The Importance of Planet Detection

The *Kepler Mission* is specifically designed to survey the extended solar neighborhood to detect and characterize hundreds of terrestrial and larger planets in or near the habitable zone and provide fundamental progress and large leaps in our understanding of planetary systems. The results will 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.

Kepler Mission Science Objectives

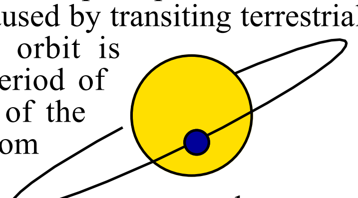
The scientific goal of the *Kepler Mission* is to explore the structure and diversity of planetary systems. This is achieved by surveying a large sample of dwarf (main-sequence) stars to:

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 planet sizes and their orbital semi-major axes
3. Estimate the frequency and orbital distribution of planets in multiple-stellar 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 systems.

The *Kepler Mission* supports the objectives of the Origin's theme and directly contributes to the design of the Terrestrial Planet Finder as recommended in the NRC 2001 decadal survey.

Mission Overview

Kepler measures repetitive stellar brightness changes on the order of 100 parts per million lasting for 2 to16 hours caused by transiting terrestrial planets. The planet's orbit is calculated from the period of the transits. The size of the planet is calculated from the transit depth. The proposed differential photometer continuously and simultaneously monitors the brightness of 100,000 dwarf stars for four years; long enough to see four transits of a terrestrial planet in the habitable zone of a solar-like star. To obtain the required precision, the photometer must be spaceborne; this also eliminates the day-night and seasonal cycle interruptions of ground-based observing.



Expected Results

We expect to perform a census of planets with periods from days to a few years and to detect:

Transits of terrestrial planets near 1 AU

- About 50 planets if most have radii about equal to the Earth ($R \sim 1.0\ R_\oplus$)
- About 185 planets if most have $R \sim 1.3\ R_\oplus$
- About 640 planets if most have $R \sim 2.2\ R_\oplus$

Transits of thousands of terrestrial planets

- If most have orbits much less than 1 AU

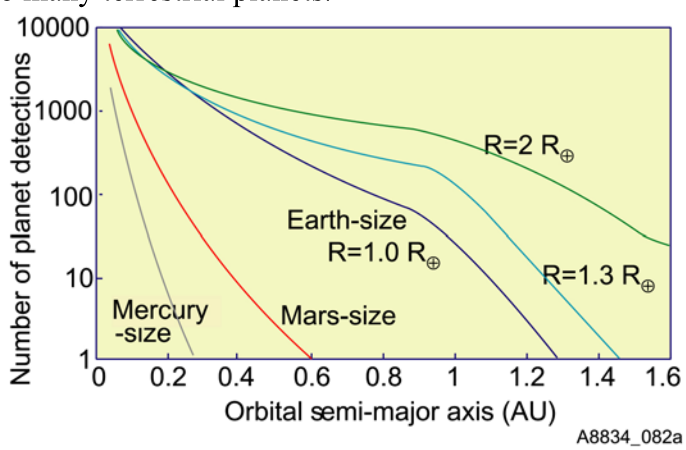
Modulation of the reflected light of giant inner planets

- About 870 planets with periods ≤1 week

Transits of giant planets

- About 135 inner-orbit planets with albedos for about 100 of these giants
- Densities for 35 inner-orbit planets
- About 30 outer-orbit planets.

The results likely consist of a mix of all of the above. From these results, we can explore the structure and diversity of planetary systems. The results are also still significant even if no planets are found, since the mission is designed to detect so many terrestrial planets.



Expected number of planetary discoveries. *The curves show the expected results based on monitoring 100,000 dwarf stars and a four-year mission and if most stars have terrestrial planets. The mission is sensitive to a large number of planets even smaller than Earth in short period orbits as a result of the larger number of observed transits.*

Flight Segment Characteristics

The photometer and spacecraft are robust; use flight-proven and conservative designs; have no single-point failures and are thoroughly tested. All software will undergo an independent verification and validation.

Photometer:	0.95-m aperture
Primary mirror:	1.4 m dia., 85% lightweighted
Detectors:	42 CCDs –2200 x 1024 pixels
Photometer noise level:	<10ppm
Total noise, m_v=12 solar-like star (1σ):	<20ppm
Data rate:	3.6 (5.4) Gbits/day in yrs 2-4 (yr 1)
Mechanisms:	Focus, HGA, ejected cover

Photometer and spacecraft budgets:

Mass: 903 kg (includes resv) plus 34% margin

Power: 613 W (includes resv) plus 32% margin

Mission Characteristics

Launch vehicle:	D2925-10L (Delta II)
Orbit:	Earth-trailing heliocentric
Pointing:	Continuously stare at one star field
Search:	100,000 dwarf stars for transits of terrestrial or larger planets
Mission lifetime:	4 years of flight
Telemetry:	Ka-and X-band, DSN

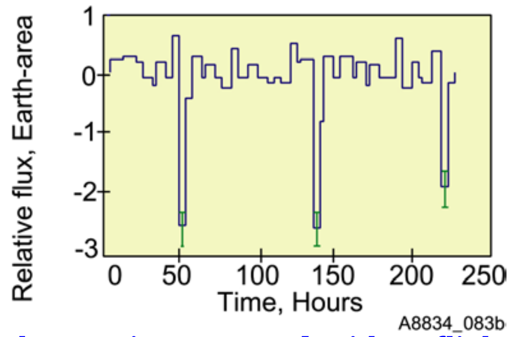
Mission Team

NASA Ames

Principal Investigator:	William Borucki
Deputy Principal Investigator:	David Koch
Project Manager:	Larry Webster
Industrial partner	Ball Aerospace
Science team	**Co-I (blue) SWG (green)**
Ball Aerospace	Harold Reitsema
Carnegie Institution of Washington	Alan Boss
Harvard University	Dimitar Sasselov
High Altitude Observatory	Timothy Brown
Lowell Observatory	Edward Dunham
NASA Ames	Jack Lissauer, David Morrison
NASA/GSFC	Yoji Kondo
Planetary Sciences Institute	Steve Howell
SETI Inst.	Edna DeVore, Jon Jenkins, Jill Tarter
Smithsonian Astrophysical Observatory	Andrea Dupree, John Geary, David Latham
Space Telescope Science Inst.	Ronald Gilliland
University of California, Berkeley	Gibor Basri, Alan Gould, Geoff Marcy
University of Hawaii	Tobias Owen
University of Texas at Austin	William Cochran
University of Washington	Donald Brownlee
York University	John Caldwell

New Technology

The mission is low risk, incorporating proven technologies, which require no additional development. Our plans include transferring CCD technology to historically black and minority colleges.



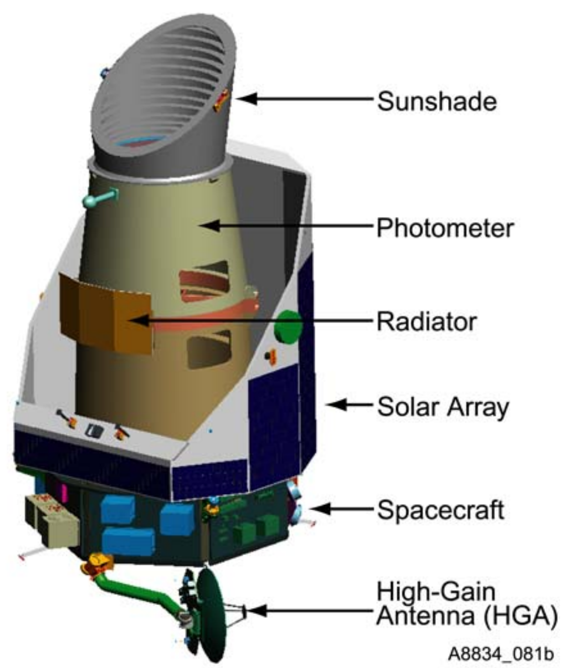
Sample transits measured with a flight-type CCD for a 12th magnitude star. *The technology demonstration of the end-to-end system showed that differential ensemble photometry can be used to reliably detect Earth-size transits (1 Earth=84ppm) in the presence of all confounding noise sources.*

Education and Public Outreach (E/PO)

The E/PO program has formal, informal and public outreach components leveraging the resources, capabilities and experiences of our E/PO partners. Products include curriculum materials, planetarium programs, exhibits, amateur astronomer support, and StarDate and PBS-style programs.

Mission Schedule

Phase B	2/02-10/03
Phase C/D	11/03-11/06
Launch	10/06
Phase E	11/06-11/11
Educational program	10/02-11/11



Kepler Flight Segment **12/01**

"Discoveries, both the pleasant and unexpected, come to those who are looking." Rudolph F. Norden