FLARE Satellite/Airborne Calibration Network Performance & Validation Progress Report

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Brandon Russell\textsuperscript{a}, Jeff Holt\textsuperscript{a}, Chris Durell\textsuperscript{a}, David Conran\textsuperscript{b}, Stephen Schiller\textsuperscript{c}

\textsuperscript{a} Labsphere, Inc., North Sutton, NH USA
\textsuperscript{b} Rochester Institute of Technology, Rochester NY USA
\textsuperscript{c} Raytheon Technologies, El Segundo, CA USA

Better Calibration | Better Data | Better Decisions
A traceable, adjustable “star” on the ground.
Lambertian vs Specular Targets

Target signal embedded in a uniform scene is elevated above the low spatial frequency background (sky path radiance, adjacency effect, stray light, etc.) and is separable

- Background becomes a bias and is subtracted out based on image data alone
- Sensor response to target radiance is integrated (DN) contained in the PSF
- Atmospheric, adjacency, multiple scattering effects reduce to transmittance only - measured with solar spectrometer coincident with overpass

\[ L_{at\_sensor}(\lambda, \theta, \phi) = \rho(\lambda, \theta, \phi) \tau_r(\lambda) \tau_t(\lambda) E_0(\lambda) \frac{R^2}{4GSD(x)GSD(y)} \]

Watts/(m² sr micron)/mirror

The convex mirror acts as an aperture stop isolating the direct solar irradiance as the only contributor to the effective at-sensor calibration radiance
FLARE Radiometric Tower: VNIR Spectrometer & SWIR Bands

Spectrometer 350-1000nm

Irradiance (W/m²/nm)

- FLARE Silicon Spectrometer
- FLARE NIR/SWIR Bands
- Top of Atmosphere (ToA)
- Modeled Surface Irradiance

Dock

Banded 8-Channel NIR/SWIR Radiometer
Integration of MODTRAN to FLARE Radiometric Processing

Feb 23 FLARE V MODTRAN $E_s$
Numerical Mismatch: 2.5%

Irrad MOD Fit 400 to 1040

Irrad FLARE

S2B, Elev 88°
Dual Traceability - Langley & Sphere Methods

Preliminary SWIR Uncertainty Analysis < 5%
FLARE Nodes

- **Alpha Node**
  - Arlington, SD
  - SDSU Evaluation partnership

- **Beta Node**
  - Ft. Worth, TX

FLARE Development

- **Mobile Node future development**
  - 2022
  - Prototype at Beta site

- **Custom Campaigns**
  - Manual campaigns for targeted geometry
  - Commissioning Projects - individual assets or constellations

- **Planned Nodes**
  - **Mauna Loa (3300m)**
    - Spring ‘22
  - Railroad Valley Playa, Tenerife – TBD
  - Atacama, Australia, Gobabeb - TBD
## FLARE Mission Quality Metrics

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Successful Engagements with Small Sat and Agency Assets
Current Agency Archive

~60% yield including partly cloudy days.
Successful LOOKS with PRISMA, ISRO LISS-3 also added.

INVITATION:
Looking for partners to examine this data set and work on performance metrics of FLARE System with Landsat 8 and Sentinel 2A/2B
Temporal Trending on Sentinel 2B and Landsat 8

Landsat 8 Normalized Radiance (FLARE = 1)

Sentinel 2B Normalized Radiance (FLARE = 1)

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<tr>
<th>Band</th>
<th>LS8/FLARE</th>
<th>S2B/FLARE</th>
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<tr>
<td></td>
<td>CW</td>
<td>16-Jan</td>
</tr>
<tr>
<td>1</td>
<td>443</td>
<td>1.02</td>
</tr>
<tr>
<td>2</td>
<td>482</td>
<td>0.92</td>
</tr>
<tr>
<td>3</td>
<td>561</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>655</td>
<td>0.93</td>
</tr>
<tr>
<td>5</td>
<td>1609</td>
<td>1.01</td>
</tr>
<tr>
<td>6</td>
<td>2201</td>
<td>1.02</td>
</tr>
<tr>
<td>7</td>
<td>590</td>
<td>1.01</td>
</tr>
<tr>
<td>8</td>
<td>865</td>
<td>1.11</td>
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PRISMA (FLARE Beta Site) - >220 Bands

Images Courtesy of Leonardo DRS
Brock Texas, July 4-15, 2021

- Worldview 2, 3 (Maxar)
- Kompsat 3, 3A (KARI)

- Multiple Assets
  - BETA Automated System
  - FLARE Radiometer
  - ASD FieldSpec 4
  - Manual Mirror Arrays
  - Lambertian Targets (Permafect)
  - Blue Tarp

Image Courtesy of KARI
Brock Texas, July 4-15, 2021

- Mirror Based Empirical Line Method
  - Linearity of Pan, MS, NIR Bands
  - Absolute gain
  - Low radiance verification
  - Offset

![Graph showing DN/Mirror: Image po_365282 Glass Mirror SPARC Target.

- Blue Tarp 9 x 15 m
- Target 6 x 6 m
- Approx. 72

![Image showing a target area with numbers and symbols indicating measurements.

- Blue Mirror
- Green Mirror
- Red Mirror
- NIR Mirror

- Number of Mirrors vs Target DN chart

- Brock Texas, July 4-15, 2021

- 5% Target 6 x 6 m
- 55% Target 6 x 6 m
- Numbers 3, 25, 20, 15, 10 indicated on the ground targets.
G-SCALE: Ground to Space Calibration Experiment
Tait Reserve, Rochester, NY July 23 2021

Simultaneous Vicarious Calibration of UAV (Hyper), Airborne (Hyper) and Satellite (MS) in VNIR-SWIR

- International Public/Private Partnership
  - Labsphere
  - Maxar
  - Rochester Institute of Technology
  - National Resource Council Canada (ESA)

- Combination of traditional and mirror-based technologies
  - Large reflective panels and tarps
  - Solar radiometers
  - Ground based ASD measurements
  - Reference and test targets
Psuedo-Lambertian Reflectance Targets
MELM arrays for linear absolute gain/offset of CASI/SASI airborne HSI

Radiometric/spatial arrays for calibration and MTF of UAV sensors
Floating SPARC – Low Radiance Calibration Targets

Water-leaving radiance is typically low SNR – and can be in non-linear response range of detector. Floating mirrors provide 2 traceable, absolute calibration points, in-situ and tuned for dark target radiometry.
Recent Campaign Activities

• Aug 8 - 13: Joint work with MAXAR, SDSU for Worldview 2,3, GeoEye

• CURRENT ACTIVITY: Big Multi Agency Collection (BigMAC):
  • Aug 27 – Sept 5
  • Multi-Team Validation of Landsat surface reflectance products
    • USGS EROS CalVal CoE
    • FLARE/Labsphere
    • RIT
    • SDSU
    • NASA
    • Univ. of AZ

Figure 1-2. Field Campaign Site
Next Stop: Mauna Loa

- NASA ESTO Contract for SLI-T
- Approved to place FLARE station at NOAA Mauna Loa Observatory
- Working through final permitting & logistics: Operational in 7-10 months
- Benefits to FLARE and EO Community
  - Elevation (~3,300 m)
  - Stable atmosphere, above marine inversion layer, aerosols
  - Low uncertainty radiometry, <2%
  - AERONET, MLO-LUSI, others: cooperation and data sharing
Testing on MLO & Hawaii is underway...

June 29, 2021 - MLO

July 9, 2021 – Sea Level

August 1, 2021 – MLO
Future Work

- Continue processing of Campaign results for Commercial Customers and Govt. Agency contracts.
- Peer-reviewed publication of results
- Examine L8-S2 Data Archive with partners
- Mobile station development
- Open to ANY campaign or test plan suggestions...come talk to us
Thank you!

Questions and Comments may be directed to:

Chris Durell, Business Development – cdurell@labsphere.com  M: 858-414-1885
Dr. Brandon Russell, Science Lead – brussell@labsphere.com  M: 203-241-7253
  Jeff Holt, Principal Architect – jholt@labsphere.com  M: 603-401-7471
Dr. Josh Hudson, Sales Manager – jhudson@labsphere.com  M: 817-771-4847