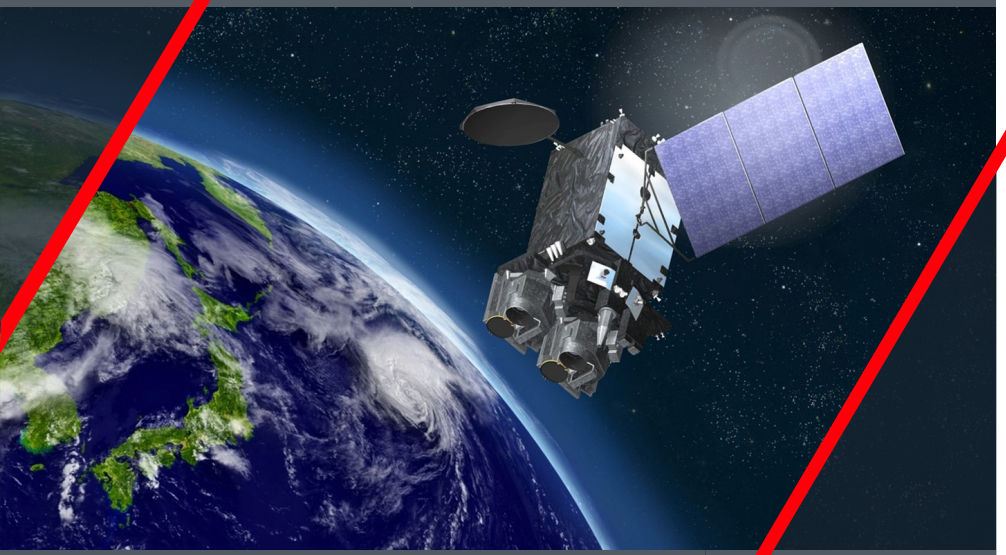


L3HARRIS
FAST. FORWARD.

HIMAWARI-10 SOUNDER OVERVIEW AND UPDATE

25th International TOVS Study Conference (ITSC-25)
8th - 14th May 2025 Goa, India

John Van Naarden
John Holder, John Ehlert, Christina Simkowski, Lawrence Suwinski

Himawari-10 builds on long heritage of cooperation between Japan and United States

- Himawari-10 is follow-on to Japan's Himawari-8/9 satellites
  - Orbital position: near 140.7 E
  - 15-year mission life
- JMA overall timeline:
  - JFY2022: Program start
  - JFY2028: Launch
  - JFY2029: Operations begin
- Mission includes three payloads:
  - Geostationary HiMawari Imager (GHMI)
  - Geostationary HiMawari Sounder (GHMS)
  - Radiation Monitors for Space weather (RMS)
- Spacecraft built and integrated by Mitsubishi Electric Corporation
- Primary GHMI and GHMS payloads built by L3Harris

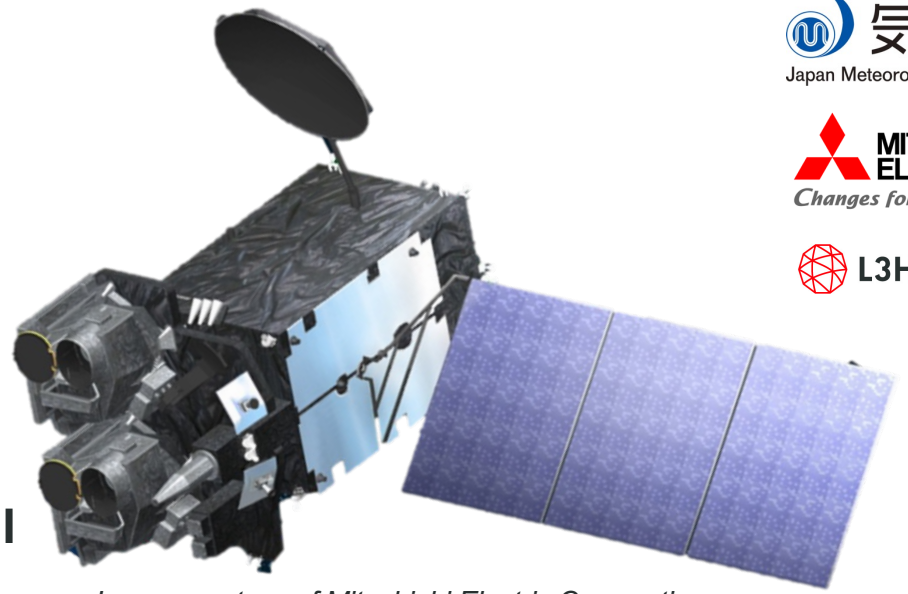
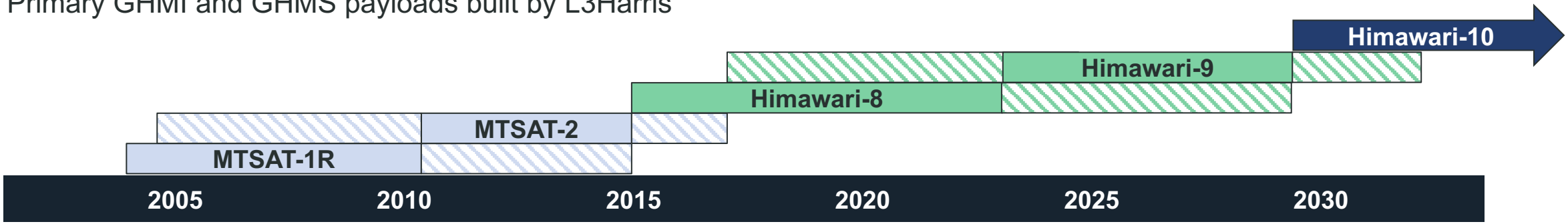


Image courtesy of Mitsubishi Electric Corporation

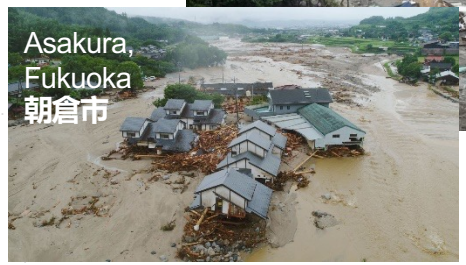


H-10 extends 20+ years of Japan/US cooperation on GEO weather satellites

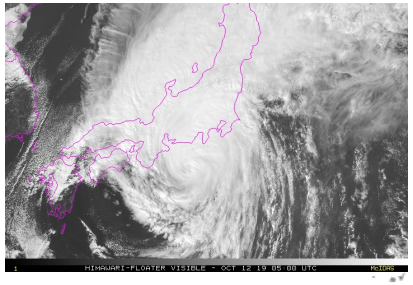
Himawari-10 Sounder (GHMS) capability to provide improved typhoon tracking prediction and improved heavy rain forecasting

Tropical cyclones and extreme rainfall continue to be major threat to people's life and property throughout Japan

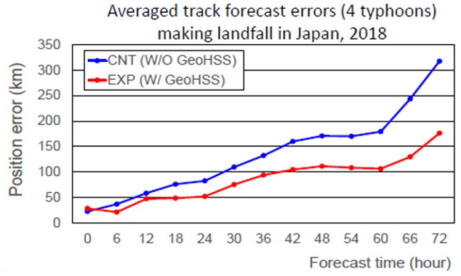
- GHMS is a hyperspectral, infrared, radiometric sounder
- Provides vertical atmospheric profiles of temperature, winds, and water vapor for numerical weather models
- GHMS ability to frequently observe 3D atmospheric structure around Japan expected improve forecasts of destructive phenomena like typhoons and linear precipitation bands

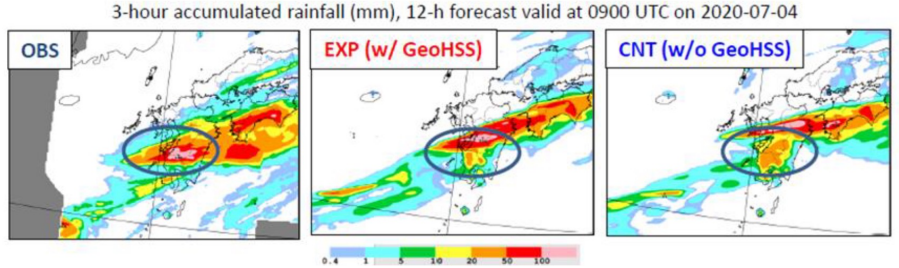


Super Typhoon Hagibis



GHMS expected to significantly improve forecasts that help protect life and property for citizens of Japan

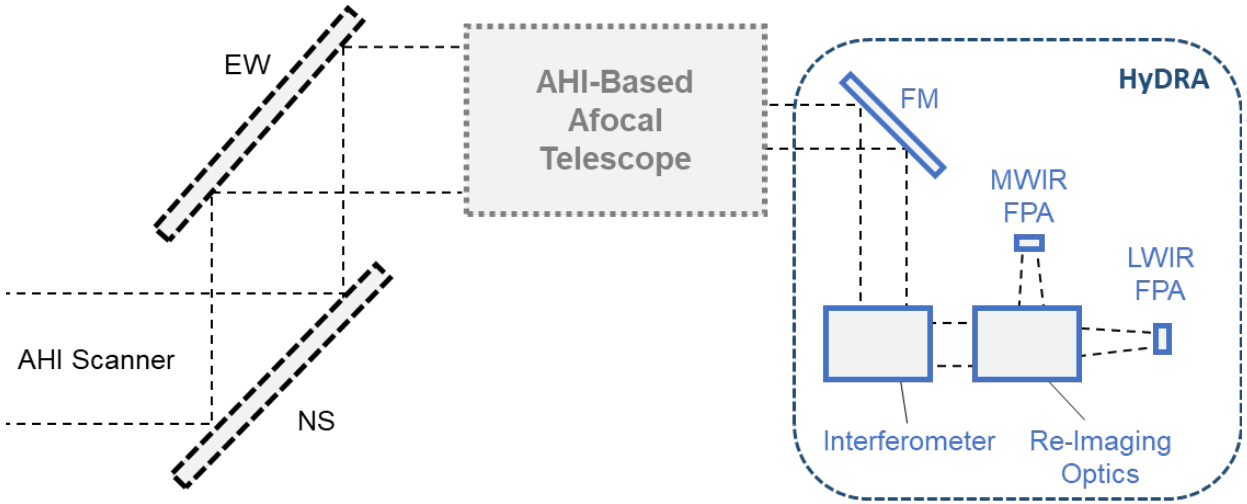




(Okamoto et al., 2020)

GHMS design adapts successful Advanced Himawari Imager (AHI) platform for Himawari-10 hyperspectral sounding mission

- Evolves legacy imager into a hyperspectral sounder
  - Maintains overall structure and high-TRL front-end scan system
  - Replaces AHI imaging back-end with Hyperspectral Detector and Reimaging Assembly (HyDRA)
- GHMS is a Fourier Transform Spectrometer (FTS) system similar to CMA GIIRS and MTG IRS
- Maintains highly-flexible AHI scan capability that allows interleaving of observation areas
  - Operates in a step-stare mode to collect scenes
  - During each stare, interferometer sweeps to collect interferograms in 2 bands (MWIR & LWIR)



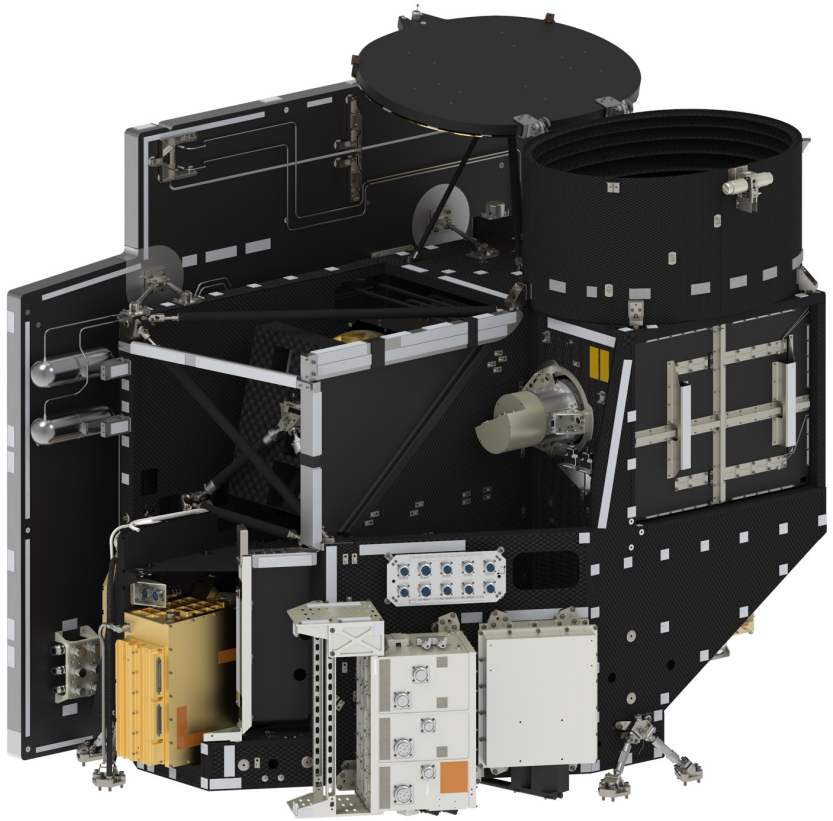
GHMS will contribute to geostationary sounder ring set out in the WIGOS 2040 vision

Parameter		(CMA) GIIRS-2	(MTG) IRS	(JMA) GHMS	(NOAA) GXS
Spectral Range	LWIR	700 – 1130 cm^{-1}	680 – 1120 cm^{-1}	680 – 1095 cm^{-1}	680 – 1095 cm^{-1}
	MWIR	1650 – 2250 cm^{-1}	1600 – 2250 cm^{-1}	1689 – 2250 cm^{-1}	1689 – 2250 cm^{-1}
Spectral Resolution		0.754 cm^{-1}	0.754 cm^{-1}	0.754 cm^{-1}	0.754 cm^{-1}
Spectral Sampling		0.625 cm^{-1}	0.625 cm^{-1}	0.625 cm^{-1}	0.625 cm^{-1}
IR GSD		8 km	4 km	4.2 km	4 km
Operational		2021	2024	JFY2029	2035

GHMS maintains AHI unit structure architecture

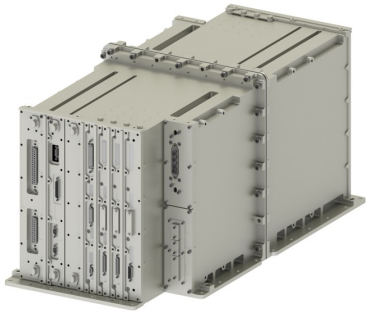
Sensor Unit (SU)

Collects scene radiance and converts to counts



Electronics Unit (EU)

Command and control and data handling



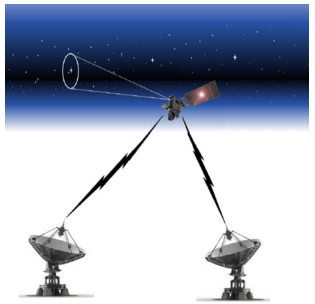
Cryocooler Control Electronics Unit (CCEU)

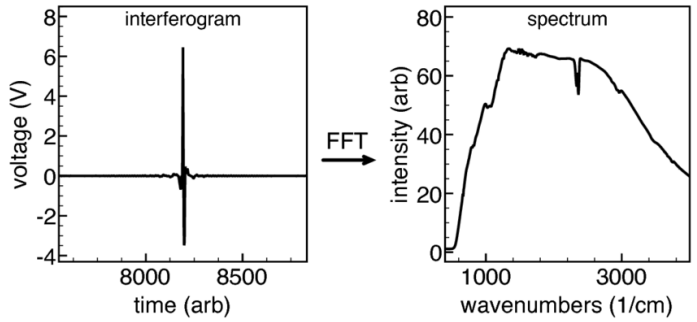
Operation of active coolers

*Comprised of 3 individual electronics boxes

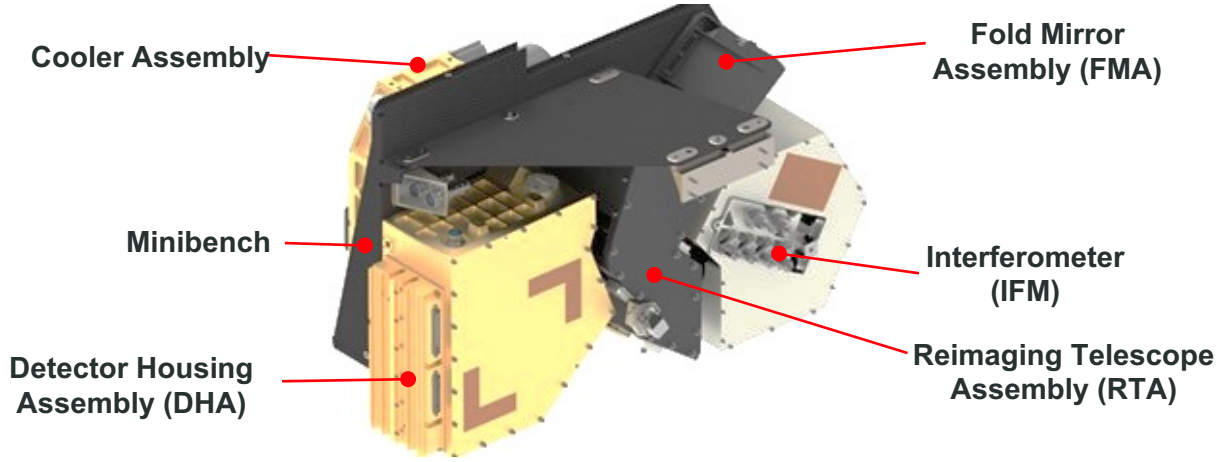
Ground Processing Algorithms

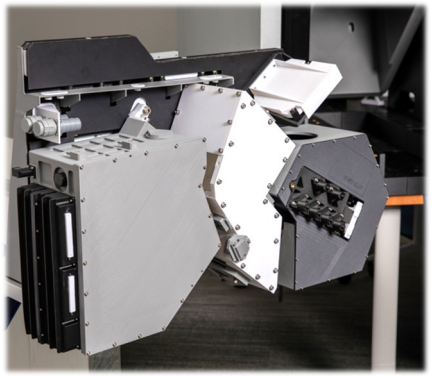
Decompression, spectral processing, calibration, and navigation





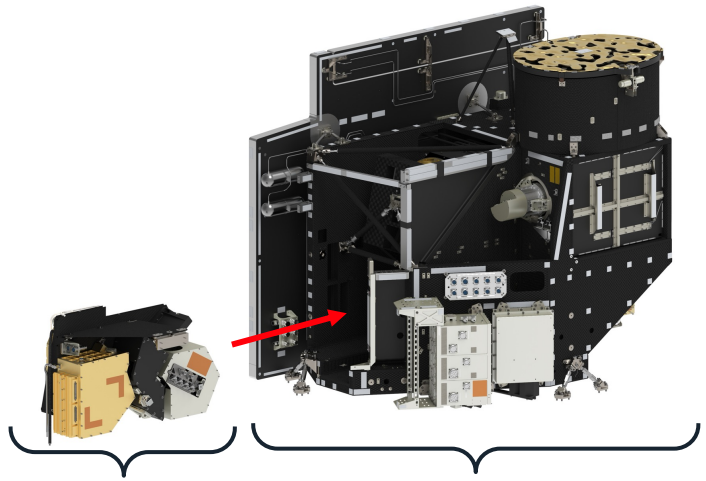
Hyperspectral Detector and Reimaging Assembly (HyDRA) is the heart of the sounding mission





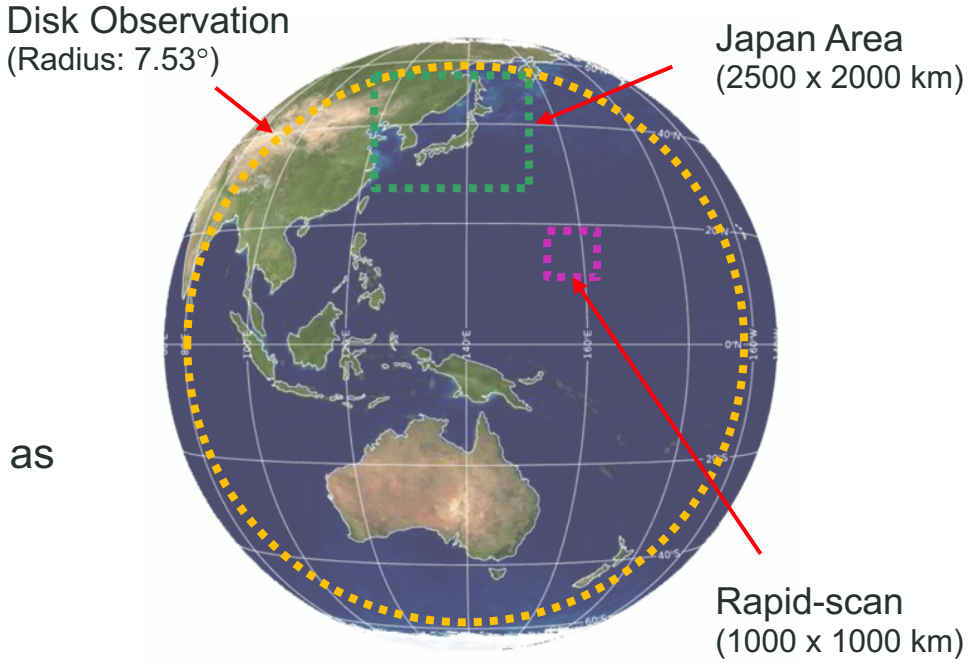
HyDRA 3D Print Model

HyDRA Component	Key Functionality / Performance
Minibench	Structurally supports HyDRA Components
Fold Mirror	Directs infrared energy from afocal telescope into interferometer
Interferometer (IFM)	Modulates incoming energy into interferogram • Defines spectral resolution and spectral sampling
Reimaging Telescope Assembly (RTA)	Focuses energy onto Focal Plane Modules (FPMs) • Defines GSD (along with FPMs)
Detector Housing Assembly (DHA)	Defines MWIR & LWIR spectral bands • Holds FPMs and maintains co-registration between bands
Cooler Assembly	Cools FPMs • Critical to NEdT performance



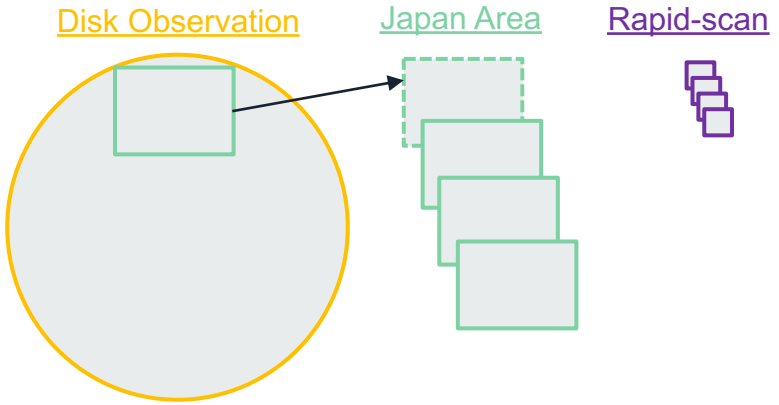
L3Harris scene & timeline architecture meets GHMS CONOPS requirements and enables flexible observations

- GHMS requires no changes to robust, flexible AHI scan system
  - Scan system directs the line-of-sight (LOS) in a step-and-stare mode
  - Two-mirror system natively supports GHMS step-stare collection scheme
- Inherently flexible scene & timeline architecture inherited from AHI
  - Multiple scenes and timelines can be loaded into memory
  - New scenes & timelines can be defined and uploaded at any time
  - Switching between loaded timelines is a single command
- GHMS is required to collect 9 or more observations areas in 60 minutes as defined in *GHMS Observation Ranges and Intervals* table
  - 1 Disk observation (every 60 minutes)
  - 4 Japan Area observations (every 15 minutes, first one cut from disk)
  - 4 Rapid-scan Target observations (every 15 minutes)



GHMS Observation Ranges and Intervals

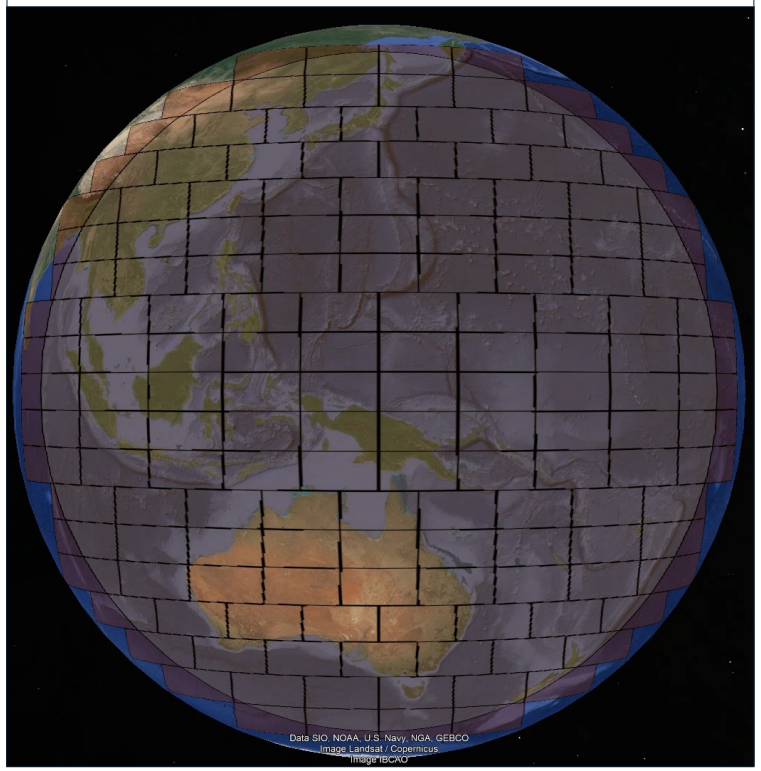
Observation Type	Minimum Range	Observation Interval
Disk	Satellite zenith angle within 60 degrees	60 min
Japan Area	2500 km (E-W) x 2000 km (N-S) *Center ≥ 25° N latitude*	15 min ± 180 sec
Rapid-scan Target	1000 km (E-W) x 1000 km (N-S) *Center ≥ 10° N latitude, ≤ 10° S latitude*	15 min ± 180 sec



Initial scene definitions created for all required observation areas

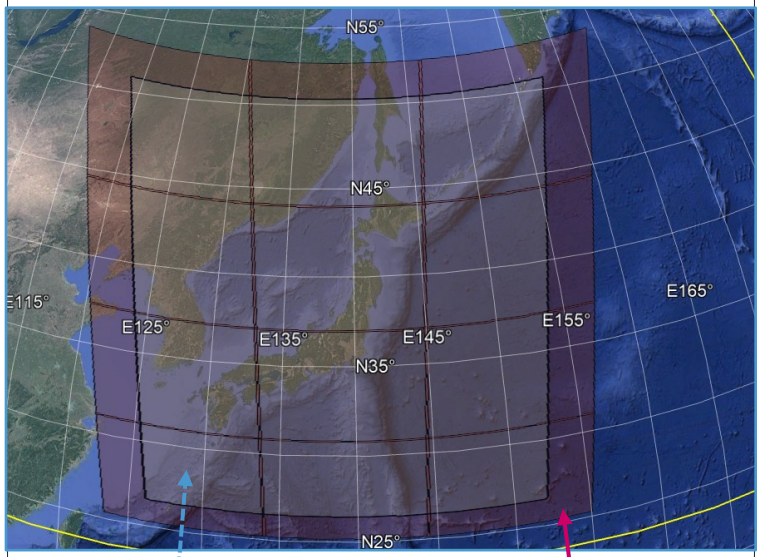
DISK OBSERVATION

- Size: >7.53° disk radius
- Center: Nadir
- Collected stares: 154 (19 rows)



JAPAN AREA

- Size: 3200 x 3200 km (@ *37°N latitude)*
- Center: Moveable anywhere on Earth
- Collected stares: 12 (4 rows x 3 cols)

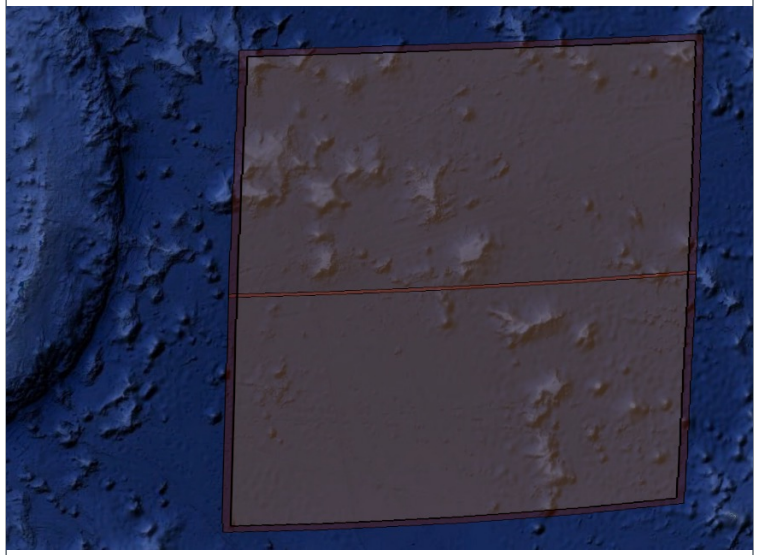


Inner Region is Required Area

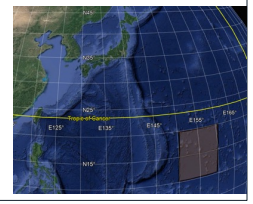
Smaller Rectangles are Individual Collected Stares

RAPID SCAN

- Size: 1000 x 1000 km (@ *10°N latitude)*
- Center: Moveable anywhere on Earth
- Collected stares: 2 (2 rows x 1 cols)



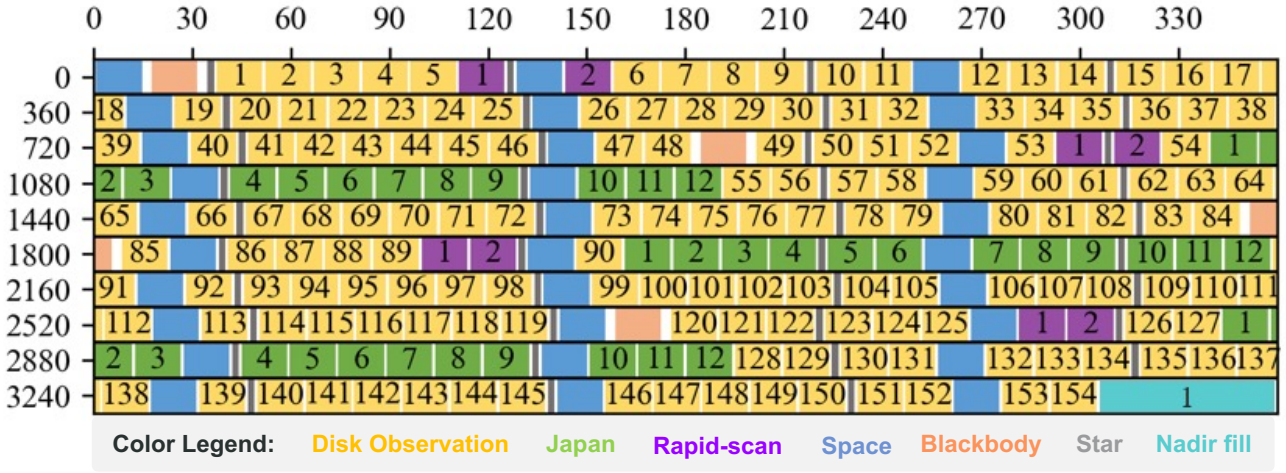
Example location



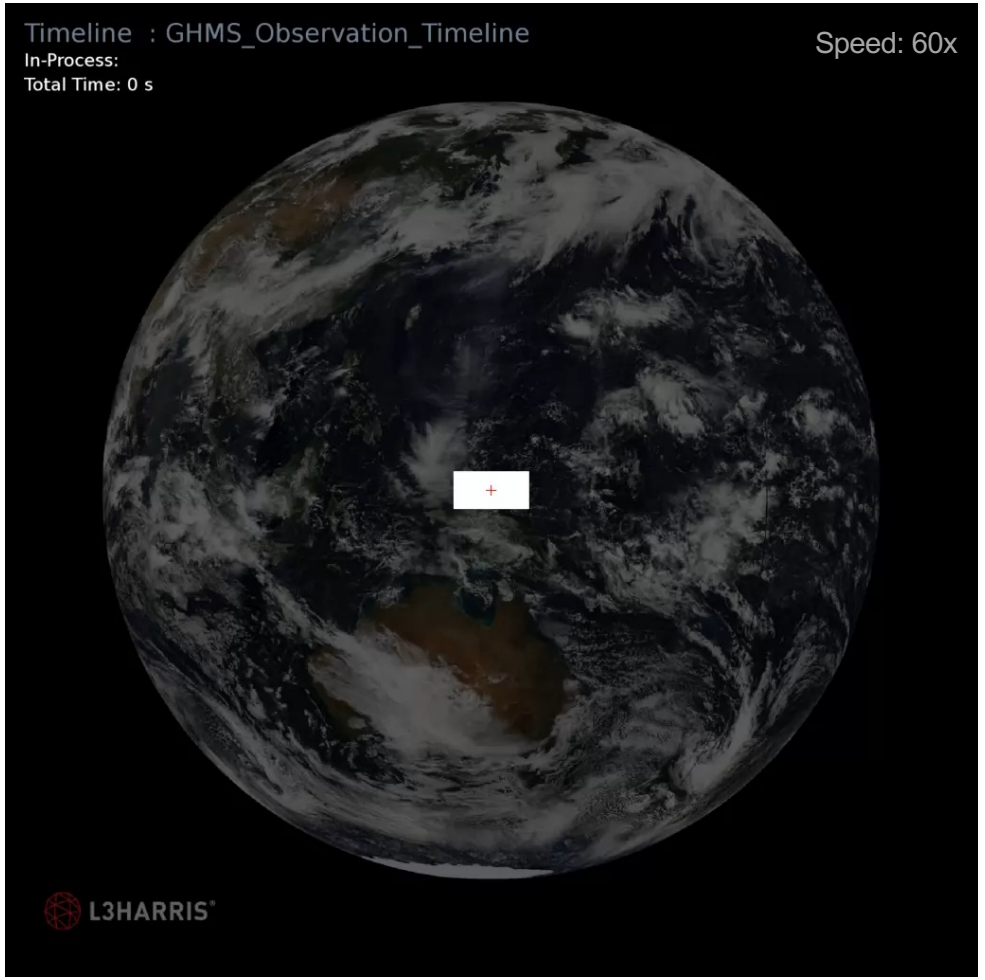
Initial *Standard Observation* timeline defined to collect all required observations

- Defined a 60-minute Standard Observation timeline to allow repeatable execution at 1-hour intervals
  - Sequence of observations meeting desired intervals
  - Includes observations necessary for calibration and navigation

Preliminary 60-minute Timeline

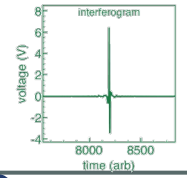


GHMS Timeline Video



Ground processing algorithms transform raw science data into geolocated radiance spectra

- GHMS outputs interferograms (Level 0)
- Five algorithms convert interferograms into calibrated, navigated radiance spectra (Level 1b)
- Lossless raw interferogram compression technique newly patented for GHMS
  - Based on applying principal components analysis (PCA) to raw interferograms
  - Forkert, R., 2025, Next Generation Geostationary Imager & Sounder Compression Algorithms, *21st Annual Symposium on Operational Environmental Satellite Systems, 105th Annual Meeting American Meteorological Society*
- Four subsequent algorithms largely based on processing from heritage instruments
  - CrIS: Cross-track Infrared Sounder
  - TANSO-FTS-2: Thermal And Near infrared Sensor for carbon Observation - Fourier Transform Spectrometer-2
- Initial draft of algorithms released to MELCO in November 2024



Level 0 Raw Interferograms

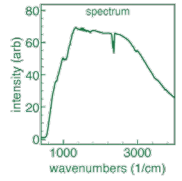
Decompression
Undo onboard PCA-based lossless interferogram compression
Heritage: New compression approach for GHMS[1]

Preprocessing
Prepare interferograms and convert to spectrum
Heritage: GOSAT TANSO-FTS-2

Spectral Calibration
Assigns accurate wavenumber to each bin (ILS, self-apodization)
Heritage: NOAA CrIS & GOSAT TANSO-FTS-2

Radiometric Calibration
Converts instrument counts into radiance units
Heritage: NOAA CrIS & GOSAT TANSO-FTS-2

Navigation
Geolocates data to Fixed Grid based on GRS80 geoid
Heritage: NOAA ABI



Level 1b Radiance Spectra

GHMS development heading toward system-level CDR

- Preliminary design phase concluded in 2024
  - Held ~45 subsystem/component PDRs
  - GHMS System PDR held November 2024
- Critical design phase in process
  - Held ~40 subsystem/component CDRs to date
  - Several critical subsystem CDRs remain
    - HyDRA CDR
    - Interferometer Electronics CDR
    - Flight Software CDR
  - GHMS System CDR tentatively planned for late 2025

Full Size GHMS 3D Print Model & H10 PDR Team