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Landsat Data Gap Implementation Plan

Landsat Science Team Meeting
Fort Collins, Colorado

January 6, 2009

U.S. Department of the Interior
U.S. Geological Survey

Discussion Agenda

- **Briefly review the findings of the Landsat Data Gap Study Team – Phase 1**
- **Discuss "Landsat Data Gap Implementation Plan" – Phase 2**
- **Science Team Input**
- **Discussion**

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Landsat Data Gap Study Team (LDGST)

- **Across civil agency LDGST formed to analyze potential strategies to continue to provide global land observations similar to Landsat**
  - Landsat data flow might be disrupted before LDCM in ~2012:
    - Landsat 5 limited lifetime/coverage and degraded Landsat 7 operations
    - Either or both satellites could fail at any time interrupting a 36+ yr time series of global land observations
- **LDGST Technical and Policy/Implementation Groups**
  - Evaluate options and scenarios to assess gap-filler data alternatives
  - Develop operational plan and agreements to receive, ingest, archive, and distribute data from alternative, Landsat-like satellite systems
  - Develop data gap implementation plan and recommendation – **Current Emphasis**
- **Data Characterization Working Group (DCWG)**
  - Technical group from USGS EROS, NASA GSFC, and NASA SSC to evaluate ResourceSat-1 and CBERS-2 data and others – on going work.

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LDGST Baseline Specifications – Phase 1

- **LDCM data specification has been vetted by science and applications communities to support the range of Landsat applications.**
- **Obtaining data identical to and in similar volume as LDCM from existing systems is not possible.**
- **Acceptable specifications were derived to support basic global change research given available sources of Landsat-like data.**
  - Global mapping of land-cover.
  - Long-term analysis of land-cover change.
- **Analysis incorporated OSTP Landsat User Survey Responses.**
  - Users require Landsat-like data (global coverage, moderate resolution, spectral coverage).
  - Many users already considering alternate sources of data following Landsat 7 Scan Line Corrector anomaly.

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Gap-filler Baseline Data Specifications

Performance Parameter	Performance Goal: LDCM Specification	Acceptable Specification*
Radiometry	<5% error at-sensor radiance	<15% error at-sensor radiance
Spatial Resolution	30m GSD VNIR-SWIR; 15m	100m GSD
Geographic Registration	<65m circular error	<65m circular error
Band-band registration	uncertainty <4.5m (0.15 pixel)	uncertainty <0.15 pixel
Spectral Bandpass (nm)	Blue 433-453	
	Blue 450-515	
	Green 525-600	
	Red 630-680	√
	NIR 845-885	√
	SWIR 1560-1660	√
	SWIR 2100-2300	
	SWIR 1360-1390	
	Pan 500-680	
Global Coverage	Seasonal (4X annually), substantially cloud-free global acquisition Includes U.S. acquisition every 16 days	Global, substantially cloud-free acquisitions twice per year (2 seasons annually)

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Systems Considered in Phase 1

- IRS ResourceSat – 1, 2 (India)
- CBERS – 2, 2A, 3, 4 (China & Brazil)
- RapidEye – 1, 2, 3, 4, 5 (Germany)
- DMC – Algeria, Nigeria, UK, China
- Terra/ASTER (METI & NASA)
- High-resolution U.S. commercial systems
  - IKONOS
  - QuickBrid
  - OrbView-3
- SPOT – 4, 5 (France)
- ALOS (JAXA)
- EO-1/ALI (NASA & USGS)

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LDGST Phase 1 - Conclusions

- **The Landsat Program is unique**
  - Single source of systematic, global land observations
- **Data quality of potential candidate systems is unverified, however, based on preliminary analysis**
  - India's ResourceSat and CBERS are the leading candidates for reducing the impact of a Landsat data gap
- **Receiving and archiving data from new source(s) - Challenges**
  - Different formats, storage media, metadata
- **Analysis/Applications of data from new source(s)**
  - Mosaicing and co-registering data from multiple sources with different spatial resolutions, registration accuracy, and scene sizes
  - Differentiating land cover change from multiple sources
  - Developing new methodologies and algorithms incorporating data from multiple sources

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LDGST Phase 1 - Conclusions

- **USGS Land Data Gap RFI April 2007**
  - Designed to identify gap-filler solutions - LDGST baseline specifications
  - Many responses, all international systems - AWiFS validated as leading capability
- **Continue data characterization and cross-calibration**
- **Develop systematic approach to new mission/data evaluations**
  - Assess expected mission capabilities (pre-launch)
  - Validate mission, data and science utility (post launch)
  - Perform initial and ongoing cross-calibration sensor testing
  - Proactively establish contracts and agreements for data acquisition
  - Develop infrastructure to receive, manage and distribute data
- **Further investigate other global and regional coverage candidates to better define technical capabilities, costs of data, and accessibility (SPOT, Rapid Eye, U.S. commercial firms, etc.)**

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Landsat Data Gap Plan -- Phase 2

- **Landsat Data Gap Implementation Plan**

Objectives

- Detailed implementation plan which will identify cost, data licensing, and data access and archiving implications for integrating new data gap missions into the USGS existing operational framework

- Reaffirm, with the Landsat Science team, data requirements for operational and scientific purposes

- Continue calibration and validation studies given the advent of new capabilities, i.e., RapidEye.

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Phase 2 Near-term Data Gap Actions

- **Data Gap Land Imaging options – Pursue all three:**
  - **CBERS** - establishes a low cost capability -- starting with U.S. coverage
  - **ResourceSat-IRS** remains the best technical Landsat data gap solution
  - **SPOT** is a viable dataset for remote sensing science and adds enhanced resolution -- starting with U.S. coverage
- **Document current accessibility to these three data sources (cost, licensing, product formats, etc.)**
- **Document all resources needed to operationally implement access to these data via most feasible method**
- **Continue characterization, calibration, and validation of new data sources – RapidEye, etc.**

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Phase 2 Programmatic Challenges

- **Schedule and business models**
  - Direct Reception or Data Pipe or Data Buy
- **International policy / relations**
  - CBERS may be problematic
- **Data policy / Licensing**
  - Less restrictive SPOT and IRS licensing to be negotiated
- **Data compatibility**
  - SPOT, CBERS and AWiFS all viable – with known Landsat compatibility/calibration concerns
- **Funding**
  - Base funds for “functional” responsibilities vs. funding missions – key!
- **Further investigation and planning needed**
  - On-going mission evaluations – RapidEye, Sentinel-2, etc.

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Science Team Input

- **Confirm and validate preferences for pursuing SPOT, CBERS, or IRS data**
  - Agree with the plan on pursuing these data?
  - Can we prioritize the 3?
  - Are there ways the Landsat Science Team can support our work externally?
- **Can we do our science/applications with a mixed bag of data instead of just Landsat.**
  - How do you use multi-resolution data from different sources in doing our jobs?
  - Mosaicing and co-registering data from multiple sources with different spatial resolutions, registration accuracy, and scene sizes
  - Differentiating land cover change from multiple sources
  - Developing new methodologies and algorithms incorporating data from multiple sources

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Science will greatly influence USGS actions in pursuit of operational data gap sources.

DISCUSSION

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BACK-UP SLIDES

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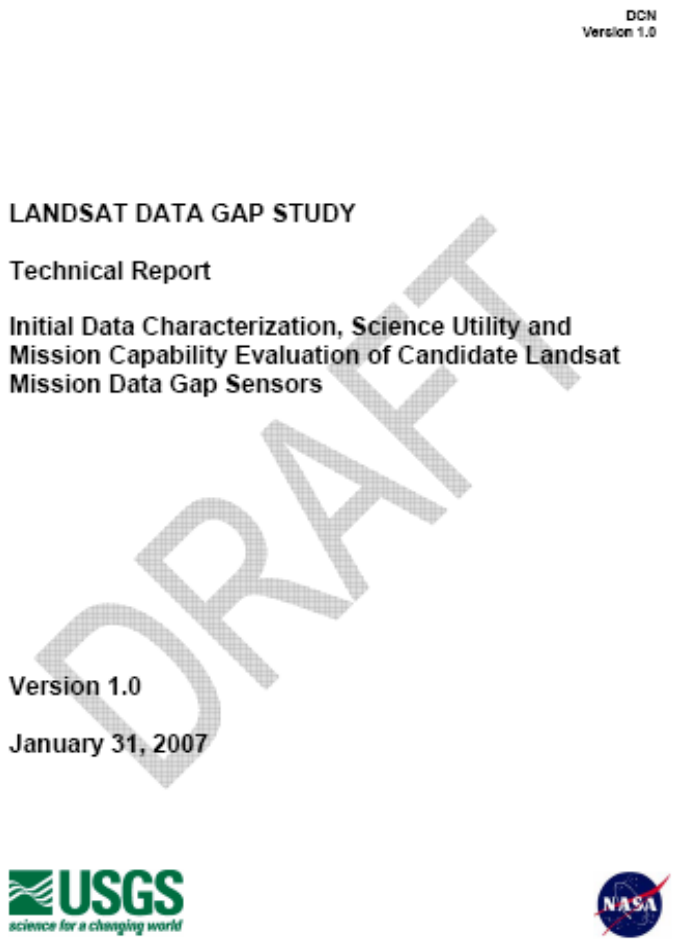
Technical Report



Report Sections

- Background and Sensor overview
- Data Characterization
- Science Utility
- Mission Assessment
- Many Appendixes

Provisional report available:
http://calval.cr.usgs.gov/LDGST.php

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Comparison of Capabilities with Requirements

KEY:																		
meets spec	OK																	
does not meet spec	X																	
need more information	?																	
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Annual Global Coverage	Spatial Resolution	Spectral Coverage	Data Quality*
ResourceSat-1																OK	OK	OK	?
ResourceSat-,2																OK	OK	OK	?
CBERS 2																?	OK	OK	?
CBERS 2A																?	OK	OK	?
CBERS 3																?	OK	OK	?
CBERS 4																?	OK	OK	?
RapidEye 1,2,3,4,5																?	OK	X	?
Terra/ASTER																X	OK	OK	OK
EO-1/ ALI																X	OK	OK	OK
SPOT 4																?	OK	OK	OK
SPOT 5																?	OK	OK	OK
ALOS																?	OK	X	?
DMC Algeria																X	OK	X	?
DMC Nigeria																?	OK	X	?
DMC UK																?	OK	X	?
DMC China																X	OK	X	?

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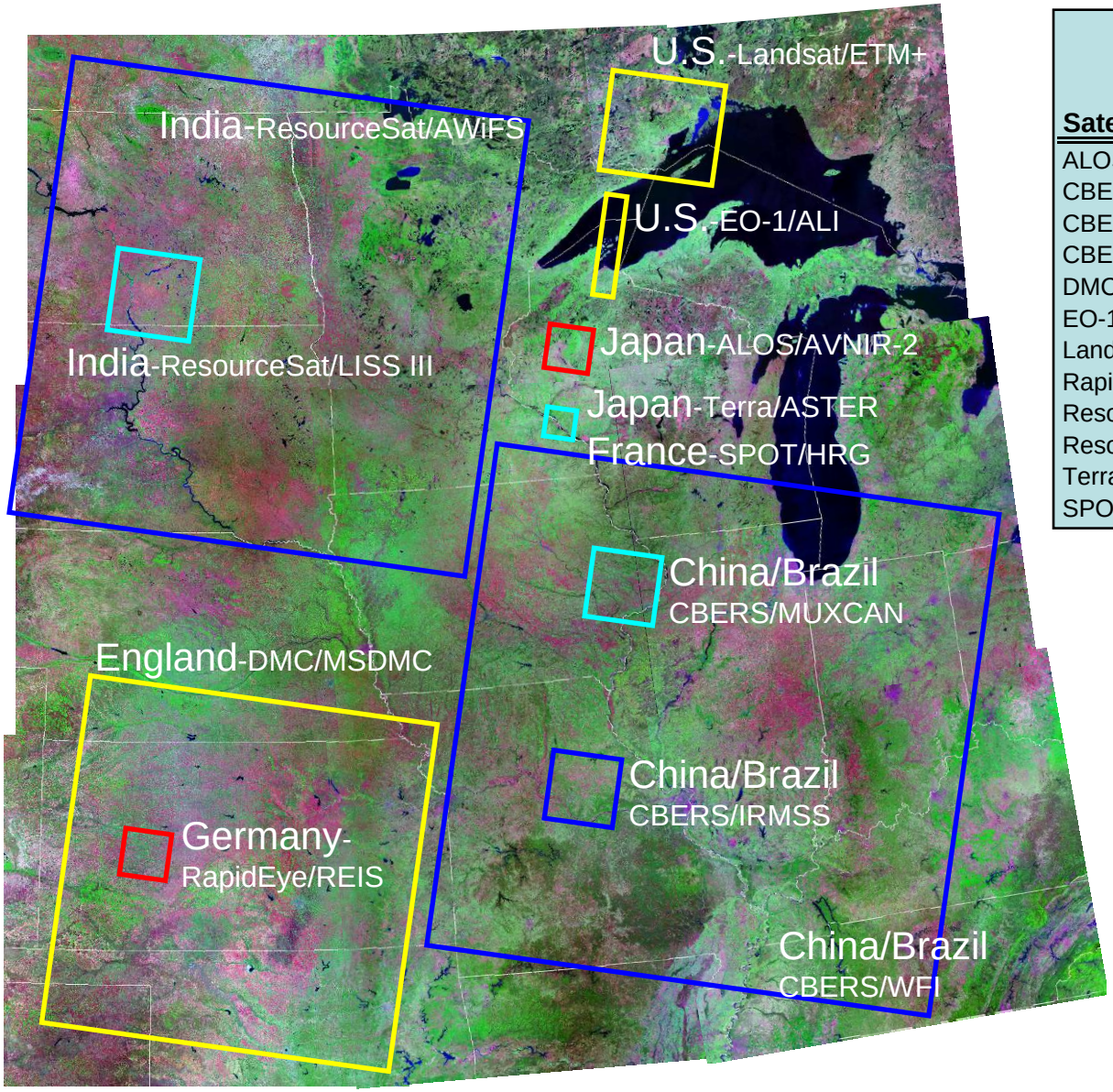
*Data quality is acceptable if verified to meet acceptable specifications for radiometric and geographic accuracy and band-to-band registration

Alternative Comparisons



Satellite	Sensor	Ground sampling distance (m)	Swath width (km)
ALOS	AVNIR-2	10	70
CBERS-3,4	IRMSS	40/80	120
CBERS-3,4	MUXCAN	20	120
CBERS-3,4	WFI	73	866
DMC	MSDMC	32	600
EO-1	ALI	30	37
Landsat	ETM+	30	185
Rapideye	REIS	6.5	78
ResourceSat	LISS-III	23.5	141
ResourceSat	AWiFS	56	740
Terra	ASTER	15/30/90	60
SPOT	HRG	10/20	60

Note: Scene size comparison only; not actual orbital paths or operational acquisitions. High-resolution scenes too small to illustrate here.

SPOT, CBERS, IRS and Landsat

Satellite	Resolution (meters)	Swath (km)	Inclination (degrees)	Repeat Coverage (effective)	Altitude (km)	Descending Node	Launch Date	Downlink Rate (Mbps)
SPOT-4	20	2 × 60	98.7	26*	832	10:30	3/24/1998	1 × 50
SPOT-5	10m MS, 20m SWIR	2 × 60	98.7	26*	822	10:30	5/4/2002	2 × 50
CBERS_2B	20	113	98.5	26	778	10:30	9/19/2007	1 × 53
Landsat-5	30	185	98.2	16	705	10:00	3/1/1984	1 × 85
Landsat-7	30	185	98.2	16	705	10:00	4/15/1999	2 × 150
IRS-P6 (AWiFS)	56	740	98.69	5	817	10:30	10/17/2003	1 × 105*

* Both SPOT Sensors are targetable ± 27° across track, effectively lowering repeat coverage for emergency response, etc.

** IRS-P6 data stream includes data from both AWiFS sensor and LISS-III sensor

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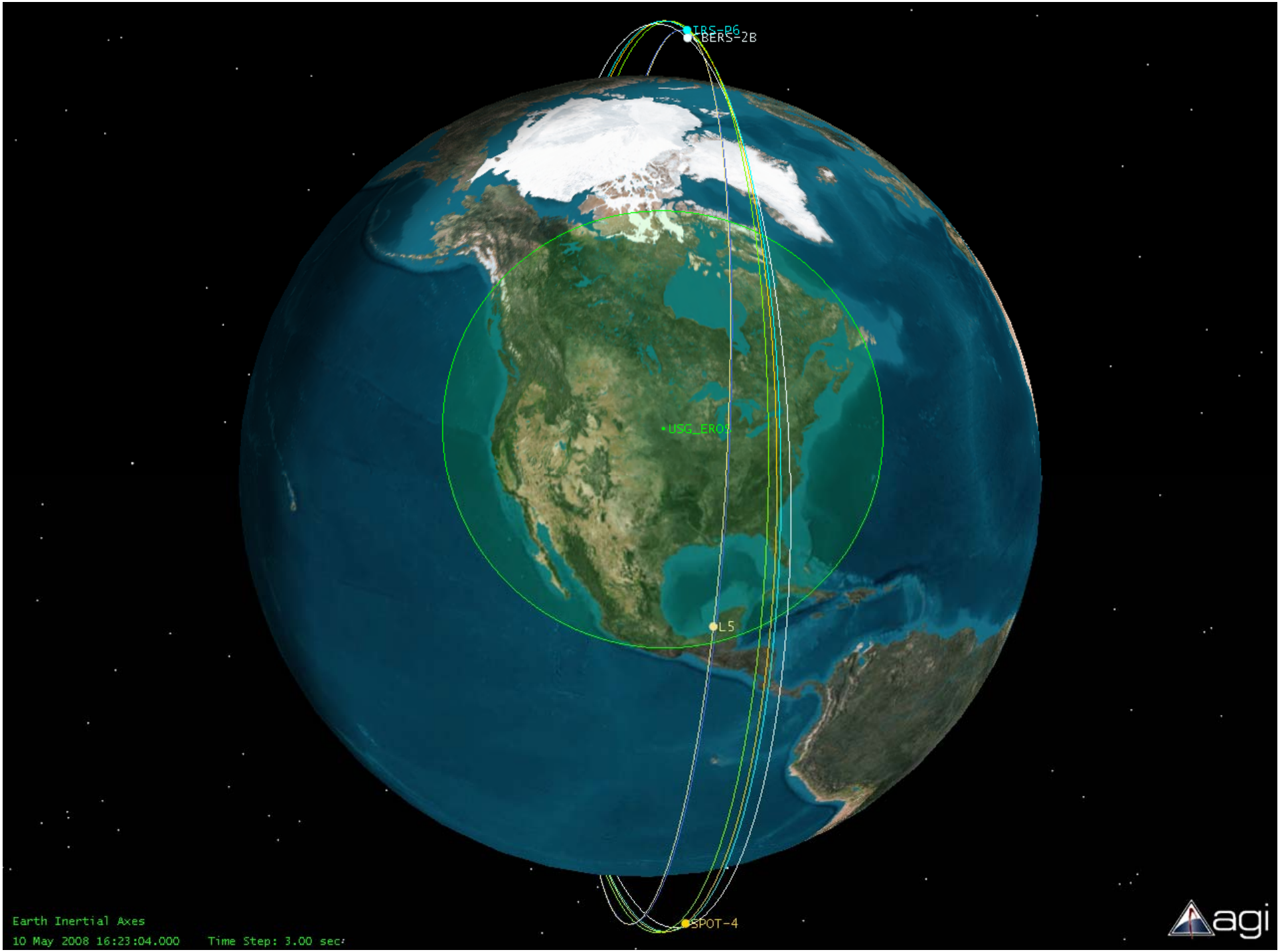
IRS-P6
CBERS-2B
USG_EROS
L5
SPOT-4
Earth Inertial Axes
10 May 2008 16:23:04.000
Time Step: 3.00 sec
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