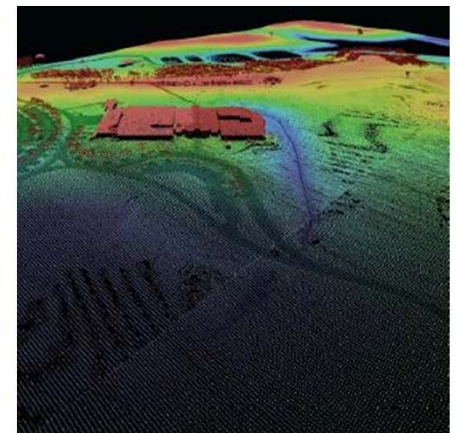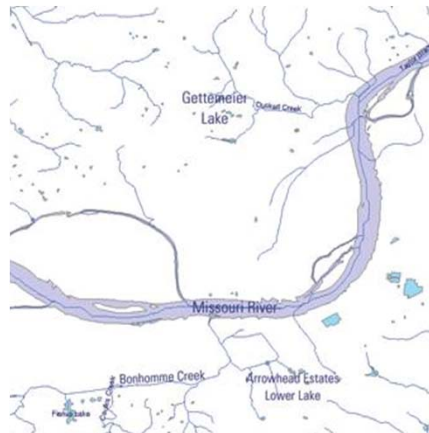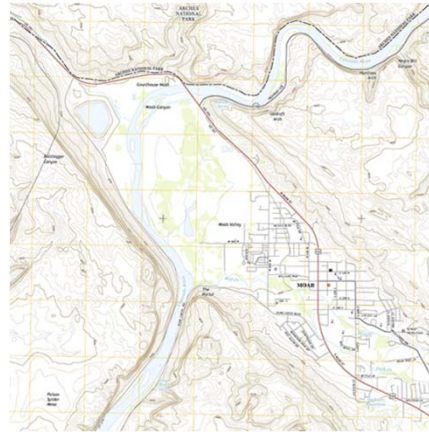# 3D Elevation Program (3DEP)

Claire DeVaughan
National Map Liaison for Oklahoma and Texas
USGS National Geospatial Program

Chris Cretini (Louisiana and Arkansas)
**April 21, 2016**

+ 3D Elevation Program (3DEP)
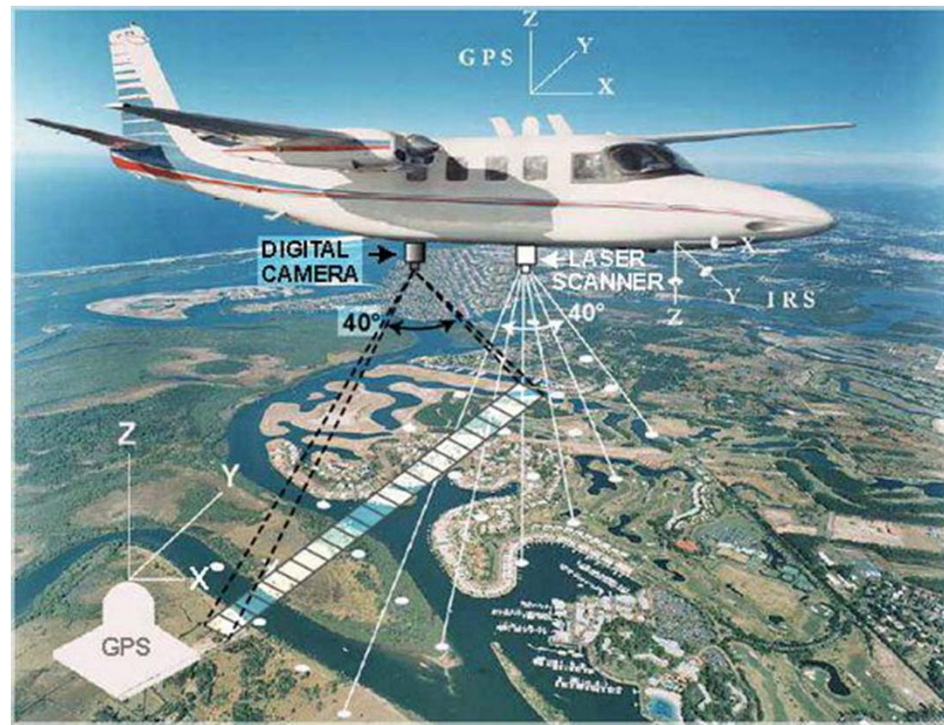
Applies ground-breaking lidar technology to acquire and distribute 3D data

Includes surface elevations and natural and constructed features

Increases the quality level of lidar being acquired to enable more accurate understanding, modeling, and prediction
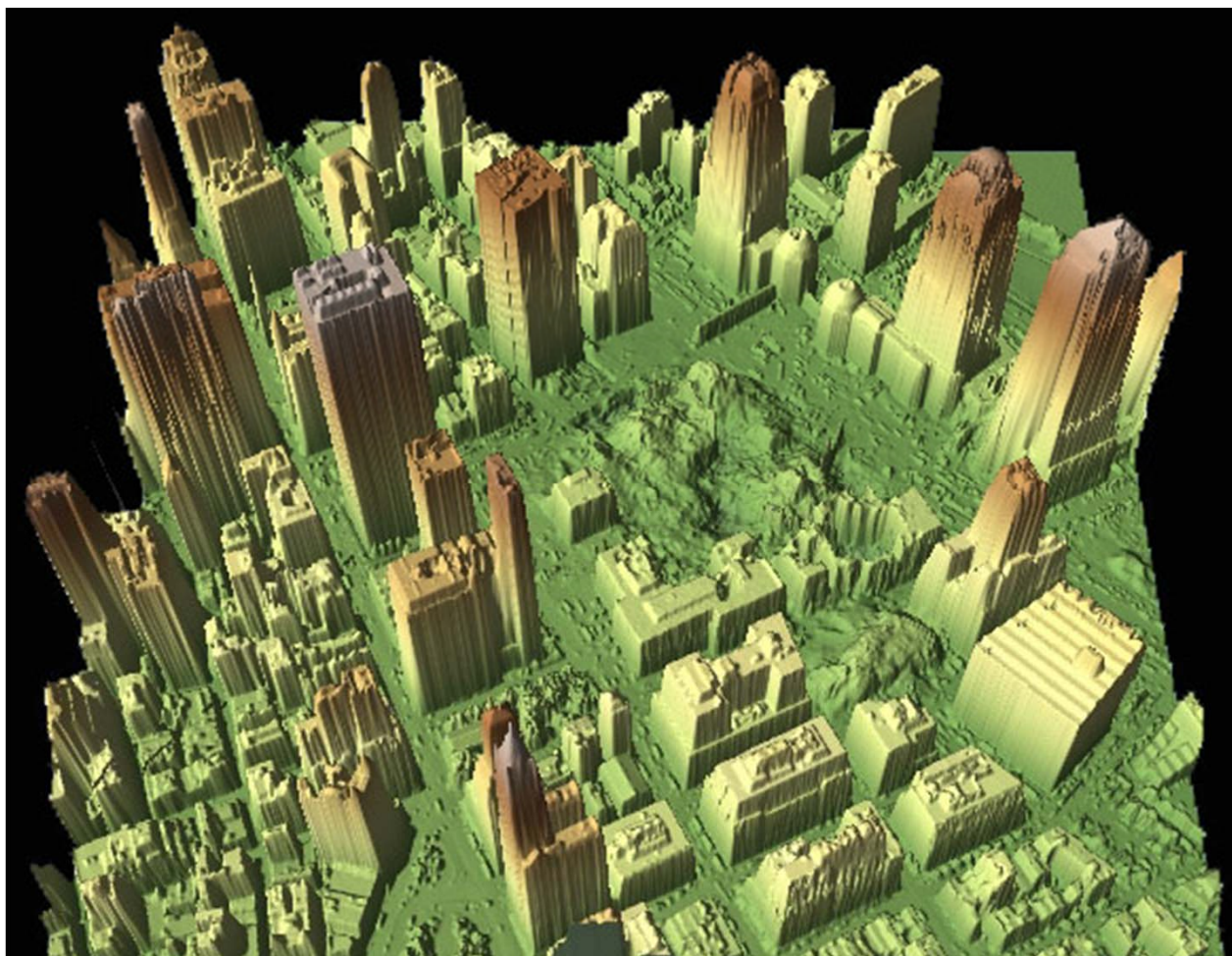
Addresses a broad range of critical applications of national significance
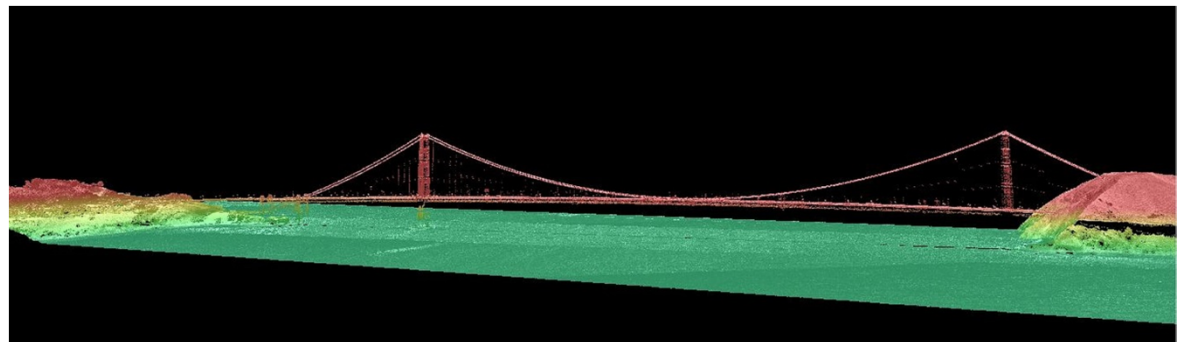
+ Light Detection and Ranging (Lidar)
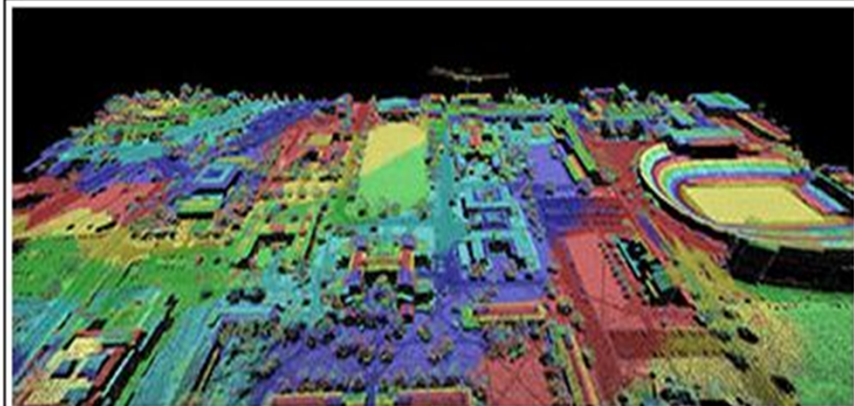
National Enhanced Elevation Assessment
Summary of Benefits for Top Business Uses

Rank		Annual Benefits	
		Conservative	Potential
1	Flood Risk Management	$295M	$502M
2	Infrastructure and Construction Management	$206M	$942M
3	Natural Resources Conservation	$159M	$335M
4	Agriculture and Precision Farming	$122M	$2,011M
5	Water Supply and Quality	$85M	$156M
6	Wildfire Management, Planning and Response	$76M	$159M
7	Geologic Resource Assessment and Hazard Mitigation	$52M	$1,067M
8	Forest Resources Management	$44M	$62M
9	River and Stream Resource Management	$38M	$87M
10	Aviation Navigation and Safety	$35M	$56M
⋮			
	Total for all Business Uses (1 – 27)	**$1.2B**	**$13B**

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+ Infrastructure Management
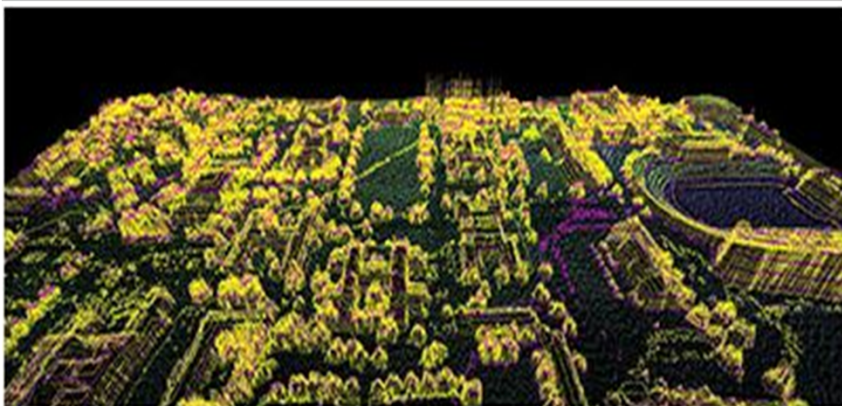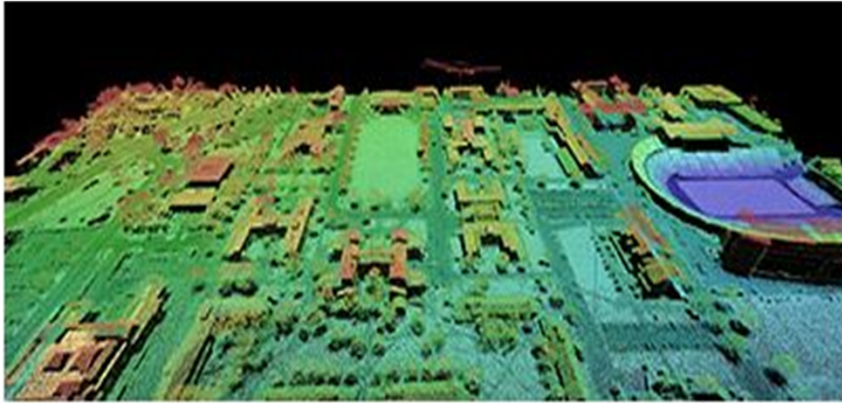
- Route, grade, line-of-sight, and utility surveys and corridor mapping
- Terrain and other obstruction identification
- Dam, levee, and coastal structure failure modeling and mitigation
- Hydraulic and hydrologic modeling

- Geotechnical evaluations
- Permit application and construction plan development and evaluation
- As-built model development
- Preliminary engineering, estimate development, and quantity estimation activities

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Powering Our Future

Alternative and Conventional Energy Resources

Lidar are essential for:

- Calculating wind potential

- Planning, construction and operation of hydro power

- Routing transmission lines and pipelines, construction planning, encroachment control, and asset inventories

- Determining solar potential - lidar provides roof pitch/aspect, etc.
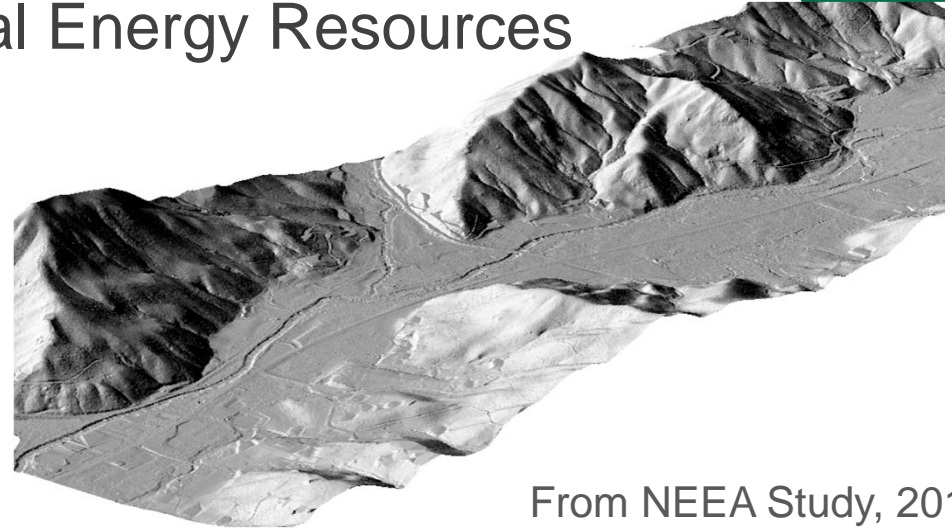
From NEEA Study, 2011
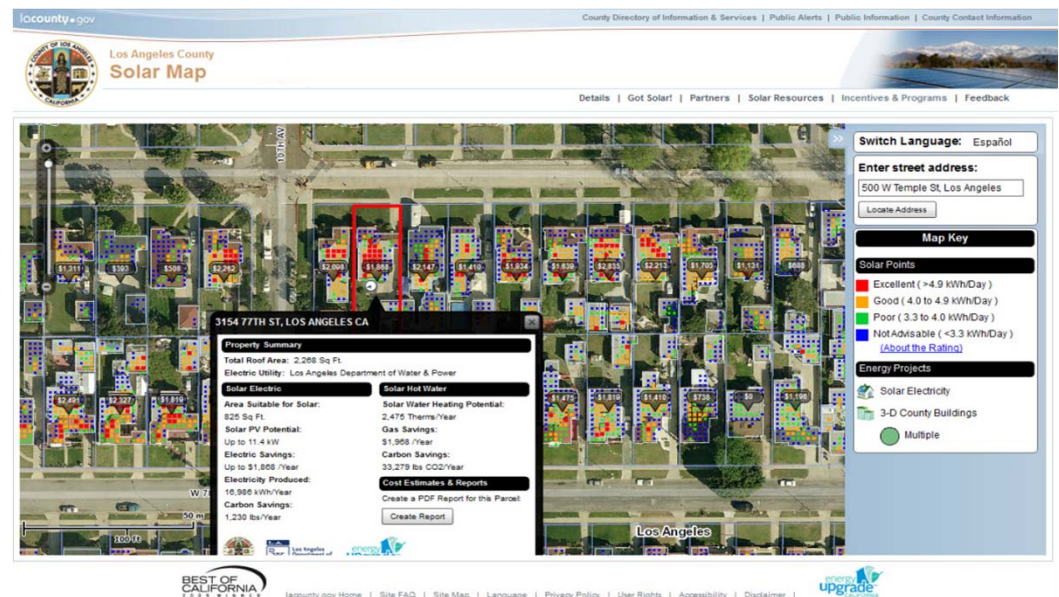
Aviation Navigation and Safety

Detect Obstacles to Air Navigation
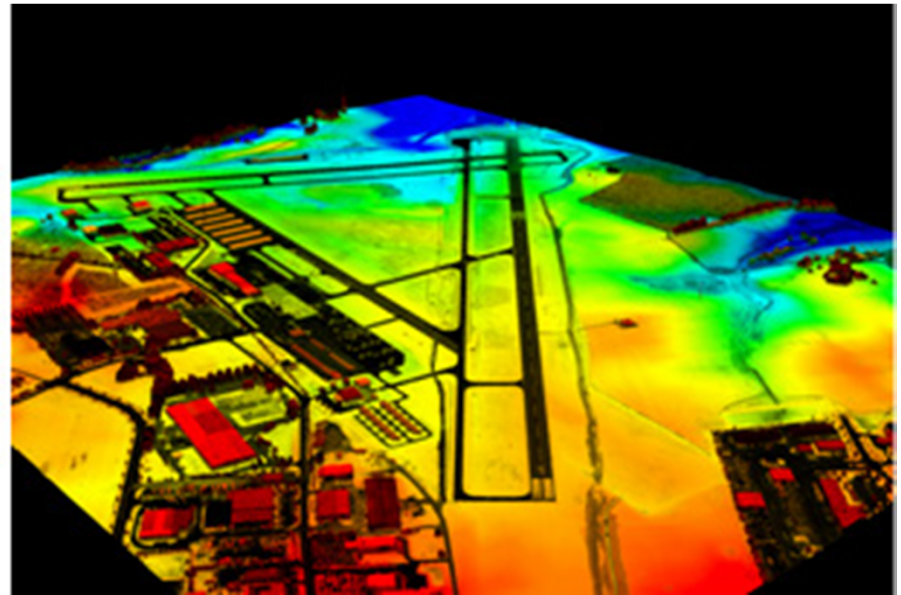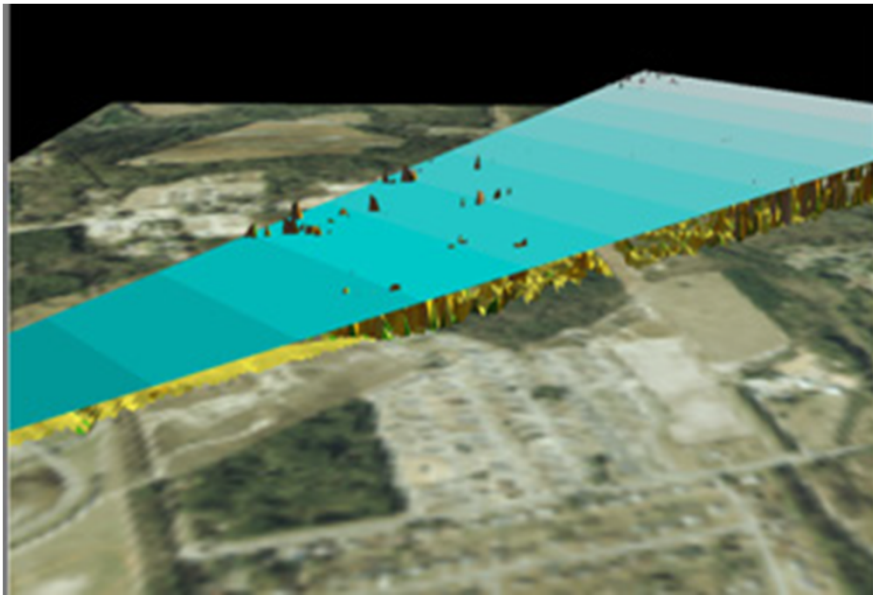
From NEEA Study, 2011

+ Flood Risk Management

- Red River, MN lidar shows changing river morphology

- QL2 provides 10 cm of additional accuracy over QL3 – critical to flood risk management, particularly in areas of low relief
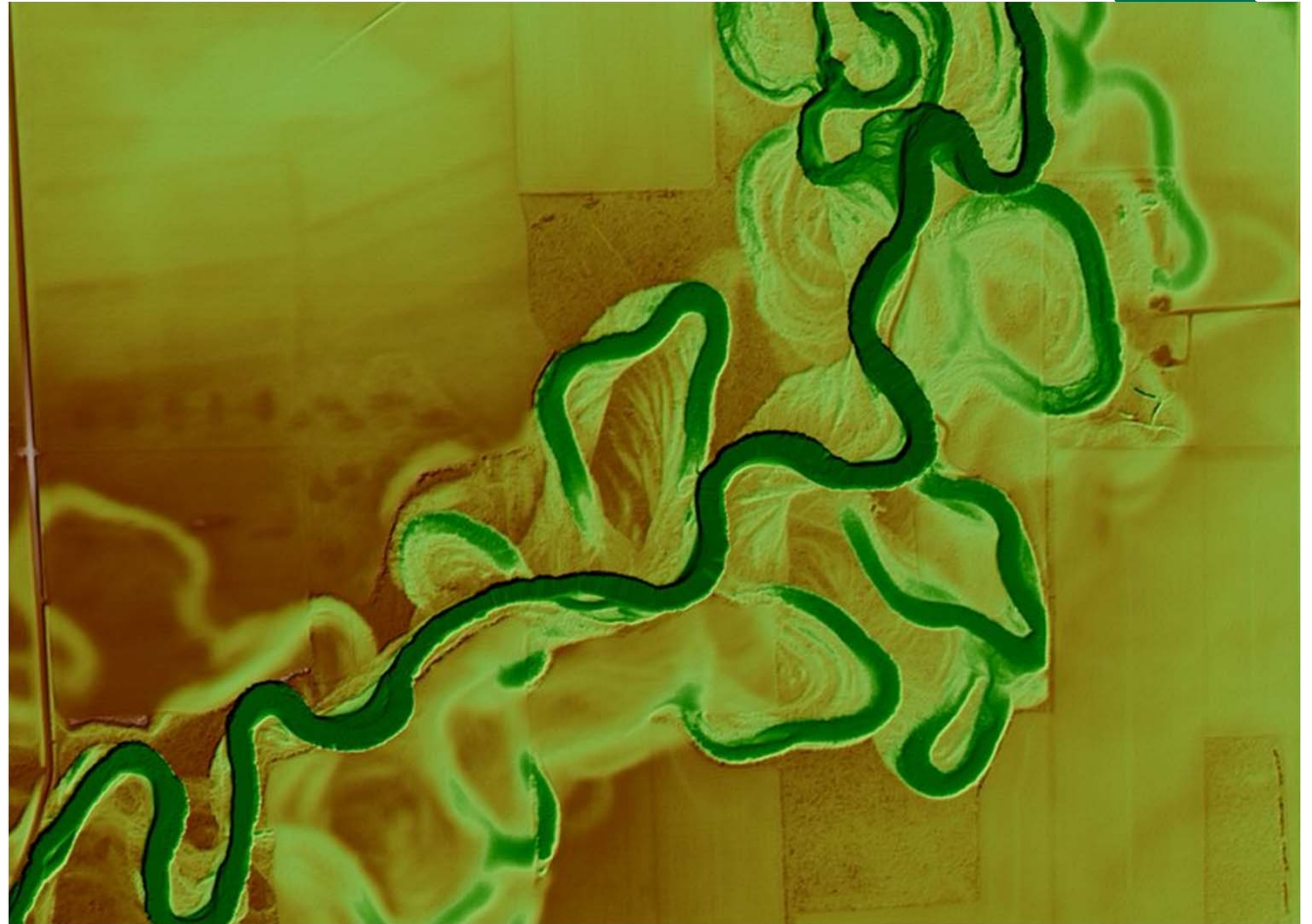
Image from Fugro Geospatial

Forest Habitat and Biomass

Habitat Suitability is Closely Related to Forest Structure

- **Canopy closure, width and height**

- **Tree Stem density**

- **Total tree volume (m³/ha)**

- **Biomass**
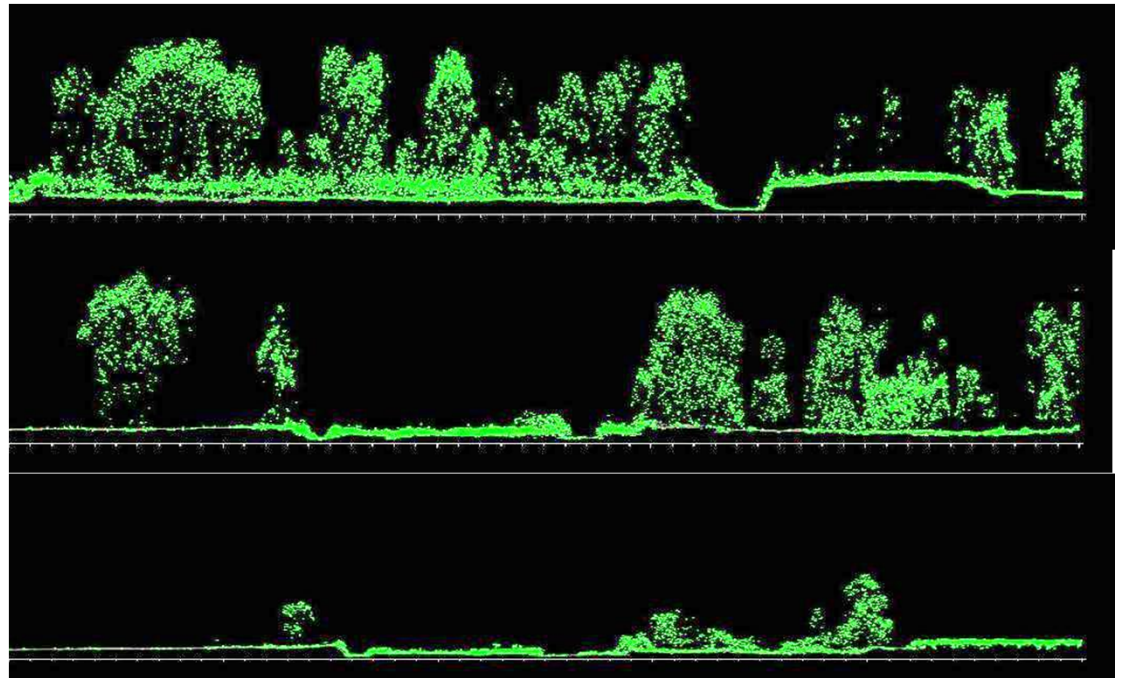
All of the above metrics can be estimated from lidar for forestry inventory and habitat assessments

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+ Enabling Precision Agriculture

Improved Data Quality
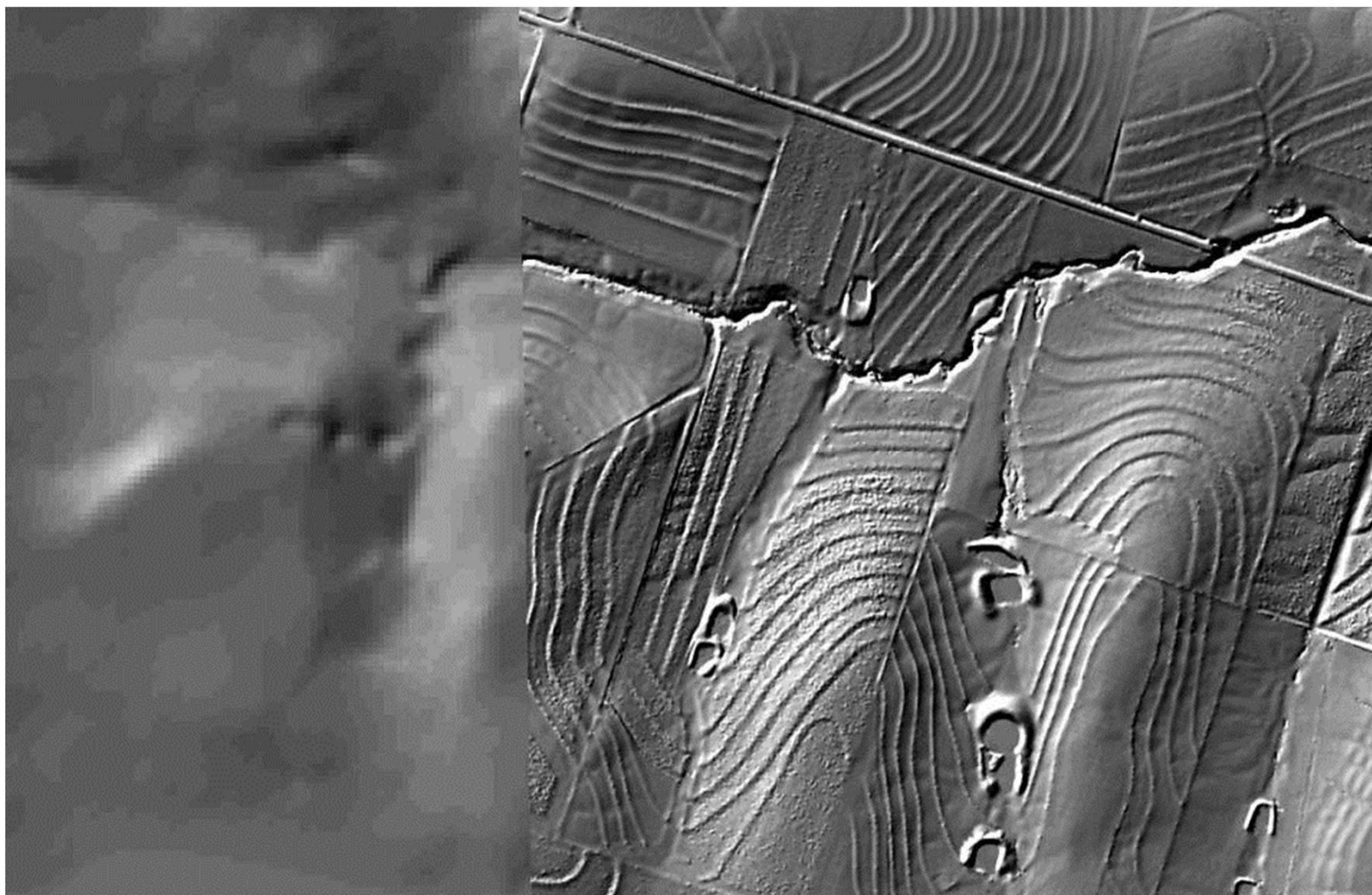
+ 3DEP Data Quality

10 meter resolution
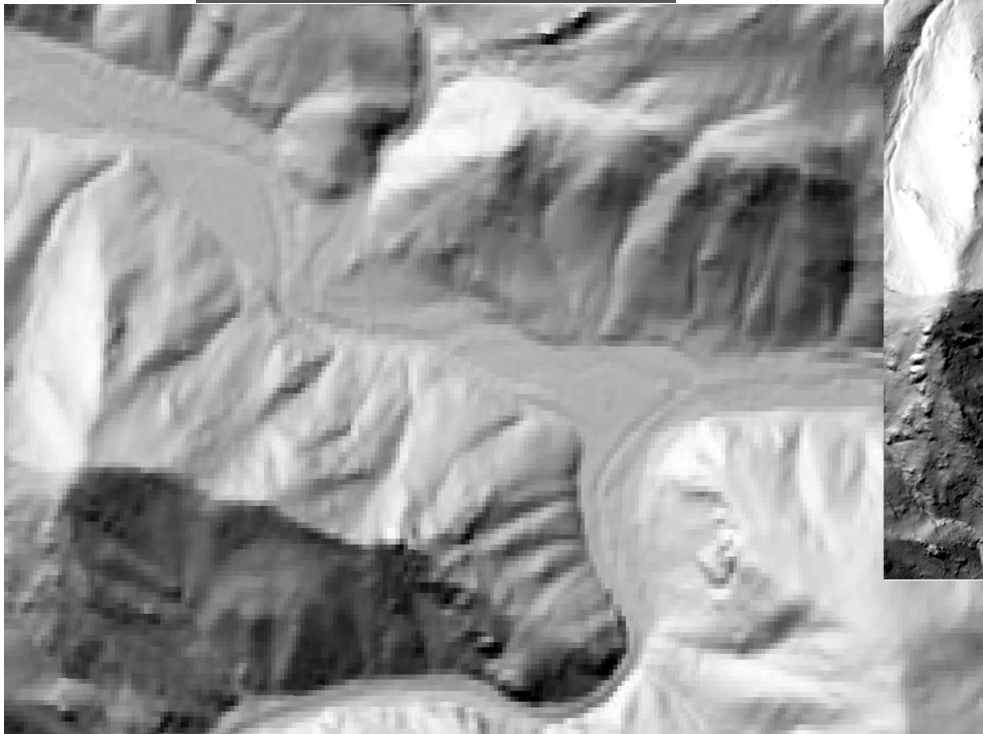
1 meter resolution

Building a Landscape-Level Understanding of our Resources

Landslide hazards
John Day, OR area

- Aerial photo image (top)

- Lidar image (bottom) of same area provides visible evidence of landslide activity

Building a Landscape-Level Understanding of our Resources

Oso, WA Landslide, March 22, 2014
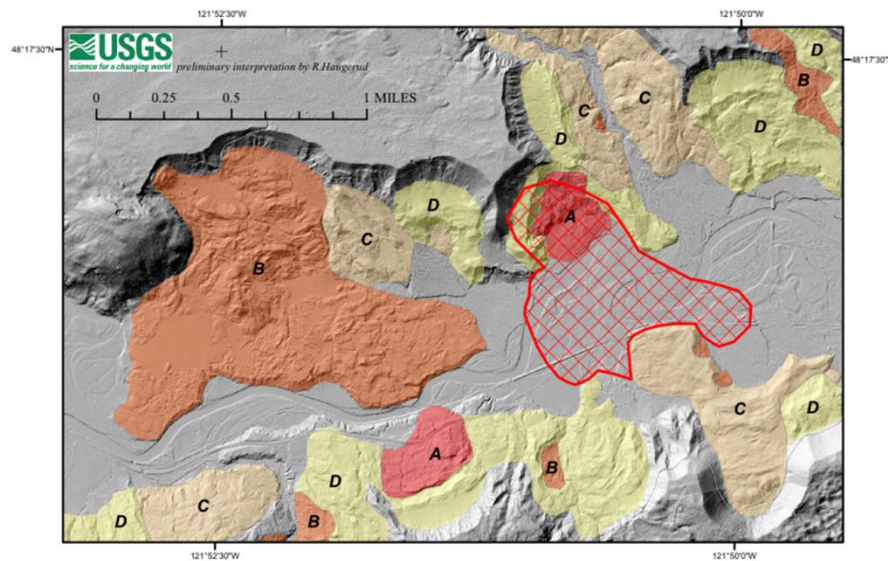
High-resolution lidar reveals historic and potential slides

Pre-landslide

Post-landslide

+
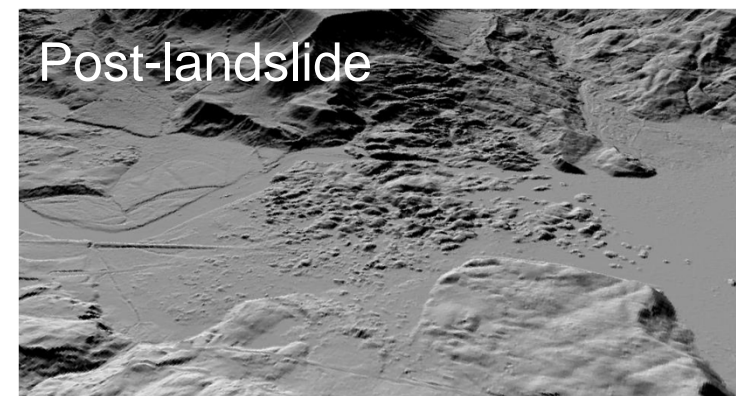
Geologic Mapping

Lidar Applications

- Higher spatial resolution base maps

- Better demarcation of geological features

  - Surficial geomorphology

  - Bedrock outcrops

  - Structural feature (e.g. Faults)

  - Previously undetected subtle features like debris flows or end moraines

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Mount St. Helens lidar

By Vivian R. Queija

GIP 116

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

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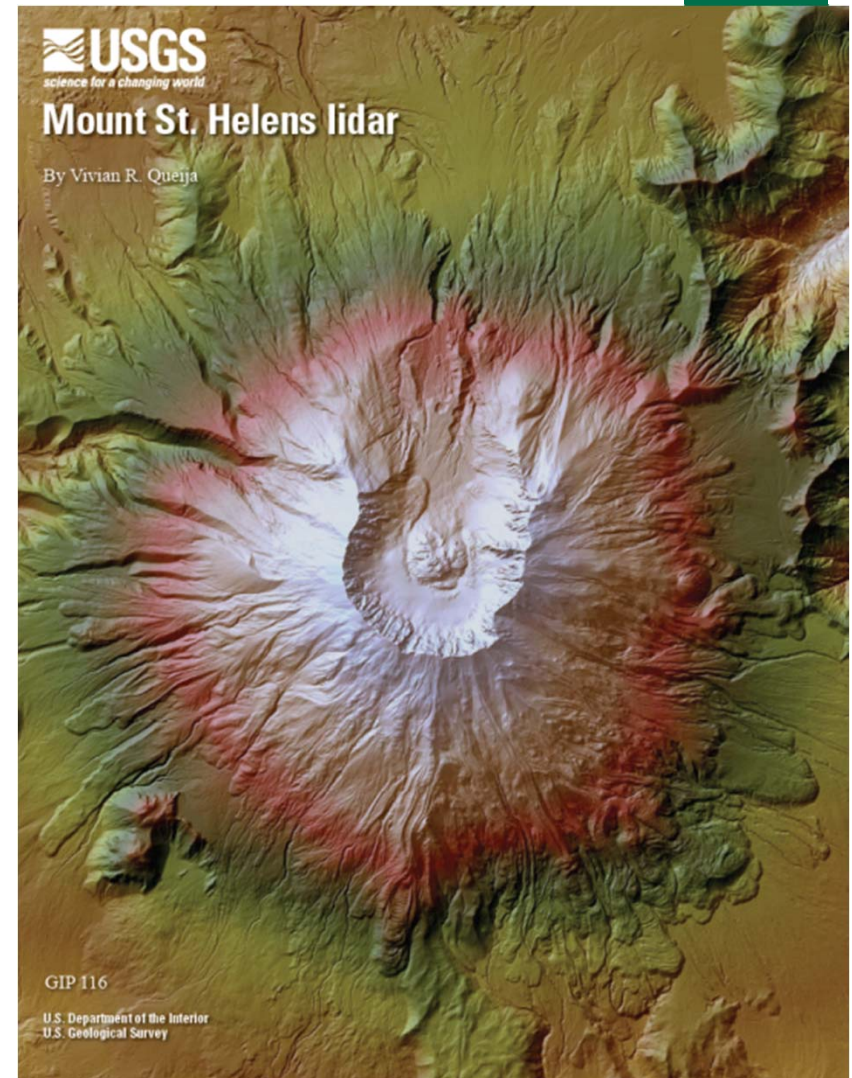
Geologic Hazards

Detecting Faults

Legend:
- Scarp found with lidar
- Scarp found other means
- ▲ Geomorphic evidence of shoreline uplift

Victoria

Seattle

Olympia

?

Holocene Tectonism PI: Ralph Haugerud, USGS
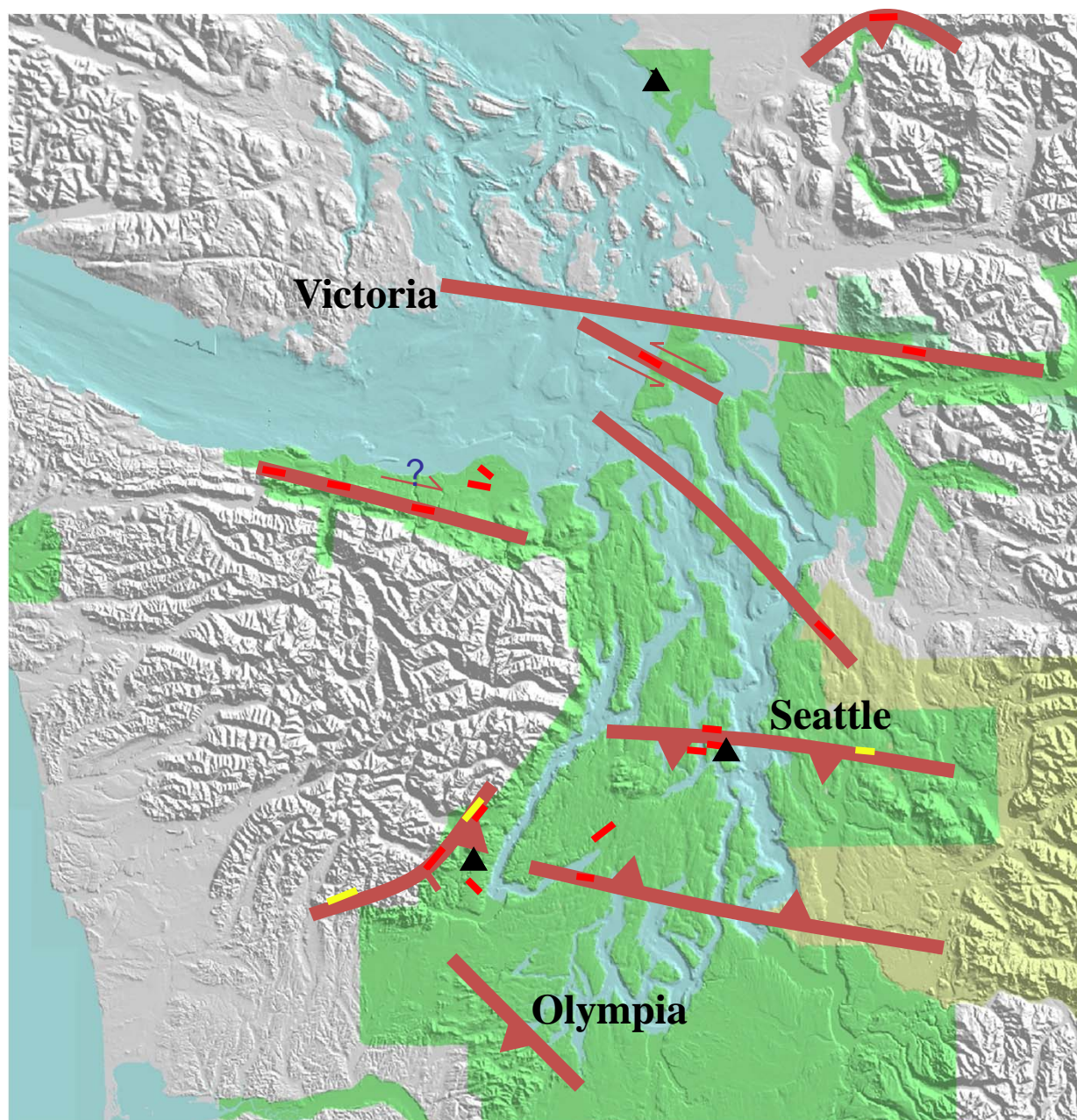
Meers Fault in southwest Oklahoma

1-meter DEM from 2015 Quality Level 2 lidar
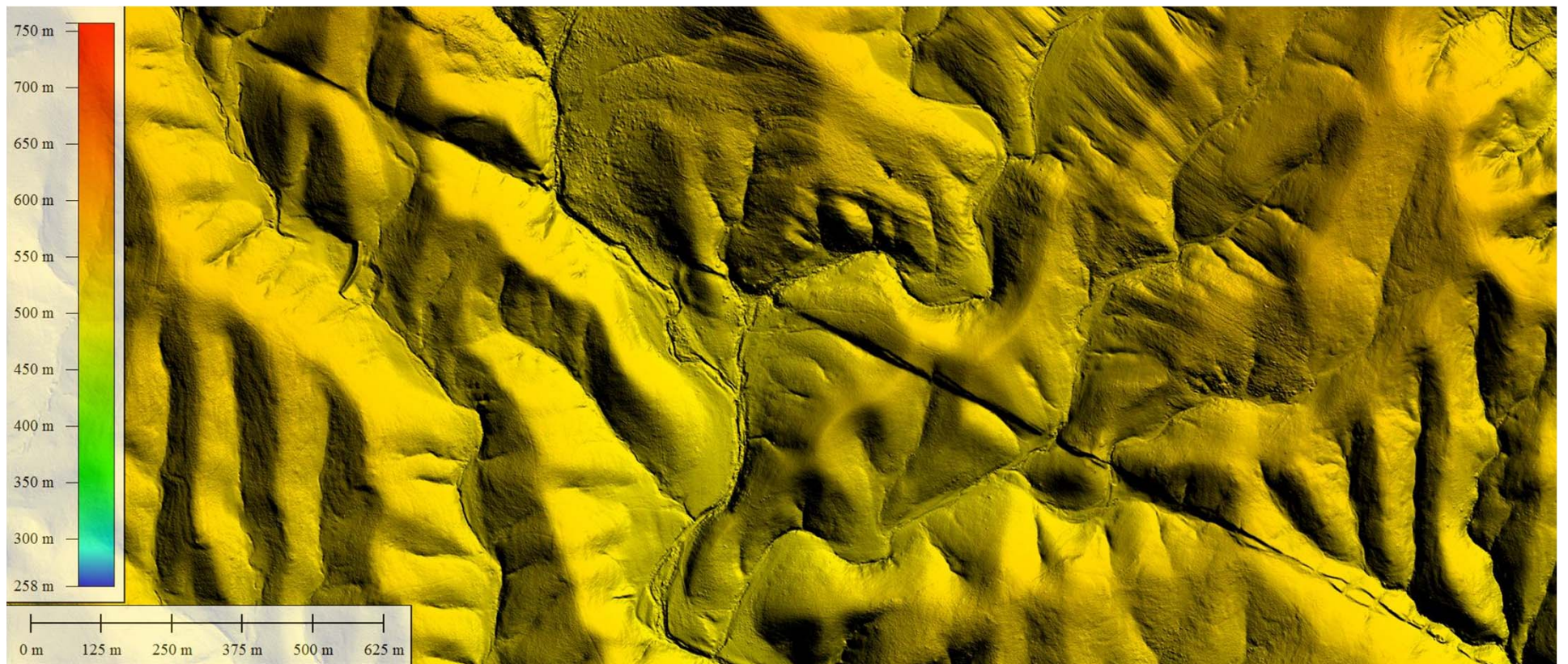
+

3DEP is a Partnership Program

- National lidar coverage with ifsar in Alaska in 8 years

- Address the mission-critical requirements of 34 Federal agencies, 50 states, and other organizations documented in the National Enhanced Elevation Assessment

- Return on investment 5:1, designed to conservatively provide new benefits of $690 million/year with the potential to generate $13 billion/year in new benefits through applications that span the economy

- Leverage the capability and capacity of private industry mapping firms

- Achieve a 25% cost efficiency gain by collecting data in larger projects

- Completely refresh national elevation data holdings with new lidar and ifsar elevation data products and services

Natural Resource Conservation

Infrastructure Management

Flood Risk Mitigation

Precision Farming
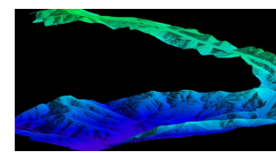
Land Navigation and Safety

Geologic Resources and Hazards Mitigation

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+ Quality Level

Quality Level	Source	Vertical Accuracy RMSEz	Nominal Pulse Spacing (NPS)	Nominal Pulse Density (NPD)	DEM Post Spacing
QL1	Lidar	10 cm	0.35 m	8 points/sq meter	0.5 meter
QL2	Lidar	10 cm	0.7 m	2 points/sq meter	1 meter
QL3	Lidar	20 cm	1.4 m	0.5 points/sq meter	2 meter
QL4	Imagery	139 cm	N/A	N/A	5 meters
QL5	Ifsar	185 cm	N/A	N/A	5 meters

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+ U.S. Interagency Elevation Inventory

Data Acquired through FY 2015

3D Elevation Program: Status of 3DEP Quality Data derived from the US Interagency Elevation Inventory

Map depicts public sources of lidar in all states that meet 3DEP specifications (2008-2015) plus ifsar data in Alaska (2004-2015)

as of October 2015

EXPLANATION

- Meets 3DEP base-level specifications for lidar collected in 2015
- Meets 3DEP base-level specifications for lidar collected prior to 2015
- Meets 3DEP base-level specifications for ifsar collected in 2015
- Meets 3DEP base-level specifications for ifsar collected prior to 2015
- Other lidar data
- No available data

- **3.4% of entire US was acquired to 3DEP quality in FY15 -** includes complete, in progress, and planned/funded

- **13.9% of Lower 49 Meets 3DEP quality (**2008-2015 only)

- **63.6% of AK Meets 3DEP quality (QL5 – IfSAR)**

+ 3DEP is a Partnership Program

Maximize Project Benefits and Minimize Project Risks

- Reduced unit costs through pooled funding with other partners, and economy of scale that 3DEP provides

- Access to qualified and experienced firms under contract that acquire and process aerial lidar data

- USGS programmatic infrastructure that issues and manages data acquisition contracts, and inspects, accepts, and distributes point cloud and derived data products

- The opportunity to "buy up" higher-quality data for demanding applications that are not satisfied by standard 3DEP data

- The opportunity to receive funding and acquire data on behalf of 3DEP

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+

3DEP Data Acquisition

Broad Agency Announcement (BAA)

- Provides detailed information on how to partner with the USGS and other Federal agencies to acquire 3DEP quality data

- Announced at [Fed Biz Opps](#) and [Grants.gov](#)

- Partners may propose contributing funds toward a lidar data acquisition project using the USGS Geospatial Products and Services Contracts or they may request 3DEP funds toward a lidar data acquisition project using the partner's contract

- Provides a systematic, transparent process for non-Federal agencies to partner with Federal agencies - state and local governments, tribes, academic institutions and the private sector are eligible to submit proposals

- Begun in FY15 and second round for FY16 is in progress

- Augmented with additional Federal investments throughout the year

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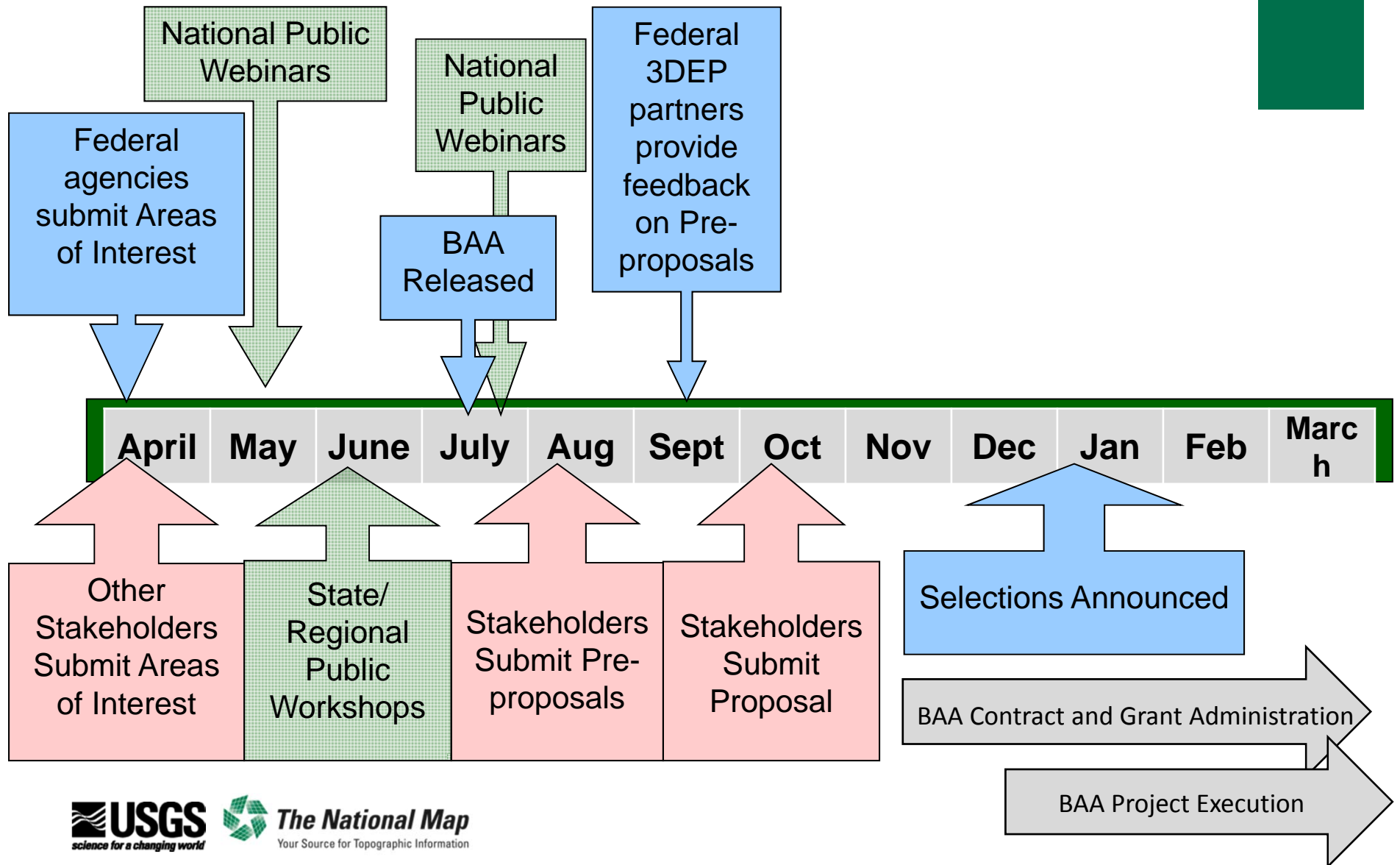
+ 3DEP 2012-2015

READY for a national, 8-year program

- Published plan for action based on extensive stakeholder input

- Issued the first Broad Agency Announcement in 2014, in partnership with FEMA and NRCS; second round in progress

- Consolidated and modernized IT systems, ready for first phase of cloud implementation

- Contracts (GPSC3) being established to address increased data volume

- Revised the base lidar specification to include 3DEP quality levels

- New products and services being made available in 2015 from *The National Map*
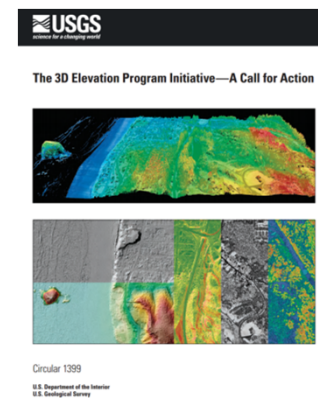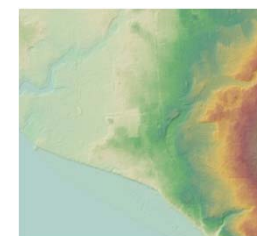
5 meter Alaska DEMs **Alaska Ifsar ORIs**
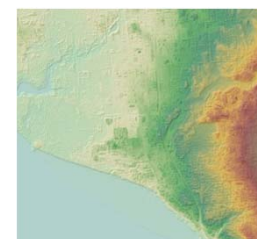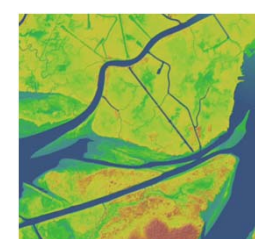
Alaska Ifsar DSMs **1 meter DEMs**

Lidar Point Cloud

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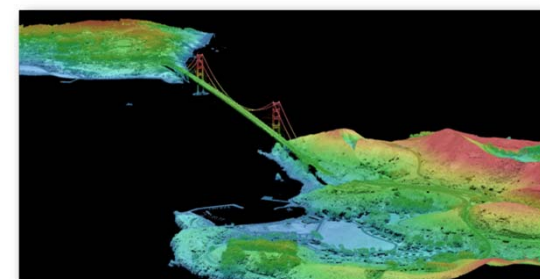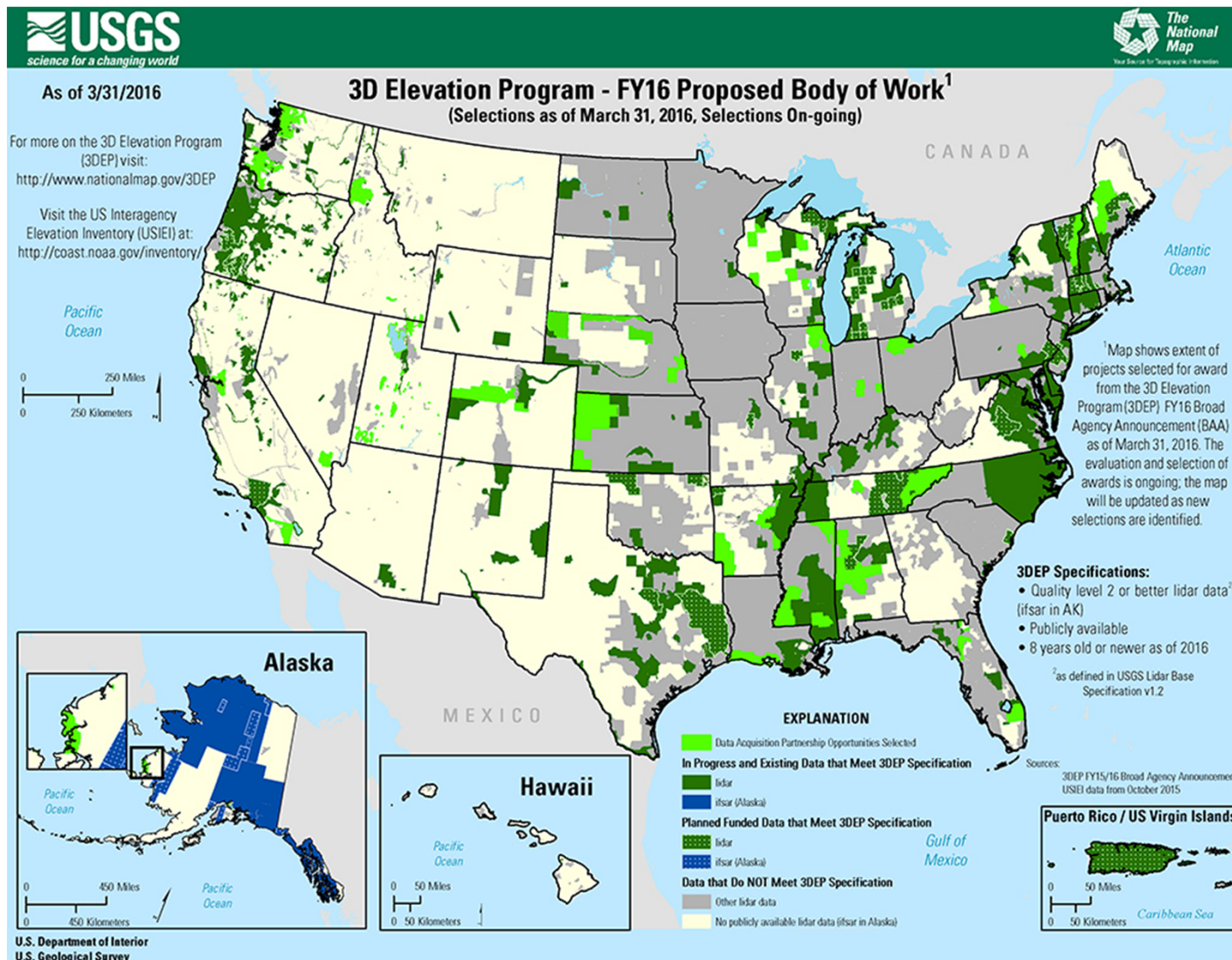
- To date the FY16 program has offered partnership funding to 26 proposals in 23 States and Territories. The map (3D Elevation Program – FY16 Proposed Body of Work) represents data acquisition partnerships offered as of March 31, 2016; as selection is on-going, the projects depicted on the map do not represent the full or final extent of FY16 BAA projects.

+ Status of lidar in SCAUG states

*** As of Fall 2015

EXPLANATION
- Quality level 2 or better lidar data
- Quality level 3 lidar data
- Quality level 4 or lower lidar data
- No publicly available lidar data
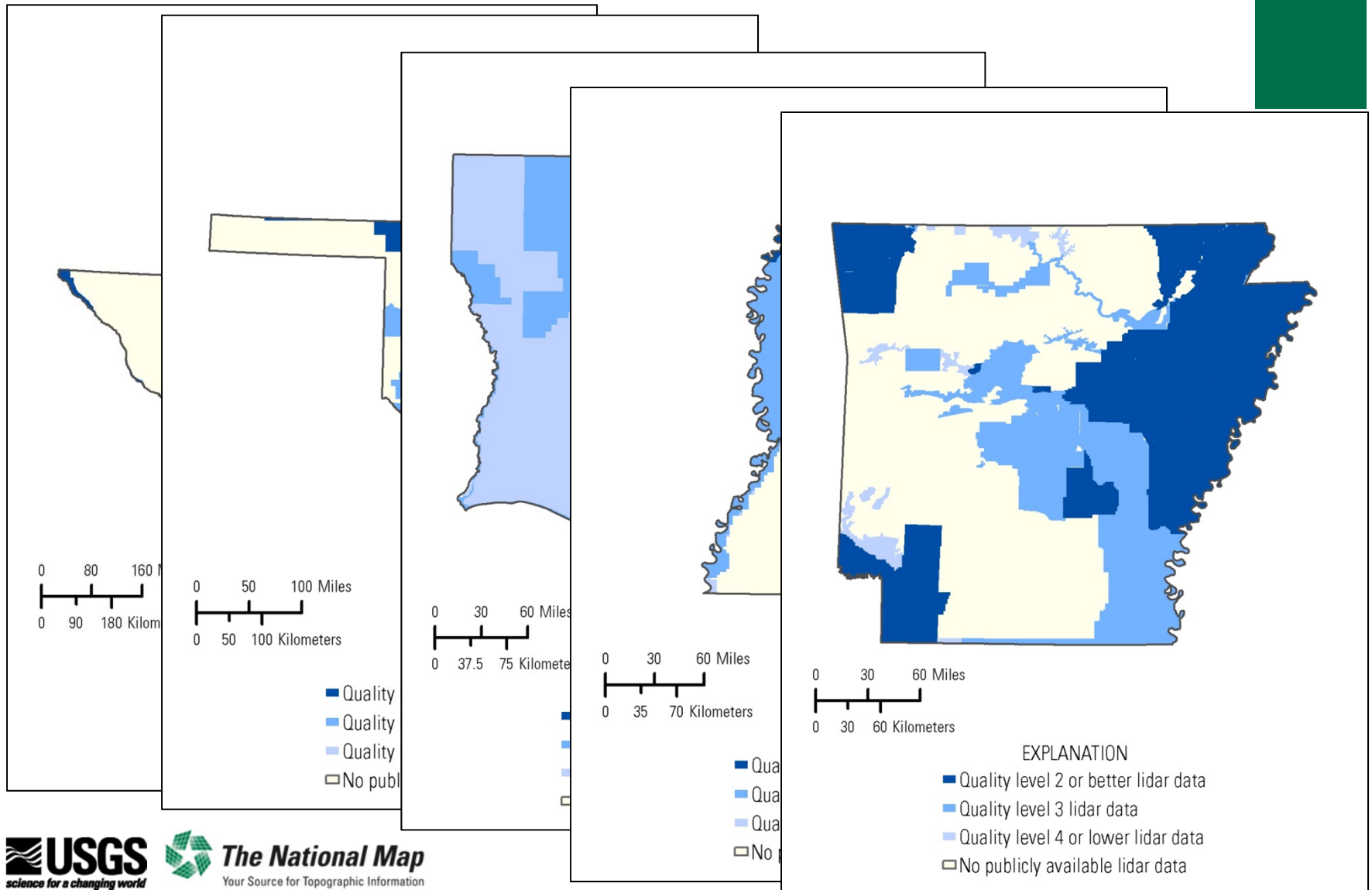
+ Interagency Tool for Sharing Areas of Interest

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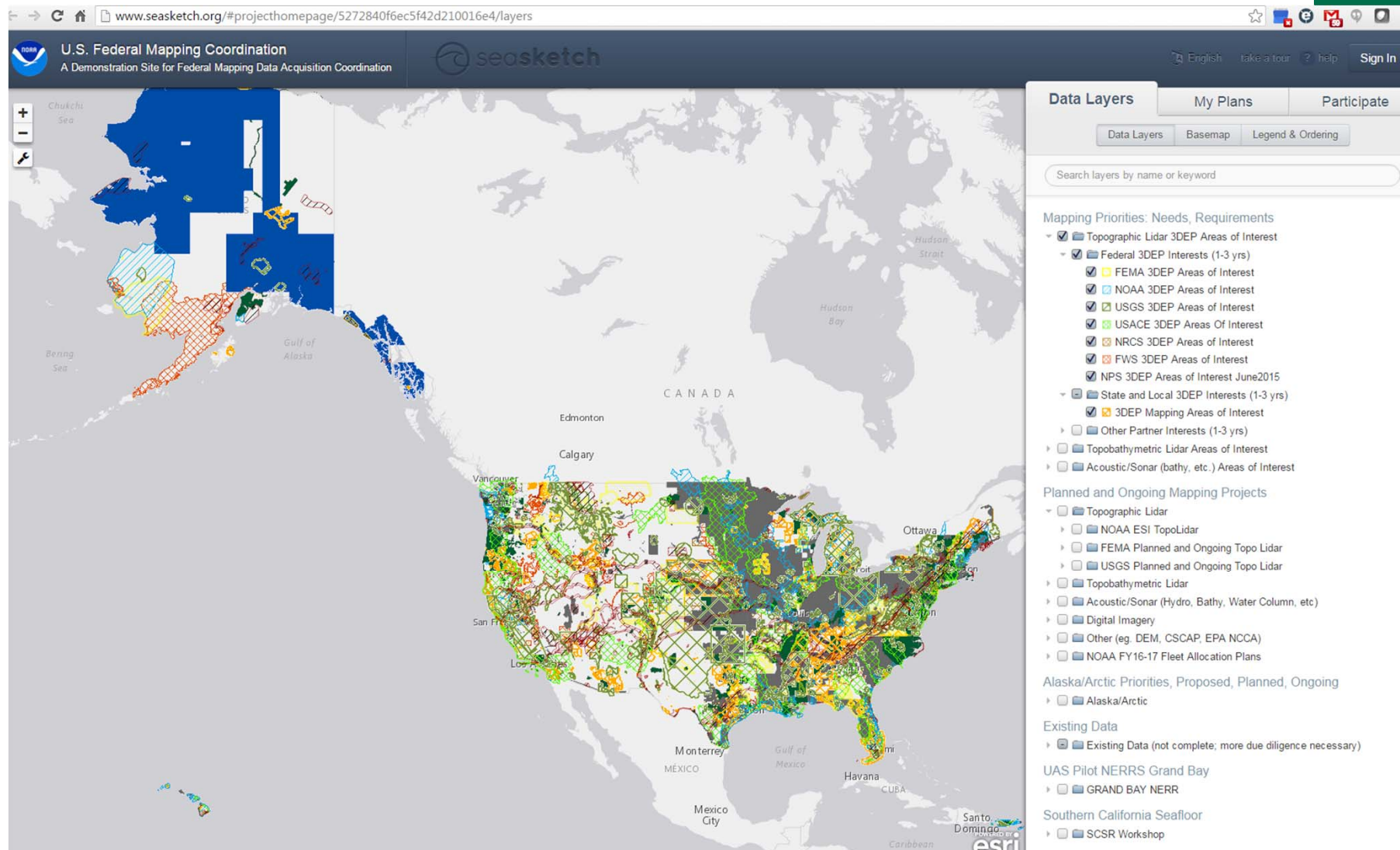
3D Elevation Program: FY15/16 BAA Federal Priority Overlap
Data Acquisition Partnerships Offered via Pre-Proposals[1]

As of 9/11/2015

Combined

■ Pre-Proposal Overlap

2016 Priorities
No. Agencies

- 1
- 2 - 3
- 4 - 5

For more on the 3D Elevation
Program (3DEP) visit:
http://www.nationalmap.gov/3DEP

Visit the US Interagency
Elevation Inventory (USIEI) at:
http://coast.noaa.gov/inventory/

0   200 Miles

0   200 Kilometers

Pacific Ocean

RUSSIA

Pacific Ocean

0   500 Miles

0   475 Kilometers

Alaska

0   50 Miles

0   50 Kilometers

Hawaii

Pacific Ocean

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

CANADA

Atlantic Ocean

Gulf of Mexico

MEXICO

CANADA

[1]Submittal of Pre-proposals
was encouraged but not
required. Therefore, projects
depicted on this graphic may not
represent the full or final extent of
project areas of interest that will be
submitted for consideration for FY16 BAA
awards. As stated in Solicitation
G15PS00558/ G15AS00123, "the USGS will
collate and may make publicly available
collective pre-proposal statistics to include
total funds requested, total square miles
requested and a graphic showing all
proposed areas of interest (in graphic and
shapefile format). Individual applicant
information will not be associated with
these collective statistics." Individual
applicant information is protected.

3DEP Specifications:
• Quality level 2 or better lidar data (ifsar in AK)[2]
• Publicly available
• 8 years old or newer as of 2016

[2]as defined in USGS Lidar Base Specification v1.2

Sources:
3DEP FY15/16 Broad Agency Announcement
USIEI data from July 2015

Puerto Rico / US Virgin Islands

0   60 Miles

0   70 Kilometers

Caribbean Sea

EXPLANATION

▨ Data Acquisition Partnerships Offered via Pre-Proposals[1]

☐ No publicly available lidar data (ifsar in Alaska)

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FY15 3DEP Preliminary Summary

Lidar Data Acquisition

3D Elevation Program: FY15 Body of Work

As of 9/30/2015

Map shows areal extent of projects proposed to the 3D Elevation Program FY15 Broad Agency Announcement (BAA) and through ongoing Federal Coordination via the 3DEP Working Group in relation to the quality level of planned, in progress, and existing publicly available lidar (ifsar in Alaska) data identified by the US Interagency Eleavtion Inventory (USIEI) that meet 3DEP base-level specification, defined as quality level 2 or better lidar data (ifsar in Alaska) and 8 years old or newer as of 2015. USIEI data from March 2015.

For more on 3DEP visit: http://www.nationalmap.gov/3DEP

Visit the USIEI at: http://coast.noaa.gov/inventory/

EXPLANATION
- FY2015 3DEP Projects (BAA, Federal Coordination)
- Meets 3DEP base-level specifications for lidar
- Meets 3DEP base-level specifications for ifsar (Alaska)
- Other lidar data
- No publicly available lidar data (ifsar in Alaska)

Puerto Rico / US Virgin Islands

Alaska

Hawaii

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

3DEP Lidar Data Contracted in FY15						
3DEP Funds $M			Partner Funds $M		Total $M	Sq Miles
USGS	FEMA	NRCS	Other Feds	Non-Fed		
$7.2	$11.2	$7.1	$2.5	$11.0	$39.0	150,000
$25.5			$13.5			

FY16 Broad Agency Announcement (BAA)
Project Selection In Progress

- 42 proposals submitted for projects in 30 states + 1 territory

- Total project value of $38M; $22M in partner contributions, requesting $16M 3DEP funding

- Coverage proposed 146,000 sq mi

- BAA remains open to new proposals through the year

- Information on each award is online at nationalmap.gov/3dep
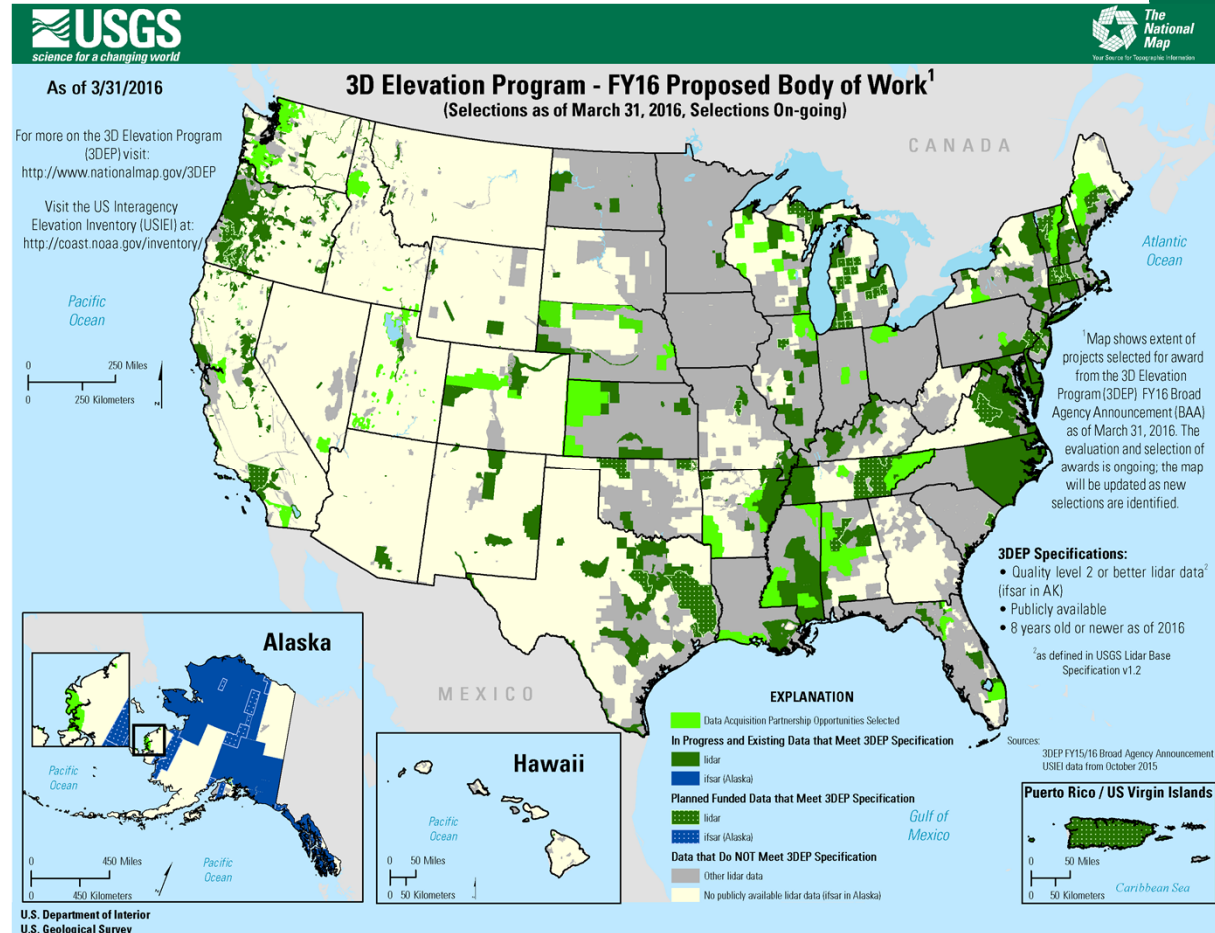
+ 3DEP Data Acquisition and BAA

Improvements for FY16 – Under Discussion

- Focus of the public state/regional workshops for providing program information and a venue for coordination

- Timeframes for project selection – considering multiple selection timeframes

- Considering adding a Federal-only option to BAA to capture EOY funding

- Standardization
  - Fund by 1 degree or quarter quadrangle cells?
  - Partnership shares

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+ Status of Emerging Lidar Technologies for use in 3DEP

Geiger Mode and Single Photon

- GM and SP lidar advertised as commercially ready

- Interest due to potential gains in data density, acquisition speed, and potential cost savings for the 3DEP program, advertised even in leaf-on conditions

- Extensive marketing, but little independent ground truthing and public domain data

- Study to address suitability of new techs for 3DEP use and provide baseline

- Independent evaluations of collections of same location with existing linear mode data available

- Not interested in picking a winner, just in evaluating and exploring the new data

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WOOLPERT Dewberry

+ Status of Emerging Lidar Technologies for use in 3DEP

Abbreviation	Data Type	Acquired By	Type of Collect	Date / Year Collected	Collection Altitude (AGL)
LMDewLF14	Linear Mode	Dewberry	Leaf-Off	April/May 2014	3,000 ft
LMWptLO15	Linear Mode	Woolpert	Leaf-On	September 2015	7,000 ft
GMHarLO15_26k	Geiger Mode	Harris	Leaf-On	September 2015	26,000 ft
GMHarLO15_7.5kDT	Geiger Mode	Harris	Leaf-On, Day Time	September 2015	7,500 ft
SPSigLO15_7.5k	Single Photon	Sigma Space	Leaf-On	August 2015	7,500 ft
GMHarLF15_26k*	Geiger Mode	Harris	Leaf-Off	December 2015	26,000 ft

* Collected after original leaf on evaluation collection

+ Vertical Accuracies

A major objective of this evaluation is to assess absolute horizontal and vertical accuracy

Specification	
Non-vegetated Vertical Accuracy (NVA)	Vegetated Vertical Accuracy (VVA)
≤19.6 cm at 95% confidence level	≤29.4 cm at 95th percentile

	Test #1 – Points		Test #2 – DEM	
	NVA	VVA	NVA	VVA
HRQLS (7,500 ft AGL)*	17.2 cm	17.4 cm	14.1 cm	40.6 cm
IntelliEarth (26,000 ft AGL)*	17.0 cm	25.6 cm	15.2 cm	92.0 cm
Existing, accepted 3DEP QL2 data (3,000 ft AGL)	12.3 cm	19.8 cm	14.6 cm	25.0 cm

* Leaf on

+ Vertical Accuracies

Assessment is ongoing

- Point densities and relative accuracies more than adequate

- Non-vegetated vertical accuracies (NVAs) are within specification

- Concerns about point densities and vertical accuracies using DEMs under dense vegetation in leaf-on conditions

  - Assumption is better performances under leaf-off, but not what we had to evaluate

- Non-compliance of attributes for USGS Lidar Base Specification 1.2 - must be worked through the 3DEP-WG and the broader community to develop policy and adapt specification and file formats

- Overall the technology shows potential - warrants additional testing and next steps – need to continue to learn about, adapt to, and help these systems come in to full compliance with our specifications, and we will adapt our specifications where needed.

- USGS will continue to work with these new sensors in an 'incubation phase'

+ Next Steps

- Need to get these findings and recommendations completely vetted by E3D-WG

- More and deeper analyses and continued dialog with Harris and Sigma Space. Both companies say that many of these issues have been addressed
  - Already claim sensor improvements since evaluation collection
  - Need to do evaluations/validations on new instruments and in traditional leaf-off conditions

- Begin working on making USGS Lidar Base Spec more flexible and less linear-mode only focused

- Need to work with ASPRS to adapt the LAS file format spec (or develop a new specification) to allow these sensors to be 'fully compliant'

- Need to better understand the full lifecycle costs of managing such data, especially data with NPS greater than QL1.
  - NEEA/3DEP has not assessed the cost/benefits of data greater than QL1
  - Increased storage costs, longer/more difficult processing, noise points, etc.

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W WOOLPERT **Dewberry**

http://nationalmap.gov/3dep

http://www.geoplatform.gov/elevation/3DEP

National Map Liaisons

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512-927-3583	337-266-8621	601-933-2950

Thank you!