



Joint Agency Commercial Imagery Evaluation IKONOS V&V Overview

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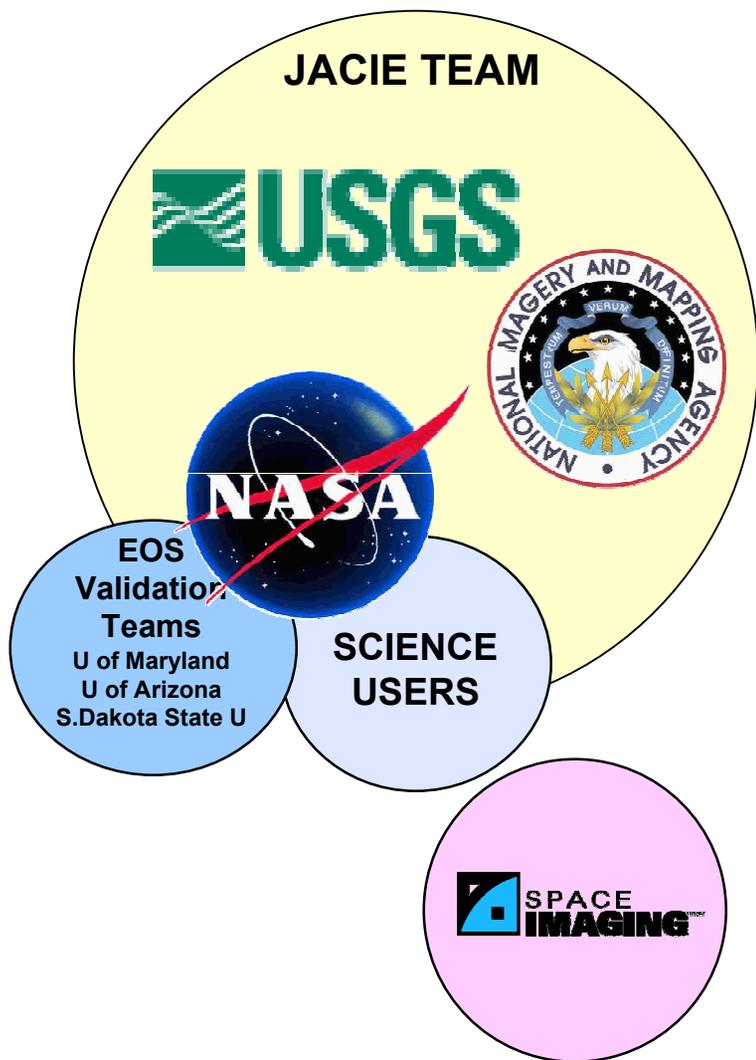
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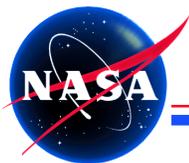


JACIE IKONOS Characterization Team

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



USGS System Characterizations

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- **Cartographic Assessment Perspective**
 - Geometric Accuracy Assessments
 - Georeferenced imagery
 - Orthorectified imagery
 - DEM / Stereo pair imagery





NIMA System Characterizations

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- **Product Evaluation Perspective**
 - Image Interpretability and Feature Extraction
 - Radiometrically corrected imagery
 - Photogrammetry
 - Orthorectified imagery
 - Stereo imagery
 - Evaluate Processing Techniques
 - Resampling methods
 - Pan Sharpening
 - Application Assessment





NASA System Characterizations

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- **System Characterization Perspective**
 - Evaluate Specifications
 - Geometric
 - Spatial
 - Radiometric
 - Evaluate Processing Techniques
 - MTF Compensation
 - Comparisons with Other Systems
 - Landsat 7
 - MODIS
 - Application Assessment

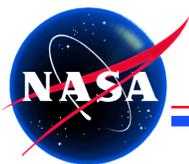




IKONOS Data Product Nomenclature

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NASA Product Name	Most Similar Carterra Product Name	Description
Standard Original	Geo	UTM/WGS-84 Georeferenced imagery No control points
Precision Original	(None)	UTM/WGS-84 Georeferenced imagery using control points
Standard Master	Pro	Orthorectified imagery No control points
Precision Master	Precision Plus (available April 2)	Orthorectified imagery using control points
DEM/Stereo Pair	(None)	Digital elevation model & stereo images



NASA SDP Imagery

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- **MTF Compensation applied**
- **Cubic Convolution Interpolation applied**
- **Dynamic Range Adjustment (DRA) not applied**
- **On-board compression performed (all IKONOS imagery)**



NASA IKONOS SDP V&V Philosophy

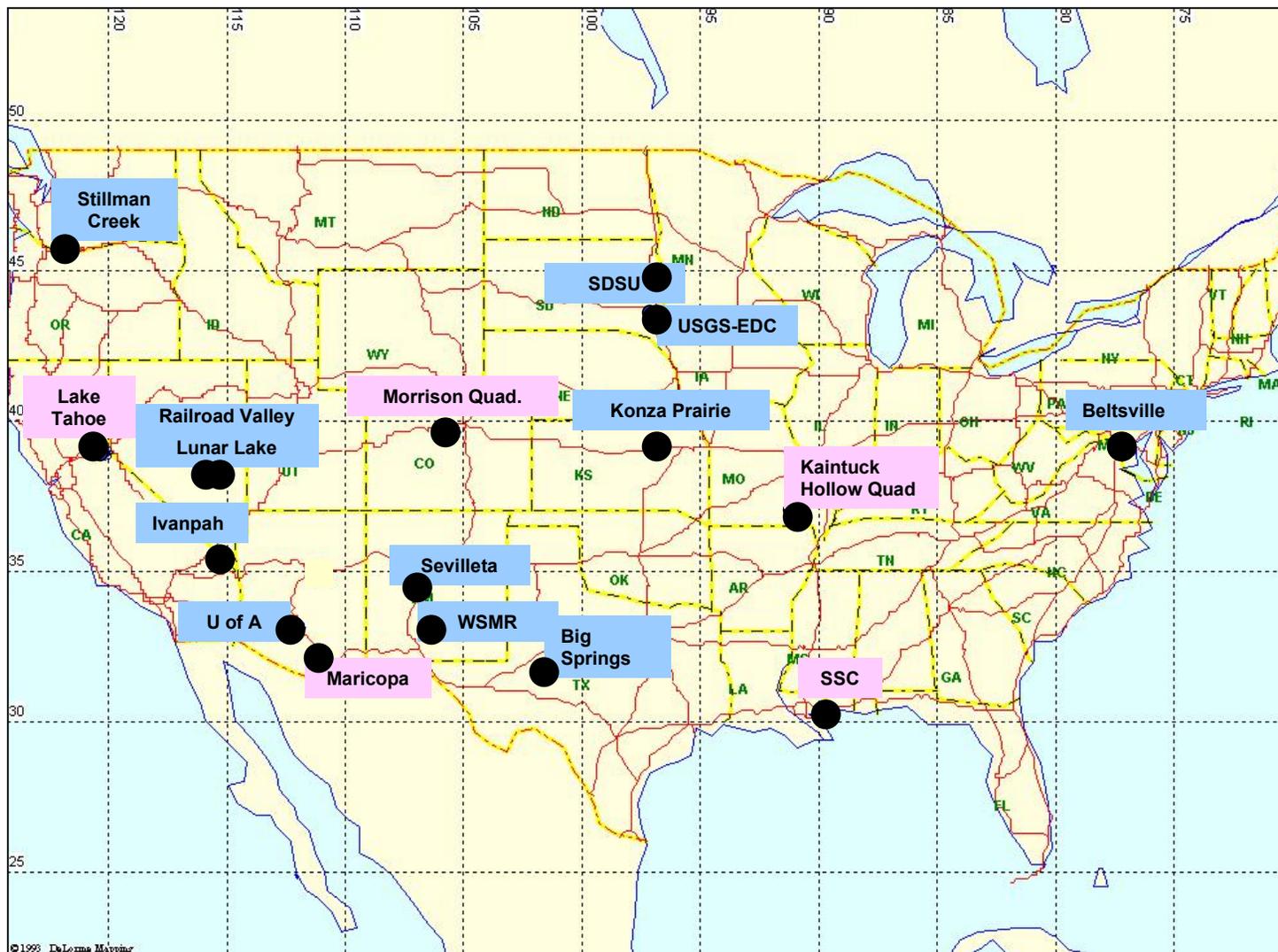
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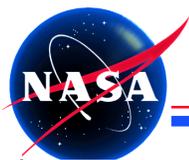
- **Perspective: SDP is an experiment**
 - Can the commercial sector provide useful, cost effective data to the science community?
 - Only one satellite (*no backup*), buy data while we can
- **Assumptions**
 - Space Imaging will attempt to provide high quality data
 - NASA Stennis will trust but verify
 - Releasing data in a timely fashion is important
 - Feedback from users is important
- **Competition is developing**
 - Earth Watch, Orbital, Russian Spin Data, ImageSat
 - Methodologies developed will be used again



IKONOS Validation Sites

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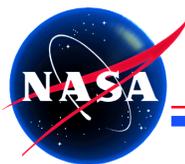




IKONOS Validation Sites Overview

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	CHARACTERIZATION			OTHER SENSOR COMPARISON	APPLICATION RESEARCH
	GEOMETRIC	SPATIAL	RADIOMETRIC		
US Ecological CORE Site Beltsville, MD			X	Landsat 7	X
Kaintuck Hollow Quad, MO	X				
NASA SSC, MS	X	X	X		
SDSU Brookings SD	X	X	X		
USGS - EDC Sioux Falls, SD	X				
US Ecological CORE Site Konza Prairie Big Springs, TX		X		Landsat 7	
Morrison Quad, CO	X				
US Ecological CORE Site Sevilleta, NM				Landsat 7	
White Sands Missile Range, NM			X		
Maricopa Agriculture Center Phoenix, AZ		X	X	Landsat 7	X
University of Arizona Tucson, AZ		X			
Ivanpah Playa, CA			X		
Railroad Valley Playa, CA			X		
Lunar Lake Playa, CA			X		
Lake Tahoe, CA			X		
Stillman Creek Pe Ell, WA					X



NASA Stennis Space Center, Mississippi

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Site: Scattered buildings within heavily wooded area, man-made reservoirs and canal

Elevation 5.5m - 10m

30.388 degrees N, 89.61 degrees W

Purpose: Spatial, geometric and radiometric characterization

Targets:

- 2 orthogonal concrete edge targets (*70x80m oriented E-W, 80x80m oriented N-S*) 130m concrete radial target (*96.4 deg arc, 0.08-5.0m range*), 4 step concrete grayscale target (*35x40m each*)
- Over 40 geodetic targets known to within 2 cm
- 4 step gray tarps (*20mx20m each*)

In-Situ Instrumentation: Cimel sunphotometer, shadowband radiometer, ASD and GER spectroradiometers, SSC weather station, radiosonde balloon launch, pyronometer

Coincident Collects: Landsat 7

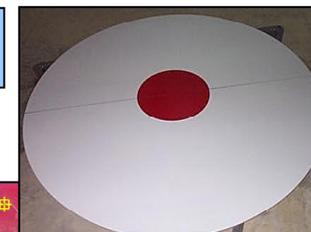


IKONOS Image showing concrete edge, radial and 4 step grayscale targets

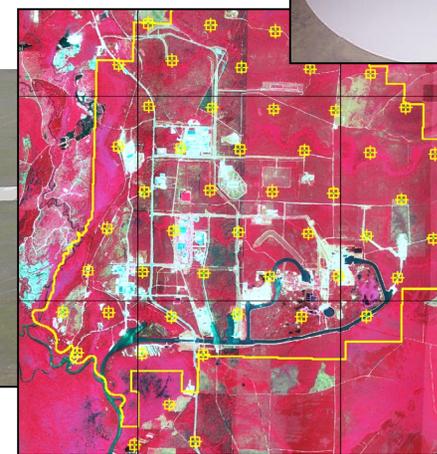


11m x 11m IKONOS Image Area

Geodetic Target



Radiometric Tarps



ATLAS image and showing geodetic target locations



NASA IKONOS Geometric Characterization Status

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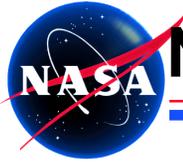
- **Four acquisitions have been made**
 - Brookings, SD - (Std/Precision Original)
 - Sioux Falls, SD - (Std Original)
 - Morrison Quad, CO - (Std Original)
- **Two acquisitions are pending collection**
 - Morrison Quad, CO - (Std/Precision Original, Std/Precision Master)
 - SSC, MS - (Std/Precision Original, Std/Precision Master)
- **Two DEM acquisitions are pending collection**
 - Morrison Quad, CO
 - Kaintuck Hollow, MO



NASA IKONOS Spatial Characterization Status

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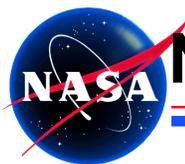
- **Four acquisitions have been made**
 - Tucson, AZ - (Std/Precision Original, Std/Precision Master)
 - Brookings, SD - (Std/Precision Original)
- **Two SI archive images have been obtained**
 - Big Springs, TX - (Std Original)
- **Two acquisitions are pending collection**
 - Maricopa, AZ - (Std/Precision Original)
 - SSC, MS - (Std/Precision Original, Std/Precision Master)
- **Six Standard Original images have been reprocessed without MTF Compensation**
 - Phoenix, AZ (SI gratis)
 - Tucson, AZ
 - Lunar Lake Playa, NV
 - Brookings, SD
 - Rail Road Valley, NV
 - Big Springs, TX



NASA IKONOS Radiometric Characterization Status

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- **Seven U.S. acquisitions have been made and evaluated**
 - Brookings, SD - (Std Precision Original)
 - Lunar Lake, NV - (Std Original)
 - Railroad Valley, NV - (Std Original)
 - Ivanpah, CA - (Std Original)
 - White Sands, NM - (Std Original)
- **Four acquisitions are pending collection**
 - Maricopa, AZ - (Std/Precision Original)
 - SSC, MS - (Std/Precision Original, Std/Precision Master)
 - Beltsville, MD - (Std/Precision Original, Std/Precision Master)
 - New Orleans, LA - (Std Original)



NASA IKONOS Radiometric Characterization Status

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- **Two North African scenes identified**
 - Mali - (Std Original) - Received
 - Libya - (Std Original) - Pending
- **One stray light scene identified**
 - Lake Tahoe - (Std Original) - Pending

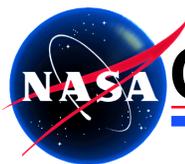


Geometric Accuracy Characterization

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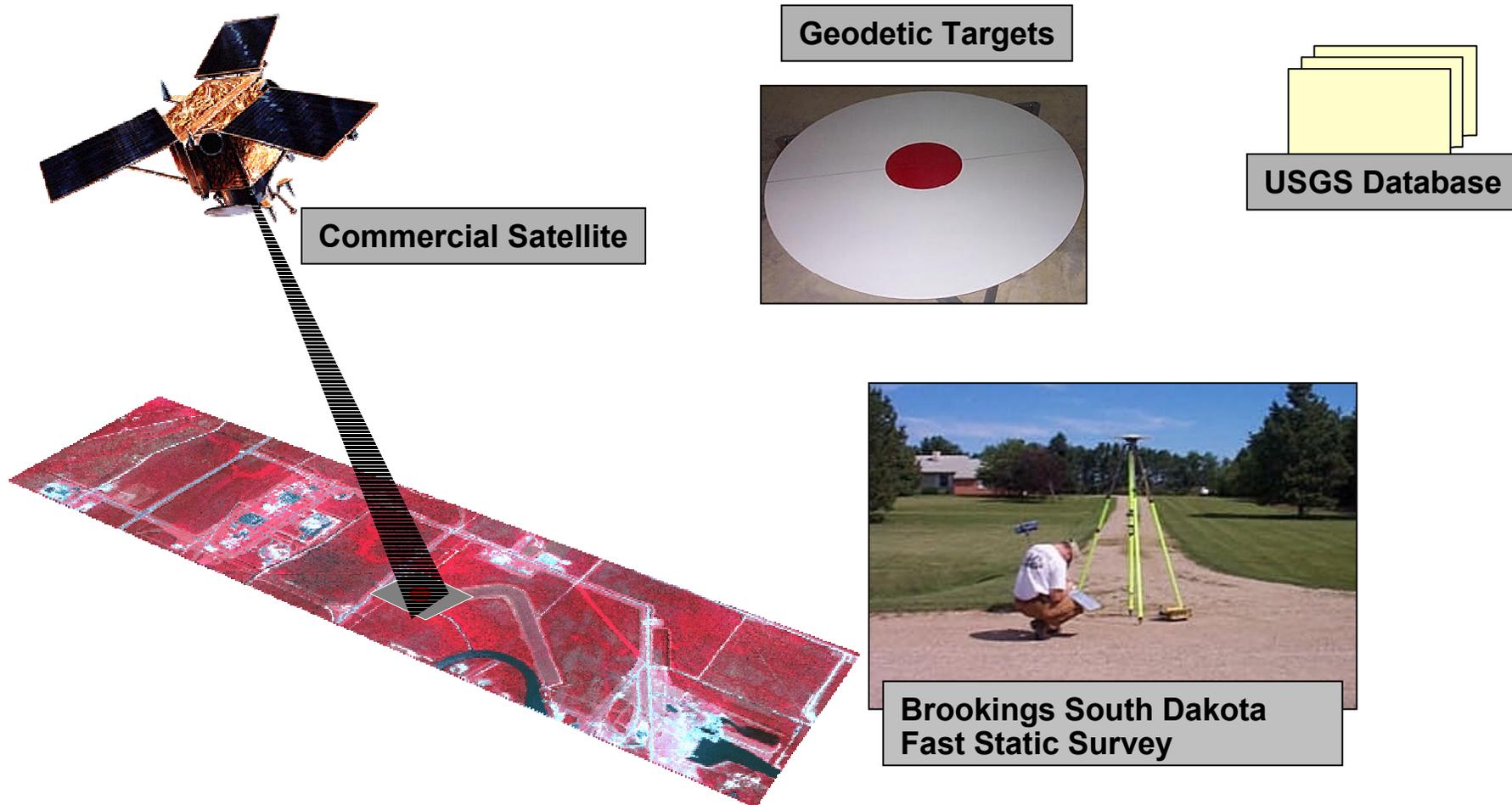
SPECIFICATION	VALIDATION APPROACH	VERIFICATION & VALIDATION			DATA SET TYPE
		Lab	Funct. Collect	Std. Collect	
Absolute Horizontal Geometric Accuracy* \pm 250 m	<ul style="list-style-type: none"> Analyze images over ground control points to obtain accuracy Validate periodically throughout the data buy 		X		Std Orig
Absolute Horizontal Geometric Accuracy* \pm 12.2 m	Same as above		X		Std Master
Absolute Horizontal Geometric Accuracy* \pm 3 m	Same as above		X		Pan Prec Orig
Absolute Horizontal Geometric Accuracy* \pm 2 m	Same as above		X		Pan Prec Master
Absolute Horizontal Geometric Accuracy* \pm 5 m	Same as above		X		MS Prec Orig MS Prec Master

* 90% circular error



Geometric Accuracy Assessment Approach

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Method: Utilize geographically positioned geodetic targets and other discernable known and surveyed features to determine the ge-positional accuracy of remote sensing systems



Spatial Accuracy Characterization

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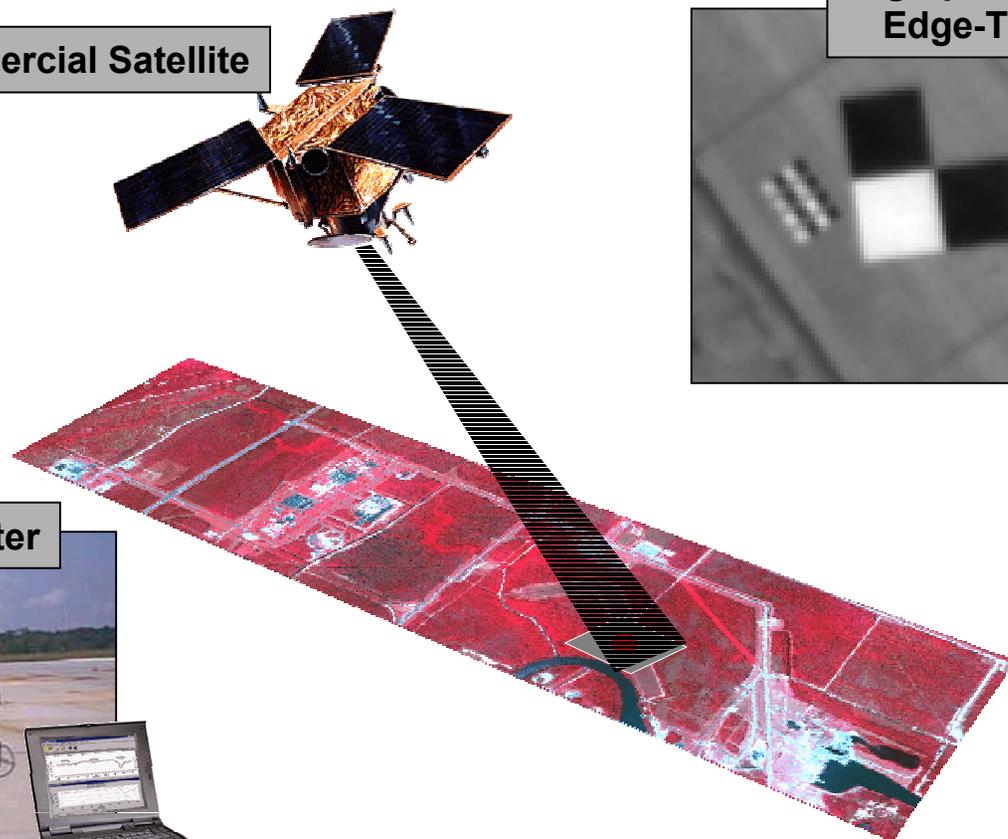
SPECIFICATION	VALIDATION APPROACH	VERIFICATION & VALIDATION			DATA SET TYPE
		SI On-Orbit	Funct. Collect	Std. Collect	
Panchromatic MTF = 0.1 at Nyquist frequency	<ul style="list-style-type: none"> Review on-board calibrations provided by SI Analyze images over various targets to obtain MTF Validate periodically throughout the data buy 	X	X		Std Orig Prec Orig SI data
Multispectral MTF = 0.24 at Nyquist frequency	Same as above	X	X		Std Orig Prec Orig SI data
Panchromatic GSD = 1.0 m Multispectral GSD = 4.0 m	<ul style="list-style-type: none"> Review on-board measurements provided by SI Analyze images over various targets to obtain GSD Validate prior to data purchase 	X	X		Std Orig Prec Orig SI data



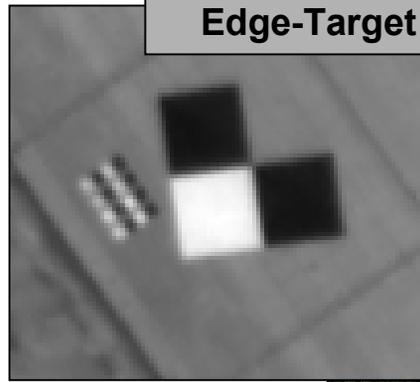
Spatial Accuracy Assessment Approach

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Commercial Satellite



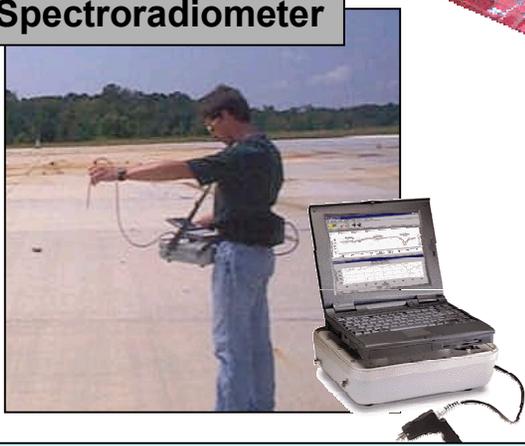
Big Springs, TX
Edge-Target



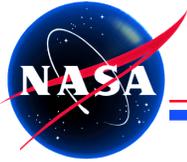
Tarps



Spectroradiometer



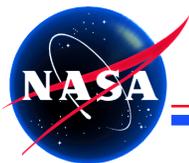
Method: Utilize edge targets (tarps, edge target or other man-made features such as painted runways or buildings) and ground reflectance measurements (Spectroradiometer) to determine the edge response of remote sensing systems



IKONOS Spectral Characterization

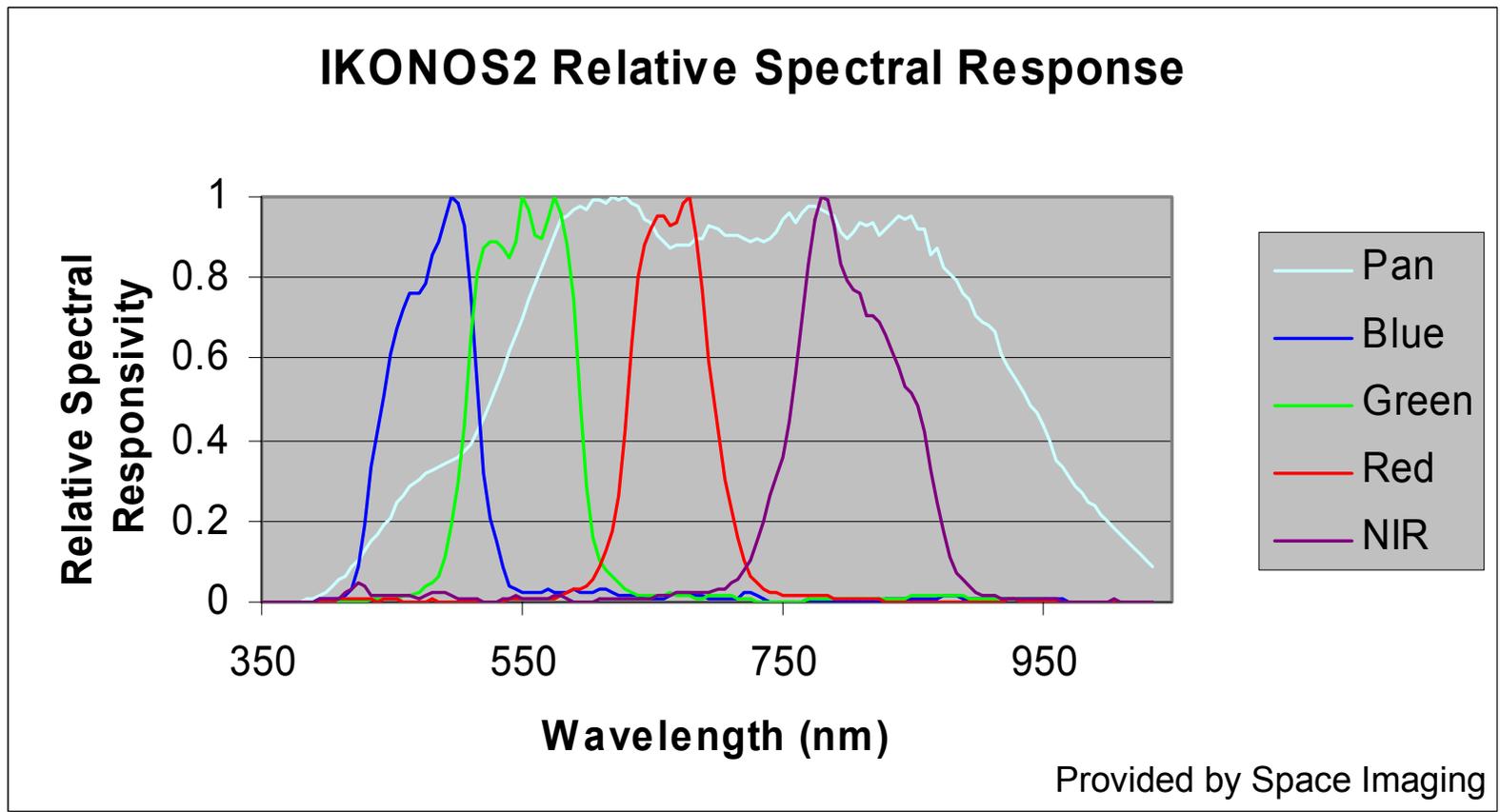
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SPECIFICATION	VALIDATION APPROACH	VERIFICATION & VALIDATION			DATA SET TYPE
		Lab	Funct. Collect	Std. Collect	
Band edge points at 50% peak response shall be within ± 0.01 microns	Review laboratory measurements provided by SI	X			SI data
Slope through the 50% point shall be at least 20% / 0.02 microns (NIR long edge slope < 20% / .04 microns)	Review laboratory measurements provided by SI	X			SI data
Out of band filter response < 5.5% of total integrated transmittance within 5% transmission points of that band	Review laboratory measurements provided by SI	X			SI data
The response for 70% of the data centered on the peak response shall be within 20% of the maximum value. (NIR response for 35% of the data centered on the peak response shall be within 20% of the maximum value.	Review laboratory measurements provided by SI	X			SI data



IKONOS Spectral Bandpasses

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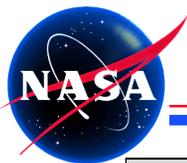




Radiometric Performance Characterization

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SPECIFICATION	VALIDATION APPROACH	VERIFICATION & VALIDATION			DATA SET TYPE
		SI On-Orbit	Funct. Collect	Std. Collect	
Absolute radiometric accuracy to within $\pm 10\%$ over the entire imaging exposure dynamic range (temporal stability)	<ul style="list-style-type: none"> Review on-board calibrations provided by SI Analyze images over radiometric targets to obtain accuracy Validate periodically throughout the data buy 	X	X		All SI data
Relative radiometric accuracy to within $\pm 5\%$ (pixel to pixel)	Same as above	X	X		All SI data



Radiometric Performance Characterization, cont'd.

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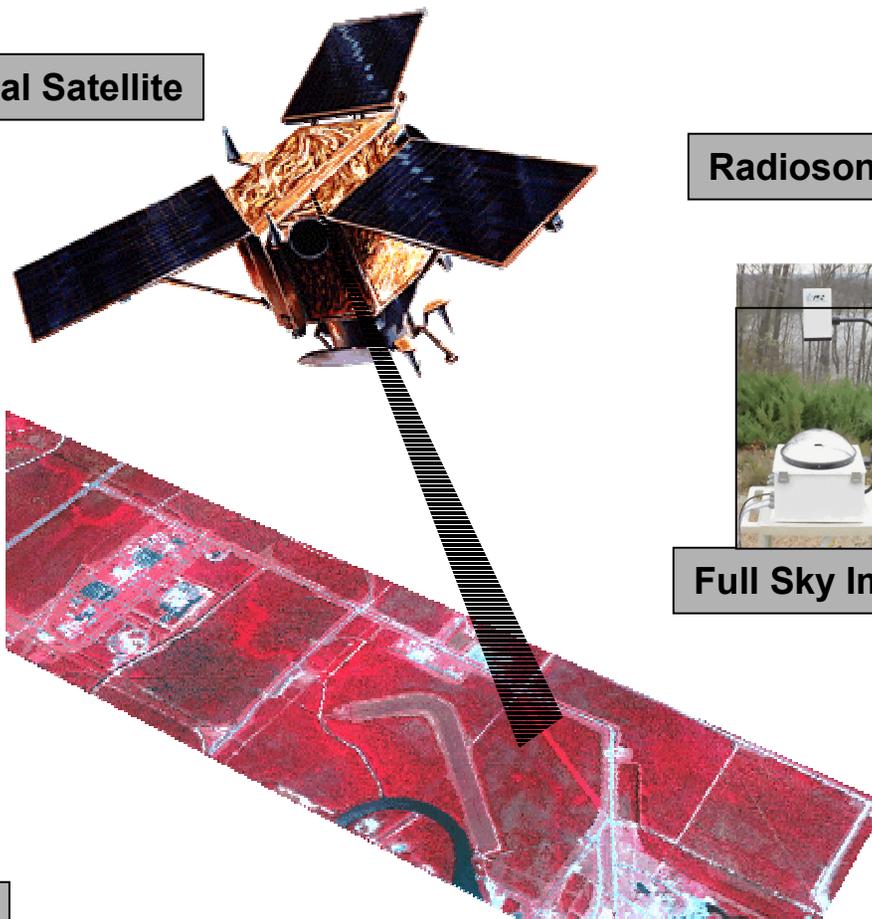
SPECIFICATION	VALIDATION APPROACH	VERIFICATION & VALIDATION			DATA SET TYPE
		SI On-Orbit & Lab	Funct. Collect	Std. Collect	
97% of all detectors should be within 5% of the mean quantum efficiency and dark current	<ul style="list-style-type: none"> Review on-board calibrations provided by SI 	X			SI data
Less than 1% inoperable detectors prior to launch and less than 3% after 5 years MMD. No more than 3 adjacent detectors inoperable.	<ul style="list-style-type: none"> Review laboratory measurements provided by SI Perform general statistical analysis of data 	X			SI data
Linearity to within $\pm 5\%$ over the entire imaging exposure dynamic range	<ul style="list-style-type: none"> Review laboratory measurements provided by SI Analyze images over radiometric targets to obtain accuracy Validate periodically throughout the data buy 	X	X		All SI data
Dynamic range of either 8 or 11 bits	<ul style="list-style-type: none"> Validate periodically throughout the data buy 		X	X	All
SNR = 94 at zero spatial frequency	<ul style="list-style-type: none"> Review on-board calibrations provided by SI Analyze images over uniform sites to obtain SNR Validate periodically throughout the data buy 	X	X		Std Orig Prec Orig SI data



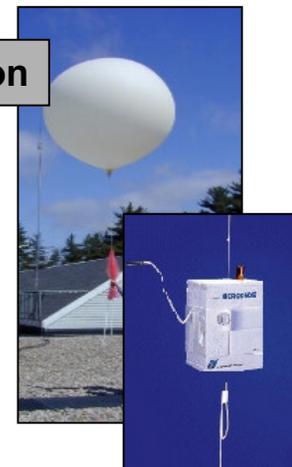
Reflectance Based Vicarious Calibration Approach

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Commercial Satellite



Radiosonde Balloon



Full Sky Imager



Sun Photometer



Tarps



Spectroradiometer

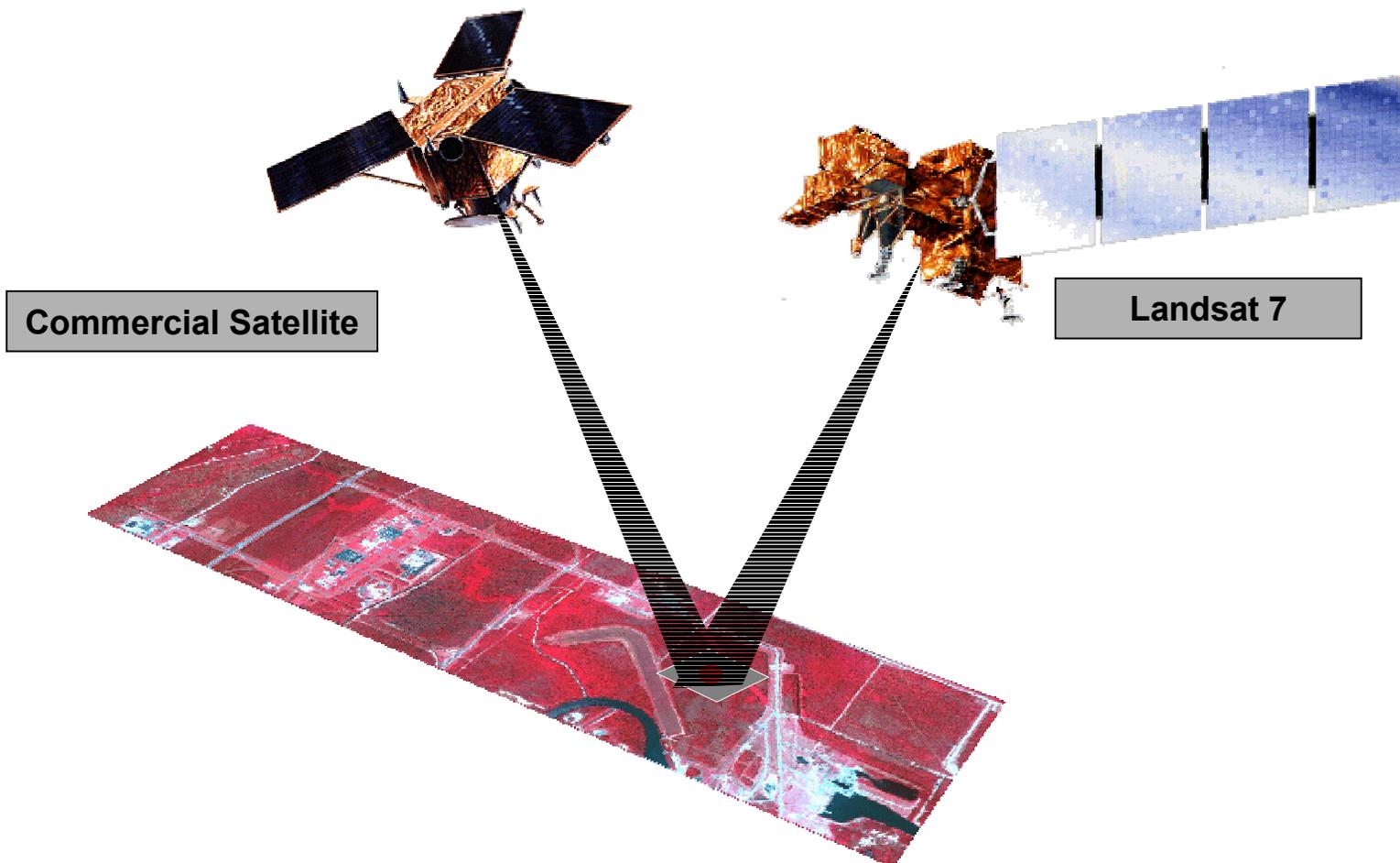


Method: Utilize ground reflectance measurements (spectroradiometer) and atmospheric measurements (sun photometer & radiosonde) to determine radiometric accuracy of remote sensing systems



Radiance Based Vicarious Calibration Approach

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Method: Utilize coincident airborne or spaceborne calibrated imagery (e.g. Landsat 7) to determine radiometric accuracy of new commercial satellite systems

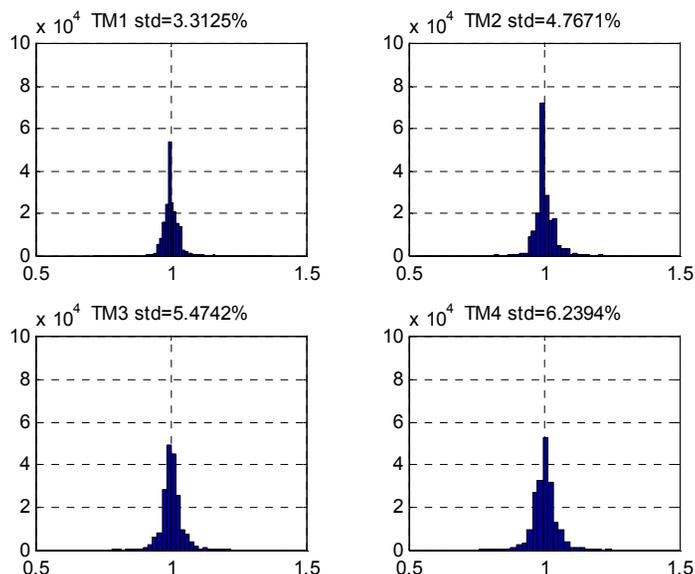
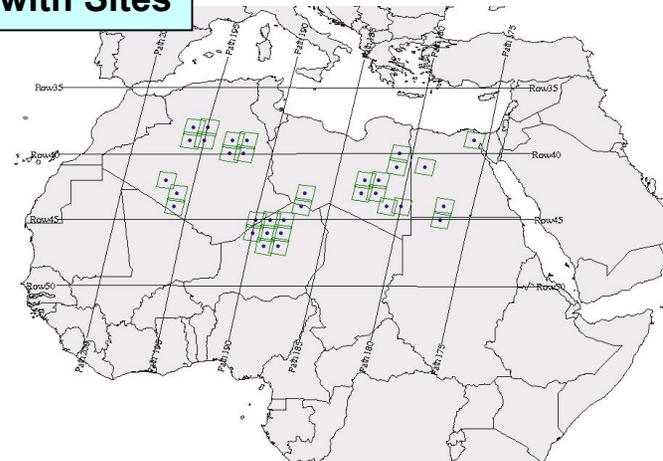


Uniform Sites Selection for SNR

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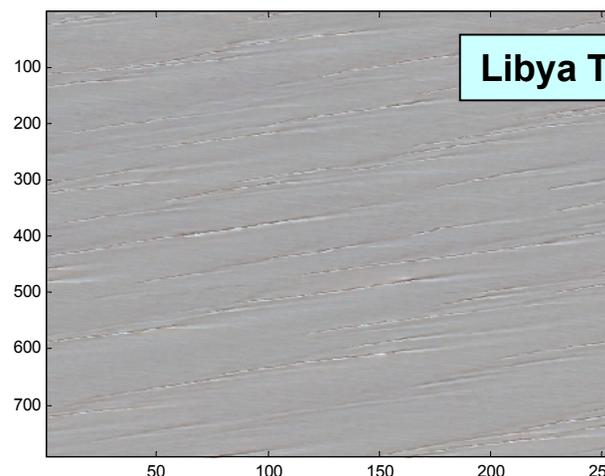
- Utilize NASA Scientific Data Purchase EarthSat Databuy
 - TM data for Africa
 - 30 meter GSD data
 - Develop algorithms to find most uniform scenes for Radiometry & SNR estimates

African Map with Sites



Tight Gaussian Histogram Indicate Uniform Scenes

RGB 321



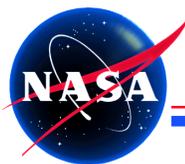
Libya TM Scene



NASA IKONOS Characterization Summary

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- **Feedback from science users state unprecedented high spatial resolution imagery is extremely useful**
- **IKONOS specifications in many cases were written as raw data specifications and not processed data specifications**
- **First Year's Results**
 - Geometric characterizations indicate imagery is well within specification
 - Spatial characterizations indicate MTF and GSD are consistent with specifications
 - Large uncertainties associated with our MTF estimation techniques



NASA IKONOS Characterization Summary

Stennis Space Center

- **First Year's Results (continued)**
 - Radiometric characterizations indicate potential concerns with the red and NIR bands
 - SI is re-evaluating their initially provided calibration coefficients
 - Early SNR estimates indicate
 - SNR low for MTFC on imagery
 - Expect SNR to improve with MTFC off imagery
 - Characterizations indicate spectral specifications are met
 - No serious issues associated with on-board compression have been found
 - For most applications, no serious issues associated with MTF Compensation have been found