Pre-launch Calibration of the Landsat Data Continuity Mission Thermal Infrared Sensor

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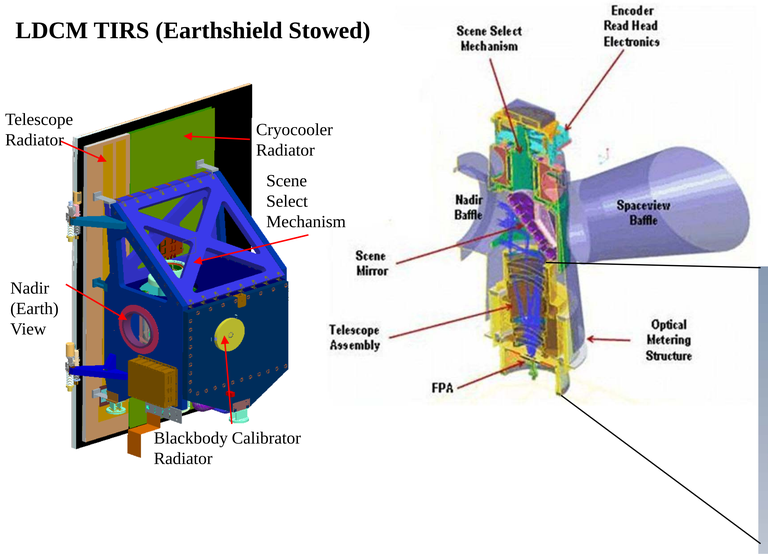
Abstract

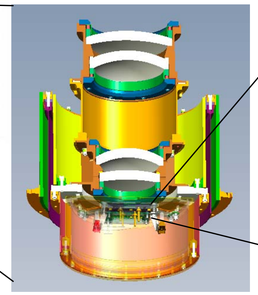
The Thermal Infrared Sensor (TIRS), designed and built at NASA Goddard Space Flight Center (GSFC), is one half of the two-sensor Landsat Data Continuity Mission (LDCM) platform. TIRS data will extend the data record for thermal observations from the heritage Landsat sensors, dating back to the launch of Landsat 4 in 1982. TIRS will operate independently from the Operational Land Imager (OLI) however, the data streams will be merged into a single data product. The two-band (10.8 and 12.0 µm) pushbroom sensor with a 185 km wide swath and 100 m spatial resolution uses a staggered arrangement of quantum well infrared photodetector (QWIPs) arrays. Regular views of an on-board variable temperature blackbody source and deep space via a rotating scene select mirror will be used to track the on-orbit performance of TIRS. During the instrument development stage, extensive thermal-vacuum chamber testing of the flight sensor was conducted using a custom-built calibration system with a NIST-traceable blackbody source. These measurements were used to calibrate and characterize the radiometric, spectral, and spatial performance of the instrument. Results of the pre-launch testing are presented in addition to the lessons learned.

LDCM TIRS (Earthshield Stowed)

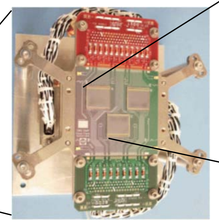


- Pushbroom design with a precision scene-select mirror to switch between two full aperture calibration sources: 1) onboard variable Temperature black body and 2) spaceview
- Two channels: 10.8 and 12 µm
- Quantum well infrared photodetectors (QWIP) (640x512 pixel arrays)
- 100 m nominal ground sample distance with 185-km ground swath (15°field of view)
- Actively-cooled focal plane operating at 43 K and passively-cooled telescope at 180 K
- 3 Year Design Life

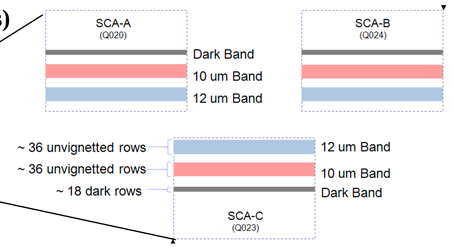
Telescope



Focal Plane (no filters)

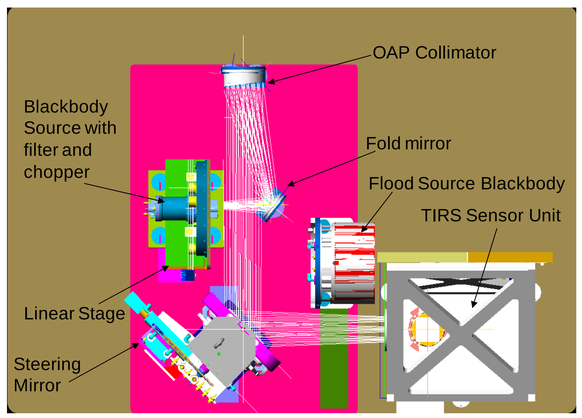


Focal Plane Layout

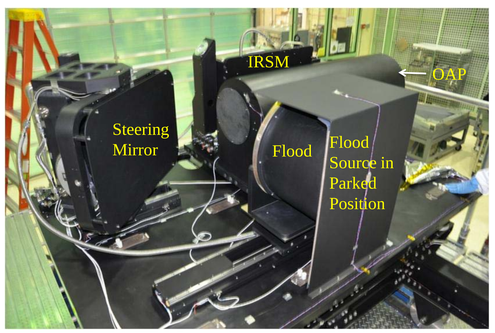


Pre-launch Calibration System

- All thermal vacuum acceptance testing performed at NASA GSFC
- Calibration sources (radiometric and spatial) located inside the chamber
- NIST calibrated cavity blackbody used for NIST traceability
- Calibration Equipment custom built by ATK

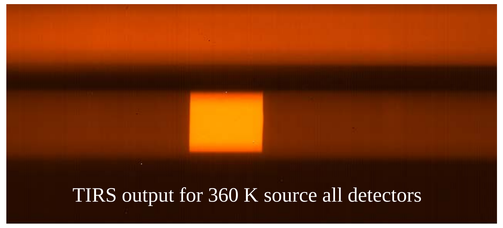


- Provides full-field, full-aperture calibration
- 16” Diameter source (**Flood Source**)
- Target Source Module (**GeoRad Source**)
- Blackbody
- 13” square steering mirror system
- All reflective, off-axis parabaloid collimator
- Precision linear stages to move sources
- Cooled enclosure over entire system
- Monochromator (spectral source)

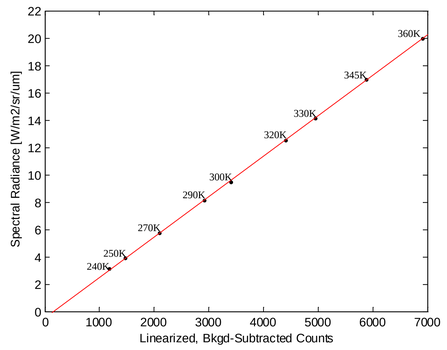


Thermal Vacuum Calibration Data Collects

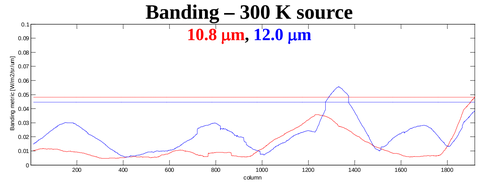
- Focus & Pointing Stability
- Uniformity (Banding/Streaking)
- Spectral Shape
- Scattering and Straylight
- Spatial Shape
- Geometric Distortion
- Bright Target Recovery
- Radiometry



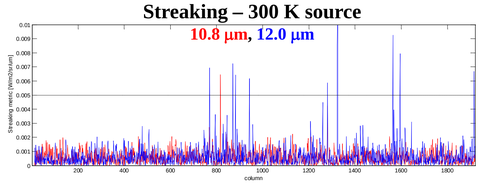
Single pixel (10.8 µm) Radiometric Response



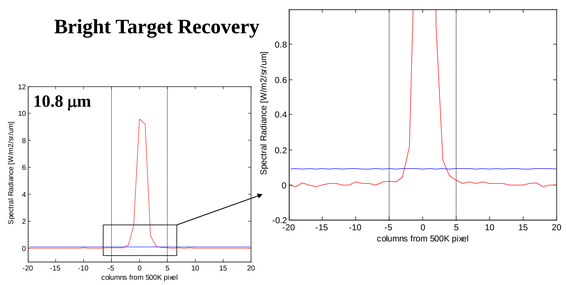
Banding – 300 K source



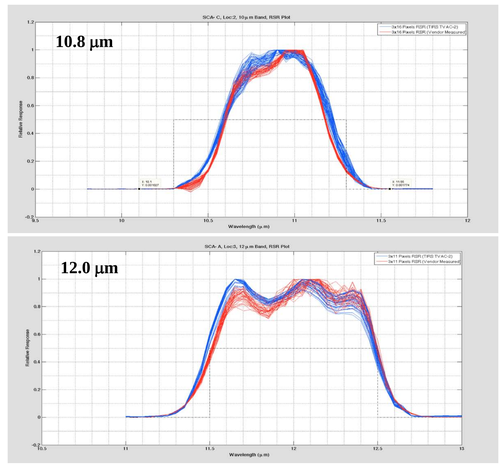
Streaking – 300 K source



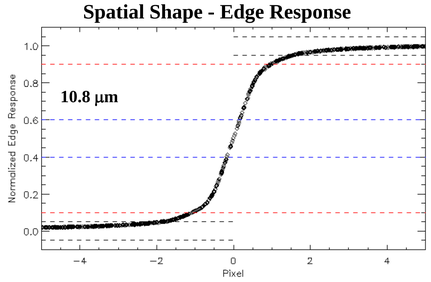
Bright Target Recovery



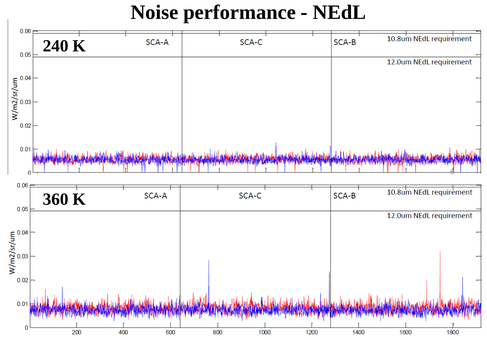
Relative Spectral Response - Measured vs Component



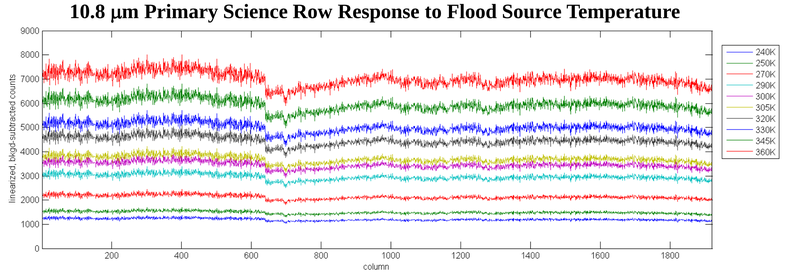
Spatial Shape - Edge Response



Noise performance - NEdL



10.8 µm Primary Science Row Response to Flood Source Temperature



Summary

- TIRS Thermal Vacuum Testing successfully completed – collecting the necessary calibration data to allow verification of instrument requirements
  - Well behaved, low noise system
- Performance remained constant pre- and post- environmental testing (Vibe & EMI)
- Analysis shows most performance metrics meet or exceed requirements
  - No science impact expected for exceedences
- On-orbit required 2% radiometric accuracy (from scenes temps 240-330 K) is achievable.