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Multiple Instrument Distributed Aperture Sensor (MIDAS) orbital remote sensing approach for characterizing the astrobiological potential of planets

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In this presentation we discuss our MIDAS (Multiple Instrument Distributed Aperture Sensor) remote sensing payload [Pitman *et al*, SPIE paper 5660-26, November 2004] as one approach to enabling a revolution in future planetary science exploration. We describe the concept, its heritage, key features, science capabilities, development plans and demonstration testing. This highly-scalable integrated electro-optical system includes a large-aperture telescope array that is diffraction-limited at its overall synthetic aperture diameter, along with an integrated laser subsystem and six modular back-end science instrument sensor modules capable of sequential or concurrent operations. Taken together, this system enables orders of magnitude improvement in planetary science remote sensing, enabling many approaches to characterizing the astrobiological potential of planets from orbit. For instance, during a 100km science orbit Europa science investigation, our MIDAS 1.5m aperture point design achieves 1nm hyperspectral imaging at 2cm spatial resolution, broadband in UV/VIS/NIR, for processing by one or multiple instrument sensors, passively or actively enhanced by laser illumination. For more distant orbits, MIDAS provides years of near-continuous remote sensing capability to build a rich science data set that features 1nm spectral resolution for all images, providing $<$1m resolution global coverage out to 5,000km altitude. For flybys of planetary satellites, MIDAS enables orders of magnitude longer duration high-resolution imaging opportunities near closest approach. MIDAS was recently awarded funding by NASA/HQ for a technology development activity to demonstrate

the effectiveness of applying many of the advanced remote sensing techniques it enables toward increasing planetary science return many fold, consistent with and guided by the science objectives, goals and visions put forth by the international planetary science community.

Orbital remote sensing to globally search, regionally characterize, and locally investigate key physical and spectral features known to be related to life sign processes here on Earth is one means of increasing the science data return and investigation results of future astrobiology science missions conducted at planets in our solar system. To date, the remote sensing payloads flown on planetary science missions have, by and large, had capabilities that have produced many discoveries from the imagery and spectral maps of these distant worlds. However, these data are at best 1m resolution with incomplete coverage, and are spectrally limited in both resolution and wavelength range. Typically only passive remote sensing techniques have been used to date (excepting laser altimetry), with the associated constraints from the magnitude, spectral content, timing and phasing of sunlight for surface illumination. In contrast, characterizing astrobiological potential from a planetary orbit requires the unambiguous characterization of organic compounds, in sufficient detail to discriminate subtle spectral signatures of key biomarkers. This must be performed at the characteristic scale of the key physical sizes of habitats and features associated with those life sign processes. Terrestrial analog studies indicate that these scales are important down to tens of centimeters or better. Accordingly, orbital systems used to date have had very limited effectiveness in life sign searches on planets in our solar system.

Advances in remote sensing payload approaches and technologies for Earth reconnaissance applications offers to increase resolution capabilities by over two orders of magnitude while introducing the possibility of using active sensing techniques. Together these advances offer to revolutionize the next generation of planetary science exploration. This paradigm shift enables more comprehensive and effective mission planning strategies for precise, global characterization of astrobiological potential on planet surfaces. For example, newly enabled strategies might include improving surface site selection for landed science probes or packages as well as for improved rover site traversing. The application of high-resolution and active sensing surface characterization of surface sites from orbit in near real-time can improve science return and potentially increase the number of landed packages. New strategies might also exploit fine resolution and active sensing capabilities by using highly elliptic orbits capable of providing both long dwell times to passively monitor dynamics of surface processes and very low altitude passes to enable, with a fast imager, even finer resolution passive or active sensing of local regions of interest. Many other new strategies emerge once orbital remote sensing reaches the resolutions needed to characterize features of astrobiological interest.

To date, our assessments of the application of MIDAS technology to NASA missions have been focused on the Prometheus class of nuclear electric propulsion system missions to the outer planets, with notional missions to Europa, Titan and Triton. The application of MIDAS technology to astrobiology science investigation goals on Mars by means of advanced orbital remote sensing, particularly as a complement to strategies that place science probes, packages or rovers on the surface, are compelling. Although the existing remote sensing capabilities of Mars Express (ME) and Mars Global Surveyor (MGS) add considerably to our science data, they are still very limited by resolutions of global maps to no better than 100m, selected regional images at about 10m resolution, and local images to 1 to 2m resolution. Even the next generation of Mars remote sensing NASA missions, the Mars Reconnaissance Orbiter (MRO) planned for launch in August 2005 will be capable of resolving some local regions of interest to only 1m. Furthermore, all these ongoing and future Mars remote sensing missions rely on only passive techniques for imagery and composition mapping. The current science data set generated by the extremely successful fly-by exploration missions of the Galileo spacecraft at Europa, as well as the ongoing Cassini mission exploration of Titan, can also be expanded upon tremendously by a MIDAS-style payload of instruments. As valuable as these existing remote sensing instruments are in advancing the planetary sciences in general, such as for increasing our understanding of their geology, the orders of magnitude improvements in resolution achieved in comparison, along with the novel remote sensing techniques it enables (such as concurrent interrogation by six instrument sensors and laser-enhanced active spectral sensing) make a MIDAS payload approach a compelling candidate for the next generation of planetary science missions satisfying the more stringent requirements for orbital characterization of the astrobiological potential of Mars, Europa, Titan and other solar system bodies.