

Kepler Spacecraft Call for White Papers: Spacedesign “Kepler Max Blue” Response

Organization Information

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Abstract

Spacedesign Corporation’s submission involves rotating the spacecraft to reduce the pointing accuracy to a single axis, subdividing the detector into two linear strip arrays (one named MAX and one named BLUE), and using a statistical two factors averaging technique to sense possible planet crossings with the MAX array while capturing precise elemental data with the trailing BLUE array. It is also suggested that transmitting data at a higher data rate may be possible using multiple input multiple output (MIMO) layered space-time communication architecture like that used by modern cell phone networks. Given these changes to the operation of the spacecraft the same science mission may be performed to achieve more or equivalent planetary candidate detection, albeit over a larger investigated area. General details are given and it is expected that the detailed operations would be worked out with the spacecraft stakeholders.

System Concept

What is the axis of rotation?

The axis of rotation keeps the solar panels oriented toward the Sun and the radiator oriented towards deep-space at all times but allows the instrument to see a swath of sky. Although finer details need to be worked out, a rotation rate of 0.1 degrees per second (1 complete rotation per hour) is selected as an initial guess. Two concerns are the instrument seeing bright sources like the Earth or Moon and how to point the high gain antenna toward the Earth given the limited rotation look angle duration without stopping the rotation. Figure 1 shows one of two possible rotation directions, the other direction being the same plane but with an opposite sign. The center of mass is not known but the best point for illustration was chosen.

Rotating the spacecraft would reduce the pointing to a single axis. This should allow the mission to proceed using a single reaction wheel with the remaining wheel acting as a backup.

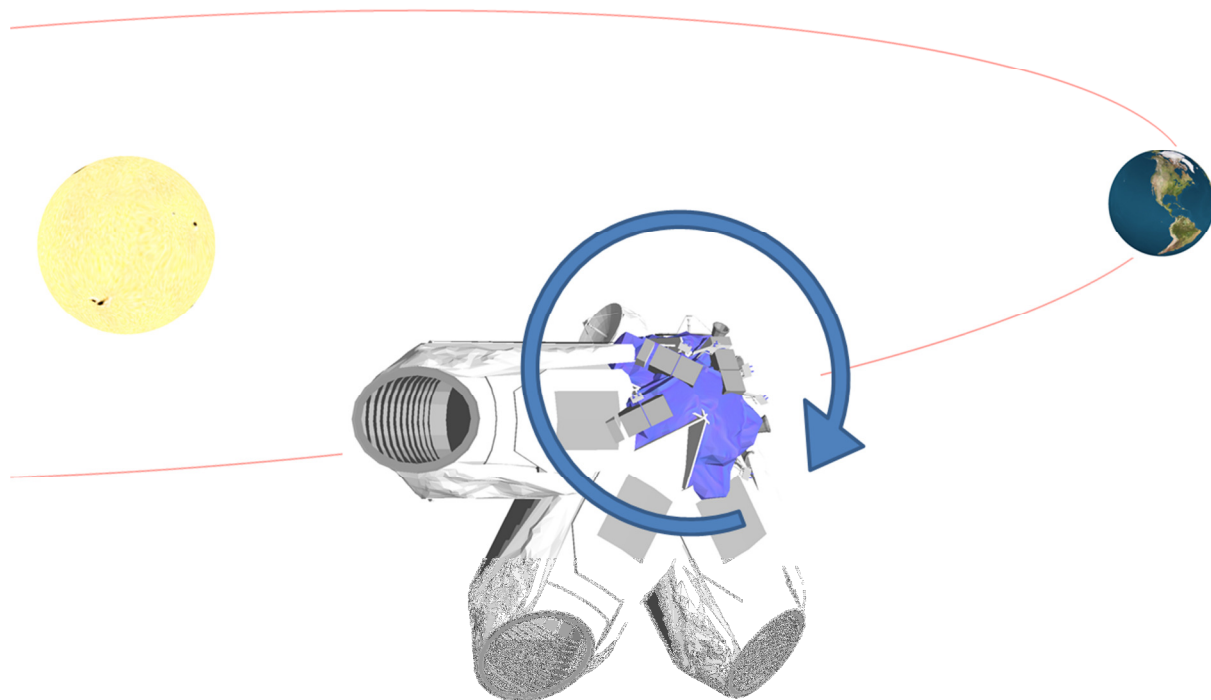


Figure 1 – Kepler Max Blue Rotation relative to Sun and Earth (note: rotation is continuous 360°)

What are the MAX and BLUE sampling arrays?

The MAX and BLUE sampling arrays are the existing detector CCD's re-organized for viewing the swath of sky that passes as the spacecraft rotates. The proposed arrays would use only 10 of the 21 CCD's.

The data sampling is performed by two instruments working in concert – MAX and BLUE. Images will first pass the Multiple Average Xeno-array (MAX) that uses the Short Cadence Collateral (SCC) data (and/or the Long Cadence Collateral (LCC)) to obtain average brightness over the detectors rows and columns. If a statistically significant event using a two-factor factorial method is sensed then the second instrument, the Binary-tree Latent Up-field Element-sampling (BLUE) that samples individual targets selected from a target definition tree will observe the suspected elemental brightness of the candidate star.

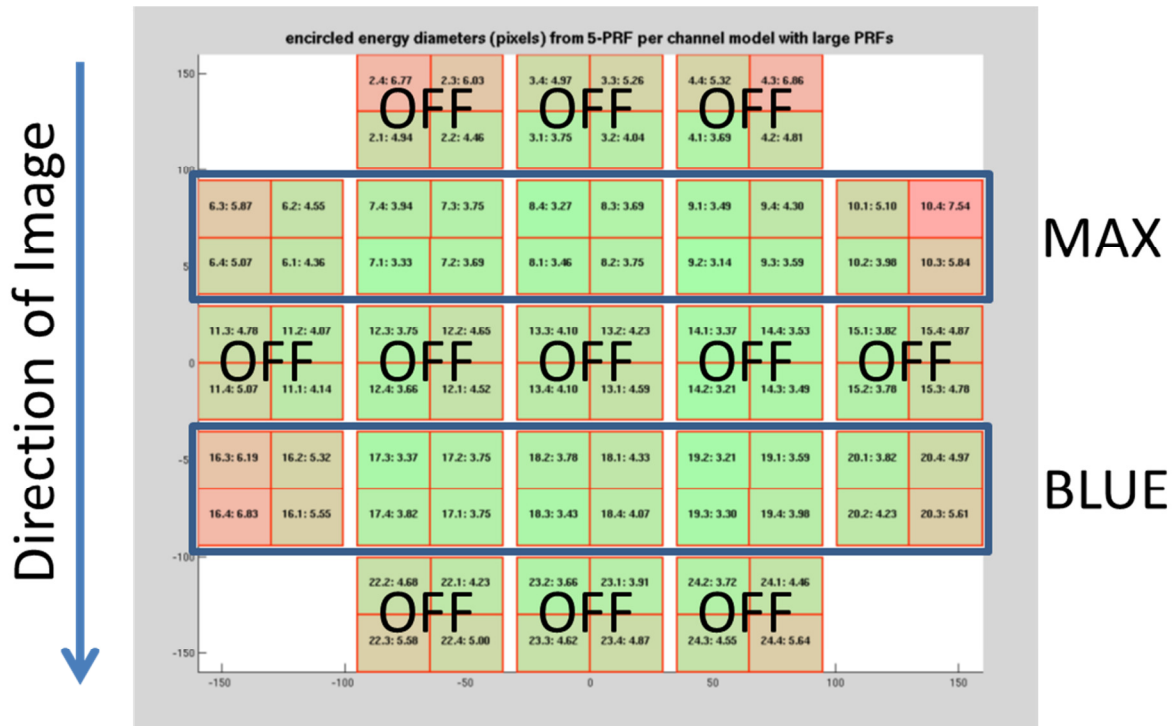


Figure 2 – Description of MAX and BLUE Sampling Arrays (illustration only, orientation may be different)

What is the statistical two factor averaging technique MAX will use to sense a statistical significance change across an entire CCD?

To eliminate noise and search for significant planet crossing (i.e. “interaction effect” of the horizontal and vertical averages) a two factor factorial method (see Chapter 6 in Hogg) will be used to process the averages obtained from the SCC (or LCC) data from the MAX array.¹ The averages are chosen to minimize the data taken from the array. Using averages also greatly reduces the per spin data reduction to keep a continuous total average.

The BLUE array will have to make multiple images of the candidate as it passes through the BLUE field of view. Work needs to be done to understand how this is possible given the slow rotation rate.

What is the science goal of the Kepler Max Blue mission?

The science goals of the Kepler Max Blue are the same as the nominal Kepler mission with changes in the operation of the spacecraft to meet the two reaction wheel pointing constraint. The nominal mission of Kepler was to determine the frequency of Earth-size exoplanets orbiting solar type stars.

How could the communications be changed?

¹ Hogg, R. V.; Ledolter, J. I. (1987) *Engineering Statistics*, New York, NY: Macmillan, ISBN 0-02-355790-7

It is also suggested that transmitting data at a higher data rate may be possible using multiple input multiple output (MIMO) layered space-time communication architecture like that used by modern cell phone networks. Although indications are that the X-band and Ka-band antennas cannot transmit at the same frequency which would have bolstered this suggestion.

What are the limitations of this response?

This response defines a top level data collection, sampling, and reduction methodology and is in no way meant to be a comprehensive operational guide or science goal document. Considerations such as pointing capabilities on a single axis while rotating, thermal response to rotation, data transfer between components/HGA/ground, etc. need to be worked out.