Commercial Systems Validation Overview

Commercial Remote Sensing Program

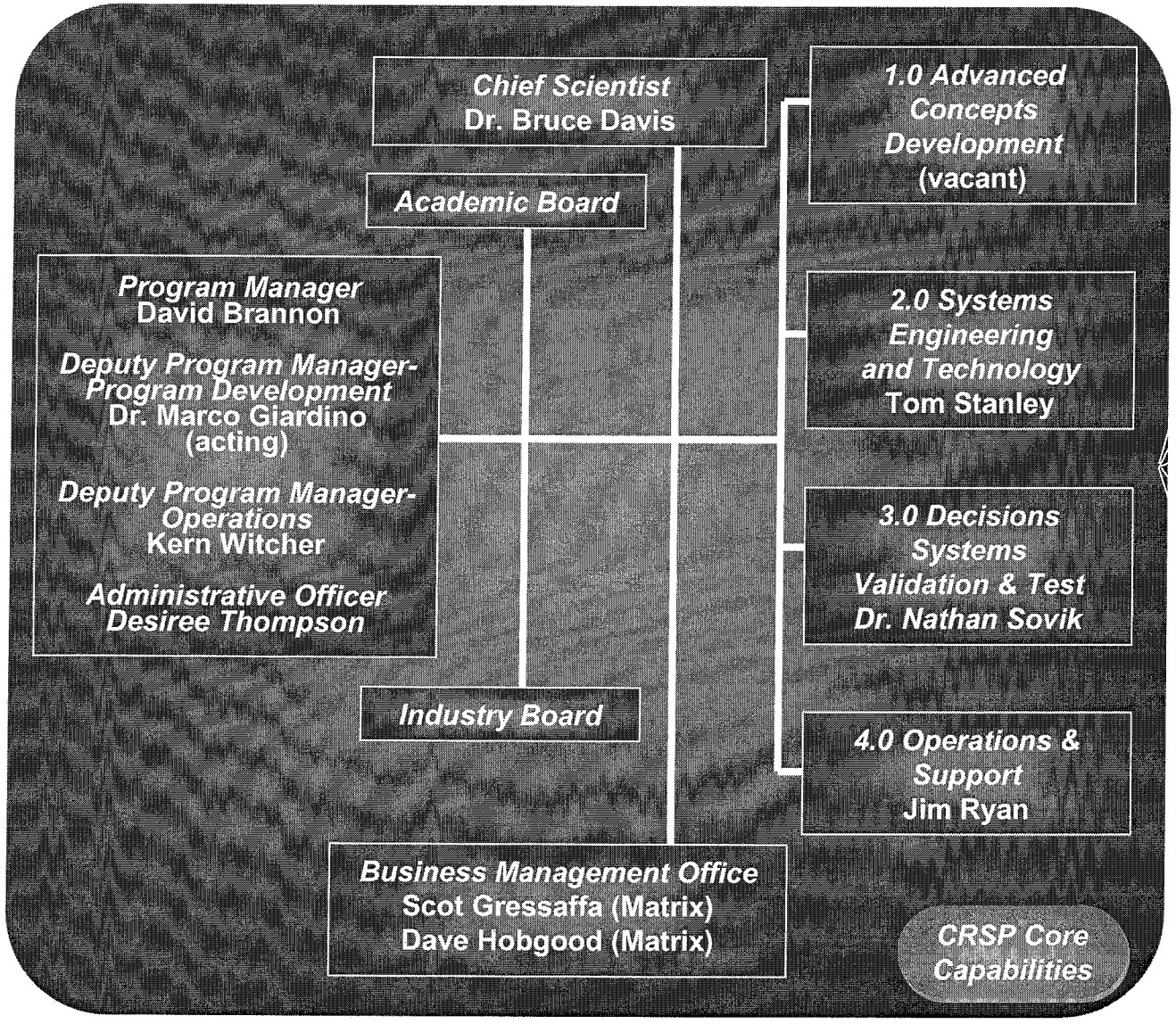
John C. Stennis Space Center, MS

NASA Earth Science Enterprise's
"Lead Center for Commercial
Remote Sensing"

CRSP Mission Elements

Commercial Remote Sensing Program Affiliations

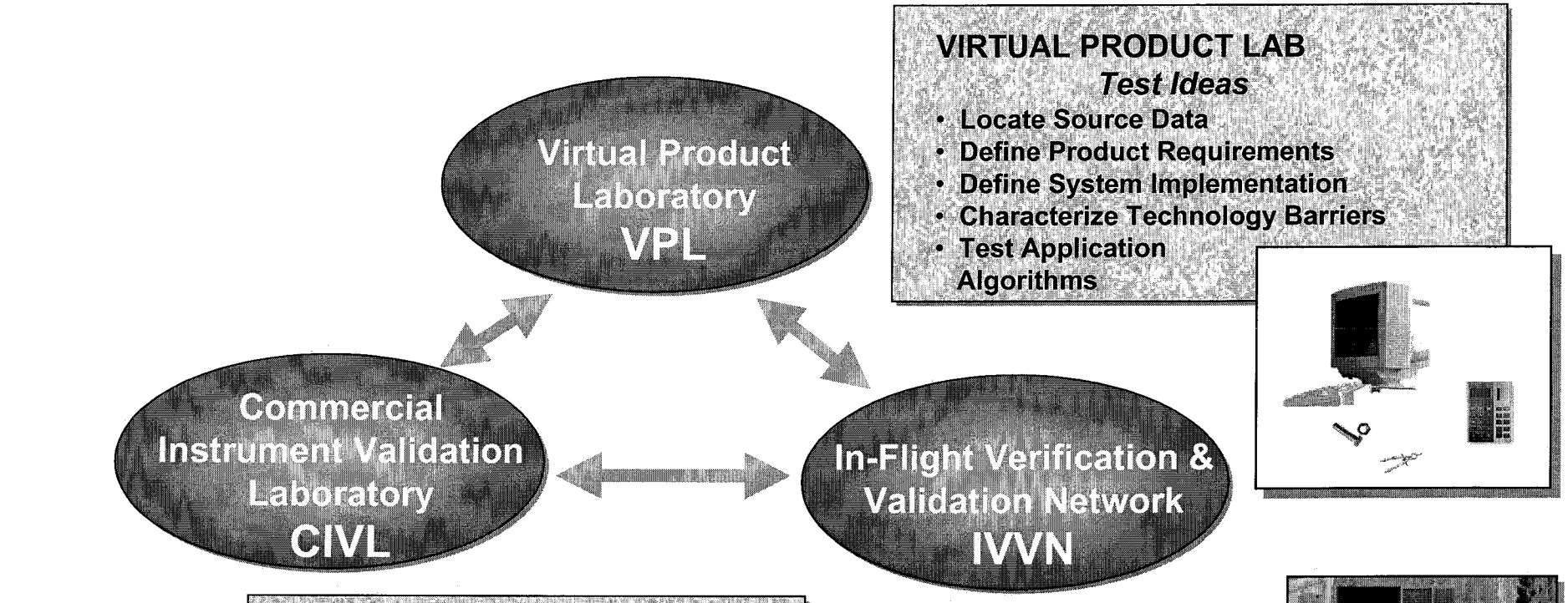
Stennis Space Center



- Universities
- Not-for-Profit Affiliations
- NASA Centers
- Other Government Agencies
- US Companies

Commercial Systems Validation Laboratory (CSVL)

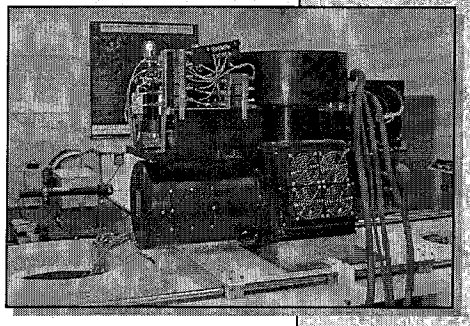
Stennis Space Center



VIRTUAL PRODUCT LAB

Test Ideas

- Locate Source Data
- Define Product Requirements
- Define System Implementation
- Characterize Technology Barriers
- Test Application Algorithms



COMMERCIAL INSTRUMENTATION VALIDATION LAB

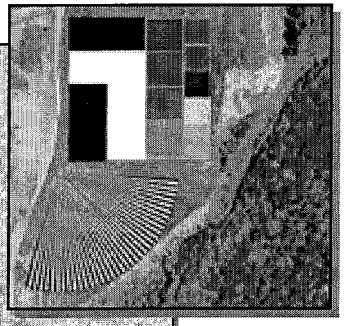
Validate Critical Sensors

- Baseline Performance in Controlled Environment
- Define Process For Sensor Truth Set

VERIFICATION & VALIDATION

Validate Installed Sensors

- Validate Baseline In-flight
- Validate Truth Set Against Controlled Imagery In-flight
- Cross-Validate Systems



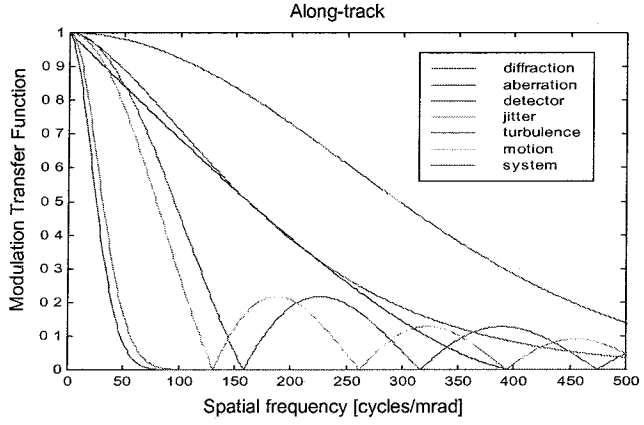
Virtual Product Laboratory *(VPL)*

Stennis Space Center

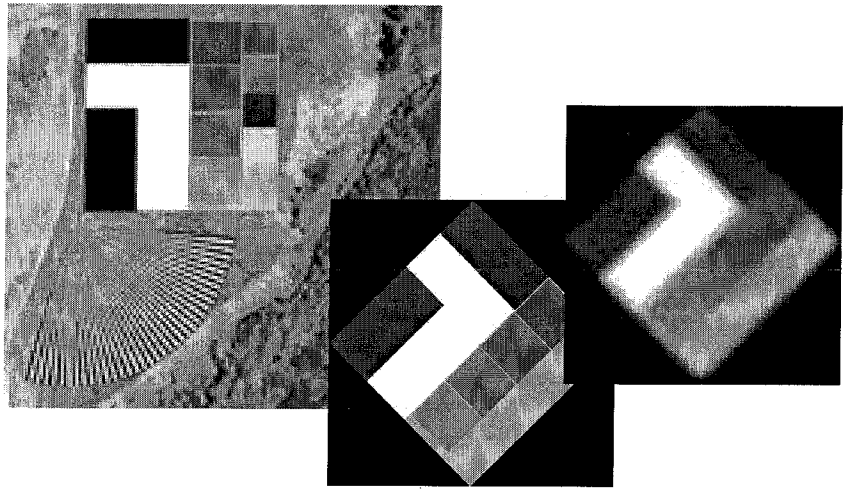
Capabilities:

- Physics-based System Performance Simulation *(UV-LWIR)*
- Physics-based Image Generation
- Atmospheric Modeling
- Subsystem Compatibility Assessment
- Mission Planning
- Sensor Data Base
- Platform Data Base
- Remote Sensing System Trades Analysis

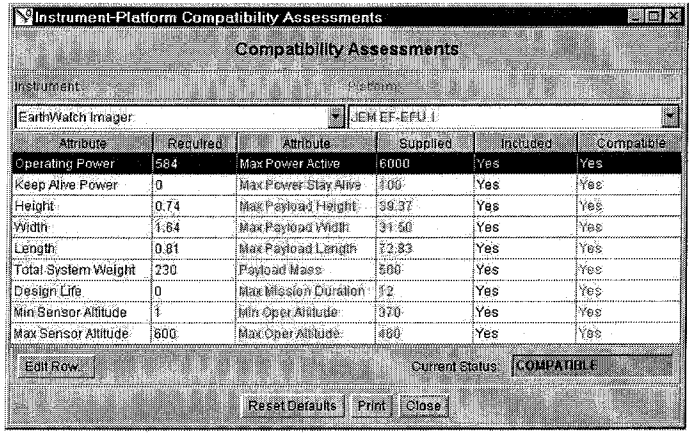
VPL Sensor Performance Evaluations

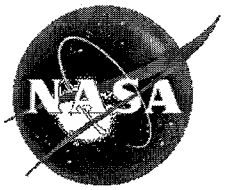


VPL Target Simulations



VPL Compatibility Assessments



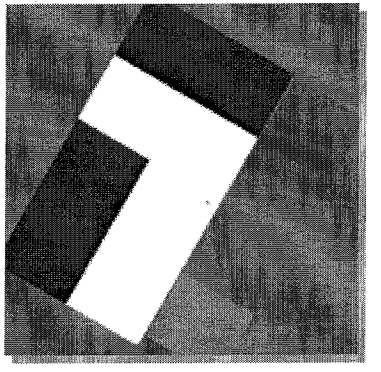


VPL Modules

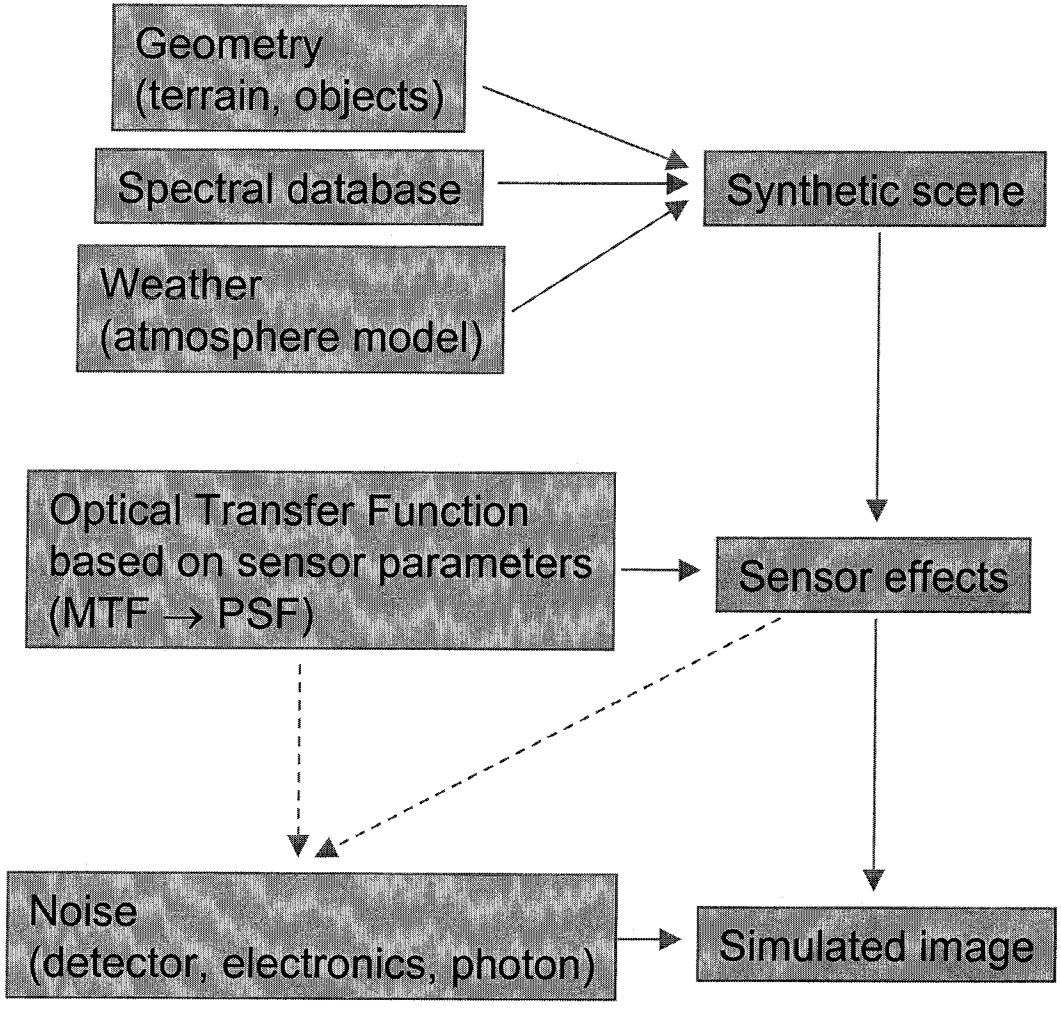
- **Knowledge Base**
  - Oracle-based database providing access to remote sensing industry-related information, products, and services
- **Design and Analysis**
  - Mission definition
  - Compatibility assessment
  - Orbit Modeling
  - Engineering trades and optimization
- **Data Simulation**
  - Physics based approach
    - » Scene generation
    - » Sensor simulation
  - Assess instrument design, performance, and error budgets
  - Sensor types
    - » High spatial resolution
    - » Multispectral
    - » Hyperspectral
    - » Thermal

Scene Generation

- **Existing imagery**
  - Utilize data acquired by real sensors
  - Resample data to system characteristics
- **Synthetic scene generation**
  - Software tools
    - » Global Change Initiative *(GCI)* Tool Kit
      - Photon Research Associates, Inc.
      - rasterized models of terrain and clouds
      - atmospheric radiative transfer modeling using MOSART
    - » Digital Imaging and Remote Sensing Image Generation *(DIRSIG)*
      - Prof. John Schott, Rochester Institute of Technology
      - high-resolution, facetized models of terrain and 3D objects
      - atmospheric radiative transfer modeling using MODTRAN
    - » Custom software
      - high-resolution 2D models -- edge target, radial target
      - atmospheric radiative transfer modeling using MODTRAN
  - Scene databases/Target models
  - Atmospheric radiative transfer models
  - Observational parameters



Synthetic Image Simulation



$$\overline{L}(x,y,\lambda_0) = \int L(x,y,\lambda) R(\lambda-\lambda_0) d\lambda$$

Atmospheric radiative transfer models (MODTRAN, MOSART)

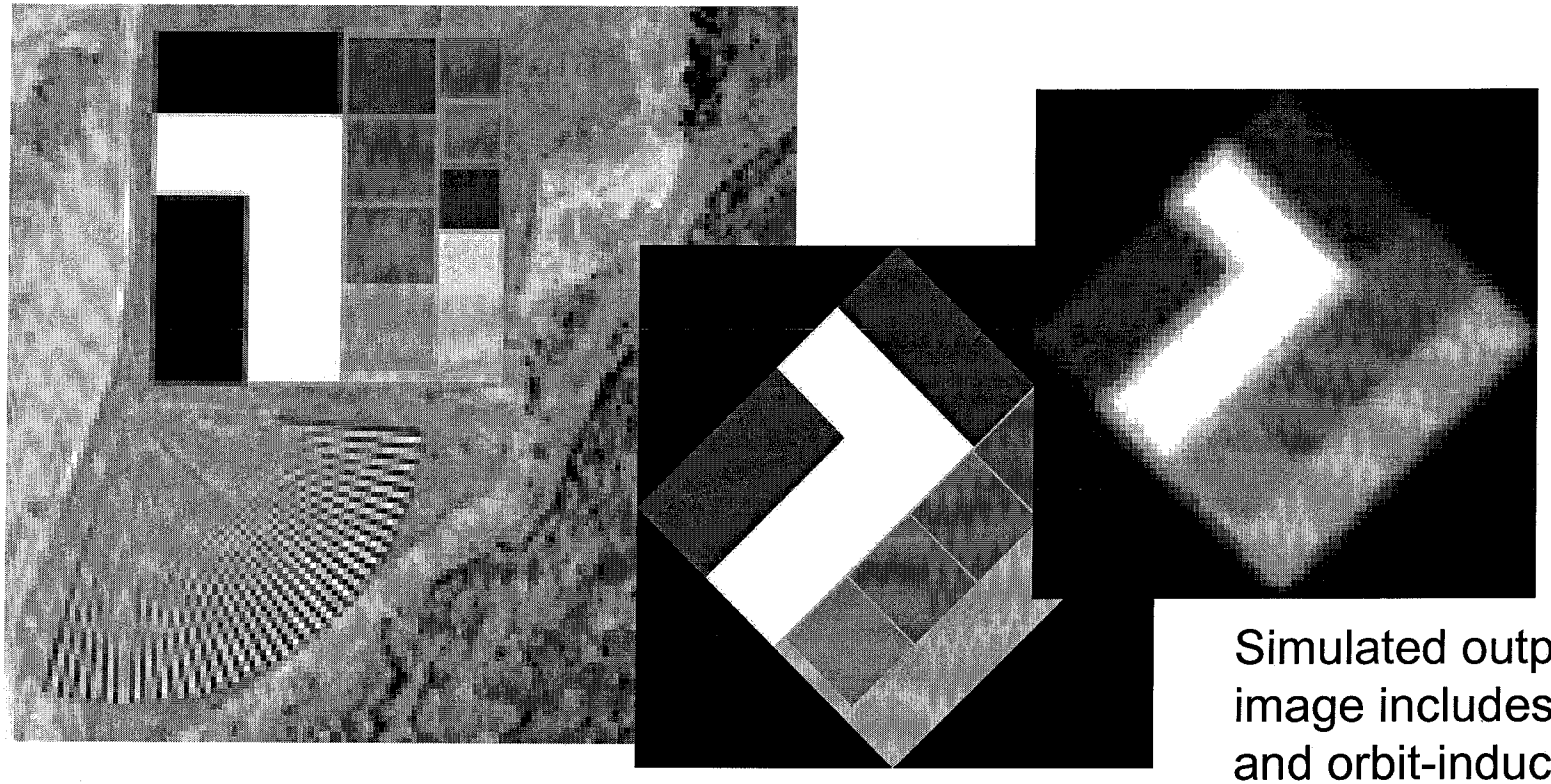
$$I(x_0,y_0,\lambda_0) = \iint \overline{L}(x,y,\lambda_0) PSF(x-x_0,y-y_0,\lambda_0) dxdy$$

I is the simulated sensor-generated image
L is the synthetic scene spectral radiance
R is the sensor spectral response
PSF is the sensor spatial response (the point spread function)

For each and every spectral band (λ_0)

Simulated Verification and Validation Target

Stennis Space Center



Synthetic scene with 10-cm GSD.

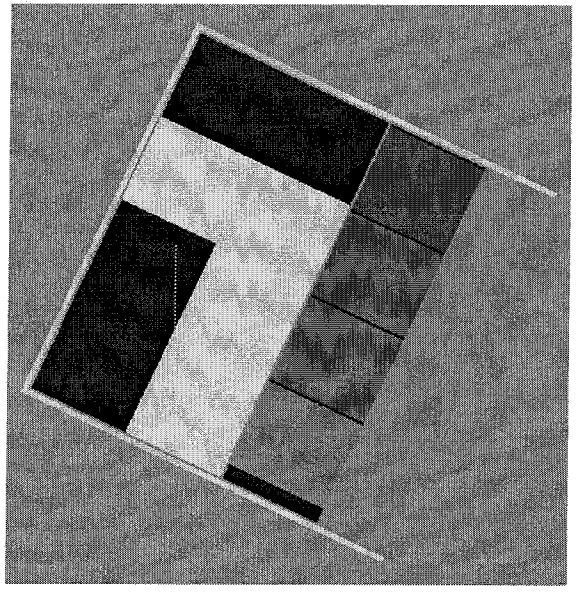
Simulated output image includes sensor and orbit-induced effects.

SSC V&V Targets:

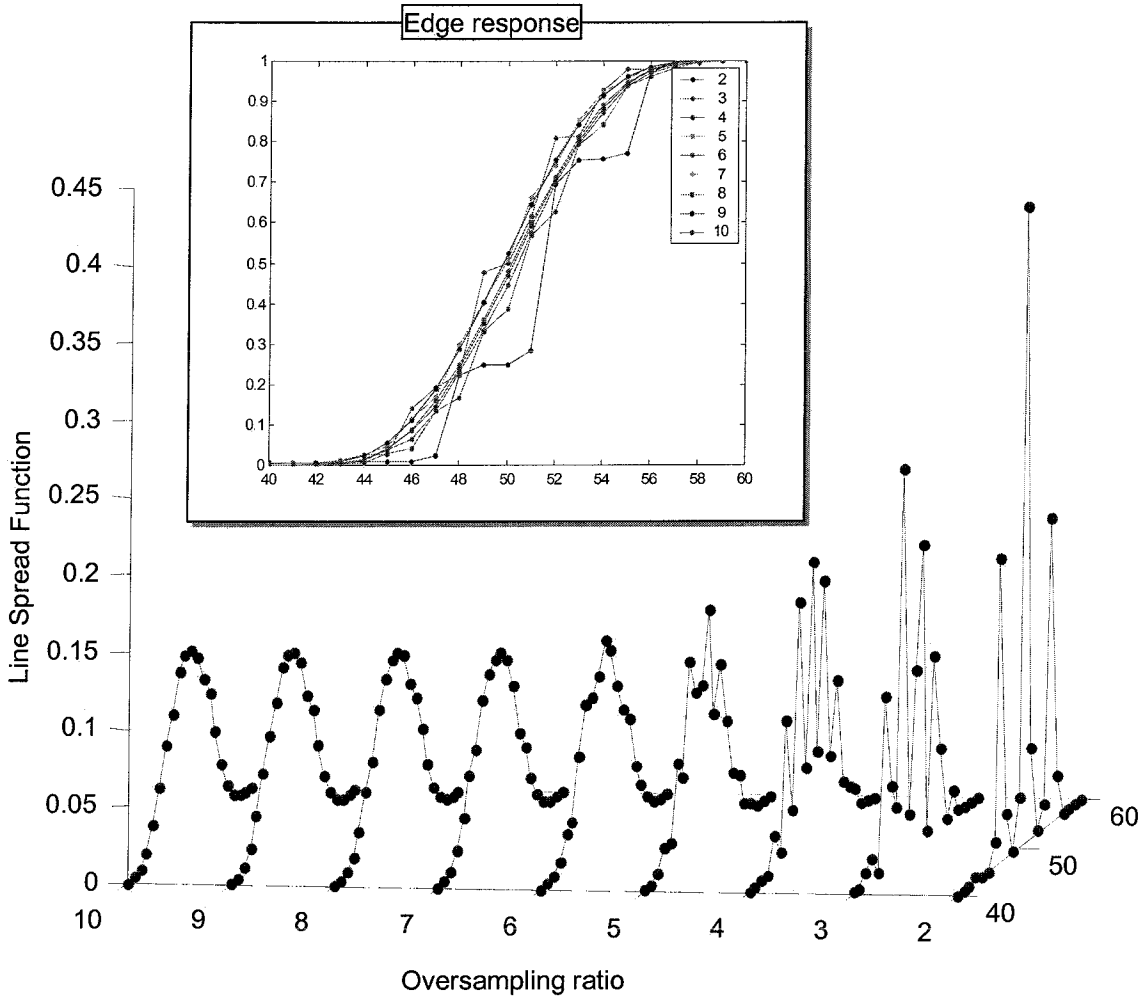
- 80m x 80m x 70m 8:1 contrast ratio edge targets
- 35m x 40m 4-step gray scale targets
- 130m radial target

Spatial Oversampling

Simulated image

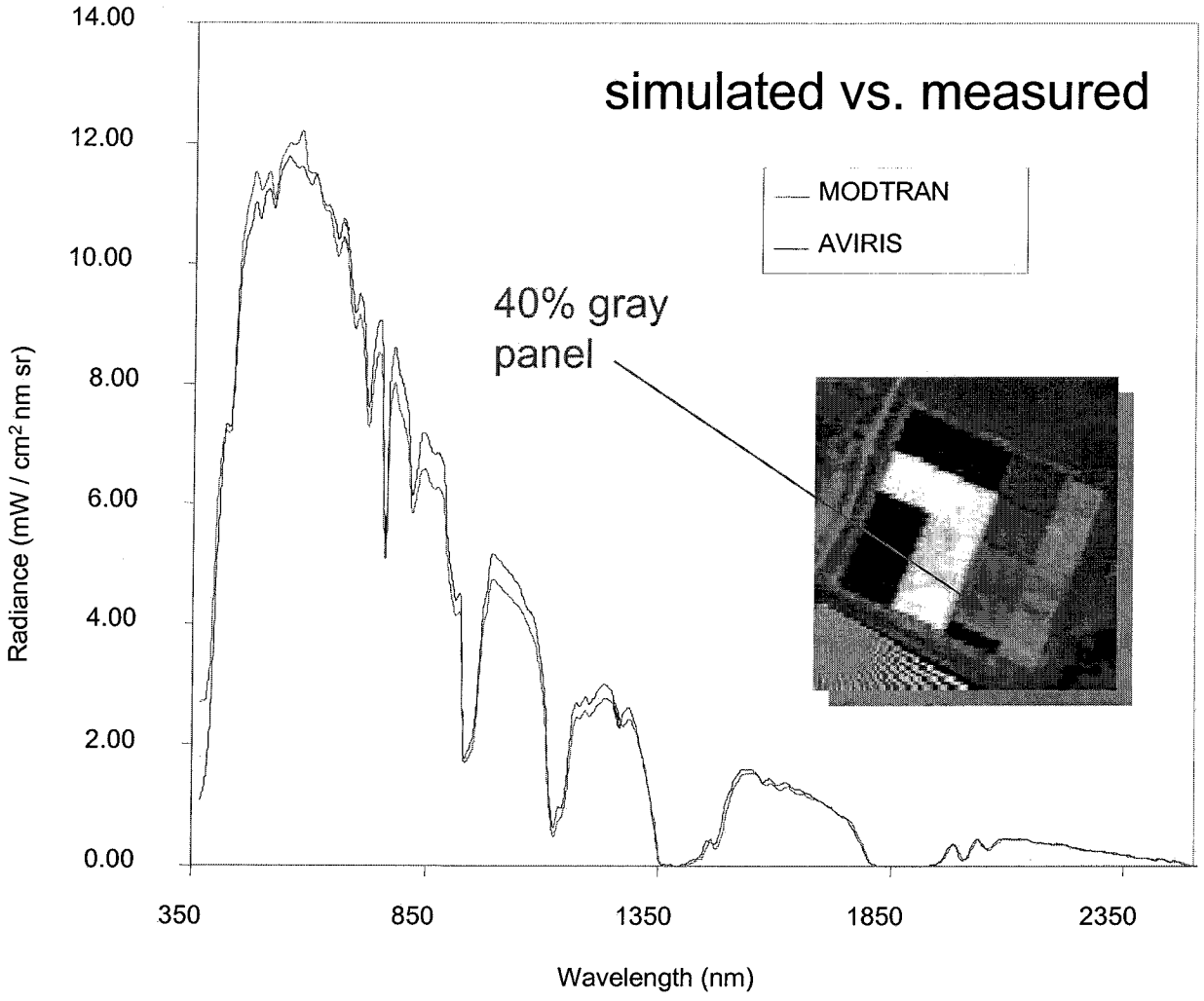


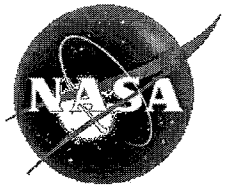
Edge target is used to derive edge response and line spread function: significant oversampling is required for proper rendering.



Target Simulation Spectral Radiance Comparison

Stennis Space Center





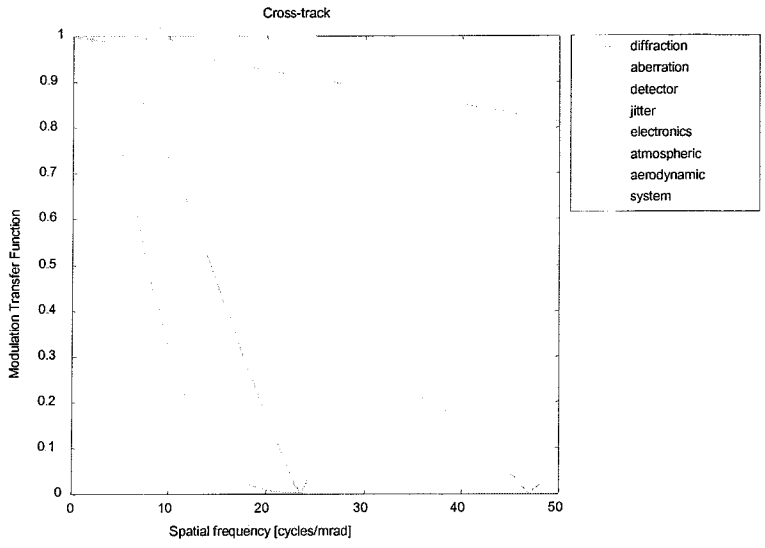
Sensor Simulation

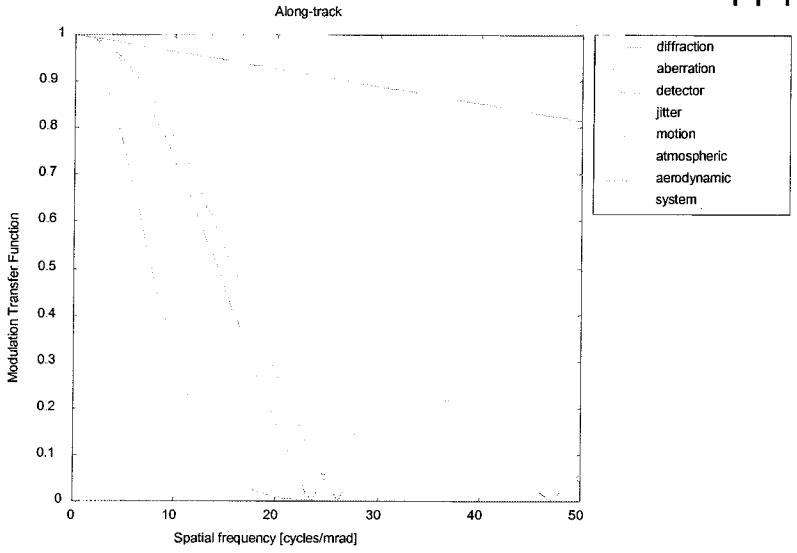
- **Input scene convolved with sensor PSF**
  - Spatial sampling of input scene must be significantly higher *(7 to 15 times)* than the sampling of output image
- **Point spread function *(PSF)* derived from OTF using an inverse Fourier transform**
- **Based on Optical Transfer Functions *(OTFs)***
  - Model sensor spatial response
  - Include modulation transfer functions *(MTFs)* and phase transfer functions
    - » Optical diffraction, optical aberrations, detector size, linear motion, random and sinusoidal jitter, low pass filter electronics, atmospheric turbulence
- **Electronic and photon noise can be applied to resultant image**

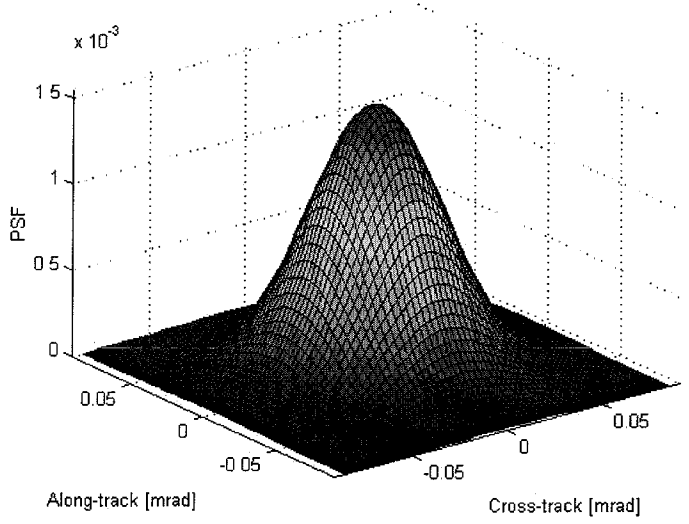
Sensor Modeling

Optical Transfer Function:

- Detector size
- Diffraction
- Linear motion
- Random jitter
- Atmospheric turbulence



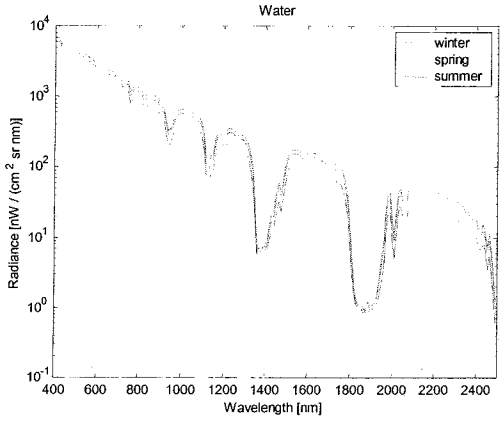




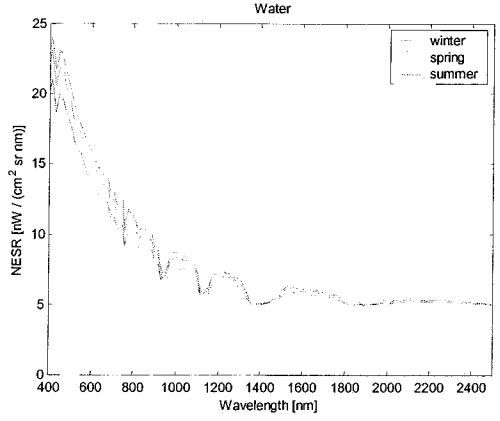
Signal-to-Noise Ratio Hyperspectral Example:

Stennis Space Center

Signal
(dominated by atmospheric radiance)

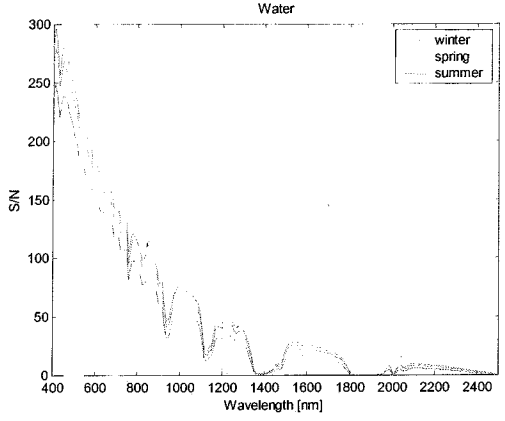


Noise
(floor level defined by detector and electronics)



=

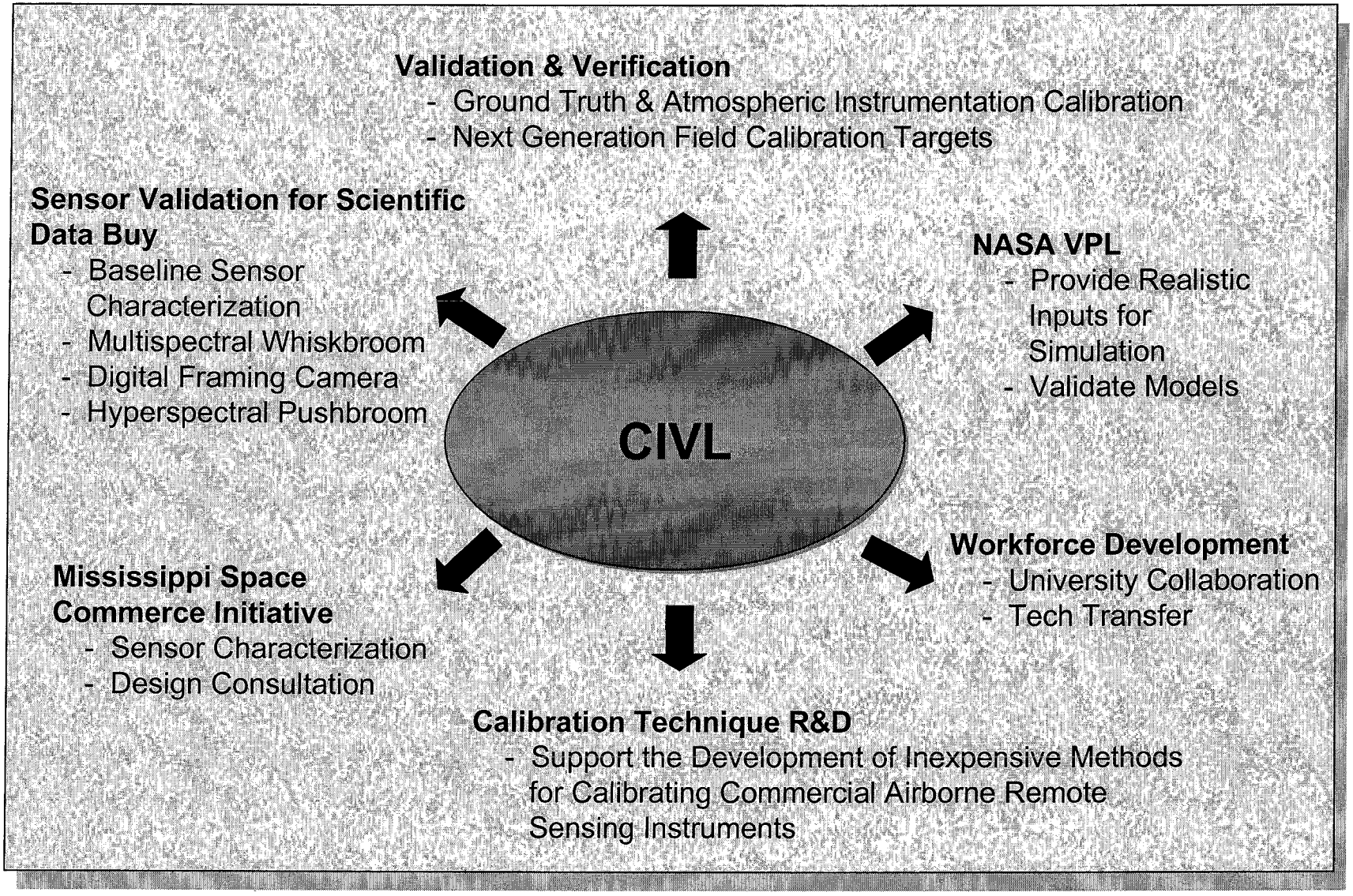
Example: water surface



SNR

Commercial Instrument Validation Laboratory Activities

Stennis Space Center

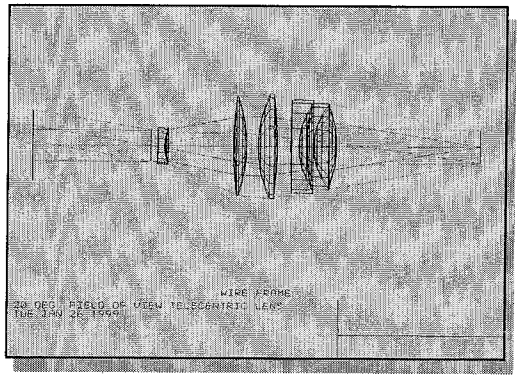


Commercial Instrument Validation Laboratory (CIVL)

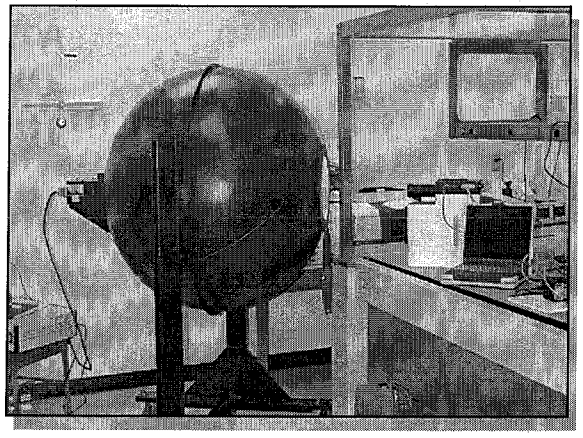
Stennis Space Center

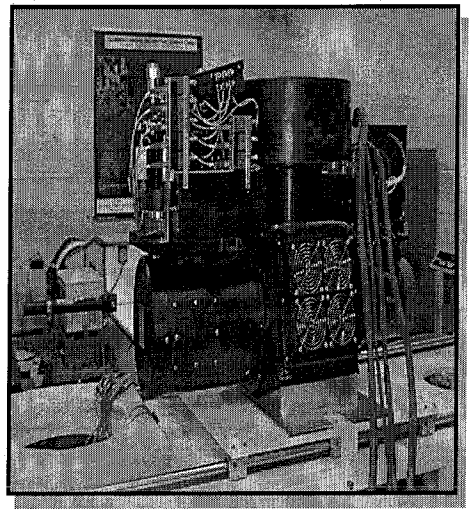
Capabilities:

- ATLAS / CAMS sensors for airborne multispectral imaging
- System & component level spectral (*350-10000nm*) and spatial (*MTF & PSF*) characterization *(350-1600 nm)*
- Radiance standards *(250-1600 nm)*
- ASD & GER field spectroradiometers
- Optical system design, modeling and performance prediction
- Dielectric filter design
- Advanced target design



Sensor design trades

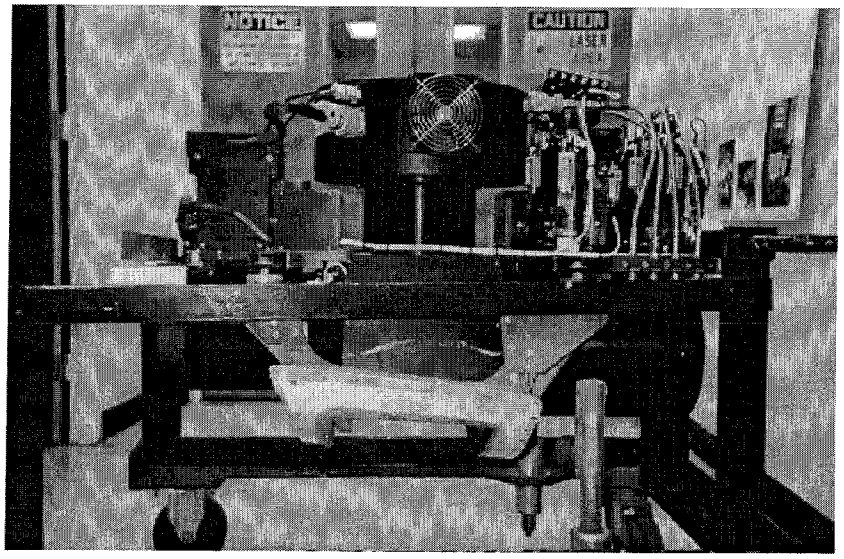




Atlas PVT

Airborne Terrestrial Applications Sensor (ATLAS)

Stennis Space Center



Calibration
Thermal: Blackbody *(2)*
VIS/NIR: Integrating Sphere

Recording
Digital Recorder: 8mm tape drive, Helical Scan type
Throughput: 500 KB/sec max
Storage Capacity: 5 GB/tape
Interface: SCSI
Digitization: 8 bit *(0-255)*
Video Words: 643/scanline
Housekeeping Words: 200 max

Spectral
Spectral Range: 0.45 - 12.2μm
Number of Channels: 14
Detectors: Ch. 1-6, Silicon
Ch. 7-8, InSb *(LN_2 Cooled)*
Ch. 10-15, HgCdTe *(LN_2Cooled)*

Spectral Coverage:

VISNIR		TIR	
Ch. 1: 0.45-0.52	μm	Ch. 10: 8.20-8.60	μm
Ch. 2: 0.52-0.60	μm	Ch. 11: 8.60-9.0	μm
Ch. 3: 0.60-0.63	μm	Ch. 12: 9.0-9.40	μm
Ch. 4: 0.63-0.69	μm	Ch. 13: 9.60-10.2	μm
Ch. 5: 0.69-0.76	μm	Ch. 14: 10.2-11.2	μm
Ch. 6: 0.76-0.90	μm	Ch. 15: 11.2012.2	μm

SWIR
Ch. 7: 1.55-1.75 μm
Ch. 8: 2.08-2.35 μm
Ch. 9: Removed

Spatial
FOV: 72° **IFOV:** 2.0 mrads
Pixels/Line: 640 ground scene and 3 calibration source pixels
Scan Speed: 6-50 scans/second
Ground Resolution: 2.5-25 m

Geometric
GPS: Trimble 4000SSE
GPS Accuracy: 1.5 RMS *(corrected)*
+/=100m *(uncorrected)*
Nav. System: Trimble 2101 *(GPS Based)*
Gyro Accuracy: 0.4°
Roll Correction: +/-15°

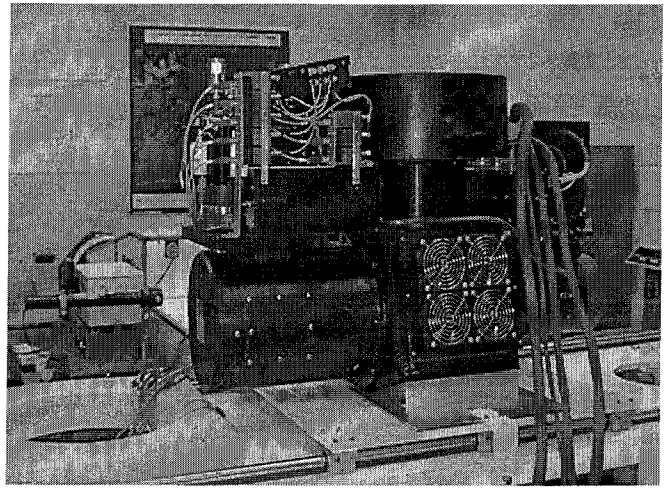
Airborne Sensor Lab Characterization

Stennis Space Center

Cross Track Scanners PVT
- Spectral
- Radiometric
- Spatial
  - MTF

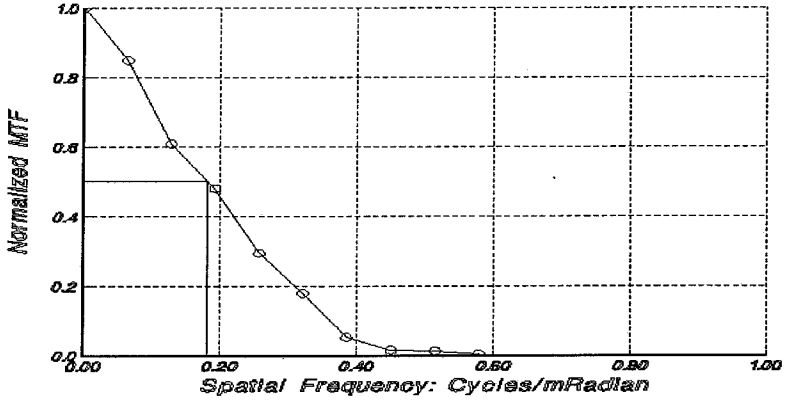
VNIR CCD Cameras
- Spectral
- Radiometric
- Spatial
  - MTF

Pushbroom Hyperspectral Imagers
- Spectral
- Radiometric
  - Linearity
  - NESR
  - Radiance

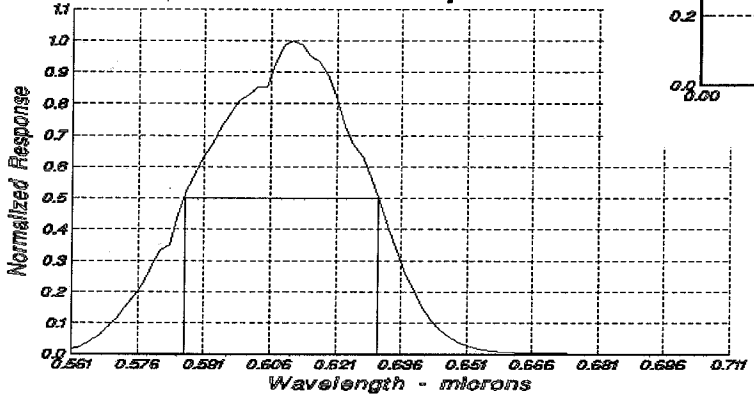


ATLAS Performance Verification Test *(PVT)* system performs radiometric, spectral and spatial resolution baseline measurements of whiskbroom scanners

ATLAS Channel 5 MTF



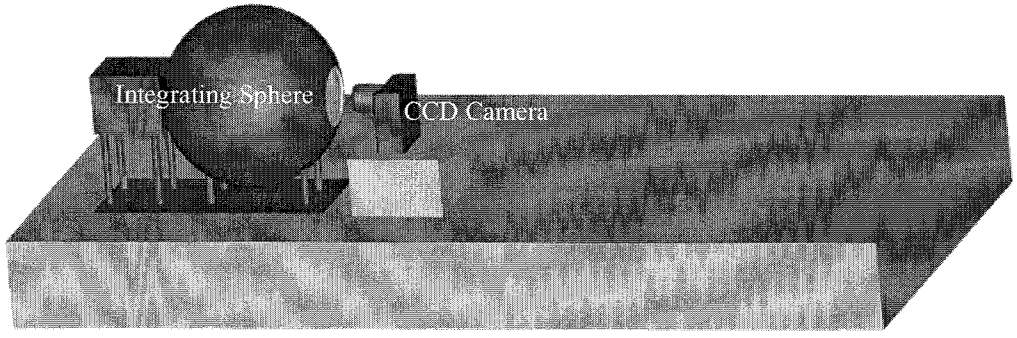
ATLAS Channel 3 Response



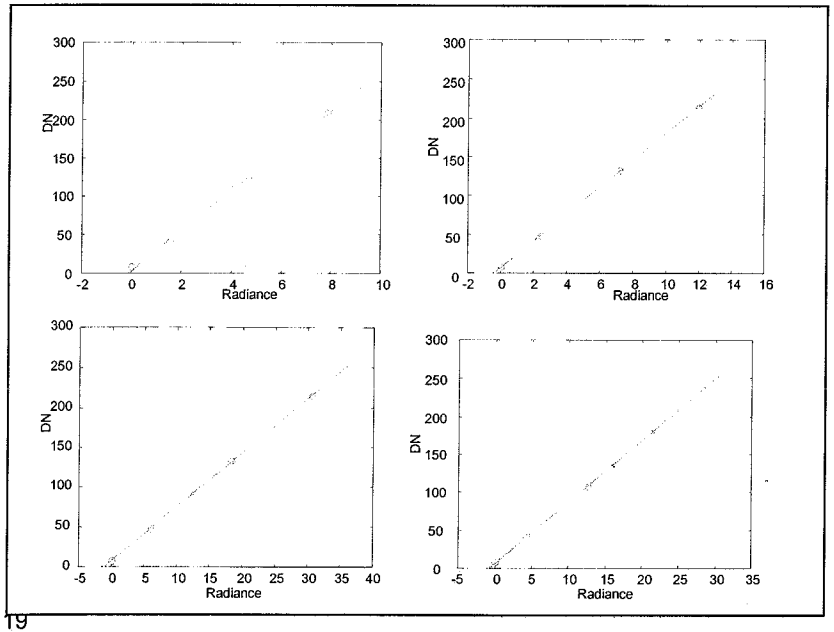
Framing CCD Camera Radiometric Characterization

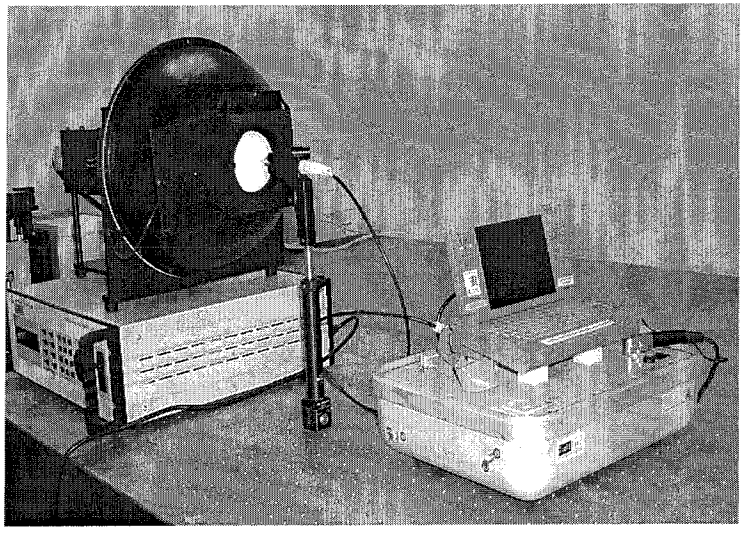
Stennis Space Center

Radiometric Calibration and linearity measured with integrating sphere source



Radiance setup





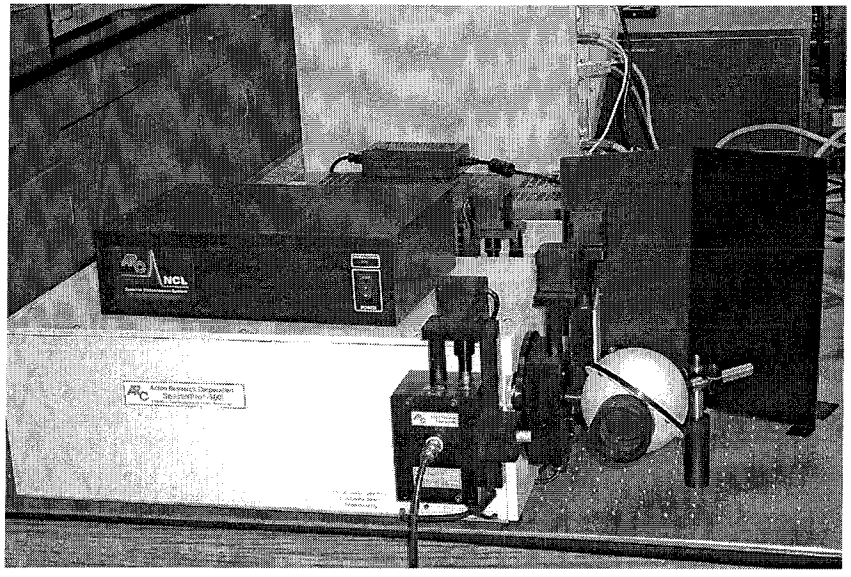
ASD characterization of radiance sources

Linearity Measurements

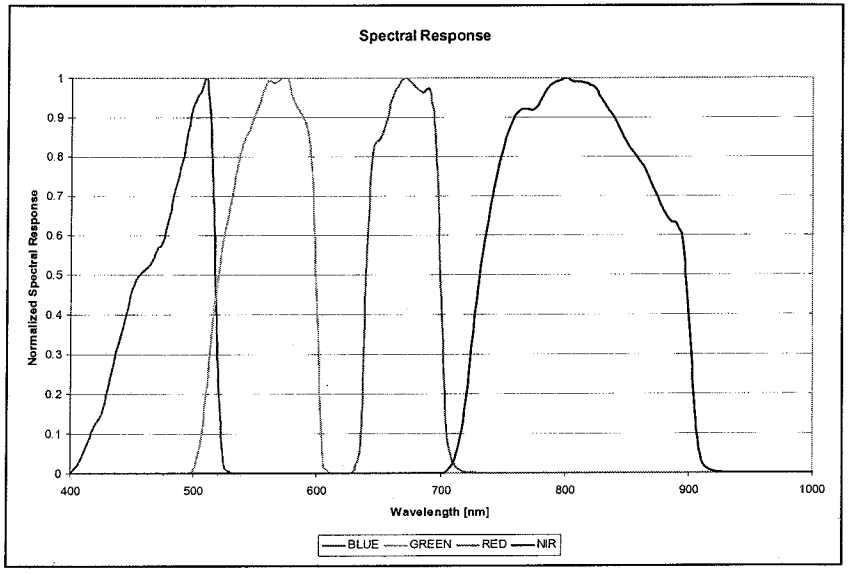
Framing CCD Camera Spectral Response

Stennis Space Center

Monochromatic Uniform Source



Multispectral CCD Camera Response

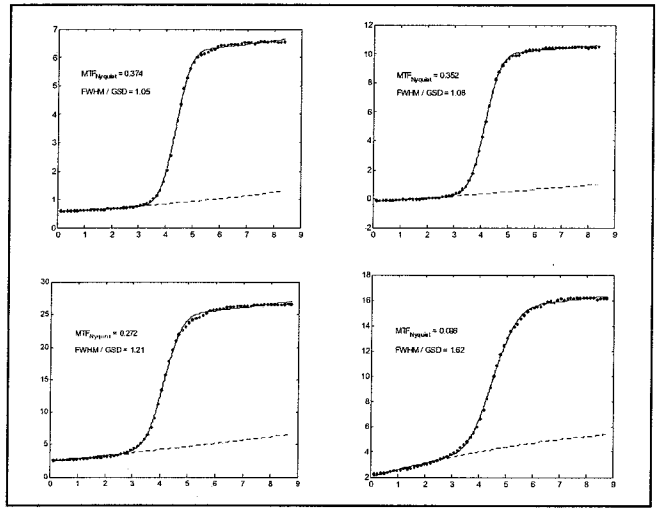


- Monochrometer illuminates 3" integrating sphere
- Provides monochrometer input for wide field of view imagers
  - Long integration time offsets low-signal levels

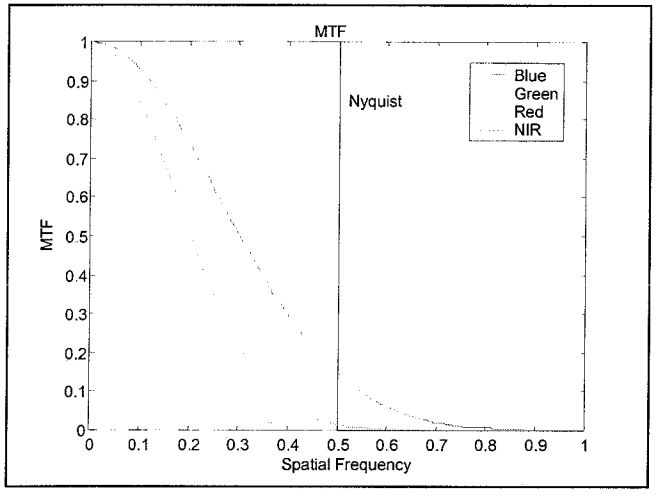
Framing CCD Camera MTF Measurement

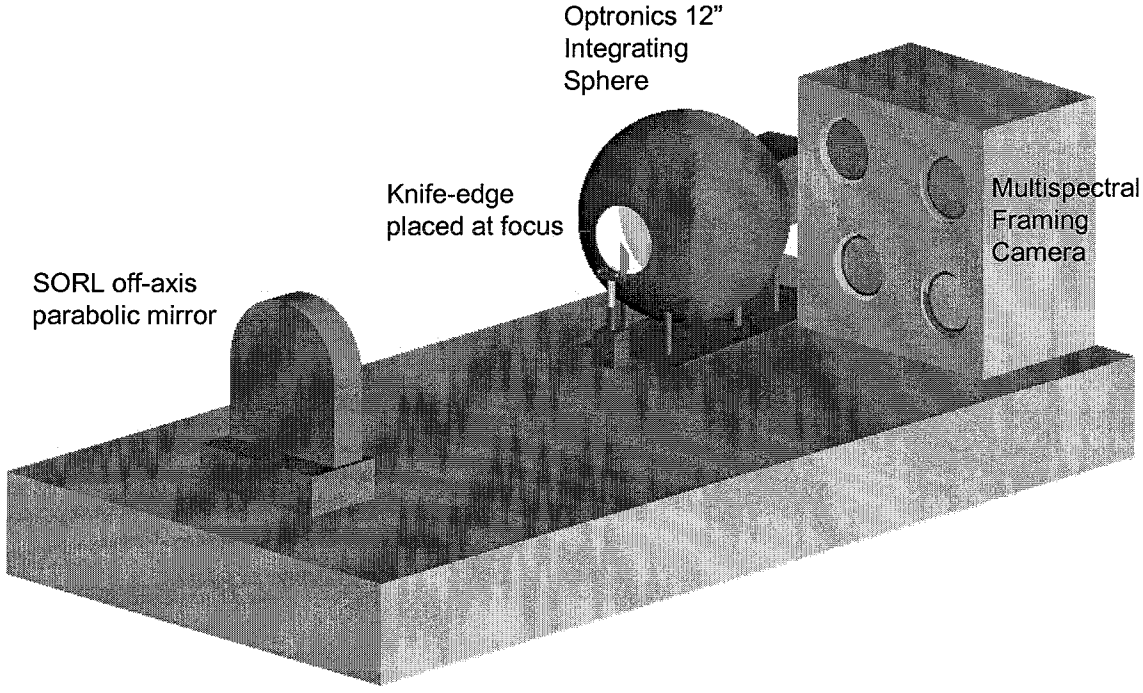
Stennis Space Center

Edge Response



MTF Estimate





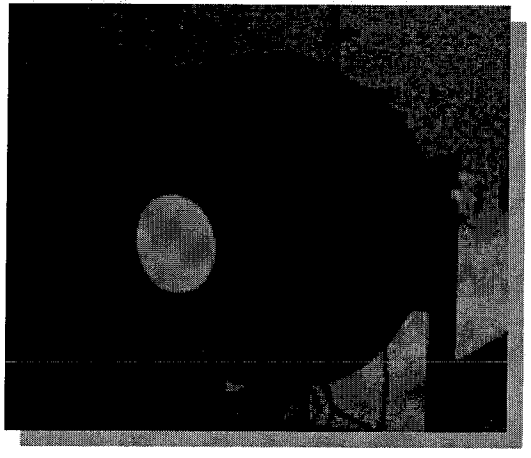
MTF estimation using tilted edge uniformly illuminated with a integrating sphere and 12" off-axis parabolic collimator

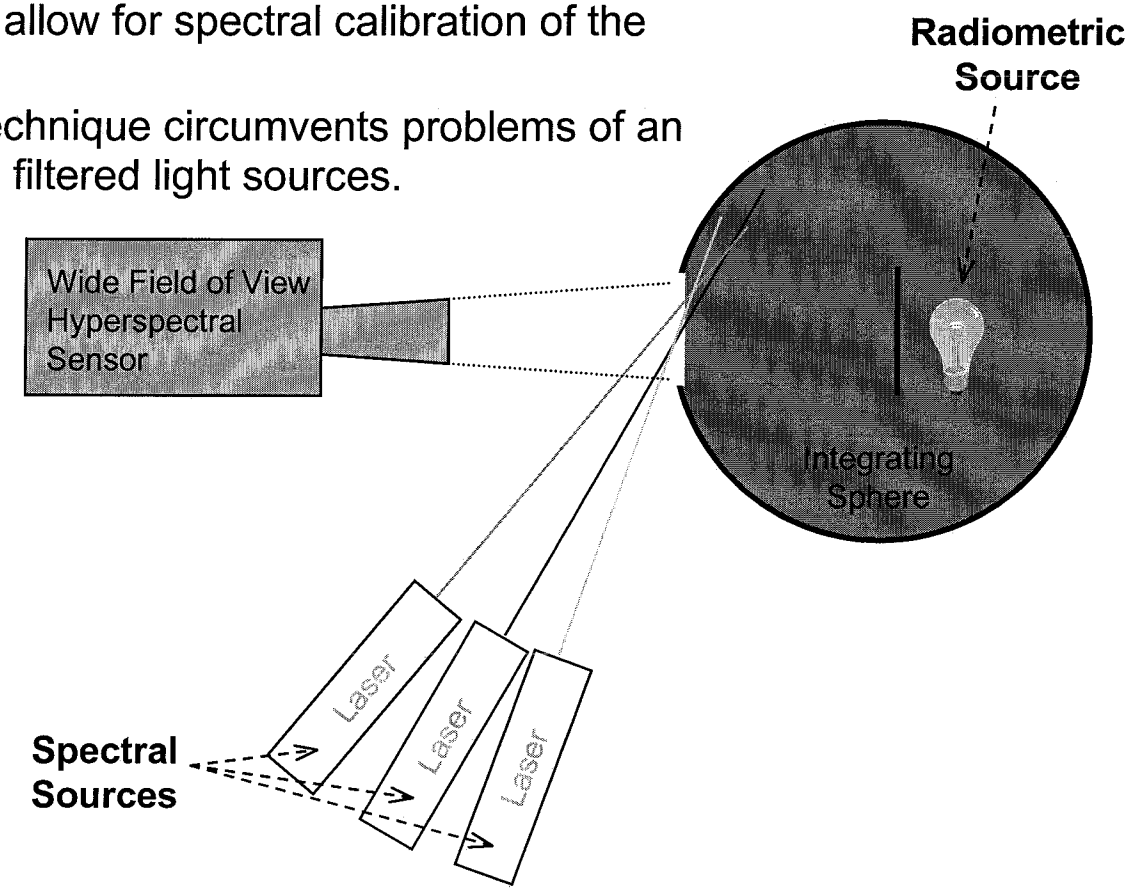
Spectral Calibration of Hyperspectral Sensors in the Laboratory

Stennis Space Center

Approach:

- Several laser beams *(each monochromatic, but with a different wavelength)* are scattered inside an integrating sphere and illuminate uniformly the field-of-view of the tested sensor.
- The integrating sphere becomes a light source with sharp spectral features that allow for spectral calibration of the sensor.
- By using lasers, the technique circumvents problems of an insufficient signal from filtered light sources.

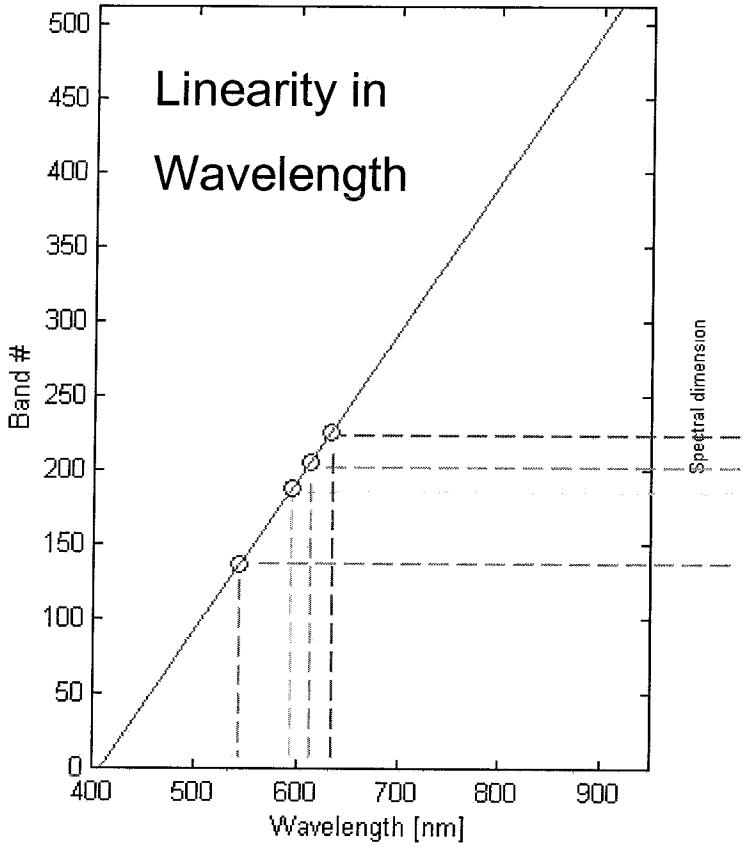


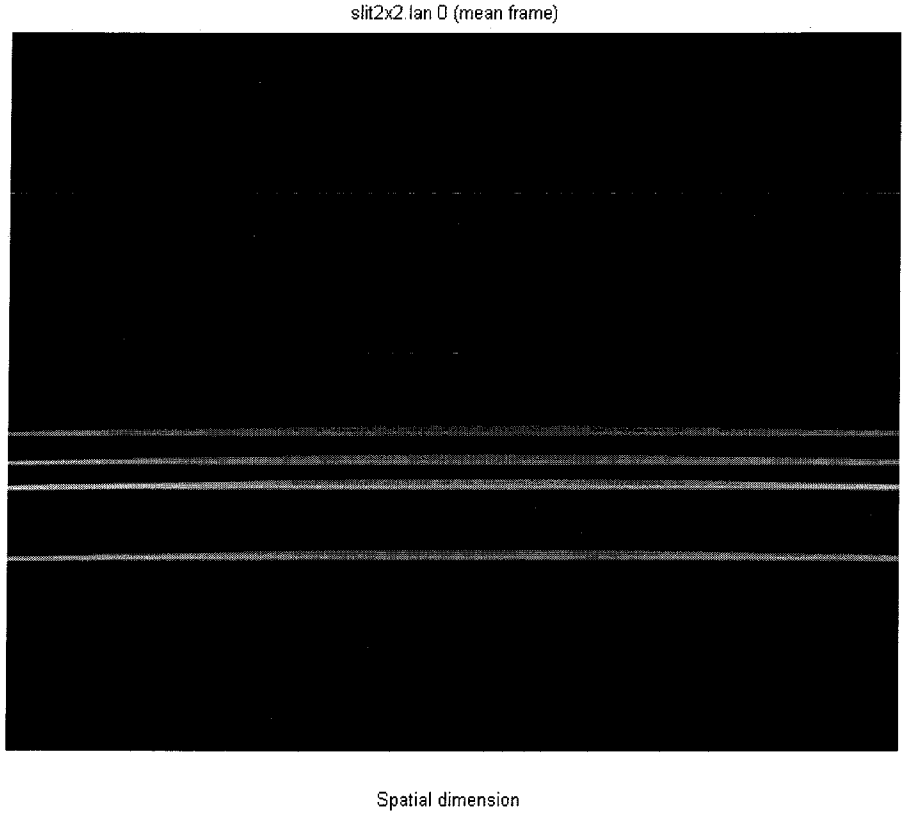


Spectral calibration of Hyperspectral Sensors in the Laboratory

Stennis Space Center

Regression analysis performed for each spatial pixel to assign wavelengths to all the spectral bands



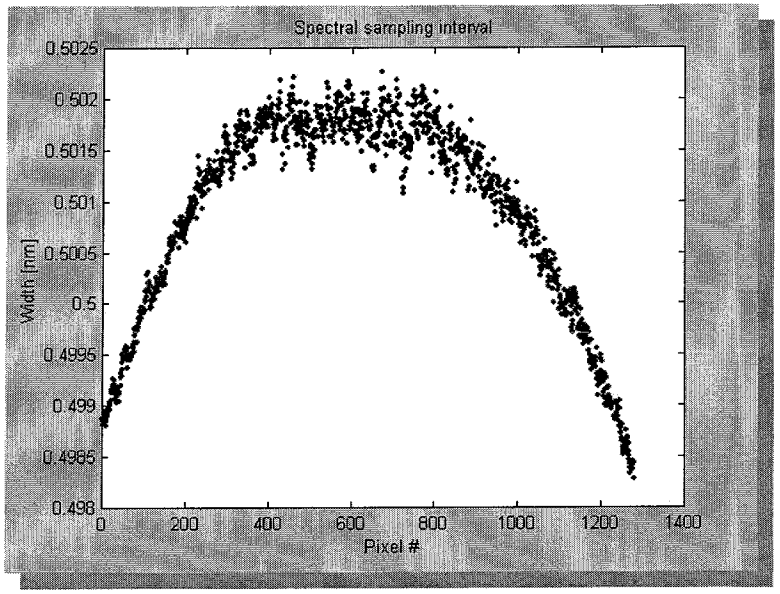


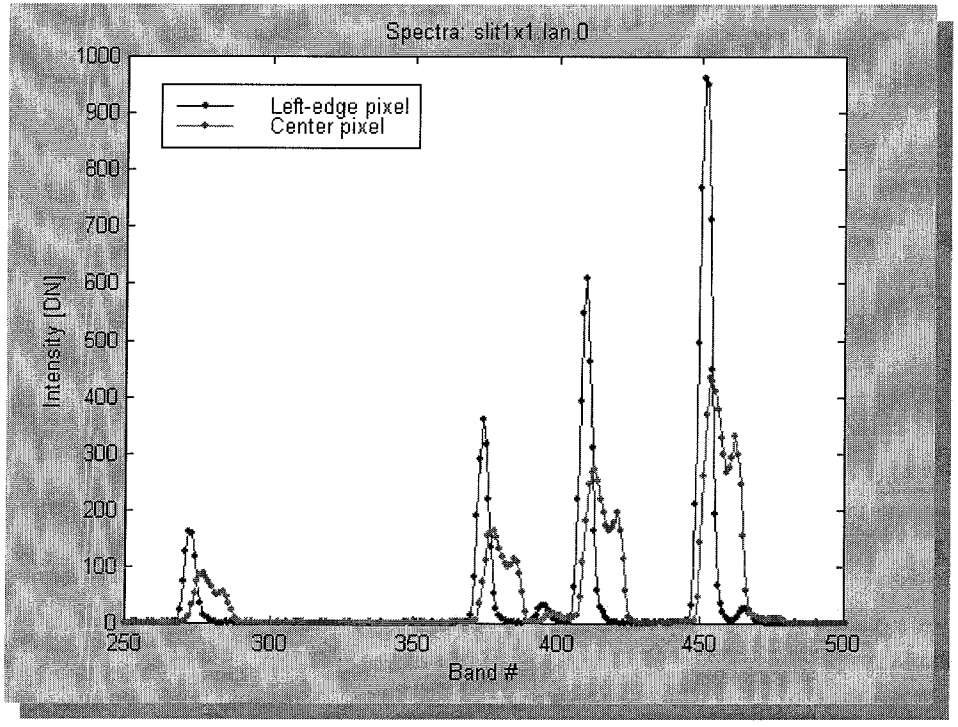
Possible improvement (in works): wider spectral range covered by lasers (tunable lasers / laser diodes, IR lasers)

Spectral Calibration of Hyperspectral Sensors in the Laboratory

Stennis Space Center

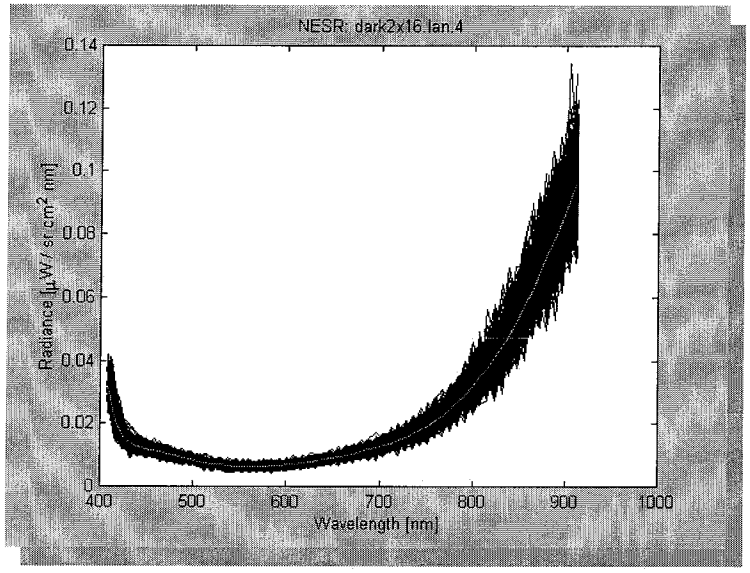
Spectral sampling intervals calculated for each spatial pixel: dependent on pixel position

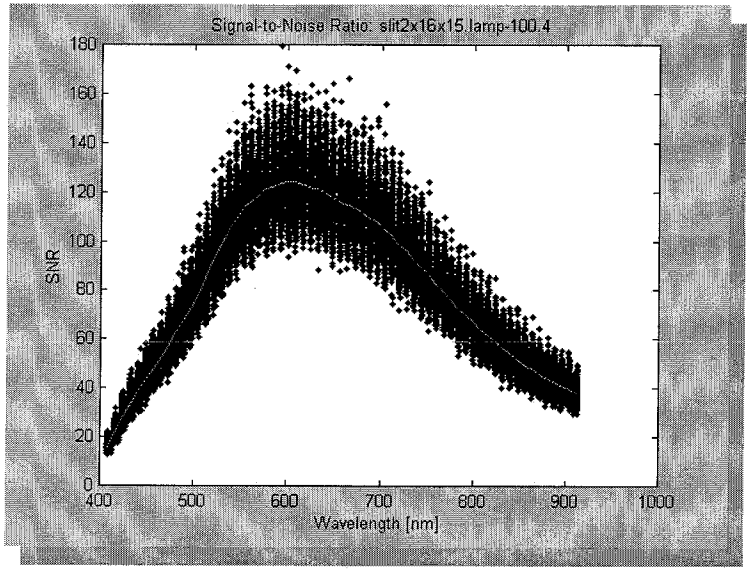




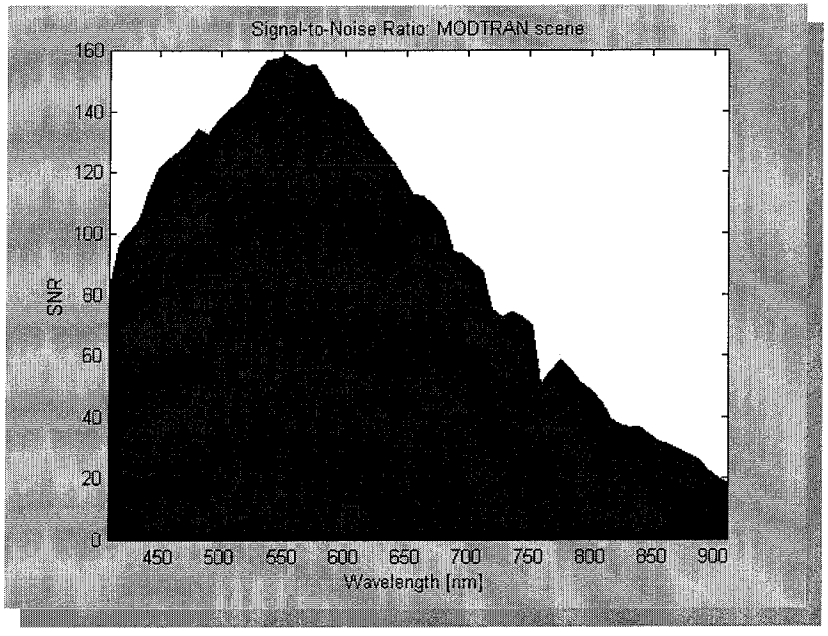
Detected a geometric distortion of the spectra: "smile" effect at center *(edge -- gaussian)*

Spectral Calibration of Hyperspectral Sensors at CIVL





Noise analysis *(determination of NESR and lamp S/N)* combined with modeling of the atmospheric radiative transfer *(MODTRAN)* allows for prediction of S/N for any arbitrary scene *(reflectance).*



Ground Reference Equipment Characterization

Stennis Space Center

Spectroradiometers

- Spectral
- Radiometric
  - Linearity
  - Radiance
  - Dark Counts
  - Drifts
- Reflectance
- FOV

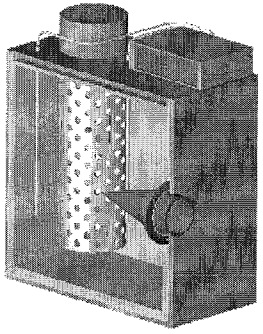
Infrared Radiometers

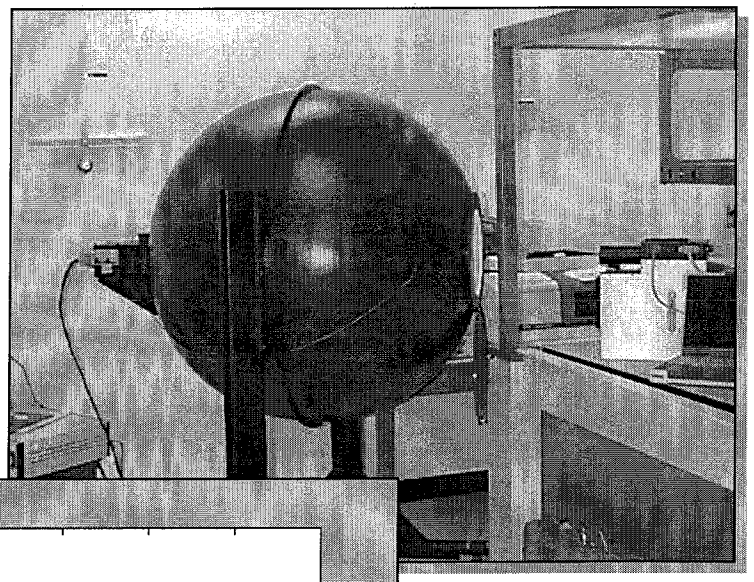
- Calibration
- Time Response
- FOV
- NEDT

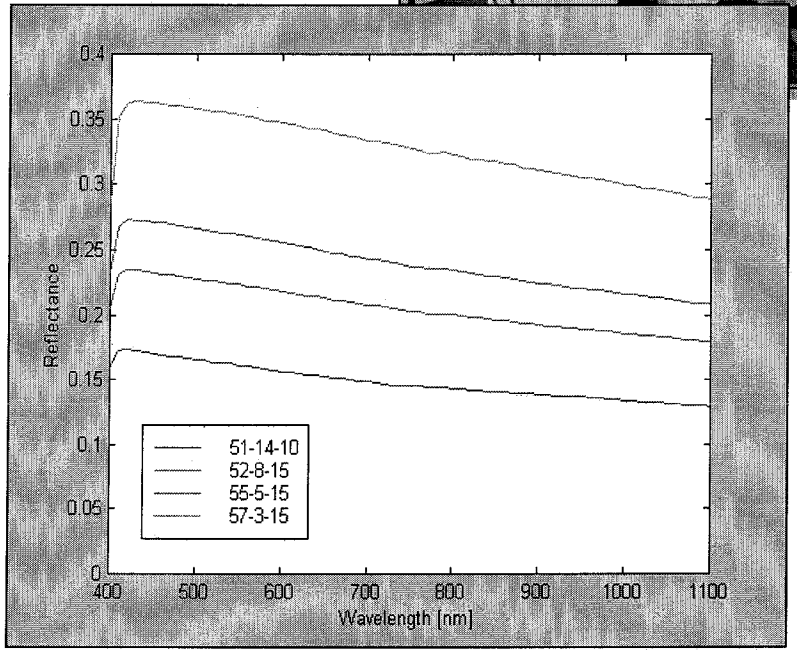
Goniometer

- Spectroradiometer
- BRDF

Ground Truthing Instrumentation







Spectral Reflectance of SSC Grayscale Targets

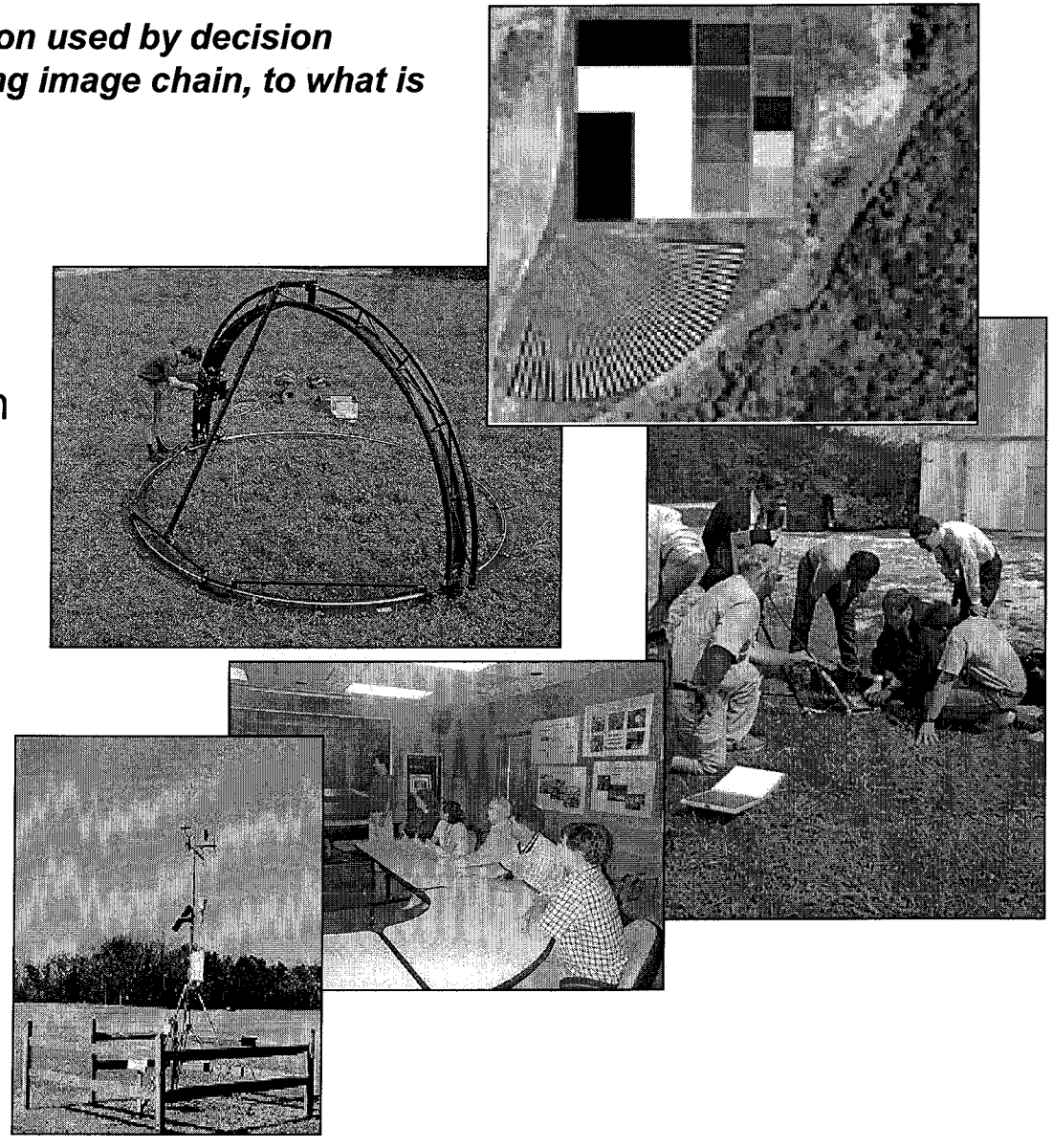
In-Flight Verification and Validation

Stennis Space Center

System Performance Validation

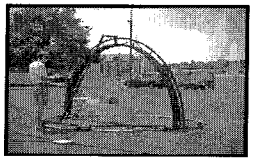
Establish traceability from the information used by decision makers, back through the remote sensing image chain, to what is actually happening on the ground.

- SSC Large Verification Targets
- Full-Field-of-View Geodetic Target Range
- Atmospheric Measurement System
- Spectral and Bi-directional Reflectance Measurement Instruments
- Thermal Measurement Instrumentation
- Algorithm Validation Process
- Data Validation Process
- Data Collection, Management, and Dissemination System
- Interagency Collaboration

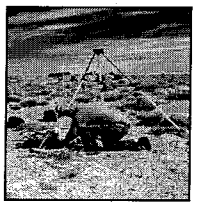


Stennis Verification & Validation Site

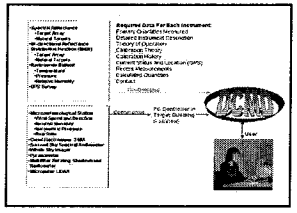
Stennis Space Center



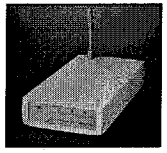
Sandmeier Field Goniometer for Bi-directional Reflectance Measurement



GPS, Spectroradiometer, and Upper Atmosphere Surveys

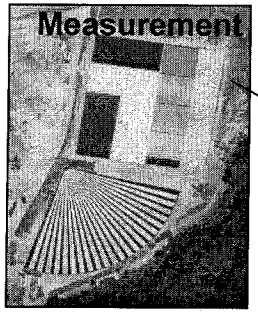


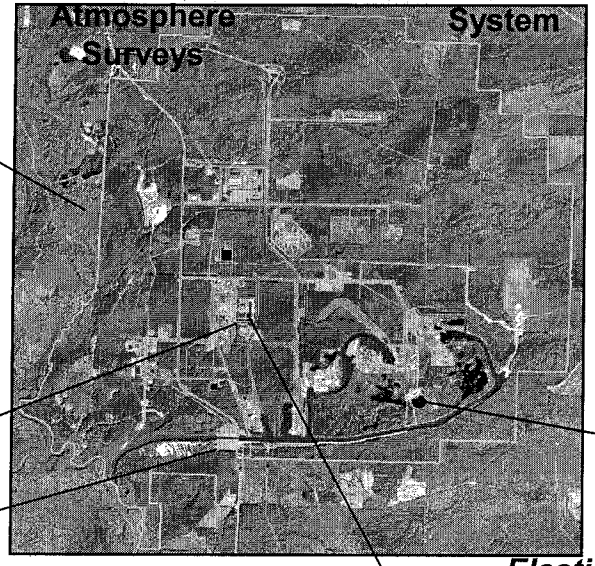
Data Collection, Management, and Dissemination System

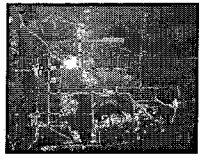


Wireless Data Transmission System

150m x 150m Edge and Grayscale Target Array

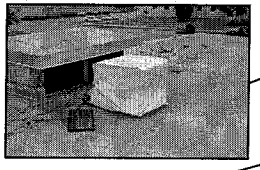


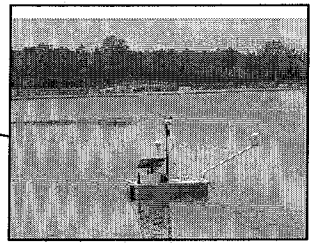




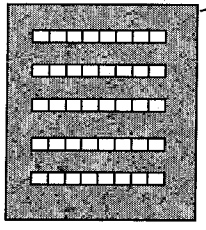
Network of Ground Control Points

Rooftop Contact Surface Temperature Sensors



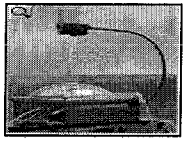


Water Surface Temperature Sensor

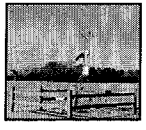


2- and 4-meter Hyperspectral Subpixel Stripe Array Targets

Total Sky Imager

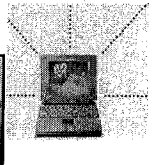


Elastic Backscatter Micropulse Lidar



Surface Meteorology Stations

Multifilter Shadowband Radiometer



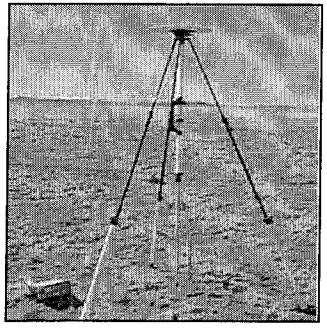
NASA GSFC AERONET Node

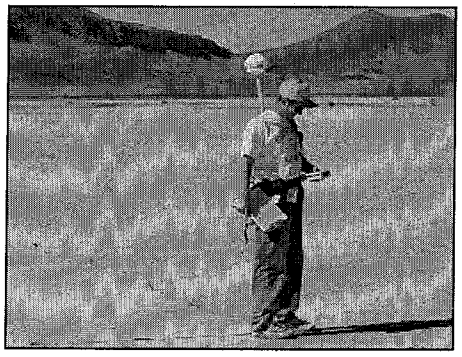
Ground Reference Information Team

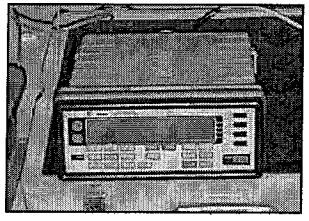
Stennis Space Center

Provides comprehensive ground support services for a wide variety of remote sensing projects.

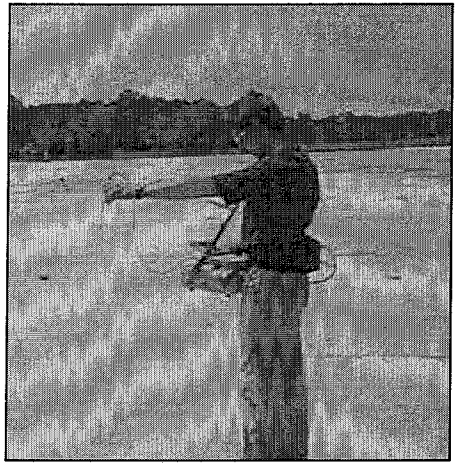
GPS Surveying

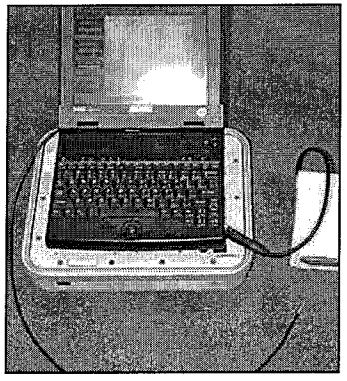




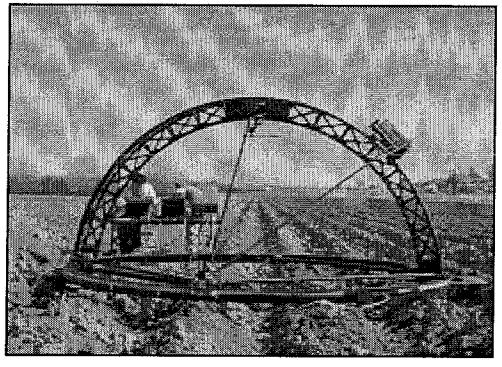


Spectroradiometry

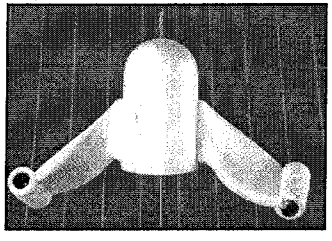


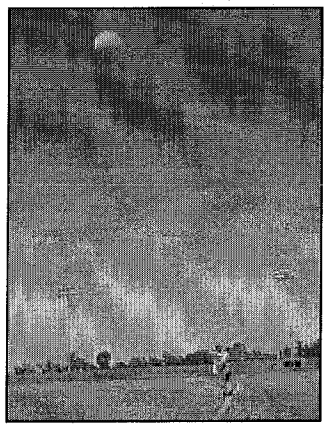


Goniometer Spectroradiometry



Atmospheric Measurement





U.S. Dept. of Energy Interagency Collaboration

Stennis Space Center

Multispectral Thermal Imager (MTI) Temperature Project

Objectives

- Expand current V&V activities to include thermal infrared to support commercial, ESE and other government multispectral thermal validation programs (MTI, ASTER, ATLAS, TIMS)
  - Characterize and instrument SSC thermal validation targets
    - » Water bodies - HPIW Reservoir
    - » Man-made flat solid surfaces- Rooftop of building 1103
  - Develop a SAA with the Multispectral Thermal Imager (MTI) Program Office through the DOE Savannah River Technical Center (SRTC) to assist in validating MTI imagery

Motivation

- Foster commercial applications of radiometric thermal sensing and physics
- Opportunity to validate upgraded ATLAS through vicarious calibration
- Opportunity to fuse multispectral thermal with multispectral reflective data for improved material classification
- Opportunity to further define future ESE mission requirements

Multispectral Thermal Imager (MTI)

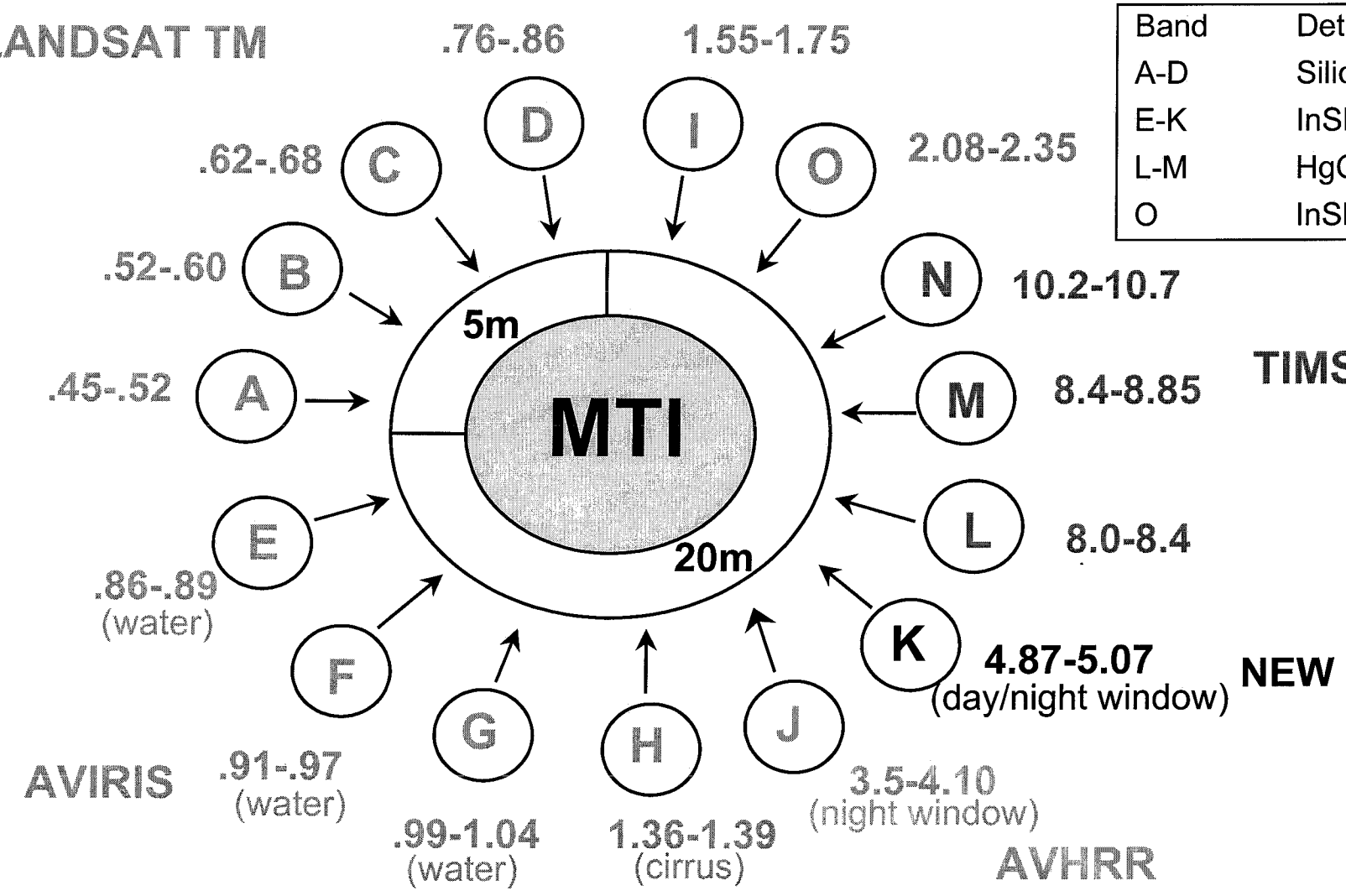
Stennis Space Center

- DOE funded
  - Sandia National Laboratories Systems Integrator
- Pushbroom System
  - Cryogenic FPAS VIS-LWIR
    - » 75 deg Kelvin Cold Finger
    - » 3 chip assembly
  - 15 bands
  - 5 m GSD VIS
  - 20 m GSD SWIR-LWIR
  - 12 km swath
- Off-nadir pointing while imaging
  - +/- 50 deg pitch
  - +/- 20 deg roll

MTI Band Heritage

Stennis Space Center

Band	Det. Material
A-D	Silicon
E-K	InSb
L-M	HgCdTe
O	InSb

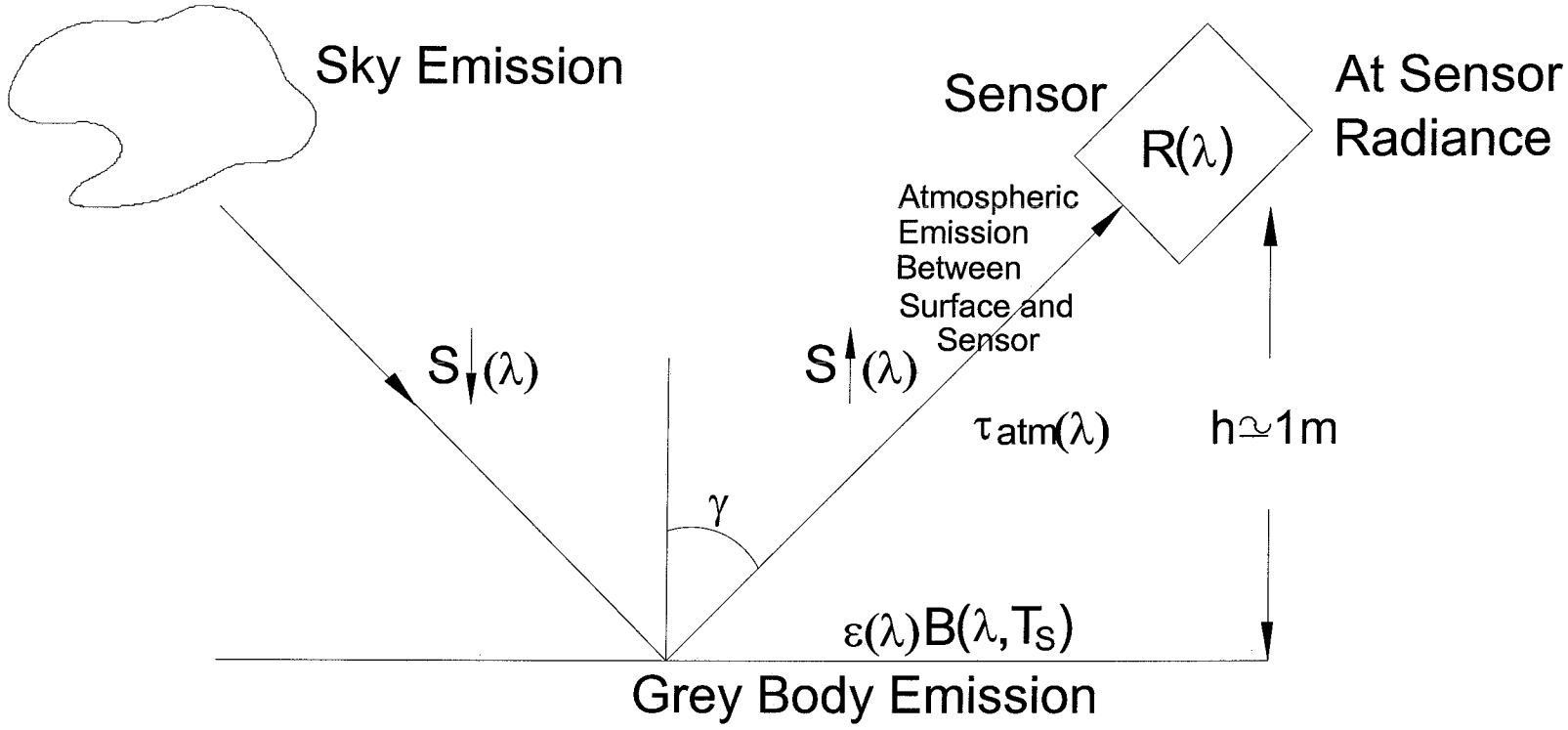


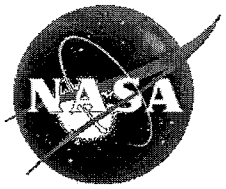
Temperature Project Technical Approach

- **Characterize the High Pressure Industrial Water (HPIW) Reservoir**
  - Model thermal radiative transport physics
  - Calibrate required instruments with black bodies in the Lab
  - Measure thermal radiation independently with multiple instruments
  - Compare measurements with model predictions
- **Develop a floating measurement system to support water body ground truthing activities**
  - Evaluate MTL Data Acquisition Float (DAF)
  - Assist DOE/SRTC in evaluating their measurement float
  - Design, build, test and field an SSC measurement float

Thermal Modeling

Monochromatic Radiative Transfer Equation





Thermal Modeling

Monochromatic Radiative Transfer Equation

$$R(\lambda) = \varepsilon(\lambda)B(\lambda,T_s)\tau_{atm}(\lambda) + (1-\varepsilon(\lambda))S_{\downarrow}(\lambda)\tau_{atm} + S^{\uparrow}(\lambda) \quad (1)$$

Where:

$\lambda \equiv$ Wavelength $[\mu m]$

$\varepsilon(\lambda) \equiv$ Emissivity of surface

$S_{\downarrow}(\lambda) \equiv$ Downwelling Radiation *(sky emission)* striking water $\left[\frac{W}{cm^2 sr}\right]$

$S^{\uparrow}(\lambda) \equiv$ Atmospheric Radiation between water surface and sensor $\left[\frac{W}{cm^2 sr}\right]$

$\tau_{atm}(\lambda) \equiv$ Atmospheric Transmission between water surface and sensor

$\gamma \equiv$ Angle of incidence, 15°

$T_s \equiv$ Skin Temperature $[^o K]$

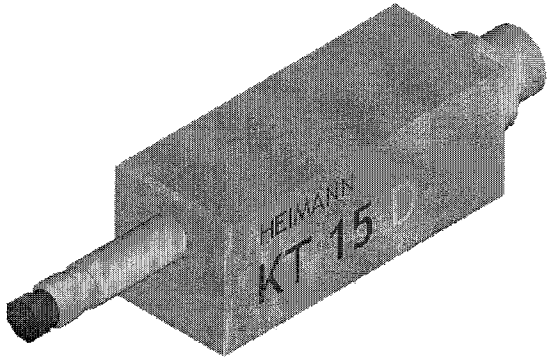
$R(\lambda) \equiv$ Radiance at sensor $\left[\frac{W}{cm^2 sr \mu m^{-1}}\right]$

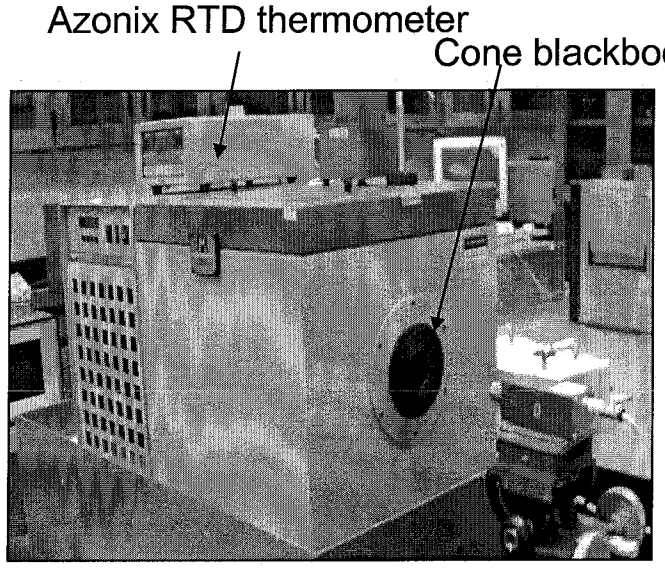
$B(\lambda,T_s) \equiv$ Plank function $\left[\frac{W}{cm^2 sr \mu m^{-1}}\right]$

Instrument Calibration

Radiometer Characterization

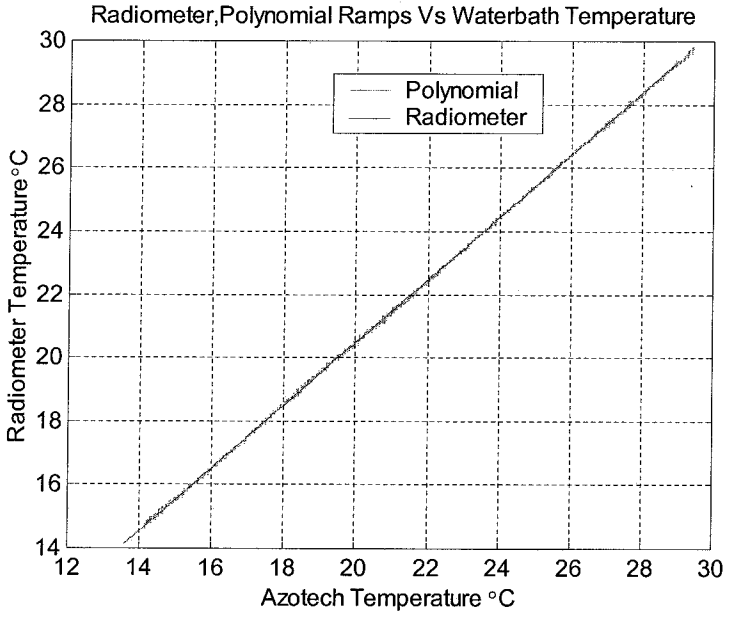
- Heimann Temperature Calibration
- Time Constant Measurements
- NEDT
- Field of View Measurements
- Warm-up Characteristics
- Spectral Response
- Ambient Temperature Effects



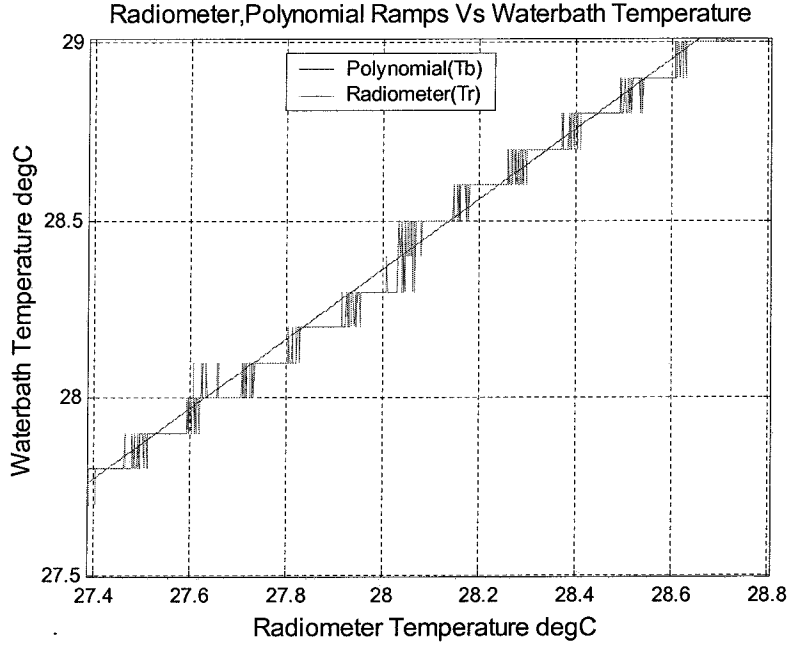


Instrument Calibration

Heimann Radiometer Temperature Calibration



Example:
Hiemann average reading: 28.3663 °C
Waterbath temperature: 28.028 °C
Polynomial corrected value: 28.0033 °C

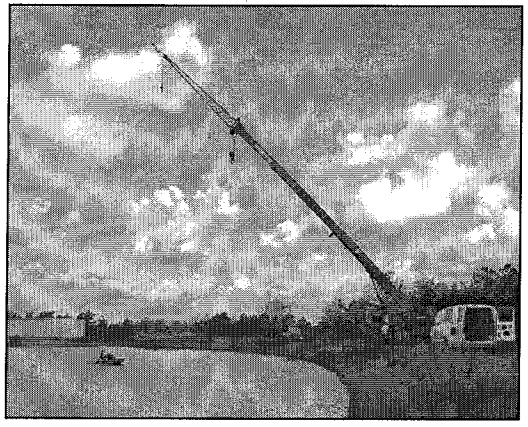


Polynomial expression:
Tb=0.0004Tr^2+1.0016Tr-0.6466
Where Tb=Brightness Temperature
Tr=Radiometer Output Temperature
Method:
Use the polynomial expression as a correction to radiometer readings.

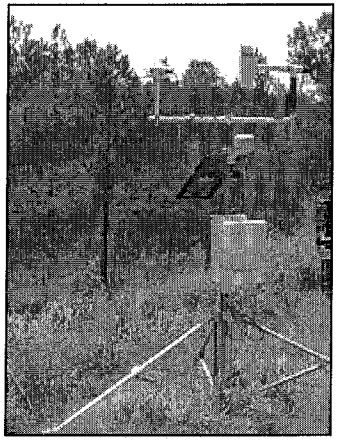
SSC HPIW Reservoir Thermal Characterization
Ground Truthing

Stennis Space Center

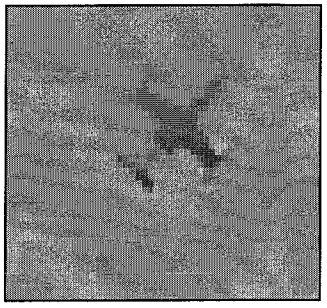
Ground Truthing Setup



Weather Station

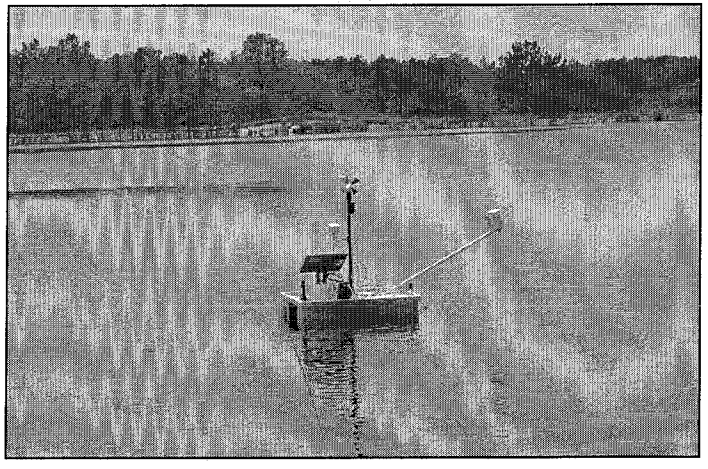


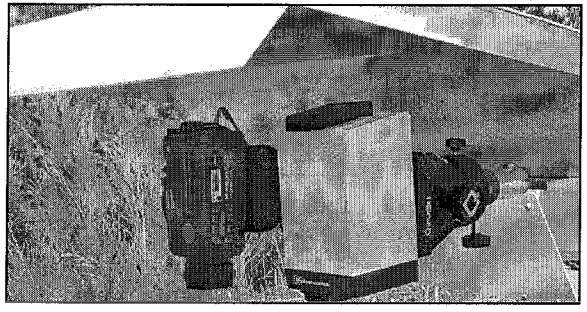
ATLAS



Radiosonde Launch

SSC Measurement Float

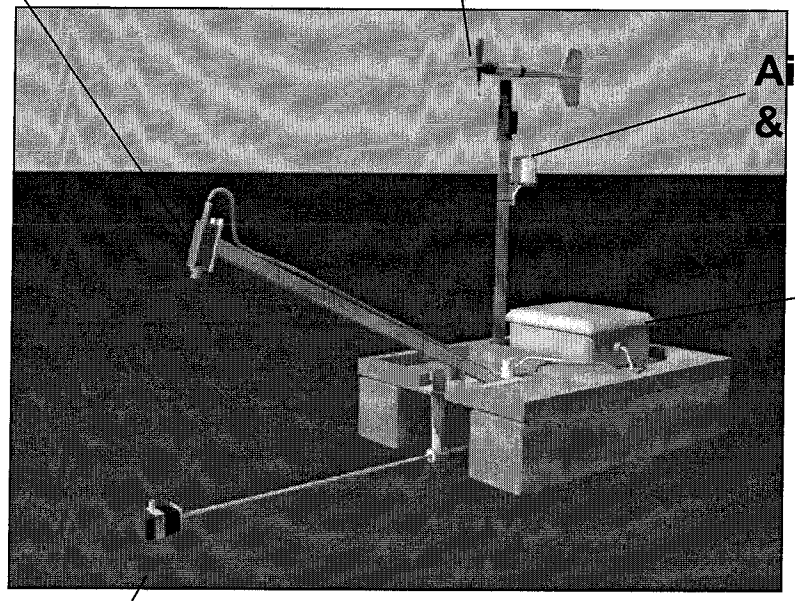


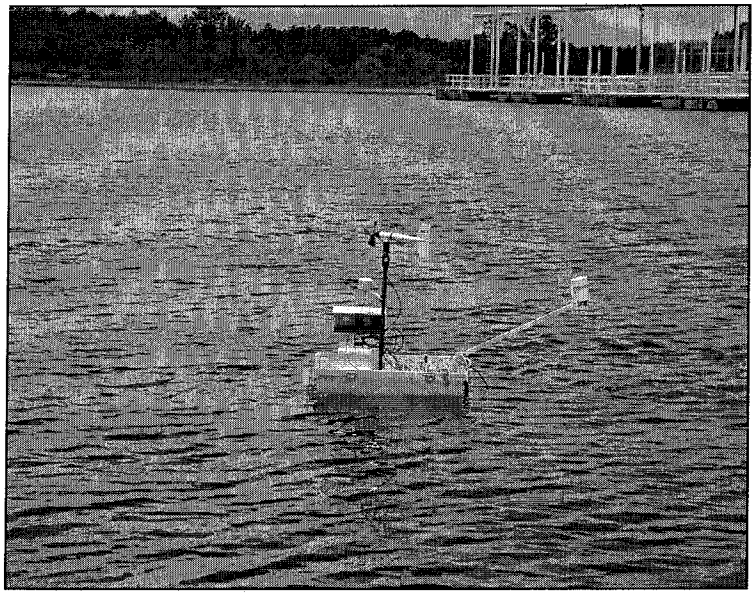


In Situ Thermal Imagers

Stennis CRSP Measurement Float

Stennis Space Center

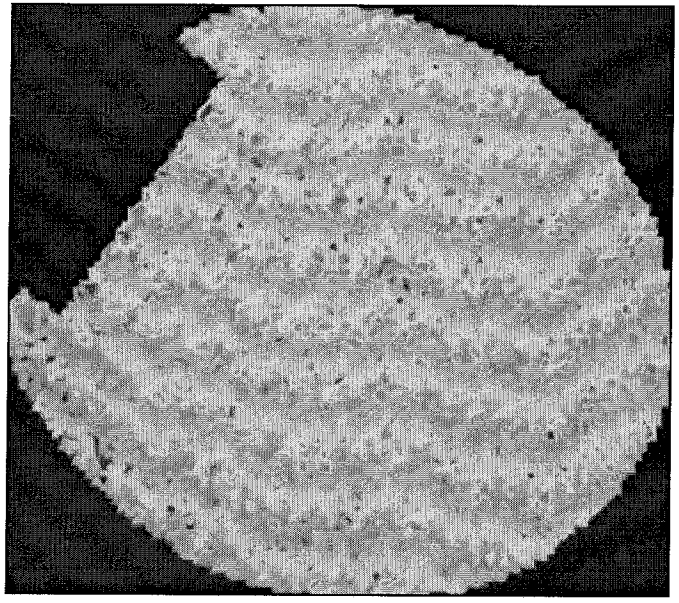




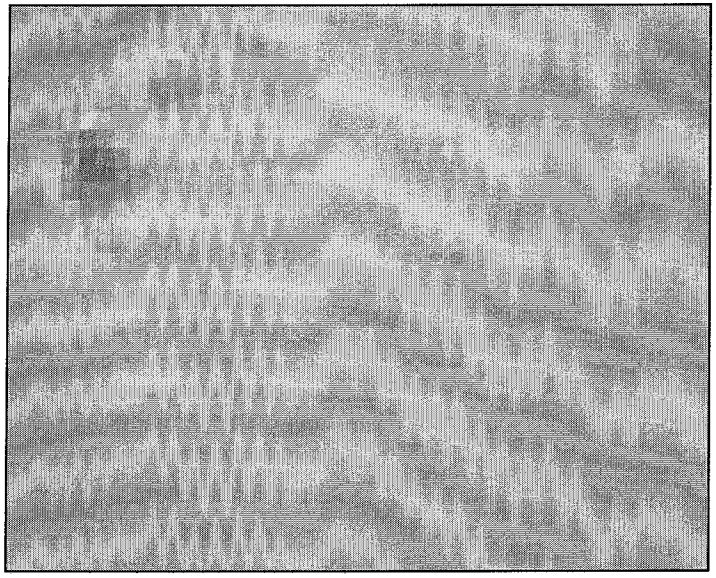
HPIW Reservoir ATLAS Thermal Imagery

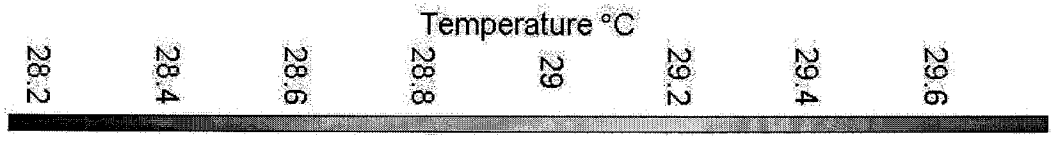
Stennis Space Center

M200006
August 10, 2000
9:30 AM
2.5m GSD



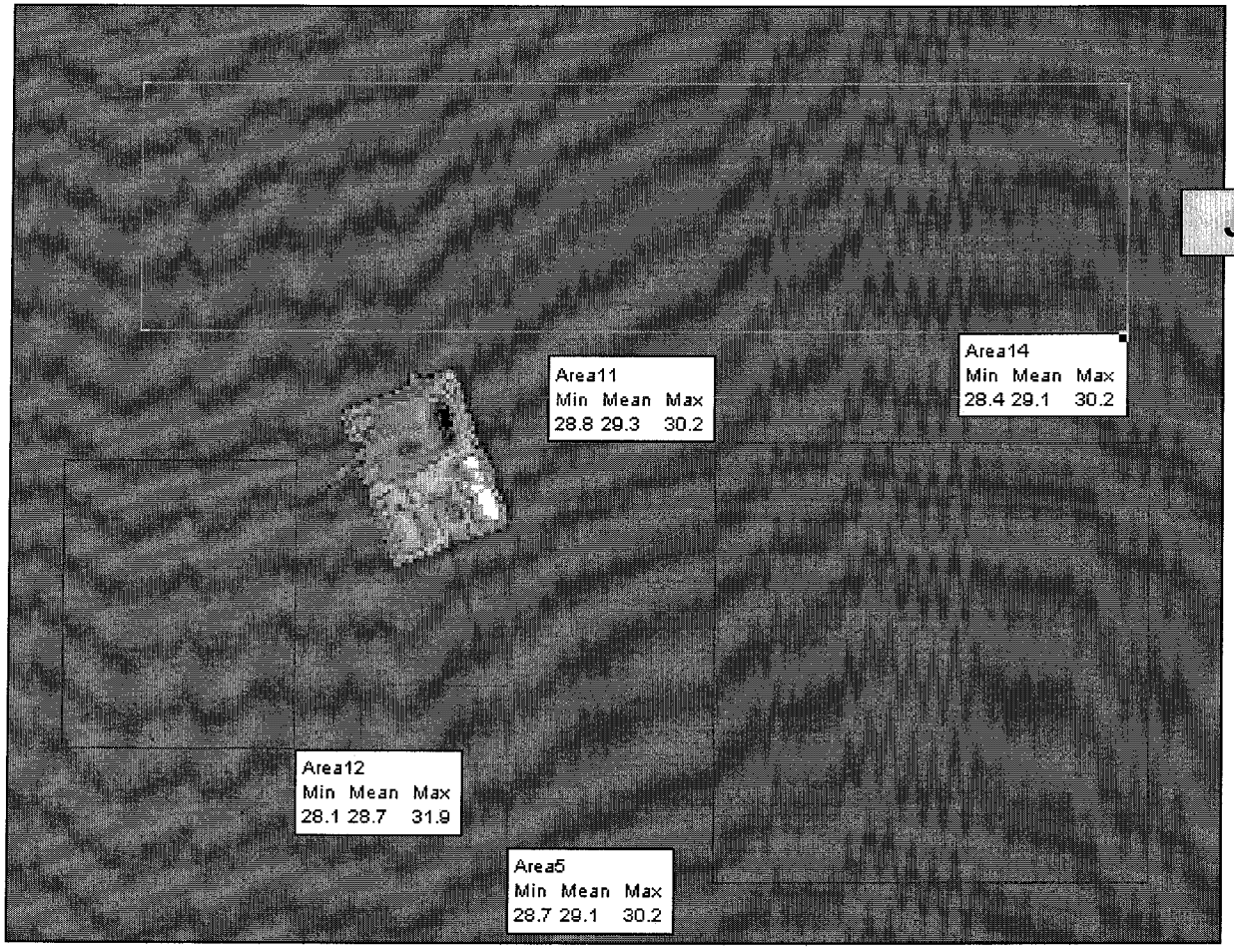
Synthesized
20m GSD
(Blurred &
Resampled)





IR Camera HPIW Reservoir Imagery of CRSP Float

Stennis Space Center



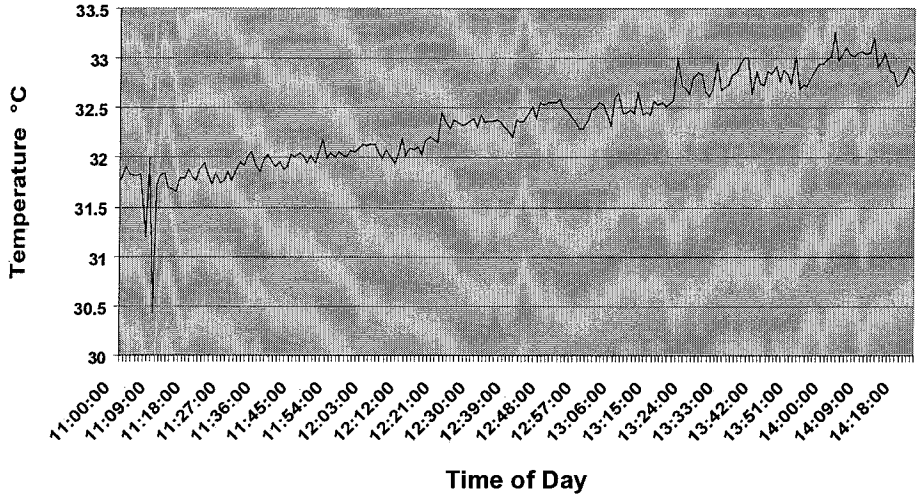
July 25, 2000

Float does not influence surrounding water where radiometer measurements are taken.

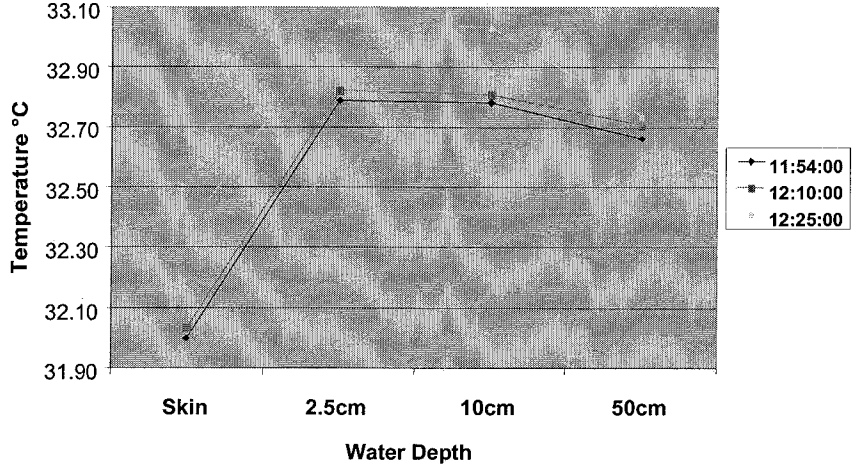
SSC Float Measurements

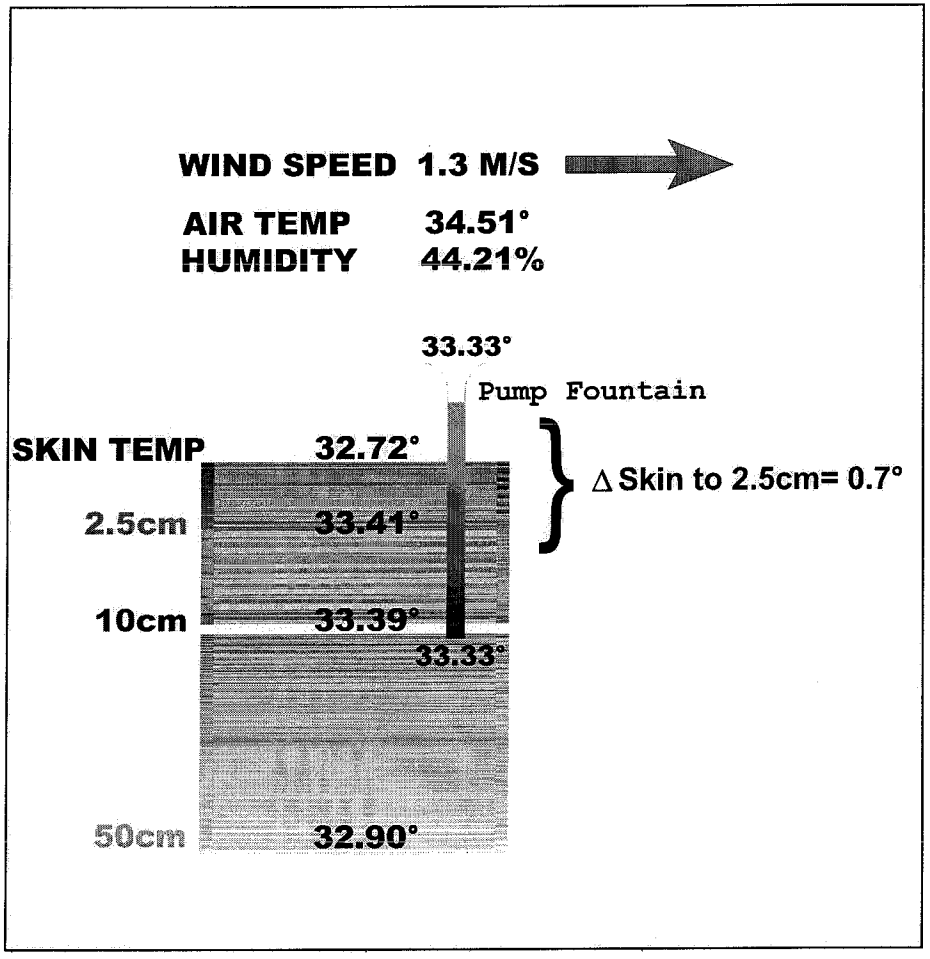
Stennis Space Center

Average Water Skin Temperature



Temperature Profile





Scientific Data Purchase

Science Data Purchase Data Providers

- EarthSat
  - Landsat Orthorectified Imagery
- Intermap
  - Star3I Interferometric SAR
- Positive Systems
  - ADAR 5500
- Space Imaging
  - IKONOS

Earthsat - Scientific Data Purchase Program

Stennis Space Center

Data Description

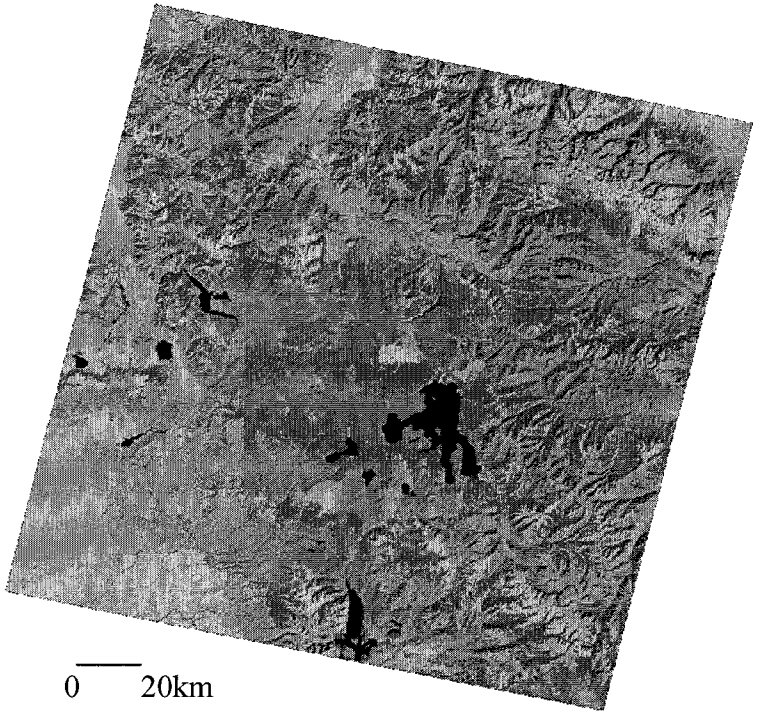
- Global coverage of orthorectified Landsat MSS and TM imagery over 2 time periods
  - MSS Scenes - from 1970s, 20% or less cloud cover, +/- 100m horizontal PA (90% CI)
  - TM Scenes - from late 1980s to early 1990s, 20% or less cloud cover, +/- 50m HPA
  - (90% CI)
  - TM Mosaics - compressed RGBs of bands 7,4, and 2, each mosaic corresponding to large region, formatted as MrSID files

Data Rights

- For all data 10 years and older, distribution unlimited within NASA ESE community for NASA related work

Area of Coverage

- MSS - 233 Scenes
- TM - 2825 Scenes
- Mosaics - 103 Data Sets



1990 Landsat Thematic Mapper Scene of Yellowstone National Park Acquired via the "Data Buy"

Space Imaging- Scientific Data Purchase Program

Stennis Space Center

Data Description

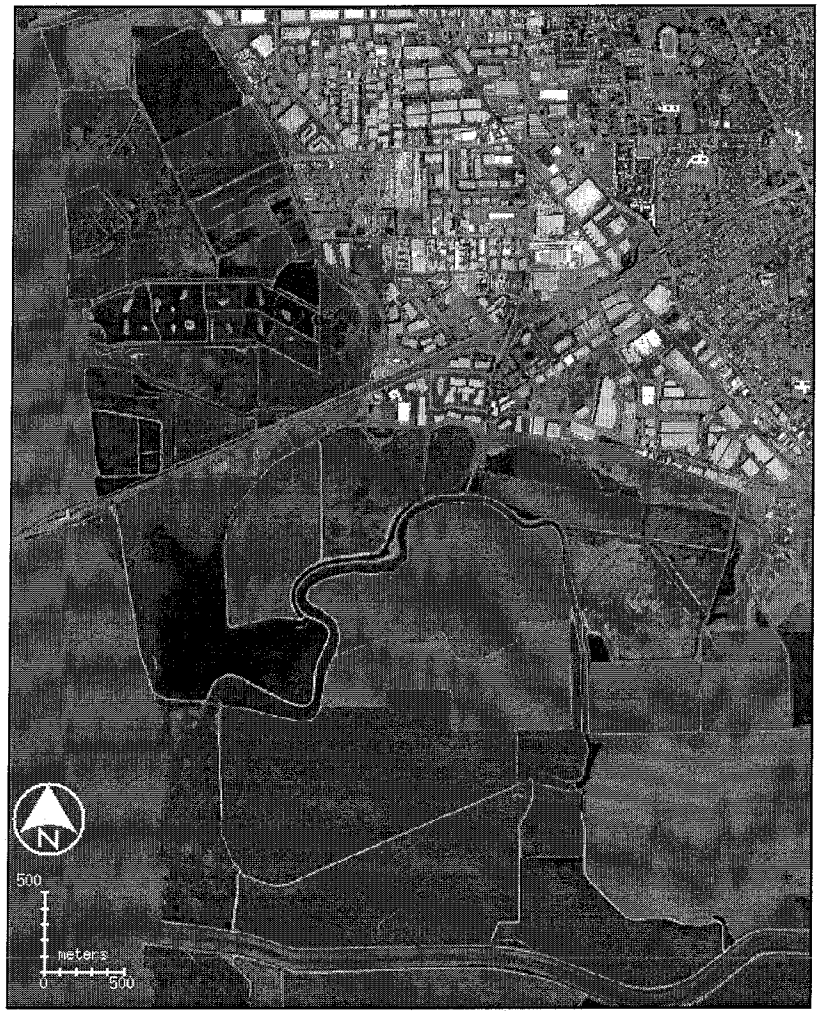
- IKONOS-2 Satellite Imagery
  - 1 meter resolution panchromatic imagery
  - 4 meter resolution multispectral imagery
- "Original Data" - rectified to constant elevation
- "Master Data" - orthorectified imagery
- "Model Product" - DEM's and stereo pairs

Data Rights

- Distribution unlimited within ESE community
- Derived products may be distributed within NASA science/ research community

Area of Coverage

- Original - 72,000 Sq.. Km
- Master - 23,000 Sq.. Km coverage
- Model - 70 scenes @ 11 km X 11 km



IKONOS four meter multispectral image of South Bay San Francisco, California

Earthwatch - Scientific Data Purchase Program

Stennis Space Center

Data Description

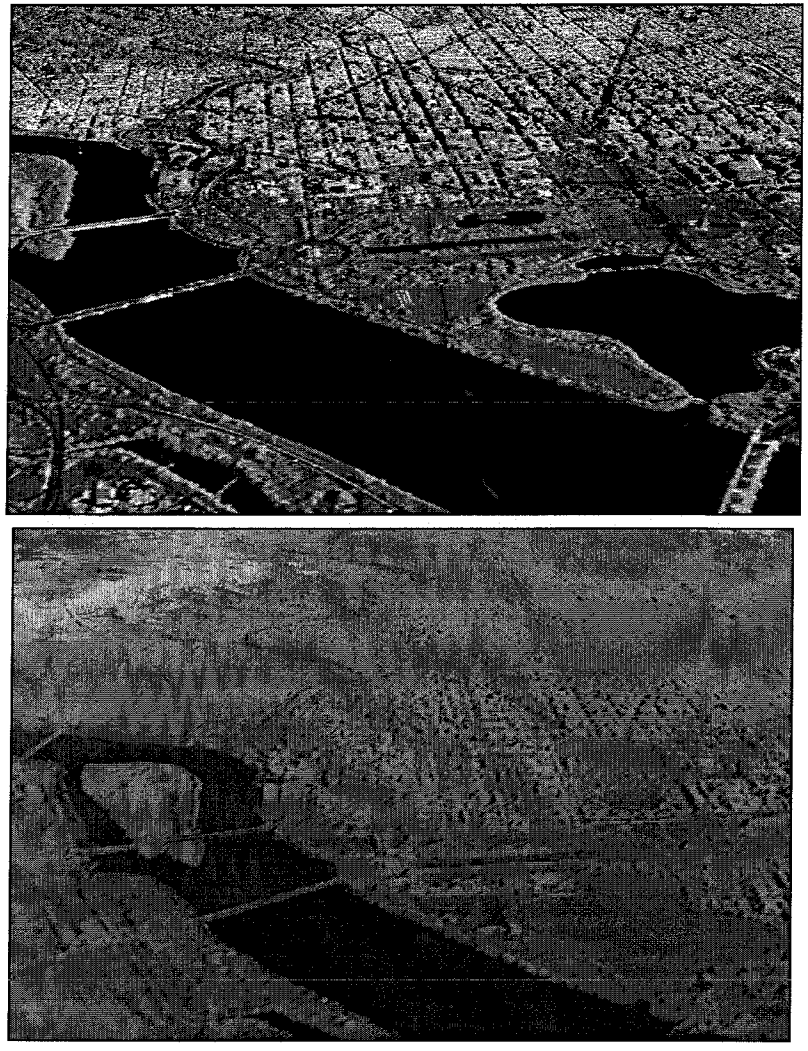
- STAR3i Airborne X Band Radar Products
  - 5-10 meter IFSAR DEM data
  - 2.5 meter resolution orthorectified SAR image map imagery
- GT-1 DEMs - 5m posting, +/- 1m RMSE vertical PA, +/-2.5m RMSE horizontal PA
- GT-2 DEMs -10m posting, +/- 2m RMSE vertical PA, +/- 2.5m RMSE horizontal PA
- GT-3 DEMs - 10m posting, +/- 3m RMSE vertical PA, +/- 2.5m RMSE horizontal PA

Data Rights

- Distribution unlimited within NASA ESE community for NASA related work

Area of Coverage

- Total Coverage 99635 sq... km as of 6/1/2000



3-D Oblique Views of Star3i Data Products Over Washington, D.C.

Positive Systems - Scientific Data Purchase Program

Stennis Space Center

Data Description

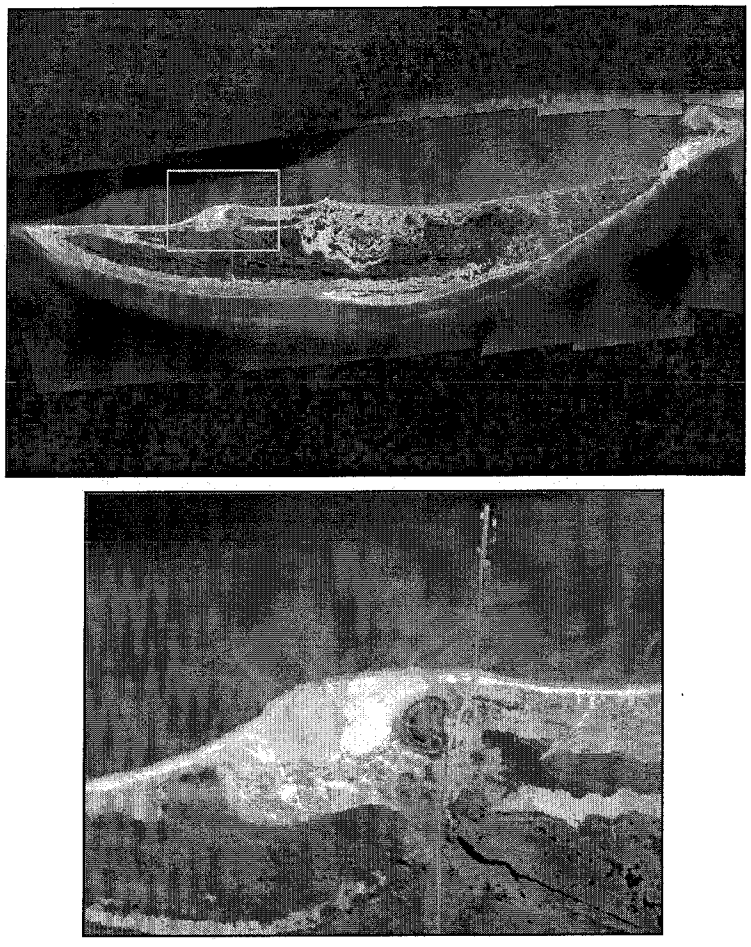
- ADAR 5500 Multispectral Data
  - IM-R1i-55 - 1m 8 bit MS data with post-flight radiometric corrections, band to band co-registration within +/- 1 pixel, contains blue, green, red, and NIR bands, absolute radiometric accuracy within +/- 10%
  - MOS-G1 - 1m 8 bit MS mosaics with <= +/- 12.2m horizontal PA for benign terrain, <= +/- 33m HPA for rugged terrain, and <= +/- 50m HPA for extreme terrain

Data Rights

- Distribution unlimited within NASA ESE community for NASA related work, providing acknowledgement of data provider is given in publications and products utilizing the data

Area of Coverage

- 7858.8 sq.. km of imagery
- 793.2 sq. km of image mosaics

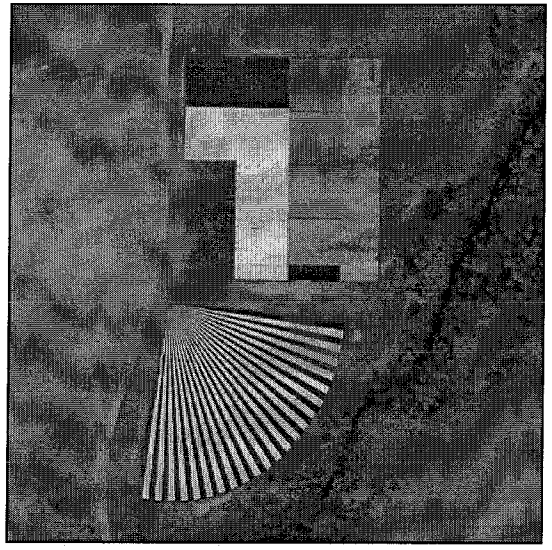


1997 Positive Systems ADAR 5500 Image Mosaic of Ship Island, Mississippi Draped over Landsat TM Image Inset of Fort Massachusetts

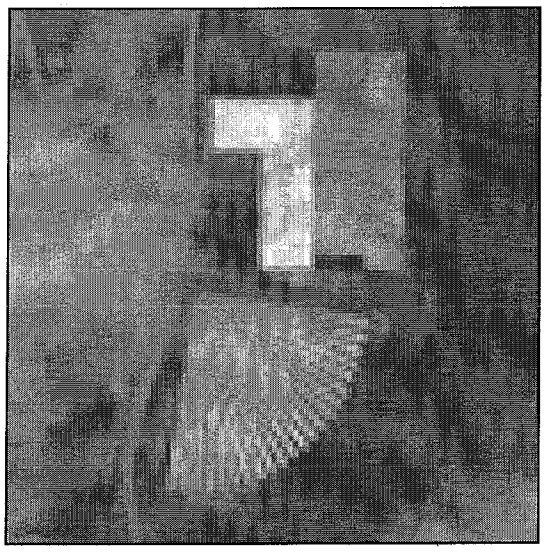
Space Imaging IKONOS - Data Validation

Stennis Space Center

1m GSD PAN



4m GSD MS



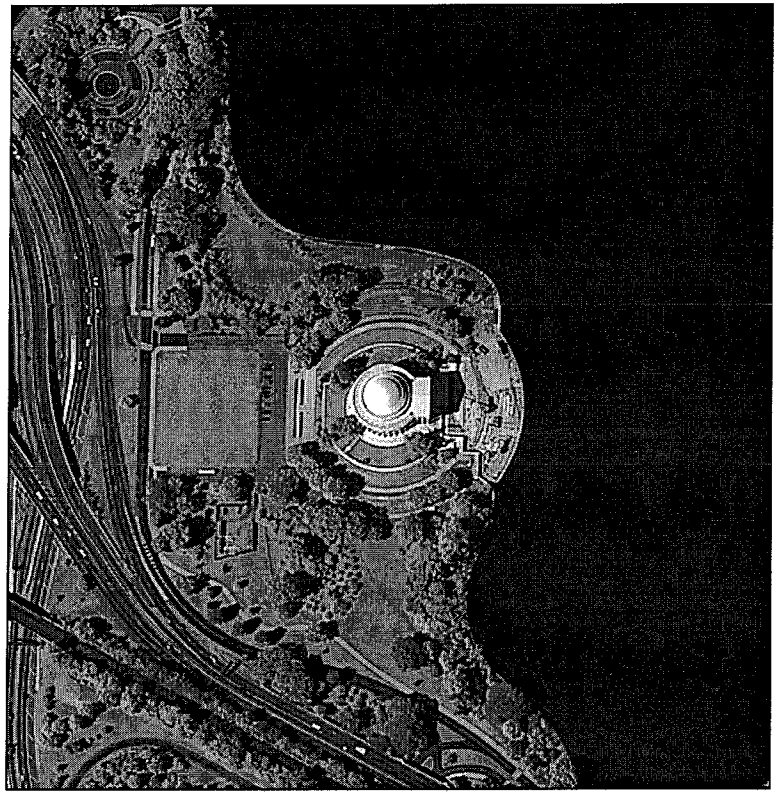
Quantitative System Characterizations:

- **MTF and spatial resolution**
- **Geometric properties of imagery**
- **SNR estimates**
- **Band-to-band registration of multispectral products**
- **Radiometric accuracies of products**
- **Intercomparison of IKONOS, Landsat 7 and other satellite imagery**
- **NIIRS rating of products**

Interagency Commercial System Validation

Stennis Space Center

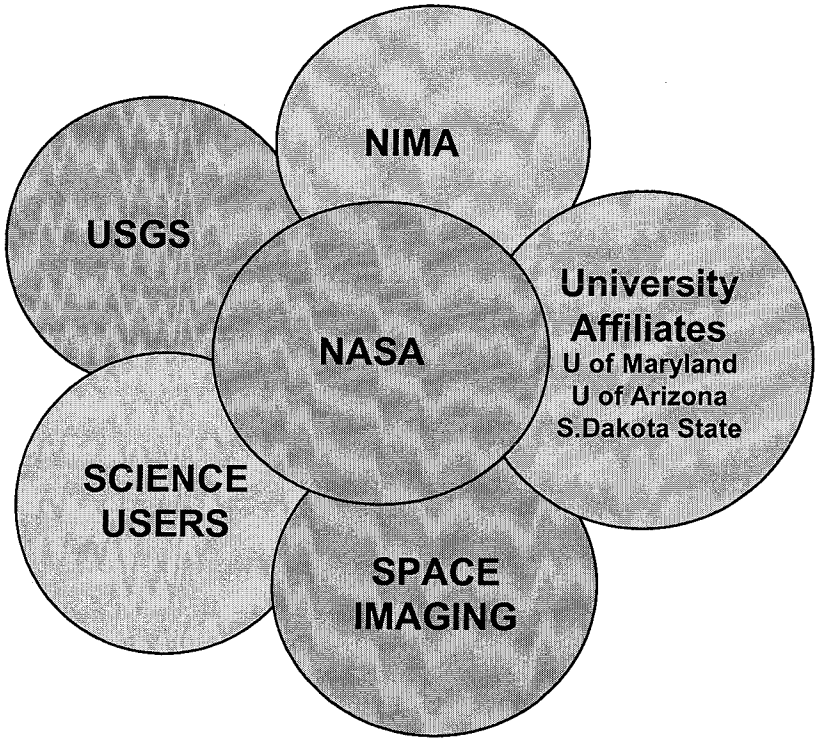
- **Joint NASA / NIMA / USGS team focused on characterizing commercial remote sensing system performances**
- **Overall performance assessment to meet each agency's mission requirements**
  - **NASA - Systems Characterization**
  - **NIMA- Photogrammetry**
  - **USGS - Cartographic Assessment**
- **Improved communications with industry**
  - **More productive interchanges between industry and government**
  - **Minimize duplication of effort**
  - **Reduction in costs incurred by industry and government**



IKONOS one meter panchromatic image of Jefferson Memorial in Washington, D.C.

SDP IKONOS Characterization Team

Stennis Space Center



	Characterization			
Organization	Spatial	Geometric	Radiometric	Application
NASA Stennis	X	X	X	X
University of Arizona	X		X	
South Dakota State University	X		X	
USGS EDC		X		
NIMA	X	X	X	
University of Maryland				X
Science Community			X	X
Space Imaging	X	X	X	

SDP Characterization Activities

Stennis Space Center

General Product Characterization
(All acquired data sets)

- **Data Format**
- **Meta File**
- **Location / Coverage**
- **Cloud Cover**
- **Band-to-band registration**
- **General Statistics**
  - mean
  - standard deviation
  - pixel histogram
  - fraction of saturated pixels
- **Auto Report generation**
- **Thumbnail generation**
- **MODTRAN / radiance intercomparison**
- **NIIRS evaluation when appropriate**

Performance Product Characterization
(Sample V&V data sets)

- **Image Quality**
- **Positional Accuracy**
- **Radiometric Performance**
- **Spectral Characterization**

Applications Utility

- **University of Maryland assessment**
- **Exploit core sites**
- **Obtain feedback from ESE researchers**