Land Measurement from Future Landsat Missions

presented by

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Presentation Outline

- Landsat Data Continuity Mission (LDCM) Chronology
- LDCM Status
- Technical challenges to Operational Land Imager (OLI) accommodation on the NPOESS platform
- Landsat 5 and Landsat 7 Status
- Landsat Data Gap

LDCM Chronology

- Landsat 7 launch — April 15, 1999
- Release of LDCM Data Buy RFI — June, 1999
- Earth Observing-1 satellite launch — Nov. 21, 2000
  - Advanced Land Imager (ALI) aboard
- Release of Formulation Phase RFP — Nov. 01, 2001
- Formulation Phase Studies — March 15, 2002 to Dec. 28, 2002
  - Two private firms selected for independent studies leading to system PDR's
- NASA releases Implementation Phase RFP for data — Jan. 06, 2003
- NASA cancels Implementation Phase RFP — Sept. 23, 2003
- Executive Office of the President (EOP) convenes interagency LDCM working group — Dec., 2003
- Marburger memorandum signed — Aug. 13, 2004

Marburger Memorandum

- The President's Science Advisor, Dr. John Marburger, III, signed a memo on August 13, 2004 providing direction on the future of the Landsat program. The memo states:
- "Landsat is a national asset, and its data have made - continue to make - important contributions to U.S. economic, environmental, and national security interests."
- "the United States Government will transition the Landsat program from a series of independently planned missions to a sustained operational program"
- "The Departments of Defense, the Interior, and Commerce and the National Aeronautics and Space Administration have agreed to take the following actions:
  - "Transition Landsat measurements to an operational environment through the incorporation of Landsat-type sensors on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) platform …
  - "Plan to incorporate a Landsat imager on the first NPOESS spacecraft (known as C-1), currently scheduled for launch in late 2009 …
  - "Further assess options to mitigate the risks to data continuity prior to the first NPOESS-Landsat mission, including a "bridge" mission."

LDCM Status

- **Since the release of the Marburger memo, NASA and the DOI / USGS have worked with the NPOESS IPO and with NGST to specify requirements for Operational Land Imager (OLI) sensors for flight aboard the C1 and C4 NPOESS satellites**
  - **NASA posted a Synopsis for an OLI Request For Procurement (RFP) on June 27, 2005**

- **Recent consideration of OLI technical challenges and NPOESS programmatic challenges have delayed release of the OLI RFP**
  - **The charter for the Nov. 16, 2005 House Science Committee hearing on NPOESS contained the following excerpt: "the ExCom is considering delaying the delivery dates of some sensors and has already eliminated at least one other (the Landsat imager) altogether. (The Landsat instrument will probably be flown separately; a decision is pending."**

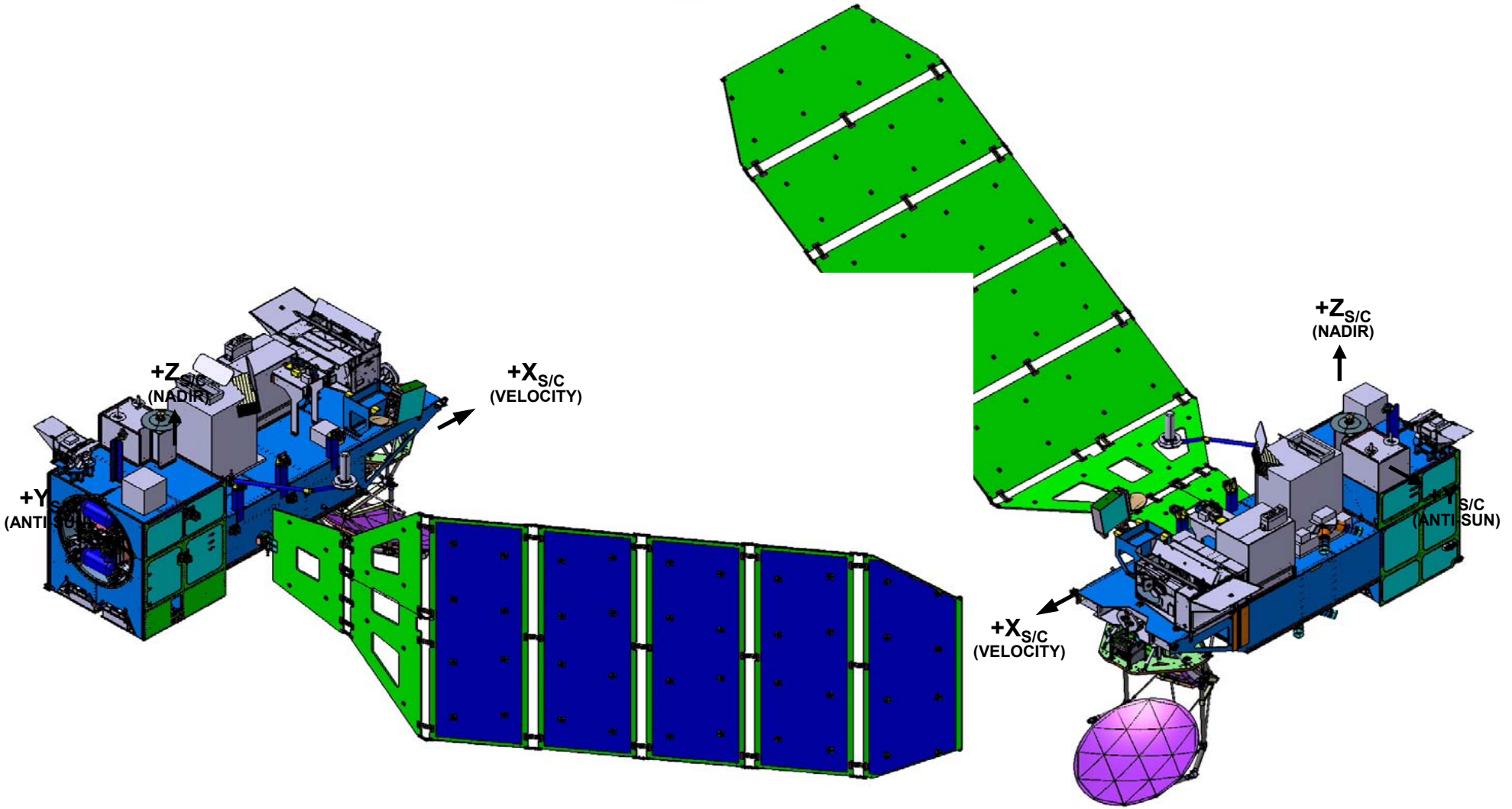
- **NASA and DOI / USGS have not yet received further direction from the Executive Office of the President**

Technical OLI Accommodation Challenges (1)

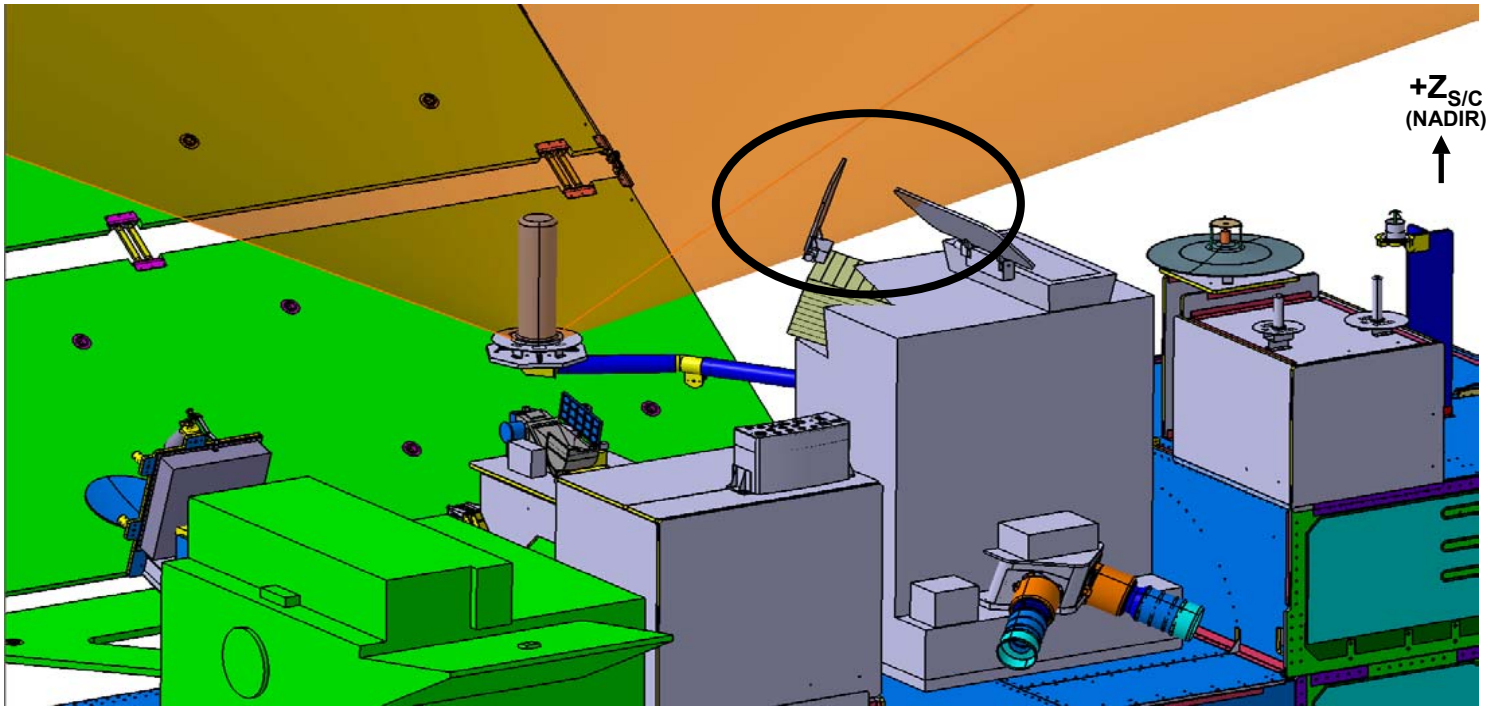
Location, Location, Location

- **OLI is a latecomer to the NPOESS manifest**
  - **Mid-morning (2130) NPOESS platform scheduled to carry at least five other sensors**
- **Only one location on the 2130 platform sufficient for an OLI**
  - **Determines the sensor volume envelope (1.2-by-1.2-by-1.5 m chamfered box)**
  - **Restricts fields-of-view for glint-free earth observation, solar calibration, and heat dissipation**
    - Solar calibration presents greatest challenge
    - No opportunity for lunar-based calibration aboard NPOESS

Isometric Views of NPOESS 2130 Satellite



OLI on NPOESS Location Close-Up



Technical OLI Accommodation Challenges (2)

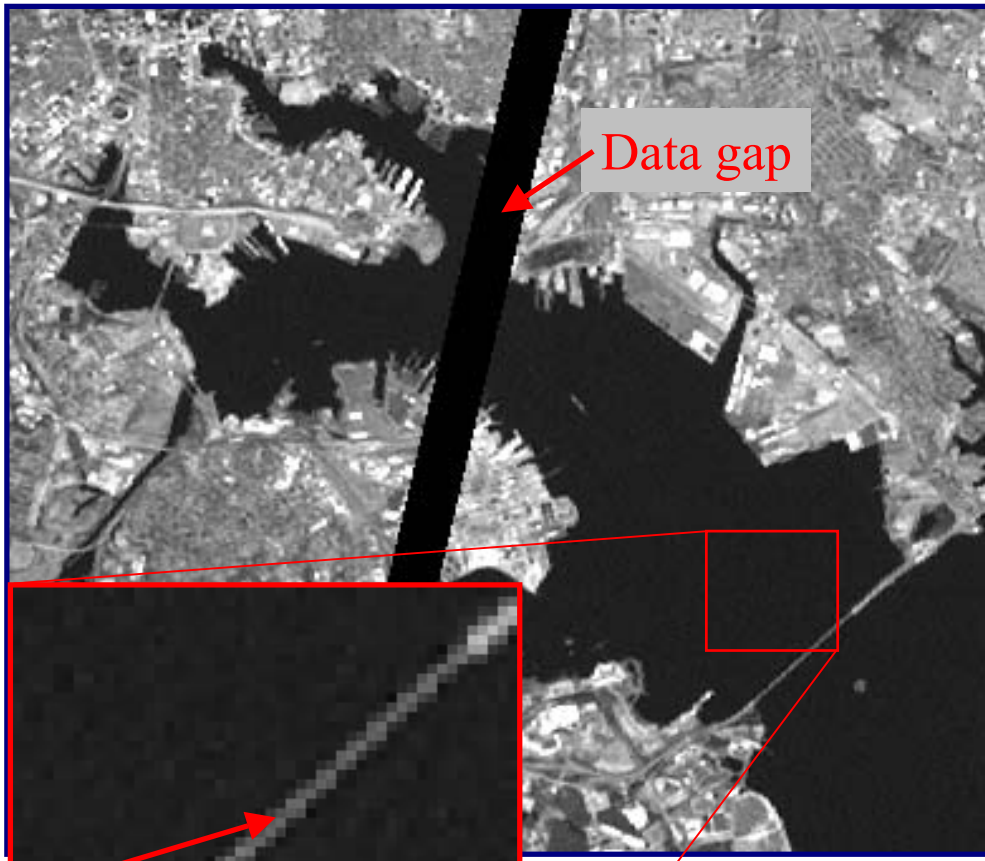
Lack of Yaw Steering

- **NPOESS operational spacecraft do not provide autonomous yaw steering to align linear focal plane detector arrays with the velocity vector along the ground track.**
  - **Yaw steering adjusts the spacecraft heading to compensate for the effects of Earth rotation**
  - **The effect of Earth rotation is largest at the equator and gets smaller toward the poles**
- **The ALI design, for example, required autonomous yaw steering of the Earth Observing-1 (EO-1) Spacecraft**
  - **Without yaw steering, Earth rotation would cause data gaps between between the ALI sensor chips**
  - **Without yaw steering, Earth rotation would misalign the even- and odd-numbered detectors causing an uneven sampling pattern and "jagged" images of linear features**
- **OLI design would be required to accommodate the lack of yaw steering**

ALI Band 7 Image of Baltimore

With Yaw Steering

Without Yaw Steering



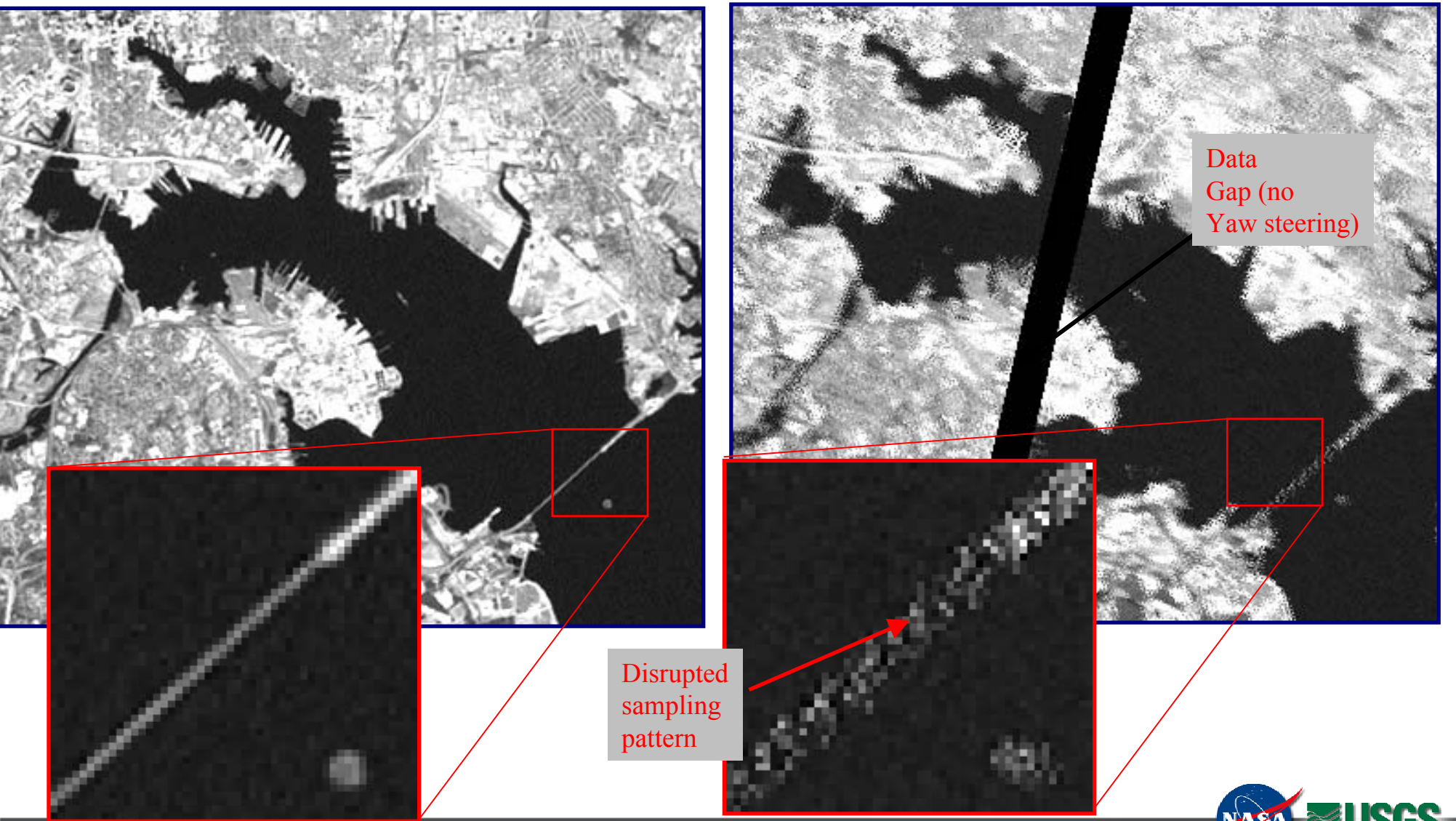
"Jagged" linear features

Technical OLI Accommodation Challenges (3)

Jitter

- **NPOESS platform stability is not sufficient for mid- or high- resolution imaging**
  - **Other NPOESS instruments afford coarser resolutions and are more jitter tolerant**
  - **Other instruments employ moving parts that contribute jitter to the platform environment**
- **Jitter suppression required to achieve OLI spatial resolution, band-to-band registration, scene-to-scene registration, and pixel geolocation requirements**
- **Jitter suppression will create a disconnect between the spacecraft attitude knowledge and the OLI line-of-sight**
  - **OLI specifications require that the sensor package provide any auxiliary devices required to achieve the necessary line-of-sight pointing knowledge**

Simulated OLI Image with & without Jitter Suppression

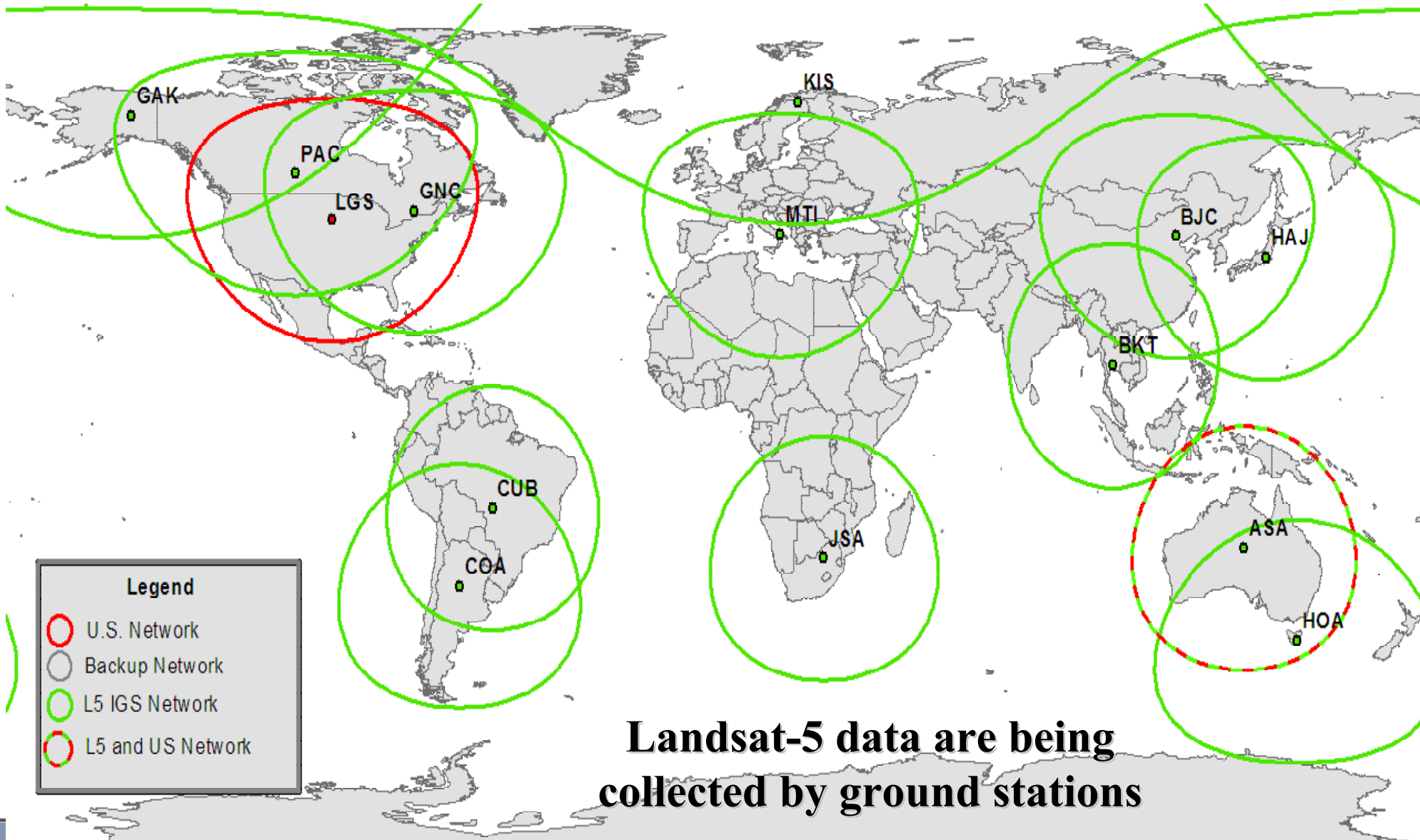


Landsat 5 Status

- **Landsat 5 and its Thematic Mapper (TM) sensor are 21 YEARS OLD, 18 years past 3-year design life**
  - **Satellite is only capable of the direct transmission of data in real time**
    - EROS Data Center directly receives data only for CONUS
  - **TM data are directly transmitted to International Ground Stations**
    - Only the Australian IGS sends tapes to the EROS Data Center
  - **No redundancy remains for most mission critical subsystems**
  - **Fuel depleted in 2009**

- **On November 26, 2005, the back-up solar array drive on Landsat 5 began exhibiting unusual behavior.**
  - **The rotation of the solar array drive became sporadic and the solar array was not able to provide the power needed to charge the batteries.**
  - **The primary solar array drive displayed similar behavior last January**
  - **Thematic Mapper operations have been suspended pending resolution**

Landsat 5 Network 1-July-2005



Landsat-5 data are being collected by ground stations

Landsat 7 Status

- Landsat 7 and its Enhanced Thematic Mapper-Plus (ETM+) sensor reached end of five-year design life on April 15, 2004
  - **ETM+ scan line corrector (SLC) anomaly occurred on May 31, 2003**
    - Results in missing pixels, or gaps, over 24% of each ETM+ scene
    - Remaining pixels are not effected with respect to radiometric and geolocation accuracies - USGS now offers composite images to fill in missing pixels
  - **One of three attitude control gyros was shut down in May 2004 with no adverse impacts on image acquisition or data quality**
  - **Fuel depleted in 2011**

ETM+ SLC Anomaly Impact

PRE-SLC FAILURE

3 MARCH 2000

POST-SLC FAILURE

20 SEPTEMBER 2003

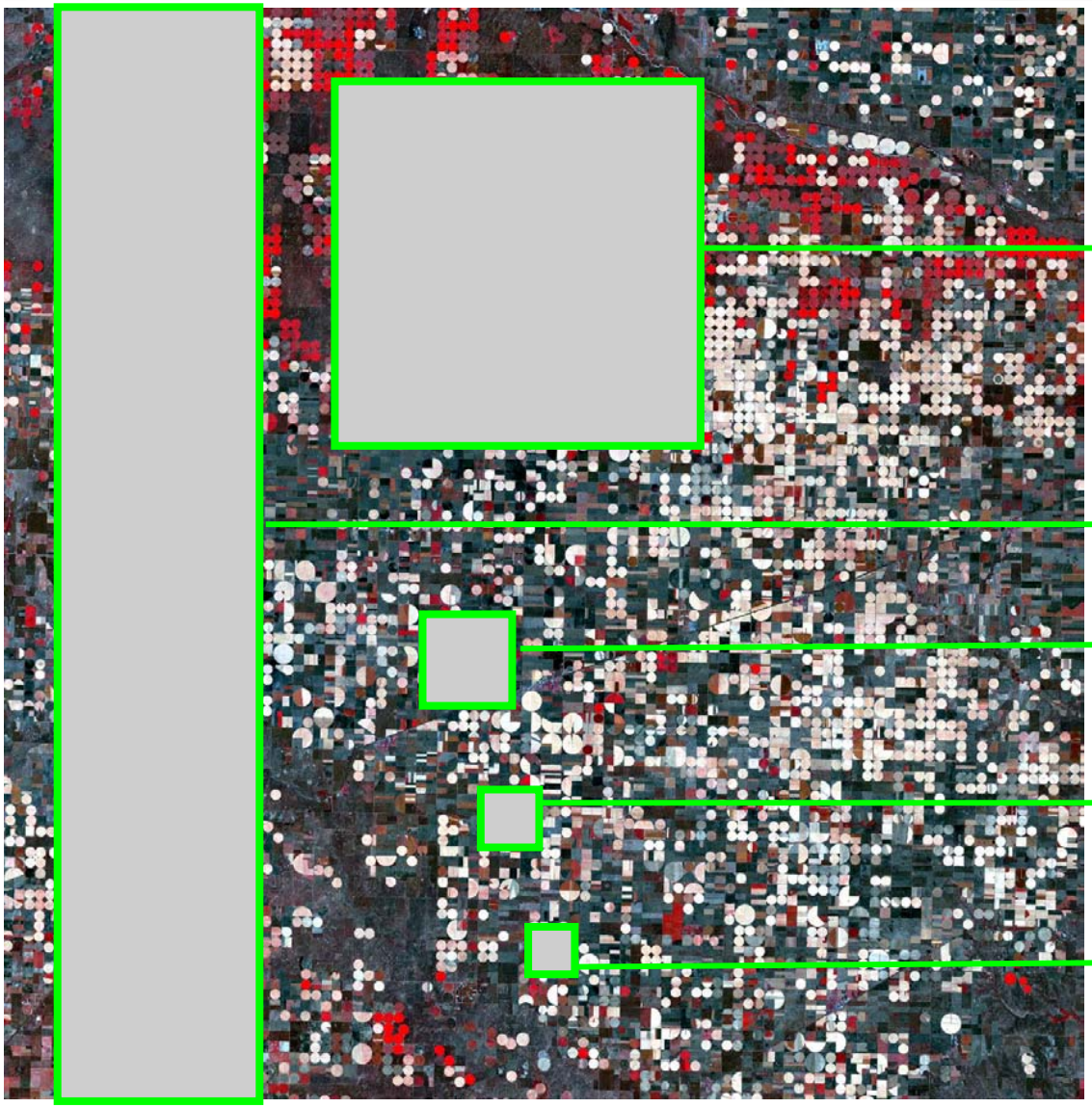
Note that the images show partial scenes, from the western edge through the scene center.

Landsat Data Gap

- **A multi-year gap in Landsat data acquisition seems inevitable**
- **NASA and the DOI / USGS are considering strategies for mitigating the impact of a Landsat data gap**
  - **Discussions of a "Mid-Decadal Global Data Set" for 2005 have just begun**
    - Goal is to create a data set affording orthorectified global coverage for 2005 using Landsat 5 data, Landsat 7 composite data, and/or data from other Landsat-like sensors (e.g., ASTER) in a consistent format
  - **NASA and DOI / USGS have convened a Landsat data gap working group**
    - Group is considering strategies for capturing Landsat-like data from alternate satellite systems into the DOI National Satellite Land Remote Sensing Data Archive (NSLRSDA)
    - Goals include achieving annual global coverage and providing public access to the data on a nondiscriminatory basis
  - **Challenges**
    - No other satellite system is designe or operated to afford seasonal to annual global coverage of the earth's land surface
    - No other nation is committed to preserving a multi-year archive with public access

Landsat's Synoptic Coverage

LDCM



Summary

- **The decision to fly Landsat sensors aboard NPOESS satellites is under reconsideration**
  - **The inclination to place the Landsat program into an operational environment remains**
- **NASA and the DOI / USGS have not yet received further direction from the Executive Office of the President**
- **Efforts to mitigate the now probable Landsat data gap have been initiated**