USGS Landsat Program Update

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

USGS National Land Imaging Program

Satellite Operations

Develop and operate systems to acquire, produce, preserve, and deliver products and services to meet civil Earth observation research and operational requirements

- Collect, archive, process & disseminate Landsat & Landsat-like data (Landsat 1-8, S-2)
- Operate the Landsat 7 and 8 satellites, calibrate and validate the incoming data
- Develop the Landsat 9 ground system in concert with NASA for 2020 launch
- Collect, maintain and analyze user requirements; inform 2019 Landsat 10 decision

Science, Research & Investigations

Conduct science, research and technology investigations to improve upon and develop new products and services

- Applied science & applications, including drought monitoring, global cropland estimates
- Remote sensing research and development, including unmanned airborne systems

Manage National Civil Applications activities

- Provide National Security Space system geospatial data supporting USGS applications
- Facilitate Federal civil agency use of these systems via Civil Applications Committee

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Fundamental goal: Ensure public availability of a primary data record about the *current state and historical condition* of the Earth's land surface

Landsat Operations and Development Status

Landsat 7 (1999-)

- Collecting about 475 new scenes per day; latest fuel estimate projects operating into 2021.

Landsat 8 (2013-)

- Collecting up to 725 new scenes per day; together with Landsat 7 supports 8-day revisit.

Landsat 9 (December 2020 launch)

- Essentially a copy of Landsat 8, but with important improvements for accuracy and resiliency
- Upgrade to fully Class B (Thermal IR instrument was a Class C instrument on Landsat 8); 14-bit data

Landsat 10 (~2025-2030 launch)

- Technology and user needs studies underway to support an architecture study to commence later this year.
- Everything is on the table at this point (e.g., smallsats, hyperspectral, data buys, Public-Private Partnerships).

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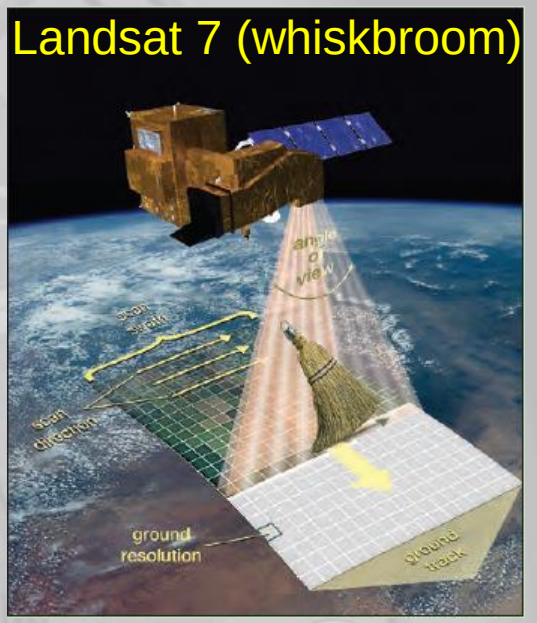

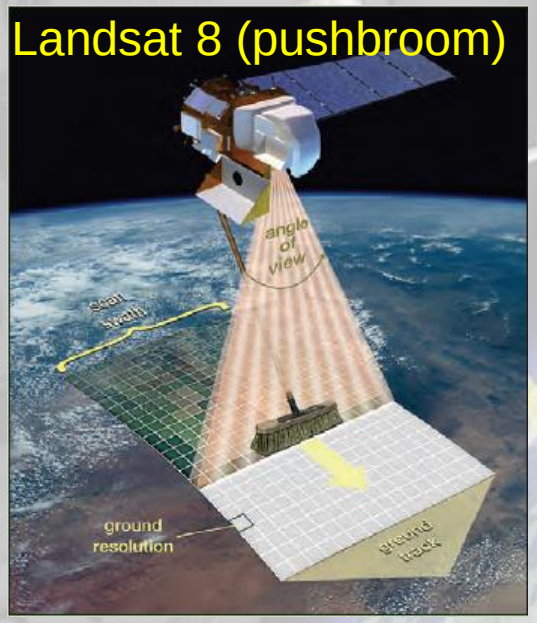

NLI Program Priorities for 2018-2019

- Inform Landsat 10 design and development via NASA-USGS **Architecture Study Team**
- Maintain **operational continuity** of Landsat 7 and Landsat 8
- Keep pace with NASA on **Landsat 9 development**
- Define and prepare for **Global Analysis Ready Data** (ARD)
- Obtain operational status and productivity from **Land Change Monitoring, Assessment, and Projection** (LCMAP)
- **IT modernization** for Landsat data leveraging commercial cloud
- Continue working toward **Landsat/Sentinel-2 harmonization**
- Investigate **UAS and small satellite** capabilities, Landsat synergies
- Release of **new Landsat user survey (now out!)**, OSTP **National Plan** for Civil Earth Observations/Earth Observations Assessment **(EOA) 2016** results synopsis
- Ensure future commercial data buys include **civil agency requirements and favorable licenses**
- Expand requirements collection scope to include all civil **high and low resolution requirements**

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Sustainable Land Imaging (SLI)

- Collaboration between NASA and DOI/USGS that enables the **development of a multi-decade,** spaceborne system that will provide users worldwide with high-quality, global, land-imaging measurements compatible with the existing 45+ year record
  - **Landsat 9 is the first SLI Mission**
  - **NASA and DOI/USGS to collaborate in developing program strategy and architecture**, identifying user needs, and defining mission requirements
  - **SLI Joint Steering Group** – Chaired by NASA Associate Administrator for Science and Interior Assistant Secretary for Water & Science – will meet periodically to coordinate and integrate SLI efforts, and to enable overall program strategy generation and approval
- Under the SLI program, NASA and DOI will continue to work together to ensure sustained access to land remote-sensing observations for U.S. research and operational users
  - **Space systems-- NASA** will maintain responsibility for developing, launching and checking out space systems on-orbit before transferring to USGS for operations
  - **Ground systems-- DOI/USGS** will be responsible for developing and maintaining, to include operating the on-orbit spacecraft, and collecting, archiving, processing and distributing SLI systems data to users

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Landsat 10 Planning under SLI

- Under SLI, USGS is working with NASA on early Landsat 10 planning activities, including requirements and technology development, to reduce cost and risk in future missions
  - USGS is partnering with Federal agencies and others to document the uses of and requirements for land imaging data
  - NASA is conducting instrument reduction studies, business model studies and other technology investigations to reduce cost and risk in next-generation Landsat missions
- USGS and NASA will continue requirements and technology activities and work together on a post-Landsat 9 Architecture Study in 2018-2019, leading to an initial decision as early as 2019 on the post-Landsat 9 system architecture, with launch in the mid-late 2020s
  - Everything is on the table at this point
  - Measurements must enable backward and forward assessments

Future Landsat systems need to ensure Earth Observation Continuity; USGS and NASA are open to new technologies, business approaches

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USGS User Needs

- Mod-res land imaging needs from Federal civil subject matter experts representing >150 science and operational applications
- Major findings:
  - At a minimum, users need continuity of Landsat data and derived products with free and open data access
  - To better perform their work, users need at least weekly clear observations; 10m spatial resolution for VNIR/SWIR and 10-30m for thermal; additional/narrower spectral (VNIR/SWIR/TIR) bands
  - Ideally, users need contiguous 10nm-wide VNIR/SWIR bands and more (5-8) thermal bands
  - Observation frequency is the most limiting factor; then spatial resolution
- Federal needs are similar to non-Federal needs
- Needs are maintained in USGS databases that can be dynamically sorted, visualized, and compared to capabilities - to support Architecture Study Team (AST) trade studies

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Landsat Data Policy Study for 2018

- Landsat Advisory Group (LAG) Task topic title: “Considerations of cost sharing models for Landsat data”
- DOI leadership is seeking to better understand economic and data policy considerations and impacts in relation to user needs, as well as the potential for public-private partnering (“P3”), with respect to various cost sharing models for Landsat data.
- The “fee recovery” issue has been looked into as recently as 2012 by the LAG—that paper can be found online at the NGAC website.
- This represents a good opportunity to inform current leadership on a number of Landsat data policy issues, in particular, the interplay with ESA’s adoption of a free and open policy for Sentinel.
- NLI’s position is to support an objective investigation by the LAG.
- Feedback and information: Email account (Landsatdatapolicy@usgs.gov) and FAQ section on EE website.

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Users, Uses, and Value of Landsat Satellite Imagery: Results from the 2018 Survey of Users

- OMB clearance & control number: 08/29/18
- Release date: 08/29/18 – Close ~ 10/24/18
- Sample size total: 27925 registered users
  - Users = EROS Registration System / CY2017
  - Mix of U.S. and International users
- Sections / Content: Use of Landsat Imagery, Landsat Characteristics, Landsat Processing & Distribution, Value of Landsat, & Work Experience

Wide impact from survey content, but note two questions…

- Willingness to Pay questions provide information about the value of Landsat to users – *input to LAG*
- Stated Choice questions provide information about Landsat improvement priority – *input for follow-on satellite(s)*

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Landsat Science Team (LST)

- The Landsat Science Team (1996-present)
  - Composed of **renowned scientists** across academia, government, and industry that rotate over 5 year terms.
  - Provides technical and scientific input to help **ensure the success of the Landsat program**.
  - Addresses issues including data acquisition, product access and format, and science and applications opportunities.
- Responsibilities include:
  - Represent the **breadth of user perspectives** and their requirements
  - Provide **feedback on critical design issues**, including functional performance specifications of the instruments and data systems that affect Landsat data users
  - Contribute to the specification of **data acquisition and data access strategies**
  - Consider **interoperability of Landsat with other systems** currently in orbit or planned
  - Conduct **studies on science and applications** elements of the program
  - Provide **insights on long-term issues** (e.g., future missions)

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Reflections on LST 2012-2017

Significant contributions made to:

- Defining Sustainable Land Imaging framework
- Providing science justification for revising the Landsat 7 and 8 acquisition schedules—**nearly doubling the scenes obtained per day** from ~650 to ~1200
- **Improving Landsat products**-- developed algorithms to deal with cloud/shadow detection, data tiling, and land cover change mapping, which were incorporated into USGS's Landsat operational systems.
- Demonstrating the **importance of absolute calibration** across the Landsat record to support the expansion of Landsat science and applications.

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Landsat Science Team Members (2018-2023)

- **Drs. Martha Anderson and Feng Gao**, USDA Agricultural Research Service: Characterizing crop water use, phenology and yield at field scales using multi-sensor data fusion.
- **Mr. Noel Gorelick**, Google: Driving cloud-based usage of Landsat with Google Earth Engine
- **Dr. Matthew Hansen**, University of Maryland: Generating time-series maps that accurately reflect land change area: a strategy for global land monitoring
- **Dr. Sean Healey**, US Forest Service: Landsat science and applications in the US Forest Service
- **Dr. Patrick Hostert**, Humboldt University of Berlin: Synergies between future Landsat and European satellite missions, from land cover to land use
- **Dr. Justin Huntington**, Desert Research Institute: Towards the development and integration of Landsat evapotranspiration ensembles and climate data for enhanced water and land management decision support
- **Mr. David Johnson**, USDA National Agricultural Statistics Service: Leveraging analysis ready Landsat products for use in crop production estimation
- **Dr. Leo Lymburner**, Geoscience Australia: Digital Earth Australia
- **Dr. Alexei Lyapustin**, NASA GSFC: Advanced atmospheric correction of Landsat 8/Sentinel 2 data using algorithm MAIAC
- **Dr. Nima Pahlevan**, Science Systems and Applications, Inc.: Landsat-Sentinel-2 constellation for monitoring aquatic systems across the United States
- **Mr. Jean-Francois Pekel and Dr. Peter Strobl**, European Commission Joint Research Centre: Copernicus Landsat convergence, architecture and applications
- **Dr. Volker Radeloff**, University of Wisconsin: Landsat data for biodiversity science and conservation
- **Dr. David Roy**, South Dakota State University: Pathfinding near real time moderate resolution land surface monitoring, looking forward to an operational Landsat 9/10 Sentinel 2A/2B era.
- **Dr. Ted Scambos**, University of Colorado: Landsat and the cryosphere: tracking interactions between ice, snow, and the Earth system
- **Dr. Crystal Schaaf**, University of Massachusetts, Boston: Global 30m snow and snow-free land surface albedo from Landsat and MODIS/VIIRS
- **Dr. Eric Vermote**, NASA Goddard Space Flight Center: Maintenance and refinement of the Land Surface Reflectance Code (LaSRC) for Landsat's and Sentinel 2's
- **Dr. Curtis Woodcock**, Boston University: New opportunities using the Landsat temporal domain: monitoring ecosystem health, condition and use
- **Dr. Michael Wulder**, Canadian Forest Service: Integrating time and space with Landsat to learn from the past, monitor the present, and prepare for the future
- **Dr. Zhe Zhu**, Texas Tech University: Toward near real-time monitoring and characterization of land surface change for the conterminous US

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U.S. Government (6)
U.S. Academia(7)
International (4)
Private Industry (2)

NLI Program Guidance to LST 2018-2023

- **Contribute to AST assessment for L-10**
  - Trade space recommendations for science
  - Radiometric sensitivity analyses
  - Impacts of error propagation from lower to higher level products
- **Contribute to Landsat harmonization with other remote sensing data**
  - Landsat / Sentinel-2 spatial and spectral
  - Commercial smallsats and Unmanned Aerial Systems
    - Techniques to exploit Landsat quality with lower-radiometric quality/higher spatial and/or temporal resolution systems
  - Future sensor assessments
    - Spectra Processing, Band aggregation, Advanced Processing

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