ISIS: Imaging Spectrometer for Icy Satellites. S. Murchie[1], K. Cooper[1], E. H. Darlington[1], D. Domingue[1], F. Morgan[1], R. Greeley[2], C. Paranicas[1], L. Prockter[1], D. Roth[1], T. Roush[3], K. Strohbehn[1], P. Thompson[1], M. Wirzburger[1], [1]The Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Rd. Laurel MD 20723 (scott.murchie@jhuapl.edu) , [2]Department of Geological Sciences, Arizona State University, Box 87104, Tempe AZ 85287-1404 (greeley@asu.edu), [3]NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035-1000 (troush@mail.arc.nasa.gov).

Introduction: The Imaging Spectrometer for Icy Satellites (ISIS) is an instrument design adapted from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter (MRO). Its measurement goals were derived from a flow-down of the JIMO (Jupiter Icy Moon Orbiter) science objectives, established during the JIMO Forum (June 2003, Houston, TX). The design investigation was originally a three year development project within the HCIPE (High Capability Instrument for Planetary Exploration) program. However, with the cancellation of the JIMO mission, subsequent curtailment of the HCIPE program to a single year of effort, and the growing support for a flagship Europa Orbiter mission, the design development for ISIS was refocused to be applicable to a Europa Orbiter mission. The mission profile and payload constraints are based on a previous Europa Orbiter mission announcement of opportunity (AO 99-OSS-04) and preliminary inputs being provided through the Outer Planets Assessment Group (OPAG) for a more current, revised Europa Orbiter mission.

Science Goals: The science objectives for a Europa Orbiter mission include:

- Confirm the presence of a sub-surface ocean
- Characterize the three-dimensional structure of the icy crust
- ***Map organic and inorganic composition of the surface***
  - o ***Determine surface composition from orbit, especially as relevant to exobiology***
  - o Potentially examine pre-biotic chemistry in situ
- ***Characterize surface geologic features, especially as relevant for landing sites***
- Characterize the magnetic field and radiation
- ***Understand heat source(s) and their time history***

The highlighted objectives are achievable with ISIS.

Mission Profile: The assumed mission profile is based on the previous Europa Orbiter announcement (AO 99-OSS-04) with a high (80°) inclination, 3 PM mean local solar time sun-synchronous orbit with a 1.3 km/sec relative ground velocity. Mission duration is assumed to be 28 days. All instrumentation is assumed to be nadir pointed. Downlink of 360 kbps is assumed to available for 60% of the time. MRO-like allotments for mass and power are assumed.

Driving Science Requirements: The driving requirements are to map the global organic/inorganic composition at relatively high spatial and spectral resolutions, to acquire information pertinent to possible future landing sites, and to do so in an extreme radiation environment. Derived instrument performance specifications include global coverage within the assumed mission duration, spectral sampling of <6 nm/channel, spatial sampling of <100 m/pixel , and an SNR adequate to measure key absorption bands. The ISIS development effort addressed each of the driving requirements, resulting in a design that meets its performance specifications.

Assumed Observing Plan: Assuming a 60% downlink allocation to ISIS and onboard compression capabilities, global hyperspectral mapping is impractical. Instead we adopted CRISM's strategy of obtaining global coverage at key wavelengths selected in software, clustering spectral resolution at key absorption bands, and complementing that with fully hyperspectral coverage of targeted localities. The acheivable data return within the resource envelope we assumed includes (1) a 4-color global map with 40 m/pxl spatial sampling, (2) 12 additional colors at 80 m/pxl spatial sampling, and (3) targeted hyperspectral coverage.

Development Focus: The ISIS instrument development effort is based on adapting CRISM's design to the constraints of Jupiter's radiation environment and obtaining global coverage in one month. In some places adapting existing designs proved feasible, and where this was impractical, new designs were developed and their performance modeled or tested. We found that much of the instrument electonics could be adapted with proper radiation shielding, but that new optics and a larger-format detector are needed to meet spatial coverage and resolution and spectral range and resolution requirements. A list of development risk areas was created, and the areas of focus were to retire the most significant of the ISIS risks. The top three risks where work has focused are:

- Proving radiation tolerance of parts and designing adequate radiation shielding for suceptible parts;
- Designing optics that simulateously meet the spatial and spectral coverage and resolution requirements
- Proving the robustness of data compression operating at a sufficient rate in a high-radiation environment .

Simultanously, the design has to meet reduced mass and power requirements consistent with the resources availability of a Europa Orbiter mission.

Design Overview: The system is required to cover the visible and IR range from 400 to 5000 nm, with a spectral sampling of ~5 nm. In the past (e.g., CRISM) it has been customary to use a silicon array for the visible and an IR array beyond 1 micron. Recent developments in detector technology yield larger format arrays that are sensitive from the visible through the IR, and have better performance in radiation environments. This enables a single-detector design with consequent mechanical and optical simplification, that keep the instrument within its assumed resource envelope while meeting performance requirements. Figure 1. shows the preliminary optomechanical design.

Performance Overview: The performance of a baseline ISIS design was modeled with realistic optical parameters in order to assess the expected performance. Spatial and spectral range and sampling requirements are met, and optical distortion is sufficiently low to enable electonic switching between multispectral and hyperspectral operating modes as in CRISM.

Required SNR values were determined using Galileo NIMS spectra of Europa and Ganymede, based on providing suitable dynamic range in the measured depth of key absorption bands. Three absorption features were targeted: (1) at 1050 nm, seen in the Europa hydrated materials spectrum, (2) at 1630 nm, seen in the comparison of Ganymede ice to Ganymede hydrated material spectra, and (3) at 4250 nm, seen in both the Ganymede ice and hydrate material spectra. Our radiometric performance model suggests that at 1050 and 1630 nm, SNRs achieved are well above the required values. Estimated SNR at 4250 nm is met in bright regions following averaging of multiple spatial pixels. .

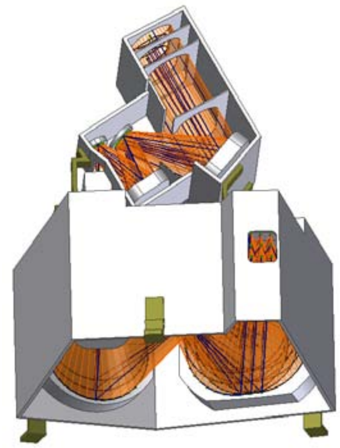

Figure 1. CAD rendering of ISIS optomechanical design.