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Environmental Evaluation and Recommendation for NASA Routine Payload Categorization of the Dawn Project

The proposed Dawn mission has been reviewed in accordance with the Routine Payload criteria established by the "*Final Environmental Assessment of NASA Routine Payloads on Expendable Launch Vehicles from Cape Canaveral Air Force Station Florida and Vandenberg Air Force Base California,*" dated June 2002 and Finding of No Significant Impact (FONSI) dated June 18, 2002. This review shows that the Dawn mission meets all of the Routine Payload Criteria and therefore it is recommended that Dawn be designated a NASA Routine Payload. Supporting mission description and Routine Payload Checklist documentation are attached.

James A. Smith for Mark Phillips — 4/17/03
J. M. Phillips, Supervisor — Date
Launch Approval Planning Group

Concurrence:

4/17/03
R. E. Wilcox, Manager — Date
Cross-Program Launch Approval Engineering

Concurrence:

4/18/03
Sarah A. Gavit — Date
Dawn Project Manager

Description of Proposed Mission:

The goal of the Dawn mission is to send a spacecraft into orbit about two massive asteroids, 4 Vesta and 1 Ceres, arriving there in approximately July 2010 and August 2014, respectively. Dawn's goals are to understand the conditions and processes present at the solar system's earliest epoch, and to determine the role of water and size in planetary evolution. The 1,300-kilogram (2,900 pounds) Dawn spacecraft would be launched from Cape Canaveral Air Force Station (CCAFS) on a Delta II- launch vehicle during a launch opportunity in May - June 2006. Following launch, Dawn would utilize a xenon ion propulsion system to provide propulsion to the asteroids. The spacecraft would spend about 11 months orbiting each body, where it would make a variety of scientific measurements.

To enable the study of the physical structure and evolution of asteroids Ceres and Vesta, Dawn would include as part of its payload a framing camera, a mapping spectrometer, a gamma ray/neutron spectrometer, a laser altimeter, and a magnetometer.

The German Aerospace Center (DLR), Institute of Space Sensor Technology and Planetary Exploration would provide the Framing Camera (FC). It would be used to image each asteroid as well as to support spacecraft navigation both during interplanetary cruise and in orbit around the asteroids. The prime science task of the FC would be to decipher the geologic history and evolution of the asteroids by characterizing and mapping their surfaces, in conjunction with the Mapping Spectrometer.

The Mapping Spectrometer (MS) would be provided by the Institute for Space Astrophysics in Rome. It would be a rebuild of the VIRTIS mapping spectrometer on board the ESA Rosetta mission. Determination of the mineral composition of surface materials in their geologic context is a prime Dawn objective. Common rock-forming minerals in asteroids exhibit distinctly different spectroscopic absorption bands. Use of the MS would create maps of the current surface mineralogy, which when combined with studies of the cratering that excavates and redistributes material would lead to an understanding of the evolution of the asteroid's surface and determine the processes affecting it.

The NASA Goddard Space Flight Center would provide the Laser Altimeter (LA), which measures the round-trip time of flight of the laser pulses from the spacecraft to the surface of the target asteroid. Each detected pulse results in a unique, high-resolution measurement of range and pulse spreading. These data, together with spacecraft position and attitude, determine the height and reflectivity of the asteroid's surface. Although the transmitter is a Class III-B laser, it would be activated only for deep-space operations and would not be used in any Earth-pointing capacity; within this capacity the LA falls within the utilization parameters outlined in the NASA Routine Payload categorization.

The Department of Energy's Los Alamos National Laboratory would build the Gamma Ray/ Neutron Spectrometer (GR/NS) for Dawn. Planetary objects emit gamma rays by the decay of naturally occurring radioactive elements, and also by nuclear reactions induced by neutrons generated by galactic cosmic ray interactions with matter. Analysis of gamma-ray/neutron spectra passively detected by the GR/NS can provide information of the abundance of rock-forming elements, and can be used to create composition maps of both asteroids. Neutron observation can also measure the amount of hydration on the asteroid's crust, and also provide an independent measure of the average atomic mass of surface soils.

The Magnetometer (MAG) provided by UCLA would allow Dawn to determine if the target asteroids possess natural remnant magnetization and, through geologic correlations, when it was produced. Detection of a remnant magnetization or an electrically conducting core at Ceres, for example, would lead to a major reassessment of the present asteroid evolution model.

Statement of Purpose and Need:

Scientific advisory committees, including the Committee on Planetary and Lunar Exploration of the Space Studies Board of the National Research Council have established general scientific objectives for the exploration of the Solar System. The Space Science Enterprise Strategic Plan published by NASA in November 1997 addresses the concept of cosmic origins, evolution and destiny -- how the universe began, how life on Earth originated and what fate awaits our planet and our species. In particular, the Strategic Plan has the near-term scientific objective to "Investigate the composition, evolution, and resources of the Moon, small bodies, and Pluto-like objects across the Solar System" and to "Investigate the processes that underlie the diversity of solar system objects".

The Office of Space Science Solar System Roadmap, published in 2000, discusses as one of its objectives "Understand the formation and evolution of the Solar System and Earth within it". One of the missions discussed is a multiple asteroid mission explorer to investigate the relationship of main-belt asteroids to planetary evolution, which would be implemented through the Discovery Program. The Discovery Program is part of NASA's initiative for lower-cost, highly focused, rapid-development scientific spacecraft, and in December of 2001, Dawn was selected by the Office of Space Science to accomplish this objective.

In the 2006 launch opportunity, NASA plans to launch the Dawn mission, having as its specific scientific objectives:

- measure asteroid mass, shape, volume and spin state
- record detailed elemental and mineral composition
- determine tectonic and thermal history, magnetism and core size
- examine the internal structure to compare these two very different bodies, one cool and wet, the other hot and dry

Instruments are carried as part of Dawn's payload in order to accomplish these scientific objectives.

NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: Dawn　　DATE OF LAUNCH: May 27, 2006

PROJECT CONTACT: Marc Rayman　　PHONE NUMBER: 818-354-2544　　MAILSTOP: T1718

PROJECT START DATE: April 2001　　PROJECT LOCATION: JPL

PROJECT DESCRIPTION: Fly to and orbit main belt asteroids 1 Ceres and 4 Vesta

	YES	NO
A. SAMPLE RETURN:	YES	NO
1. Would the candidate mission return a sample from an extraterrestrial body?		X
B. RADIOACTIVE SOURCES:	YES	NO
1. Would the candidate spacecraft carry radioactive materials?		X
2. If Yes, would the amount of radioactive sources require launch approval at the NASA Associate Administrator level or higher according to NPG 8715.3 (NASA Safety Manual)?		
Provide a copy of the Radioactive Materials Report as per NPG 8715.3 Section 5.8.3.		
C. LAUNCH AND LAUNCH VEHICLES:	YES	NO
1. Would the candidate spacecraft be launched using a launch vehicle/launch complex combination other than those indicated in Table 1 below?		X
2. Would the proposed mission cause the annual launch rate for a particular launch vehicle to exceed the launch rate approved or permitted for the affected launch site?		X
Comments:		
D. FACILITIES:	YES	NO
1. Would the candidate mission require the construction of any new facilities or substantial modification of existing facilities?		X
2. If Yes, has the facility to be modified been listed as eligible or listed as historically significant?		
Provide a brief description of the construction or modification required:		
E. HEALTH AND SAFETY:	YES	NO
1. Would the candidate spacecraft utilize any hazardous propellants, batteries, ordnance, radio frequency transmitter power, or other subsystem components in quantities or levels exceeding the Envelope Payload characteristics (EPCs) in Table 2 below?		X
2. Would the candidate spacecraft utilize any potentially hazardous material as part of a flight system whose type or amount precludes acquisition of the necessary permits prior to its use or is not included within the definition of the Envelope Payload (EP)?		
3. Would the candidate mission release material other than propulsion system exhaust or inert gases into the Earth's atmosphere or space?		X
4. Would launch of the candidate spacecraft suggest the potential for any substantial impact on public health and safety?		X
5. Would the candidate spacecraft utilize a laser system that does not meet the requirements for safe operation (ANSI Z136.1-2000 and ANSI Z136.6-2000)? For Class III-B and IV laser operations, provide a copy of the hazard evaluation and written safety precautions (NPG 8715.3).		
6. Would the candidate spacecraft contain pathogenic microorganisms (including bacteria, protozoa, and viruses) which can produce disease or toxins hazardous to human health?		X
Comments: For item 2 and 5: The spacecraft does include a laser system. The laser is a diode-pumped Nd:YAG, operating at 1.064 μm. It emits 8 pulses/sec. The pulses are 7 ns long and 5 mJ. The beam divergence is around 50 μrad.		

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NASA Routine Payload Checklist (2 of 2)

PROJECT NAME: **Dawn** DATE OF LAUNCH: May 27, 2006

PROJECT CONTACT: Marc Rayman PHONE NUMBER: 818-354-2544 MAILSTOP: T1718

PROJECT START DATE: April 2001 PROJECT LOCATION: JPL

PROJECT DESCRIPTION: Fly to and orbit main belt asteroids 1 Ceres and 4 Vesta

F. OTHER ENVIRONMENTAL ISSUES:	YES	NO
1. Would the candidate spacecraft have the potential for substantial effects on the environment outside the United States?		X
2. Would launch and operation of the candidate spacecraft have the potential to create substantial public controversy related to environmental issues?		X
Comments:		

Table 1: Launch Vehicles and Launch Pads

Launch Vehicle	Eastern Range (CCAFS Launch Complexes)	Western Range (VAFB Space Launch Complexes)
Atlas IIA & AS	LC-36	SLC-3
Atlas IIIA & B	LC-36	SLC-3
Atlas V Family	LC-41	SLC-3
Delta II Family	LC-17	SLC-2
Delta III	LC-17	N/A
Delta IV Family	LC-37	SLC-6
Athena I & II	LC-46 or -20	California Spaceport
Taurus	LC-46 0r -20	SLC-576E
Titan II	N/A	SLC-4W
Pegasus XL	CCAFS skidstrip KSC SLF	VAFB airfield

Table 2: Summary of Envelope Spacecraft Subsystems and Envelope Payload Characteristics (EPC)

Structure	**Unlimited:** aluminum, magnesium, carbon resin composites, and titanium **Limited:** beryllium [50 kg (110 lb)]
Propulsion	Mono- and bipropellant fuel; 1000 kg (2200 lb) (hydrazine); 1000 kg (2200 lb) (monomethyhydrazine) Bipropellant oxidizer; 1200 kg (2640 lb) (nitrogen tetroxide) Ion-electric fuel; 500 kg (1100 lb) (Xenon) SRM; 600 kg (1320 lb) (AP)-based solid propellant
Communications	Various 10-100 W (RF) transmitters
Power	Solar cells; 150 A-Hr (Ni-H_2) battery; 300 A-Hr (LiSOC) battery; 150 A-Hr (NiCd) battery
Science instruments	10 kW radar ANSI safe lasers (Section 4.1.2.1.3)
Other	Class C EEDs for mechanical systems deployment Radioisotopes limited to quantities that are approved for launch by NASA Nuclear Flight Safety Assurance Manager Propulsion system exhaust and inert gas venting