Europa Orbiter Mission Concept

Young H. Park
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109
young.h.park@jpl.nasa.gov

1 Abstract

In the past few years, Europa Orbiter mission concepts have been developed at Jet Propulsion Laboratory. The Europa Orbiter is not an approved mission but a concept for future consideration. This paper will present one option for the Europa Obiter mission.

The Europa Orbiter will be launched on a direct trajectory to Jupiter. The orbiter will be captured into a highly elliptical orbit about Jupiter, where many gravity assists from Jupiter satellite flybys will help it to be inserted into the final orbit around Europa. The altitude of the final circular orbit will be around 200 km.

The science objectives of the mission are to:
(1) Determine the presence or absence of a subsurface ocean;
(2) Characterize the three-dimensional distribution of any subsurface liquid water and its overlying ice layers;
(3) Understand the formation of surface features, including sites of recent or current activity, and identify candidate sites for future lander missions.

The straw-man science payload includes an imaging system, a laser altimeter, a radar sounder, and a radio-science measurement capability.

The challenges of the Europa Orbiter mission are the substantial energy required for a direct trajectory, the long duration of the mission, the high total-radiation dose, and the need for Radioisotope Thermoelectric Generators (RTG).

2 Introduction

Europa is the sixth moon of Jupiter (Figure 1). Based on pictures taken by the Galileo spacecraft, the surface of Europa is covered with ice that is broken in pieces, as shown in Figure 2. This fracturing leads scientists to speculate that Europa may have a liquid ocean under the ice (Figure 3).

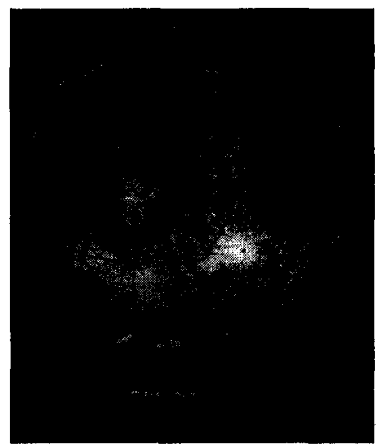

Figure 1. Europa with Jupiter in the Background

Figure 2. Picture of Europa's Surface taken by the Galileo Spacecraft

The Europa Orbiter mission will send a spacecraft into a low Europa orbit to determine whether there is a liquid ocean under the frozen ice layer and to explore a possible landing site for future missions.

Figure 3. Conceptual Three-Dimensional Diagram of Europa

3 Mission and Science Overview

The option considered in this paper assumes a March 2008 direct trajectory, with Europa orbit insertion in 2011. The primary mission orbit will be at approximately 200 km of altitude, to provide high resolution for remote-sensing instruments. The nominal mission will last 30 days. The length of the primary mission is very short, since the intense radiation field around Jupiter will limit the lifetime of many components in the spacecraft.

The science objectives are as follows:
(1) Determine the presence or absence of a subsurface ocean;
(2) Characterize the three-dimensional distribution of any subsurface liquid water and its overlying ice layers; and
(3) Understand the formation of surface features, including sites of recent or current activity, and identify candidate landing sites for future lander missions.

The science payload being considered to meet the science objects is: an imaging system, a laser altimeter, and a radar sounder, along with the usual radio-science measurement capability provided by the spacecraft's telecommunications subsystem.

The imaging system may include a narrow-angle camera with 3 to 30 m of resolution and, for global coverage, a wide-angle camera with around 300 m of resolution. A radar sounder at a low frequency (50 MHz) is being considered to penetrate the ice layer of the Europa surface. A laser altimeter is being considered to measure accurately the shape of Europa and the tidal bulge caused by Jupiter's gravitational pull. The radio-science system will measure the second-degree harmonic gravity coefficients to sufficient accuracy.

4 Mission Design

The Europa Orbiter reference-mission calls for a Delta IV launch in March 2008. The spacecraft will take a direct trajectory to Jupiter (see Figure 4), arriving in 2011. Upon arrival at the Jupiter system, the Europa Orbiter will go through a Galileo-like tour, with gravity-assists from the satellites Europa, Ganymede, and Callisto. It will take at least a year from its arrival at Jupiter to get the spacecraft to the beginning of what is called the "endgame," which is the part of the trajectory during which the spacecraft will use only Europa flybys and substantial propulsive maneuvers to achieve the desired final approach to Europa. The primary goal of the tour/endgame is to minimize the delta-V in reaching a high-inclination orbit about Europa.

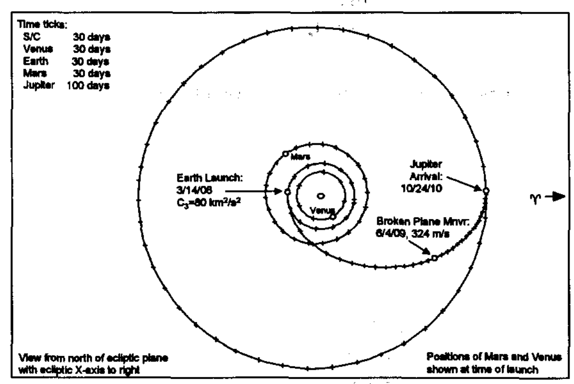

Figure 4. Europa Orbiter 2008 direct trajectory

5 System Overview

The flight system for the reference mission will consist of a three-axis-stabilized spacecraft bus housing the following: engineering and science electronic subsystems, a high-gain antenna subsystem, a propulsion module, and a Radioisotope Thermoelectric Generator (RTG). Figure 5 shows the Europa Orbiter spacecraft concept.

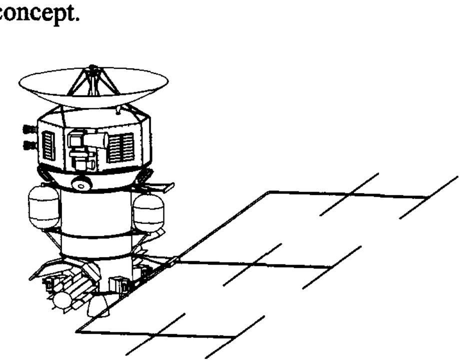

Figure 5. Europa Orbiter spacecraft with the Yagi radar antenna deployed

The concept calls for a dry mass of approximately 800 kg, propellant mass of approximately 900 kg and a total mass of approximately 1700 kg. The flight system supports approximately 30 kg of science payload. The height of Europa Orbiter spacecraft is approximately 3.5 m.

One of the major challenges for the Europa Orbiter mission is the high total-radiation dose due to the Jovian radiation field. As shown in Figure 6, the total dose for the 30-day Europa mission is more than ten times that of the 4-year Galileo mission. This dosage imposes severe challenges to spacecraft design. In order to meet this challenge, radiation-hardened avionics have been developed under the X2000 program. In addition to the radiation-hardened avionics, extra-thick shielding using with aluminum and tungsten has to be adopted, to weaken radiation dose.

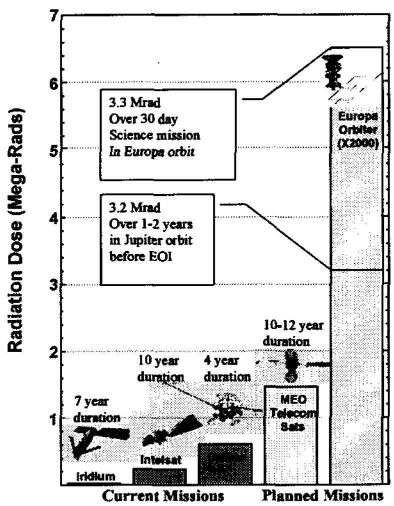

Figure 6. Radiation Dose for Different Missions

Some of subsystem characteristics are as follows. Attitude determination and control subsystem will include star trackers, gyros, a sun sensor, and reaction wheels. The telecom subsystem for the Europa Orbiter reference-mission consists of a 2.5-meter high-gain antenna (HGA), a steerable-beam medium-gain antenna (MGA), redundant X-band solid-state power amplifiers (SSPAs), and redundant transponders. The Europa Orbiter will use a bipropellant system (NTO and hydrazine).

6 Summary

The Europa Orbiter mission is an exciting mission concept to determine whether there is a liquid ocean under the surface-ice layer. A liquid ocean may be possible because of energy generated by the gravitation tidal force from Jupiter. If such an ocean exists, it will provide for the possibility of life.

The mission concept described here is a viable concept. However, it requires a substantial mission cost and has to compete with many priority planetary missions such as the Mars program.

This paper is a high-level summary of the mission concept developed by Europa Orbiter project team at Jet Propulsion Laboratory. The concept presented here is one of many tradeoff concepts.

7 Reference

[1] Announcement of Opportunity, Deep Space Systems Program Including Europa Orbiter, Pluto-Kuiper Express And Solar Probe, NASA Headquarters, September 10, 1999.

8 Acknowledgement

The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.