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

(818) 354-1181

May 15, 2003

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

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

James A. Smith
for Mark Phillips — 5/26/03

J. M. Phillips, Supervisor — Date
Launch Approval Planning Group

Concurrence:

5/29/03

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

Concurrence:

6/23/03

Chester Sasaki — Date
Kepler Project Manager

Description of Proposed Mission:
Kepler, a NASA Discovery mission, is a spaceborne telescope designed to look for Earth-like planets, around stars beyond our solar system. The Kepler mission's objective is to conduct a census of extrasolar, terrestrial and Earth-size planets in or near a habitable zone by using a photometer in an Earth-trailing heliocentric orbit to observe the periodic dimming in starlight caused by planetary transits. In this orbit, the spacecraft slowly drifts away from the Earth and is at a distance of 0.5 AU (worst case) at the end of four years. The results would yield a broad understanding of planetary formation, the frequency of formation, the structure of individual planetary systems and the generic characteristics of stars with terrestrial planets. The Kepler spacecraft would be launched in October 2007 on-board a Delta-II 2975 expendable launch vehicle. The end of the baseline mission would be October 2012.

The Kepler Mission's Goals and Objectives are to explore the structure and diversity of planetary systems. This is achieved by surveying a large sample of main sequence stars to:

1) Determine the frequency of terrestrial and larger planets in or near the habitable zone of a wide variety of spectral types of stars;
2) Determine the distributions of sizes and orbital semi-major axes of these planets;
3) Estimate the frequency of planets and orbital distribution of planets in multiple-star systems;
4) Determine the distributions of semi-major axis, albedo, size, mass and density of short-period giant planets;
5) Identify additional members of each photometrically discovered planetary system using complementary techniques
6) Determine the properties of those stars that harbor planetary system

The Kepler Mission was proposed in response to a NASA Announcement of Opportunity (for the Discovery Program in 2000. The Discovery Program is part of NASA's initiative for lower-cost, highly focused, rapid-development scientific spacecraft. It is an ongoing program that offers the scientific community the opportunity to assemble a team and design exciting, focused science investigations that complement NASA's larger planetary science explorations. Kepler was selected in December 2001 as the tenth Discovery Mission. The Kepler Mission as planned, is consistent with the Discovery Program Plan that provides opportunities for the space science community to perform innovative and streamlined planetary science missions complementary to those planned Space Science Enterprise Strategic Plan roadmaps but not specifically addressed therein. The mission selection was based on the KEPLER Concept Study Report dated July 2001.

The mission is low risk with high reliability and incorporates proven technologies which require no additional development. Both the photometer and spacecraft are robust and use flight proven designs:

- Photometer 0.95-m aperture
- Primary mirror 1.4 dia., 85% lightweighted

The photometer is composed of just one "instrument," which is, an array of 42 CCDs (charge couple devices). It measures the brightness of light and would be like a giant camcorder with a 95 cm (37 inch) diameter lens, flying through space. It would continuously measure the brightness of 100,000 stars and send back this information to be analyzed by the science team. Over 100 gas giant planets have been discovered outside of our solar system to date, but the approach used in the past cannot detect planets much smaller than Jupiter. Only in the last few years have the technologies necessary to conduct a search for small rocky, or terrestrial, planets with the requisite high precision reached maturity. The Kepler Mission would be the first search capable of detecting Earth-size planets

Statement of Purpose and Need:
The scientific goals of the Kepler mission speak to many prominent strategic issues and recommendations from scientific advisory committees, including the Committee on Planetary and Lunar Exploration of the Space Studies Board of the National Research Council (NRC), the NASA Strategic Plan, the Space Science Enterprise (SSE) Strategic Plan. The NRC has established general scientific objectives for the exploration of the Solar System. The NRC 2001 decadal survey proposes to NASA the following questions on formation and evolution of planets:

- What fraction of stars have planetary systems?
- How many planets are there in a typical system?
- What are their masses and distances from the central star?
- How do these characteristics depend on the mass of the star, its age, and whether it has a binary companion?

The NRC survey also recommends the use of space-based photometry to conduct a planetary census to answer the above questions. Moreover, the Kepler Mission would utilize a NRC recommended method to answer the questions posed in the 2001 NRC decadal study.

The NASA Strategic Plan, another strategic issue the Kepler mission speaks to, poses several fundamental questions which serve as goals for NASA research activities to endeavor to answer. The Kepler Mission could answer several of the fundamental questions*; Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on Earth? Are there Earth-like planets beyond our solar system?* By performing an unbiased search of the extended solar neighborhood, and with a sensitivity to detect Earth-size planets in the habitable zone of solar-like stars, Kepler is able to answer the questions about the existence of Earth-like planets.

The Space Science Enterprise (SSE) Strategic Plan, published in 2000, describes the science goals and objectives that will lead toward answers to the fundamental questions: *How did the universe begin and evolve? How did we get here? Where are we going? Are we alone?* The plan lays out a near-term program of activities to pursue these goals. It discusses as one of its objectives to "look for signs of life in other planetary systems". Determining whether habitable or life-bearing planets exist around nearby stars is a fundamental Enterprise goal. The Discovery Program, through the Kepler Mission, would accomplish the prime objective of the SSE of enhancing our understanding of the Solar System

NASA Routine Payload Checklist (1 of 2)

PROJECT NAME: **Kepler** DATE OF LAUNCH: October 1, 2007

PROJECT CONTACT: Chester Sasaki PHONE NUMBER: 818-354-9298 MAILSTOP: 301-450

PROJECT START DATE: January 2000 PROJECT LOCATION: JPL

PROJECT DESCRIPTION: A spaceborne telescope designed to look for Earth-like planets around stars beyond our solar system.

	YES	NO
A. SAMPLE RETURN:		
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: 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.		

continued on next page

NASA Routine Payload Checklist (2 of 2)

PROJECT NAME: **Kepler** DATE OF LAUNCH: October 1, 2007

PROJECT CONTACT: Chester Sasaki PHONE NUMBER: 818-354-9298 MAILSTOP: 301-450

PROJECT START DATE: January 2000 PROJECT LOCATION: JPL

PROJECT DESCRIPTION: A spaceborne telescope designed to look for Earth-like planets around stars beyond our solar system.

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