National Research Council (NRC) Report

In 2011, USGS tasked NRC Space Studies Board to assess needs and opportunities for a national, space-based, operational land imaging capability:

- Identify stakeholders and their data needs
- Recommend characteristics and support areas for a sustained land imaging program
- Suggest baseline products and services to be derived
- Provide recommendations to facilitate the transition from single NASA research missions to a sustained land-imaging program

NRC Report (2013) Recommendations

The U.S. Government should establish a “Sustained and Enhanced Land Imaging Program” with persistent funding for current and future needs:

- Develop a plan for a comprehensive, integrated program that capitalizes on NASA and USGS strengths, maintains current capabilities, and enhances imaging capabilities and data products via emerging technology
- Ensure data flow continuously from satellites and periodically from aircraft to respond to the needs of image analysts and producers and consumers of derived products

NRC Recommendations, continued

- Establish partnerships with commercial firms and international programs
- Coordinate land-imaging data buys across the Government
- Include an R&D component for improved data products, new measurement methods, and evolving requirements
- Final NASA/USGS land imaging program decisions should be made by the agency that has been given the budget

Landsat Advisory Group (LAG) Review

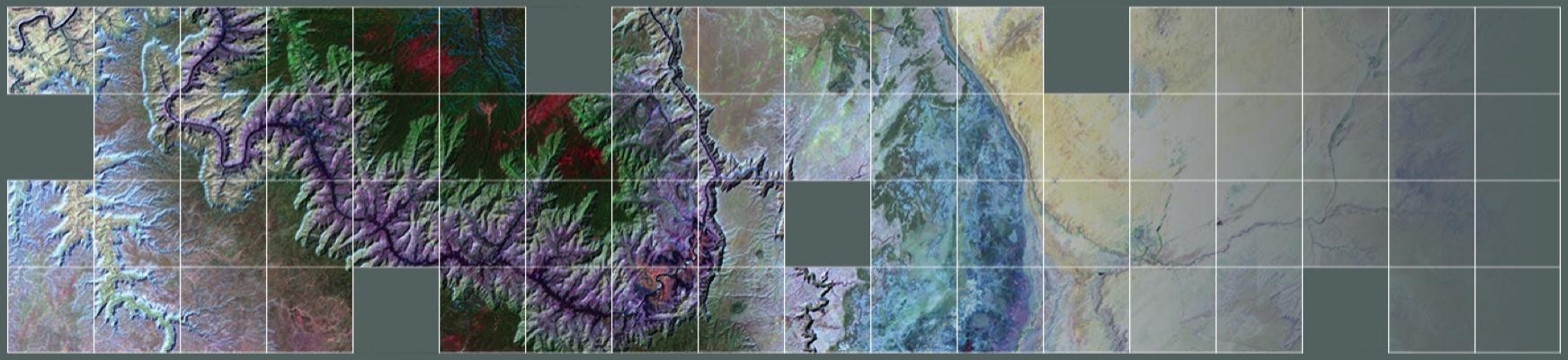
- USGS LAG found NRC report to be highly accurate in terms of Landsat program history, issues, and challenges for moving to operational status
- Special note was taken of NRC content on:
  - Land-imaging budget placement (NASA or DOI/USGS)
  - Landsat as part of an extensive, multi-sensor program
  - Major value of medium-resolution data
  - Applications that cannot be supported by Landsat
  - Consideration of low-cost alternatives for data continuity
  - Landsat as a unique global asset

NRC report: http://www.nap.edu/catalog.php?record_id=18420

USGS
science for a changing world

Climate and Land Use Change
Land Remote Sensing Program

National Land Imaging Requirements & Sustainable Land Imaging Update



Tim Newman
October 31, 2013

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

National Land Imaging Requirements (NLIR) Update

- NLIR continues elicitation of science and user communities and development of requirements assessment tools
- NLIR team completed a pilot project assessment in October, offering additional insight into user needs for land imaging
  - Pilot focuses on applications using moderate resolution imagery (5-120 m resolution)
  - Develops and tests the requirements elicitation methodology, process, and tools
  - Provides a representative sample of user requirements that can support near-term needs for mission formulation
- Results of the Pilot analysis to be used by Sustainable Land Imaging Architecture Study Team (AST)
- USGS continuing the NLIR elicitation and assessment process - LST members or colleagues may be consulted

USGS

Land Imaging in FY 2014 President's Budget for NASA

- *President's FY 2014 Budget release*
- *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.*

USGS

NASA – USGS Collaboration for Land Imaging

- **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.

USGS

Needed Assistance from the LST

- **For the study phase - NASA and USGS formulated an Architecture Study Team (AST) to assess architecture options for a long-term, sustainable land imaging program**
  - In addition to elicitation sources, the AST needs the support of the LST to assess the following:
    - Ascertaining the critical characteristics and reference parameters that define and maintain science data continuity
    - Determining the relative compatibility Sentinel 2 offers the Landsat community in terms of usability for science applications
    - Assessing required radiometric accuracy and stability needed for applications and the science impact of temporal variability in radiometry

USGS

Needed Assistance from the LST (cont.)

Ascertaining the critical characteristics and reference parameters that define and maintain science data continuity

- **USGS established a set of attributes to facilitate traceability between science/user needs and system specifications derived by the AST.**
  - Data Consistency and Continuity
    - Consistent and adequately calibrated with historical Landsat data record
  - Data Accessibility
  - Geographic Coverage
    - Cloud free global coverage; global extent; mean-crossing time
  - Temporal Frequency
    - Revisit rate; coincident or near-coincident imaging
  - Latency
  - Spectral Bands
  - Spatial Resolution
  - Accuracy
    - Absolute radiometry; SNR; stability; uniformity; geodetic accuracy; co-registration
- **What are the critical characteristics within these attributes needed to maintain continuity? Input needed by January 2014**

USGS

Needed Assistance from the LST (cont.)

Determining the relative compatibility Sentinel 2 offers the Landsat community in terms of usability for science applications

- **Assessment of Sentinel 2 characteristics to accomplish applications**
  - Known challenges include lack of thermal measurement, BRDF, data format, & non-WRS 2 orbital characteristics
  - What applications does Sentinel 2 not satisfy? In other words, can Sentinel 2 by itself maintain Landsat data continuity?
- **Other proposed analysis?**
- **Initial response desired by January 2014 with final response needed by April 2014**

USGS

Needed Assistance from the LST (cont.)

Assessing required radiometric accuracy and stability needed for applications and the science impact of temporal variability in radiometry

- What level of absolute calibration is required for specific applications?
- What is the science/applications impact of temporal variability in radiometry?

- **Response needed by April 2014**

USGS

Other Potential LST Study Topics by Application

- **Spectral precision**
  - Hyperspectral capabilities
- **Inherent spectral band registration**
- **Radiometric error and sensitivity analysis**
- **Coincident measurement analysis**

USGS

User Requirements Workshop - December

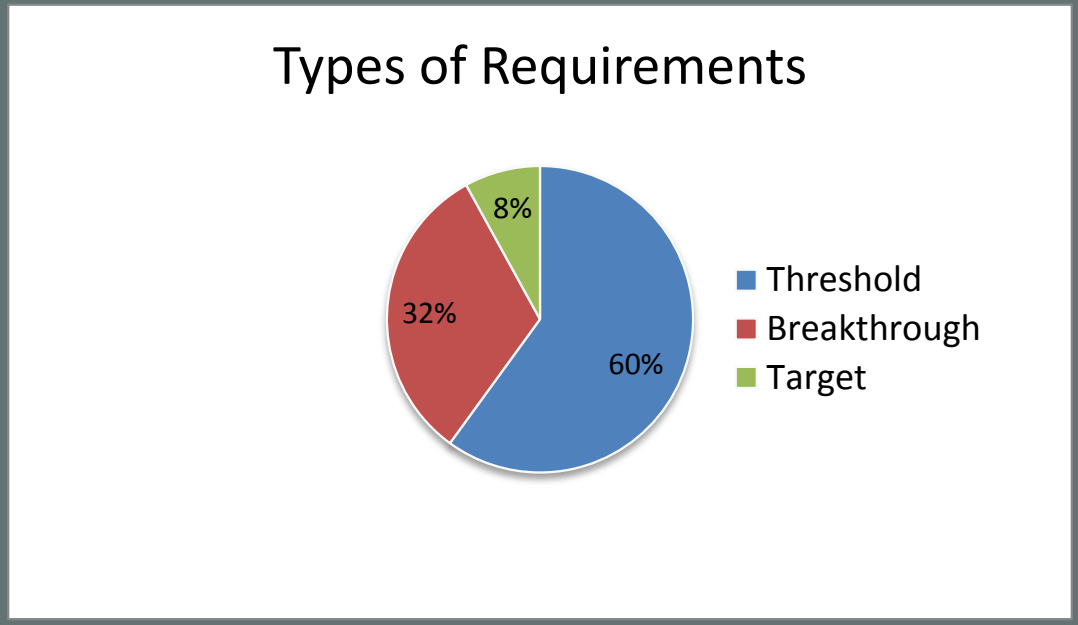
- **Purpose**
  - Seek community feedback on user requirements that will be used by the AST for the development of system performance requirements for the Sustainable Land Imaging Architecture Study
- **Date and Location**
  - Tentatively scheduled for the afternoon of December 4
  - Goddard Space Flight Center
- **Draft Agenda**
  - 1:00-1:15 Introduction – Tim Newman
  - 1:15-1:30 NASA Sustainable Land Imaging Program – Dave Jarrett/Steve Volz
  - 1:30-2:00 User Requirements Process – John Crowe/John Dwyer
  - 2:00-2:30 Architecture Study Team – Jim Nelson/ Del Jenstrom
  - 2:30-4:15 AST User Requirements – John Dwyer/Jeff Masek
  - 4:15-4:30 Closing Comments – Tim Newman
- **Other venues will be used to capture community feedback on AST architecture progress**

USGS

Backup

NLIR Pilot Project

- **User Requirements (preliminary results)**
  - 191 user requirements documented (3 levels)
    - **114 "Threshold" level** – minimum specification to be of any value
    - **62 "Breakthrough" level** – if met would result in significant improvement for the application
    - **15 "Target" level** – specification beyond which only limited additional increase in performance expected for the application



USGS

Detail Suggested LST Study Topics

(1) Spectral precision (e.g. hyperspectral capabilities).

- One option under consideration is to focus future (post-2020) land imaging development on a hyperspectral capability.
- What applications and science issues *require* hyperspectral data?
- What new science is likely to result from 8- to 16-day hyperspectral observations @ 30m resolution compared to current capabilities?
- Given a potential trade between more frequent multispectral coverage, and less frequent hyperspectral coverage, which capability comes closest to meeting your specific needs?

(2) Inherent spectral band registration

- A portion of the community is vocal about the pitfalls of relying on resampling to achieve band-to-band registration. An independent look at the errors by induced by resampling for Earth targets with various spatial content would be useful.

USGS

Detail Suggested LST Study Topics (cont.)

(3) Radiometric Error & Sensitivity Analysis and Other Radiometric Drivers

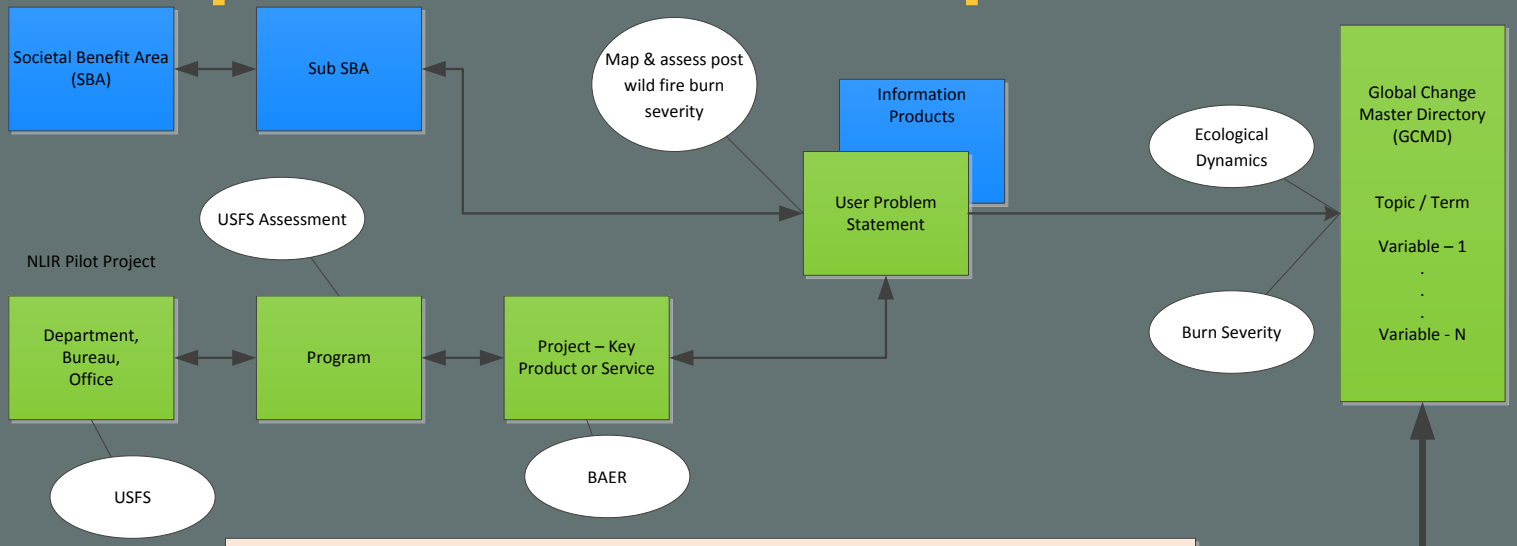
- Other radiometric drivers for OLI were pixel-to-pixel uniformity (drove spectral filters, linearity, stability, temperature control), ghosting, stray light, testing requirements, polarization. These factors could be rolled into an overall radiometric error & sensitivity analysis.

(4) Concurrent Measurement Requirements

- For specific applications, what are impacts of having measurements vary temporally between VNIR, SWIR, TIR. Look at the impact of having variation in coincidence measurement from sensor on board the same platform and across multiple platforms.
- For example, "In monitoring, what can or cannot be tolerated to maintain the consistency of the archive for long term monitoring, and what are the acceptable tolerances for measurement consistency in general and for key specific Landsat applications?"

USGS

Traceability of User Requirements to System Requirements – Example



	Data Consistency & Continuity	Data Accessibility	Geographic Coverage	Temporal Frequency	Latency	Spectral Bands	Spatial Resolution	Accuracy
	Consistent with Landsat Bands 4 & 7	*Free & open access*	*Cloud free CONUS, HI, AC, PR*	*8 Day Repeat* *Coincident VNIR & SWIR*		*NIR* *SWIR*	*20-60 m*	
Sustainable Land Imaging Architecture **"Threshold" System Specifications & Requirements**	*Preserve and extend Landsat Data Record*	*Free & open access*	*Cloud free* *Global Repeat*	*16 Day Repeat* *Coincident VNIR & SWIR*		*NIR* *SWIR*	*30 m*	