# A Mission Concept of Phobos/Deimos Exploration

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We have been designing the concept of Phobos/Deimos mission using the Japanese H-II rocket as a first step in asteroid exploration. In planning the mission concept, we focused on development of methods to characterize the materials of Phobos/Deimos. The development of such methods will contribute to both scientific and resource explorations of asteroids. Here we report the preliminary concept of the mission.

## Introduction

The exploration of space resources will be a part of space developments in the 21st century. Among the extraterrestrial bodies in the solar system, minor bodies, especially asteroids, are very attractive targets not only because of their scientific value, but also because they are promising extraterrestrial resources for future utilization. In considering the exploration of these bodies, the minute characterization of their component materials is the most important instrumental problem.

Phobos and Deimos are selected as the first targets of our exploration strategy of minor bodies. This choice stems from the following four reasons : (1) they are easily accessible compared with other minor bodies; (2) we can use them to study and develop methods to characterize materials of other minor bodies, including approaching and landing (docking) technologies; (3) fairly good information on these bodies, necessary for mission design, has been obtained by previous missions; (4) it is a suitable mission for H-II launching Vehicle, being developed now in Japan. Here we report the preliminary mission concept for Phobos and Deimos exploration.

## Mission Outline

The launching windows to Mars and the payloads using H-II launching vehicle are shown in Table 1. The outline of the mission is shown as a schematic sketch in Fig. 1. The mission consists of several exploration phases shown below:

### *1. Observation of Deimos*

After insertion into the capture orbit of Mars, the orbit of the spacecraft is changed to one crossing Deimos' orbit (Fig. 1: a). In this phase, the image data of the whole surface of Deimos are obtained using a CCD camera, and UV-Visible and/or Visible-NIR spectrometer. The imaging spectrometer, using area solid state sensor, is now being developed. Chemical analysis employing X-ray fluorescence (XRF) and $\gamma$-ray spectrometry is also performed.

### *2. Rendezvous with Phobos*

The orbit of the spacecraft is again transferred to the rendezvous orbit, which has slightly different a, e, and i from those of Phobos (Fig. 1: b). We have calculated an appropriate rendezvous orbit for global survey of Phobos. The mean distance for

observation is about 50km and the same instruments as those for Deimos are used. In addition, determination of the depth of regolith layer (probably, using underground radar) will be performed to obtain the information for selection of Landing (docking) site(s) on the surface.

*3. Hovering and Landing (Docking) on Phobos*

In order to obtain more information of selected docking site(s), the observation distance is decreased to about a few hundreds to tens of meters (Fig. 1: c). After that, the spacecraft contacts with the surface, and in-situ experiments to characterize materials are performed (Fig. 1: d).

Since the data derived by remote sensing techniques such as imager, XRF, and reflectance spectroscopy provide information only about surface, we must obtain data under the surface by sampling underground materials, and characterize them using the techniques of material sciences such as mass spectrometry and powder X-ray diffractometry.

One of the serious problems during sampling is to anchor the spacecraft to a surface with a thick regolith layer under microgravity. Solving this problem will be essential in asteroid missions, and its research development is now taking place.

*4. Sample return*

The possibility of sample return from Phobos, which is our long-cherished desire, has also been examined, but at present, we have to take a pessimistic view of it's materialization, judging from the ability of the booster.

## Future Direction of Mission Design

Although the mission design has not been fully established yet, the effort for design of scientific instruments, spacecraft systems and operation systems is going to be made in parallel. The simulational study of the observation of asteroidal materials using meteorites is also planned.

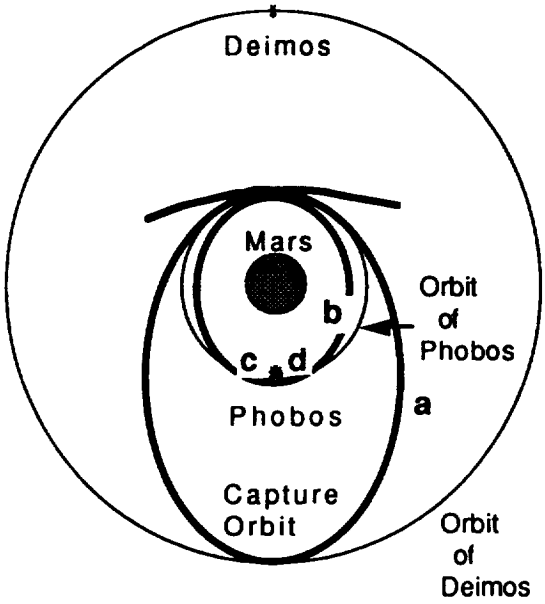


*Fig. 1*

| Launch Date | Injectable payload into transfer orbit | Injectable payload into Mars capture |
|---|---|---|
| 01-Mar-08 | 2168 | 1084 |
| 03-June-23 | 2925 | 1100 |
| 05-Aug-14 | 2835 | 1439 |
| 07-Sep-18 | 2855 | 1409 |
| 09-Oct-17 | 2922 | 1187 |
| | | (kg) |

***Table 1. Injectable Payload by H-II booster***