Geometric and Spatial Performance of Landsat 8

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Overview

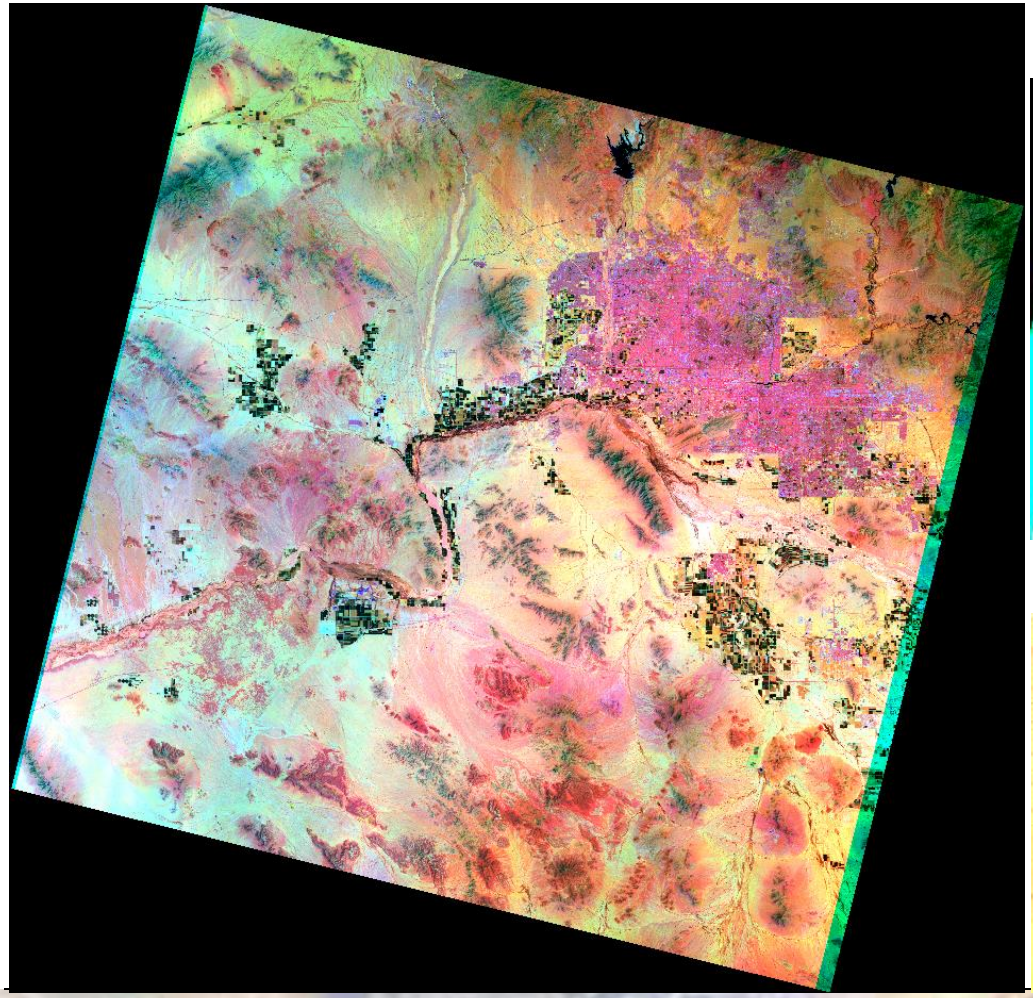
- **Geometric Calibration**
  - Geometric calibration approach
  - Instrument field of view alignment verification
  - OLI geometric calibration
  - TIRS geometric calibration
- **OLI and TIRS Geometric Performance**
  - Band registration accuracy - OLI, TIRS, TIRS-to-OLI
  - Internal geometric accuracy
  - Geolocation accuracy
- **OLI Spatial Performance**
- **Geometric Performance Summary**

Geometric Calibration Approach

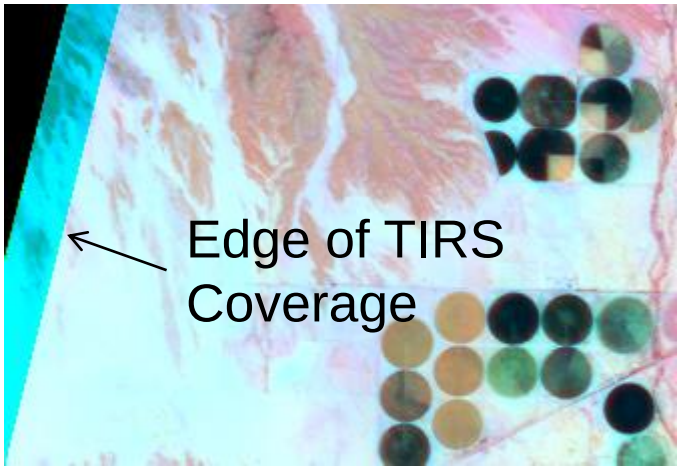
- **Prelaunch geometric models and calibration parameters were derived using instrument and spacecraft design information**
  - The design-based parameters were refined using measurements from instrument-level thermal vacuum testing and observatory integration and test
- **The initial on-orbit geometric calibration was performed during the commissioning period in the following sequence:**
  - Measured OLI to spacecraft alignment using ground control points
  - Measured OLI focal plane module (FPM) alignment using reference imagery
  - Measured OLI band-to-band alignment
  - Measured TIRS-to-OLI alignment
  - Measured TIRS FPM-to-FPM alignment using OLI as a reference
  - Measured TIRS band-to-band alignment
- **The geometric calibration is monitored and updated as necessary during routine operations**

OLI / TIRS Field of View Alignment

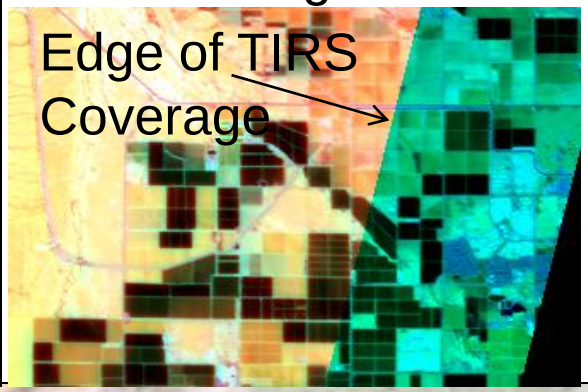
- **Red = Band 10 (TIRS) : Green = Band 7 (OLI) : Blue = Band 1 (OLI)**



West Edge of Scene

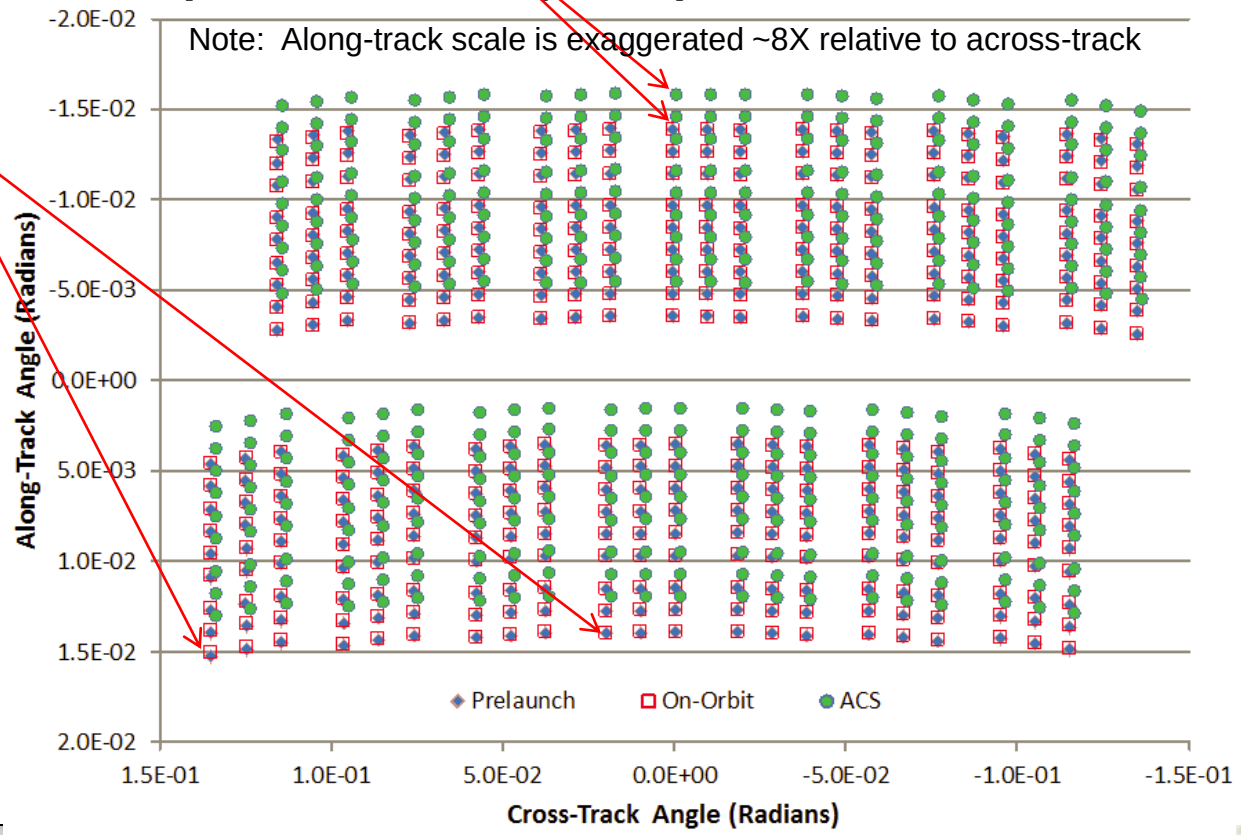


East Edge of Scene



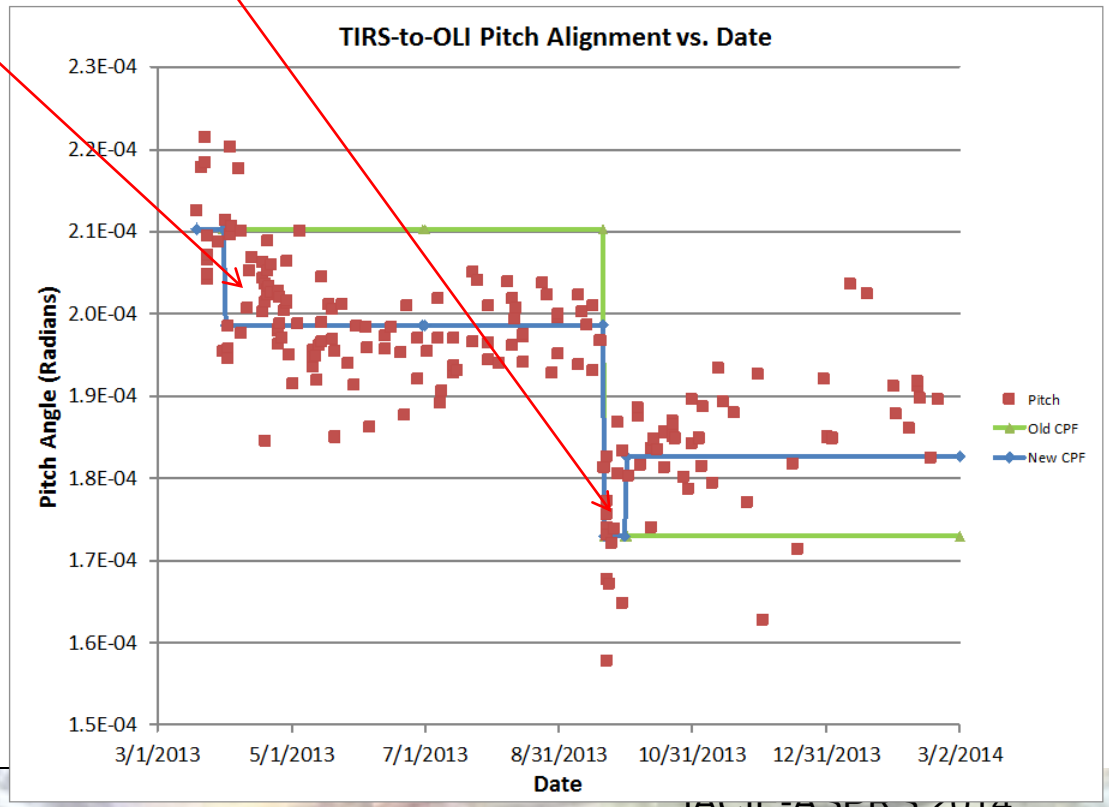
OLI On-Orbit Calibration

- **Used ground control points to adjust OLI-to-spacecraft alignment**
  - Changes from prelaunch: 1.734 mrad roll, -1.770 mrad pitch, -0.106 mrad yaw
- **DOQ reference images and the OLI pan band were used to adjust the alignment of the 14 OLI focal plane modules (FPMs)**
  - Outboard FPMs required larger (up to 175 mrad) adjustment than nadir FPMs
- **Multispectral bands were then aligned to the pan band**
  - Based upon band-to-band tie point measurements



TIRS On-Orbit Calibration

- **TIRS-to-OLI alignment was measured by comparing TIRS 10.8 μm band to OLI SWIR1 band**
  - The TIRS alignment appeared to change slightly as Landsat 8 maneuvered into its final WRS-2 orbit
  - A spacecraft anomaly in late-September caused a step change which has partially recovered
- **The alignment of the 3 TIRS focal plane modules (FPMs) was measured using OLI SWIR1 as a reference**
- **The TIRS 12.0 μm band was aligned to the 10.8 μm band**
  - Based upon band-to-band tie point measurements



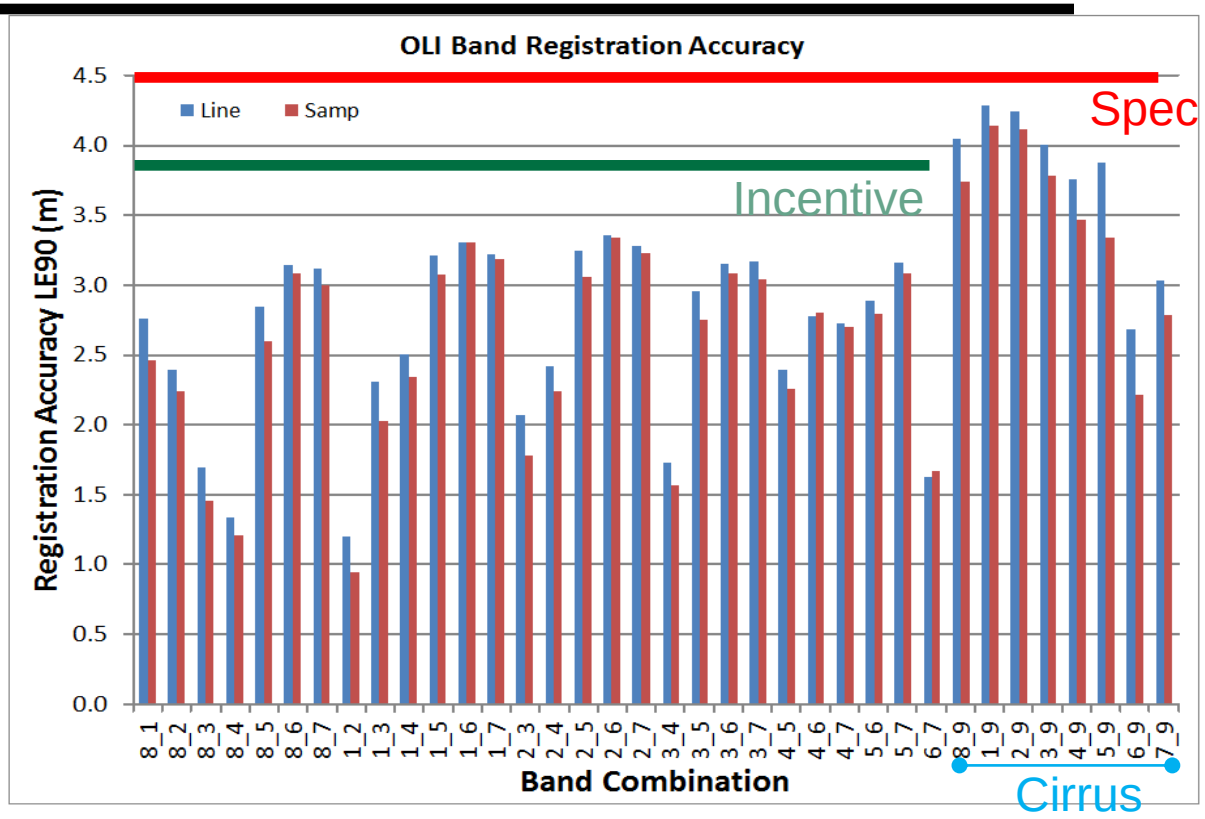
On-Orbit Calibration Updates

- **Several additional on-orbit calibration updates have been issued since the end of commissioning**
  - All are minor and none involve internal image geometry

Calibration Parameter	Date of Update	Effective Date	Reason for Update
OLI-to-S/C Alignment	07/01/2013	Launch	Analysis of additional data from WRS-2 orbit
Ground Control Thresholds	08/21/2013	Launch	Allow scenes with GLS control errors > 100m to process to L1T
TIRS-to-OLI Alignment	09/27/2013	09/21/2013 – 09/30/2013	Step change following late-September spacecraft anomaly
TIRS-to-OLI Alignment	11/27/2013	10/01/2013 -	Account for recovery of TIRS alignment following anomaly
TIRS-to-OLI Alignment	11/27/2013	04/01/2013 - 09/20/2013	Improve accuracy for period from arrival in WRS-2 orbit to spacecraft anomaly
OLI-to-S/C Alignment TIRS-to-OLI Alignment	02/03/2013	10/01/2013 -	Account for seasonal drift in alignment of both instruments to the spacecraft

OLI Band Registration Accuracy

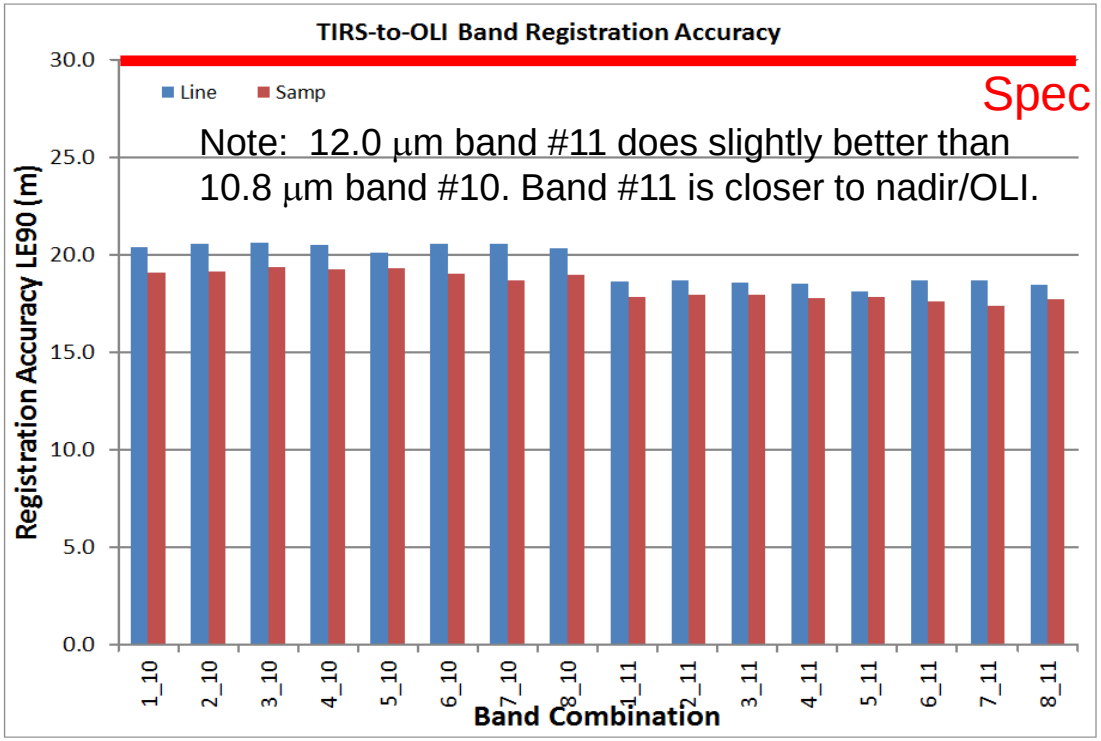
- **Band-to-band registration is evaluated using cloud-free test site scenes**
  - These are mainly desert sites to ensure good inter-band correlation



- **Using 482 OLI test scenes:**
  - 29 high-altitude scenes used for cirrus band assessment
  - OLI band registration accuracy (worst band pair)
    - Line/Sample/Spec: 4.15 / 4.01 / 4.50 meters LE90 (with cirrus)
    - Line/Sample/Incentive: 3.36 / 3.40 / 3.80 meters LE90 (no cirrus)

TIRS Band Registration Accuracy

- **TIRS 10.8 μm to 12.0 μm band registration**
  - Results from 215 TIRS band registration test scenes
    - Line/Sample/Specification: 10.4 / 8.8 / 18.0 meters LE90
- **TIRS-to-OLI band registration**
  - Results from 171 cloud-free TIRS-to-OLI registration test scenes over 39 selected test sites
  - TIRS-to-OLI band registration accuracy (worst band pair)
    - Line/Sample/Specification: 20.6 / 19.3 / 30.0 meters LE90

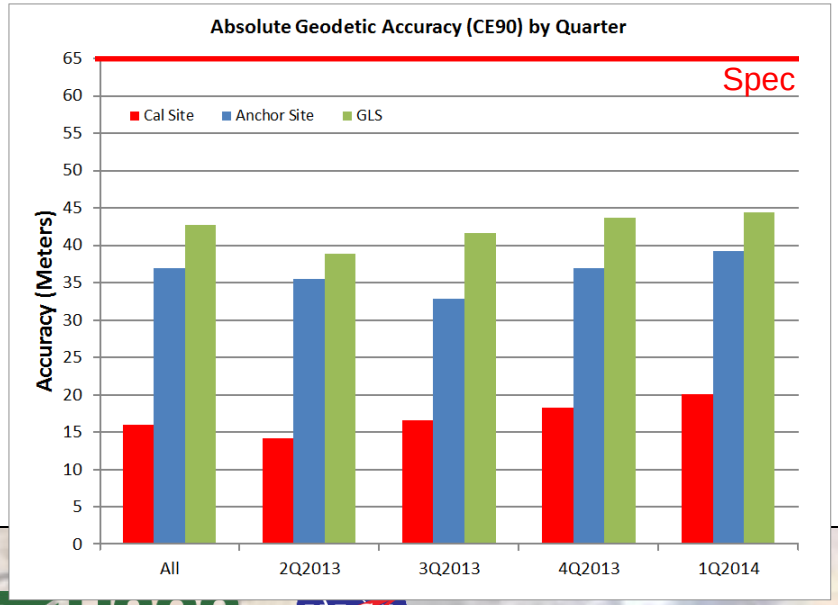


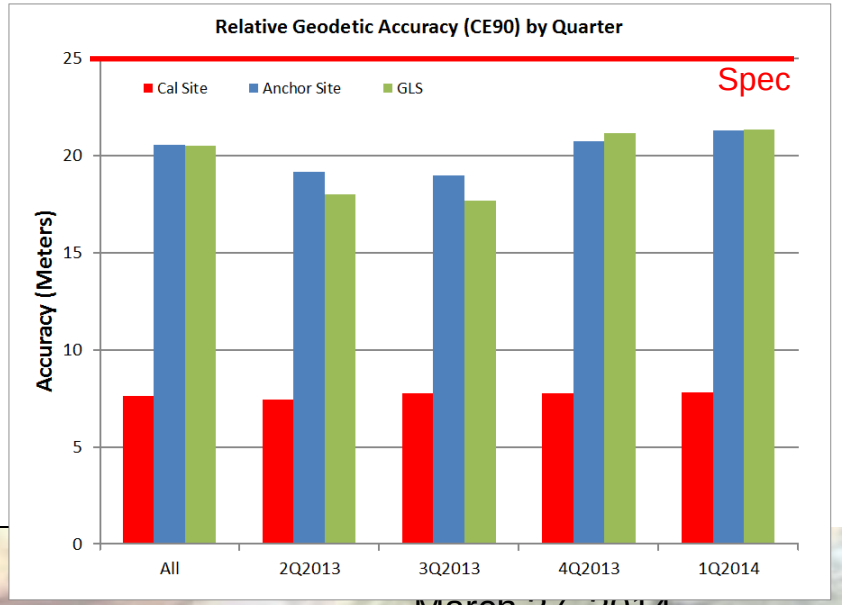
Internal Geometric Accuracy

- **Internal geometric accuracy is assessed in two ways**
  - Using validation points to assess the accuracy of L1T products
    - Landsat 8 space/ground system accuracy is evaluated at calibration sites with very accurate control and test points
    - Level 1T product consistency, including control effects, is evaluated in every scene containing GLS validation points
  - By comparing L1T products of the same area
- **Geometric accuracy**
  - Using independent validation points after control is applied
  - For 640 calibration site scenes with GPS-quality control:
    - Accuracy/Spec: 7.8/12.0 meters CE90
  - For 78962 scenes with GLS control:
    - Accuracy: 12.6 meters CE90 (relative to the GLS control)
- **Multi-temporal image registration accuracy (128 scenes)**
  - Line/Sample/Spec: 6.6/5.1/12.0 meters LE90

Geolocation Accuracy

- **Assessed during L1T product generation using the GLS control**
  - Absolute accuracy – difference between predicted ground positions and known GCP positions
  - Relative accuracy – residual difference after mean offset is corrected
- **~38m CE90 GLS control accuracy poses a problem**
  - Separate out GLS “anchor” sites that were used to control the original GLS global data set as these should be more accurate
  - Also assess accuracy using high quality control at calibration sites





Ground Control Accuracy Improvement

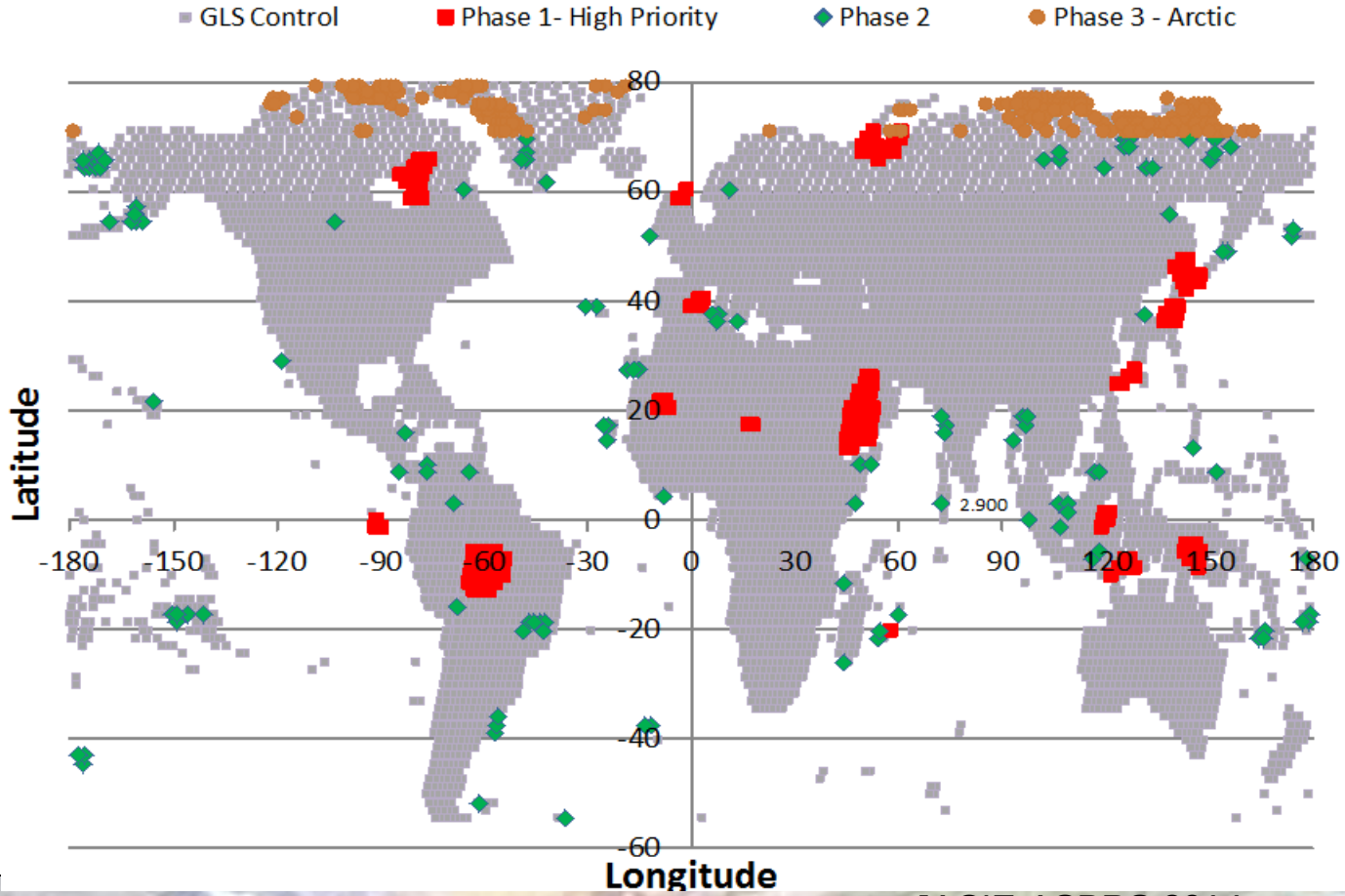
- **The global control point library used in Landsat L1T processing was derived from the GLS data set**
  - Ensures that new products are consistent with the existing archive
- **The GLS was established by triangulating blocks of ETM+ imagery containing control provided by NGA**
  - Some areas (notably islands) had little or no NGA control
    - Landsat 7 L1GT products were used to control these areas
- **L8 geolocation accuracy has allowed us to identify some areas where the GLS control base is deficient**
  - This is manifested as repeatable large (tens of meters) offsets for particular WRS path/row locations
- **The control library image chips are all L7 ETM+ (8-bit) circa 2000**
  - We want to extract new OLI chips for the GCPs in any case
- **A GLS control improvement activity is now underway to upgrade the problem areas**

GLS Ground Control Rework

- **Weak areas are being re-triangulated using L8 data**
  - Worked in three phases:

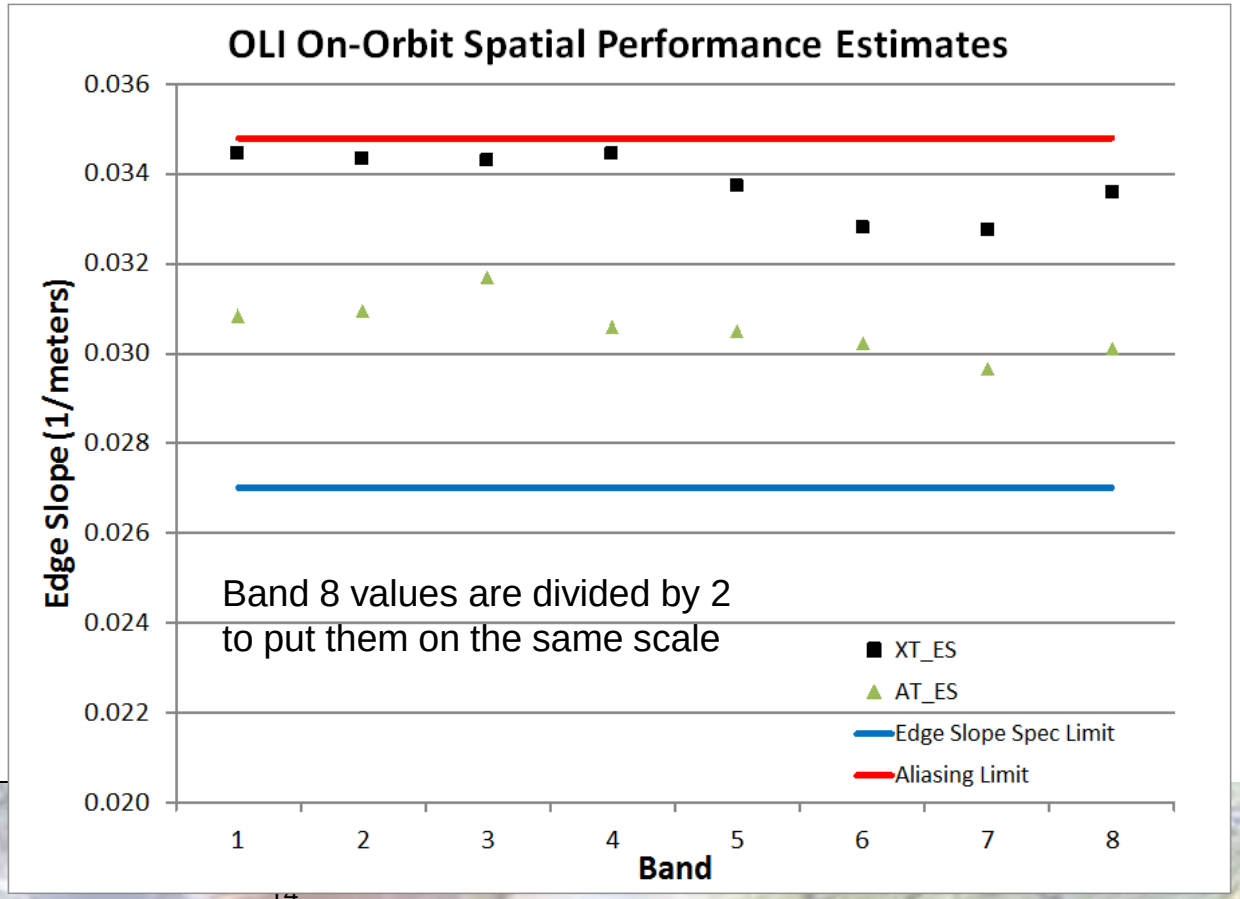
1. Fifteen high priority areas
2. Remaining low latitude areas
3. High latitude (arctic) areas

  - Adjacent areas held fixed to ensure consistency

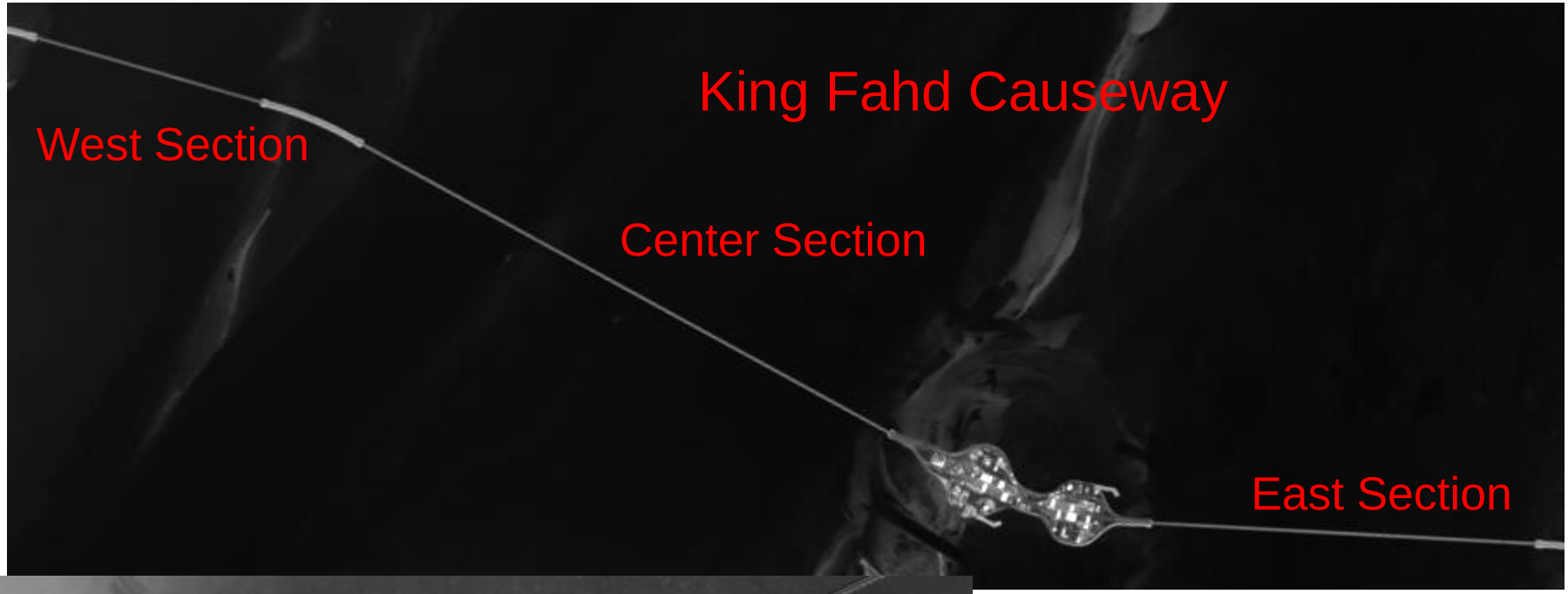


Spatial Performance - Edge Slope

- **OLI spatial performance was specified as the slope of the response to a unit step function**
  - Minimum edge slope between the 40% and 60% response points
  - Maximum response slope is also specified to control aliasing
    - Prelaunch performance measured during OLI T/V testing
    - Estimate on-orbit performance using bridge targets
- **Don't measure TIRS on-orbit performance**



Bahrain and China Bridge Targets



Panchromatic Band Images

Single Span Bridges

L8 Geometric Summary

- **Landsat 8 on-orbit geometric performance is excellent and meets all requirements**
- **The Cal/Val team continues to monitor on-orbit performance, adjusting the calibration when necessary**

Requirement	Measured Value	Required Value	Units	Margin
OLI Swath	190.2	>185	kilometers	2.8%
OLI MS Ground Sample Distance	29.934	<30	meters	0.2%
OLI Pan Ground Sample Distance	14.932	<15	meters	0.5%
OLI Band Registration Accuracy (all bands)	4.29	<4.5	meters (LE90)	4.7%
OLI Band Registration Accuracy (no cirrus)	3.35	<4.5	meters (LE90)	25.6%
Absolute Geodetic (Pre-Control) Accuracy	36.9	<65	meters (CE90)	43.2%
Relative Geodetic Accuracy	20.5	<25	meters (CE90)	18.0%
Geometric (Post-Control) Accuracy	7.8	<12	meters (CE90)	35.0%
OLI Edge Slope	0.02965	>0.027	1/meters	9.8%
TIRS Swath	186.2	>185	kilometers	0.6%
TIRS Ground Sample Distance	103.424	<120	meters	13.8%
TIRS Band Registration Accuracy	10.4	<18	meters (LE90)	42.2%
TIRS-to-OLI Registration Accuracy	20.6	<30	meters (LE90)	31.3%