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HYPERSPECTRAL IMAGER FOR THE COASTAL OCEAN (HICO)

USER DATA COLLECTION AND DISSEMINATION POLICY

International Space Station Program

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National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas

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1 Introduction

This document describes pathways for obtaining data from the Hyperspectral Imager for the Coastal Ocean (HICO) instrument. This includes criteria for selection of authorized users that can request data acquisitions, prioritization of competing acquisitions, data dissemination policies for the authorized user and data access policies for the broader research community, and policies regarding reporting of results.

2 Background

The Hyperspectral Imager for the Coastal Ocean (Corson et al. 2008) is an imaging spectrometer built as part of a technology demonstration that could be deployed swiftly to the space station to obtain environmental information in the coastal regions. The HICO mission was sponsored by the Office of Naval Research (ONR) and the DoD Space Test Program, and the sensor, based on an airborne sensor (Davis et al., 2002) was designed, built and is operated by the U.S. Naval Research Laboratory (NRL). It was launched to the International Space Station (ISS) in 2009 and mounted on the Japanese Experiment Module – Exposed Facility (JEM-EF) for operations. HICO is the first space-borne imaging spectrometer designed to sample the coastal ocean. HICO samples selected regions at approximately 90 m Ground Sample Distance (GSD) with full spectral coverage (400 to 900 nm sampled at 5.7 nm), and signal-to-noise ratio sufficiently high to resolve the complexity of the coastal ocean. HICO data have much greater spatial (90 m vs. 1000 m) and spectral (87 channels vs. 9-15) resolution than current space-borne ocean color imagers, and the data are of great interest for studying the dynamics of the coastal ocean. Additional technical details of the HICO instrument are summarized in Table 1. Scientists from US agencies, US commercial interests, ISS international partners, and academia (both nationally and internationally) have expressed interest in receiving and using HICO data to develop new algorithms and to study coastal ocean properties.

At the beginning of 2013, HICO transitioned from an instrument funded by the Department of Defense to collect data for their investigators, to an ISS facility with sustaining operational funding provided by the NASA ISS Program. The primary mission of HICO as an ISS facility is to provide hyperspectral remote sensing data to U.S. users to benefit the nation, expand and extend the applications of hyperspectral data from orbit, and meet NASA science goals from the Earth Science Decadal Survey.

3 HICO Operations

The Naval Research Laboratory (NRL) will continue to operate the instrument, with support of the science management team comprised of representatives from NASA ISS, NASA Science Mission Directorate (SMD), the Center for the Advancement of Science in Space (CASIS), NRL and the HICO project scientist at Oregon State University

(OSU). The HICO science management team will also support and manage the integration of authorized users. HICO tasking will be based on authorized investigator requests, with the goal of fully satisfying data collection needs for authorized users. NASA ISS, CASIS, and NASA SMD will work together to identify authorized users, decide acquisition priorities when necessary, and facilitate expansion of the use of HICO data. The existing public interface for receipt of new user proposals, and notification/delivery of acquired data is a website maintained by OSU (http://hico.coas.oregonstate.edu/); this site will be modified as needed to track sponsorship of users.

3.1 Authorized Users for New Data Acquisition

Authorized users will have sponsorship of either NASA or CASIS. To become an authorized user, researchers will be required to register through the HICO web portal (http://hico.coas.oregonstate.edu/join/join.shtml). Authorized users are allowed to request new data acquisitions, which will be prioritized by the science management team using science and operational considerations, and in accordance with NASA's programmatic goals. Figure 1 summarizes the new user and data acquisition process.

NASA-authorized users include the following: scientists at U.S. institutions that currently have NASA grant funding; NASA researchers approved by the Science Mission Directorate or the ISS Program; and approved ISS international partner users under specific ISS Program agreements.

CASIS-authorized users include the following: researchers from U.S. commercial or non-profit organizations; non-NASA funded researchers from academic institutions; and other U.S. government agencies. All CASIS authorized users must be evaluated and approved through the CASIS proposal evaluation process (http://www.iss-casis.org/Opportunities/UnsolicitedProposals.aspx). CASIS and NASA will work together to validate and track other government agency (OGA) users.

Other international investigators not covered by specific NASA or ISS agreements, and not prohibited by US State Department or NASA policy, may request data acquisitions, but those requests will be prioritized below NASA and CASIS requests.

As a condition of acquisition requests, all authorized users must provide the following information on objectives of the acquisition: sponsor (CASIS or NASA), principal investigator names and institutions, co-investigators or collaborators names and institutions, title of study, abstract of the study objectives and expected benefits, classification of study as commercial, basic research, or applied research. Requestors will also supply data acquisition parameters required for operational tasking.

The expectation is that all data acquired by HICO for authorized users will be incorporated into a publicly accessible archive as soon as possible. Authorized users making an acquisition request can request a short-term embargo of the data, specifying

the shortest necessary time to protect proprietary or sensitive applications, not to exceed one year.

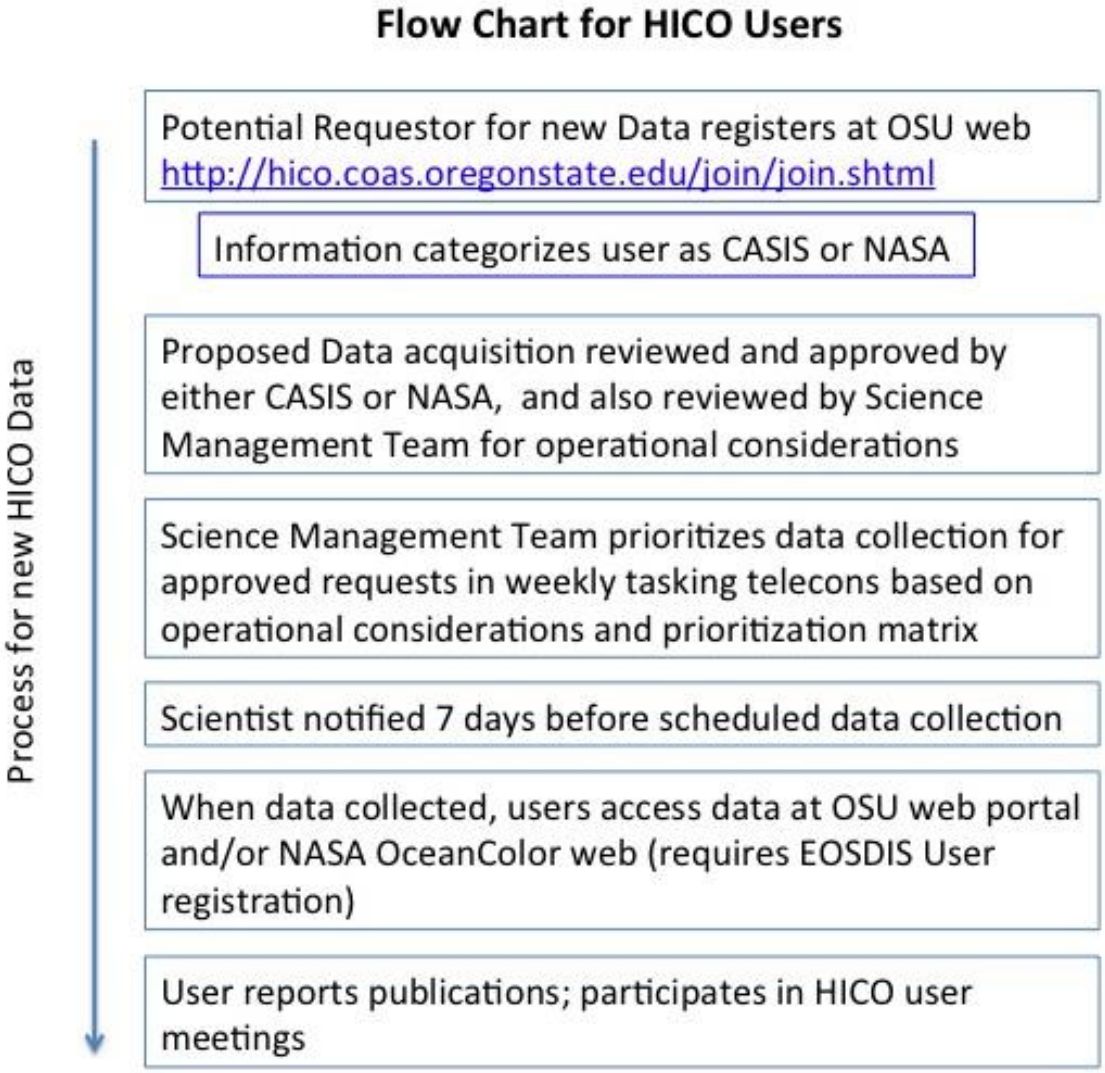

Figure 1. Process for new user registration and data access.

3.2 Prioritization of Competing Acquisitions

It is NASA's goal that the HICO instrument data collection be made available to NASA-sponsored users and CASIS-sponsored users (including other government agencies) on an equivalent basis. The duty cycle of the instrument currently allows only one data acquisition session per orbit, therefore it is possible that multiple users will have competing requests for an acquisition on a specific orbit. Every effort will be made by the science management team (representatives from CASIS, ISS Program Science, NASA HQ SMD, NRL and OSU project scientist) to accommodate all requests whenever possible. The priority guidelines will help to guide the science management team in choosing among conflicting requests, and provide criteria for referral to the ISS

Program for further evaluation under ISS prioritization processes when conflicts and impacts of priority calls require additional review.

General priorities:

1. Urgent requests from NASA or CASIS-authorized investigators, which have time sensitive data collection needs, on an equitable basis between NASA and CASIS.
2. Requests from the U.S. Geological Survey under activations of the International Disaster Charter (IDC), with data to be provided to the U.S. Geological Survey.
3. Standard requests from NASA or CASIS-authorized investigators, on an equitable basis between NASA and CASIS, and following internal priorities of user tasking to be provided by NASA and CASIS on a periodic basis. Tasking priorities will consider concurrent field work, evolving environmental phenomena, rarity of target acquisition, orbit/target geometry, and other operational aspects that impact data collection.
4. Requests from international users who are approved by NASA but do not have ISS Program agreements in place.

See Figure 2, HICO Tasking Decision Tree.

Equitable basis and referral to the ISS program:

1. On a semi- annual basis (by increment pair), overall access to acquisitions should be equitable between NASA and CASIS. However, because the level of interest of each type of user, as well as operational constraints associated with the instrument, ISS orbits, or weather cannot be predicted, the actual level of tasking will be reported periodically.
2. If within a 6-month period of time, either CASIS- or NASA-sponsored users have not received equivalent levels of tasking, then the other type of user will be given priority for <u>standard requests</u> to provide equitable access during the remainder of the 6-month period.
3. The ISS Program scientist will handle priority calls that are not covered by the general rules, following the *NASA ISS Science Prioritization Desk Instruction, Version 2*[i].
    a. If a specific set of acquisitions requested by different users will overlap and conflict routinely.
    b. If a specific user is consistently not having their request met, due to conflicting priorities.
    c. Any appeals of data acquisition priority.

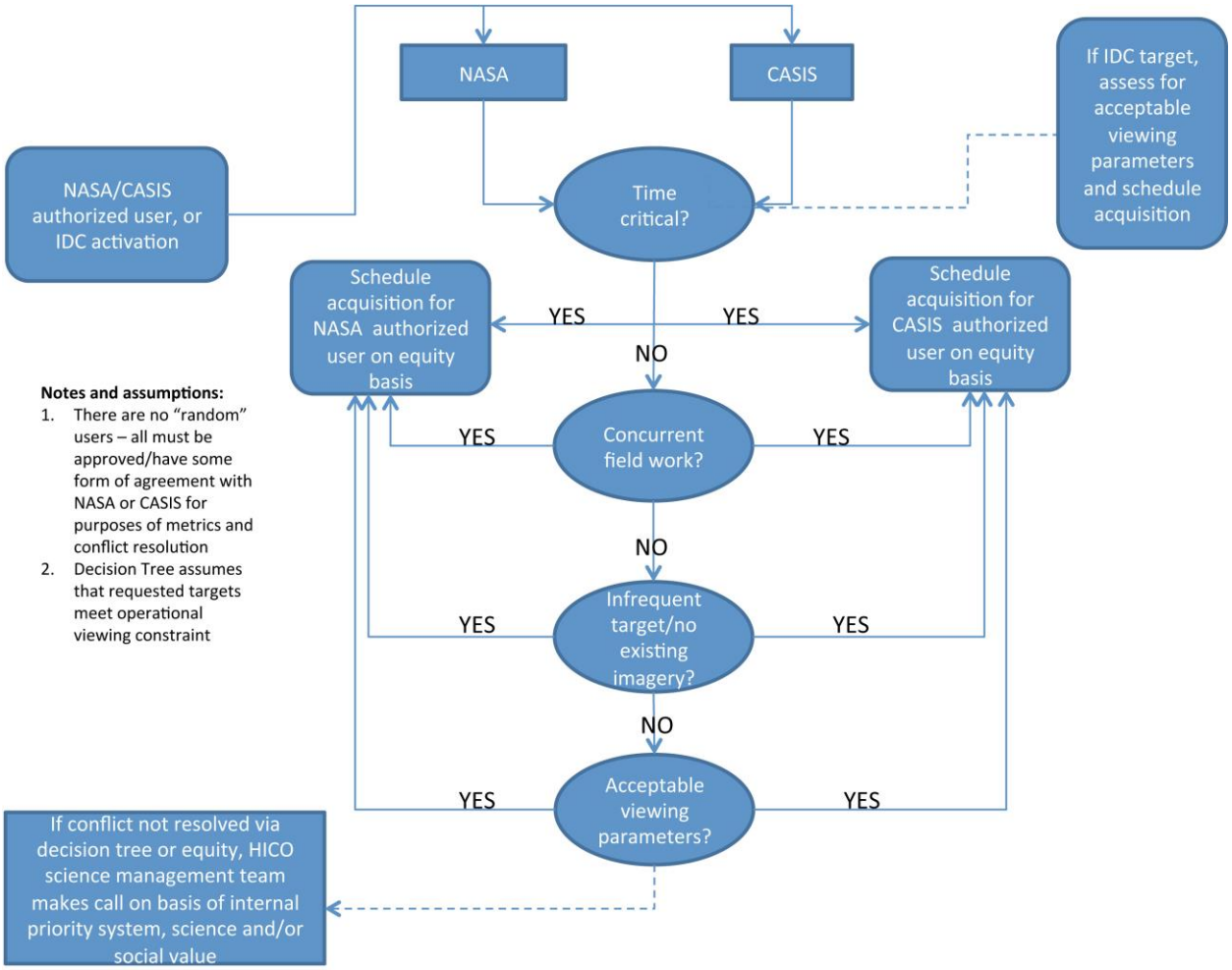

Figure 2. HICO Tasking Decision Tree. Decision tree applies only to accepted tasking targets that meet operational viewing parameters.

3.3 Data Archiving and Distribution

Investigators will be provided 7 days advance notice when their data request is scheduled. Under current operating scenarios, Level 1B data will be provided to authorized users through the Oregon State HICO web portal. All publically released Level 0, 1, 2, and 3 data[ii], and basic software algorithms for processing Level 0 data will be incorporated into the NASA OceanColor Web (http://oceancolor.gsfc.nasa.gov) to be distributed according to NASA SMD open data access policies. All researchers seeking access to the HICO data via NASA's OceanColor Web will require registration with the EOSDIS User Registration Services (URS) at https://earthdata.nasa.gov/urs/register . Distribution metrics will be cataloged in the EOSDIS Metrics System (EMS). These metrics can be made available to the HICO data providers (NRL/OSU) and funding agency (NASA).

CASIS-sponsored users can request an embargo period not to exceed 1 year to protect commercial proprietary or sensitive uses of the data. NASA sponsored users cannot request data embargo periods, their data will be freely available on the OceanColor Web. NASA-sponsored users will follow the NASA SMD "Rights in Data" clause (December 2006, amended January 2012)[iii] standard in SMD cooperative agreements.

Data distribution of any products that are not publicly released will be governed by the appropriate memorandum of understanding or cooperative agreement. The ISS Program will notify the science management team of any such agreements and the associate terms.

Each authorized user is responsible for data distribution and export control of data they receive that has been processed to higher levels beyond the publicly released levels if it is redistributed to any foreign collaborators.

3.4 Science and Science Management Team Reporting

Each authorized user will provide a copy of all resulting reports and publications to the science management team and ISS Program Scientist's office. The science management team will track the number of acquisitions for each study and sponsor, providing semi-annual reports (each ISS increment pair) of usage levels to the ISS Program Scientist's office.

3.5 More information about HICO

Points of contact for HICO information:

HICO use through CASIS: Ken Shields (kshields@iss-casis.org)

HICO use through NASA: ISS Program Science Office: Julie Robinson, Ph.D. (Julie.a.robinson@nasa.gov)

HICO user interface: Curtiss Davis,Ph.D., Oregon State University (Cdavis@coas.oregonstate.edu)

HICO operations and instrument specifics: Mary Kappus, Ph.D., Naval Research Laboratory (mkappus@nrl.navy.mil)

ISS National Lab Office: Michael Read (michael.e.read@nasa.gov)

Oregon State University maintains a website for HICO at http://hico.coas.oregonstate.edu. The site is designed to provide all the background information and links to publications to allow scientists to learn what HICO is, what the data are like, and how the data are calibrated and processed, and how to become an authorized user.

HICO data that have been released will be posted on NASA's Ocean Color Data website (http://oceancolor.gsfc.nasa.gov).

4 Literature Cited

Corson, M. R., D. R. Korwan, R. L. Lucke, W. A. Snyder and C. O. Davis, 2008, "The Hyperspectral Imager For The Coastal Ocean (HICO) On The International Space Station," IEEE Proceedings of the International Geoscience and Remote Sensing Symposium, 978-1- 4244-2808-3/08.

Davis, C. O., J. Bowles, R. A. Leathers, D. Korwan, T. V. Downes, W. A. Snyder, W. J. Rhea, W. Chen, J. Fisher, W. P. Bissett and R. A. Reisse, 2002, "Ocean PHILLS hyperspectral imager: design, characterization, and calibration," Optics Express, 10(4): 210–221.

D. R. Korwan, R. L. Lucke, N. R. McGlothlin, S. D. Butcher, D. L. Wood, J. H. Bowles, M. Corson, W. A. Snyder, C. O. Davis, D. T. Chen, 2009, "Laboratory Characterization Of The Hyperspectral Imager For The Coastal Ocean (HICO)", IEEE Proceedings of the International Geoscience and Remote Sensing Symposium, In Press.

Appendix A – HICO Data Characteristics and Classification

HICO was fully characterized in the NRL Remote Sensing Division Calibration Facility prior to launch. Key characteristics of the data are presented in **Table 1**. HICO is designed to image the coastal ocean and thus it has large area coverage, large GSD and very high SNR suitable for imaging this large but optically very dark environment. Laboratory measurements and initial on-orbit data indicate that they are excellent data for imaging the coastal ocean.

Table 1. HICO requirements and as built values as measured in the calibration laboratory prior to launch. Table from Korwan, et al. (2009).

Parameter	Requirement	As-built Value
Off-nadir pointing	45 deg port, 30 deg starboard	45 deg port, 30 deg starboard
Spectral Range	400 to 860 nm (goal 380 to 1000 nm)	350 to 1080 nm sampled (distributing 400 to 900 nm data)
Spectral Channel Width (normal mode)	10 nm (goal 5 nm)	5.73 nm
Spectral Channel Width (HR mode)	No requirement	1.91 nm
Signal to Noise Ratio	> 200 to 1 for a 5% surface albedo (10 nm spectral bins)	> 200 to 1 for a 5% surface albedo (11.46 nm spectral bins)
Polarization Sensitivity	< 5% (goal < 2%)	< 5% for most wavelengths
Nadir Crosstrack Ground Sample Distance	100 m @ 400 km alt.	94 meters @ 400 km alt.
Nadir Along-track Ground Sample Distance	100 meters	99 meters
Scene Size	(50 km wide)×(200 km long)	(42 km wide)×(192 km long) depending on altitude and angle
Vignetting	No vignetting	No vignetting
Saturation	Will not saturate when viewing 95% albedo cloud	Close to this value
Image quality	MTF > 0.35 at Nyquist spatial frequency of 0.5 cycles/pixel	PSF about 1 pixel
Spectral stray light	< 1% albedo error	Not strictly measured
Jitter	< 0.2 IFOV per frame	Space craft dependent
Long term stability	+/- 5% after calibration	On orbit measurement

Appendix B – Authorized User Request Form

Sponsor (NASA or CASIS)
Source of Funding (Agency)
Grant number, if applicable

PI Name

PI Institution

PI contact information (email, phone)

Co-I or Collaborators names and institutions

Title of Study

Abstract of Study, including objectives, expected benefits and results. 1 page

Short description of study written for the general public explaining project objectives (no more than 3 sentences: the “what”)

Short description written for the general public explaining project benefits (“the why”)

Study Type (Commercial, basic research, applied research)

Study Location (Latitude-Longitude)

Site description

Requested number of images to meet basic science objectives

Temporal preferences

Concurrent field work? (if yes, please provide anticipated dates)

Constraints on solar illumination

Other targeting information /constraints

Restrict Data release (Y/N)? If yes, time period and rationale

Educational activities or student involvement

Appendix C – Acronyms

CASIS	Center for the Advancement of Science in Space
GSD	Ground Sample Distance
HICO	Hyperspectral Imager for the Coastal Ocean
IDC	International Disaster Charter
ISS	International Space Station
JEM-EF	Japanese Experiment Module – Exposed Facility
NASA	National Aeronautics and Space Administration
NRL	Naval Research Lab
OGA	Other Government Agencies
OSU	Oregon State University
PHILLS	Portable Hyperspectral Imager for Low-Light Spectroscopy
SMD	Science Mission Directorate
US	United States

Appendix D – Glossary

Center for the Advancement of Science in Space (CASIS) is the manager of the International Space Station U.S. National Laboratory.

Ground Sample Distance (GSD) is a remote sensing term that defines the distance between pixel centers, measured on the ground, of a digital image. It is a measure of image resolution, and is usually given in meters per pixel.

Hyperspectral Imager is an imaging spectrometer that collects and processes information from a specified range of the electromagnetic spectrum in many individual bands, each with a narrow (less than 10 nm) bandwidth.

International Disaster Charter (IDC). Officially, the International Charter, Space and Major Disasters, originally signed in 2000, is an international charter that aims to provide a unified system of space data acquisition and delivery to those effected by natural or man-made disasters when activated by an authorized user. See http://www.disasterscharter.org/home .

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[i] NASA ISS Science Prioritization Desk Instruction:
https://iss-science.jsc.nasa.gov/presentations/internal/Science_Prioritization_Desk_Instruction_Jan_2012.pdf

[ii] Using Earth Science Data Observing System (EOSDIS) definitions:
Level 0. Reconstructed, unprocessed instrument and payload data at full resolution, with any and all communications artifacts (e.g., synchronization frames, communications headers, duplicate data) removed.
Level 1A. Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information, including radiometric and geometric calibration coefficients and georeferencing parameters (e.g., platform ephemeris) computed and appended but not applied to Level 0 data.
Level 1B. Level 1A data that have been processed to sensor units (not all instruments have Level 1B source data).
Level 2. Derived geophysical variables at the same resolution and location as Level 1 source data.
Level 3. Variables mapped on uniform space-time grid scales, usually with some completeness and consistency.
Level 4. Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

[iii] http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/data-rights-related-issues/