Jet Propulsion Laboratory
California Institute of Technology
MS 301-472
4800 Oak Grove Drive
Pasadena, California 91109-8099

(818) 393-1259

JPL

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

The proposed Phoenix 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. The review shows that the Phoenix mission meets all of the Routine Payload Criteria and therefore it is recommended that Phoenix be designated a NASA Routine Payload. Supporting mission description and Routine Payload Checklist documentation are attached.

Victoria Mowrey 1-5-05

V.S. Mowrey — Date
Supervisor
Launch Approval Planning Group

Concurrence:

1-05-05

Robert Shotwell — Date
Phoenix Project Systems Engineer

Concurrence:

1/05/2005

J. M. Phillips, Manager — Date
Mars Launch Approval Engineering

Concurrence:

1/7/05

R. E. Wilcox, Manager — Date
Cross-Program Launch Approval Engineering

Description of Proposed Mission:
Phoenix, a Mars Scout mission, was selected for the 2007 launch opportunity as an element of the Mars Exploration Program (MEP), which is within NASA's Space Mission Directorate (SMD). The goals and objectives of the MEP are outlined below. Mars Scout investigations are also governed by these overall goals:

- Determine whether life ever arose on Mars
- Characterize the Climate of Mars
- Characterize the Geology of Mars
- Prepare for human exploration of Mars

Phoenix would be a low-cost mission dedicated to NASA's crosscutting theme for Mars: "follow the water." Phoenix would fly the Mars Surveyor Program 2001 (MSP'01) lander with a rich and diverse scientific payload chosen from the 1998 Mars Polar Lander (MPL'98) and the MSP'01 missions. Phoenix would be the first fully competed and investigator-led mission as part of NASA's new Mars Scout program. Phoenix, being designed to be a stationary lander (i.e., no roving capability) in the high northern latitudes of Mars, would perform follow up investigations on Mars Odyssey's spectacular discovery of near-surface water ice in such regions. It would land in terrain suspected of harboring as much as 80 percent water ice by volume within one foot of the surface, and would conduct the first subsurface analysis of ice-bearing materials on another planet. The Phoenix baseline mission would provide NASA with the following:

- A Mars soft lander, implemented by Lockheed Martin (LM), Denver. This lander would be equipped with a rich complement of instruments.
    - A Thermal Evolved Gas Analyzer (TEGA) would be implemented by the University of Arizona (UA) and the University of Texas, at Dallas
    - The Solid State Imager (SSI) would also be implemented by the University of Arizona.
    - The Phoenix Robotic Arm would be built at the Jet Propulsion Laboratory (JPL), along with the Microscopy, Electrochemistry and Conductivity Analyzer (MECA).
    - The Mars Descent Imager (MARDI) would be provided by Malin Space Science Systems (MSSS).
    - Two instruments would be provided by international partners: the Robotic Arm Camera (RAC), to be provided by the Max Planck Institute, DLR; and the Meteorological package (MET), which would include a two-degrees of freedom atmospheric LIDAR, to be provided by the Canadian Space Agency.

Specifically, Phoenix would have two overall goals. The first would be to study the geologic history of water, the key to unlocking the story of past climate change. The second would be to search for evidence of a habitable zone that may exist in the ice-soil boundary. The Phoenix robotic arm would scoop up Martian soil samples and deliver them for heating into tiny ovens of the TEGA, the volatiles-analysis instrument, so that team members could measure how much water vapor and carbon dioxide gas are given off, how much water ice the samples contain, and what minerals are present that may have formed during a wetter, warmer past climate. The TEGA instrument would also measure any organic volatiles. Using the MECA, researchers would examine soil particles as small as 16 microns across. They would measure electrical and thermal conductivity of soil particles using a probe on the robotic arm scoop. One of the most interesting experiments planned is the wet chemistry laboratory that would be enabled by the MECA instrument.

The Phoenix spacecraft would be launched in August 2007 on board a Delta II 2925 expendable launch vehicle from Cape Canaveral Air Force Station (CCAFS), Florida. Phoenix would land on Mars in May 2008, and would complete its primary baseline mission in August 2008.

Statement of Purpose and Need:
The key NASA goals of studying Martian climate and the potential for life, translate directly into the Phoenix mission's top two objectives: study the history of water and search for habitable zones (zones in which life might have existed in the past or may currently exist). The Mars program's crosscutting theme to "follow the water" proves to be difficult on a desert planet. Besides tiny abundances of water vapor in the thin atmosphere and exposed water ice on the Northern Polar cap, only vestigial remnants mark the flowing rivers and crater lakes from ancient times. Phoenix would carry instruments for performing surface investigations based on the recent Mars Odyssey science discovery, which suggests that large amounts of water ice are clearly seen by the Gamma Ray Spectrometer (GRS) in the circumpolar regions. Modeling of the gamma ray and neutron fluxes from Odyssey predicts that high concentrations of ice, up to 80% by volume, are found within 50 cm (19.69 inches) of the surface. The Phoenix Robot Arm instrument is capable of digging a trench of up to 50 cm (19.69 inches) deep and could acquire samples for the TEGA and MECA, as well as characterize the trench and document acquired samples with the attached Robotic Arm Camera.

Additionally, continuing GRS measurements verify that the Martian arctic, near 70N, contains water ice protected from solar UV by a thin layer of regolith. Lastly, high-resolution images from the Mars Orbiter Camera (MOC) on the Mars Global Surveyor (MGS) spacecraft show a "basketball-like" texture on the surface with low hummocks spaced 10's of meters apart; polygonal terrain is also common. These geologic features are common in Earth's polar regions indicating permafrost and an active freeze-thaw cycle, further strengthening the possibility that water could be found on the surface of Mars. Phoenix plans to land between 65 and 72 degrees North latitude and take samples there to verify these findings.

The Science Mission Directorate has been given the goal of solving the mysteries of the universe, exploring the solar system, discovering planets around other stars, searching for life beyond Earth; from origins to destiny, to chart the evolution of the universe and understand its galaxies, stars, planets, and life. The Phoenix mission would seek to verify the existence of near surface ground water, and further to assess the potential habitability of that environment. Phoenix would gather data to address several of NASA's fundamental science objectives: 1) *determine how the solar system evolved to its current diverse state; 2) determine how the processes that shape planetary bodies operate and interact; 3) understand why terrestrial planets are so different from one another; and 4) determine the nature, history, and distribution of volatile and organic compounds in the solar system.* The Mars Scout program, through the Phoenix mission, would perform investigations that would provide answers to whether water, which accomplish the SSE's prime objective of enhancing our understanding of life on Mars. Determination of Mars' volatile history and study of its geological and climatic evolution could tell us whether Martian environments ever became habitable.

NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: **Phoenix** DATE OF LAUNCH: August 28, 2007

PROJECT CONTACT: Robert Shotwell PHONE NUMBER: 818-354-6969 MAILSTOP: T1710

PROJECT START DATE: September 2003 PROJECT LOCATION: JPL

PROJECT DESCRIPTION: Mars Scout Mission, flight of Mars Surveyor Program '01 Lander, landing at ~70 degrees N latitude.

	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)?		X
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).		X
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:		

continued on next page

NASA Routine Payload Checklist (2 of 2)

PROJECT NAME: Phoenix DATE OF LAUNCH: August 28, 2007

PROJECT CONTACT: Robert Shotwell PHONE NUMBER: 818-354-6969 MAILSTOP: T1710

PROJECT START DATE: September 2003 PROJECT LOCATION: JPL

PROJECT DESCRIPTION: Mars Scout Mission, flight of Mars Surveyor Program '01 Lander, landing at ~70 degrees N latitude.

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