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TAILORING INFRARED FILTERS FOR GLOBAL MAPPING OF ENCELADUS' SURFACE TEMPERATURES

Abstract

Introduction: The Cassini Mission revealed Enceladus to be a prime candidate for astrobiological study, with a subsurface ocean and cryovolcanism concentrated at the 'tiger stripe' fractures at its South Pole. Acquiring precise data on daily temperature variation, as well as spatial temperature distribution across the moon's surface, will be critical for interpreting its evolution, geological behaviour and evaluating potential habitability. Combining heritage from TechDemoSat-1, Mars Climate Sounder, and Lunar Trailblazer, the University of Oxford's Enceladus Thermal Mapper (ETM) brings new opportunities and challenges in observing this active icy moon of Saturn. This high heritage instrument will measure Enceladus' day, night, and polar-night temperatures, characterising the moon's activity, and surface properties. Winter temperatures on Enceladus can reach as low as 45 K, presenting significant challenges that necessitate adaptations in the previously lunar-focused filter assembly design and instrument operations - such as extended integration times and rigorous noise control.

High-Resolution Multi-Band Radiometric Thermal Mapping vs Spectroscopy: Cassini's Composite Infrared Spectrometer (CIRS) achieved high spectral and spatial resolution, with its highest spatial resolution detectors (focal planes 3 and 4) having 10 pixels, each with an instantaneous field-of-view (iFOV) of 0.273 mrad [1]. However, due to the limited flyby nature of Cassini much of Enceladus was left without high spatial resolution thermal mapping. In contrast, the University of Oxford's multi-band radiometric instrument operates 384 cross-track line scanning pixels, each with an iFOV of 0.540 mrad. The instrument has space for 15 wavelength bands and operates as a 384 x 288 pixel push-broom sensor. Preliminary mission concepts anticipate flying this instrument in orbit around Enceladus at an altitude of 150 km. This would mean ETM could globally map Enceladus at 80 m/pixel resolution, with a track 31 km wide.

Digital Instrument Model for Optimised Filter Selection: We will discuss the newly developed model of the instrument filter assembly, which creates a framework for systematically optimising bandpass filter selection to meet scientific goals. Strategically chosen filter profiles will enable the determination

of the full seasonal and diurnal range of Enceladus' thermal emission, allowing for precise temperature measurements with a goal of improving constraints on global thermal emission due to tidal heating. The suitability of different filter assemblies for different science goals will be discussed.

References: [1] Howett, C. J. A., Spencer, J. R., Pearl, J., and Segura, M. (2011) J. Geophys. Res., 116, E03003. [2] NASA/JPL/GSFC/SWRI/SSI (2010) "Zooming in on heat at Baghdad Sulcus", Cassini-Huygens, https://saturn.jpl.nasa.gov/