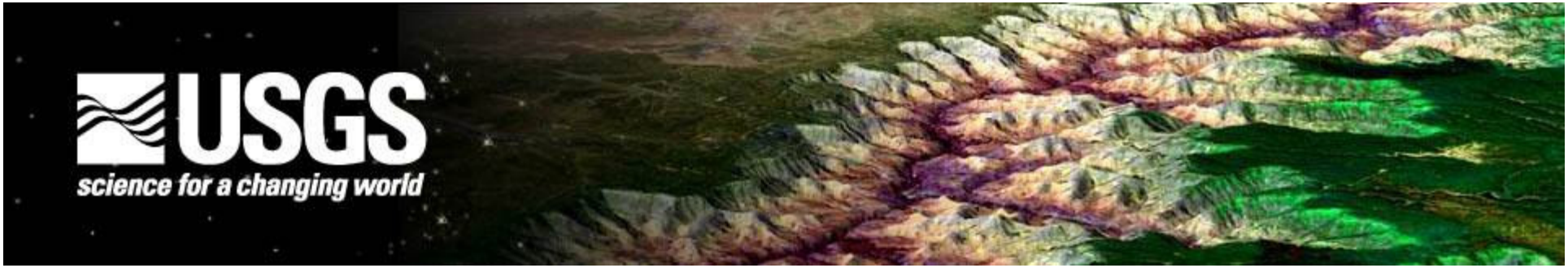

Geometric Assessment of TopSat and BEIJING-1 Data

JACIE 2008 Workshop

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*Work performed under USGS contract 03CRCN0001

U.S. Department of the Interior

U.S. Geological Survey

Outline

- **Landsat 7 (L7) Image Assessment System (IAS)**
  - Image to Image (I2I) registration assessment tool
  - Band to Band (B2B) registration assessment tool
- **BEIJING-1 and TopSat Overview**
  - Panchromatic (Pan) data
  - Multispectral (MS) data
- **Conclusions**

Sensor	QA	I2I	B2B
BEIJING-1			
MS	✓	✓	✓
Pan	✓	✓	N/A
TOPSAT			
MS	✓	-	-
Pan	✓	✓	N/A

L7 IAS Overview

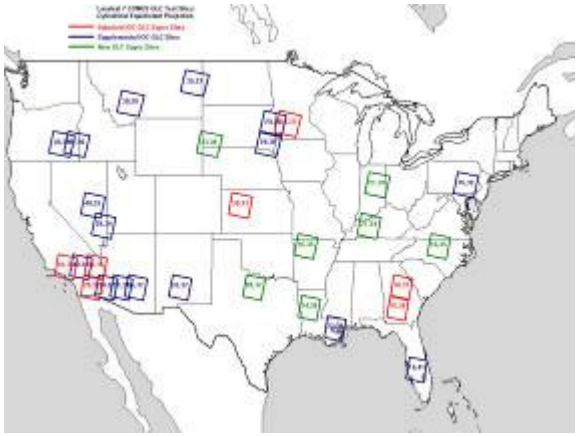
- **The IAS is responsible for offline assessment of image quality to ensure compliance with the radiometric and geometric requirements of the L7 spacecraft and the ETM+ sensor throughout the mission**

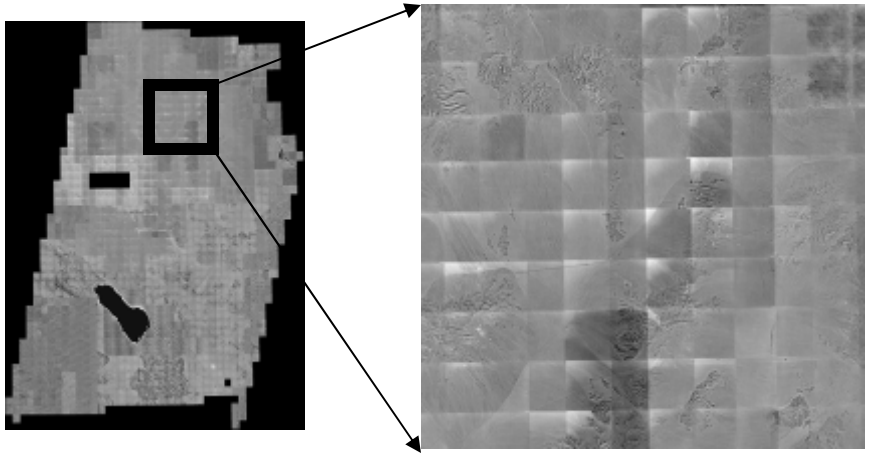
- **IAS contains B2B registration assessment tool**
  - B2B is performed to ensure that the proper band alignment parameters are provided
  - It is typically done by registering each band against every other band
  - A reference band is selected and all other bands are adjusted (offset determined) by least square adjustment of the registration solution

- **IAS contains I2I registration assessment tool**
  - I2I is usually performed to compare the relative accuracy between two images
  - One image is selected as reference and another as the search image
  - Image chips are selected from reference image and are correlated with search image
  - The co-registration results provide an insight to the relative accuracy of the search image with respect to the reference image
  - When the correlated points are plotted in the image, it also helps to detect any systematic bias in the image

Ground Control using Digital Orthophoto Quadrangles (DOQs)

- **DOQs are mosaicked to create a dataset equal to one WRS-2 nominal swath**
  - Resampled to match Landsat resolution - 1 m DOQs reduced in resolution to match Pan band (15 m for ETM+ and 10 m for ALI)
  - USGS 1-arc-second DEMs used for ground control height
- **Supersites built from DOQs**
  - DOQs are designed to meet national mapping accuracy standards of 1:24 k maps, or ~6 m (Inspection with highly accurate GPS surveyed locations showed most DOQs exceeded 6 m)
- **Supersites are georeferenced images derived from high-resolution source**





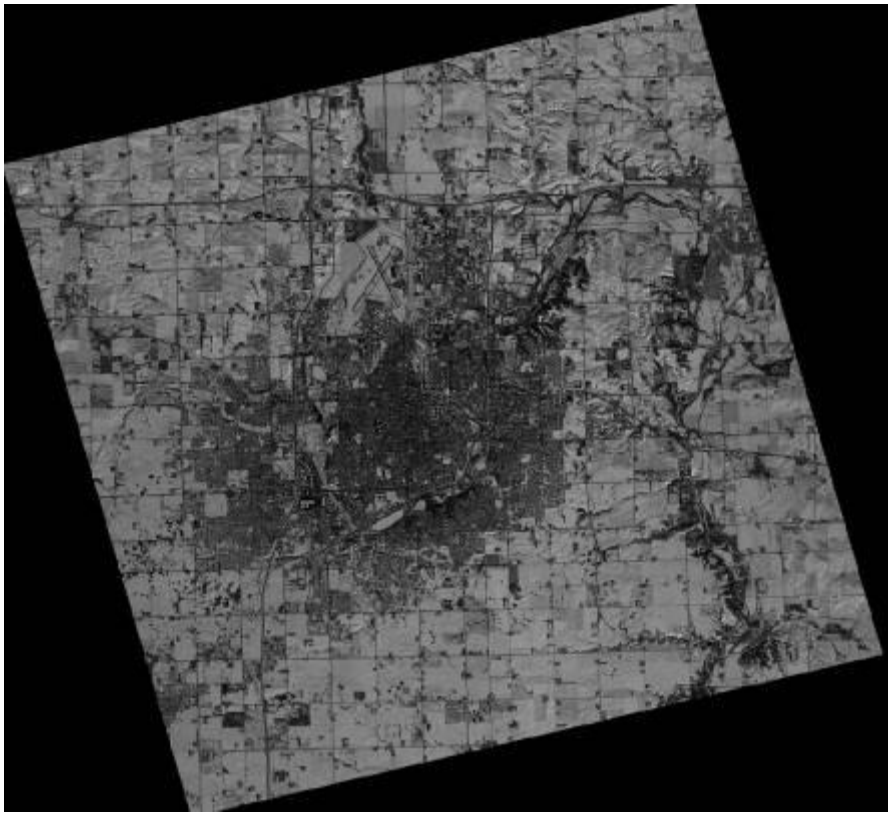
Ground Control using High Resolution Digital Imagery

- Digital Aerial imagery available over Minnehaha county, SD
- Red, green, blue bands acquired
- Data projected to UTM, zone 14, WGS84, with 2 feet pixel size
- Accuracy of dataset is 4.0 m

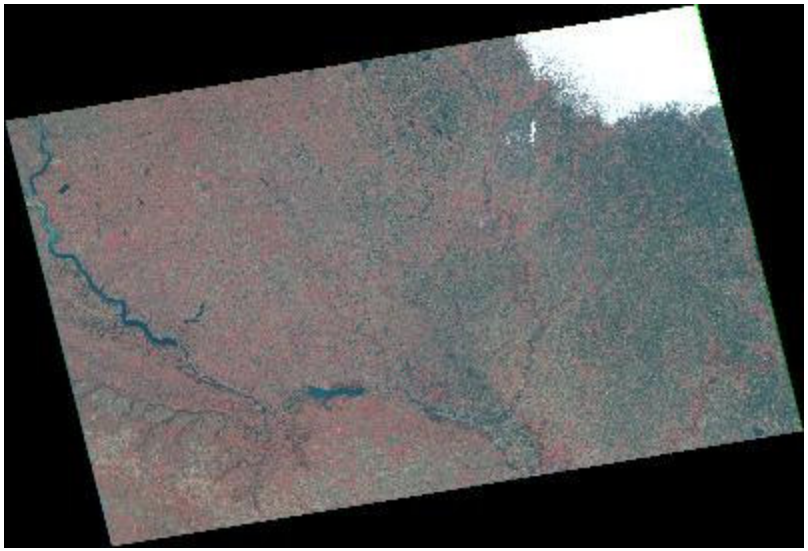
BEIJING-1 Overview

- Launch date : October 27th 2005
- Imaging Camera:
  - Pan images – 1 band, 4 m GSD with 24 km swath
  - MS images – 3 bands (NIR, red, green), 32 m GSD and 640 km swath
- Mass: ~ 166.4 kg
- Altitude : 686 km
- Storage Units: HDDR (240Giga Bytes) + SSDR (4 Giga Bytes)
- Downlink Data Rate :
  - X-Band: 40Mbps/20Mbps
  - S-Band: 8Mbps
- Lifetime : 5 Years
- Off-Pointing Capability : ±30°

BEIJING-1 Data: Sioux Falls area



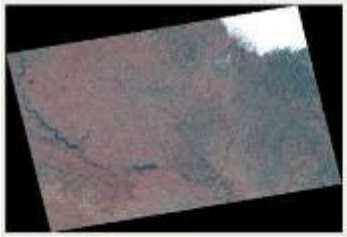
BEIJING-1 PAN
Imaging date: 2007-12-19
Product Level –Systematic Correction
dc000794hp_l3.jpg



BEIJING-1 MS
Imaging date: 2007-11-19
Product Level: L1T
DC000760p_L1T_ql.jpg

One of the best metadata files!

DC000760p_L1T



Source

Imaging Date	2007-11-19
Imaging Time	18:41:27
Mission	BEIJING
Instrument	SLIM-6
Viewing Angle	31.4518584460316 (DEG)
Sun Azimuth	162.5177241021660 (DEG)
Sun Elevation	22.9397220996084794 (DEG)

Raster Dimensions

Columns	11051
Rows	8001
Bands	3

Raster Encoding

Data Type	BYTE
Number of Bits	8
Byteorder	I

Data Access

Format	GEOTIFF
Data file	DC000760p_L1T.tif

Dataset ID

Copyright	DMC International Imaging Ltd

Production

Producer	DMC International Imaging Ltd
Url	http://www.dmc.com
Production Date	2008-01-22
Type	
Job ID	

Data Processing

Geometric	1T
Radiometric	Cubic convolution

Coordinate Reference System

EPSG

Type	PROJECTED
Name	WGS 84 / UTM zone 14N
Code	EPSG:32614

Geographic Coordinate System	Name	WGS 84			
	Code	EPSG:4326			
	Prime Meridian				
	Horizontal Datum	Name	World Geodetic System 1984		
		Code	EPSG:6326		
		Ellipsoid	Name	WGS 84	
			Code	EPSG:7030	
			Parameters	Major Axis	6378137.0 (M)
				Minor Axis	6356752.314245179 (M)
Projection	Name	UTM zone 14N			
	Code	EPSG:16014			
	Coordinate Transformation Method	Name	Transverse Mercator		
		Code	EPSG:9807		
		Projection Parameters	Name	Code Value	
			Latitude_of_natural_origin	0.0 (DEG)	
			Longitude_of_natural_origin	-99.000000000000 (DEG)	
			Scale_factor_at_natural_origin	0.9996	
			False_easting	500000.0 (M)	
			False_northing	0.0 (M)	

Raster Coordinate System

Type	POINT

Image Display

Red	1
Green	2
Blue	3

	Mean	Std
1	59.0812003087888	24.5523662751648
2	35.5466109146533	29.7334960050430
3	41.3273728100174	40.9786119429977

	Min	Max
1	0.0	255.0
2	2.0	251.0
3	0.0	253.0

	Lin Min	Lin Max
1	-3.2997122064143060	119.4621140061601
2	-38.9120903990737	110.0953059150146
3	-58.0221570008710004	142.2709020411167

Image Interpretation

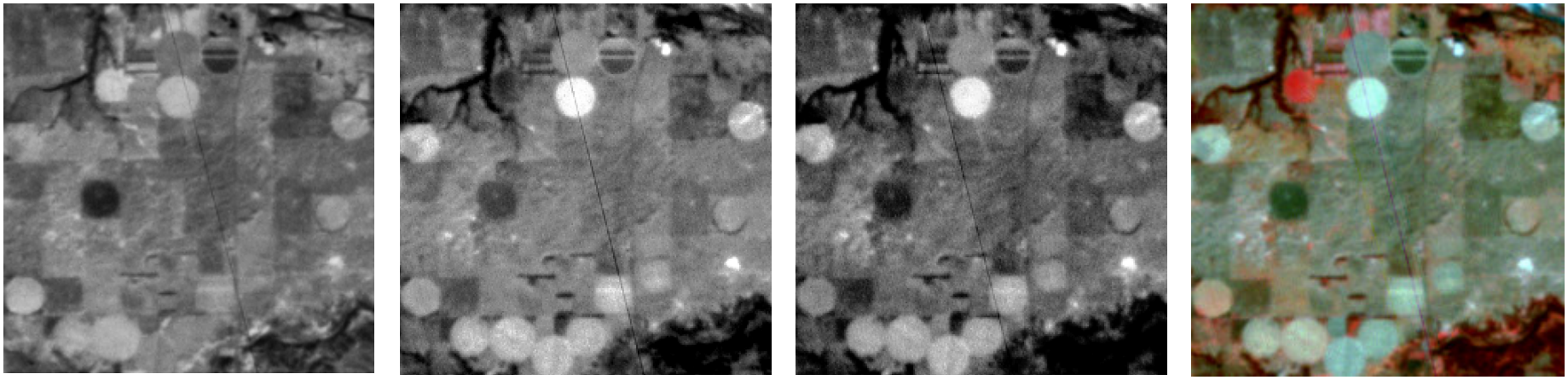
	Description
1	NIR
2	Red
3	Green

	Gain	Bias	Unit
1	2.3145873249836475	4.8796887106517	W/m2/sr/µ-6
2	1.741102441079787	8.87992158861632	W/m2/sr/µ-6

BEIJING-1 (MS)

- Appears to be a missing detector
- The data is missing in all three bands, but at different locations

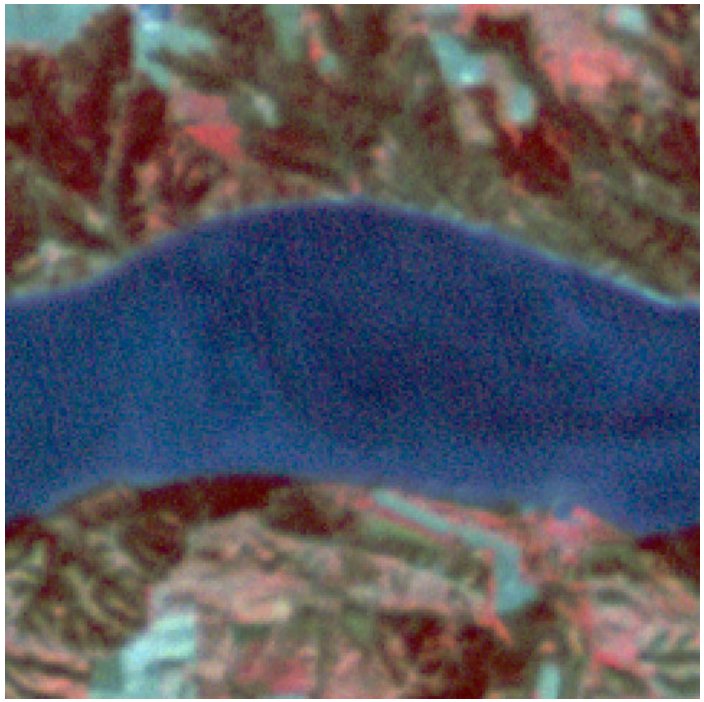
NIR **Red** **Green** **RGB**



DC000760p_L1T_MS

BEIJING-1 (MS)

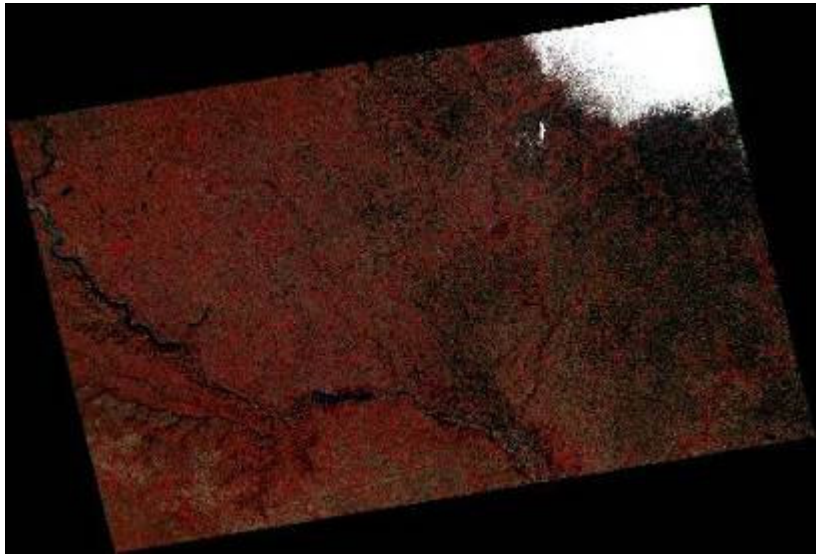
- There is some residual striping, about 2 DN in magnitude, which is visible only with harsh stretches over homogenous regions
- The MTF is better in green and red compared to NIR
- No other artifacts were found, overall, the data is pretty clean!



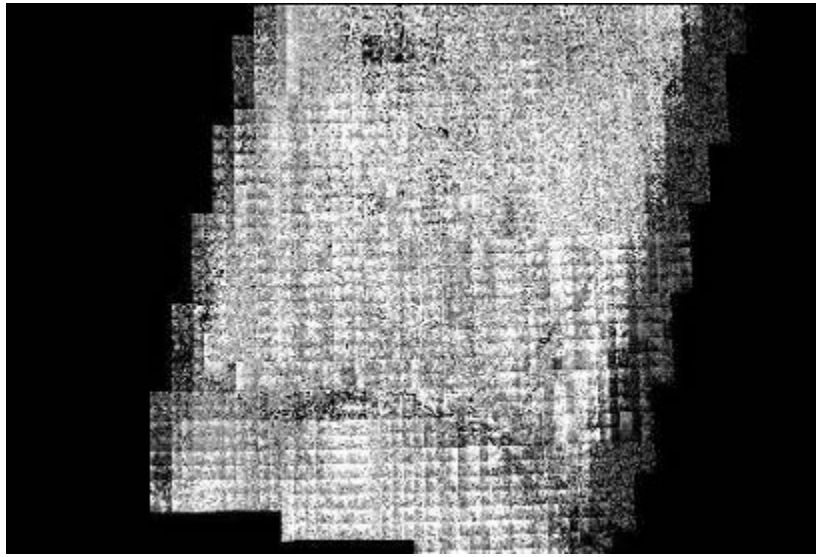
DC000760p_L1T_MS

BEIJING-1 (MS): I2I

- **MS band assessed against DOQ imagery**
- **Data looked somewhat blurry and grainy against DOQ**



BEIJING-1 (MS)



DOQ mosaiced Imagery

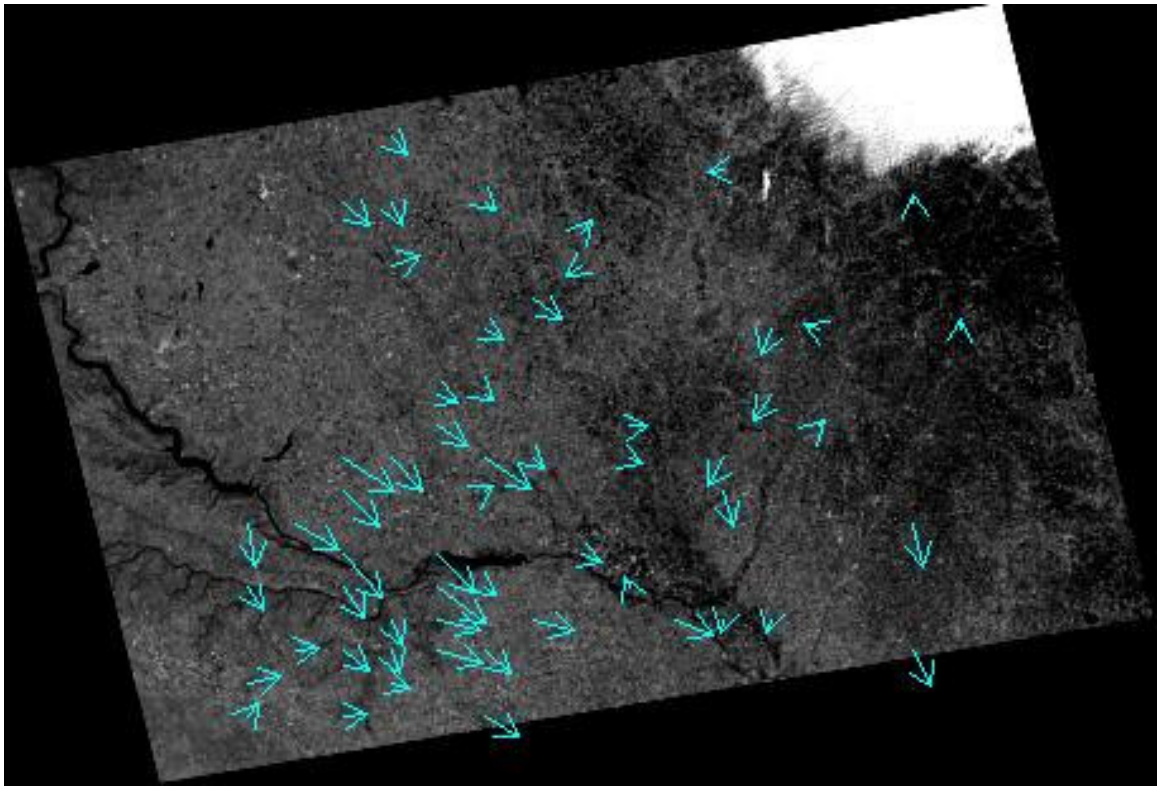
BEIJING-1 (MS): I2I

- Compared against DOQ imagery with an accuracy of ~6 meters a mean offset of 10.65 and 12.35 m was observed in the line and sample direction
- Quick visual inspection through ENVI supported results produced from I2I process
- BEIJING-1 MS imagery registered to DOQ imagery to sub-pixel accuracy

	Pixels		Meters	
	Line	Sample	Line	Sample
Mean	0.33	0.39	10.65	12.35
Standard Deviation	0.36	0.40	11.52	12.68
RMSE	0.49	0.55	15.62	17.63

57 points were used to calculate statistics

BEIJING-1 (MS): I2I Vector Residual Plot



Vectors scaled to indicate pattern not magnitude

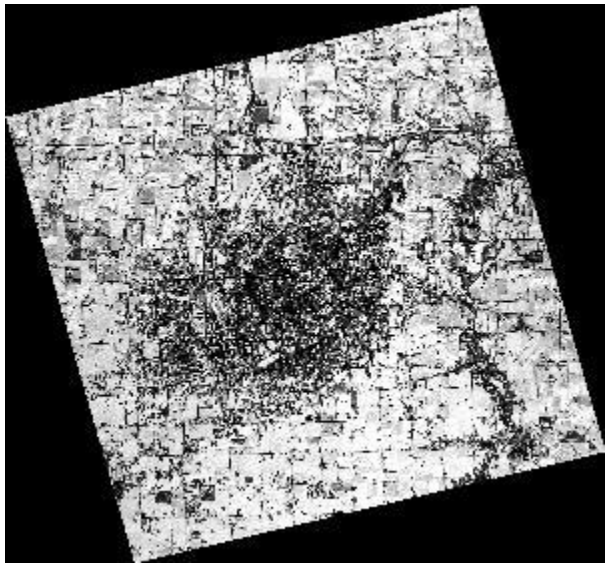
BEIJING-1 (MS): B2B

- Band alignment assessment gave the following statistics in line and sample direction
- BEIJING-1 MS B2B registration assessment on MS imagery showed bands registered to a sub-pixel level

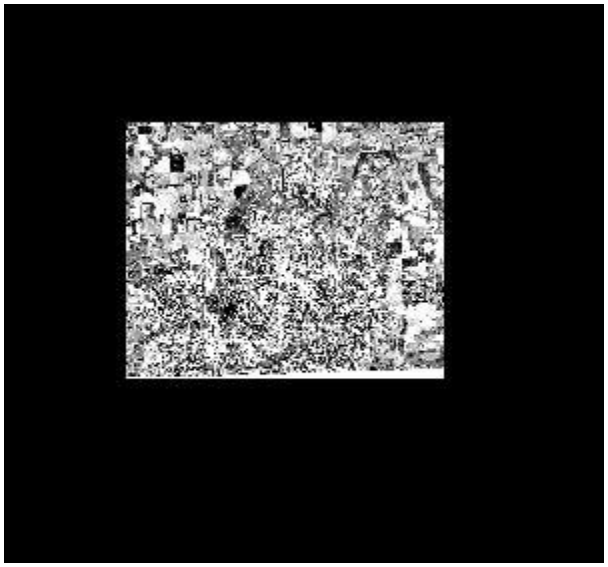
Bans-2-Band Assessment				
Band 1 to Band 2				
113 points used to calculate statistics	Pixels		Meters	
	Line	Sample	Line	Sample
Mean	0.18	0.05	5.73	1.63
Standard Deviation	0.19	0.18	5.95	5.86
RMSE	0.19	0.18	5.95	5.86
Band 1 to Band 3				
140 points used to calculate statistics	Pixels		Meters	
	Line	Sample	Line	Sample
Mean	0.07	0.06	2.27	1.82
Standard Deviation	0.24	0.28	7.62	8.80
RMSE	0.25	0.28	7.94	8.96
Band 2 to Band 3				
260 points used to calculate statistics	Pixels		Meters	
	Line	Sample	Line	Sample
Mean	0.05	0.00	1.47	0.06
Standard Deviation	0.09	0.09	2.75	2.88
RMSE	0.10	0.09	3.10	2.88

BEIJING-1 (Pan): I2I

- **Pan band assessed against aerial imagery**
- **BEIJING-1 dataset covers much larger area than control**



BEIJING-1 (Pan)



High resolution control
reprojected to BEIJING image frame

BEIJING-1 (Pan): I2I

- **BEIJING-1 and control were not spectrally well matched**
  - This creates issues with the correlation

BEIJING-1 (Pan)

Minnehaha Control

BEIJING-1 (Pan): I2I

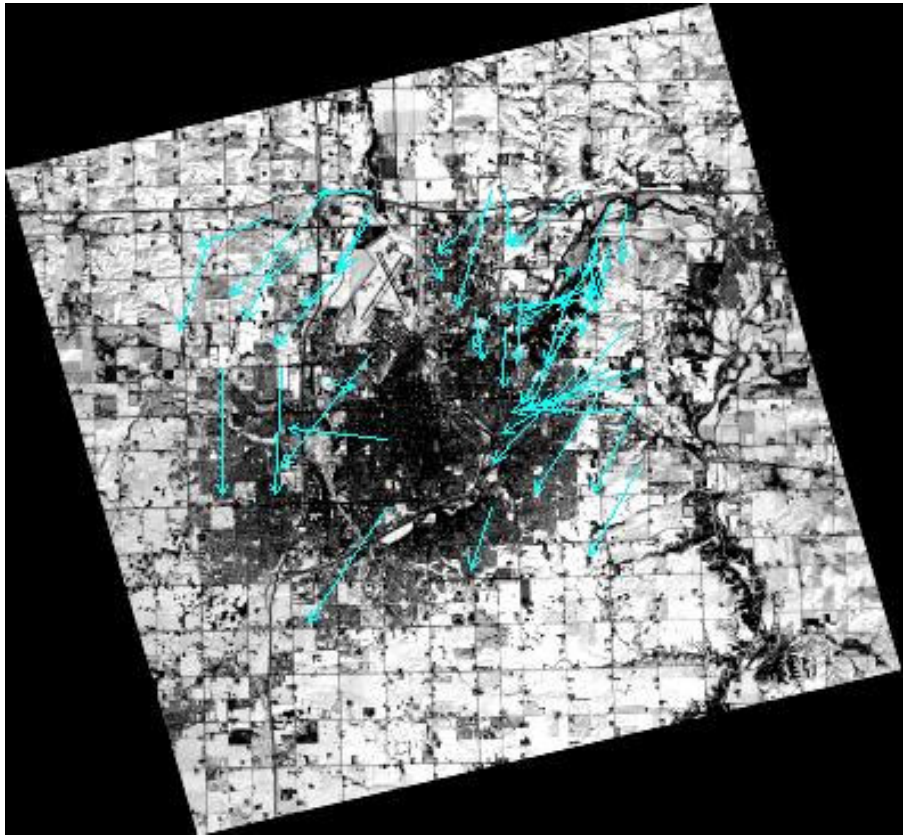
- **BEIJING-1 I2I was compared against aerial imagery with an accuracy of 4.0 m a mean offset of 8.11, -6.05 m was observed in the line and sample direction**
- **Quick visual inspection through ENVI supported results produced from I2I process**
- **Several items affected assessment**
  - Limited extent of control
  - Spectral differences between datasets

	Pixels		**Meters**	
	Line	**Sample**	**Line**	**Sample**
Mean	2.03	-1.51	8.11	-6.05
Standard Deviation	1.20	1.26	4.81	5.03
RMSE	2.35	1.96	9.40	7.83

49 points were used to calculate statistics

USGS

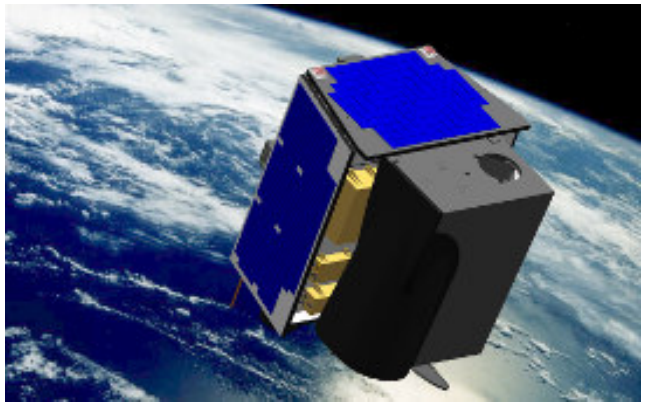
BEIJING-1(Pan): I2I Vector Residual Plot



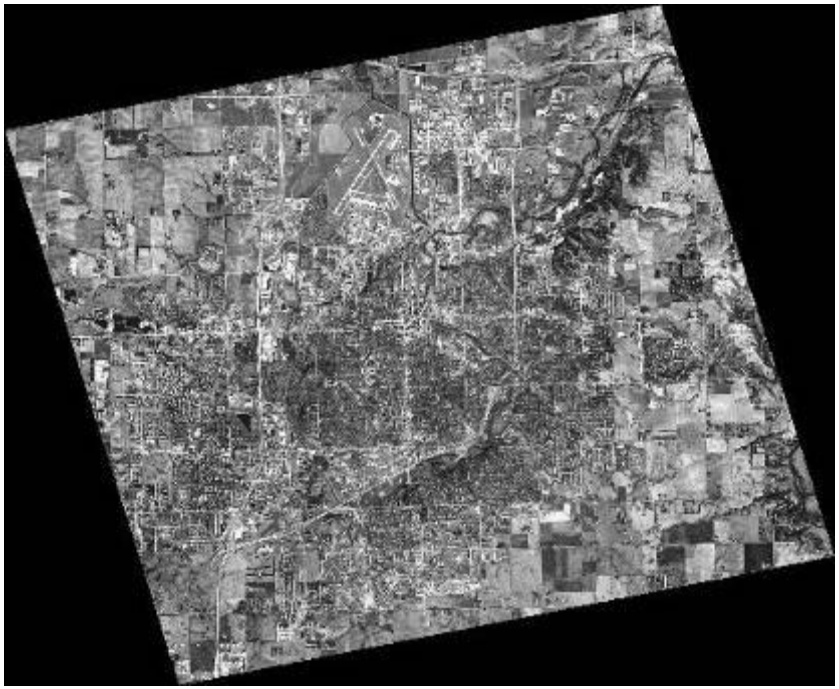
Vectors scaled to indicate pattern not magnitude

TopSat Overview

- TopSat was launched successfully on 27th October 2005
- Carries an optical camera capable of delivering
  - Pan images – 1 band, 2.8 m GSD with 16 km swath
  - MS images – 3 bands (red, green, blue), 5.6 m GSD with 16 km swath
- The sensor used is a 6,000-pixel linear array device from Kodak
- TopSat weighs just 120 kg



TopSat Data: Sioux Falls area
Image Date: 2007-11-25



TopSat PAN
Product Level 1 G
WF26110701-2158-ax0_ortho_ql.jpg

TopSat MS (L1R)
image-2158-ms.jpg

TopSat (MS)

- The TopSat MS data is not geometrically corrected
  - Therefore the aspect ratio seems off in the TopSat MS “L1R” imagery
  - Example 1 is canaries baseball stadium, which should be square
  - Example 2 is the rural sections, where there are parcels of land that should be exactly one mile square
- In both cases, the aspect ratio appears to be about 13:11

image-2158_MS

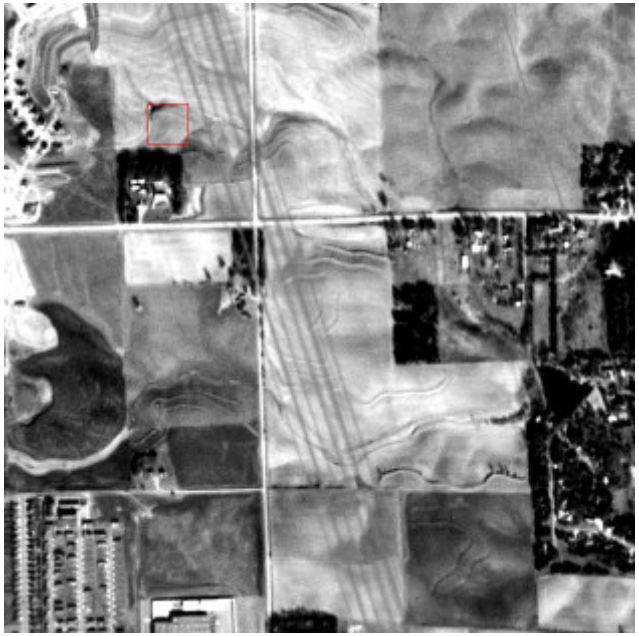
TopSat (MS)

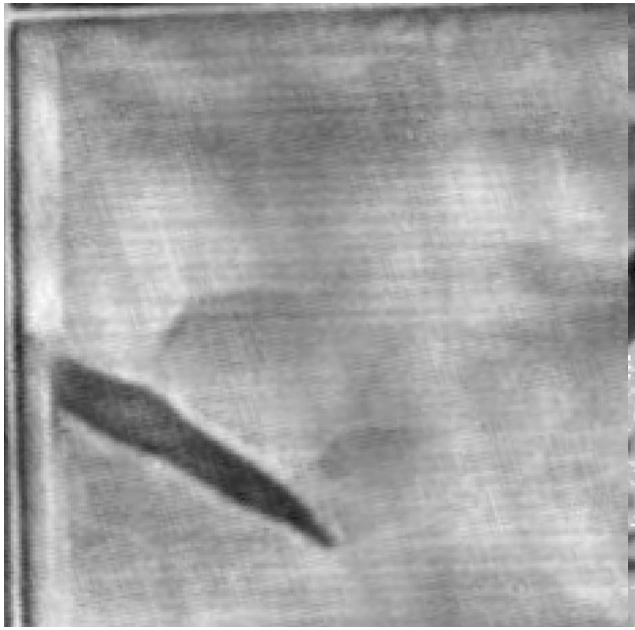
- There are strange noise artifacts in water regions -they are very minor (maximum of about 3 DN) and only appear in very harsh stretches
- But their appearance looks algorithmic
- It seems like a sharpening filter applied to this data?

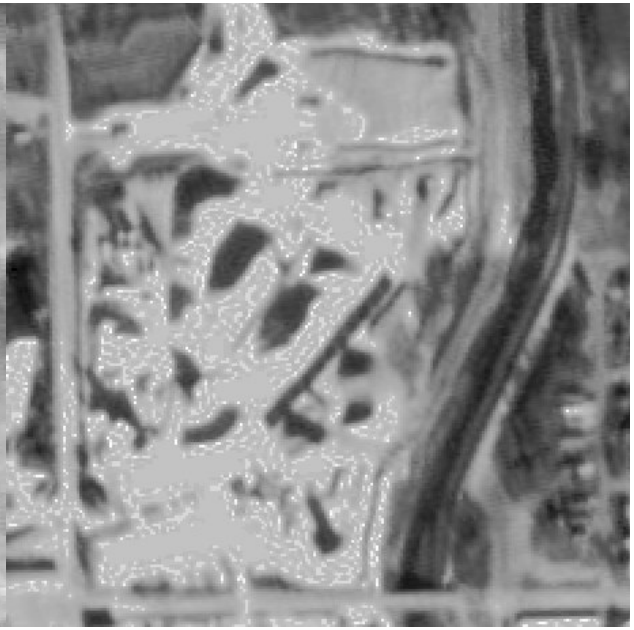
image-2158_MS

TopSat (Pan)

- There appears to be a series of flat or dead detectors
- There is a striping artifact in the PAN image
- There are odd artifacts around very bright objects (edge filter effect?)







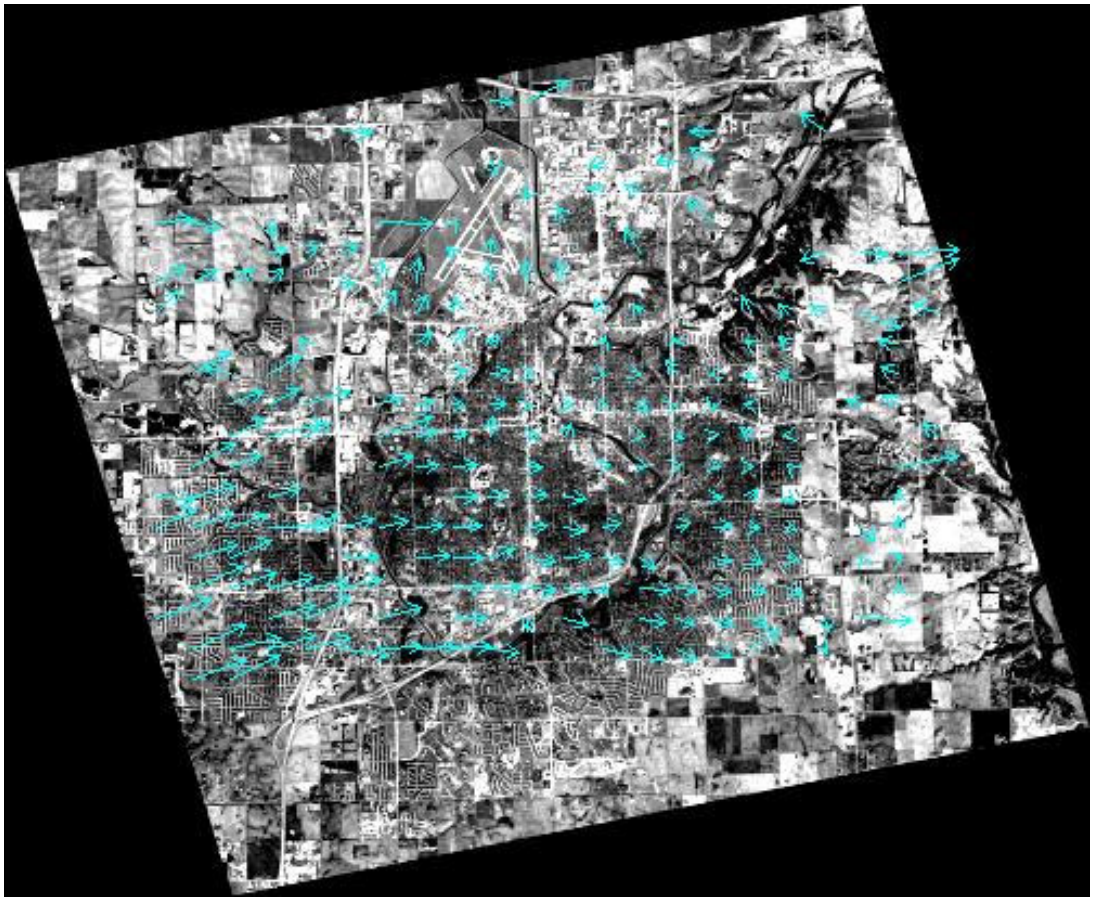
ortho_2158_PAN

TopSat (Pan): I2I

- Minnehaha data resampled to 2.5 meters and grey scale correlation performed between datasets
- TopSat I2I was compared against aerial imagery with an accuracy of 4.0 m a mean offset of -3.38, 11.18 m was observed in the line and sample direction with a small time varying component in the vector residuals

	Pixels		Meters	
	Line	Sample	Line	Sample
Mean	-1.35	4.47	-3.38	11.18
Standard Deviation	2.56	5.59	6.39	13.97
RMSE	2.89	7.15	7.22	17.86

TopSat (Pan): I2I Vector Residual Plot



Vectors scaled to indicate pattern not magnitude

Conclusion

- **L7 IAS can be expanded for use beyond that of the ETM+**
- **BEIJING-1**
  - MS “L1T” imagery when compared to DOQ achieved sub-pixel accuracy
  - MS “L1T” B2B assessment showed bands registered to very high accuracy
  - Pan imagery “L1G” was difficult to assess geolocation accuracy as only systematic correction applied
- **TopSat**
  - MS “L1R” data had several artifacts that needs further examination
  - Pan “L1G” was analyzed for geolocation accuracy and there seemed to be a small time varying component in the vector residuals

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