The Stellar Reference Unit for the Europa Orbiter mission

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Scientific data indicate that Jupiter's fourth largest satellite, Europa, is covered with a surface of ice. Due to Jupiter's tidal pull, it is believed that the underside of the ice pack may be melted, forming an ocean of liquid water underneath the surface. Scientists are interested in searching for evidence of life that may have evolved near undersea volcanic vents. At the Jet Propulsion Laboratory, development has begun on a mission to send a spacecraft to Europa in November, 2003. The primary scientific objectives will be to measure the thickness of the surface ice and to detect if a liquid ocean does exist.

The radiation environment close to Jupiter poses a unique and significant challenge in the field of spacecraft avionics design. The Total Integrated Dose (TID) mission exposure is estimated to be 4 Mrads-Si behind 0.1" of aluminum shielding. While orbiting Europa, the spacecraft will experience a flux of 2.6x10E7 electrons/(s-cm^2) for electrons of 1 MeV or greater, and a flux of 1.5x10E5 protons/(s-cm^2) for protons of 10 MeV or greater.

This paper will discuss the Stellar Reference Unit (SRU) onboard the spacecraft. No existing star tracker design can operate in the Europa environment. The problems are multitude. The TID will cause ordinary optical glass to darken. Silicon based detectors typically experience threshold shifts, increased dark current, reduced quantum efficiency and reduced charge transfer efficiency (in the case of CCDs). An even more severe impact on the star tracker design is the proton and electron flux at Europa. An electron impinging on a silicon detector will typically deposit thousands of electron-holes pairs in a pixel. A proton hitting a silicon detector will typically generate a bright spot. Electrons and protons incident on glass in the optical path will generate fluorescence, phosphorescence and Cerenkov effects, which contribute to the background signal.

To address these problems, while keeping the mass of the SRU to about 5 kg, the current baseline is to shield with 10 g/cm^2 and use a folded optical pathway. This will decrease the TID to less than 100 KRads, the electron flux to approximately 5.0x10E5 electrons/second pr cm^2 and the proton flux to an insignificant level. While a TID of 100 KRads is manageable using radhard components and materials, the residual electron flux will make it very difficult to determine star centroids accurately using any silicon detector, due to the radiation-induced noise. It is believed that sampling the image rapidly (> 10 Hz), will make it possible to reject radiation corrupted star centroids by processing multiple images and performing frame to frame correlation.

This paper will describe the current understanding of the problems and discuss ways to overcome the technical challenges in the Europa environment.