Wind Imaging Spectrometer and Humidity-sounder (WISH): a Practical and Effective NPOESS P3I Sensor

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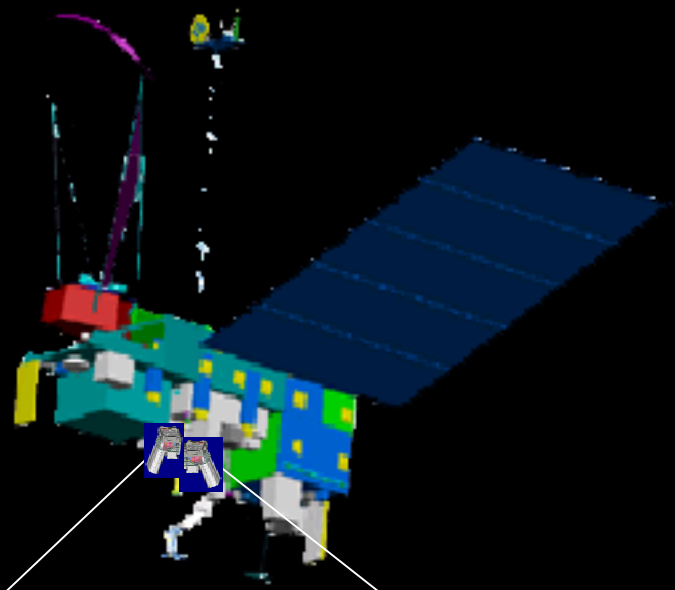
Overview

- **Tropospheric wind is a top priority NPOESS Pre-Planned Product Improvement (P3I) EDR candidate**
- **We propose to retrieve this EDR by tracking high spatial resolution altitude-resolved water vapor sounding features in imagery provided by a humidity-sounding imaging spectrometer**
- **Our Wind Imaging Spectrometer and Humidity-sounder (WISH) is suitable for flight on any of the NPOESS spacecraft and can be developed in time for NPOESS C2**
  - **Takes advantage of payload capacity available for P3I demonstrations in NPOESS**
  - **Serves as a risk reduction and technology demonstration for future NOAA environmental satellite missions**

WISH consists of two identical spectrometers that measure wind by observing Earth in the 6.7 micron H_2O band.

Measurement Concept:

- Measure wind by looking for movement of water vapor features between observations made with two identical spectrometers
  - First observation occurs with spectrometer that is pointed 50 deg ahead of nadir along track
  - Second spectrometer occurs with spectrometer that is pointed 50 deg behind nadir along track
- Approximate time between measurements is 5.3 min
  - Feature will appear to move ~10 pixels for 20 mph wind

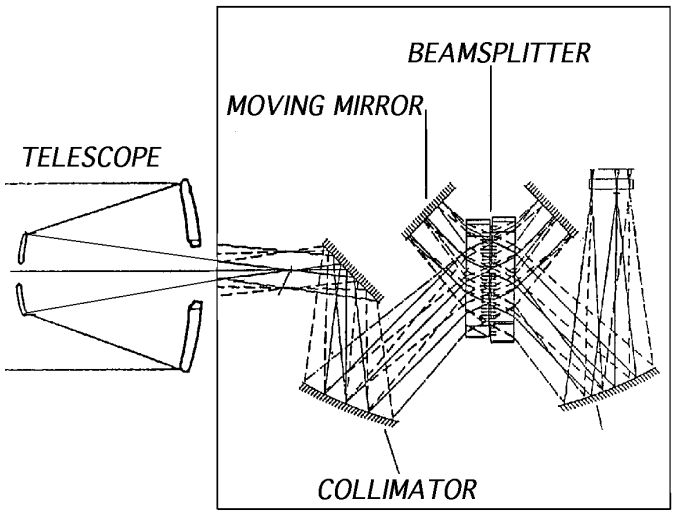


±50 deg from nadir

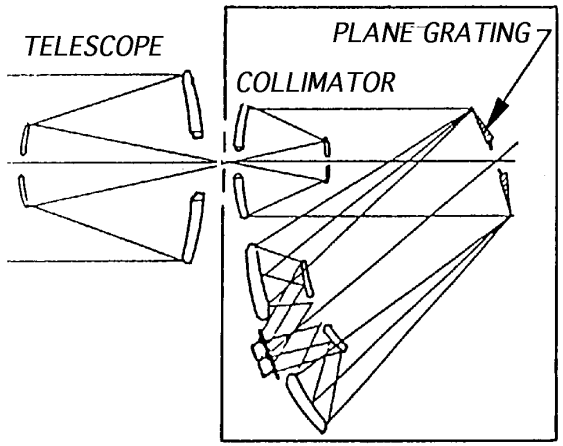
Line of Sight for Spectrometer 2

Line of Sight for Spectrometer 1

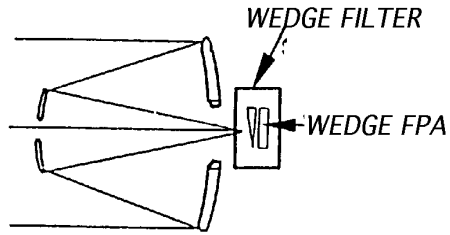
WISH has a Simple Optical Layout



FOURIER TRANSFORM SPECTROMETER



GRATING SPECTROMETER



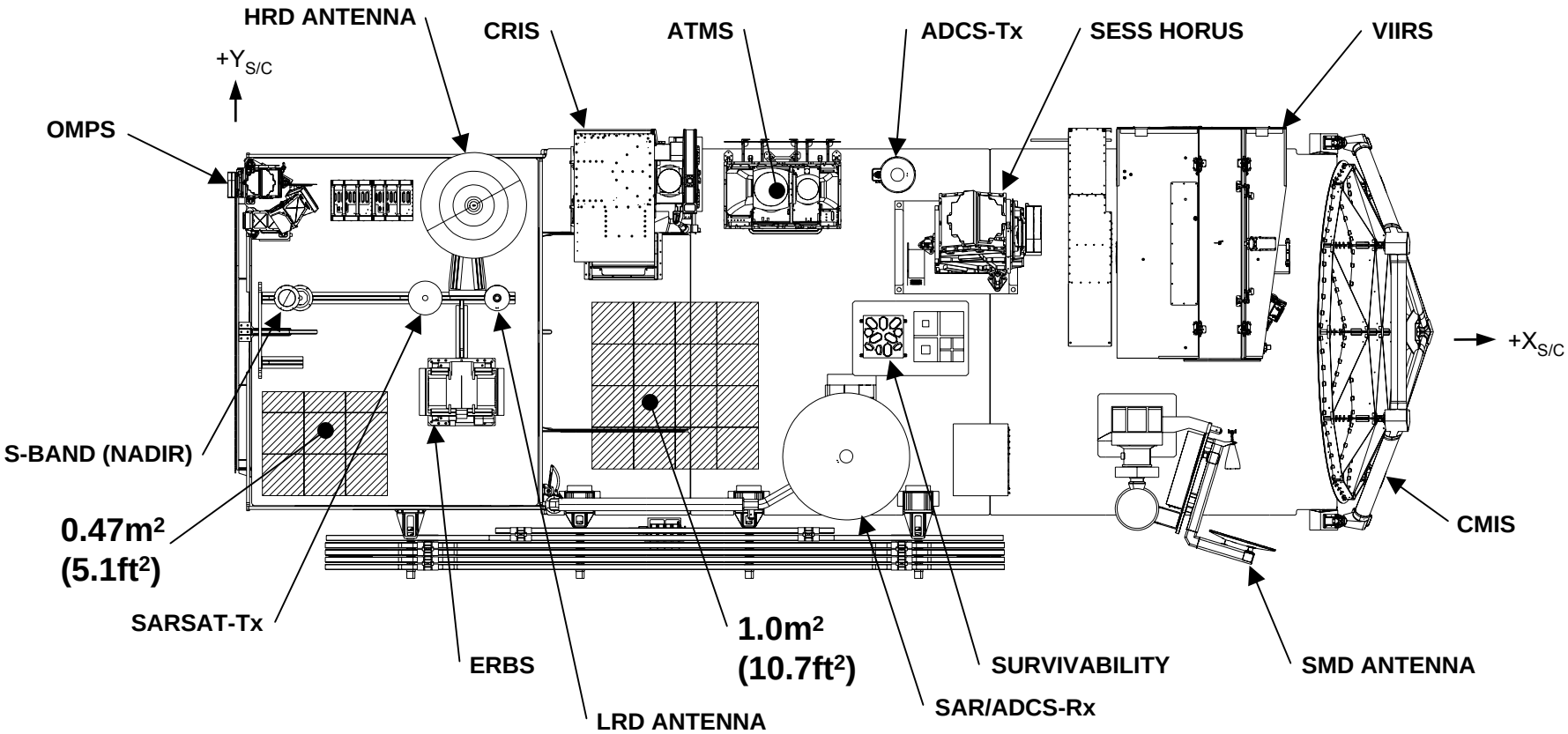
WEDGE SPECTROMETER

General Characteristics

- Twin spectrometers fit within available NPOESS P3I footprints
  - WISH can be accommodated in any NPOESS configuration
- Difference in nadir angle is large enough to enable accurate wind measurements
  - 50 deg nadir angle along track (fore and aft) of spectrometers leads to 5.3 min interval between measurements of same region
  - During this interval, a H_2O feature will appear to move ~10 pixels in a 20 mph wind
    - 1 m/s wind corresponds to movement of ~1 pixel in 5.3 min
- Lightweight and low power
- Low cost
  - Small, low risk instrument using existing technology
- Low risk
  - Requires no new technology
- Good spatial resolution from NPOESS orbit
  - 290 meter detector samples at 50 deg nadir angle
- Excellent sensitivity
  - Fast f/#, high IR transmittance, PV HgCdTe detectors, active cooling

NPOESS: 1330 CONFIGURATION

Planned for C2



Unused Real Estate

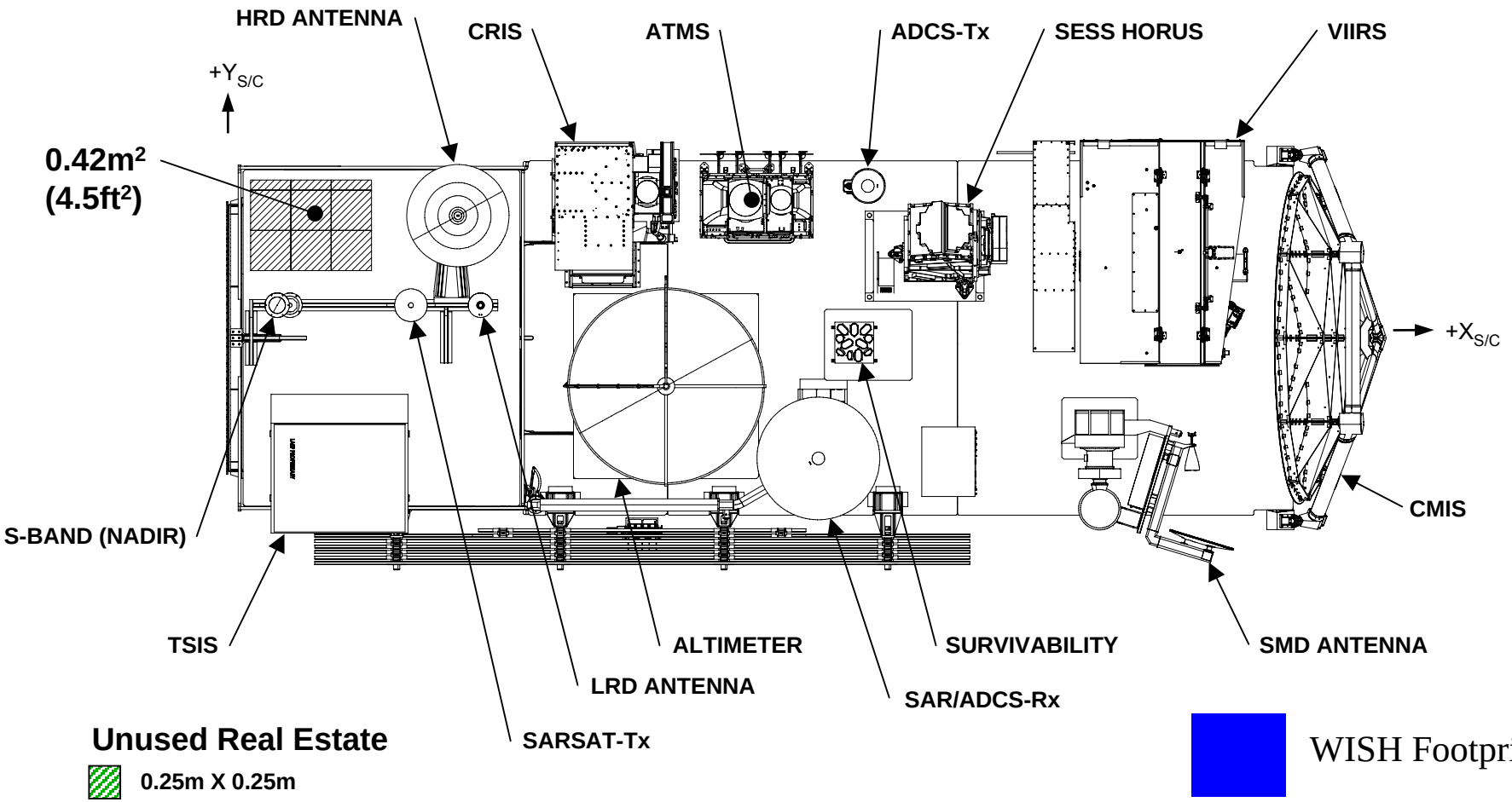
0.25m X 0.25m

WISH Footprint

STOWED CONFIGURATION

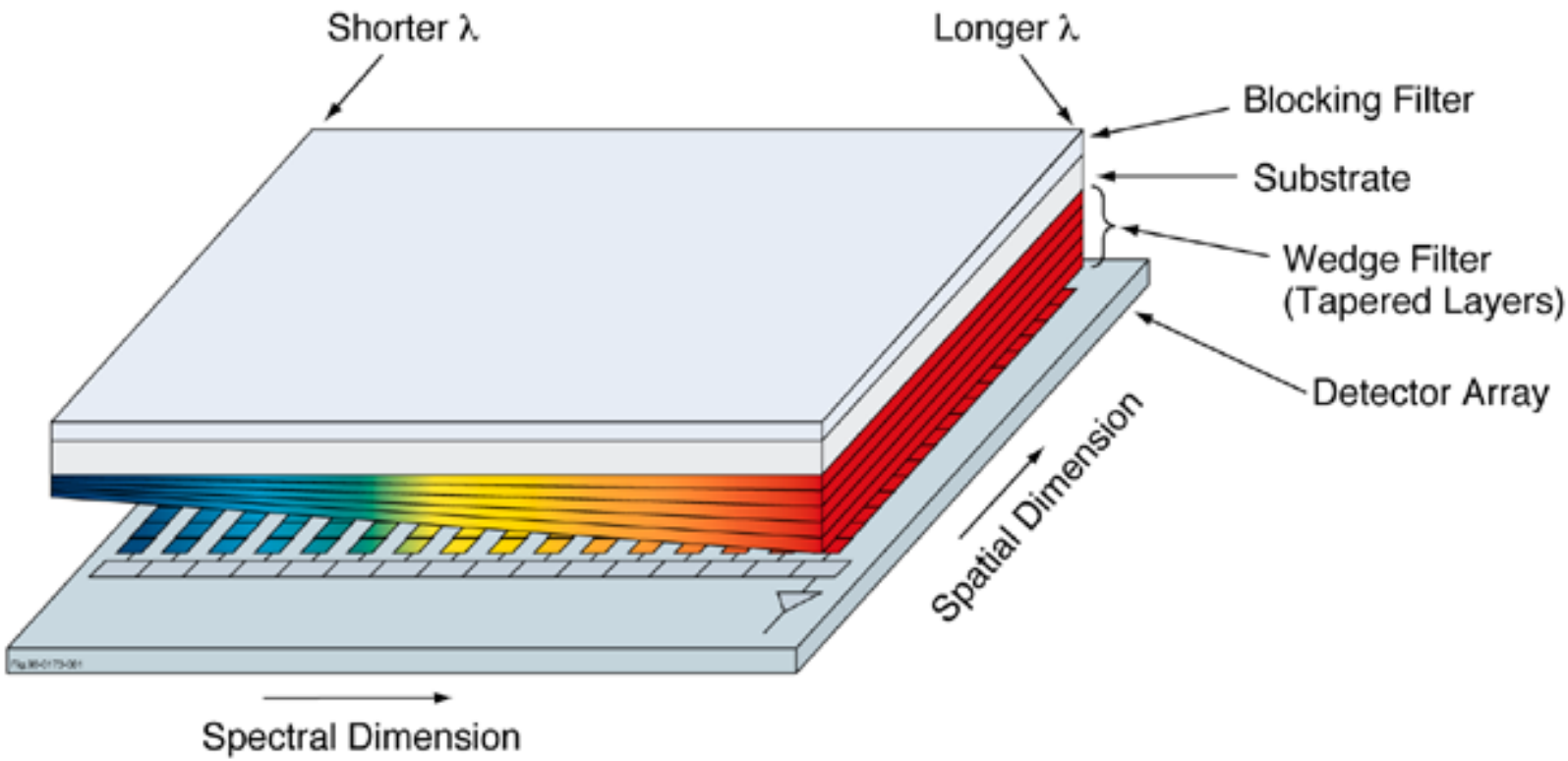
NPOESS: 1730 CONFIGURATION

Planned for C3

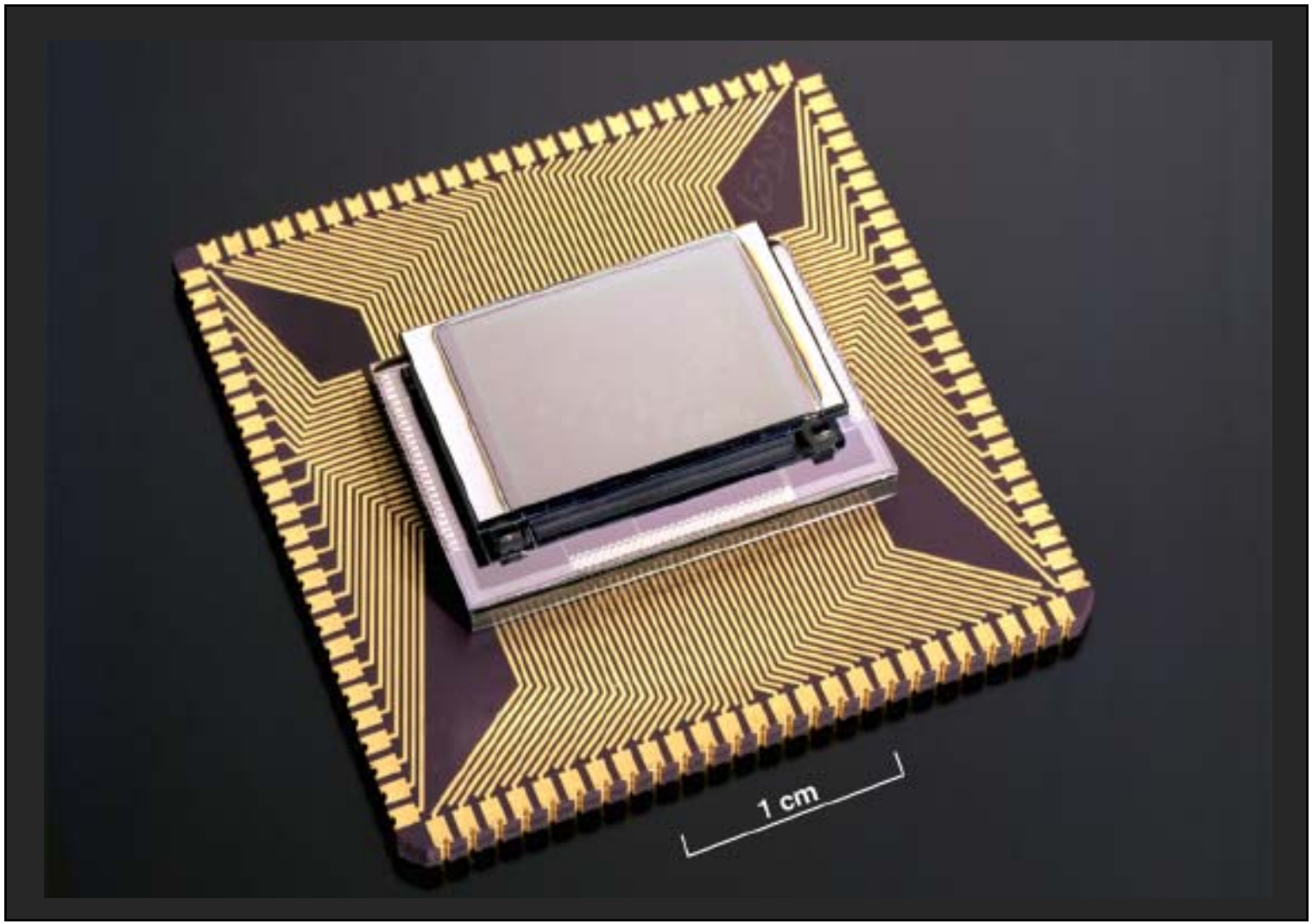


STOWED CONFIGURATION

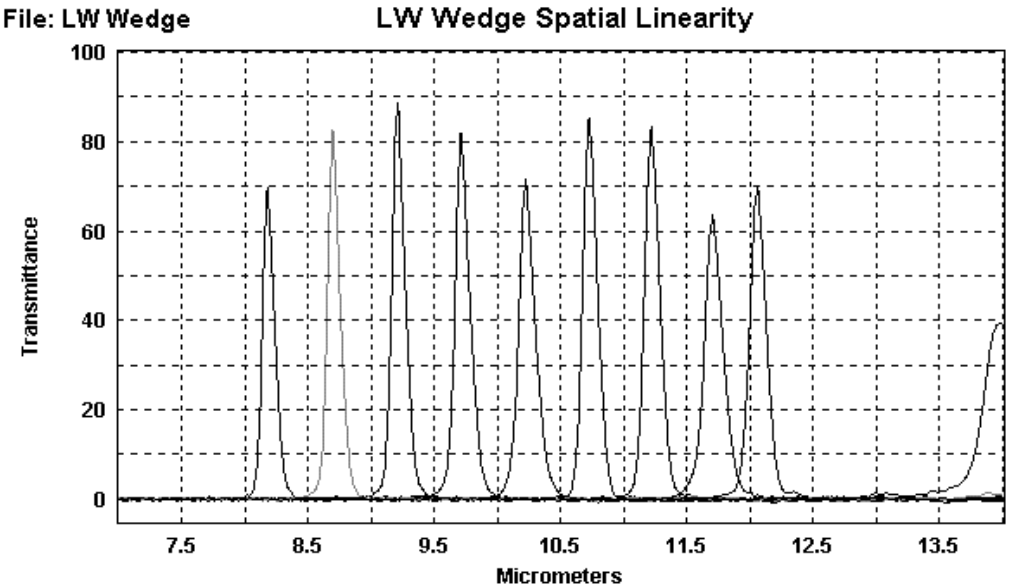
Wedge Spectrometer Concept



LWIR Hybridized Sensor Chip Assembly



Characteristics of a Recent Raytheon LWIR Wedge Filter



Spectral Range: 8-11.8 μm
Array Size
Spatial: 320
Spectral: 210
Detector Size: 40 μm
Orthogonal Channels: 27
Point Bandwidth: 1.5%
Tranmission: ~80%

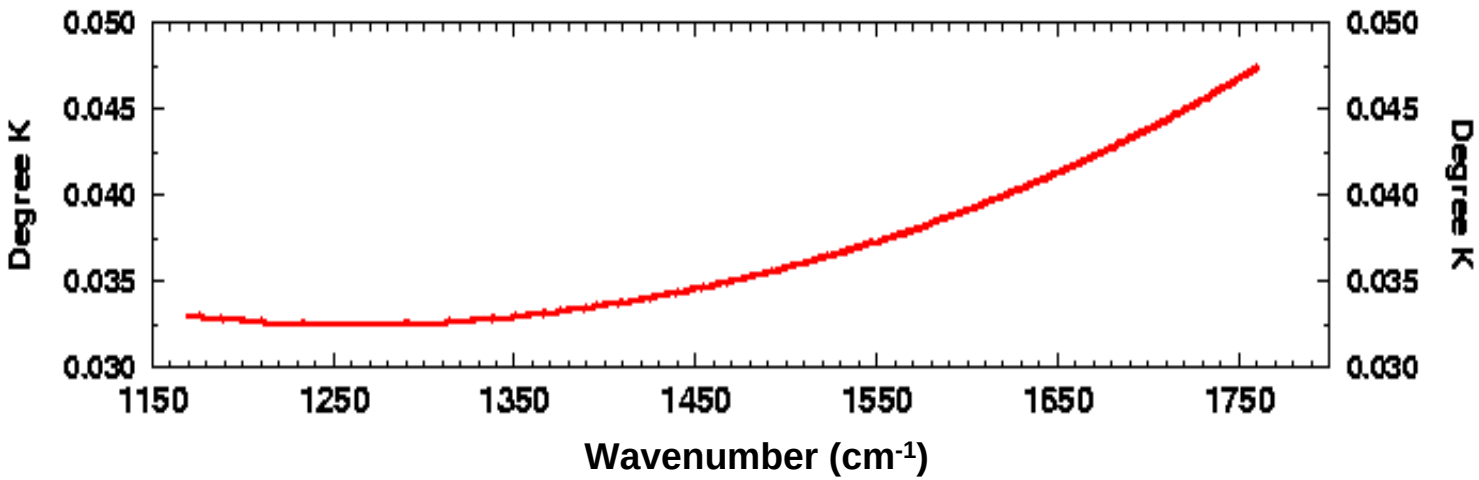
Wedge filter technology has been applied in the MWIR, too, and can be used out to 14 μm and beyond, making it a candidate technology for atmospheric sounders.

WISH Radiometric Sensitivity

Infrared Wedge Imaging Spectrometer

NEdT @ 300 K (60 K Detector)

1% spectral resolution (e.g. 15 cm^{-1} resolution at 1500 cm^{-1})



Technical Issues Requiring Further Study

- **Radiometric calibration accuracy performance of wedge spectrometer**
  - **How does focal plane spectral/spatial sampling approach affect accuracy?**
- **Spectral calibration**
  - **Requires accurate mapping of wedge filter positions on detector arrays**
  - **Spectral calibration of data from specific earth grid points also depends on sensor pointing knowledge**
- **Absolute line of sight accuracy for each pixel aboard NPOESS spacecraft**
- **Optimization of WISH design for more complete set of sensor requirements is needed to define sensor better**
  - **Do we need to point the spectrometers 50 deg off nadir or can we look closer to nadir and minimize parallax and possible optical depth issues?**

Summary

- **A Wind Imaging Spectrometer and Humidity-sounder (WISH) that incorporates recent MWIR/LWIR Raytheon technology developments offers a practical approach for measuring water vapor winds using spacecraft capacity available in NPOESS**
- **Due to its excellent (290 m) spatial resolution WISH can measure water vapor winds accurately with only a ~5 min measurement separation**
- **WISH offers an unprecedented combination of spectral and spatial resolution and would represent the first true imaging sounder**
- **More work is needed to optimize WISH sensor design and assess its absolute radiometric and spectral calibration and line of sight accuracy performance**

International TOVS Study Conference, 14th, ITSC-14, Beijing, China, 25-31 May 2005. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2005.