Evolution of the USGS National Land Imaging Requirements Project

- President’s FY12 budget request that included funding for Landsat 9
  - Language included “understanding Federal land imaging requirements.”
- Initiated National Land Imaging Requirements Project Plan
- Collaboration with NOAA Technology Planning and Integration for Observations (TPIO) office
USGS EO Requirements Evaluation System Goals

- Institutionalize the characterization and exploitation of all EO requirements to attain greater awareness of user community needs and potential solutions
  - Land Remote Sensing (LRS) Focus on service to Land EO Requirements
    - Understanding the broader picture critical
  - Build on Previous Successful Models
  - Design towards a Unified EO requirements architecture
  - Partner with EO community Practitioners
    - Producers and Consumers
    - US Federal
    - International
USGS EO Requirements Evaluation
System Goals

- **Program and Budget Justification**
  - Characterization of Communities of use
  - Documentation of requirements being served
  - Valuation of services being delivered

- **Informing Program Direction**
  - Informing Land EO System Design/Development
  - Informing Services Design/Delivery
  - Validating/Adjusting Data/Information Offerings, Informing value added product generation
USGS Requirements Evaluation System Principles

- Broaden access to user/practitioner community and expand view to all EO requirements and assets/solutions

- Maintain Requirements and Solutions separately
  - Collect and Maintain requirements in a solution agnostic approach
    - Common Requirements architecture
    - EO Requirements cross over communities of practice and Programs
  - Collect and Characterize solutions in a standardized architecture which will align with the broader EO services community
    - Platform/Sensor Inclusive
      - Space/Air/Land/Sea
    - Products and Services
Joint Approach: Two Complementary Components

System Development
Joint Unified Architecture
- Earth Observation Requirements Evaluation System (EORES)
  - Repository for requirements and capability information
  - Analytical tools

Requirements Elicitation
Customizable to Agency Needs
- User Requirements Elicitation
  - All earth observation needs – broad and diverse user community
  - Traceability via value tree
  - Repeatable and transparent process

Joint development with NOAA/TPIO And USGS/LRS Program

Developed from previous and current efforts: NOSIA, NOSIA II, NLIR Mod Rez Pilot.
(Value Tree) + Requirements
Requirements Elicitation

- **NOT Starting from Scratch!**
  - NOAA (2003-Present)
    - User requirements documentation and validation
      - NOSA, CORL, Casa Nosa…
    - Requirements analysis
    - NOSIA I and II (integrated portfolio analysis)
  - Provided basis for assessment structure in the National Earth Observations Task Force Strategy
  - Landsat Applications Study (NASA/USGS, October 2012)
  - Many years of corporate knowledge
    - Program and solutions specific requirements analysis
  - Joint effort between NOAA and USGS to build off of those bodies of work
Requirements Elicitation (cont.)

- **Requirements Elicitation Process**
  - Series of step-wise engagements/activities
  - Iterative process, NOT a one-time consultation
  - Customer-focused, customized discussions

- **Some key elements of the methodology**
  - Value Tree
  - Expert Elicitation
  - Multi-Attribute Utility Theory
  - Swing-Weighting
Mission Service Area: A grouping of like activities, products or services intended to achieve a stated agency, office, bureau strategy, goal, or objective

Key Products/Services: The means of delivery of value for the Mission Service Area

Earth Observation Datasets: The information needed to produce Key Products/Services

- Can consist of intermediate products, model output, or be directly used from observing systems to produce the Key Product
Key Products/Services provide a consistent and enduring component that can be mapped/remapped to any value tree:

- Organizational
- SBA
- Other
Joint Approach: Two Complementary Components

**System Development**

- **Joint Unified Architecture**
  - **Earth Observation Requirements Evaluation System (EORES)**
    - Repository for requirements and capability information
    - Analytical tools

**Requirements Elicitation**

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Joint development with NOAA/TPIO and USGS/LRS

Developed from previous and current pilots: NOSIA, EOA, NOSIA II, NLIR Mod Rez Pilot.

(Value Tree) + Requirements
Earth Observation Requirements Evaluation System (EORES)

- EORES being Developed utilizing AGILE Development Methodology with Interagency development teams

- EORES provides processes, databases and software tools to:
  - Ingest, validate, store, and prioritize platform-independent user requirements
  - Manage and maintain information describing Earth Observation Systems and solutions
  - Provide data and analyses to inform decisions related to Earth Observation needs, gaps, and priorities, to inform satellite mission formulation and other observing systems decisions

- EORES provides the architecture to store and manage information:
  - Documentation of requirements using a standard set of attributes (temporal, spatial, spectral resolution, coverage, frequency, etc.)
  - NASA Global Change Master Directory (GCMD) base taxonomy
  - Capturing traceability of each requirement to agency missions, service delivery and/or societal benefit using a “value tree” approach
Earth Observation Requirements Evaluation System (EORES)

- **Project Elements**
  - System Conceptual and Logical Design
    - Detailed Analysis and design phase
    - All EO assets and requirements considered
      - Solutions: all platform, all types
      - Requirements: all EO, Land, Air, Ocean…
    - Blueprint for development
  - IT/Software/Database Development
    - Hardware, software and database components
    - Data model to supports current and future analytical needs with standardized nomenclatures, data formats, etc.
  - Working Project as a “Joint Development” with NOAA (TPIO)
    - Leverage resources and experience of both Agencies
    - Goal is a system that will meet both agency’s highly-compatible needs
    - AGILE Development Methodology fits joint development
  - Development of Standardized and Enduring Processes***
    - User requirements elicitation, validation, analysis
    - Value tree construction and population (traceability of requirements)

***Processes established must be credible and repeatable
Ongoing Activities
Future Steady State

- Maintain-Expand-Refine-Exercise
  - EORES Maintenance
    - Systems maintenance/enhancement (DB’s, hardware, software, interfaces)
    - Information Maintenance (Content currency: Requirements and solutions)
  - Ongoing Elicitation
    - Addition of Customers, Stakeholders and Communities of interest, adding depth
    - Periodic Re-validation/update of User’s Requirements
  - Tools and Processes
    - Tools for analytical support/modeling
    - Processes for program applications/integration
Purpose

- Develop and test the requirements elicitation methodology, process, and tools
  - Risk reduction for larger-scale NLI requirements elicitation
  - Evaluate the role/value of existing analytical tools in supporting USGS’ needs
  - Determine the sufficiency/adequacy of initial requirements attributes in meeting management needs; refine as needed

- Provide a representative sample of user requirements that can provide support to near-term needs for mission formulation
NLIR Pilot Project

**Scope**

- **Representative sample** of applications/requirements which use moderate resolution imagery
- Focus on applications using moderate resolution imagery (5-120 m resolution)
- Both internal and external to DOI to exercise the process
  - Broad topical coverage (see next slide)
  - Focused on identifying SMEs at the right level; generally those engaged in service delivery (direct mission accomplishment) for their organization
Application Areas included in the Pilot Project

- Agriculture
- Climate and Land Use
- Forestry
- Land Management
- Mineral Resources
- Natural Resource Conservation
- Solid Earth Hazards
- Surface Mining
- Water Management
- Wildlife/Ecosystems
NLIR Pilot Project Process

- **Two major components**
  - Evaluation of current moderate resolution data sources
    - **Value tree** construct provides context and traceability for the use of Earth observation data
      - Understand the relative criticality and performance of current moderate resolution data sources on each application
      - Calculate the relative impact of individual Earth observation data sources (down to individual spectral bands) on Application Areas
  - Elicit user requirements
    - Document user needs in terms of specific measurements/information needed, spatial and temporal resolution, geographic coverage, and other attributes
NLIR Pilot Project

From the Value Tree (sample result):

- Cumulative impact of each of the spectral bands from moderate resolution sources across Application Areas
  - Shows which bands overall have the greatest/least impact
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

Types of Requirements

- Threshold: 60%
- Breakthrough: 32%
- Target: 8%
NLIR Pilot Project

- **User Requirements (preliminary results)**
  - Horizontal Resolution and Revisit Frequency for the 114 Threshold level requirements summarized by category

**Horizontal Resolution for Threshold Requirements**
- Horizontal Resolution < 5 m: 2%
- Horizontal Resolution = 5 m: 9%
- Horizontal Resolution ≤ 15 m: 17%
- Horizontal Resolution ≤ 30 m: 8%
- Horizontal Resolution ≤ 60 m: 2%
- Horizontal Resolution = 100 m: 57%
- Horizontal Resolution ≥ 100 m: 5%

**Revisit Frequency for Threshold Requirements**
- Revisit Frequency < 2 days: 11%
- Revisit Frequency ≤ 4 days: 40%
- Revisit Frequency = 8 days: 24%
- Revisit Frequency ≥ 16 days: 25%
Requirements to help inform the USGS NASA Architecture Study Team

- Full capability of the USGS NLI Requirements not available to provide full support
- NLI Requirements Pilot project
- Previous Art
  - 40 Years of program engagement
  - Numerous studies and targeted requirements efforts
    - Project, Product, or Sensor specific
  - 2012 Applications Study in support of the USGS/NASA assessment of alternatives and 2012 Landsat Alternatives RFI
Applications Study from the 2012 USGS Landsat 9 RFI

Example:

Ag Plant Production

- NDVI
- Crop Type
- Chlorophyll Indices

NDVI:
- temporal: every 4-8 days
- spectral: red, NIR
- resolution: <50m
- radiometric: <5% TOA reflectance

Crop Type: ...

Chlorophyll Indices: ...
## Table 2. Spectral and Radiometric Requirements for Surveyed Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Information Product</th>
<th>Spectral Requirements</th>
<th>Radiometric Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>VIS</td>
<td>NIR</td>
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<td>National Land Cover Database (NLCD)</td>
<td>Cover Type/Change</td>
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<td>% Treecover</td>
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<td>% Impervious</td>
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<tr>
<td>USGS/USFS Landfire</td>
<td>Vegetation characteristics</td>
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<td>Disturbance</td>
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<td>Burned Area Emergency Response (BAER)</td>
<td>Burn severity maps (e.g., dNBR)</td>
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<tr>
<td>FAO/FAO Forest Change</td>
<td>Forest change maps</td>
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<tr>
<td>Foreign Agricultural Service (FAS)</td>
<td>Crop area</td>
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<td>Crop production</td>
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<td>Crop health</td>
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<tr>
<td>National Agricultural Statistical Service (NASS)</td>
<td>National crop and data layer (crop type)</td>
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<tr>
<td>USDA Crop Insurance/Disaster</td>
<td>Verification of Crop Insurance/Disaster Claims</td>
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<tr>
<td>Western States Evapotranspiration</td>
<td>Land surface temperature</td>
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<td>Surface reflectance</td>
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<td>NDVI</td>
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<td>Cloud/shadow mask</td>
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<td>USDA/TT/Residue Monitoring</td>
<td>Crop residue</td>
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<tr>
<td>LandSat Image Mosaic of Antarctica</td>
<td>Ice sheet features</td>
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<td>(LIMA)</td>
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<td>Minnesota Lake Clarity Monitoring</td>
<td>Water clarity</td>
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<td>USFS Forest Management</td>
<td>Terrestrial Ecologic Unit Inventory</td>
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<td></td>
<td>Mid-level Vegetation classification</td>
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<td>National insect disease risk map (NVDRM)</td>
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<td>Post-storm damage assessment</td>
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<td>Rapid Assessment of Vegetation Post-fire (RAVG)</td>
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<td>MDA/NSG Land Change</td>
<td>Correlated land change (new construction)</td>
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<tr>
<td>Ohio Agricultural Tax Verification</td>
<td>NDVI (to establish presence of crops)</td>
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<td>USGS Volcano monitoring</td>
<td>At-sensor radiance (plumes, minerals)</td>
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<td>Surface temperature</td>
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<tr>
<td>USGS Flood Monitoring</td>
<td>At-sensor radiance (flooded area)</td>
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<tr>
<td>USGS Essential Climate Variables (ECVs)</td>
<td>Surface reflectance</td>
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<td>Surface temperature</td>
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<td>Land cover &amp; surface water extent</td>
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<td>LAI/PAI</td>
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</table>
## Applications Study 2012 RFI
Revisit and Spatial Requirements for Surveyed Applications

### Table 3. Temporal Revisit and Spatial Resolution Requirements for Surveyed Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Information/Product</th>
<th>Revisit (days)</th>
<th>Resolution (m)</th>
<th>Geolocation (m)</th>
<th>Revisit Required</th>
<th>Resolution Required</th>
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<tbody>
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<td>National Land Cover Database (NLCD)</td>
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<td>%Impervious</td>
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<td>10 to 100</td>
<td>&lt;15 m</td>
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<tr>
<td>USGS/USFWS Landfire</td>
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<tr>
<td>Vegetation characteristics</td>
<td>8</td>
<td>30</td>
<td>&lt;0.5 pix</td>
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<td>USGS/USFWS Burned Area Emergency Response (BAER)</td>
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<tr>
<td>Burn severity maps (Rock, NM/GB)</td>
<td>8</td>
<td>30</td>
<td>&lt;0.5 pix</td>
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<td>Foreign Agricultural Service (FAS)</td>
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<tr>
<td>Forest change maps</td>
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<td>30</td>
<td>&lt;0.5 pix</td>
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<td>National Agricultural Statistical Service (NASS)</td>
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<td>National crop land data layers (crop types)</td>
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<td>coreg/ortho</td>
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<td>USDA Crop Insurance/Disaster</td>
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<td>Verification of Crop Insurance/Disaster Claims</td>
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<td>coreg/ortho</td>
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<td>Western States Evapotranspiration</td>
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<td>Land surface temperature</td>
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<td>30 to 120</td>
<td>&lt;15 m</td>
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<td>Surface reflectance</td>
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<td>Cloud/Shadow mask</td>
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<td>&lt;15 m</td>
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<td>USDA Tillage/Residue Monitoring</td>
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<td>Crop residue</td>
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<td>30 to 60</td>
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<td>Land/State Image Mosaic of Antarctica (SIMA)</td>
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<td>Ice sheet features</td>
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<td>75</td>
<td>&lt;50m (15m)</td>
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<td>Minnesota Lake Clarity Monitoring</td>
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<td>Water clarity</td>
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<td>30</td>
<td>500 (10)</td>
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<td>USGS Forest Management</td>
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<td>Terrestrial Ecologic Unit Inventory</td>
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<td>5 to 30</td>
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<td>Mid-level Vegetation Classification</td>
<td>8</td>
<td>10 to 30</td>
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<td>National forest disease risk map (NFDRM)</td>
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<td>Post-storm damage assessment</td>
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<td>Rapid Assessment of Vegetation Post-fire (BA/GR)</td>
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<td>Cropland change (new construction)</td>
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<td>8</td>
<td>30 (15)</td>
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<td>Ohio Agricultural Tax Verification</td>
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<td>NDVI (for estimates of water quality)</td>
<td>16</td>
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<td>USGS Volcanomonitoring</td>
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<td>Surface temperature</td>
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<td>8 to 90</td>
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<td>USGS Flood Monitoring</td>
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<td>Surface reflectance</td>
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<td>USGS Essential Climate Variables (ECV)</td>
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<td>Land cover &amp; surface water extent</td>
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<td>LAI/FRP</td>
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</tbody>
</table>

**Note:** The table outlines the temporal revisit and spatial resolution requirements for various applications, with specific details provided for each category.
Thank You

- Panel Session will use a similar applications based approach to discuss Observational Requirements and System Parameters

- Contact

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