy maps .15-1.5 km resolution	1.5
UV Spectrometer (PHEBUS)	70-350 nm	3.5	3	Atmosphere comp	2
X-ray Spectrometer (MIXS) and Solar Monitor (SIXS)	0.5-10 keV	4.5	8	Na,Mg,Al,Si,S,Ca,Fe surface conc at 10's km monitor Xray source(Sun)	0.1
Combined Gamma-ray Spectrometer and Neutron Spectrometer (MGNS or MANGA)	0.1-8 MeV 0.01-5 MeV	7.5 5	5 3	K,Th,U,O,Fe conc to 10s cm depth at 100's km Volatiles to 1 meter at 100's km	0.1 0.05
Laser Altimeter (BELA)				Topography map	
Radio Science Package (MORE)	32-34 GHz 10^{-4}-10^{-1} Hz	11.5	15.3	Gravity, interior structure	0.1
Magnetometer (MERMAG)	4096 nT	0.88	0.35	Mag Field, anomalies	0.8
Neutral/Ionized Particle Analyzer (SERENA)				space (Particle-induced) weathering processes	
ISAS Mercury Magnetic Orbiter (MMO) http://www.stp.isas.jaxa.jp/mercury/pro-mmo.html#AO as of 1/1/2005 15 rpm spinstabilized S/C, orbit 400x12000 km, periapsis anti-solar point, 1.5Gb data					
Instrument	Range	Mass kg	Pwr W	Measurement	Bw kbs
Magnetometer (MGF)	4096 nT	0.88	0.35	Mag field, anomalies	0.8
Low/Hi Energy Ions, Electrons, Hi Energy Energetic Neutrals (MPPE)	.0-300 keV	7.5	10	electron, Ion, neutrals mass, charge, energy distributions	1.0
Electric Field, Radio Wave, Plasma Wave Detectors (PWI)	0.1-1 MHz	1.0	5	electric field, radio wave, and plasma wave sources	0.5
Na Imaging (MSASI)				Na spatial and temporal distribution	
Dust Detector (MDM)				Dust count and moment	

are of high priority. The onboard spectrometers with broader and more sensitive coverage than previously available should provide this information. Combining the more sensitive spectrometer results with the magnetometer data should lead to a more comprehensive understanding of how iron, the cause of Mercury's high density, is distributed, and thereby increase our understanding of core formation and the evolution of the magnetic field. Combining the more sensitive spectrometer results with more extensive higher resolution images should lead to new insight into the nature of geological evolution. Combining the more sensitive spectrometer results with altimeter and radio science package data should allow the interior structure of the planet to be better understood. The ultraviolet spectrometer should allow further characterization of the exosphere, and the entire MMO package will permit a comprehensive study to be made of local interactions between particles, waves, plasmas, and the solar wind in the magnetosphere in the absence of an ionosphere.

2.12 SUMMARY

The Mariner 10 mission provided the basis for the basis for our current understanding of Mercury but provided some startling revelations and many unanswered questions. The MESSENGER mission now enroute to Mercury is a NASA Discovery Class planetary orbiter which should provide the basis for understanding Mercury's magnetic field, the first direct compositional data for Mercury as well as in situ observations which will provide intriguing snapshots of the environment around Mercury. Bepi Colombo, an ESA multi-platform mission that could potentially provide more information on the dynamic environment is currently being planned.

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2.14 SOME QUESTION FOR DISCUSSION

1. What surprises and unresolved issues did the Mariner 10 mission leave in its wake?

2. Compare the MESSENGER and Bepi Colombo missions. How would you improve either mission and what would be the impact on spacecraft resources (mass, power, bandwidth) and cost.

3. Discuss what spatial and temporal resolutions and coverage will be provided by instruments on both missions, and the adequacy and limitations of this instrumentation in revealing the dynamic character of Mercury's interaction with its environment.

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