GeoXO Hyperspectral Infrared Sounder (GXS) Instrument Architecture, Performance, and Calibration

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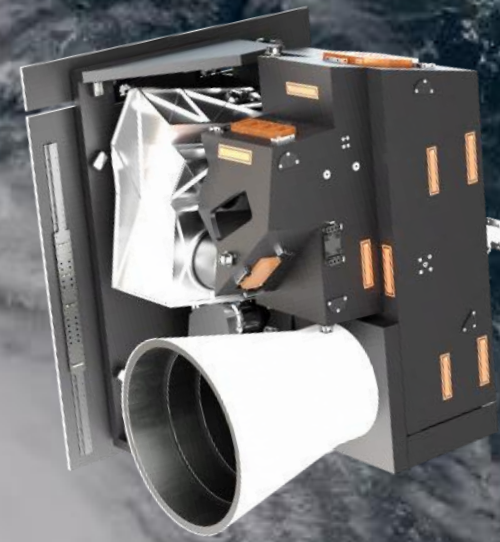
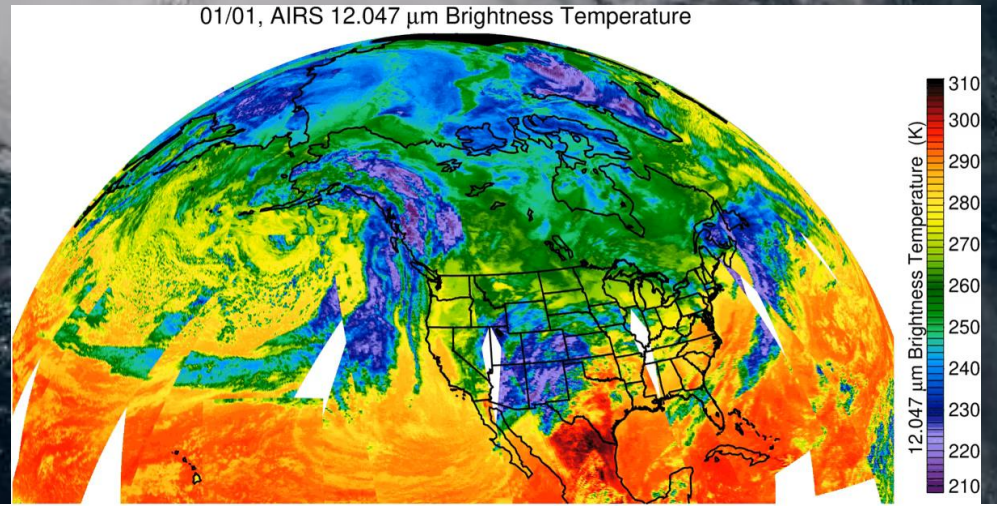
GXS Instrument Introduction

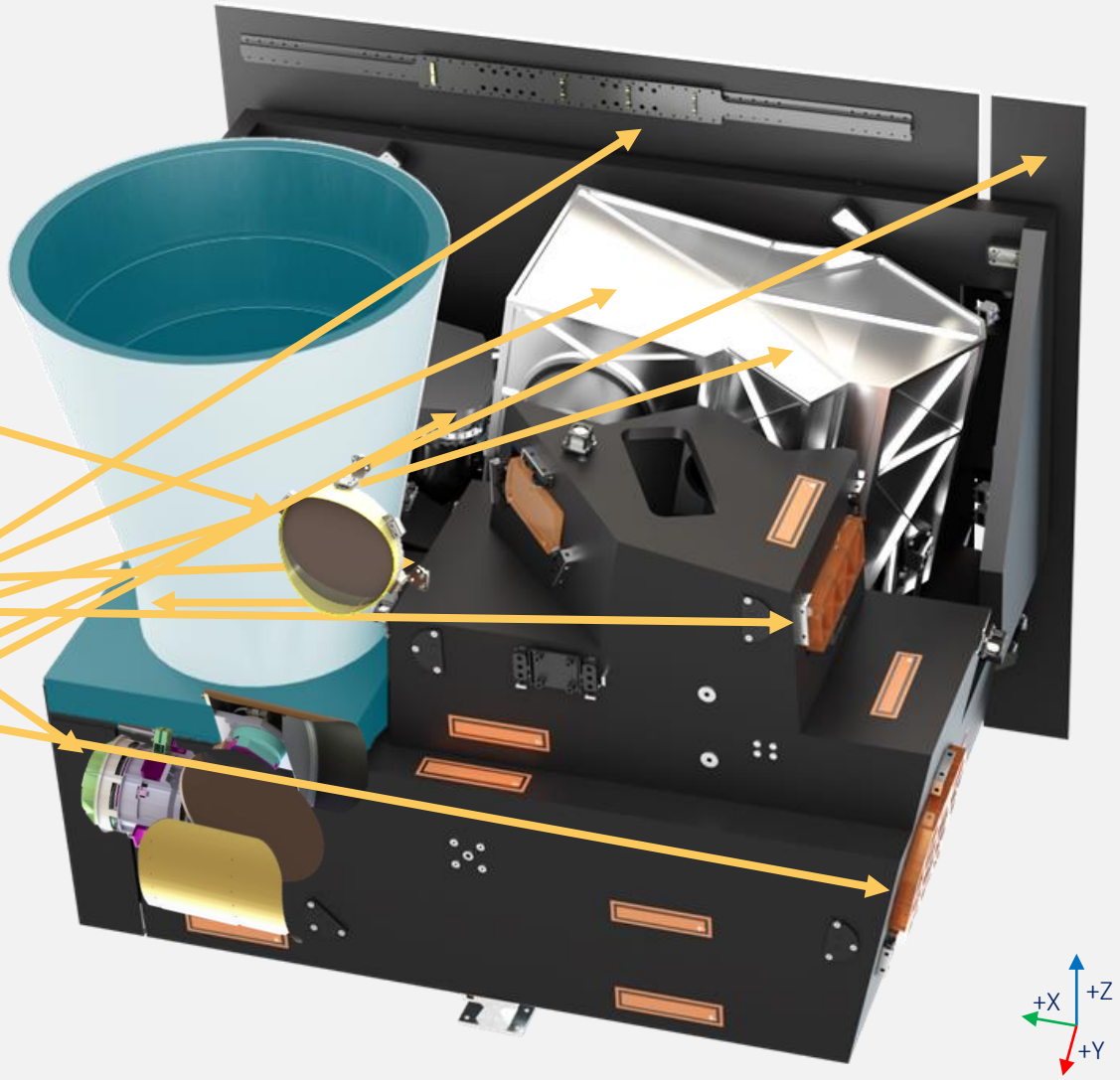
- What is the GeoXO Sounder (GXS)?
  - A hyperspectral infrared instrument that measures the atmosphere as a function of height, in this case, temperature, water vapor and trace gases
  - Collects radiance observations of the earth's atmosphere with spectral and horizontal resolution that yields vertical temperature and moisture information
- GXS provides L1b data for use in near real-time soundings and in numerical weather prediction models
  - Improved nowcasting for tornadoes, thunderstorms, floods, severe storms, and icing conditions
  - Improved hurricane track predictions
  - Improved weather forecasts
- BAE SMS's dispersive grating spectrometer technology enables the GXS mission
  - 2 independent spectrometers with a common aperture
    - MWIR 4.44-5.92 µm
    - LWIR 9.13-14.7 µm
  - Driven by modern high resolution infrared focal planes





GXS Instrument Architecture

- Baffle to limit sun exposure on scan mirror
- 24-cm Aperture
- Full Aperture Calibration assembly (stationary BB) positioned 90° off optical axis
- Scan mech assembly uses encoders for positioning to provide 22° conical FOR and rotates 90° to BB
- Three mirror telescope
- 2 spectrometer assemblies for LWIR / MWIR
  - Sealed off from ice contamination
  - Separated by a beam splitter
- Cryocooler and cold radiators
- SC-235 Cryocooler Assembly



Instrument architecture enables the GXS mission

Sounder Science and Geostationary Environmental Requirements Drive Instrument Architecture

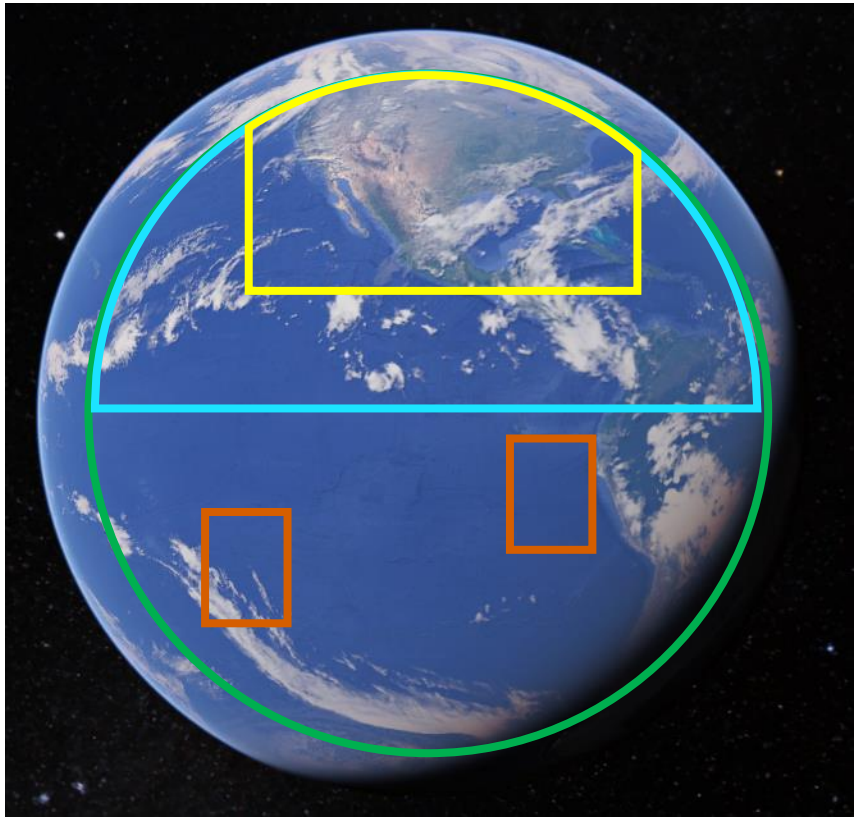
Driving Mission Requirements*	Influence on Architecture
Mass, volume, and ground sample angle	• Telescope optical form, Aperture size
Coverage Rate The GXS shall acquire each Sounding Disk (SD) and perform all necessary housekeeping and calibration functions in less than 30 minutes.	• Aperture Size • Dispersive Littrow Spectrometer
Ensquared Energy The GXS EE shall be greater than or equal to 70% for the aggregate of the channels within each band	• Slit width and binning of detector elements • High resolution infrared focal planes
Spectral Uniformity Differences between the corrected spectral response functions across the FPAs and the nominal on-axis reference spectral response shall be less than the NEdN	• Optical design optimized for spectral purity performance
Noise Equivalent delta Radiance (NEdN) For corresponding black body scenes, the instrument shall have a maximum NEdN as specified in the instrument specification for various scene temperatures	• Aperture size, slit width, optical thruput and count • Temperature control/stability • Dispersion, binning of detector elements • Stray light • Dark current, read noise, QE
Spectral Resolution The GXS sounding channels shall have a maximum width, 0.625cm^{-1}, where the full-width-half-maximum (FWHM) of the instrument line-shape function (ILS) of the Level 1b product is used for filter or grating implementations	• Dispersive Littrow Spectrometer • Spectral sampling and binning in spectrometers • High resolution infrared focal planes • Data bandwidth requirements

* Requirements paraphrased

GXS requirements drove the architecture decisions for the sounder mission

Flexible and Autonomous Scan Patterns

- GXS utilizes a flexible scan pattern to avoid clouds and optimize sounding collections
- 7 day autonomous operation capability with default scan patterns

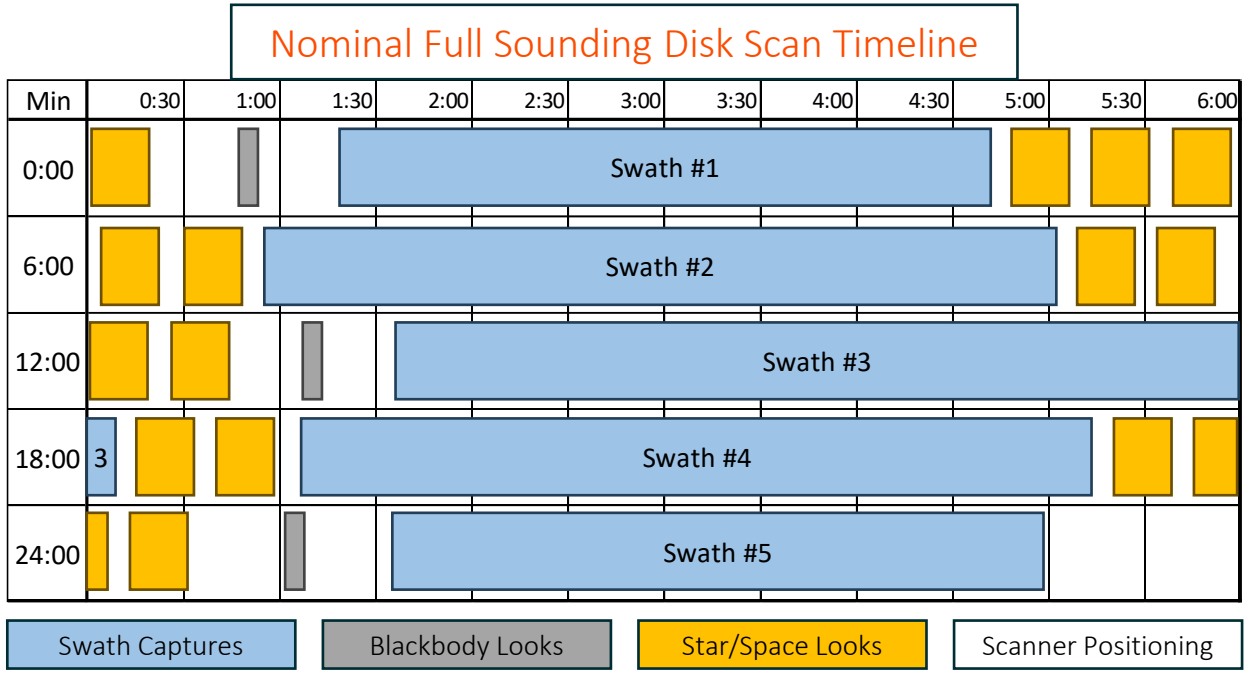


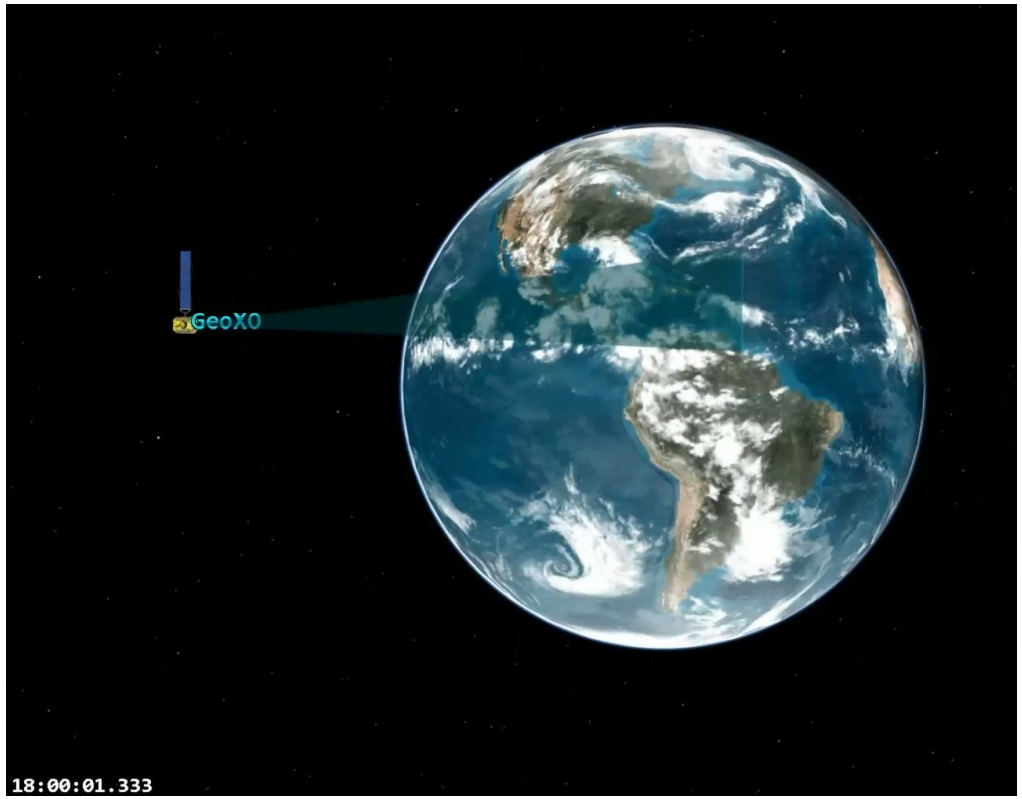
Example Scan Pattern Collections

Revisit Time	45 Minutes	38 Minutes	30 Minutes	18 Minutes	9 Minutes	6.5 Minutes	5 Minutes
Sounding Full Disk	1	1	1	N/A	N/A	N/A	N/A
Northern Hemisphere SFD	N/A	N/A	N/A	1	N/A	N/A	N/A
Super-Regionals	1	N/A	N/A	N/A	1	1	N/A
Mesos	13	12	N/A	N/A	3	N/A	4

Full Sounding Disk Scans

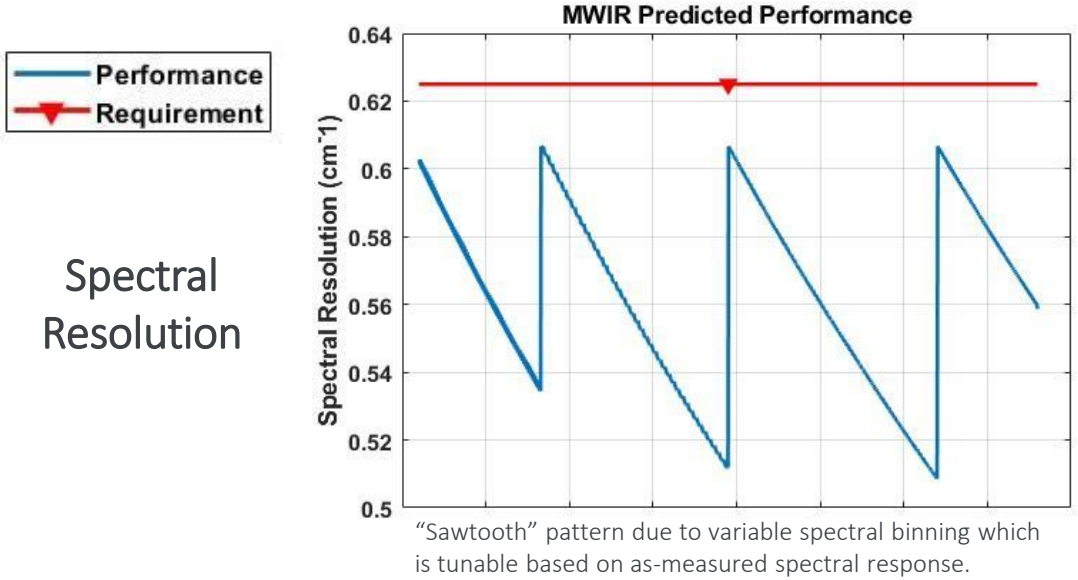
- Nominal 30-minute Sounding Full Disk scan pattern of 62° Local Zenith Angle
- Regular blackbody looks utilized for spectral calibration
- 2-5 Star looks between each swath navigate the pixels in the L1b products





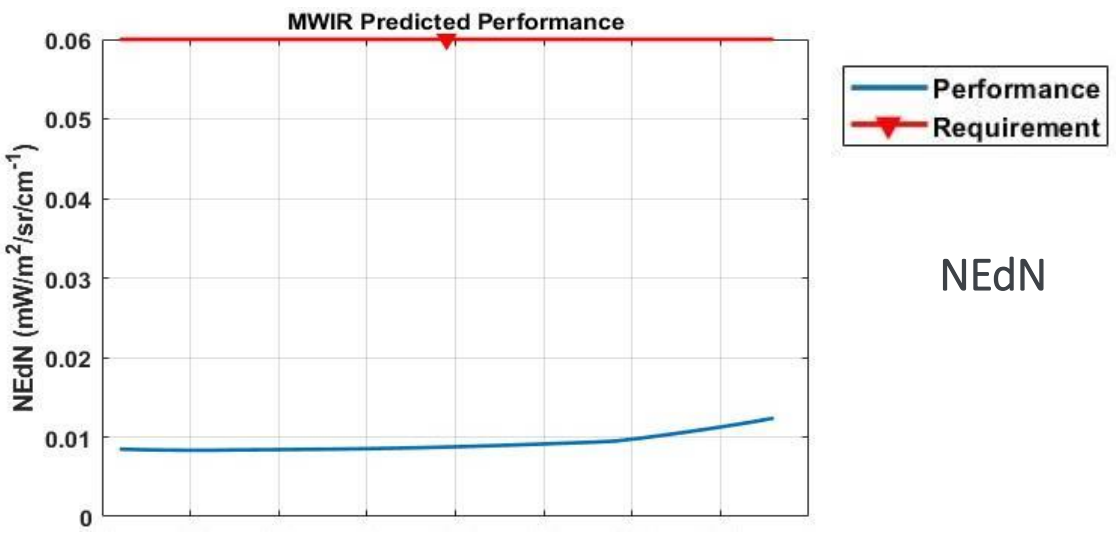
GXS Initial System Performance Estimates - MWIR

Spectral Resolution

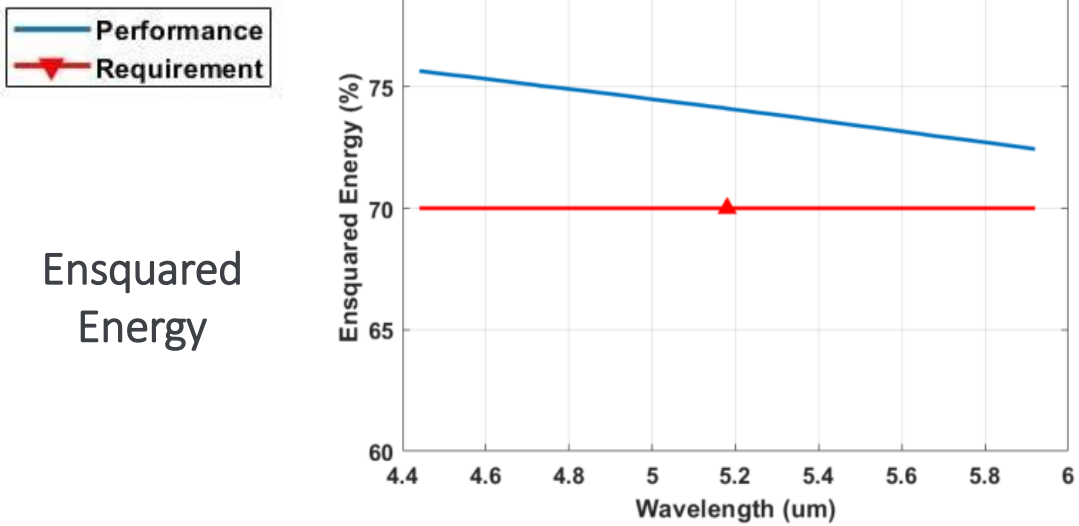


"Sawtooth" pattern due to variable spectral binning which is tunable based on as-measured spectral response.

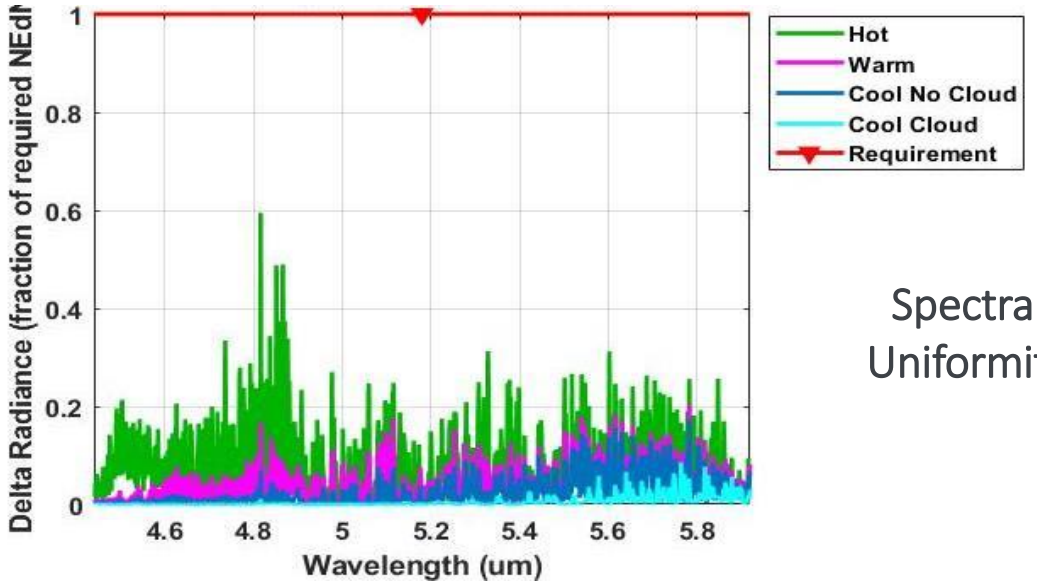
NEdN



Ensquared Energy



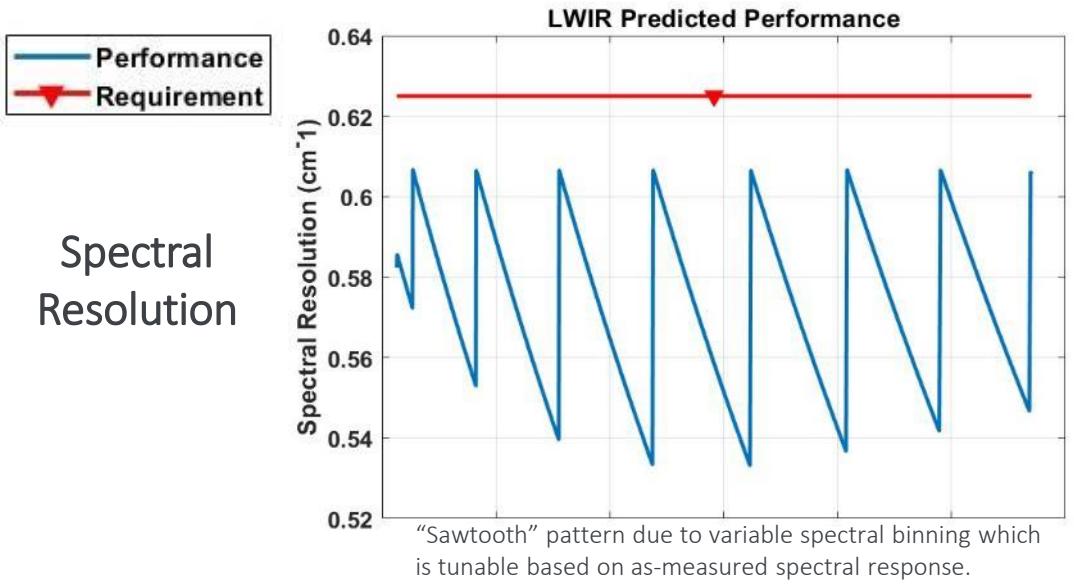
Spectral Uniformity



GXS meets MWIR performance requirements with comfortable margins

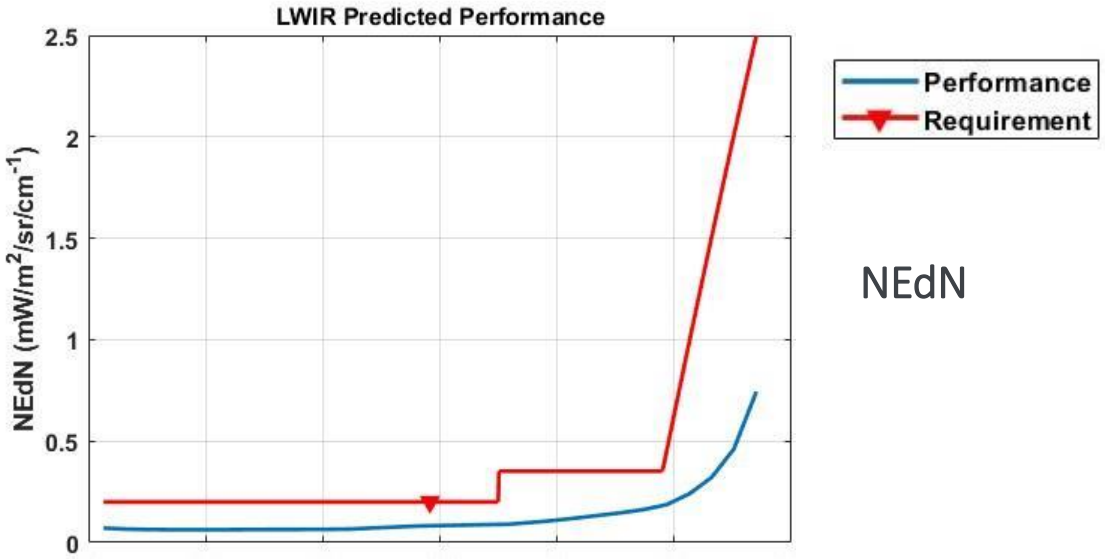
GXS Initial System Performance Estimates - LWIR

Spectral Resolution

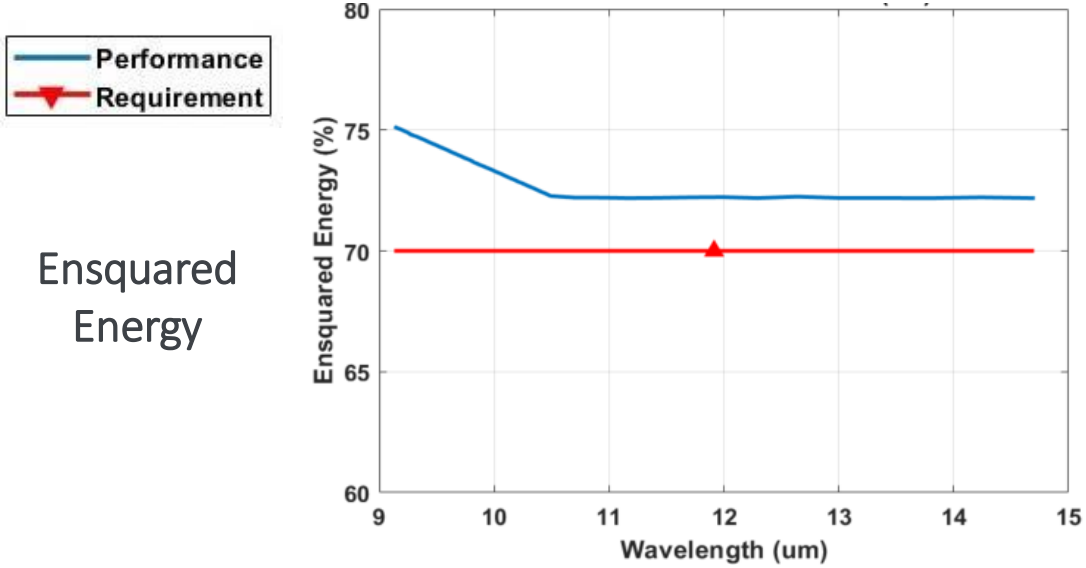


"Sawtooth" pattern due to variable spectral binning which is tunable based on as-measured spectral response.

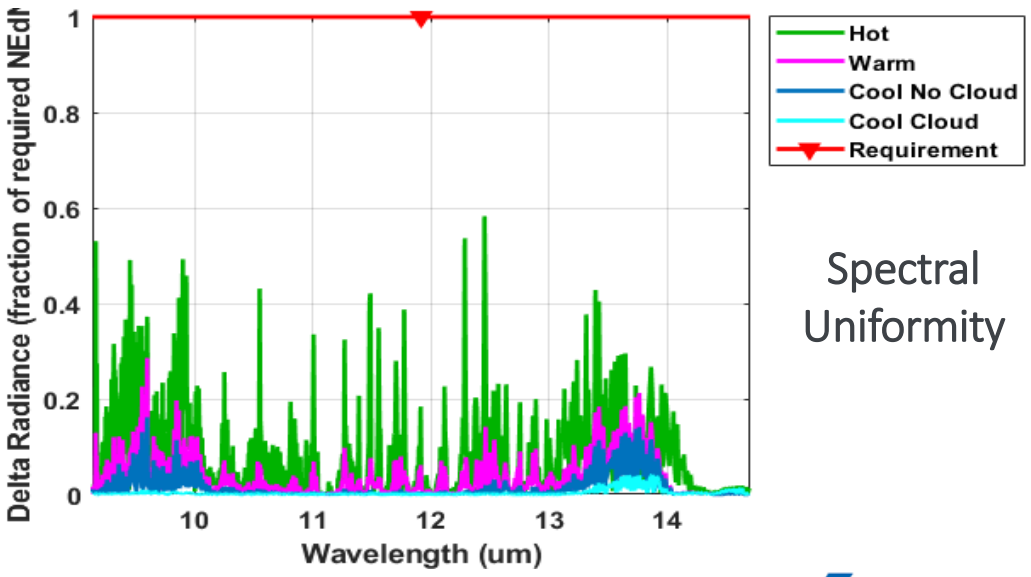
NEdN



Ensquared Energy

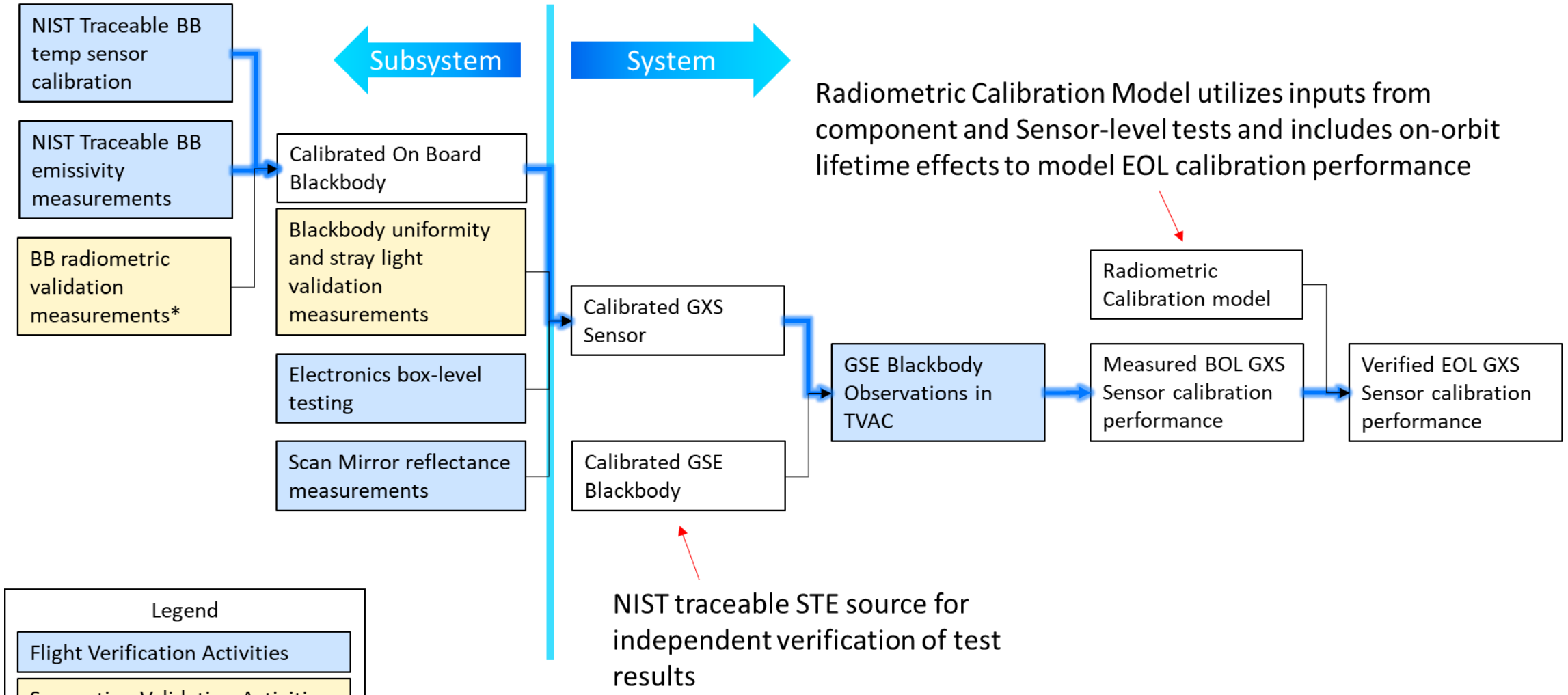


Spectral Uniformity



GXS meets LWIR performance requirements with comfortable margins

NIST Traceable Sensor Calibration Plans



*Validation activity already performed in support of immersion bath process

GXS calibration will be NIST traceable

Summary

- GXS will fly on the central GeoXO satellite, GeoS, approximately in 2035
- GXS will provide unprecedented temperature, humidity, and trace gas measurements of the visible western hemisphere with a revisit time that enables dramatic improvements in weather forecasts
- SRR/SDR was successfully completed in July 2024 and the program is working towards subsystem and instrument PDR

BAE Systems Inc., Space and Mission Systems is proud to be working with NASA, NOAA, and the scientific community to build and field the GeoXO Sounder (GXS)