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TIRI: A MULTI-PURPOSE THERMAL INFRARED PAYLOAD FOR PLANETARY EXPLORATION

Abstract

TIRI is a multi-purpose Thermal InfraRed (TIR) Imager, initially designed for the Asteroid Impact Mission, an ESA Technology Mission of Opportunity targeting Didymos, a binary near–Earth asteroid. TIRI is conceived to pursue scientific and technology development goals. It will be used to determine asteroid surface physical parameters, such as temperature, thermal inertia, chemical composition, rock shape, and to aid the spacecraft navigation.

A European consortium, formed by cosine measurement systems and GMV, has carried out the TIRI preliminary design within the ESA General Studies Programme.

TIRI takes advantage of the recent technology developments in TIR sensors, optical manufacturing and materials, electronics, and navigation algorithms. The result is a medium sized payload (11 kg mass and 18 litre volume) enabling both scientific and navigation tasks. TIRI integrates two optical systems. The first is an imaging line-spectrometer, exhibiting a spatial resolution of few metres and a spectral resolution in the range of tens of nanometres. It allows to determine the asteroid surface temperature with an accuracy of 5 K, to quantitatively evaluate its thermal inertia, and to sample its spectrum with more than 20 bands in the 8 m - 14 m range for asteroid composition retrieval. The second TIRI optical head is NavIR$^{\mathrm{TM}}$, a miniaturised thermal infrared navigation camera (less than 1.5 litre volume), based on the HyperScout® design, developed by cosine under an ESA GSTP contract. It exhibits a fully reflective telescope with a large 2D field of view (up to 24x16).

Both optical instruments are integrated in the same mechanical structure and employ uncooled micro-bolometer arrays as detectors. The TIRI electronic system controls both detectors. It is capable to process the acquired frames enhancing their radiometric quality and to run the navigation algorithms.

The navigation system uses the NavIR$^{\text{TM}}$ imagery to determine the spacecraft position and velocity relative to the asteroid. The image processing algorithms include centroiding (providing line-of-sight) and unknown feature tracking (identifying and tracking a-priori unknown features on the asteroid surface). The navigation algorithms have been tested in a functional engineering simulator. TIR images have been simulated, considering the asteroid and the navigation camera models and achieving a high level of realism. The simulations showed that performance comparable to those of a visible navigation system is achieved. Irrespective of the observation phase, a position error in the order of tens of metres and a velocity error of centimetres per second are obtained in the line-of-sight direction.