THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) ENVIRONMENTAL LITTORAL IMAGING FROM THE INTERNATIONAL SPACE STATION

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1. INTRODUCTION

The Hyperspectral Imager for the Coastal Ocean (HICO), developed and built by the Remote Sensing Division of the Naval Research Laboratory (NRL), is the first spaceborne hyperspectral imager optimized for environmental characterization the coastal ocean and land. Hyperspectral imaging has demonstrated the ability to retrieve bathymetry, suspended and dissolved matter content, chlorophyll content, and bottom type from complicated coastal scenes [1, 2]. However, designing a hyperspectral imager for environmental characterization of the coastal zone presents several challenges that are often not encountered for systems designed for land applications. The coastal ocean is a low-albedo scene, and from space is viewed through atmospherically-scattered light that is significantly brighter than the ocean surface but contains no information about the water column. This leads to a requirement that the hyperspectral imager must have a very high signal-to-noise ratio to ensure an adequate signal-to-noise ratio for the underlying water scene after the atmospheric light is removed. Additionally, quantitative environmental characterization of a scene often requires matching the observed spectral radiances of the scene pixels to spectral libraries or the results of bio-physical models. This consideration leads to stringent requirements for accurate radiometric calibration and coverage of all water-penetrating wavelengths (400-700 nm) in contiguous bands of 5 to 10 nm width. In addition, the spaceborne sensor

must provide spectral image data from 700 to 900 nm, which is needed to accurately determine the effects of the atmospheric scattering and surface reflection so they can be removed [3].

2. HICO DESIGN AND PERFORMANCE

HICO is sponsored by the Office of Naval Research (ONR) under ONR's Innovative Naval Prototype (INP) program. The flight model HICO imager is shown in Figure 1. During laboratory calibration

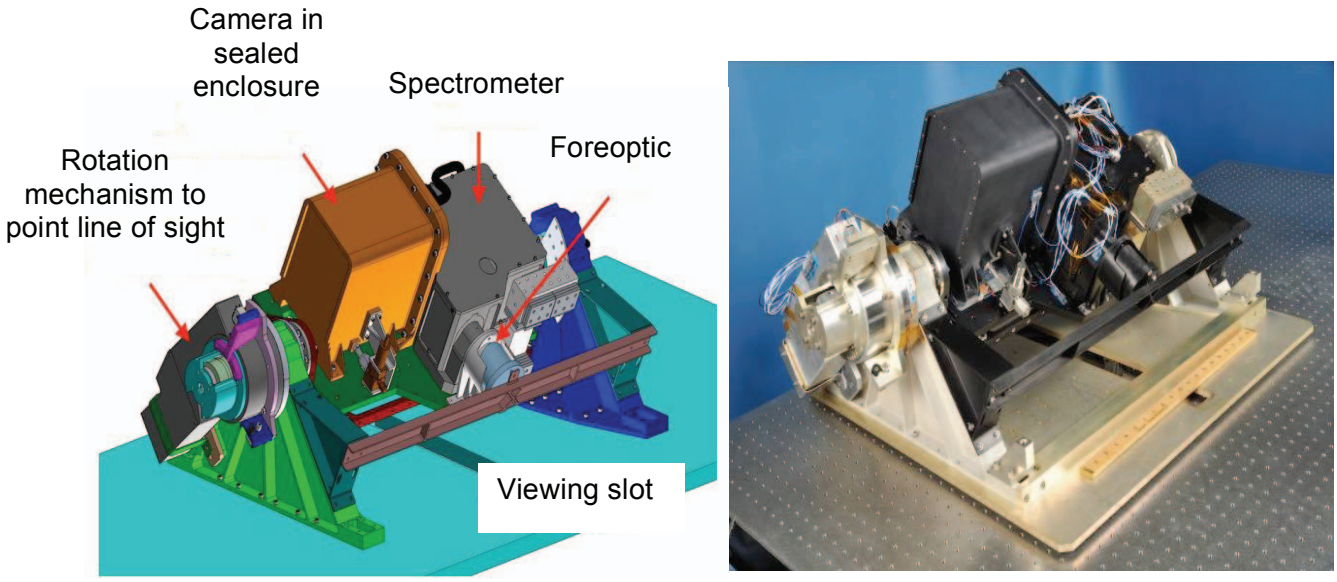

Figure 1. The functional components of the HICO imager are shown on the left. The flight imager is shown on the right. HICO images through a slot in the nadir panel of the payload enclosure.

HICO was shown to have a signal-to-noise ratio greater than 200 to 1 for water-penetrating wavelengths, when viewing a scene modeled using MODTRAN [4] assuming 5 % surface albedo to represent the coastal ocean. Radiometric calibration of HICO over the wavelength range 380 to 900 nm was performed with error of less than 5 %. In addition to HICO's pathfinder role in demonstrating the ability to retrieve products of Naval utility from space, HICO also addressed the INP goal of demonstrating ways to save cost and time in building a space payload. HICO was built using a commercially-available Offner spectrometer, a commercial CCD camera and camera electronics, and a commercial vacuum-rated laboratory-style motorized rotary stage for cross-track pointing of the line of sight to increase the frequency of scene accesses. The camera is not designed to operate in vacuum and

therefore is housed in a sealed enclosure containing nitrogen gas and a fan to circulate it. The HICO imager was designed, built, calibrated, and completed vibration and thermal-vacuum testing, in 16 months.

HICO is one of two science instruments in the HICO RAIDS Experiment Payload (HREP); the other is the NRL Remote Atmospheric and Ionospheric Detection System (RAIDS), which is a limb imager for atmospheric research. HREP also incorporates a star tracker to provide the payload attitude, which in combination with the Space Station ephemeris is used to geolocate the HICO images. HREP was launched to the International Space Station from the Tanegashima Space Center in Japan on September 10, 2009, and attached to the Japanese Experiment Module – Exposed facility which provides electrical power and telemetry. HREP is integrated and flown under the direction of the Department of Defense Space Test Program.

From the Space Station at approximately 350 km altitude and 52 degrees orbital inclination, HICO images at 90 m ground sample distance over the wavelength range 380 to 900 nm in contiguous 5.7 nm-wide wavelength bands. HICO is designed to image one 43 km wide by 190 km long scene per orbit, and the full hyperspectral data set is transmitted to the ground without data compression.

3. HICO IMAGERY

HICO on the International Space Station offers the opportunity to image diverse coastal types worldwide. The spatial scale of HICO imagery is indicated by Figure 2, which shows the Han River Estuary and the adjacent coast.

This presentation will discuss HICO data characteristics and products retrieved from HICO imagery, such a maps of bathymetry, in-water constituents, and bottom type.

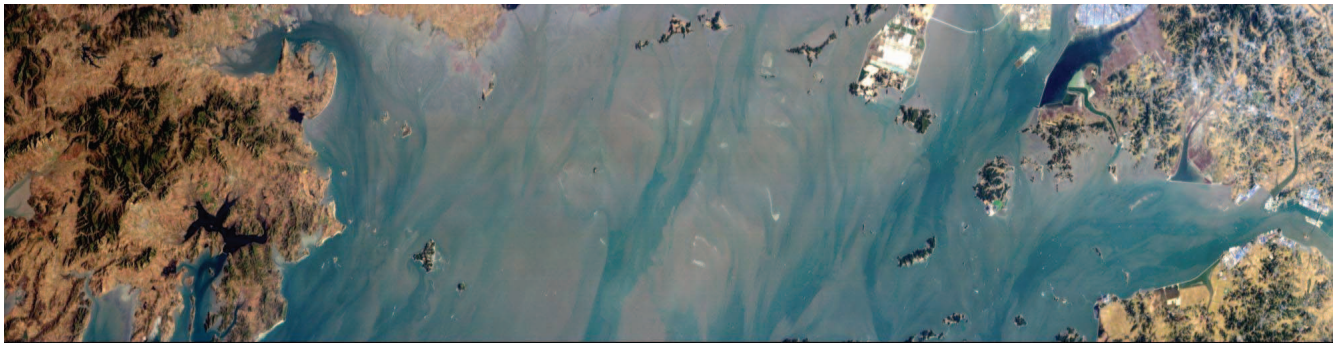

Figure 2. HICO picture of the Yellow Sea off the coast of Korea, constructed using three color bands. The scene is approximately 43 x 190 km, and shows extensive mud flats and channels. The scene orientation from the left to right edges is approximately northwest to southeast. The bright area at center-right is Incheon International Airport, which is partially saturated in this stretched image.

4. REFERENCES

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[4] MODTRAN, MODerate spectral resolution atmospheric TRANsmittance algorithm, developed by The Air Force Research Laboratory, Space Vehicles Directorate. Windows-compatible version available from Ontar Corp., 9 Village Way, North Andover, MA 01845.