Source Test and Characterization Program

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Motivation

Stricter requirements for absolute and relative calibration drive the use of internal sources for EO sensors

• NASA’s CLARREO program specifies <<1% from visible to LWIR

• The Spatial Infrared Imaging Telescope III (SPIRIT III) on MSX was one of the early examples of internal sources being used to trend sensor responsivity and thus calibration, resulting in ~6% absolute from stars and ~1% trending accuracy in the 4-28 micron spectral range

• Other programs have now joined in this robust calibration and sensor performance assessment and trending philosophy

• Provides insight into focal plane changes vs. optics changes
  – Use ground surface (vicarious) calibration regions & stars for point targets to assess end-to-end response variations

• Can provide assessment of contamination, especially if multiple spectral filters are used

• Sources can be used for a variety of wavelengths and illumination levels
Statement of the Problem

Basic requirements for such internal sources include:

- Most significant requirement is constancy or repeatability, typically better than 1%/year, and long lifetime (~10-15 years for current programs)
- Desirable to have flood illumination of the focal planes, preferably relatively uniform, but high uniformity is not required (better than a factor of 2 across the focal plane is usually “good enough,” ~25% is fine)
  - Enables characterization of ALL pixels or detectors in the sensor
- A range of sources is needed to meet various sensor requirements
  - Need to span dynamic range of the sensor
  - Need to span range of wavelengths – typically about 0.4 – 13 microns
  - Need continuum and narrowband sources
- Sources may be needed that operate at cold temperatures (down to 77K or even 10K)
- Not necessary to pass through the whole optical system
  - In fact, direct illumination of the focal planes enables separation of effects, with external point and flood sources to characterize effects of optics

Programs tend to only want to use known components that are already space-qualified, so the higher the TRL level, the better
Test and Characterization Plan (1/2):

• Procure a variety of sources (accomplished):
  – Visible filament sources (e.g., Tungsten)
  – Visible, Near IR and IR LEDs
    • Narrowband and wideband
    – Nichrome ribbon sources used in one space program already, but not fully characterized for spectral performance or performance at various temperatures

• Perform repeatability tests at ambient temperature
  – Explore circuits/requirements for the driving power supplies, commandable controllers, detector stability and temperature control requirements

• Perform lifetime tests at ambient temperature and pressure to start – plan to begin with ~50,000 cycles under automated computer control

Automation will be key to collecting adequate data from many sensors spanning visible to IR
Test and Characterization Plan (2/2):

- Perform repeatability tests over a range of lower temperatures typical of orbiting sensors
  - *Using 1 m³ TVAC chamber with internal LN2 piping for vacuum cold testing down to 77K.*
  - *May perform lifetime tests at cold temperatures (TBD)*

- Characterize spectral energy distributions
  - *At ambient and cold temperatures*
  - *Narrowband and broadband*
  - *Look for aging effects in those spectral energy distributions*

- May add effects of vibe testing and thermal cycling on parts (TBD)

Propose characterizing sources and then to fly some of them on Aerocube sats to raise TRL in a relevant environment
Specific sources (already procured) to be tested include:

- Blue (0.39 to 0.46 um) LEDs
- Custom LEDs – “white light” by combining phosphor LEDs with blue LEDs
- Carley Incandescent bulbs (replace Welch-Allyn halogen bulbs – found bad on Hubble Space Telescope cameras)
- Energetique – characterization already begun – not small internal sources!
- OD 800 W LEDs – 810 nm
- Chicago Miniature Lamp (CML - model CM 7220) grain of wheat bulbs, tungsten filaments, ~1800K, ~18V at ~25 mA (SPIRIT III - MSX legacy – Duane Miles thesis work in IR), expanded to visible to IR
- IR LEDs in 7 – 10 um range
- Ion Optics Nichrome strips

Wide variety to start – may redirect testing or add sources during the program, based on interactions with various programs
Examples of data taken to date

• Used Aerospace Visible Near-IR Imaging Spectrograph – VNIRIS - .4 – 2.5 microns – to characterize repeatability and spectral energy distributions at ambient conditions
• Welch-Allyn bulbs
• Energetique bulbs
Welch-Allyn Bulbs used on HST initial cameras – later rejected for second round of cameras due to non-repeatability.

Beyond setting 4, spectra start to deform. Bulb failed at input power ≈14 W, aging effects have been noted in testing by other groups.
Spectra are only approximately blackbodies, and vary with drive current, as expected.

Emitted flux is linear with power for input power<6 W and non-linear beyond that. Suggested operational levels would only be below 6 W.
Energetique sources – EQ-99

Measured spectra for EQ-99Cal compared to company-provided data and data on a Tungsten Lamp
Expanded wavelength coverage into Near IR for this source

Spectrum of the EQ-99CAL source from 0.4 to 2.1 microns. The dotted line corresponds to a blackbody at 1000 °C. Note the precipitous drop beyond 2.1 microns, limiting usefulness in Near IR, and Xe I features 0.8-1.0 um
Summary

• Goal of the program is to provide characterization of a wide range of potential internal sources at ambient pressure and vacuum conditions
  – Repeatability
  – Lifetime
  – Temperature effects
  – Spectral effects – visible to thermal IR
• Raise TRL by flying on Aerocubes
References


