

The Hyperspectral Imager for the Coastal Ocean (HICO) on the International Space Station

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INTRODUCTION

The HICO (Hyperspectral Imager for the Coastal Ocean) program is the first demonstration of environmental characterization of the coastal zone using a spaceborne maritime hyperspectral imager. HICO is sponsored by the Office of Naval Research as an Innovative Naval Prototype (INP), to demonstrate products of utility to Naval forces such as maps of water optical properties, bathymetry and on-shore vegetation. As an INP, HICO also demonstrates innovative ways to reduce the cost and schedule of this space mission by adapting a proven aircraft imager architecture and using Commercial-Off-The-Shelf (COTS) components where possible.

Visible and near infrared wavelengths in the approximate range 0.4 to 0.8 microns constitute the only portion of the electromagnetic spectrum that penetrates water and directly probes the water column. In the coastal environment where the water contains significant dissolved and suspended matter and the bottom may be visible, the scene image is spectrally complicated requiring well-calibrated hyperspectral imaging to retrieve water optical properties, chlorophyll content, bathymetry, and bottom type. Furthermore the coastal ocean scene is dark, with an albedo of only a few percent, and from space it is viewed through the atmosphere which is significantly brighter in the visible wavelengths than the water surface due to scattered sunlight. These conditions impose stringent requirements for the maritime hyperspectral imaging system which are in general not fully met by systems designed for land applications. The HICO imager, data system, and product algorithms constitute the first spaceborne maritime hyperspectral system specifically designed for environmental characterization of the coastal environment.

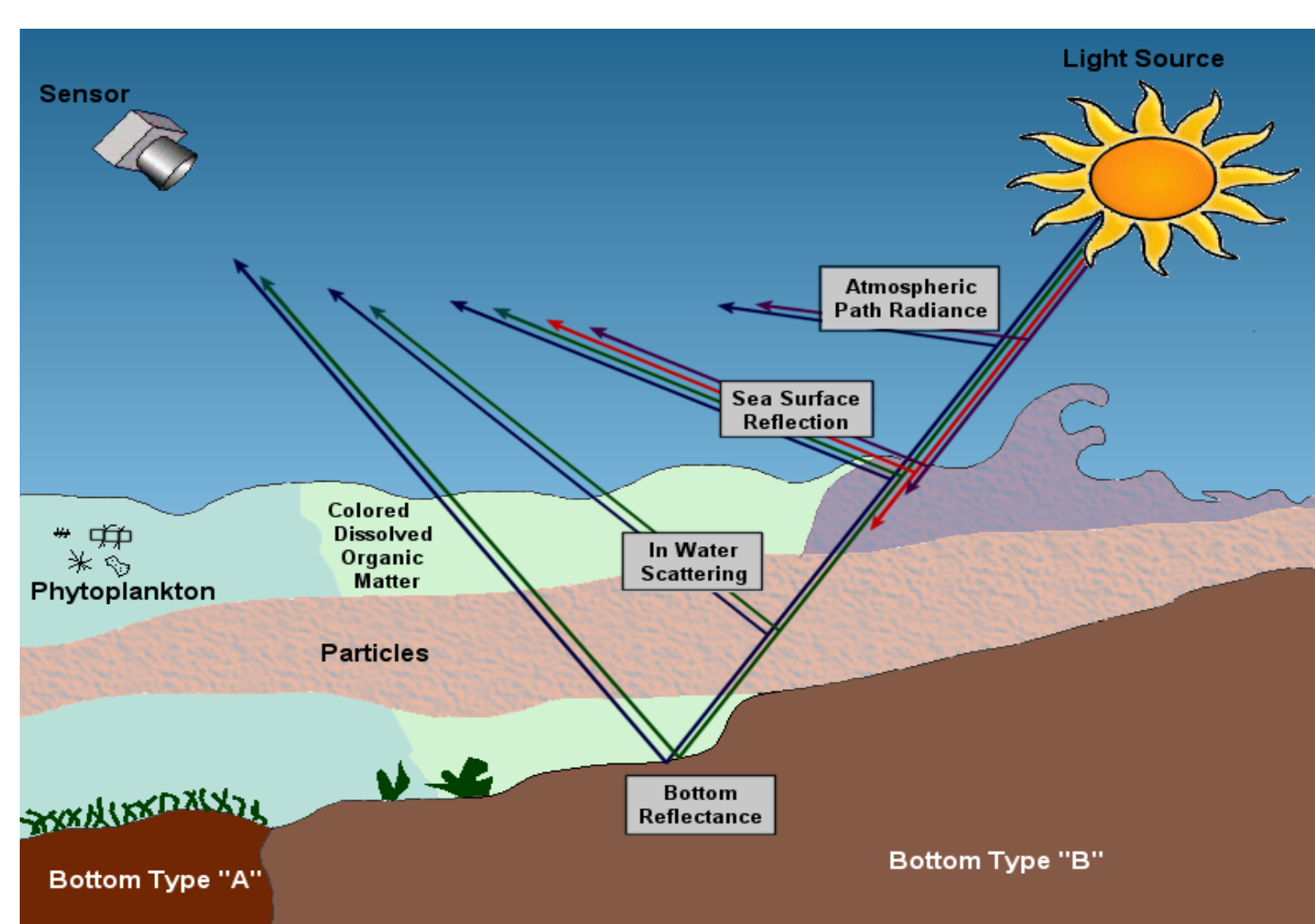
MARITIME HYPERSPECTRAL IMAGING OF THE COASTAL ZONE PRESENTS UNIQUE CHALLENGES

Coastal and Riverine Scenes are very complicated

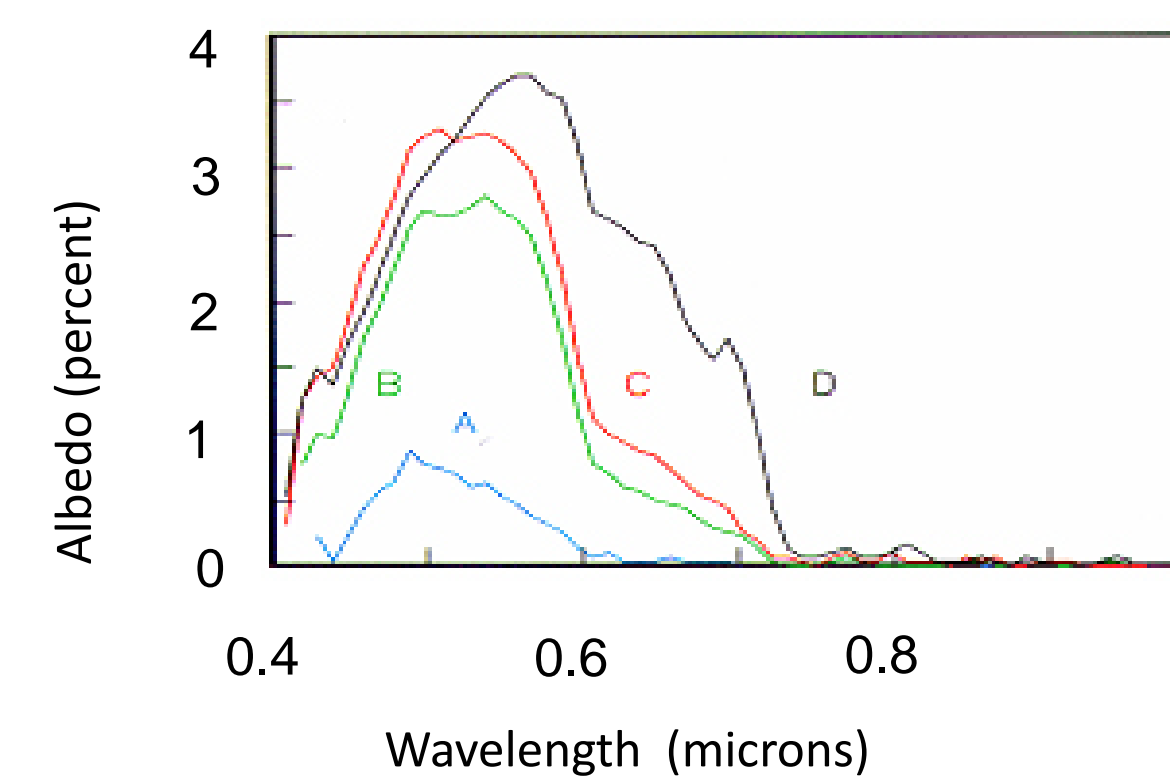
- Significant scattering from aerosols, surface, suspended solids, bottom
- Absorption by air, dissolved matter, and water
- Scattering and absorption are convolved

The atmosphere is brighter than the underlying scene

Modeled (using MODTRAN) spectral radiance above the atmosphere for 5% surface albedo and 45 degree solar zenith angle

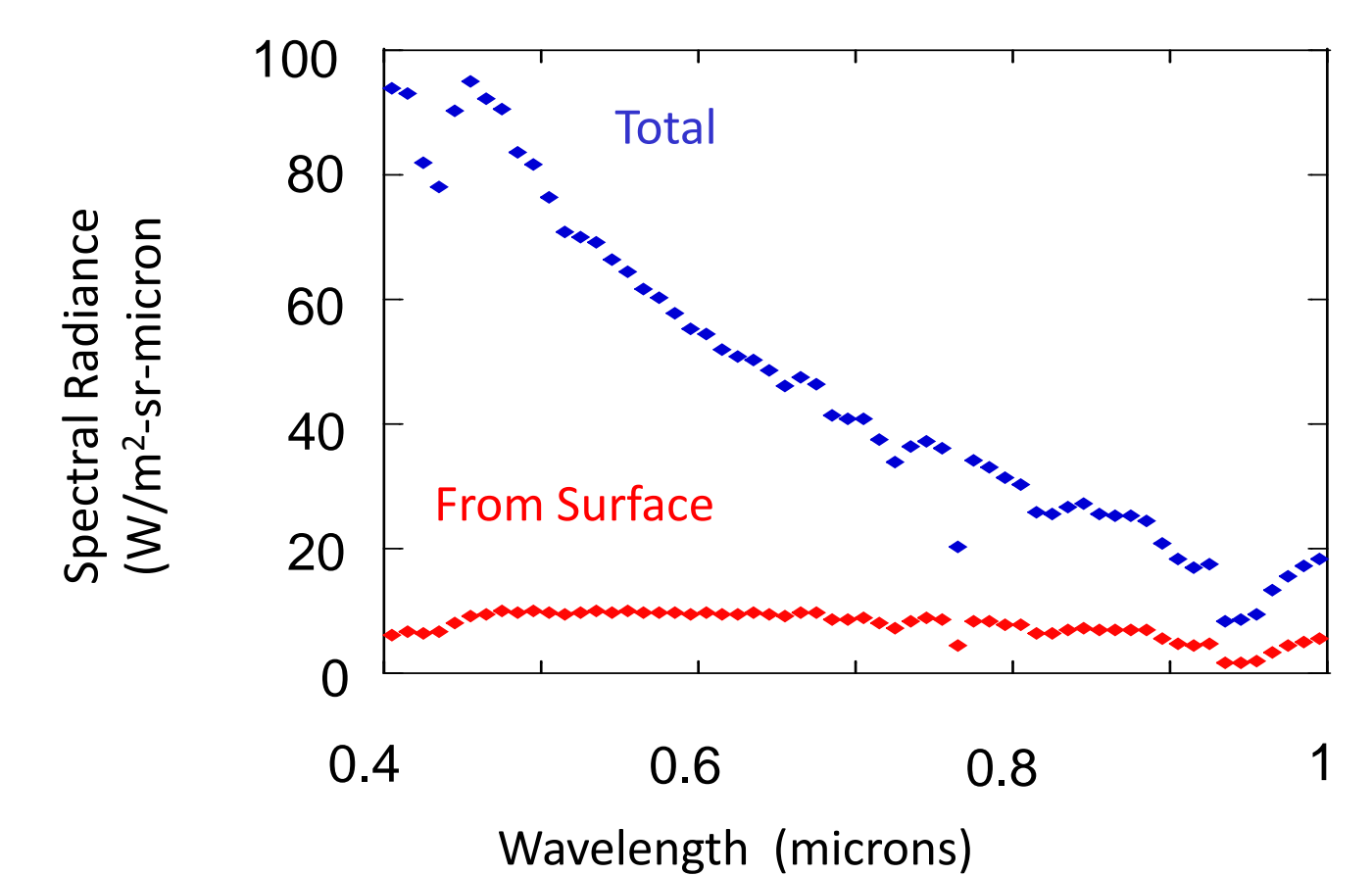


Water scenes are dark (low albedo)



Point A (deep water): 1% maximum albedo

Point D (shallow submerged bright sand): 4% maximum albedo



Blue points: total top-of-atmosphere spectral radiance including atmospheric scattering

Red points: upwelling spectral radiance from surface (the desired signal)

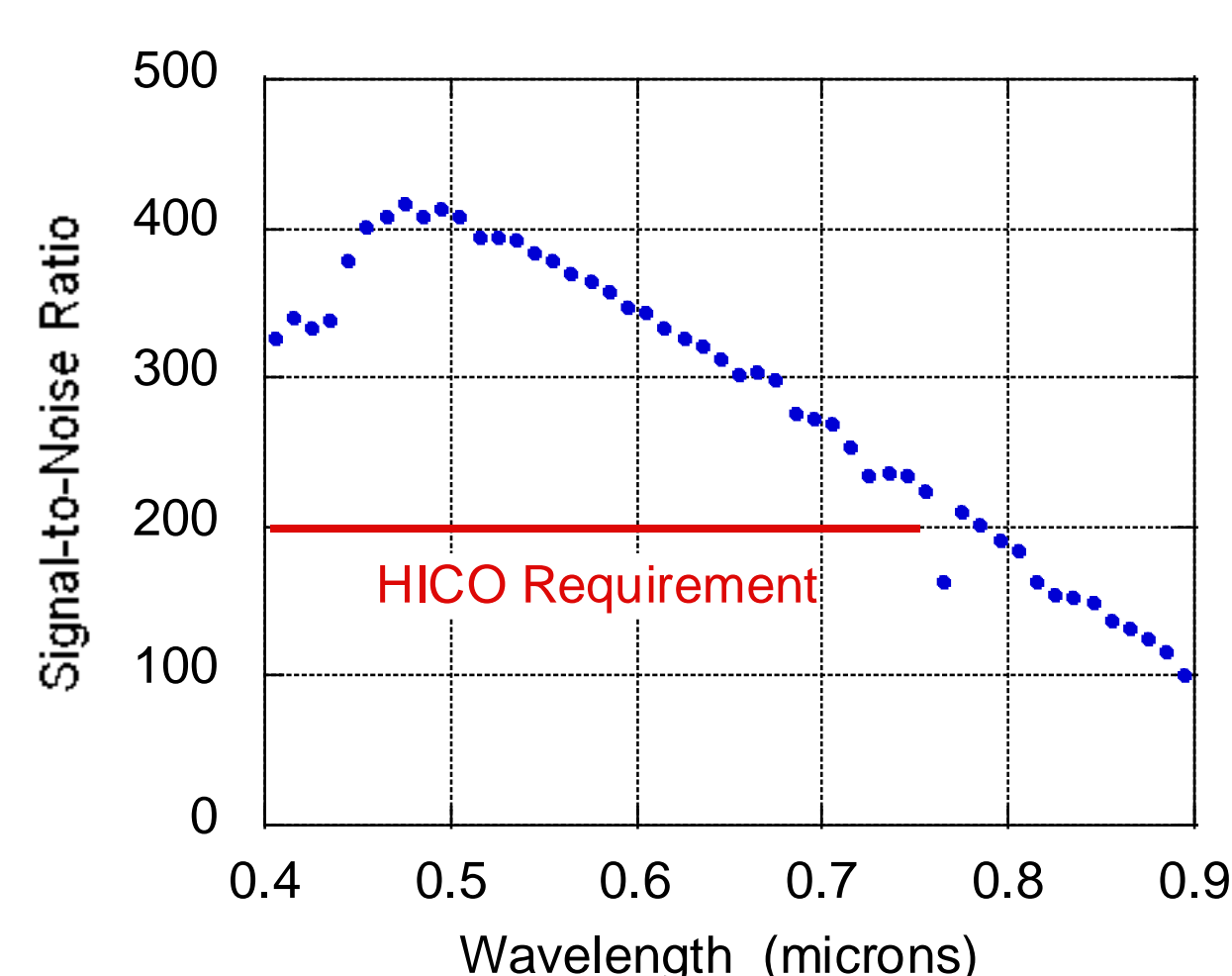
Detailed physical modeling and accurate radiometric calibration are required to retrieve water optical properties, bathymetry, bottom type, and other environmental products

THE SPACE-BASED HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO) IS A COST-EFFECTIVE PROGRAM FOR DEMONSTRATING COASTAL NAVAL ENVIRONMENTAL PRODUCTS WORLDWIDE

HICO on-orbit imaging system performance

- Ground Sample Distance: 95 meters at nadir
 - Sufficient resolution for selected coastal environmental features
- Spectral coverage: 0.4 to 0.9 microns
 - Includes all water-penetrating wavelengths
- Spectral sampling: 0.01 microns sampling for water-penetrating wavelengths
 - Sufficient to resolve spectral features in coastal scenes
 - 0.02 micron sampling for wavelengths longer than 0.8 micron
- Signal to Noise Ratio: greater than 200 to 1 per spectral bin for water-penetrating wavelengths
 - For sufficient residual signal to noise after atmospheric correction
 - Assumes 5 percent effective surface albedo

Modeled HICO Signal to Noise Ratio for each 0.01 micron-wide spectral bin Assumes 5% surface albedo



- Radiometric accuracy: 5% or better
 - Required to fit image data to physical models to retrieve environmental data products
- Polarization sensitivity: 5% or less
 - To preserve radiometric accuracy when observing polarized scene
- Scene size: 42 x 190 km at nadir
 - Large scene required to capture coastal dynamics
- On-orbit lifetime: one year minimum
 - Required to collect data over all seasons

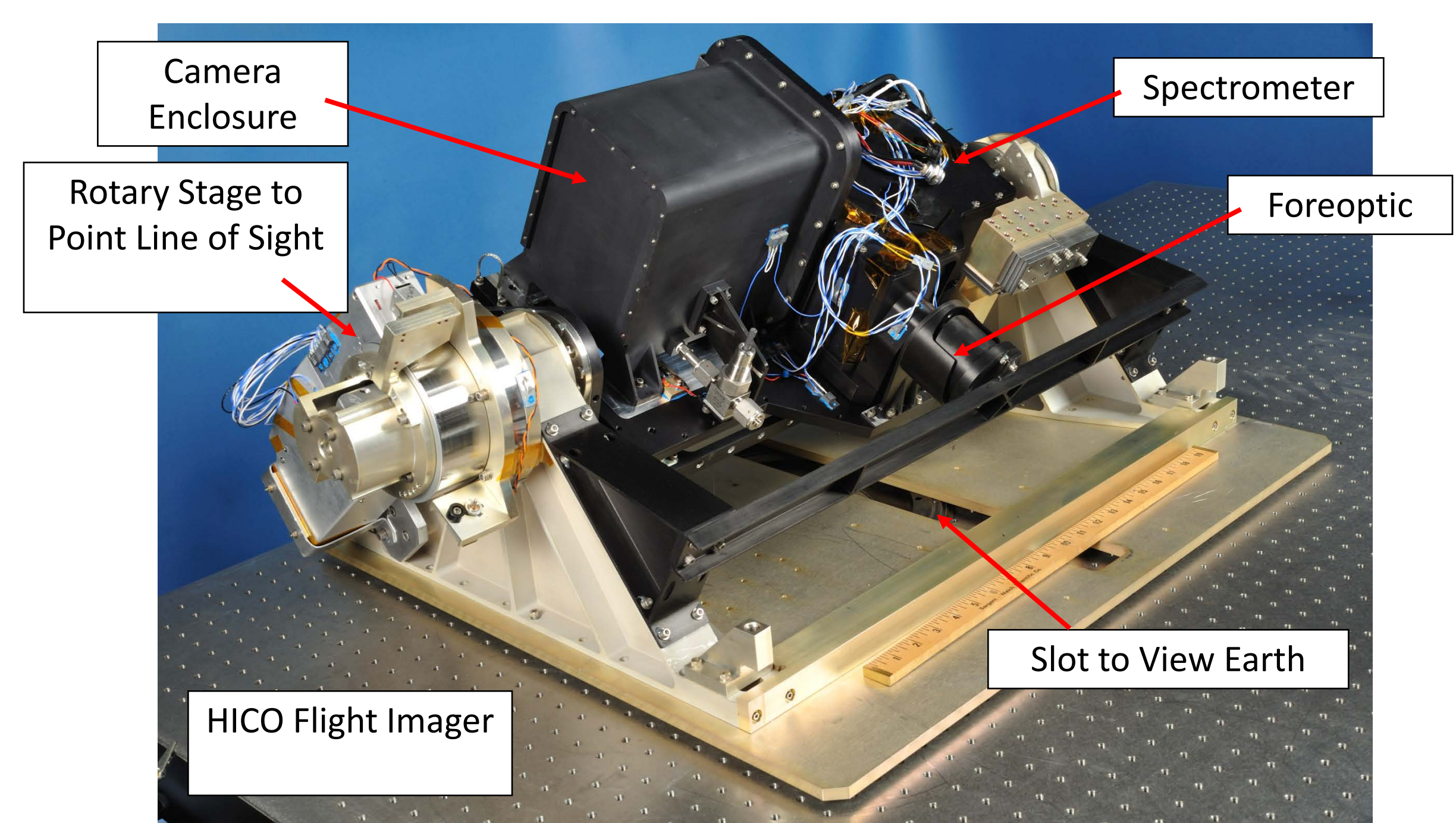
HICO DATA PROCESSING AND ENVIRONMENTAL PRODUCTS

See companion poster *Data Processing and First Products From the Hyperspectral Imager for the Coastal Ocean (HICO) on the International Space Station*, C.O. Davis et al., Session D4

HICO IS AN INNOVATIVE NAVAL PROTOTYPE SPONSORED BY THE OFFICE OF NAVAL RESEARCH

HICO uses Commercial Off The Shelf components and a hermetic enclosure for the camera and electronics

- Enables use of rugged aircraft-grade hardware
- Saves significant cost and development time
- Enables rapid transition from laboratory to flight



HICO was launched September 10, 2009 to the Japanese Experiment Module – Exposed Facility on the International Space Station



HICO is integrated and flown under the direction of DoD's Space Test Program