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Overview and status of the *Kepler Mission*

D. Koch[a], W. Borucki[a], E. Dunham[b], J. Geary[c], R. Gilliland[d], J. Jenkins[e], D. Latham[c], E. Bachtell[f], D. Berry[f], W. Deininger[f], R. Duren[g], T. N. Gautier[g], L. Gillis[f], D. Mayer[a], C. Miller[f], D. Shafer[f], C. Sobeck[a], C. Stewart[f], M. Weiss[f]
[a]NASA Ames Research Center, Moffett Field, CA 94035
[b]Lowell Observatory, Flagstaff, AZ 86001
[c]Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138
[d]Space Telescope Science Institute, Baltimore, MD 21218
[e]SETI Institute, Mountain View, CA 94043
[f]Ball Aerospace and Technologies Corporation, Boulder, CO 80306
[g]Jet Propulsion Laboratory, Pasadena, CA 91109

ABSTRACT

The *Kepler Mission* is a search for terrestrial planets specifically designed to detect Earth-size planets in the habitable zones of solar-like stars. In addition, the mission has a broad detection capability for a wide range of planetary sizes, planetary orbits and spectral types of stars. The mission is in the midst of the developmental phase with good progress leading to the preliminary design review later this year. Long lead procurements are well under way. An overview in all areas is presented including both the flight system (photometer and spacecraft) and the ground system. Launch is on target for 2007 on a Delta II.

Keywords: Extra-solar planets, Earth-size planets, planet detection, photometry, transit method, Kepler Mission

1. INTRODUCTION

Presently we know of more than one-hundred planets[1] orbiting other stars with orbital periods from about one day to a few years. All of these planets are known or presumed to be gas-giants with minimum masses typically greater than that of Saturn, except for a few Earth-mass planets that are known to be orbiting pulsars. The challenge is to detect Earth-size planets that are about 1/300th the mass of Jupiter with orbits in the habitable zone (HZ) of their parent star, typically of one year period for a solar-like star. The HZ is taken to be at distances from the star where liquid water can exist on the planet's surface.

The *Kepler Mission*, a principal investigator (PI) class mission, was competitively selected as NASA's tenth Discovery mission. The *Kepler Mission* is specifically designed to detect habitable planets in the HZ of solar like stars[2]. A habitable planet is taken to be between about one-half to ten Earth masses. If the planet's mass is less than about half that of Earth it doesn't have sufficient gravity to hold onto a life-sustaining atmosphere. If it is much more than about ten Earth masses then it has sufficient gravity to hold onto the abundant light elements hydrogen and helium and turn into a gas giant by accretion during the planet formation phase[3.4].

Most of the giant planets discovered to date have been detected using the radial velocity method with three planets having been discovered by the ground-based OGLE survey using the transit technique. Another method is required to find Earth-size planets. The *Kepler Mission* utilizes space-based photometry to detect planets transiting their parent stars. A Sun-Earth-like transit produces an apparent change in brightness of the star of 84 parts per million (ppm) with a duration of 13 hours, if it crosses near the center of the star. Three or more transits all with a consistent period, duration and amplitude provide a rigorous method of detection. For a statistically significant detection, the minimum detectable single transit signal-to-noise ratio (SNR) requirement is taken to be 4σ, leading to a combined average significance for four transits of 8σ. The detection threshold is set at 7σ regardless of the number of transits to yield an 84% detection rate. The total system noise, defined to be the combined differential photometric precision (CDPP) must be less than 21 ppm in 6.5 hours (half of a central transit duration for a Sun-Earth analog).

The probability for alignment of the orbital plane along the line-of-sight from the observer to the star is relatively small, equal to the ratio of the diameter of the star to the diameter of the orbit. For the Sun-Earth analog this is only

0.5%. Thus, to detect a significant number of planets one needs to look at not just a few stars or even a few hundred stars, but rather many thousands of stars.

The top level driving requirements for the *Kepler Mission* design are:

1. A CDPP of 20 ppm in 6.5 hrs and the ability to detect a single Earth-like transit with an SNR>4;
2. The capability to monitor >100,000 stars simultaneously (>170,000 stars in the first year); and
3. A mission duration of at least four years.

2. MISSION SYSTEMS

A design principle for the mission is to minimize cost and maximize success by having a single prime contractor, Ball Aerospace and Technologies Corporation, responsible for both the photometer and spacecraft. The prime contractor is also responsible for operating the mission. This approach removes many contractual barriers to optimal mission design, efficiency, risk, and schedule for the flight hardware and software. Having a single contractor allows for a single systems engineering team and common subsystem engineering teams for software, thermal, integration and test, etc. for both the photometer and the spacecraft. This approach has allowed for the broadest possible trade space when conducting studies and further eliminates the need for defining many controlled interfaces to external entities, which may often be artificial. This approach is especially important when allocating resources or requirements. For example the CDPP described above, has contributions from both the photometer and the spacecraft. The system engineer (SE) has the flexibility to balance contributions from both the photometer and spacecraft as deemed appropriate to achieve the best performance. Likewise, a 94% data completeness is needed and the SE can allocate portions of this based on the most cost effective concept for hardware/software design and mission operations. A more comprehensive discussion of the system engineering including the ground system is given elsewhere in this meeting[5].

3. MISSION DESIGN

A comparison of system impacts from candidate orbits showed that an Earth-trailing heliocentric orbit provides the best approach to meeting the mission requirements. The need for constant viewing of the selected star field and a benign environment drove the orbit selection. Orbit maintenance is not required. Reaction wheels are capable of maintaining pointing in the presence of slight solar radiation pressures. A small hydrazine reaction control system provides for the desaturation of the wheels without contaminating the optics.

Kepler is planned for launch on a Delta 2925-10L. A 2007 launch has been selected as the mission baseline. The flight segment mass is well within the performance of the Delta II launch vehicle. Unlike most interplanetary missions, *Kepler* has a daily launch window opportunity. The daily window is one second in duration, which is not uncommon. Launch on a Delta II with a C_3 of about +0.6 km^2/s^2 ensures escape into a satisfactory orbit with a period of approximately 372 days. The spacecraft will trail the Earth by 70 million km (0.47 AU) after four years.

The flight profile is straightforward, with no maneuvers after separation from the launch vehicle and no mission critical events requiring autonomous on-board decisions. Following the 30-day commissioning period *Kepler* will commence acquiring its scientific data and operate for at least four years.

4. PHOTOMETER

The photometer can be thought of as a multi-channel light meter. Its purpose is to simultaneously record very small brightness variations in over 100,000 stars, not to provide pictorial images of the sky. The photometer is a classical Schmidt telescope and is shown in Figure 1.

4.1. Optical design

Low shot noise is necessary to achieving the CDPP, so the spectral bandpass is as broad as possible from 420 to 865 nm (50% responsivity), The short wavelength cutoff is chosen to avoid the Ca II H&K, lines which are known to be the most variable portion of the solar spectrum. A trade between aperture and field-of-view (FOV) found that the most feasible choice in providing the largest number of useable stars is a 0.95 meter aperture and an FOV of >100 square degrees, making it the largest Schmidt telescope in orbit and the ninth largest ever built[6]. The celestial FOV is dictated by the desire to have the richest star field possible while still remaining well out of the ecliptic plane, so that the field can be continuously monitored throughout the orbital year. The location chosen has an RA=19^h36^m and Dec=34°40’, which is just off of the galactic plane and >55° from the ecliptic plane.

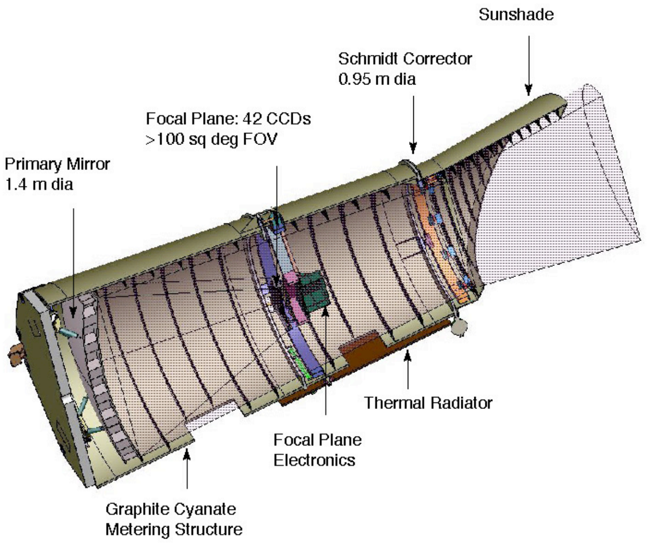

Figure 1. The Photometer consisting of the CCDs, telescope and processing electronics.

Meter-class optical components are typically high-risk, long-lead items. The critical design review (CDR) of these components has already been completed. The Schmidt corrector is manufactured from fused silica and the 85% light-weighted primary mirror is of a ULE Frit bonded construction. Both are fabricated by Corning Inc. The optical figuring is being performed by Brashear LP. Delivery of the corrector is scheduled for this fall. The primary mirror has been slumped by Corning. Delivery of the primary mirror is scheduled for mid-2005.

The optics are maintained in alignment with a graphite cyanate/ester structure that provides the thermal-mechanical stability between the corrector, primary mirror and focal plane. The mirror focus mechanisms and the redundant one-time aperture-cover release mechanism are the only mechanisms on the photometer.

4.2. Focal plane

An array of 42 charge coupled devices (CCD) are mounted at the focal surface of the telescope to measure the stellar brightness variations. Each CCD is 2200 columns by 1024 rows, thinned, back-illuminated, anti-reflection coated, 4-phase devices manufactured by **e2v** of Chelmsford, England. Each CCD has two outputs with the serial channel on the long edge. The pixels are 27 μm square, corresponding to 3.98 arcsec on the sky. The point-spread-function (psf) from each star will have 95% of its light within 2.5 to 5 pixels depending on its location in the FOV. The CCDs are packaged into 21 modules (Figure 2). The module tolerances permit a bolt-and-go approach, thus eliminating expensive shimming and alignment during integration and test. The CCDs are passively cooled by a radiator facing deep space.

The dynamic range, which meets the CDPP, is 9th to 15th visual magnitude. At 12th magnitude 1.0 Earth-radius planets can be detected about solar-like stars. At fainter magnitudes the minimum detectable planet size is larger. For example, at 15th magnitude one can detect 2.2 Earth radii planets (equivalent to 10 Earth masses) orbiting M-dwarf stars. To achieve the photometric precision, the shot noise must be made small by collecting a large number of photons. At 12th magnitude it is 14 ppm after 6.5 hours. For the brightest stars the CCDs will be operating near full well capacity. Even for the fainter stars, read noise and cosmic ray effects are relatively small compared to the total noise[7,8].

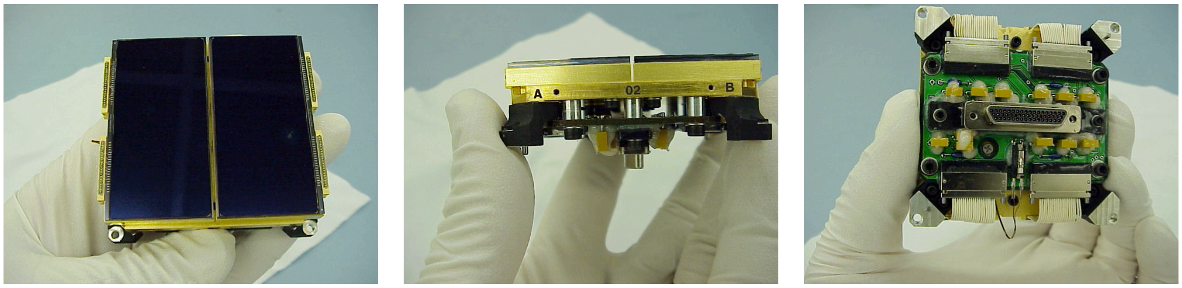

Figure 2. Views of one of 21 flight modules composed of two CCDs mounted to a common carrier.

The entire satellite is rotated ninety degrees about the optical axis four times per orbital year to maintain the radiator pointing to deep space and the solar array toward the Sun. Therefore, the CCD layout was made to be four-fold symmetric, so gaps between CCDs always fall on the same place on the sky in each of four rotations. In addition, the CCD orientations on the focal plane are such that the readout row and column directions remain the same with each rotation (except for the center module), so that potential effects of smearing due to other stars in the same column remain the same.

The CCDs are long-lead items. Thus to mitigate risk, the procurement has been phased to provide mechanical-, evaluation-, engineering- and flight-grade CCDs as a means to ensure product performance. The project has started to receive flight devices with delivery of all units scheduled for completion by December 2004.

4.3. Data handling

To minimize the amount of downlinked data, only the pixels of interest that compose each star of interest are saved, since the objective of the mission is to perform photometry and not take images. On average there are 32 pixels of interest per star, including some additional pixels surrounding each star. To preclude saturation of the brighter stars of interest, the CCDs are read out every three seconds. The readout requires just over 0.5 sec. All of the stars in each column contribute to smear, since there is no shutter. This additional signal in each column can be measured and removed later by ground processing using data from several overclocked pixels in each column. Additional collateral data from masked-dark pixels, overclocked bias pixels and sky background pixels are also recorded and used in ground processing to derive the calibrated flux levels.

The data from each pixel is co-added on-board to form a 15-minute accumulation. At the completion of a 15-minute accumulation, the data are requantized, since for higher amplitude signals the larger shot noise is substantially greater than the value of a least significant bit. Next a baseline value of each pixel is subtracted from the current value and only the difference is saved. This provides significant data compression, since the scene is always the same. Finally, the resultant is Huffman encoded, so that on average each star only uses less than 5 bits of data per 15-minute sample. For the first year 170,000 target stars will be observed when the downlink data rate is high. After the first year a down selection process will reduce the number of target stars to 100,000 by eliminating those that exhibit the greatest noise. In addition to the 15-minute cadence, the system can also provide 1-minute cadence data for 512 targets. This shorter cadence will be used to measure pressure-mode (p-mode) oscillations of stars and to better define the transit shape for high SNR transits.

The on-board data processing is performed on a radiation-hardened version of the PowerPC 750. Software reuse and heritage is from the *Ozone Mapping Profiler Suite*, HST instruments, SIRTF instruments and *Calipso*. The data are stored on a 64 Gbit solid state recorded (SRR) and nominally downlinked every four days. The SRR has a data storage capacity of nine days, sufficient to allow for a missed contact and later downlinking without having to declare a spacecraft emergency to recover the data.

5. SPACECRAFT

The *Kepler* spacecraft (Figure 3) has significant heritage from *Deep Impact* and *Orbital Express* for many of its subsystems, particularly the avionics. The purpose of the spacecraft is to provide power, pointing and telemetry for the photometer. The three-axis-stabilized spacecraft is fully redundant and single-fault tolerant.

5.1. Attitude determination and control subsystem (ADCS)

Of primary concern for achieving the photometric precision is attitude stability. Image motion has an adverse affect on the photometric precision[7] due to both the extended wings of the psf and the inter- and intra-pixel responsivity variations. The requirement is to keep the temporal frequency of anything that can affect the photometric precision well outside of the time domain for a transit. Transits can occur on time scales from an hour or so (a grazing transit of a planet with an orbit of a few days) up to 16 hours (a central transit of a planet with an orbit like Mars). To achieve the short term stability the ADCS needs to operate at about 10 Hz to keep jitter low. The specification is 0.1 arcsec 3σ about each of three axes. To prevent long-term drifts, four fine guidance sensor CCDs are mounted to the scientific focal plane at the four corners. Note that in heliocentric orbit, the only external torque is solar radiation pressure (photons). Unlike Earth orbit, there is no gravity gradient, magnetic torquing or atmospheric drag. Control is provided by four reaction wheels, which are unloaded periodically by a twelve-thruster hydrazine reaction control system. There are ten coarse sun sensors, two star trackers, and two three-axes inertial measurement units for initial acquisition, roll maneuvers and safe-survival modes.

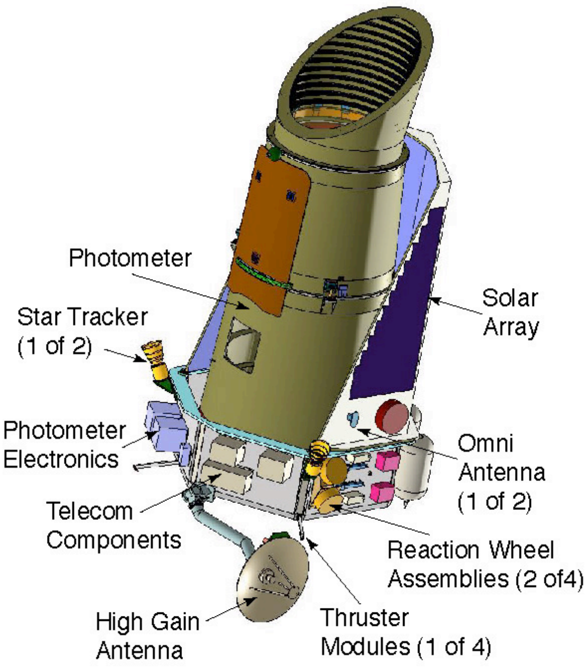

Figure 3. The *Kepler* spacecraft with the HGA deployed and the photometer.

5.2. Telecommunications

Telemetry for the stored data will be transmitted to the ground using a Ka-Band (32 GHz) high-gain antenna (HGA) with a diameter of 0.8 m. Data rates range up to 2.88 Mbps and use a 35 W traveling wave tube amplifier (TWTA). Command uplink and realtime engineering data downlink will use an omni-directional X-band (8 GHz) antenna system and a 25 W TWTA. A 34 m beam wave guide (BWG) antenna is baselined for the uplink transmitter. The one-time release HGA boom and the redundant two-axes gimbal are the only mechanisms on the spacecraft. Telcom contacts and data downlinks should not interrupt the precision or recording of the scientific data.

5.3. Power

The spacecraft power subsystem is based on a direct-energy transfer architecture. The solar array is designed to produce at least 615 W at 29±4 V at the end of mission in the nominal observing attitude. Solar-array strings are switched as required to provide power to flight segment loads. The spacecraft is rotated ninety degrees every three months to maintain the Sun on the solar array. The solar array is thermally isolated from the spacecraft and photometer. A Li-ion battery is provided to support launch and emergency modes, but is not needed for the observing mode.

5.4. Avionics

The spacecraft avionics are derived from the design used for the *Orbital Express* mission. They are fully redundant and can be cross switched between the A and B sides. The processors are the same as for the photometer, radiation hardened PowerPC 750s built by BAE. The avionics provide command and telemetry processing, formatting and storage of spacecraft housekeeping data, thermal control processing, ADCS processing, a mission unique board for items like the cover release, and network interfaces between all of the subsystems and with the photometer. Redundant crystal oscillators are used for on-board time keeping with drift rates of less than $5x10^{-11}$.

6. GROUND SYSTEM

The major interfaces of the Ground System are shown in Figure 4. During mission operations, direction for the mission comes from the Science Office and scientific data flow from the photometer to the ground where they are analyzed, eventually providing the scientific results on terrestrial planet detection.

6.1. Science Office (SO) at Ames

The *Kepler Mission* is a competitively selected principal investigator (PI) led mission. Therefore the PI (W. Borucki) at NASA Ames Research Center provides the overall strategic direction for the mission. The PI is supported by a science team made up of the Deputy PI (D. Koch), twelve co-investigators (Co-Is), a project scientist (N. Gautier) and eleven other Science Working Group (SWG) members. The Co-Is each have a specific task assigned to them that is an integral part of the mission.

Based on the data from the stellar classification program (see below), the PI will select the initial 170,000 target stars to monitor and provide this list to the Science Operations Center (SOC) (see below).

A Co-I (J. Jenkins) in the SO has developed the analysis algorithms for performing the photometry, production of the light curves and performing the transit search and reflected light search for planets. The SO will then evaluate the planetary detection candidates, direct the Follow-up Observing Program (FOP) (see below) by various Co-Is, perform the scientific interpretation with the assistance of the entire science team and present and publish the mission results.

The SO will also receive requests for targets from the guest observer and participating scientist programs and forward them to the SOC. The SO is the single source of target inputs to the SOC for building of the target files.

6.2. Stellar Classification Program (SCP)

It is necessary to preselect the target stars to obtain the greatest benefit from the mission, since in any given field there is a broad distribution of stellar sizes from supergiants and giants to dwarfs. The desire is to detect planets orbiting solar-like stars, that is, main-sequence stars, also known as dwarf stars or luminosity class V stars. Giant stars are up to one-hundred times larger in diameter than the Sun. The ability to detect a transit of a giant star is hopelessly diminished due to the enormously larger stellar area. One also prefers late spectral-type stars such as F-, G-, and K- dwarfs with effective temperatures from 7000K to 4000K rather than the much hotter, larger and shorter lived O-, B- and A-stars. One also would like to enhance the set of targets with as many early M-dwarf stars as possible. Being of lower mass, they are smaller and have their HZ closer in, making the detection of terrestrial planets possible even though these stars are fainter. There are no existing star catalogs with all the necessary information about the stars in the *Kepler* FOV. Thus the project is in the process of producing a *Kepler Input Catalog*.

The *Kepler Input Catalog* work is being led by Co-I D. W. Latham at the Smithsonian Astrophysical Observatory with the goal of providing the information needed to select a set of optimum targets, initially 170,000 from more than a million stars in the *Kepler* FOV down to about 16th magnitude. The radius of the target star is of fundamental interest, because it sets how deep the transit light curve will be. Stellar radii cannot be measured directly, but the *Kepler Input Catalog* will include stellar parameters and characteristics that can be used to estimate radius, including effective temperature, reddening, metallicity, surface gravity, and distance. Both multi-band photometry and spectroscopy will be used to estimate the astrophysical characteristics, calibrated using well-studied open clusters and stellar models. Initially reddening derived from two-color diagrams will be used to estimate stellar distances, but after the first year precise astrometry from the *Kepler* data itself will be used to derive much more accurate distances.

6.3. Science Operations Center (SOC) at Ames

The SOC develops the tools needed to perform the target selection, and formats and supplies the target list to the Flight Planning Center (FPC) (see below). The SOC develops the pipeline data processing software based on the scientific algorithms from the SO.

During operations, the SOC receives the calibrated pixel data from the Data Management Center (DMC) (see below), applies the analysis algorithms to produce light curves for each star, performs transit and reflected-light searches for detection of planets (threshold-crossing events) and performs data validation of candidates by evaluating various data products for consistency as a way to eliminate false positive detections.

The SOC also evaluates the photometric performance on an on-going basis and provides the performance metrics to the SO and Mission Management Office (MMO) (see below). The SOC develops and maintains all of the scientific databases, both catalogs and of the processed data, that the project uses.

6.4. Mission Management Office (MMO) at Ames

The MMO provides overall tactical direction for the mission to all of the elements to ensure that all the necessary resources are available and their performance meets the mission requirements. The MMO is the single source of direction to the FPC for how the mission is to be operated.

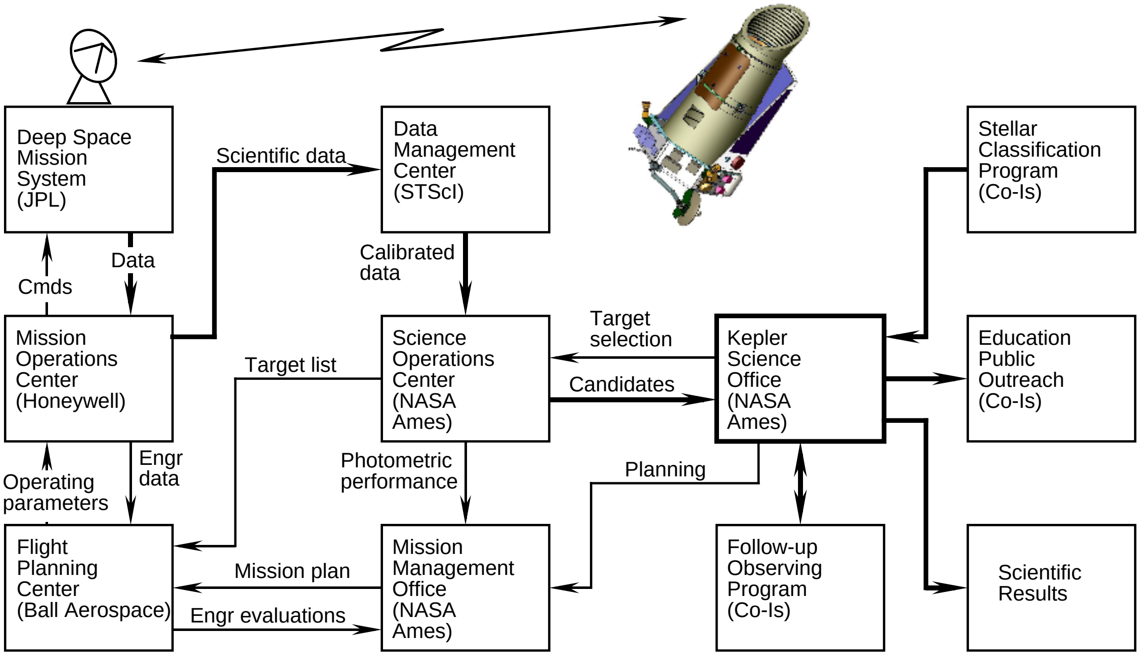

Figure 4. Major elements of the ground system. Thin lines represent operations to acquire the data. **Bold** lines represent scientific data flow.

6.5. Flight Planning Center (FPC) at Ball Aerospace

During the operational phase, Ball Aerospace, via the FPC, has the overall responsibility for the mission meeting the photometric performance, acquiring data from the desired set of targets and safely operating the mission so that it can meet the mission goals. The FPC will continuously manage the satellite performance, evaluate the engineering data, and take the lead in resolving any flight anomalies. It will receive the target list and target apertures from the SOC and generate the uplink information that the photometer requires for extraction of the pixels of interest. It will be the single source for defining the uplink information for operating the satellite.

6.6. Mission Operations Center (MOC) at Honeywell

The MOC will be operated as a subcontract to Ball Aerospace by Honeywell Technology Solutions Inc. It will build all command loads and receive all downlinked data. The scientific data will be sent on to the DMC (see below), along with any ancillary engineering data that will be used during data processing. It will also process, monitor and archive all of the spacecraft engineering data. The MOC will determine the downlinked data completeness and prepare the commanding to retransmit selected portions of the on-board data to provide as complete a data set as possible.

6.7. Deep Space Mission System (DSMS) at Jet Propulsion Laboratory

The communications link to the spacecraft will utilize the DSMS 34 m BWG system. Once contact is established, the DSMS will telemeter the command loads from the MOC to the spacecraft. Downlink data from the spacecraft will be transferred from the DSMS to the MOC.

6.8. Data Management Center (DMC) at Space Telescope Science Institute (STScI),

The scientific data will be processed at the DMC to provide a calibrated data set in flux units for each pixel of interest in the focal plane. The calibrated pixel data sets will be sent to the SOC.

The DMC will also archive the data for scientific community access for at least ten years after the end of the mission. The archived data will be made accessible to the scientific community through the existing Multi-mission Archive at Space Telescope (MAST) based on the *Kepler* data release policy. The light curves produced at the SOC for each target will also be archived in the MAST.

6.9. Data Validation & Follow-up Observing Program (FOP)

When a threshold-crossing event occurs the *Kepler* data must be examined for internal consistency to eliminate false positives. Follow-up observing will be performed by the Co-Is to both eliminate false positives and obtain further detailed information about the detected planetary systems and their parent star - or stars, if they happen to be a binary star system.

6.9.1. Data validation

This process within the SOC will look at the *Kepler* data itself to ensure that each threshold-crossing event is internally consistent by parsing the data both temporally and spatially to ensure that each sample of information that goes into a threshold-crossing event is consistent and not due to any anomalous data sample. Each of the transits must be consistent in period, depth and duration to within the statistical limits of the data. Further, the data will be examined not only with differential-ensemble aperture photometry, but also using difference image analysis. The later involves looking for residuals from the average image waveform caused by a non-central time-varying background object. In this way, background events, such as eclipsing binaries, five stellar magnitudes or more fainter can be eliminated as false positives.

6.9.2. Follow-up observing program (FOP)

Once the data have been validated for a candidate, additional information will be sought from ground-based and space-based observing. Moderate precision (~300 m/s) radial velocity observations will be made to eliminate any grazing eclipsing binaries. The spectra obtained will also be used to refine the stellar characteristics of the parent star. The stellar mass is needed for computing the planet's orbit, using Kepler's third law. The stellar size is needed for computing the planetary size. And the effective temperature is used for computing the planet's characteristic temperature. The orbit and effective temperature are used to determine if the planet is of a habitable size in the star's HZ. High-spatial resolution images will be obtained to assure oneself that there is a very low probability of a background eclipsing binary or transiting giant planet of a background star causing the event. High-precision radial-velocity observations (~3m/s) will be used to search for additional non-transiting giant planets within the systems, as a means to provide a more comprehension view of the planetary systems detected.

7. OPERATIONS AND SCHEDULE

The schedule for the mission is shown in Figure 5. Launch is scheduled for October 1, 2007 on a Delta II 2925-10L into an Earth-trailing helio-centric orbit. However, an October launch prevents performing follow-up observations until mid-2008, when the *Kepler* FOV is again available for ground-based observing. Therefore, the project is working to a schedule for a June 1, 2007 launch. Commissioning will take thirty days. The first thirty days of data will be available by August 1 and follow-up observing can be performed in August to October. All giant planets with periods less then 10 days and even terrestrial planets with periods of a week can be detected in the first month (see the following section). The mission is planned to have four years of observing with expendables to support at least a two-year mission extension.

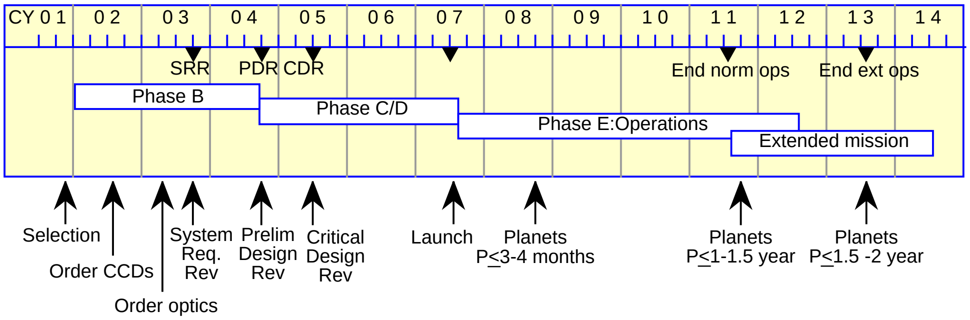

Figure 5. Major events in the *Kepler Mission* schedule.

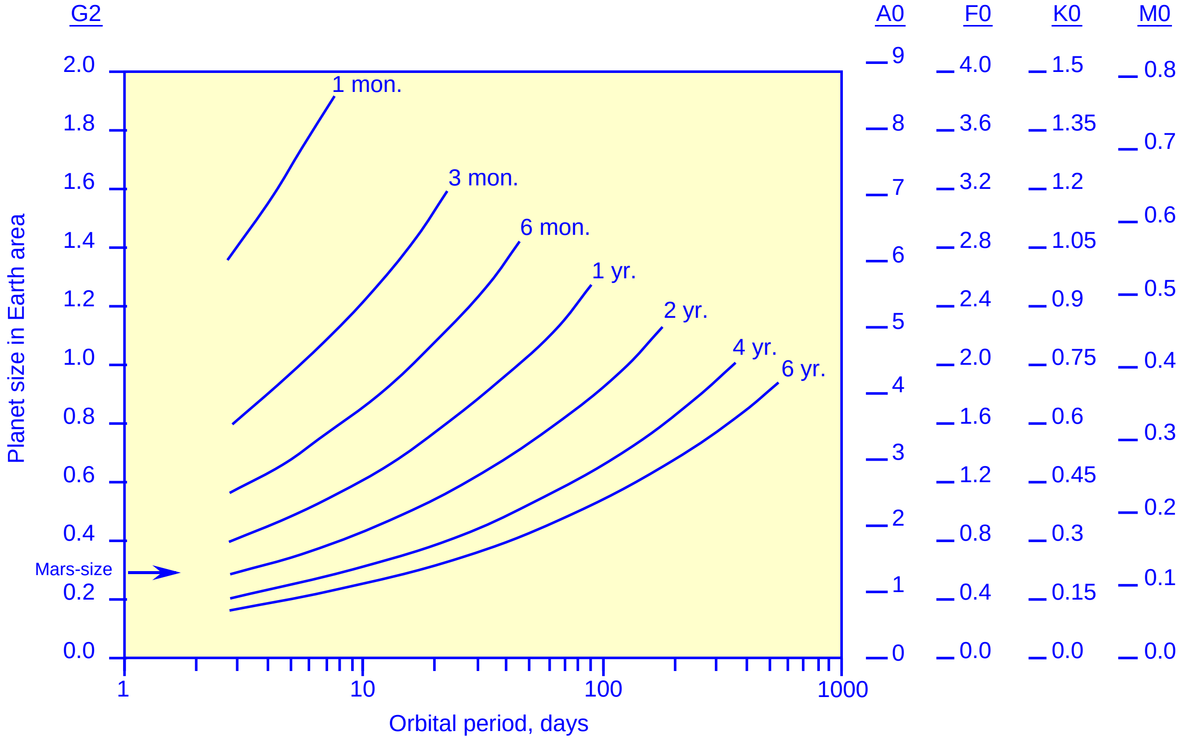

Figure 6. The minimum detectable planet size versus planetary orbital period for a 12th magnitude solar-like star (G2), a CDPP of 20 ppm and four grazing transits. Each curve represents the results for a given mission elapsed time. The scales on the right give the planet sizes for other spectral type stars.

8. EXPECTED RESULTS

The results from this mission depend on the length of the data set. The minimum detectable planet size A_p in units of Earth-area A_e is given by:

$$\frac{A_p}{A_e} = \frac{P^{1/3}}{(T/4)^{1/2}} \frac{CDPP}{21ppm} \frac{A_*}{A_o} \left(\frac{\rho_*}{\rho_o}\right)^{1/6} \frac{1}{(f/0.5)^{1/2}}, \quad (T > 4P) \qquad (1)$$

where P is the orbital period in years and T is the mission duration in years. Note that the mission duration must be greater than four times the period to ensure detection of four transits. The *CDPP* (total system noise) is in ppm for a 6.5 hour integration and depends on the root sum square of the photon shot noise, stellar variability, instrument noise and background noise[9]. The minimum detectable planet size is directly proportional to the stellar area, A_*. However, the dependence on stellar spectral type and luminosity class is rather complex[9], since the stellar size and mass also affect the duration of the transit and the mass affects the orbital period. This appears in the equation as a stellar density term ρ_* relative to the Sun to the 1/6th power and weakens the dependence on period P from a 1/2 to 1/3 power. Smaller stars, shorter orbital periods, lower *CDPP* and a longer mission improve the ability to detect smaller planets. The last term accounts for the fractional duration of a transit relative to crossing the center of a star. The minimum detectable planet size shown in Figure 6 assumes a transit with $f=0.5$. Transits with $f \geq 0.5$ account for 86.6% of the cases.

Planets with periods less than a week will be detected within the first-month's data set with the minimum detectable planet size being as small as 0.6 Earth-area for an M0 star. By the end of the first year, 1.0-Earth-size planets will be detectable out to orbits of 1.5 months and by four years 1.0-Earth-size planets in one-year orbits will be detectable about solar-like stars. By the end of six years of observing planets substantially smaller than Mars will even be detectable in short period orbits and the SNR for all planets found earlier in the mission will have been improved.

ACKNOWLEDGEMENTS

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