SMALL OPTICAL NAVIGATION CAMERA FOR INTERPLANETARY MISSIONS

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ABSTRACT:

High accuracy planet-relative navigation requirements for direct-entry landers or aerocapture orbiters, primarily at Mars, have driven the development of a small visible light camera which can acquire images of planetary satellites (or other solar system objects for other navigation applications) against a field of reference stars. The primary measurements are the distances in pixels between the centroids of the stars and the centroid of the the solar system object . Tenth pixel centroiding is expected for both stars and extended objects at the expected signal-to-noise ratios and with the size of the optical point-spread relative to the physical pixel size (12 microns). A series of pictures will allow estimation of both the orbits of the planetary satellites as well as the trajectory of the approaching spacecraft.

The camera uses a 6 cm aperture in a Cassegrain design, with refractive correcting elements immediately in front of the focal plane. The focal length is 50 cm. The mass of the system is about 2.75 kilograms, roughly an order of magnitude smaller than the cameras that have been or will be used for interplanetary optical navigation on a number of missions such as Viking, Voyager, Galileo and Cassini. The low mass was in part driven to allow the camera to fly on small Discovery and Scout missions. A preliminary effort to further lightweight the camera shows that it may be possible to drive the mass below 2 kg.

To reduce the mass, footprint and power required for operation, the camera makes use of component hybridization for the detector electronics. The imaging device consists of a 2048 by 1024 frame transfer CCD array. A custom analog CMOS signal-processing chip is hybridized directly to the imager, and custom clock drivers are attached to the imager package. The remaining camera components such as power supplies, analog-to-digital conversion, image storage and control clock generation reside on a peripheral electronics board. The resulting miniaturized imager assembly has 12 micron physical pixels, which equates to twenty four micro-radians angular pixels.

The camera will be flight-tested on the Mars Reconnaissance Orbiter (MRO) to be launched in 2005. With the expected accuracy of a few microradians, the positional accuracy with respect to Mars will be sub-kilometer with data taken down to 1 day from encounter. This would be equivalent to an error of about 0.03 degrees in flight path angle

for an atmospheric entry mission, three times better than the tightest requirements that have been levied by aerocapture orbiter or direct entry lander missions.

The operational scenario, the number of images expected, the image processing and the expected navigation accuracies will be discussed, as well as future mission applications.