Stennis Space Center Verification and Validation Capabilities

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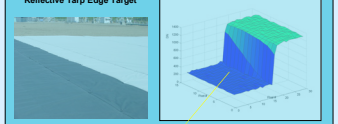
Spatial Response

Edge Response of Tarps

Reflective Tarp Edge Target



Painted Concrete Edge Target

Purpose: Measure spatial response of 1-meter GSD class systems

Reflectance: ~50% and ~4% reflective painted rectangles

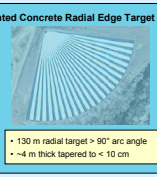
Dimensions: 4 rectangles, 10 m x 20 m each

Total Dimensions: 20 m x 40 m

Orientation: North-South and East-West orientation

Painted Concrete Tri-bar Target Array

Painted Concrete Radial Edge Target



- 130 m radial target > 90° arc angle
- ~4 m thick tapered to < 10 cm

Reflectance Radiometry

ASD Measuring Tarps

Analytical Spectral Devices

Purpose: Analytical Spectral Devices (ASDs) used to calculate accurately target reflectance values used to validate imager radiance values

Spectral Range: 350 - 2500 nm

Sensors: One 512-element photodiode array and two thermoelectrically cooled, extended-range InGaAs photodiodes

Sampling Interval: 1.4 nm from 350 - 1000 nm; 2 nm from 1000 - 2500 nm

Spectral Resolution: 3 nm @ 700 nm; 10 nm @ 1500 nm; 10 nm @ 2100 nm

Number of Channels: 512 channels

Wavelength Accuracy: ±1 nm

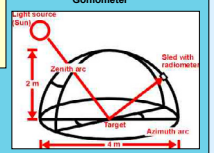
Purpose: Measure BRDF effects of target surface

Spectral Radiometer: GER

Zenith Range: 180° sampled every 15°

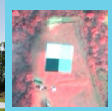
Azimuthal Range: 180° sampled every 30°

Goniometer



NIST characterized Spectralon© Panels

Reflective Tarps



Purpose: Tarp panels form two 20-meter edges to measure the edge response of panchromatic and multispectral imaging systems with ground sampling distances of 1 meter or less

Tarps' highly uniform spectral reflectance can be utilized in the characterization of multispectral and hyperspectral sensors

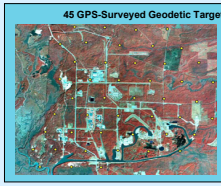
- Tarp Panel 1 - 3.5% Reflectance
- Tarp Panel 2 - 22% Reflectance
- Tarp Panel 3 - 34% Reflectance
- Tarp Panel 4 - 52% Reflectance

Positional Accuracy

QuickBird Observed Geolocational Accuracy

QuickBird Product	Acquisition Date	Empirical CE_{90} (m)	Empirical CE_{90} (m)	Elevation Angle (deg)
Panchromatic Standard	8/23/2003	12.67	12.76	76.8
	9/13/2003	17.40	17.62	83.3
	10/21/2003	13.69	13.72	81.3
Panchromatic Orthorectified	1/10/2004	16.27	16.39	89.2
	8/23/2003	7.93	8.11	76.8
Multispectral Standard	8/23/2003	12.74	12.93	76.8
	9/13/2003	17.34	17.66	83.3
	10/21/2003	13.76	13.77	81.3
Multispectral Orthorectified	8/23/2003	7.90	8.43	76.8

45 GPS-Surveyed Geodetic Targets < 3 cm Accuracy



Forty-five, 2.44-meter outer 0.6-meter red center radius geodetic targets evenly spaced throughout site

17 A-Order monuments On Site

136 Manhole Covers On Site—9 m to 2.44 m

136 Manhole covers painted with 50% reflectance paint

Trimble 5700 GPS

- Centimeter-level accuracy
- Sub-cm accuracies for static survey
- 24-channel receiver

NGS/NOAA-NDBC Operated CORS Site

Continuously Operating Reference Station provides carrier phase and code range measurements for added ease of post-processing GPS survey data

Trimble Pathfinder GPS

Purpose: Field portable real-time GPS survey

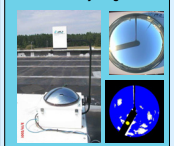
Accuracy: 10 m to submeter

Stationary Atmospheric Monitoring

Atmospheric Monitoring Station

- Live Web publishing
- Entirely automated

Total Sky Imager



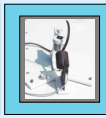
Cimel Sun Photometer

Channels: 440, 670, 870, 936, and 1020 nm

FWHM: 10 nm

FOV: 1.2°

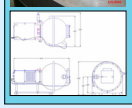
Part of AERONET network



Multi-filter Rotating Shadow-band Radiometer

Laboratory Calibration

NIST-Certified Integrating Spheres



Purpose: Calibration and characterization of spectral radiometers

Controls: Microprocessor-controlled integrating sphere calibration standard

Illumination: 150-W tungsten-halogen, reflectorized lamp with a motorized, computer-controlled, variable aperture

Temperature Range: 2000 to 3000K

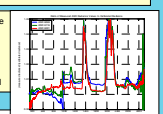
Spectral Range: Calibrated from 300 to 2500 nm

Calibration & Characterization of ASD FieldSpec Spectroradiometers

Purpose: Perform spectral and radiometric calibration of ASD FieldSpec Pro spectroradiometers

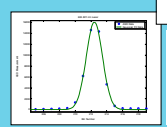
Radiometric Calibration: NIST-calibrated integrating sphere serves as source with known spectral radiance

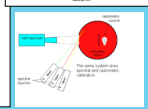
- Calculate coefficients for conversion of measured DN values to radiance
- Perform periodic checks of ASD radiance calibration using known radiance source
- Check linearity of ASD response by varying integrating sphere radiance level

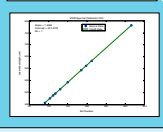


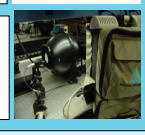
Spectral Calibration:

- VNIR - laser illumination of integrating sphere produces monochromatic Lambertian source
- SWIR - use gas discharge lamps to illuminate integrating sphere
- Fit Gaussian curve to each spectral peak to estimate bin number corresponding to wavelength at center of peak
- Perform linear regression to assign wavelengths to all spectral bins









Mikron Water Bath Blackbodies

Purpose: Calibration of radiometers

Emitter Area: 12" x 12"

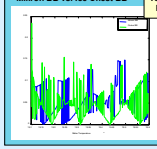
Temperature Range: 0 °C to 148.9 °C

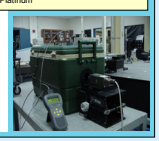
Temperature Resolution: 0.01 °C ≤ 99.99 °C; 0.1 °C ≥ 100 °C

Stability: ±.04 °C for 8-hour period

Temperature Sensor: Precision Platinum

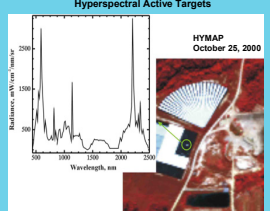
Mikron BB vs. Ice Chest BB





Hyperspectral Radiometry

Hyperspectral Active Targets



HYMAP October 25, 2000

Purpose: Vicariously evaluate wavelength calibrations of airborne hyperspectral sensors

Design: 1500 W metal halide lamps

ESPEC Environmental Chamber

Purpose: Simulation of field conditions to validate instrument performance under non-laboratory conditions

Temperature Range: -75 °C to 150 °C

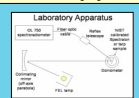
Relative Humidity Range: 10% to 90%

Interior Dimensions: 32 ft³

Bidirectional Reflectance

Purpose: Evaluate target bidirectional reflectance to account for the differences between ground measurement viewing angles and satellite acquisition angles

Laboratory Apparatus



Laboratory setup

Reflectance of 52% Tarp

Test results indicate that bidirectional reflectance effects can change the effective reflectance by as much as 10%

Thermal Radiometry

FLIR Systems SC2000: Thermal Camera

Purpose: Image float's influence on waterbody

Range: Thermal (8-12 µm)

Accuracy: ±0.5 °C

Target Spot Size (@ 1 m): 10 cm

Response Time: 0.05-10.0 seconds

Accuracy: 14-bit digitization with 0.1 °C NED, 240 x 320 pixel array

IFOV: Uncooled, 1.3 milliradian

Heimann Radiometer

FTIR Spectropolarimeter

Purpose: Measure hyperspectral thermal data in two polarization

Resolution: ~0.5 (cm^-1) in two polarizations

Range: 5000-600 (cm^-1) for KBr

Detector: LN2 cooled MCT

Thermal Float on Stennis Pond

- Float employs 2 Heimann radiometers to measure skin surface temperature
- Additional Heimann measures cold sky temperature
- Two honeycomb black bodies calibrate radiometers during field exercises
- Thermocouple probe measures bulk water temperature

Portable Atmospheric Monitoring

Automated Solar Radiometer

Purpose: Measure direct solar irradiance

Spectral Channels: Nine channels – one total solar and eight 10 nm bandwidth center wavelengths at 382, 400, 440, 521, 610, 671, 781, 870, 940, and 1030 nm

Multi-filter Rotating Shadow-band Radiometer

Purpose: Measure diffuse/direct/horizontal solar irradiance

Spectral Channels: Seven channels – one total solar and six 10 nm bandwidth center wavelengths at 415, 500, 615, 673, 870, and 940 nm

Cosine response: <5% for 0-80 degree zenith angle; <1% with correction

Solar Plot

Langley Regression Plot

Radiosonde Balloon

Full Sky Imager

Portable Meteorology Station

Purpose: Record atmospheric measurements during field collects

Atmospheric Measurements: Temperature, humidity, pressure, and wind speed/direction sensors

Solar measurements: Pyranometer, Pyrheliometer

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