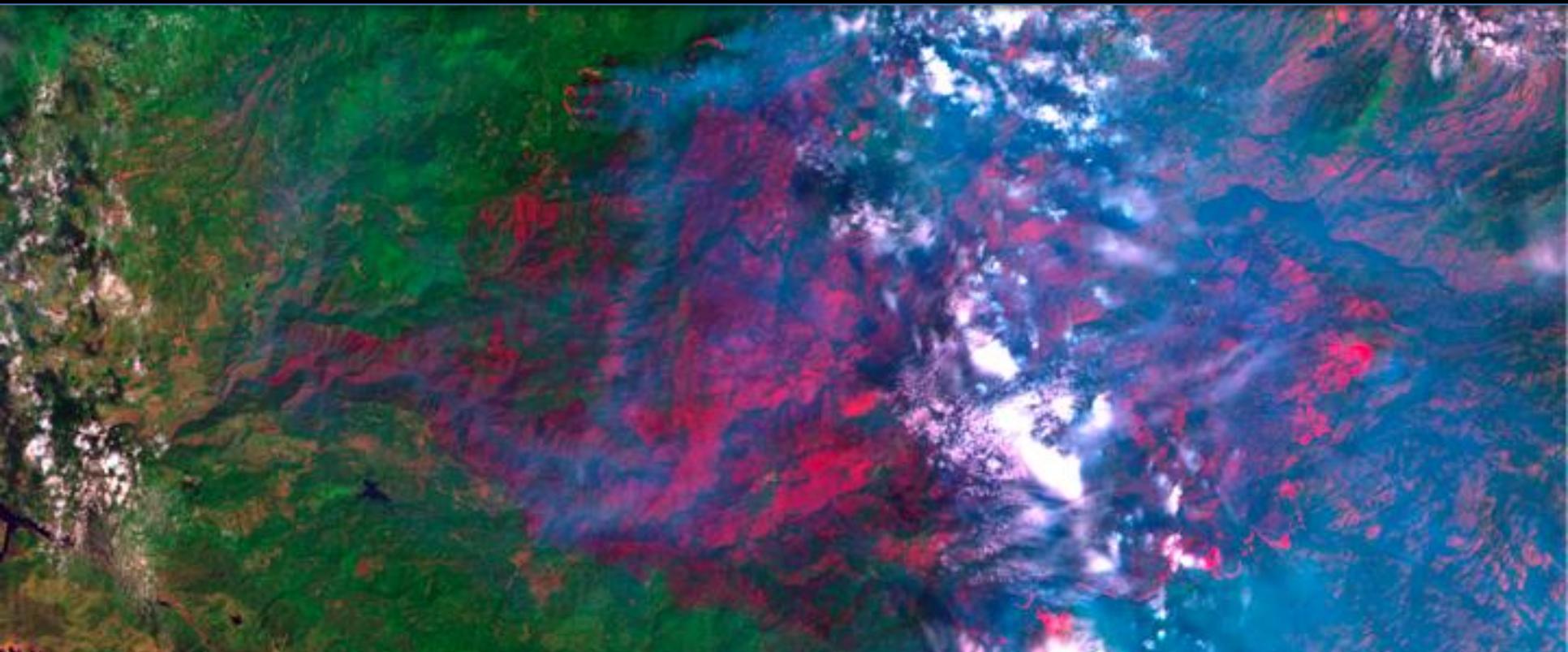




SUSTAINABLE LAND IMAGING

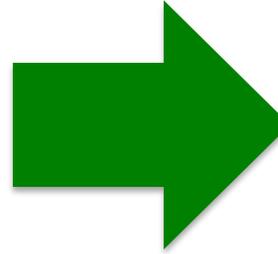


JACIE ANNUAL MEETING, 28 March 2014, Louisville, KY

Bradley Doorn
NASA Earth Science Division

Agenda

- Quick Review
- Where Are We Going



Land Imaging in FY 2014 President's Budget for NASA

*In FY14 NASA will initiate the definition of a sustained, space-based, global land imaging capability for the nation, ensuring continuity following LDCM. Near-term activities led by NASA, in cooperation with USGS, will focus on **studies** to define the scope, measurement approaches, cost, and risk of a viable long-term land imaging system that will achieve national objectives. Evaluations and design activities will include consideration of stand-alone new instruments and satellites, as well as potential international partnerships. It is expected that NASA will support the overall system design, flight system implementation, and launch of future missions, while USGS will continue to fund ground system development, post-launch operations, and data processing, archiving, and distribution.*

- President's FY 2014 Budget release

OMB-OSTP Direction to NASA

- \$30 million in FY14 for NASA to study options for a future sustained land imaging system, in collaboration with USGS.
- The study shall define a system for sustained global land-imaging multispectral and thermal infrared information for an approximately 20-year period starting in 2018.
- The study should provide options which consider various weightings of near-term capability, continuity/gap risk mitigation, and technology infusion over the system's lifetime.
- While the basic system requirement is the continuation of global data and information having the quality of Landsat-8 products, the study should consider refined capabilities requested by the user communities.

OMB-OSTP Direction to NASA - continued

- The study should also consider a range of implementation strategies that could spur innovation and increase efficiencies, including international and private sector collaborations.
- The study should recognize that lowering the cost of the system is an important goal.
- NASA should report the results of the study to OSTP and OMB by August 15, 2014.

Sustainable Land Imaging Study Execution

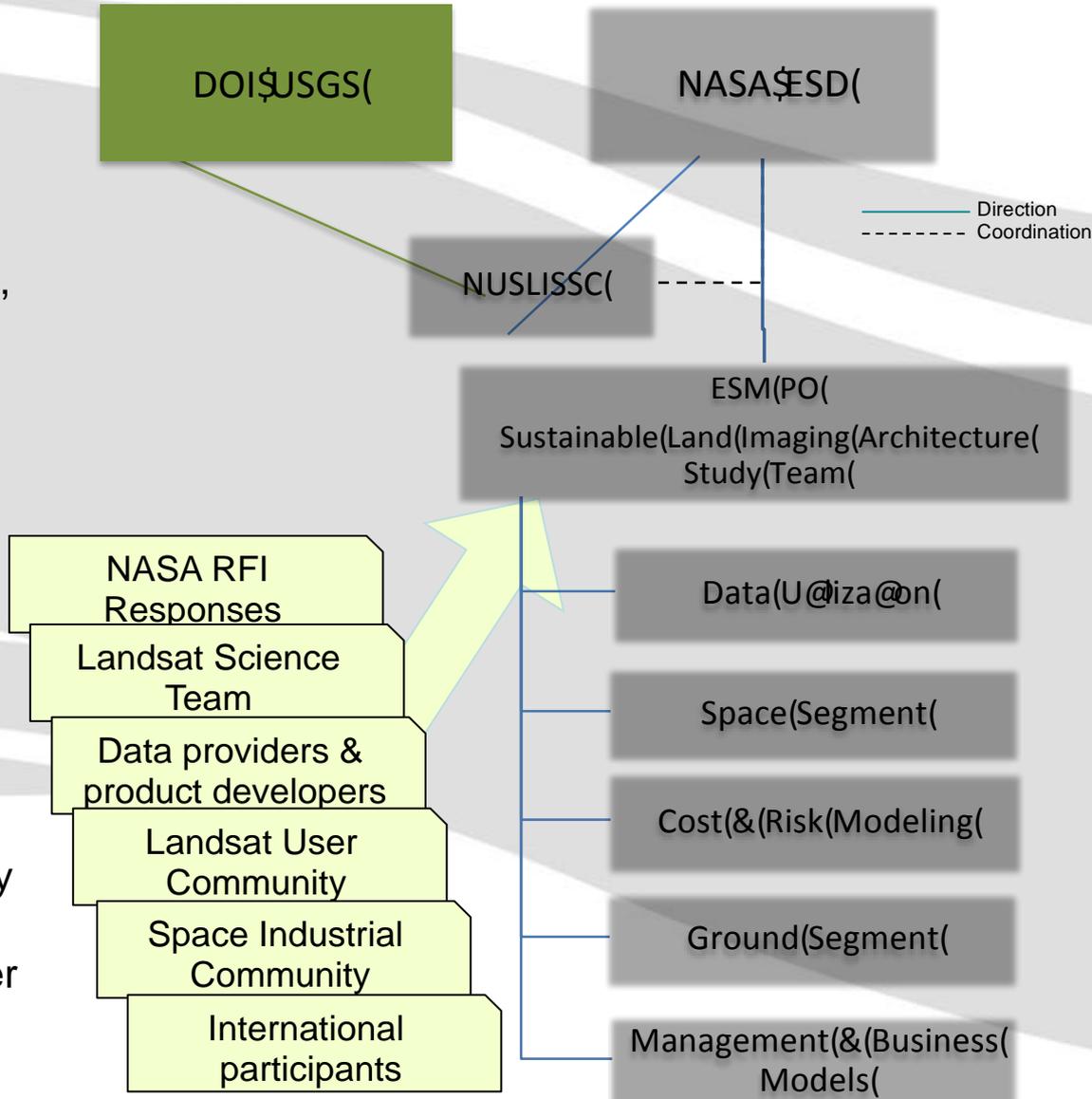


✧ **NUSLISSC = NASA/USGS Sustainable Land Imaging System Steering Committee**

- NASA Members: Dave Jarrett, Brad Doorn, Woody Turner
- USGS Members: Tim Newman, Tom Cecere, John Crowe, Ray Byrnes, Steve Covington

✧ **Landsat Science Team (LST) also will provide the AST with technical evaluation of:**

- Applications requirements
- Possible contributed measurements (Sentinel 2, for example)
- Status on radiometric sensitivity analyses
- Architecture trade spaces under consideration



Three Basic Study Tenets for the Program

- Sustainability

- The LI program should provide the *data products* with a long-term support plan, without extraordinary infusions of funds, within the budget guidance provided.

- Continuity

- The LI program should continue the long term Landsat data record. This does not mean a continuity of how the Landsat data record is produced. Also, it should not preclude adjustments to the data record that improve the efficacy of how the data records are produced OR used, as long as there is an adequate ability to relate the data records over time.

- Reliability

- The LI program should be robust and *not susceptible to single point failures*. The loss of a single satellite or instrument on orbit should not cripple the program or significantly impact users.

Legacy Landsat Performance



Performance Parameter	Rationale
Spectral coverage across VNIR, SWIR, and TIR	<ul style="list-style-type: none"> • <i>Most applications require multiple spectral regions</i>
30m (120m) spatial resolution for VSWIR (TIR)	<ul style="list-style-type: none"> • <i>Spatial resolution supports land management, land use, and ecosystem studies;</i> • <i>Broad area coverage supports regional/continental monitoring</i>
Ability to image each point on the globe every 16 days (8 days realized for majority of Landsat history)	<ul style="list-style-type: none"> • <i>Time series needed to characterize seasonal change</i> • <i>More frequent observations help mitigate cloud cover</i>
Sun-synchronous orbit, ~10 AM crossing time	<ul style="list-style-type: none"> • <i>Radiometric continuity with existing Landsat record</i>
Near co-incident imaging of spectral bands (VSWIR within seconds; TIR within minutes of VSWIR)	<ul style="list-style-type: none"> • <i>Near-simultaneous VSWIR required for multi-band indices;</i> • <i>TIR and VSWIR coincidence supports ET, water resources applications</i>
Global coverage of land area	<ul style="list-style-type: none"> • <i>Required for global land science & applications</i>
Less than 5% uncertainty in absolute spectral radiance	<ul style="list-style-type: none"> • <i>Provides radiometric continuity for long-term monitoring and change detection</i>
View angles < +/- 15 degrees	<ul style="list-style-type: none"> • <i>Limit BRDF variability within archive</i>
Free and open data distribution	<ul style="list-style-type: none"> • <i>Hallmark of Landsat program</i>

Other Parameters & Features Being Considered

- ✧ The long term nature of the study means we cannot just look at current capabilities, but we must also look into future capabilities
- ✧ Current and evolving capabilities of small satellites, including nanosats (<10 kg) to minisats (100-200 kg)
 - Include constellations or swarms
 - Capabilities are limited by physics (*e.g.* aperture) and enabled by technology (*e.g.* detectors & ROICs, ASICs, mini cryo-coolers)
 - Shrinking telescopes/instruments enable smaller spacecraft; assessing performance trades and their impact
- ✧ Hyperspectral capabilities
 - Data could simulate OLI data; for example, convolving AVIRIS data sets to OLI resolution and spectral bands
- ✧ Detailed investigations of these options to be deferred until after the May 2014 deliverable to Congress

NASA – USGS Collaboration

Study Phase

- NASA will lead the overall system architecture study, utilizing its space systems engineering expertise
- USGS will support all aspects of the study; USGS will represent the consolidated needs and desires of the Landsat user communities and provide expert analyses of the data processing and data dissemination aspects of the system

Implementation Phase

- NASA will be responsible for the overall system design, as well as the implementation, launch, and commissioning of the system's space-borne elements
- USGS will provide unique expertise and guidance in the design of the operations, ground network, data processing (including integration of measurements from multiple sources), and data dissemination components of the complete system
- USGS will be responsible for operating the space-borne assets after commissioning, as well as the downlink, ground processing, archiving, and distribution of the system's information and data products
- The USGS will maintain the national archive of Landsat data, distribute data to users, and administer, on behalf of the U.S. Government, data acquisition by non-USG ground stations.

Sustainable Land Imaging

WHERE ARE WE GOING

Four Classes of Candidate Architectures



- ✧ Architecture 1: Full Capability Observatories
 - Two instrument (or combined instrument) strategies on same spacecraft
 - No international partnership – U.S. Government covers all costs
- ✧ Architecture 2: Disaggregated System
 - Alternate building of thermal and reflective imagers on dedicated spacecraft
 - Viability of mini-sat and micro-sat constellations
 - No international partnership – U.S. Government covers all costs
- ✧ Architecture 3: International Participation
 - Reliance on International partners to provide reflective imagers and/or data to preserve continuity
 - International partnership a must – U.S. Government covers portions of cost
- ✧ Architecture 4: Commercial Approach
 - Reliance on commercial partners to provide hosted or data buy opportunities
 - Partnerships with Commercial or other Federal Agencies
- ✧ Common Features for All:
 - Launch vehicle can be shared or dedicated
 - Consider various risk classes
 - Consider precursor full-spectrum or thermal-only “gap filler” mission
 - International/commercial systems assessed for backup role
 - Technology infusion is an option in this architecture

Architecture Trade Space – Design Cycle #2

Design Cycle #2 will focus on:

- Completion of Architecture Classes #1 and #2 investigations
 - Improved instrument and spacecraft building block cost models
 - Considering alternate business strategies, such as block buys and ridesharing
 - Refined value measures including satisfaction of user needs, robustness, and risk
- Architecture Class #3 – International partnerships for both full capability and disaggregated systems
- Near term bridging approaches that lead to a sustained implementation
- Technology Infusion
 - Identification of promising techniques and technologies for potential later infusion to reduce cost or improve performance

AST Initial Assessments (1 of 2)



- ✧ Landsat 8 is healthy and meeting all needs, projections show the satellite is likely to exceed the 5 yr lifetime, and TIRS the 3 yr lifetime
- ✧ Analysis of historical and expected user needs indicates
 - Close simultaneity of calibrated full spectral band coverage (within a few seconds for Vis-NIR-SWIR and within minutes for VSWIR to thermal) needed for large majority of data users to support routine data products
 - Partial spectral vicarious-calibrated solutions can augment, but do not negate need for backbone architecture providing calibrated near-simultaneous full-spectrum synoptic coverage
- ✧ We have narrowed our trade space for our more detailed immediate assessment
 - Focusing on architectures most likely to address near term issues **and** lead to a sustainable capability
 - Downsizing and decimation of instruments to enable microsat/nanosat constellation implementations is under study, but not considered a near-term solution due to performance risk
 - Full analysis will be included in complete report planned for August 2014
- ✧ Too few hosted payload opportunities exist in appropriate orbits to form basis of sustainable program
 - May be appropriate for targeted demonstrations
- ✧ The thermal IR measurements have the highest risk of a gap in the near term

AST Initial Assessments (2 of 2)



- ✧ Sentinel 2 satellites may serve as a reflective band component of or backup to a near-term capability
 - “... Sentinel-2 may augment Landsat capabilities, especially in frequency of (some) observations, and it may provide a bridge between Landsat 8 and 9 should Landsat 8 not exceed its five-year design life ...” (From the Landsat Science Team summary assessment, Jan 23, 2014)
 - Even while it is not necessarily a long term replacement for a USG solution
- ✧ Preliminary cost assessment conclusions are:
 - The program budget profile is the dominant factor constraining launch cadence
 - Sustainable architectures appear to exist that meet most program needs within the budget profile
 - Block buy efficiencies and robustness to launch failure may be difficult to achieve within budget constraints
 - A thermal-only near-term mission can address near-term thermal gap risk, but significantly delays soonest full capability USG architecture
 - Program budget constraints can amplify the inherent inefficiencies of disaggregated approaches (e.g., separate satellites for thermal and reflective band imagers) by delaying component launches, resulting in low availability of on-orbit full spectrum capabilities
 - Smaller microsat secondary-launch approaches may overcome this inefficiency if challenges to capturing and assembling full spectrum, calibrated, synoptic imagery can be overcome and demonstrated
 - A USG full spectral coverage capability likely not feasible until 2021 or later within our budget profile

Community & Stakeholder Engagement

- NASA and USGS will communicate the progress of the study with the community at established, planned events:
 - Oct 2013 Landsat Science Team Meeting
 - Dec 2013 USGS/NASA User's Workshop
 - Mar 2014 ASPRS/JACIE Meeting
 - Apr 2014 NASA/USGS Interim Status Briefing
 -on-going

Architecture Study Highlights To-Date

- ✓ Complete Check Point 1 Review and Industry/User Briefings Posted at:

<http://espd.gsfc.nasa.gov/landimagingstudy/>

- ✓ Check Point 2 Review completed and will be posted soon

SLI today and in the future

- Landsat is foundational but no longer an island
 - ✓ ***SLI – the integrator?***
 - ✓ ***SLI – the baseline?***
 - ✓ ***SLI – the innovator?***
 - ✓ ***SLI – the enabler?***

SLI Architecture Study Interim Status Briefing

Sustainable Land Imaging Architecture Study

Home

Request for Information

Reference Documents

Frequently Asked Questions

Event Archive

Sustainable Land Imaging Architecture Study Interim Status Briefing

Time: 9:00 a.m. - 12:00 p.m. EDT

Date: Tuesday, April 1, 2014

Location: NASA Headquarters James E. Webb Auditorium, 300 E Street, SW, Washington, D.C.

Related Links

- > [Landsat @ GSFC](#)
- > [Landsat @ USGS](#)

[Register for this Event](#)

<http://espd.gsfc.nasa.gov/landimagingstudy/>