NEAR EARTH ASTEROID RETURNED SAMPLE MISSION (NEARS)

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NEARS is a small mission to be proposed for the NASA Discovery Program. It will use a modified version of the Near Earth Asteroid Rendezvous spacecraft being developed by the Johns Hopkins Applied Physics Laboratory. The NEARS mission will return a set of samples from a near-Earth asteroid to Earth for analysis in terrestrial laboratories. NEARS will be the first sample from return outside the Earth-Moon system and will be a pathfinder for future sample returns from other small bodies in the Solar System. NEARS will also be the first space resource assessment beyond the Moon and the first assessment of the surface physical properties of a small body. With samples from a near-Earth asteroid, our laboratory knowledge of materials from specifically identified sources will be extended beyond the Moon to Earth's next nearest neighbors. NEARS will establish the first detailed history for another body beyond the Earth and Moon and will be the decisive experiment for linking the fields of asteroid and meteorite science.

The NEARS mission will use a Delta II 7925 to launch in January 2000 to the primitive (probably C-type) asteroid 4660 Earth return occurs 4 Nereus. later. The return years capsule will use Pioneer Venus heritage and will be supplied by Martin Marietta Astrospace. The pre-Phase A study of the NEARS mission was supported by NASA Solar the System Exploration Division.

We are currently developing a sample acquisition device that will be suitable This for NEARS. instrument development is supported by the Planetary NASA Instrument Definition and Development The sampler is a Program. pyrotechnic device that will be capable of obtaining a core sample from rock or regolith surfaces. It does not require the spacecraft to tether itself to the surface of the asteroid and does not require a manned presence. The NEARS spacecraft will carry six of these samplers, integrated with the return capsule, in a cluster called the "six-shooter". We will present the NEARS mission and spacecraft, the design and test program for the sampler, and a systems integration and packaging concept for the six-shooter.

Introduction

NEARS is a low cost planetary mission to be proposed to the NASA Discovery Program. Discovery Program The will consist of small planetary missions costing no more than \$150 million to launch plus 30 in FY92 dollars. davs. The first two missions in the Discovery Program are the Mars Pathfinder and the Near Earth Asteroid Rendezvous (NEAR). Both of these missions were started in FY94 and will launch 1996. in The third and subsequent missions in the Discovery Program will be selected competitively via the Announcement of Opportunity (AO) process.

The Discovery Program is modeled after the Explorer Program for astrophysics and space physics. It is intended to enable rapid response to emerging scientific opportunities; to increase the breadth of activities in solar system exploration; to enhance timeliness of new information return; to provide increased access to space; to expand industrial, academic, and public involvement in solar system exploration missions; and to facilitate cooperative ventures with other space agencies. Missions in the Discovery Program will emphasize focused science. will They have rapid development cycles, < 36 months, and will use launch vehicles no larger than a Delta 2.

The NEARS mission was one of 14 mission concepts funded by NASA for pre-phase A studies in preparation for the release of the first Discovery Mission AO. NEARS is a follow-on to the NEAR mission (with which it should not be confused; the S in NEARS stands for Sample) that will return a set of bulk from near-Earth samples a asteroid to Earth for analysis terrestrial laboratories. in NEARS is the logical next step, in the scientific after NEAR, exploration of primitive bodies in the inner solar system.

NEARS Consortium

NEARS mission will The be performed by a consortium involving university, industry, and government partners. The Principal Investigator will be Eugene Shoemaker, of the Lowell Observatory, and formerly of the U.S. Geological Survey. The Johns Hopkins University Applied Physics Laboratory will provide the (APL) which will spacecraft, be and designed, fabricated, integrated at APL. APL will provide sample also the collection system for NEARS, perform spacecraft integration and test, and carry out The Earth mission operations. return capsule will be designed and fabricated by Martin Marietta Astrospace at Valley Forge, PA. Martin Marietta Astrospace provided the reentry capsules for the Pioneer Venus mission as well as the Jupiter Probe Galileo . The NASA Deep Space Network will be used for telecommunications, and the lunar sample facility at the NASA Johnson Space Center will be responsible for curation and distribution of samples.

Science Rationale

NEARS will be the first sample return from outside the Earth-Moon system. It will also be the first sample return mission since the time of the Apollo missions. NEARS will be a pathfinder for future robotic sample return missions and will provide the first space resource assessment from beyond the Moon. With samples from a near Earth asteroid (NEA), our laboratory knowledge of extraterrestrial materials from specifically identified sources will be extended beyond the Moon to Earth's next nearest neighbors.

The NEARS mission will return samples from multiple sites on an NEA and will lead to profound advances in our understanding of the early solar system and the processes and conditions leading to the formation of the terrestrial planets . NEARS will establish the first detailed history for another body in the solar system beyond the Moon and will be the decisive experiment for linking the fields of asteroid astronomy and meteorite science. Meteorites are believed to be fragments of asteroids, but it has proved to

difficult be extremelv to establish clear relationships specific meteorite between types and asteroid types on the of remote sensing basis of asteroids. Only analysis of asteroid samples in terrestrial laboratories can definitively establish such a linkage, if in fact any linkage exists. It is guite possible that a returned asteroid sample will contain previously unknown material not currently that is represented in the meteorite collection. Any friable or semi-volatile material on the surface of asteroids would most likely not survive collisional ejection from the asteroid and then hypersonic reentry through Earth's atmosphere, except in the form of interplanetary dust particles.

Mission Overview

NEARS will return to Earth samples of 10 to 100 grams each from four to six sites on a near-Earth asteroid. It will perform also global a characterization of the asteroid, including mass volume and density determinations, and will study the geologic it context of the sample sites. The objectives for NEARS are summarized in Table 1:

Table 1. Science Objectives

Provide the first direct and detailed petrological, chemical, age, and isotopic characterization of a near Earth asteroid. Relate the asteroidal material to terrestrial, lunar, and meteoric materials

Sample the asteroid regolith and characterize any exotic fragments

Identify heterogeneity in the asteroid's isotopic properties, age, and elemental chemistry

The prime target for the NEARS mission will be the asteroid 4660 Nereus, which has been reported to be a primitive C-type asteroid. The type identification for Nereus is regarded as tentative, but it is established that Nereus is not an S-type asteroid. The NEAR mission target, 433 Eros, is an S-type, as are the two target asteroids for the Galileo flybys, 951 Gaspra and 243 Ida. Our current knowledge of Nereus is summarized in Table 2.

Table 2. NEARS Target Nereus 4660

(460) NereusType:C? (definitely not Type S)Perihelion:0.953 AUAphelion:2.03 AUInclination:1.43°H Magnitude:18.3Size:1-km class

Rotation: Unknown

The prime launch opportunity for NEARS occurs in January, asteroid 4660 2000 to the Nereus. The launch vehicle will be a Delta II-7925. The backup mission opportunity is a January 2002 launch to 4660 which can be Nereus, accomplished with an identical flight system design. The the January, trajectory for 2000 prime mission opportunity is plotted in Figure 1. Both ballistic of these are trajectories to be performed using conventional bipropellant propulsion systems. We are also studying electric propulsion options that would use arcjet propulsion systems.

Figure 1. 2000 Launch



Figure 2 sketches an overview of the NEARS mission. After arrival at Nereus in October, the 2001. spacecraft will execute a slow flyby of the asteroid and then enter rendezvous orbit. A global characterization of the including asteroid. determinations of the mass. density, shape, and spin state and a search for compositional heterogeneity, will be carried out. The sites for sample collection will also be selected during this orbital phase of the mission, which will occupy approximately one month.

landing phase The of the mission will then take place, during which four to six samples will be collected from various points on the asteroid. "touch-and-go" Α sampling strategy will be used, in which there is no long duration landing and contact with the surface is maintained for only a very short time, about a The sampler will be second. able to obtain samples from either rock or regolith surfaces, pyrotechnic using devices to fire core tubes into the surface. Each sampler is a single shot device, and firing is triggered by a proximity

sensor to signal contact with The complete the surface. sample collection system (the "six-shooter") will comprise four to six samplers and is a single unit, mounted, as within the Earth return No robotic capsule. manipulator arm is required to transport samples into the Earth return capsule. The landing phase will occupy approximately the second month of the rendezvous with Nereus. The spacecraft will touch down up to six times on the asteroid and obtain up to six samples from multiple sites. After each touchdown, the spacecraft will re-establish orbit around the asteroid and prepare for the next touchdown. NEARS will include a Laser Altimeter to assist in control of the landings.

After the landing phase the spacecraft will be boosted to an Earth return trajectory. Several hours before Earth the return capsule arrival, will be separated from the will spacecraft. It then through Earth's reenter atmosphere and descend on a parachute to Earth's surface, for land recovery.





Mission Requirements

The mission requirements are summarized in Table 3. The fundamental requirement is to return samples of 10 gram minimum size from an asteroid As the surface of an surface. asteroid is subjected to temperatures and conditions comparable to those on the lunar surface, the asteroid samples can be handled like the lunar samples. In

particular, the maximum allowed the samples temperature of during reentry can be 100C, and the samples do not need to be vacuum. A global kept in the characterization of asteroid is required during the orbital phase. This will the scientific enhance interpretation of the asteroid samples, and is also required for mission operations to ensure safe landings.

Table 3. NEARS Mission Requirements

-Sample multiple sites on an asteroid surface with a minimum sample size of 10 grams

-Sample temperatures are not to exceed 100 C during reentry

-Obtain a global characterization of the asteroid, for sampling site selection and for establishing the geological context of sample sites

-Measurement of the target asteroid's mass, volume and density to within 10%

Strawman Instrument Payload

The strawman payload is shown in Table 4. In addition to the sample collection system, Earth return capsule, and laser altimeter mentioned above, NEARS will accommodate two small imaging systems. These will be copies or close derivatives of the highly successful UV-Vis imager on the Clementine mission, which was a Ballistic Missile Defense Organization (BMDO) mission that mapped the Moon (it was fly by also planned to an asteroid, but this goal was

not achieved because of a failure; the spacecraft instruments were all successful). One of the NEARS imagers will be a copy of the Clementine unit and will perform the global of characterization the asteroid, including color unit mapping and site surveys. The other imager will be slightly modified to serve as a descent imager to take close-up images of the sample sites.

Table 4. Strawman Payload

Strawman Payload

Instrument	Heritage
Survey camera with filters capable of lithologic discrimination	BMDO - Clementine flight spare unit
Descent Imager	Clementine flight spare
Laser Altimeter	NEAR LIDAR
Sample Coilector	
Earth Return Capsule	Pioneer Venus Probes
Radio Science	Many missions

Spacecraft Summary

The NEARS spacecraft will be based on the NEAR spacecraft design and will use many of the same subsystems. Like NEAR, the NEARS spacecraft will be solar powered and three axis stabilized, with both reaction and small wheels thrusters available for attitude control. The baseline design for NEARS will use dual a mode bipropellant propulsion system (although electric an option propulsion is under study) with spacecraft a delta-v capability of 1475 m/s. The spacecraft will use X-band telemetry to the NASA Deep Space Network. The maximum launch mass for NEARS is 792 kg.

NEARS will involve the following modifications to the NEAR spacecraft design. The 60 kg instrument payload on NEAR will be replaced with а comparable mass on payload NEARS that includes the sample collection system, the Earth return capsule, and the small Clementine-derived imaging systems. No robotic manipulator arm is required for sample handling. As for spacecraft subsystems, the baseline NEARS will require

minor modifications to the dual mode propulsion system used for NEAR. No change is required to the following NEAR subsystems: the power system, the telemetry system, the command and data handling system, the guidance and control system, and the attitude system.

Sampler Introduction

The NEARS Sample collection system consists of to six independent four samplers packaged into a return The intent of the capsule. design is to provide extremely robust, simple mechanisms to minimize expensive testing and maximize flexibility as well as redundancy.

Sampler Design

Sampler will use Each а pyrotechnic charge to drive a hardened steel core tube into the surface to obtain a 10-100 gram sample depending on the surface composition. A section view of the sampler in the "pre-fired" or launch configuration is depicted in Figure 3.

Figure 3. Layout of Sampler



The teflon shear ring in conjunction with the flange on the core tube act together to prevent the core tube from exiting the housing should the surface be covered with a deep layer of dust. Figure 4 depicts the sampler in the "fired" condition prior to retraction into the re-entry capsule.

Figure 4. Sampler in "Fired" Condition







Figure 8.



Figure 9.

Six-Shooter and Return Capsule Configuration (Cont.)



Configuration after separation

Figure 10. Spacecraft Launch Configuration

