

# Landsat Next Update

## Water Resources Committee Western States Water Council Fall Meeting

Anchorage, Alaska  
September 14, 2023

Timothy Stryker

Chief, Outreach and Collaboration Branch

National Land Imaging Program

Core Science Systems Mission Area

U.S. Geological Survey

U.S. Department of the Interior



# USGS Mission Areas

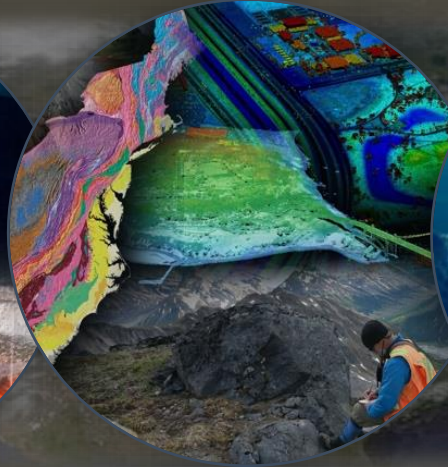
## Water Resources



## Natural Hazards



## Core Science Systems



## Ecosystems



## Energy and Minerals



### Vision

- Lead the Nation in 21st-century integrated research, assessments, and prediction of natural resources and processes to meet society's needs

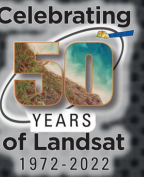
### Mission

- Monitor, analyze and predict current and evolving dynamics of complex human and natural Earth system interactions
- Deliver actionable intelligence at scales and timeframes relevant to decision makers



# USGS National Land Imaging Program: Roles and Responsibilities

AS DEFINED BY **PUBLIC LAW** AND **NATIONAL SPACE POLICY**,  
TO CARRY OUT THE PUBLIC INTEREST OF THE UNITED STATES:



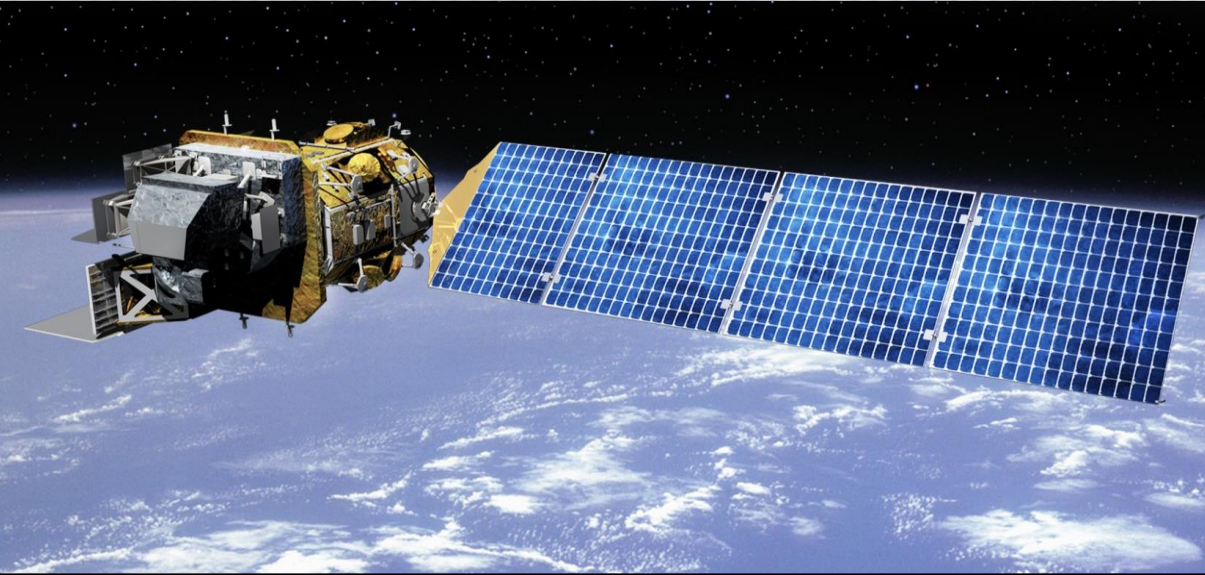
- **Operate and maintain a National Land Imaging Archive** to house a Basic Data Set of global data – for historical, scientific, and technical purposes – includes data from U.S. civil, commercial and foreign satellite systems
- **Operate and maintain the Landsat** flight and ground systems
- **Collect, process, archive and distribute these data** as Public Domain holdings of the United States
- **Determine U.S. civil operational requirements** for global land surface data and to conduct a national program of civil-operational land imaging
- **Conduct science, research and development in the applications of remote sensing** in order to enhance the ability of the U.S. to manage and utilize its renewable and nonrenewable resources
- **Develop civil applications and information tools** using known standards and protocols and make them available to the general public; facilitate federal civil agency use of National Security Space system data via the Civil Applications Committee

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



# What is Landsat?

The world's longest continuously operated land remote sensing satellite series and most widely used land remote sensing data set, helping us understand and manage natural and human-induced landscape change via a multitude of land, water, and natural resource management applications.



## Common Uses of Landsat data by Federal Agencies, States, and the private sector:

- |                              |                               |                           |
|------------------------------|-------------------------------|---------------------------|
| ● Agriculture and Forestry   | ● Water Quality and Resources | ● Famine Early Warning    |
| ● Regional Land Use Planning | ● Global Change Science       | ● Carbon Assessment       |
| ● Land Use/Land Cover        | ● Flood Management            | ● Drought Monitoring      |
| ● Fire/Disaster Management   | ● National Security           | ● Transportation Planning |
| ● Energy and Mineral Mapping | ● Ecosystem Monitoring        | ● Calibration/Validation  |

## Multi-spectral coverage in VNIR-SWIR-TIR\*\*

-> to map surface composition & temperature

## 15- / 30- / 100- meter spatial resolution

-> to resolve human-scale land dynamics

## 16-day revisit frequency (8-days with L8 and L9 satellites)

-> global, seasonal coverage

## Broad area collection => 12,000+ square miles per image

-> 1400 images/day = 20 million square miles/day

## Highly calibrated “science quality” data

-> to resolve long-term trends & retrieve biophysical variables

## Free and Open Data policy since 2008

-> 100 million products distributed and 4 billion data accesses via Commercial Cloud in the last year alone

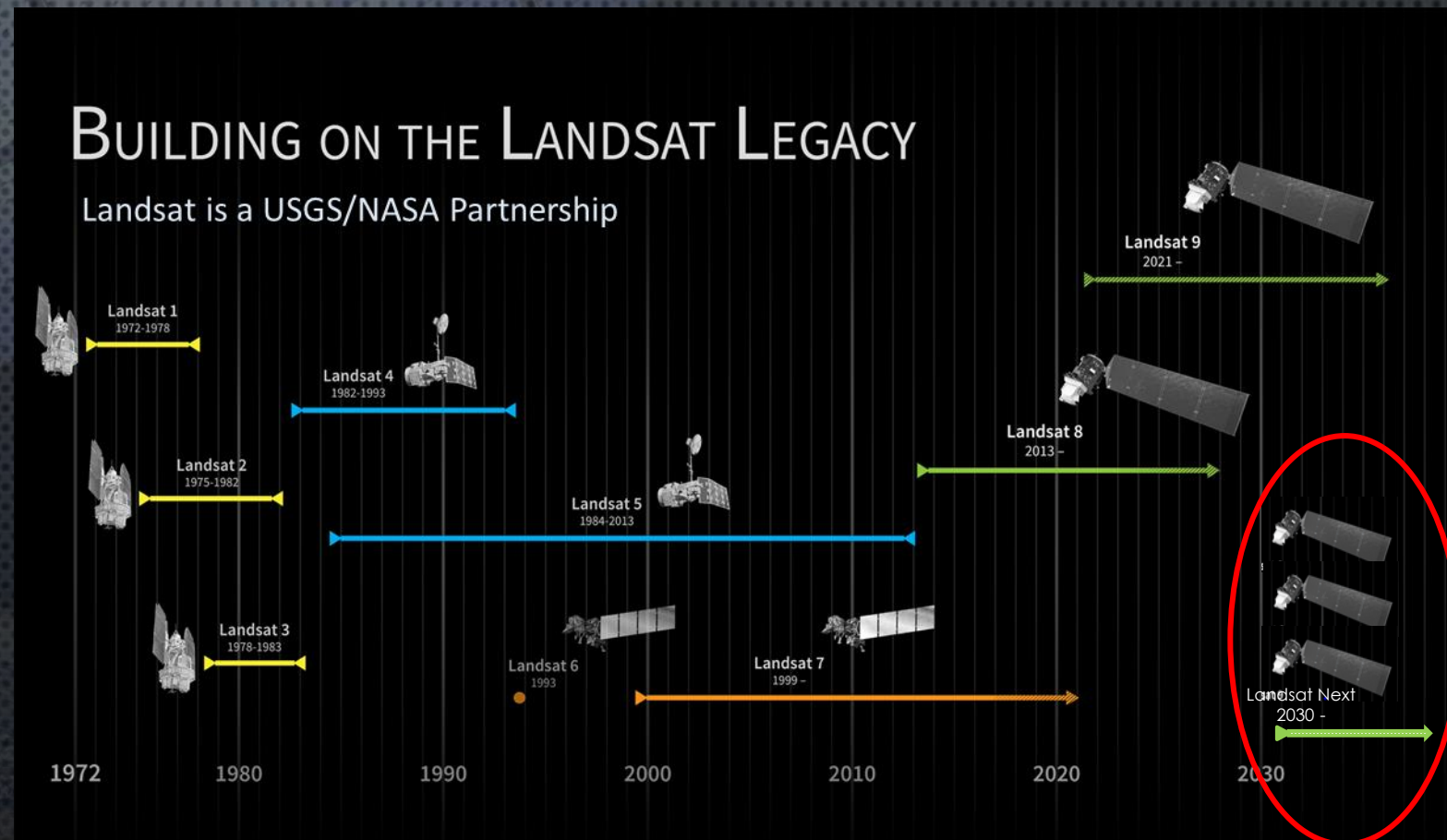
\*\*VNIR: Visible Near-Infrared SWIR: Shortwave Infrared TIR: Thermal Infrared



## Sustainable Land Imaging (SLI)

A partnership between DOI/USGS and NASA to ensure sustained access to high-quality, global, land-imaging measurements compatible with the existing 50-year Landsat record for research and operational users

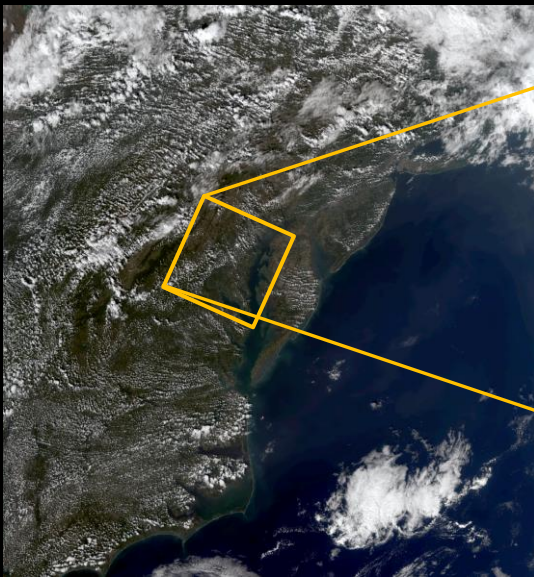
- NASA is responsible for developing the space segment, launch, and on-orbit check-out
- DOI/USGS is responsible for establishing user needs, developing the ground segment, and flight and ground system operations



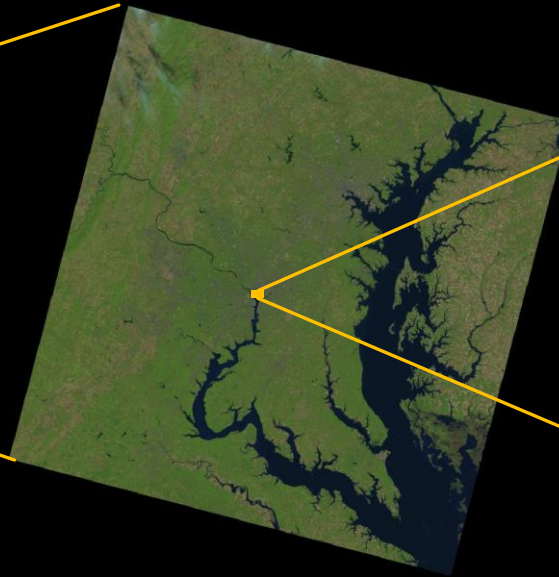


# Why is Landsat Unique?

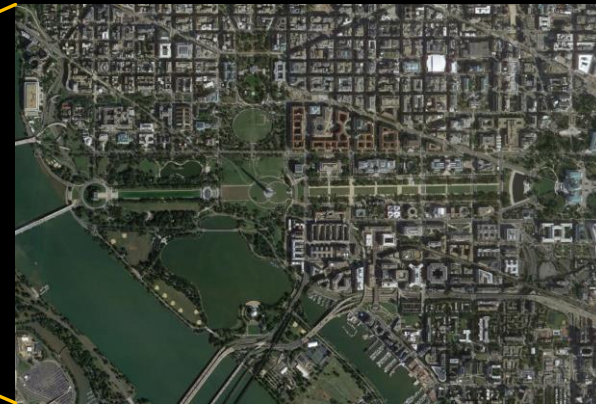
- Quality of imagery and global coverage
- Cross-calibration of sensor data
- Irreplaceable 50-year record of historical change of Earth's land surfaces
- Free and open data policy
- Landscape-scale resolution
- Simultaneous observations across the spectrum from visible to shortwave to thermal infrared bands
- Supports government (civil and military), commercial, non-profit, and education users across the U.S. and worldwide in a broad set of diverse applications



Weather-scale



Landsat



Commercial High-resolution



# Landsat Next Requirements Meet Emerging Needs

Multi-spectral → Super-spectral

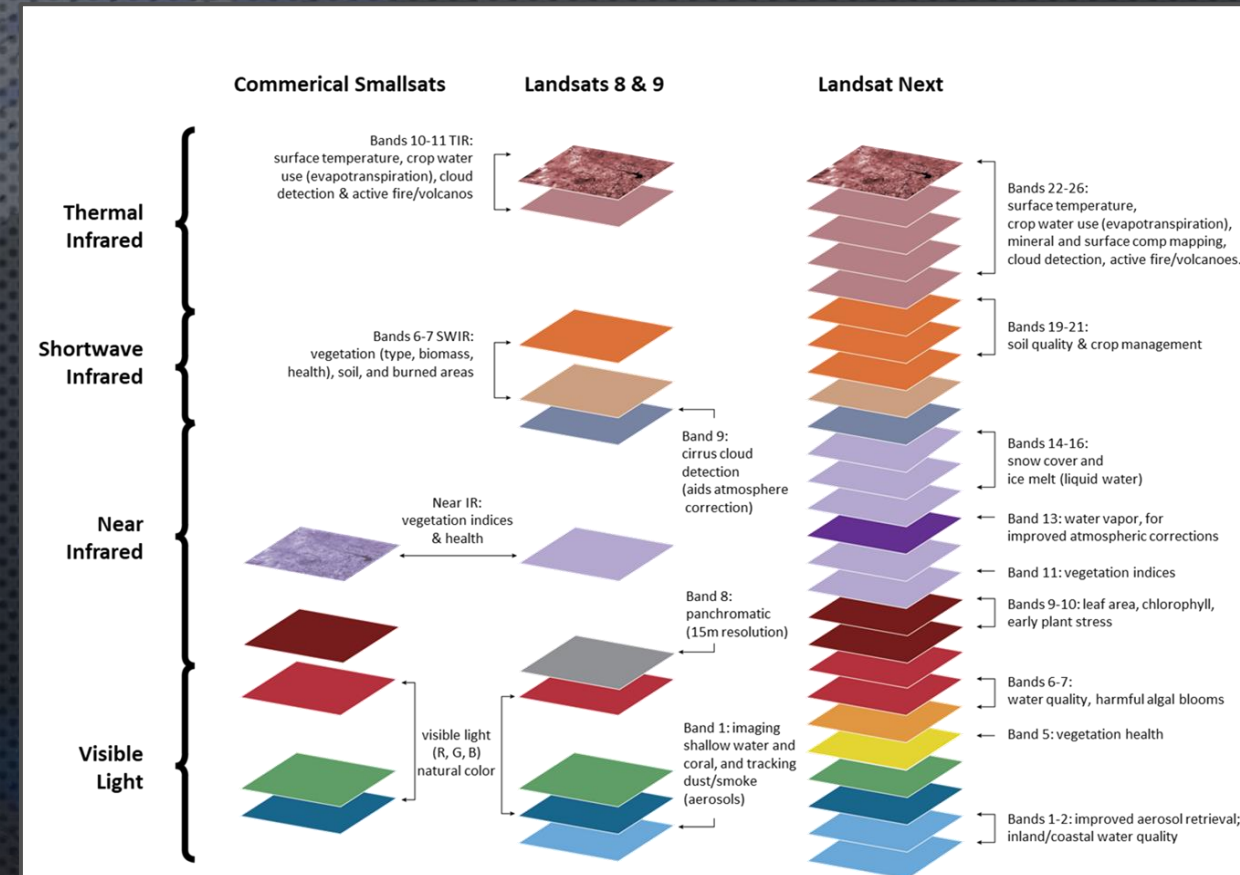
The USGS spent several years engaging with the user community to develop and validate requirements and set priorities for Landsat Next to meet emerging needs:

**Improved revisit frequency** to support applications which require ~weekly clear views, such as crop health & productivity, water quality, snow/ice state, wildfire

**Higher spatial resolution** (10-meter data vs 30-meter) to support monitoring of small agricultural fields, forest disturbance, urbanization, and other applications

**Additional spectral bands** to support emerging applications in water quality, snow hydrology, soil mapping, and other areas

**Maintaining radiometric quality** established by Landsat 8/9



Landsat Next will provide more than twice as many spectral bands as Landsat 8/9, with spatial resolution improved by a factor of two, and significantly improved repeat coverage



# Driving Applications for Landsat Next

Societal Benefit Area	Application	Science Benefits from Landsat Next
Agriculture	U.S and global agricultural monitoring	Landsat Next will allow states and USDA national and international services to have more precise observation of crop emergence.
	Crop residue monitoring/soil conservation	Landsat Next observations in the early growing season can allow states and the USDA Natural Resources Conservation Service to detect cover crop and crop residue for soil conservation at the field-scale.
Forestry	Forest health monitoring	Landsat Next will aid states, USFS, BIA, BLM, FWS, NPS and USGS in the detection and identification of insect/disease agents for forest health monitoring, since symptoms are often seasonal and transient.
Water Resources	Evapotranspiration and water use	Landsat Next frequent observations of evapotranspiration (ET) are needed for field-scale ET estimates and continuous water use monitoring operationally by Western States, BOR, USGS, FAS, and NASS.
Water Quality	HAB detection and monitoring	The new targeted spectral bands for water quality provided by Landsat Next will enable detection of specific organisms that cause harmful blooms.
Cryosphere	Snow/water availability	Higher temporal frequency and new targeted spectral measurement capabilities of Landsat Next will reduce cloud cover contamination while increasing detection.
Public Health	Monitoring urban heat islands	Landsat Next can help capture more frequent, intense, and longer heat waves as climate change indicators.
Wildfire	Pre- and post-fire assessment	Landsat Next higher temporal revisit is needed to capture the onset of more frequent wildfires and provide immediate post-fire response.





## Water Consumption

Agriculture accounts for 80-90% total US consumptive water use. In California alone, agricultural exports totaled \$21.7 billion in 2019

**Field-level evapotranspiration (ET) and continuous water use monitoring operationally benefit local/international farmers and water managers**

- **Landsat-derived actual ET** helped one large almond grower save ~25,000 gallons and a southern California grape grower saved 50% (~100,000 gallons) across 100 acres of vineyard.
- Continuous monitoring of irrigated water use requires **at least weekly observation**.





In collaboration with

# OPENET

OpenET, a public-private collaboration with over 30 experts in remote sensing science and technology. That includes NASA, USGS, USDA, DRI, the Environmental Defense Fund, and Google Earth Engine, to name a few!

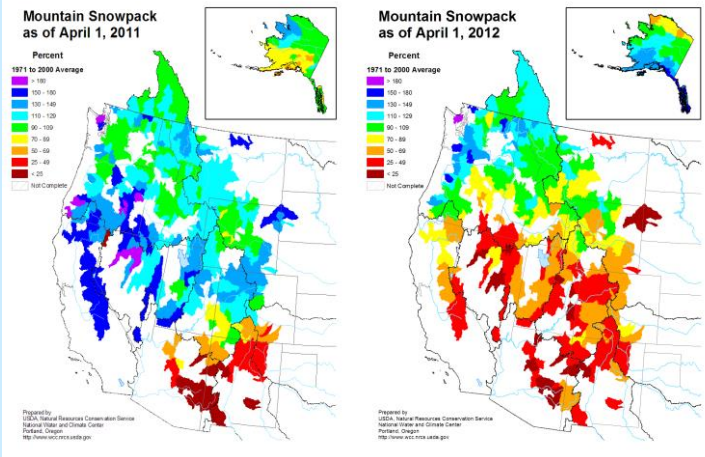
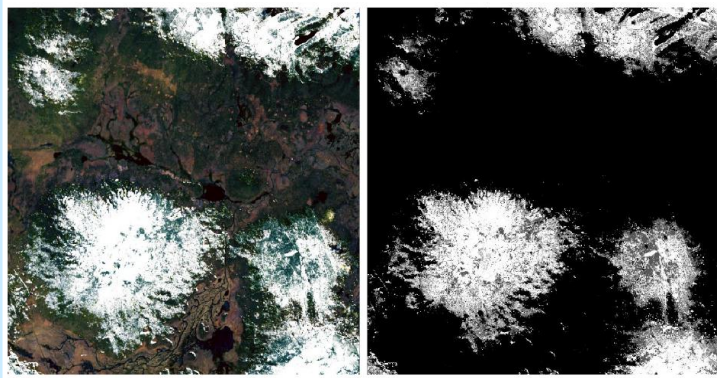
The result is after years of effort from partnering Federal agencies, universities, environmental groups, water managers, and farmers who use water to irrigate crops.

Find Data at:

<https://openetdata.org>

***Landsat provides  
crucial thermal  
information for  
estimating  
evapotranspiration and  
water use***





# Snow Hydrology

Landsat is needed to map and quantify snow-covered area and extent, snow cover duration and melt timing, surface albedo and light absorbing impurities.

- Long term trends in decreasing Northern Hemisphere spring snow cover show significant correlations with warming temperatures
- Western US seasonal snowpack contributes between 50 to 70% of available annual water quantity in storage reservoirs
- Light absorbing impurities on snow trigger earlier melt in dust prone regions

**Increased temporal frequency and new spectral measurement capabilities are needed for snow hydrology to:**

- Reduce cloud cover contamination while increasing detection of rapidly evolving snow processes and melt timing
- Measure the presence of liquid water content and snow grain size for melt state determination





## Water Quality

In the U.S. alone up to 48 million Americans drink from sources susceptible to Harmful algal blooms (HABs). HABs occur with increasing frequency and impact human health, the fishing industry, coastal and lakeside property, and tourism

- For Lake Erie, a summer-long algal bloom could result in 3600 fewer fishing licenses issued and \$2.25 million to \$5.58 million in lost economic activity.

**New spectral capabilities are needed to better detect the specific organisms that cause harmful blooms at higher frequency to allow early detection and timely mitigation**

- Narrow visible bands are needed for cyanobacteria tracking.
- A recent study indicates that Landsat Next spectral bands will improve the accuracy of HAB mapping by **up to 50%** compared to Landsat 8/9 (Zolfaghari et al., 2021)



# Landsat's Enduring Value *vis-a-vis* Commercial Earth Observation Satellites

**Rapidly growing commercial space industry is expanding the number of available Earth observation satellite systems**

- High resolution (5-meters or less) visible and near-infrared imaging Cubesats

**Although providing benefit in terms of higher resolution and more frequent revisit, commercial Earth observation satellites are unable to replicate full-spectrum Landsat, due to their size**

- Landsat's visible-near/shortwave/thermal infrared not possible on a CubeSat
- CubeSats' 1-day revisit, 5-meter resolution not possible on Landsat
- CubeSats are essentially cameras; Landsat is an advanced scientific instrument

**The Landsat full-spectrum global survey mission remains unique among U.S. federal and commercial missions**

- Collects **highly-calibrated science data** adhering to NIST & FGDC standards
- Provides **consistent global coverage**, regardless of commercial value
- Serves as a **trusted calibration reference** for other land-imaging satellites

***Commercial Earth-observing systems cannot replace Landsat, but are very complementary for environmental research and monitoring purposes***



Planet Dove



Landsat 8



# Landsat Next – The Follow-on Mission to Landsat 9

- SLI Joint Steering Group in 2017 requested a NASA/USGS study to consider post-Landsat 9 options
- SLI Architecture Study Team completed detailed study in 2020
- SLI Joint Steering Group approved a *multi-element* architecture in 2020, including Landsat Next, and approved the Landsat Next “Triplets” mission concept in 2022
- NASA & USGS Landsat Next project teams on track for instrument award in early 2024, with launch projected for 2030



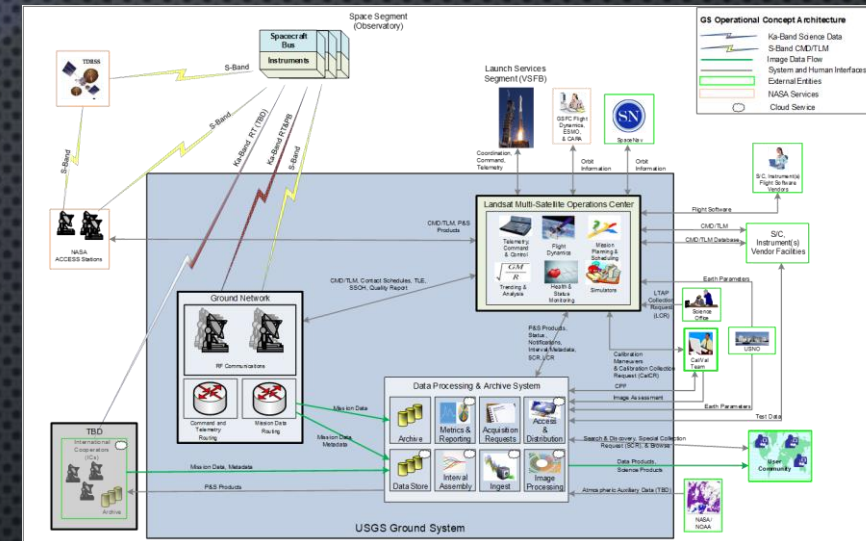
“Superspectral” Landsat Next will provide a completely new next-generation Landsat, meeting the users’ needs for richer spectral information and improved spatial and temporal resolution.

***2023 is a critical year for LNext***



# USGS Landsat Next Ground System Challenges

- **Mission Operations:** USGS will be potentially operating 4-5 satellite missions.
- **Data Volume:** Landsat Next will collect about 15 times the amount of data as Landsat 9.
- **Space-to-Ground Data Rate:** Given the increased data volume, Landsat Next requires more robust communications systems to transmit imagery data to the ground.
- **Ground Station Access:** Additional ground station contacts will be needed to download all of the imagery data.
- **Data processing:** More data processing will be needed for the increased data volume.
- **Data Storage:** The larger Landsat Next data volume will require more storage in the commercial cloud and come at an increased cost over today's data.
- **Data Product Dissemination:** With the increased demand by governmental and private users for the data, new ways to disseminate it will be needed.
- **Data Product Interoperability:** Future solutions will utilize observations and ancillary data from numerous sources, requiring improved data interoperability.



Landsat Next Ground System Architecture includes many components and interfaces

The increasing demands on the USGS Landsat Next ground system development require additional resources beyond the current NLI program baseline in order to keep pace with NASA on the multi-year development



# Landsat Next Programmatics



Federal Landsat Next activities are funded from two Congressional committees:

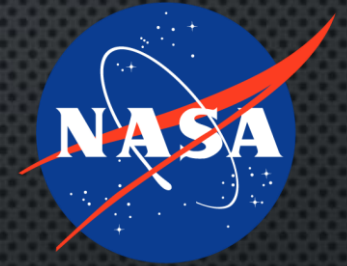
- Commerce, Justice, Science and Related Agencies for NASA
- Interior, Environment, and Related Agencies for DOI/USGS

NASA Landsat Next funding is contained within the NASA Earth Science Division

- Development of the space and launch segments – **Landsat Next** funding line
- Technology development – **Sustainable Land Imaging – Technology** line

DOI/USGS Landsat Next funding is contained within the National Land Imaging Program of the USGS Core Science Systems Mission Area

- Development and operation of the ground system and flight operations is through the **Satellite Operations** component of the NLI program funding line
- Science and applications work is through the **Science, Research and Investigations** (SRI) NLI funding line



**Both NASA and USGS requires full funding in FY24 to develop Landsat Next**





# USGS National Land Imaging (NLI) Program Budget

	2022 Enacted	2023 Enacted	2024 PB Request
<b>NLI Total</b>	<b>107,492</b>	<b>115,921</b>	<b>143,707</b>
--Satellite Operations (No-year dollars)	84,788	92,184	110,252
--Science, Research & Investigations (2-year)	22,704	23,737	33,455

FY24 President's Budget for NLI includes:

- Satellite Operations increases (+\$18,068,000) for:
  - **Landsat Next (+\$12,000,000)**
  - Commercial Data Pilot (+\$5,000,000)
  - Fixed Costs (+1,068,000)
- Science, Research & Investigations increases (+9,718,000) for:
  - Tools Supporting Conservation, Planning, Monitoring and Projection (+\$5,400,000)
  - Biologic Carbon Sequestration (+\$4,000,000)
  - Fixed Costs (+\$318,000)

A Satellite Operations increase to the USGS NLI base of \$12 million in FY24 is **critically needed** to allow the USGS to meet its Sustainable Land Imaging Landsat Next ground system development obligations.

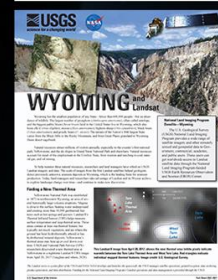
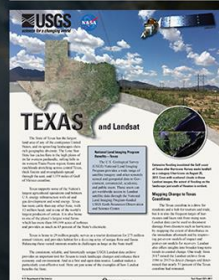
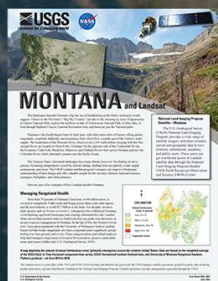
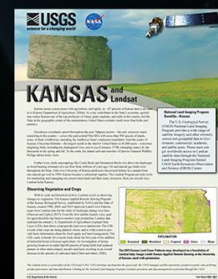
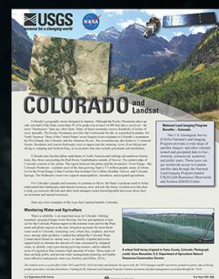
The Landsat Next mission will result in the largest collection of new Landsat data in the history of the program, estimated at 15 times the data volume of today's missions.

This significant increase in data volume and quality will place an enormous burden on the ground segment of the mission, the segment USGS is responsible for designing, developing, testing and fielding.

(Note: FY2023 Enacted included an NLI Satellite Operations increase (+\$6,546,000) for improved flight operations and maintenance of Landsats 8 and 9)



# LANDSAT in **your** State



50 YEARS EXPLORING OUR PLANET  
<https://geonarrative.usgs.gov/eroslegacy/>



# Thank You!

[tstryker@usgs.gov](mailto:tstryker@usgs.gov)



*False color image of the Anchorage, Alaska area, as observed by Landsat 9 on November 20, 2021.  
The image was built using infrared, red, and blue bands of the electromagnetic spectrum.*