



Earth Observations – Meeting the Requirements of the Science and Operational Communities

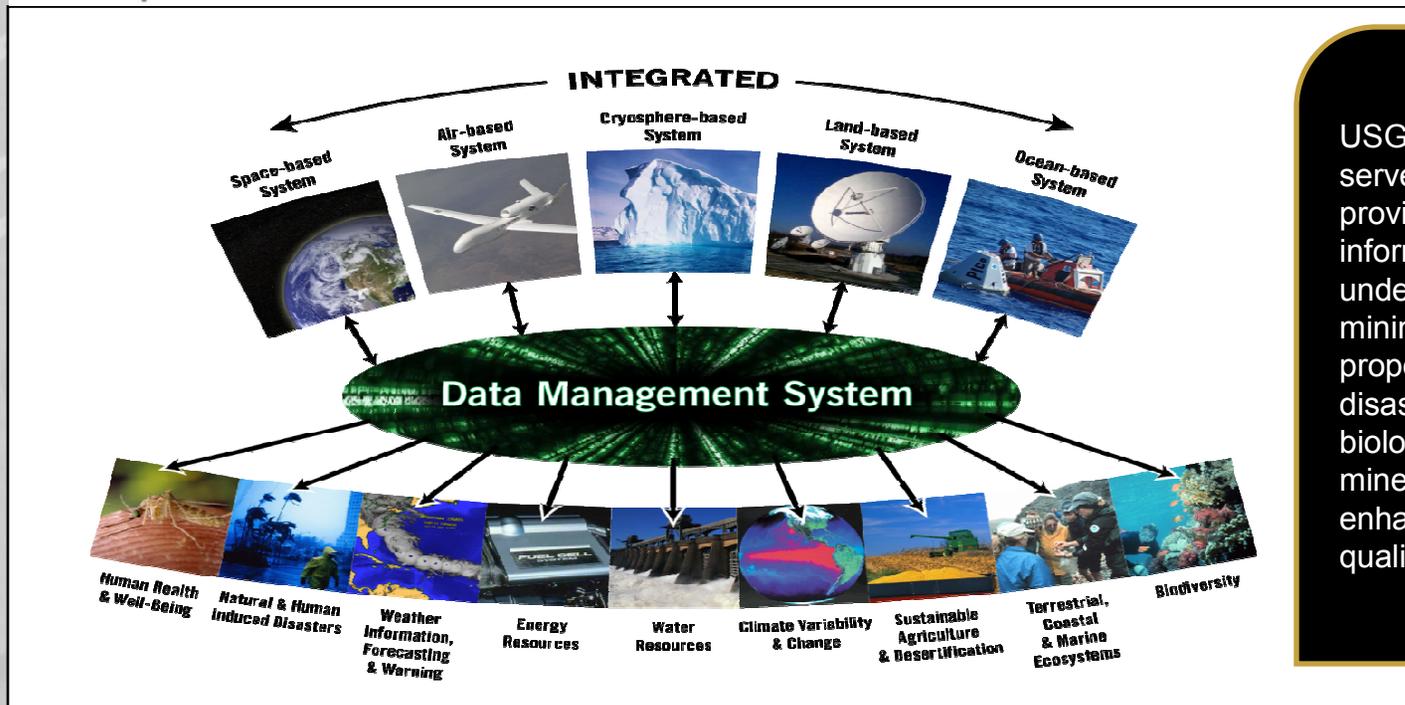
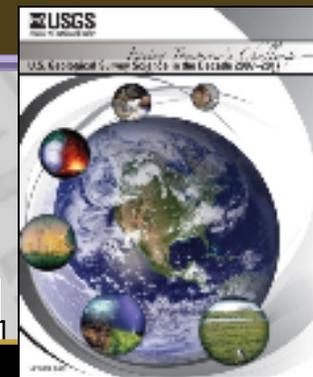
Bruce K. Quirk
JACIE Civil Commercial Imagery
Evaluation Workshop
March 31, 2009

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

USGS Science Strategy

- Provides key information and services that supports all the science themes.
 - “Report regularly on the Nation’s environmental and natural resource condition...”

Earthquakes ★ Floods ★ Hurricanes ★ Landslides ★ Tsunamis ★ Volcanoes ★ Wildfires



USGS Mission: The USGS serves the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

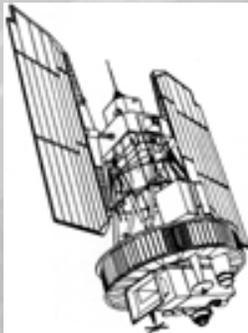


Earth Observation at Interior

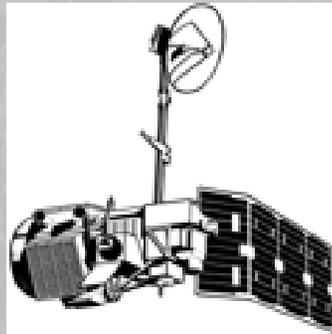
1966 - Initiated Earth Resources Observation Systems Program

“...the time is now right and urgent to apply space technology towards the solution of many pressing natural resource problems being compounded by population and industrial growth.”

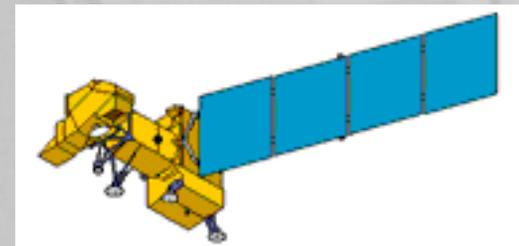
Secretary of the Interior Stewart L. Udall, 1966



Landsat 1-3
Multi-Spectral Scanner (MSS) 79 meter
Return Beam Vidicon (RBV) 80/40 meter



Landsat 4-5
Multi-Spectral Scanner (MSS) 79 meter
Thematic Mapper (TM) 30 meter



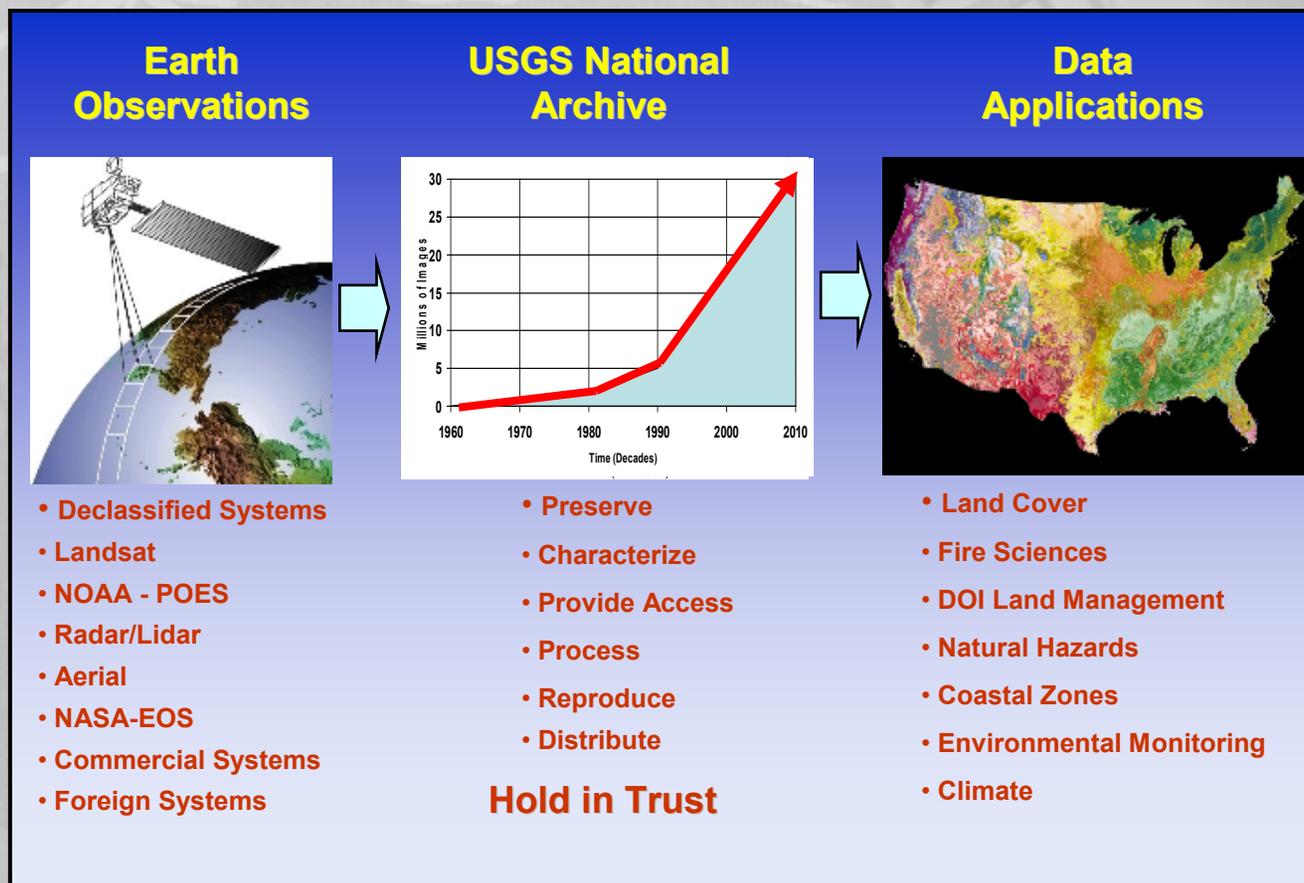
Landsat 7
Enhanced Thematic Mapper Plus (ETM+)
30/15 meter

**2009 – USGS Owns and Operates Landsats 5 and 7;
Archives and Distributes Earth Observation Data from 6 Operational
Satellites**



Land Remote Sensing Program

➤ *To be the leading operational source for Earth observation data and information.*



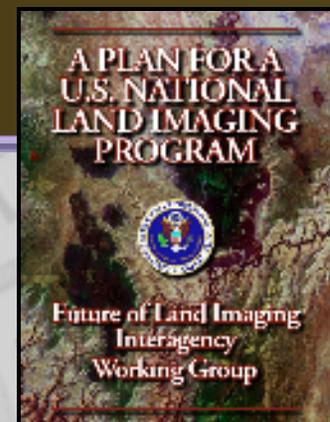
Land Remote Sensing Program Activities

- **AmericaView**
- **Landsat 5 Operations**
- **Landsat 7 Operations**
- **Landsat Data Continuity Mission (LDCM)**
- **Remote Sensing Science & Applications**
- **National Land RS Archive**
- **Aerial Film & Digital Archive**
- **Camera Calibration**
- **AVHRR Reception & Archive**
- **USGS QA Plan for Digital Aerial Imagery**
- **Inter-Agency Digital Imagery Working Group (IADIWG)**
- **National Elevation Dataset**
- **NOAA Backup Ground Station**
- **National Lidar Group**
- **EO1-Mission Archive**
- **Future EO requirements**
- **Nat'l Civil Applications Project (NCAP)**
- **Remote Sensing Technology Exploration**
- **CEOS representation**
- **GEO representation**
- **JACIE**
- **Landsat Data Gap**
- **.....and more!**

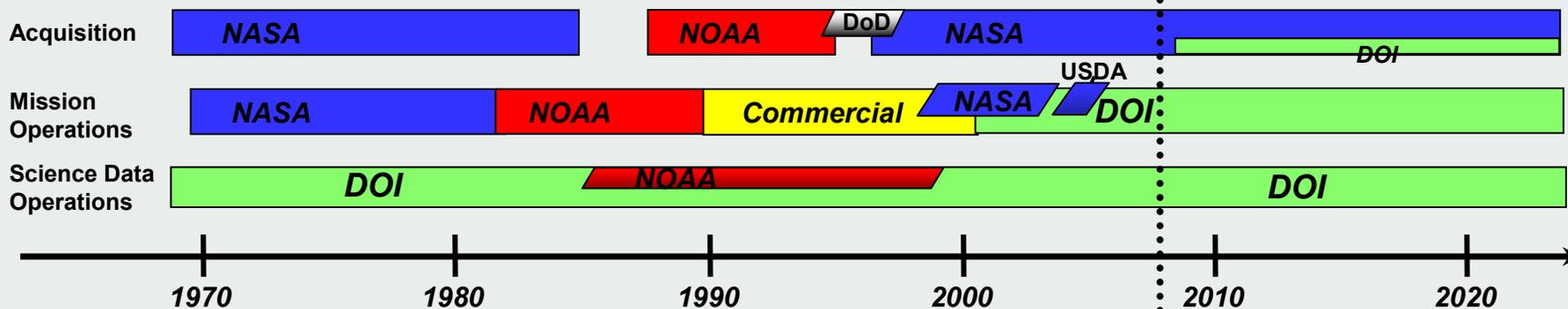
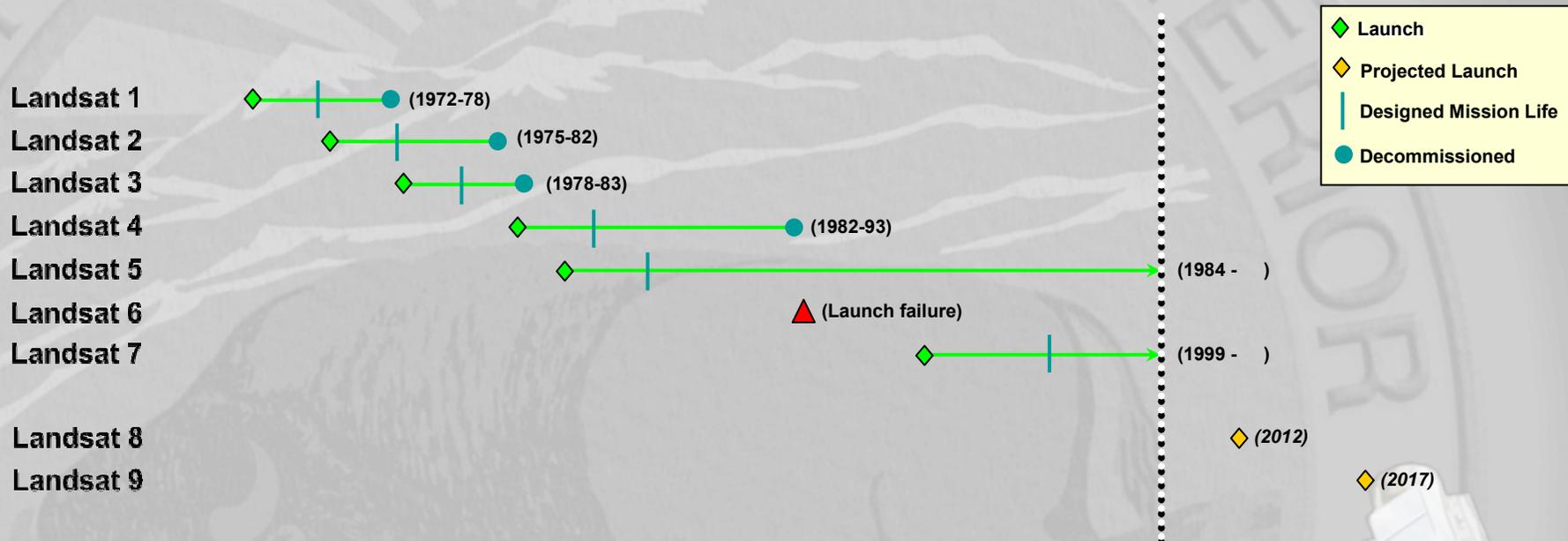


Current Year Objectives

- **Landsat 5 and 7 operations.**
- **Making data available - web enabling data sets.**
- **Landsat Data Continuity Mission.**
- **Landsat data gap implementation plan (JACIE).**
- Future requirements for Earth observation data (operational land monitoring).
- Cost/benefit analysis of moderate-resolution data.
- Radar, UAS, lidar, and aerial image data (JACIE).
- Applications of classified data.
- Redefining Research agenda.
- Make Landsat program operational – as envisioned in Future of Land Imaging report.



Landsat – Past, Present and Future



Earth Observation Activities

- **Conduct Landsat flight operations, data capture, archive, processing, and distribution.**
- **Routinely collect, archive, and distribute data from other sensors (e.g. Advanced Land Imager, Hyperion, MODIS, ASTER, and AVHRR).**
- **Developing ground data-processing and flight-operations systems for Landsat 8/LDCM as NASA develops satellite and sensor for December 2012 launch.**
 - **Operational Land Imager (OLI) instrument development on schedule.**
 - **Thermal instrument proposed in American Recovery and Investment Act of 2009.**
 - **Thermal instrument (TIRS) in initial design phase at NASA.**
 - **Spacecraft meeting key Preliminary Design Review milestone this week.**

Landsat Data Continuity Mission

Mission Science Objective: Extend the multi-decadal Landsat land surface observations to study, predict, and understand the consequences of land surface dynamics

Key Science Products: Moderate resolution maps of land cover/land use change over multiple decades including deforestation, agricultural extensification, and urbanization; documentation of ecosystem fragmentation and connectivity; identification and quantification of regional to continental scale sources and sinks of carbon

Mission Description and Status:

S/C: Awarded to General Dynamics Advanced Information Systems

Instrument: Operational Land Imager (OLI) multi-spectral, 30m,
185km swath (Ball Aerospace)

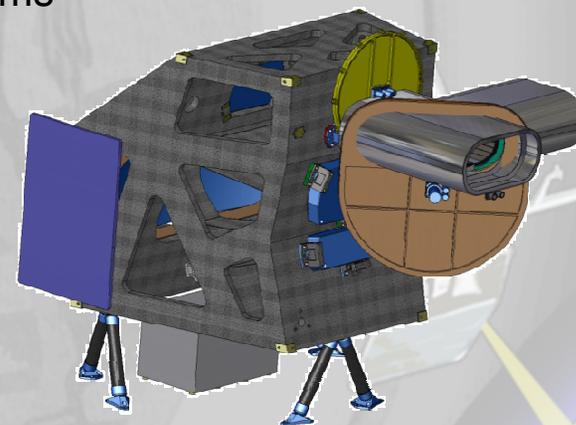
Launch Vehicle: Atlas V Model 401 (Lockheed Martin)

Orbit: 705 Km circular, sun-synch, 98.2°, 10:00 am +/- 15 mins.,
16-day repeat

Mission Life: 5 Years (with consumables for 10 years)

Mission Project Management: NASA/USGS

Launch Date: No Earlier Than (NET) December 2012



Operational Land Imager Spectral Bands

| Operational Land Imager (OLI) | | | Enhanced Thematic Mapper Plus (ETM+) | | |
|-------------------------------|----------------------------|------------------------|--------------------------------------|--------------------------------|------------------------|
| LDCM | Wavelength (micrometer) | Resolution (meters) | Landsat 7 | Wavelength (micrometer) | Resolution (meters) |
| Band 8 (pan) | .500-.680 | 15 | Band 8 | .52-.90 | 15 |
| Band 1 | .433-.453 | 30 | | | |
| Band 2 | .450-.515 | 30 | Band 1 | 0.45-0.52 | 30 |
| Band 3 | .525-.600 | 30 | Band 2 | 0.53-0.61 | 30 |
| Band 4 | .630-.680 | 30 | Band 3 | 0.63-0.69 | 30 |
| | | | Band 4 | 0.78-0.90 | 30 |
| Band 5 | .845-.885 | 30 | | | |
| Band 9 | 1.360-1.390 | 30 | | | |
| Band 6 | 1.560-1.660 | 30 | Band 5 | 1.55-1.75 | 30 |
| Band 7 | 2.100-2.300 | 30 | Band 7 | 2.09-2.35 | 30 |
| Band 10* | 10.3 - 11.3 | 120 | | | |
| Band 11* | 11.5 - 12.5 | 120 | Band 6 | 10.40-12.50 | 60 |

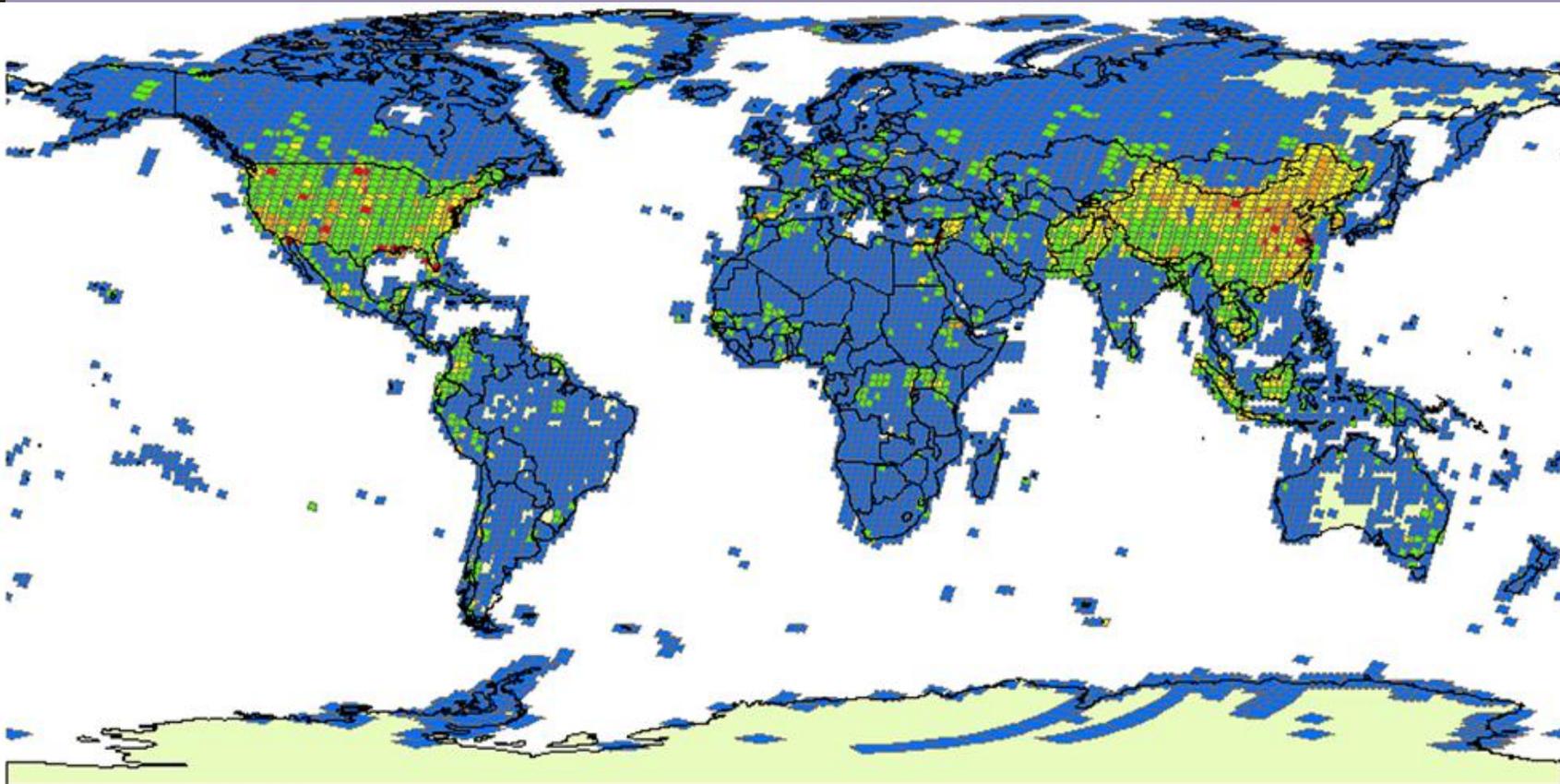


*Contingent upon requirement trades between program elements, technical elements, and mission risk as part of the LDCM procurement.

Earth Observation Activities (cont.)

- **Distribute over 2500 free Landsat scenes per day to broad range of users***
 - Over 455,000 scenes delivered since October 1, 2008
 - Seven fold increase in scientific and educational users
 - User shift toward multi-year scenes of same location
 - Landsat data downloaded in 155 countries
 - Highly favorable user responses
 - **Expanding free electronic data distribution to other USGS-managed data sets**
 - Historical SPOT satellite scenes over U.S.
 - Scanned photos from declassified intelligence-satellite archives
 - Scanned photos from USGS aerial mapping archives
- *Averaged 53 scenes sold per day in best sales year (2001)

Free Landsat Scenes Distributed Since October



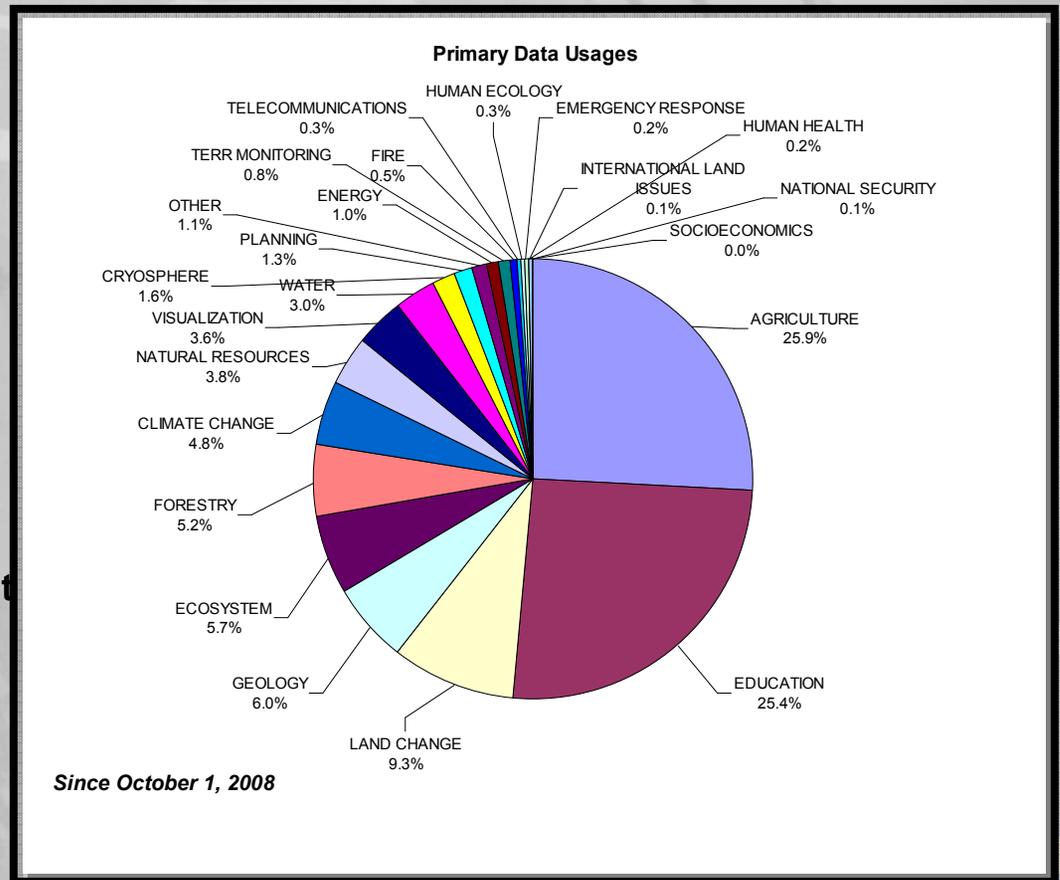
WRS2 Standard L1T Downloads
via User Interface and Bulk Users
October 1, 2008 through March 24, 2009
455,293 Total Scenes
8,479 Unique Locations

1 - 59 60 - 175 176 - 356 357 - 678 679 - 1511



Primary Uses of the Landsat Data

- Strong user endorsement of free data.
- Strong user demand for multiple historical scenes over specific locations vs. current scenes only.
- Increased use by scientists and educators.
- Working to improve web-enabling capability for users.
- Wider range of data uses - global forest inventory, tracking global deforestation, etc.



Web-enabling USGS Data

Summary list of Multi-Mission Data Sets at EROS.

NASA Funded Data Sets

NGP Funded Data Sets

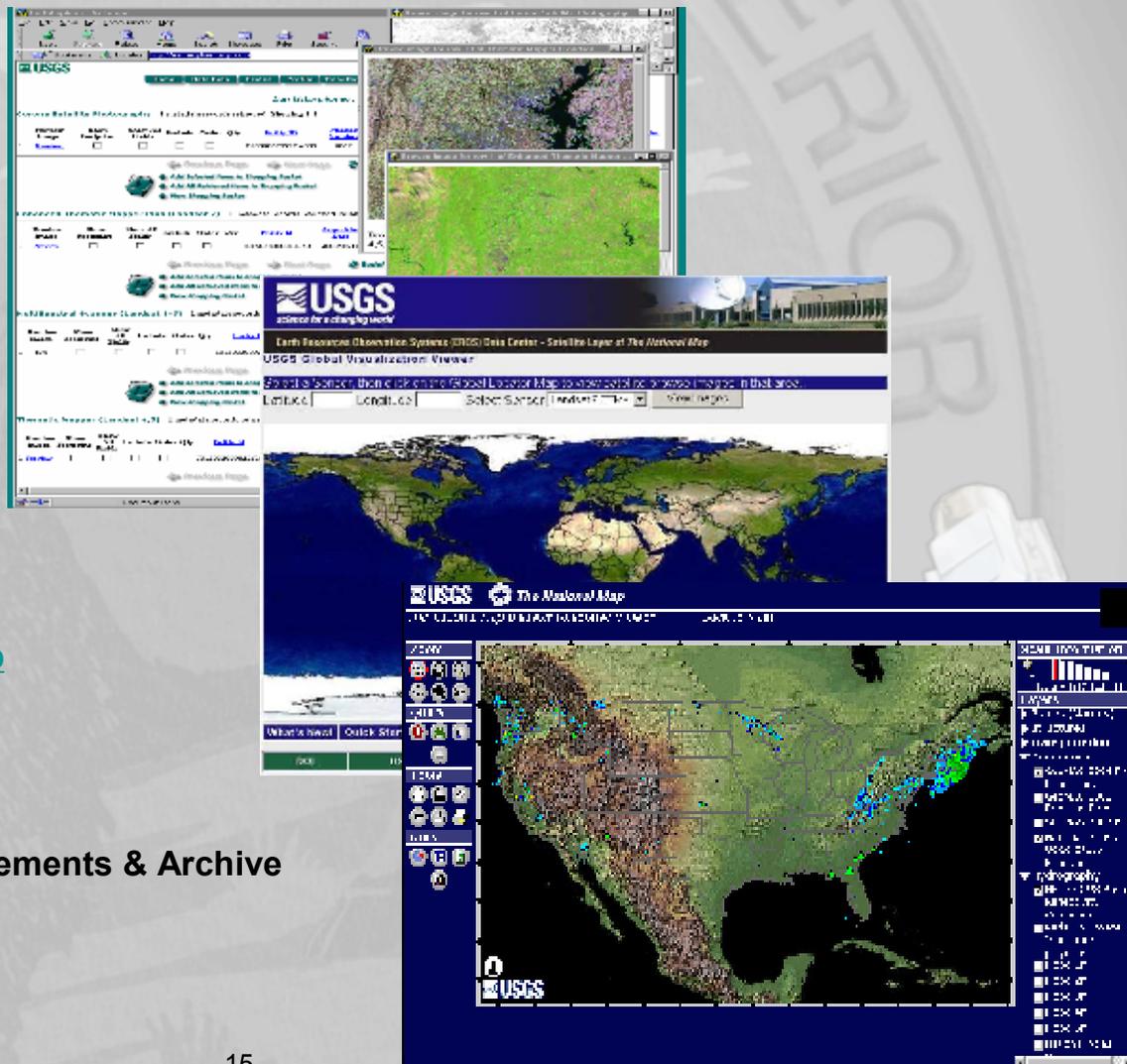
LRS Funded Data Sets

| USGS Satellite Film and Digital Data Sets | |
|---|--|
| Film Data Sets | Digital Data Sets |
| Skylab | Landsat Processed Data Collection |
| Gemini | TM Scrounge |
| Large Format Camera | NASA (V0) Landsat Processed Data Collection |
| Declassification I (CORONA, ARGON, LANYARD) | Landsat Orthorectified Scenes and Mosaics |
| Declassification II (KH-7, KH-9) | North American Landscape Characterization (NALC) |
| Landsat MSS, TM, and RBV Film | Global Land Cover Test Sites (GLCTS) |
| Digital Data Sets | Shuttle Imaging Radar-C (SIR-C) |
| EO-1 | Global Land Cover Characterization (GLCC) |
| SPOT | Multi-Resolution Land Characterization (MRLC) |
| Shuttle Radar Topography Mission (SRTM) | AVHRR Greenness maps (7/14 day) |
| AVHRR | ALOS Pulsar |
| Landsat 1-5,7 | WorldView |
| NASA LPDAAC Digital Data | QuickBird |
| MODIS | AWIFS |
| ASTER | SPOT / Eagle Vision |
| USGS Aerial Film and Digital Data Sets | |
| Department of Interior (DOI) Film | NASA Film |
| USGS Aerial Mapping Photography | Ames Research Center |
| National Aerial Photography Program (NAPP) | Johnson Space Center |
| National High-Altitude Photography (NHAP) | Wallops Island |
| High Resolution Ortho Imagery (Urban Areas) | Stennis |
| Bureau of Land Management | Kennedy Space Center |
| Bureau of Reclamation | Marshall Space Flight Center |
| National Park Service | Environmental Research Institute of Michigan |
| South Dakota State University | Digital Aerial Data Sets |
| InterMountain Survey | NASA Daedalus Scanner |
| McDonnell Douglas | Airborne Ocean Color Imager Aerial Scanner |
| Corp of Engineers (COE) | Side Look Airborne Radar (SLAR) |
| Department of Defense (DOD) Film | National Uranium Resource Evaluation (NURE/LIL) |
| Army Map Service | NPS Geophysical Research Program |
| U.S. Air Force | Advanced Solid-State Array Sensor (ASAS) |
| U.S. Navy | MODIS/ASTER Airborne Simulator (MASTER) |
| Scientific Committee on Antarctic Research (SCAR) | LIDAR |
| USGS Carto/Topo Digital Data Sets | |
| Digital Orthophoto Quad (DOQ) | Digital Elevation Model (DEM) |
| Digital Raster Graphic (DRG) | Digital Line Graph (DLG) |
| High ResOrtho Digital Imagery | National Atlas |



Accessing Earth Observation Data

- Earth Explorer
 - <http://earthexplorer.usgs.gov>
- Global Visualization Viewer
 - <http://glovis.usgs.gov/>
- The National Map
 - <http://nationalmap.usgs.gov>
- Seamless
 - <http://seamless.usgs.gov>
- NASA DAAC EDG
 - <http://lpdaac.usgs.gov/main.asp>
- Web Mapping Services
 - <http://gisdata.usgs.net>
- Commercial RS Satellite Requirements & Archive
 - <http://crssp.usgs.gov>



Landsat Data Gap Study Team

- **Landsat Program maintains a national archive of land remote sensing data (PL 102-555).**
- **Landsat data flow might be disrupted before LDCM.**
 - Landsat 5 limited lifetime/coverage.
 - Degraded Landsat 7 operations.
 - Either or both satellites could fail at any time interrupting a 37 year time series of land observations.
- **Landsat Program Management needed to consider.**
 - Performance and utility of alternate data sources to lessen the impact of a gap.
 - Feasibility of acquiring gap-filler sources.
 - Potential to “augment” archive.
- **Landsat Data Gap Study Team formed to analyze potential mitigation strategies.**



Landsat Data Gap Plan

➤ Landsat Data Gap

- Phase 1: identify requirements to determine imagery that would minimally fulfill user needs; identify, assess, and recommend alternative sources that can best provide repeat global land observations.
- Phase 2: Preparing multi-source data-acquisition plan, including enterprise architecture and business model options, to mitigate potential Landsat data gap and augment single-satellite (Landsat 8) data stream.

Landsat Data Gap – Phase 2

➤ Deliverables for May 2009

- Detailed plan of the USGS business model (including cost, licensing, archiving) for integrating new missions into our existing operational framework.
- Reaffirm, with the Landsat Science Team, data requirements for operational and scientific purposes.
- Updating the calibration and validation studies previously performed, if required, and doing new calibration and validation studies given the advent of new capabilities.

Phase 2 Candidate Systems

- **Primary focus is on five systems:**
 - ResourceSat-1 / IRS-P6
 - CBERS-2B
 - SPOT 4/5
 - RapidEye constellation
 - DMC-2 constellation
- **Other satellites can be considered as they become available.**

Land Remote Sensing Vision: 2012

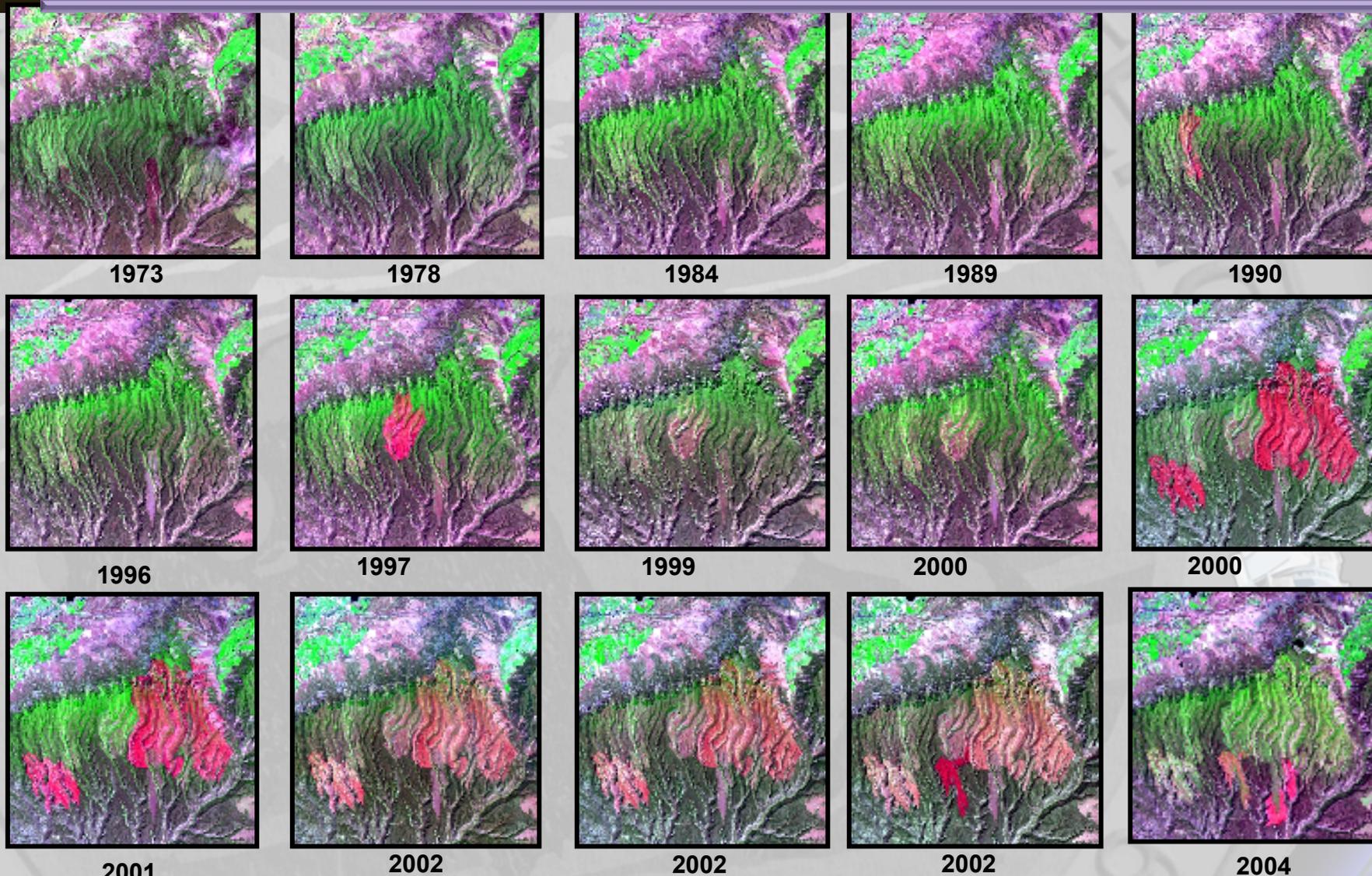
- **A DOI-centric, operational Earth Observation System (of systems)**
 - Needs of DOI users form primary requirements
 - Anchored by moderate resolution data - Landsat
 - Provides consistent, high quality, calibrated, seasonal, global data
- **“Gaps” filled by other systems**
 - Data evaluation, validation, and acquisition
 - International moderate resolution data
 - U.S. commercial high resolution data
 - Provides site/event specific data
 - Future moderate resolution systems (small satellites)
 - Low resolution data (VIIRS)
 - Aircraft/UASs
- **Buy data to influence future system development**
- **Robust research program**



Remote Sensing Summary

- **Remote sensing is a powerful tool for monitoring the Earth's global health and environment**
- **These data are critical for compilation and maintenance of U.S. government programs**
 - *Currency*
 - *Cost-effective*
 - *Broad-area coverage*
 - *Multi-resolution and multi-sensor*
- **USGS is committed to acquisition, preservation, data interoperability, and application of remote sensing data and technology**
- **Commercial and international cooperative partnerships are critical to success**

Value of the Archive Mesa Verde National Park Fire Atlas



JACIE

Joint Agency Commercial/Civil Imagery Evaluation

- **An important part of LRS**
- **Understand other datasets**
 - **Calibration**
 - **Science Usability**
- **Coordinate with other agencies**
 - **Input from industry and academia**
- **Critical to data gap, Multi-mission, International Operations**
- **Vital to answering science questions to address societal needs**

JACIE Characterization Activities

- **Coordinate/partner with other agencies**
 - Input from industry and academia
- **Understand remote sensing data and applications**
 - Calibration and validation
 - Science Usability
- **Assessment ranges and process**
 - high resolution satellite and digital aerial systems
 - Medium resolution satellite and Landsat comparison
- **Critical to data gap, Multi-mission , and International Operations**
- **Vital to answering science questions to address societal needs**

JACIE type Quality Process

➤ Interoperability

- CEOS/GEO QA4EO Framework and Guidelines
 - <http://calvalportal.ceos.org/CalValPortal/welcome.do>
- JACIE Process - <http://calval.cr.usgs.gov/jacie.php>
- USGS Catalog of Worldwide Test Sites for Sensor Characterization
 - http://calval.cr.usgs.gov/sites_catalog_map.php
- USGS High Resolution Sensor Calibration and Validation Sites
 - http://calval.cr.usgs.gov/digital_aerial_imaging_quality_assurance.php

