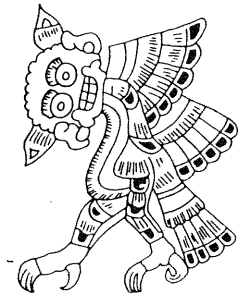




# The Mercury MESSENGER



Issue 1

The newsletter concerned with exploration of the planet Mercury

December 1987

## Mercury Comes of Age

Why has a resurgence of interest in Mercury occurred in the last few years? The consensus was, after the Mariner 10 encounter of the planet more than a decade ago, that Mercury, which appeared to be a subdued version of the Moon, was "the boring planet." Many of those who study Mercury now are referring to this planet as elusive or enigmatic because of the intriguing nature of some of the formerly and recently obtained observations of the body. Such measurements can be difficult to acquire and, when acquired, difficult to interpret.

In fact, the innermost planet has become an increasingly important target of scientific interest for the following reasons:

1. During the last decade, a growing body of significant results has been achieved from analysis of the wide range of ground-based data acquired for Mercury. These results include the discovery of an atmosphere by means of visual and near-visual observations, and the imaging/profiling of the imaged and unimaged (by Mariner 10) hemisphere by means of ground-based radar observations.

2. Recent in-depth study of the existing Mariner 10 database, a decade after it was acquired, has led to extensive reevaluation of the proposed models for the evolution of Mercury's surface.

3. Major technological barriers, which had prevented any serious consideration of a Mercury orbiter in the past, have been essentially eliminated due to (a) advances in thermal shielding capabilities, and (b) the discovery of new ballistic launch trajectories for a near-polar orbiter of reasonable size that could use existing launch capabilities (see "From Here to Mercury" by Chen Wan Yen in this issue).

4. In 1986, two prominent science agencies recognized the need for a Mercury orbiter: the National Academy of Science Space Science Advisory Board recommended that high priority be given to a Mercury orbital mission due to the

broad spectrum of scientific interest for that target, and the European Space Agency proposed a Mercury orbiter as a primary candidate for a future mission.

5. The recognition that we have a dearth of information about Mercury, information that is crucial for the resolution of recently raised issues on the origin of the solar system, is becoming widespread. Data on Mercury, which is viewed as an endmember in most models because of its position as the innermost planet, is crucial in resolving these issues.

6. Interest in and recognition of the ongoing Mercury work, which is occurring across a wide range of disciplines, increased substantially after the Mercury Meeting that was held last year. This meeting resulted in greatly increased efforts to coordinate Mercury research activity and generate awareness of this activity in the planetary science community.

*"Mercury, that planet which has seemed a rather boring lunar analog for so long, has recently shown itself to be, on the contrary, intriguingly elusive."*

Our logo is a symbol for Mercury, "the messenger," which originated among the Quiche Maya people who still live in the highlands of Guatemala. Such Mayan messenger symbols, which correspond to the planet Mercury, appear as owls. The particular symbol used in the logo, Skull Owl, was suggested by Andrew Potter. Dr. Potter describes Skull Owl as "a rather cheerful and alert fellow, gritting his teeth to overcome difficulties encountered as the lowest ranking messenger. He might be a fitting symbol for the present-day Mercury researcher, who faces many difficulties but remains optimistic." Dr. Potter will provide a more detailed explanation of the origin of the Mayan Mercury in the next newsletter.

## Mercury: The Elusive, Enigmatic, and/or Endmember Planet

The first meeting in over a decade devoted to study of the planet Mercury was held less than a year ago. The meeting was cosponsored by the International Astronomical Union and the AAS Division of Planetary Scientists, and was co-chaired by Clark Chapman and Faith Vilas. Over 100 scientists from a wide range of disciplines were registered for the international conference that was held during the height of summer in Tucson, Arizona (the environment being kind of a Mercury analog, but hospitable nevertheless). Topics were intensely discussed by this interdisciplinary group, and future cross-discipline collaborative activity was planned. The highlights of the meeting were as follows:

1. Models for the temporally varying structure of the recently discovered Na and K atmosphere of Mercury were presented, and implications for the origin of this atmosphere and predictions for other elements that might be present were discussed.

2. Further constraints were placed on interior structure and composition, and on the origin of the planet. A consensus was reached on the need to send an orbital mission to Mercury to obtain geochemical information so that major questions on the origin of Mercury and the other terrestrial planets can be resolved.

3. The magnetosphere and solar wind/surface interactions have been further characterized. Again, the need for an orbital mission to provide further data in this area was discussed.

4. Analysis of geologically related data available for Mercury provided further indications that the plains are volcanic in origin and that structural and albedo features are related to global-scale tectonics. Structural and terrane mapping of Mercury's surface has yet to be completed.

5. In the part of the hemisphere unimaged by Mariner 10 that has been

characterized by ground-based radar observations, smooth plains appear to be more prevalent, and another major basin may be present. The production of unambiguous radar images for Mercury's surface, along with higher resolution topography profiles, is now being planned.

6. As discussed in more detail by Chen Wan Yen in this newsletter, recent flight configuration studies have amply demonstrated that now, contrary to a decade ago, reasonable payload missions to Mercury can be flown using existing ballistic launch vehicles.

7. In summary, the study of Mercury can provide further insight in many areas, including early solar system history, core/crust interaction, magnetic field genera-

tion, solar wind properties, atmosphere formation, the interaction of volcanotectonic processes and bombardment in surface formation, and tests for general relativity theory. Furthermore, we now have testable hypotheses and sophisticated models of planetary formation against which to compare any new data.

The Tucson meeting was followed by briefings to the Solar System Exploration Division at NASA Headquarters and to the Solar System Exploration Division Management Council, this latter in July. Those involved in the presentation included Clark Chapman, Ken Goettel, Chris Russell, Chen Wan Yen, and Pamela Clark.

The burgeoning of interest in the planet Mercury resulted, first of all, in the success

of the Mercury Conference. As illustrated above, the conference further enhanced the serious consideration of the elusive planet as an object of exploration. To continue the momentum, a group of 13 interested Mercury scientists met informally at the Lunar and Planetary Science Conference in March to consider the establishment of a Mercury consortium. There was unanimous agreement that such a consortium should be established both within this group and among other interested members of the planetary community who could not be present. By consensus, the goals of the consortium, which include the publication of this newsletter, were formulated, as discussed below.

## The Mercury Messenger: Good News to Mercury Fans

The goals of the Mercury Consortium, as formulated at the Lunar and Planetary Science Conference meeting in March, are as follows:

1. To increase the awareness of present Mercury research, which is occurring across a wide range of disciplines, such a wide range in fact that those potentially interested in such work would ordinarily be unaware of all but a small portion of it, unless special efforts were made.

2. To encourage intra- and inter-discipline collaboration.

3. To increase support for ongoing Mercury research, particularly for observational work, by encouraging and giving a higher profile to those participating in such work.

4. To provide the basis for further consideration of Mercury as a flight project candidate.

5. To provide a freely available means for exchanging data and ideas, for planning collaborative activity, and for increasing awareness of ongoing Mercury work, in keeping with the above goals: a regularly published newsletter.

There you have it—the origin of this newsletter. Kevin Burke, director of LPI, generously agreed to have that organization publish the newsletter, and the rest is history. The name, *Mercury Messenger*, was suggested by Larry Friesen, of the editorial board.

A brief description of the goals and scope of the newsletter, identification of those involved in editing and publishing the *Messenger*, and instructions on submitting material for features will be included in every issue.

## From Here To Mercury

### How can we get there?

A decade ago, a spacecraft mission to Mercury was thought to be difficult without solar/nuclear electric propulsion or a solar sail. New flight paths to Mercury designed in 1985 using Venus and Mercury swingbys will make a traditional chemical rocket orbiter mission possible. In order to augment insufficient lift capabilities of launchers, planetary swingbys, once considered rather exotic and time consuming, are becoming an indispensable and common occurrence in interplanetary flight-path design. A case in point is the Galileo mission to Jupiter. The Galileo spacecraft to be launched with an STS/IUS needs to have a swingby of Venus and two swingbys of Earth before heading for Jupiter and will take nearly six years to travel to Jupiter.

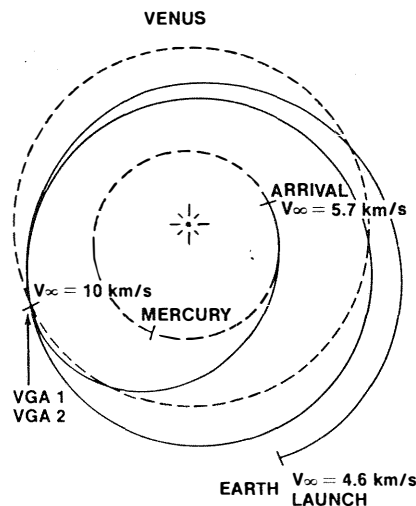


Figure 1. Path to Mercury.

Figures 1 and 2 illustrate a typical flight path to Mercury and the advantages obtained by Venus and Mercury swingbys. In Figure 1, the path to the first Mercury encounter is shown. If the spacecraft went directly to Mercury, the earth departure velocity ( $V_0$ ) would have to be about 8 km/s, but the energy gained by a Venus encounter will allow the spacecraft to leave Earth with a velocity of 4.6 km/s. This is the first part of the energy savings. The second part of energy savings comes from the Mercury swingbys. In Figure 2, the Mercury approach velocity of the spacecraft is shown to be reduced from 6.1 km/s to 2.2 km/s after three gravity-assisted encounters, thus saving the orbit capture delta-v requirement substantially. Note the successive heliocentric orbit size reduction being achieved with each swingby encounter and with a rather small deep-space delta-v expense. These orbits are in approximate resonance of 2:3, 3:4, 5:6, with the Mercury orbit. The total flight time shown is 4.5 years here, because a perfect Earth-Venus-Mercury phasing was assumed. However, for most mission opportunities, the offset in the alignment of these planets will make the mission time slightly longer.

If a multiple flyby mission is the goal, one will enter into a perfect 2:3 resonance at the first Mercury encounter. The flyby speed will be about 6 km/s.

### When and how much can we deliver?

Mission opportunities depend on the favorable alignment of three planets. Available opportunities for years 1990-2010 with corresponding payloads are as follows:

**Opportunity:**

1991 1994 1996 1999 2002 2004 2005 2007

**Payload (kg):**

1247 1477 1209 1000 929 1000 1294 947

The payload indicated here is the useful mass in a 300-km-circular orbit and excludes the propulsion system mass. This is the expected payload if a Titan IV/Centaur G' is used to fly the kind of trajectory shown in Figures 1 and 2.

Years 1991 and 1994 are the two best mission opportunities of the 1990-2010 time period but will obviously have to be missed. According to the current NASA Solar System Exploration Program agenda, 1996 will be the earliest possible launch date for a Mercury mission. Then there is the question of which launch vehicle could be used. NASA's present position is to rely on a mixed fleet launch strategy as given in the NASA News Release 87-76, "NASA Plans Use of Expendable Launch Vehicles," May 15, 1987. With this we may consider the use of STS/TOS and STS/IUS, or the expendables, TITAN III and TITAN IV with various upper stages.

Table 1.

Mission	Launch Vehicle	Flight Time
Multiple flybys	STS/TOS	1.2 to 2 years
	TITAN III/TRANSTAGE	
	TITAN III/IUS	
24-hr elliptic orbiter	STS/IUS	3 to 5.5 years
Circular orbiter	TITAN IV/IUS	3 to 5.5 years
	TITAN IV/Centaur G'	

If one bases the mission feasibility assessment on the aforementioned criteria, one can come to the conclusions as summarized in Table 1. The table contains three classes of missions, from easy to difficult, and provides the needed launch vehicle types. In these examples, a minimum of 700 kg spacecraft mass is assumed, which is about 100 kg more than the Mars observer spacecraft. This assumption is made to allow for the mass increase expected as a result of providing thermal protection for the Mercury spacecraft. In the category of circular orbiter missions, the performance possibilities exceed the one orbiter requirement. This excess performance may be used to cut the mission time by 1.5 years or to accommodate additions of second satellites or small landers depending on the extent of the excess performance available.

—Chen Wan Yen  
NASA/JPL

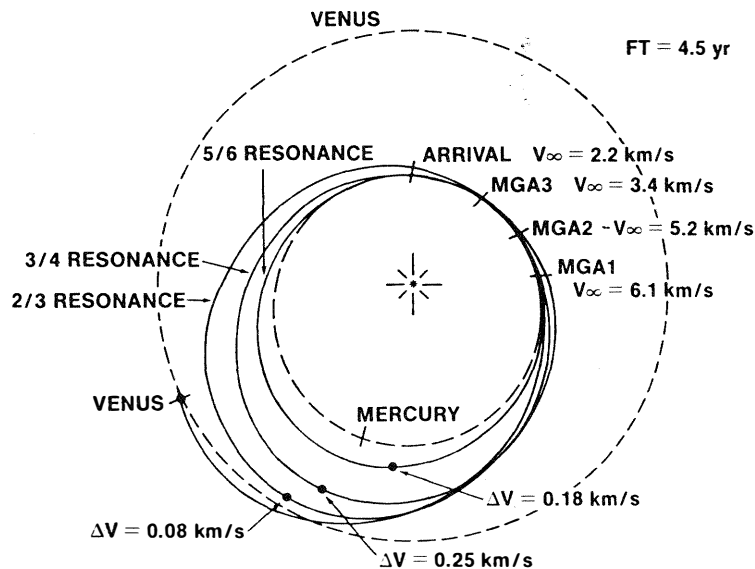


Figure 2. Mercury orbit capture with Mercury gravity assists.

## Report from the Spring Meeting of the American Geophysical Union

As evidence of the resurgence of interest in the planet Mercury, the Spring Meeting of the AGU devoted one session to reviewing latest developments concerning this planet. The session began with an overview of Mercury by R. G. Strom. The high mean density of Mercury indicates that its large iron core occupies about 42% of the planet's volume, larger than any other solar system body. Although Mercury's surface superficially resembles that of the Moon, there are significant differences. For example, unlike the Moon the most extensive terrain on Mercury is the intercrater plains, which occupy large areas of Mercury's heavily cratered terrain. These intercrater plains and the smooth plains may be volcanic deposits resulting from extensive melting and global expansion due to core formation. A unique and probably global system of thrust faults was probably formed by planetary compression resulting from core and lithospheric contraction during cooling.

C. T. Russell reviewed the magnetosphere of Mercury. While Mercury's intrinsic magnetic field is weak, it is sufficient to stand off the solar wind well above the planet. Thus, it has a bow shock and a magnetopause similar to their terrestrial counterparts but smaller in dimension. The absence of any significant atmosphere or ionosphere alters the flow of current in the Mercury magnetosphere so that it differs from that of the Earth

and may affect the transfer of energy from the solar wind to the magnetospheric plasma. The measurements from the Mariner 10 energetic charged particle instruments indicate that this energy transfer is more efficient at Mercury than at the Earth.

D. N. Baker, S. P. Christon, and W. C. Feldman all made contributions on aspects of Mercury investigation. D. N. Baker reported on observations with the VLA in Socorro, New Mexico. He showed an image of Mercury obtained this year at 6 cm showing the thermal emission properties at a depth of tens of centimeters. S. P. Christon discussed his continuing analysis of the Mariner 10 energetic particle data, contrasting these data with those obtained at the Earth during magnetospheric substorms. Finally, W. C. Feldman discussed the neutron environment of Mercury and the relativistic electrons resulting from this neutron decay. It was clear from these discussions that while there is much we do not know about Mercury a number of well-focused questions have been formulated in the years since Mariner 10 and that it is time that serious plans be formulated for a return to Mercury.

—C. T. Russell  
Institute of Geophysics  
and Planetary Physics  
University of California, Los Angeles

## About Your Newsletter: Instructions for Input

So, the time has come for a newsletter devoted to one of our favorite topics: Mercury. However, feedback from you will determine the long-term (and possibly the short-term) fate of the *Messenger*. We don't want this first issue to be the only one!

Those interested in being added to the *Mercury Messenger* mailing list should contact LPI Publications Office, Attn: L. Bowman, 3303 NASA Road One, Houston, TX 77058-4399, or SPAN address LPI::BOWMAN. Feel free to share the newsletter with your colleagues. We may have overlooked the names of some persons who are potentially interested in Mercury and would like to receive the newsletter.

The editorial board would like to request input for the newsletter from any of you (subject to review by the editor) in the following categories:

1. A summary of your Mercury research activity, past or present, which would be of general interest to the broad spectrum of scientists who are newsletter recipients. (See Chen Wan Yen's article in this newsletter as an example.)

2. Brief reports on any Mercury topical activities, such as special sessions at

professional society meetings, briefings for scientific agencies, Mercury consortium member coordinated efforts.

3. Comments, in the form of "letters to the editor," on issues of current interest that affect ongoing or planned Mercury exploration.

4. Lists of recent Mercury-related publications.

5. Schedules of planned Earth-based observations of Mercury and requests by observationalists for collaboration and/or input from observationalists in other disciplines.

Please send any inputs to Tom Morgan, co-editor, using NASAMAIL address TMORGAN/JSC/NASA, SPAN address LPI::TMORGAN, or by mailing correspondence to the following address: Code SN3, NASA Johnson Space Center, Houston, TX 77058. The co-editor would appreciate receiving such inputs no later than one month prior to publication. For the next newsletter, this would be no later than April 1988.

At this point, our plan is to maintain a modest size of up to four pages and a biannual publication schedule for the *Messenger*, but we would certainly consider more frequent and timely publication if that was warranted by a larger volume of input from newsletter recipients or consortium members.

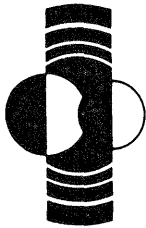
We look forward to hearing from you!

## About Your Newsletter: Organizational Information

Published by the Lunar and Planetary Institute  
Pamela E. Clark, Editor. NASA JPL.  
Faith Vilas and Tom Morgan, Co-editors,  
NASA/JSC.

### Editorial Board:

Jeffrey Bell, University of Hawaii, HIG/PGD,  
Honolulu, Hawaii.  
Clark Chapman, SAI, Planetary Science  
Institute, Tucson, Arizona.  
Larry Friesen, McDonnell Douglas, Houston,  
Texas.  
Ken Goettel, Brown University, Providence,  
Rhode Island.  
Bruce Hapke, University of Pittsburgh,  
Pittsburgh, Pennsylvania.  
B. Ray Hawke, University of Hawaii, HIG/  
PGD, Honolulu, Hawaii.  
Martha Leake, Valdosta State College, Val-  
dosta, Georgia.  
Gerhardt Neukem, European Space Agency.  
Andrew Potter, NASA/JSC, Houston, Texas.  
Chris Russell, UCLA Institute of Geophysics  
and Planetary Physics, Los Angeles,  
California.  
Martin Slade, NASA/JPL, Pasadena,  
California.  
Paul Spudis, USGS/Flagstaff, Arizona.  
Al Stern, University of Colorado, LASP,  
Boulder, Colorado.  
Robert Strom, University of Arizona, Lunar  
and Planetary Laboratory, Tucson, Arizona.  
Chen Wan Yen, NASA/JPL, Pasadena,  
California.



Universities Space Research Association  
LUNAR AND PLANETARY INSTITUTE  
3303 NASA Road One  
Houston, Texas 77058-4399

**FIRST CLASS MAIL**