

LABORATORY CHARACTERIZATION OF THE HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO)

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1. ABSRACT

The HICO (Hyperspectral Imager for the Coastal Ocean) instrument, developed at the Remote Sensing Division of the Naval Research Laboratory and funded by the Office of Naval Research (ONR), will be the first spaceborne maritime hyperspectral imager. It incorporates Commercial Off The Shelf (COTS) components, including a CCD camera, rotation mechanism, and hermetically sealed computer to reduce schedule and cost. HICO is integrated with the Remote Atmospheric and Ionospheric Detection System (RAIDS), developed at NRL's Space science division, to form the HICO-RAIDS Experiment Payload (HREP). HREP has been manifested by the DoD Space Test Program to fly aboard the International Space Station (ISS), which has an orbital inclination of 52° at an altitude of about 400 km. It is scheduled to launch on the demonstration flight of the Japanese H-II Transfer Vehicle in September 2009 and to be deployed as the first U.S. payload on the Japanese Experiment Module-Exposed Facility. The payload will launch from the Tanegashima Space Center located off the southern coast of Japan.

Stringent requirements must be met for maritime hyperspectral imaging, which in general are not fully met by systems designed for land applications. In the complicated coastal environment, where the water contains significant dissolved and suspended matter and the bottom is visible, hyperspectral imaging has demonstrated the ability to retrieve bathymetry, bottom type, chlorophyll content, and water inherent optical properties. However, the coastal ocean is dark, with an albedo of only several percent, and from space it is viewed through the atmosphere which due to scattered sunlight is significantly brighter in visible wavelengths than the water surface. These requirements include a minimum 200 to 1 signal to noise ratio for water-penetrating wavelengths when viewing the dark coastal scene; full and contiguous spectral coverage from 0.4 to 0.8 microns recorded in 0.01 micron or smaller spectral bands to resolve the spectral features in the scene, and areal coverage of thousands of square kilometers. In addition, the HICO sensor must provide spectral image data from 0.8 to 1.0 microns, to use to accurately remove the effects of the atmosphere and surface reflection.

HICO is designed to meet the specifications that flow down from the requirements. The final design parameters and the rationale for each are listed in table 1. The required signal to noise parameter is based on a Modtran model using a 5% albedo as seen above the atmosphere for a sun angle of 45 degrees and a 23km rural aerosol model. Most of the other parameters are derived from the required ground sample distance and the spectral requirements as described above. Note that the high resolution (HR) spectral mode will be used as a diagnostic tool to check spectral registration and is not part of the requirements. Using the Naval Research Laboratory's calibration and characterization facility, HICO

has undergone intensive testing to verify that the requirements have been met and to quantify how well it will operate on orbit. The results of these tests are presented.

Parameter	Value	Rationale
Off-nadir pointing	45 deg port, 30 deg starboard	Ground Swath \approx 600 km, increase observations
Spectral Range	350 to 1070 nm	water-penetrating wavelengths and NIR for atmospheric correction
Spectral Channel Width (normal)	5.7 nm	Sufficient resolution to resolve spectral features
Spectral Channel Width (HR mode)	1.9 nm	
Signal to Noise Ratio	> 200 to 1 for a 5% surface albedo (11.4 nm spectral bins)	Provides adequate residual SNR after atmospheric removal
Polarization Sensitivity	< 5% for most wavelengths	Sensor response to be insensitive to polarization of scene light for simplified retrievals
Ground Sample Distance	94 meters @ 400 km alt.	Comparable to scale of coastal features
Scene Size	(48 km wide) \times (200 km long)	To encompass the scale of coastal dynamics
Focal Length	68 mm	From FPA and GSD
F#	3.6	From SNR
Pixel Size	16 μ	FPA chosen based on SNR and saturation
FPA Size, total: used:	512 \times 512 512(spatial) \times 384(spectral)	1 Spatial Pixel = 94 m 1 Spectral Pixel = 1.9 μ
Frame Time (normal)	13.7 ms	Gsd and orbit
Frame Time (HR mode)	30 ms	

Table 1: HICO Characteristics as designed

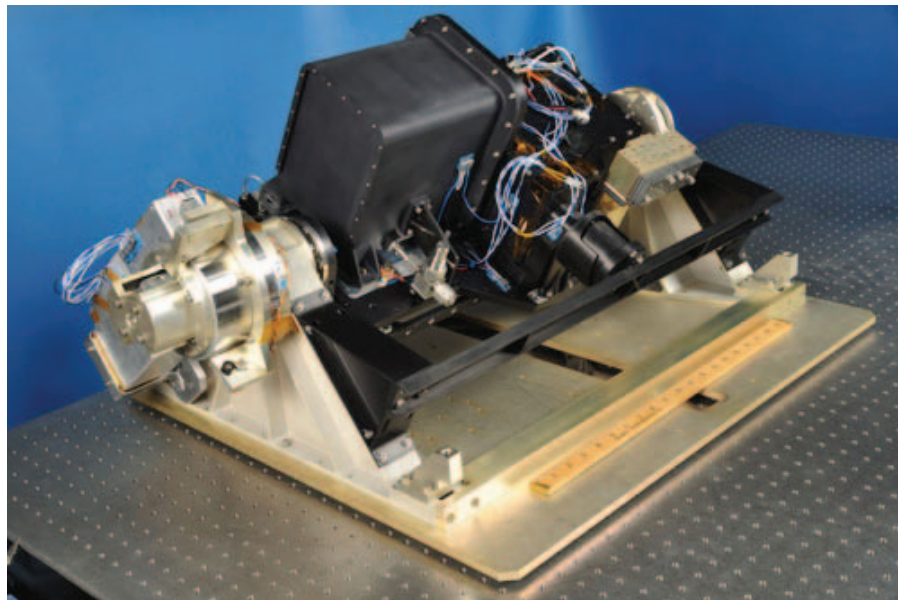


Figure 1. The Hyperspectral Imager for the Coastal Ocean (HICO)