National Enhanced Elevation Assessment

– Introduction –

NOAA LiDAR Workshop
August 18, 2011

Greg Snyder
USGS Project Manger

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Dewberry

National Enhanced Elevation Assessment

About the Project

Sponsor:

- National Digital Elevation Program (NDEP) member agencies

Funding Partners:

- U.S. Geological Survey (Managing Partner)
- National Geospatial-Intelligence Agency
- Federal Emergency Management Agency
- Natural Resources Conservation Service

In-kind Partners:

- National Oceanic and Atmospheric Administration
- Many Federal agencies, state agencies and other study participants

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Federal Agencies Participating

Business Requirements Assessment

Bureau of Indian Affairs
Bureau of Land Management
Bureau of Ocean Energy and Management
Bureau of Reclamation
Center for Disease Control and Prevention
Department of Energy
Department of Homeland Security
Department of Housing and Urban Development
Department of Justice
Department of State
Department of Transportation
Environmental Protection Agency
Farm Service Agency
Federal Aviation Administration
Federal Communications Commissions
Federal Emergency Management Agency
Federal Energy Regulatory Commission
National Aeronautics and Space Administration
National Geospatial-Intelligence Agency
National Oceanic and Atmospheric Administration
National Park Service
National Science Foundation
National Telecommunications & Information Admin
Natural Resources Conservation Services
Office of Surface Mining
Office of the Secretary of Defense
Tennessee Valley Authority
U. S. Nuclear Regulation Commission
U.S. Army Corps of Engineers
U.S. Bureau of Census
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Geological Survey

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Enhanced Elevation Data

Many Stakeholders

- Fifty States, local and Tribal governments
- Thirty plus Federal agencies
- Private sector – Forest Products, Development, Energy and others
- Regional organizations
- Professional Organizations representing many interests
  - American Geophysical Union
  - American Society for Photogrammetry and Remote Sensing (ASPRS)
  - AmericaView
  - Association of American Geographers (AAG)
  - Association of American State Geologists (AASG)
  - Coastal States Organization (CSO)
  - Floodplain Management Association (FMA)
  - Management Association for Private Photogrammetric Surveyors (MAPPS)
  - National Association of Counties (NACo)
  - National Governors Association (NGA)
  - National States Geographic Information Council (NSGIC)
  - Association of State Floodplain Managers (ASFPM)
  - Urban and Regional Information Systems Association (URISA)

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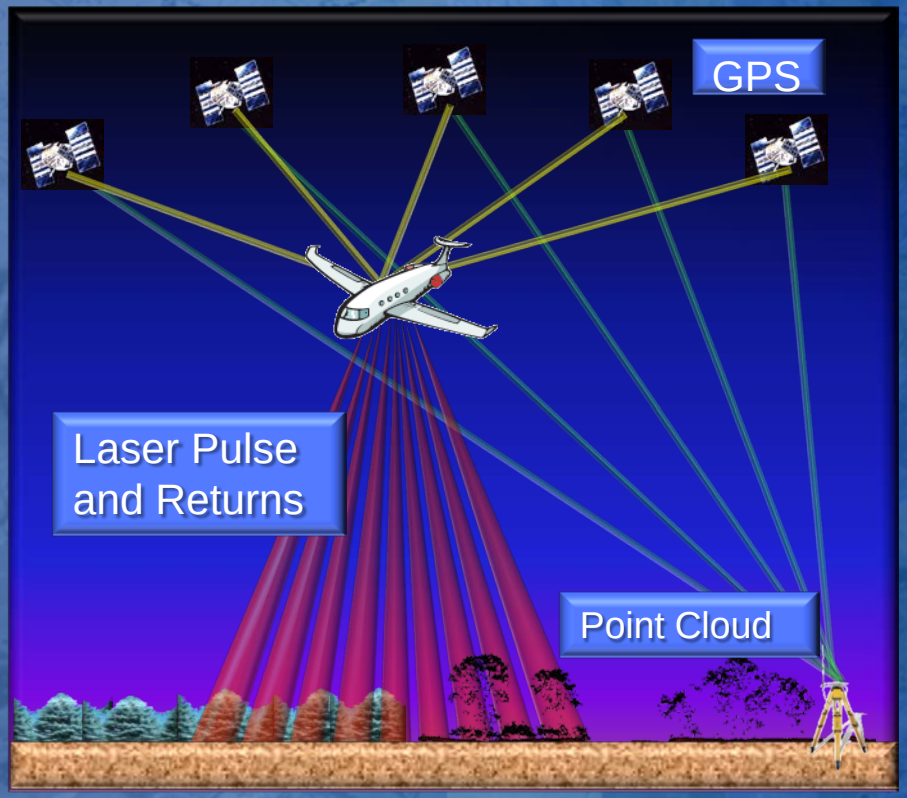
Technologies of Choice

Light detection and ranging (LiDAR)

- System with a laser and detector (range), scanning mirror (laser direction), GPS (location), and IMU (orientation)
- Output 300,000+ laser pulses per second
- Record laser reflection information
- Billions of recorded points create 3-dimensional representation of bare earth, vegetation and structures at centimeter-level accuracy



Interferometric synthetic aperture radar (IfSAR)

- Cloud penetration
- Lower acquisition cost than LiDAR

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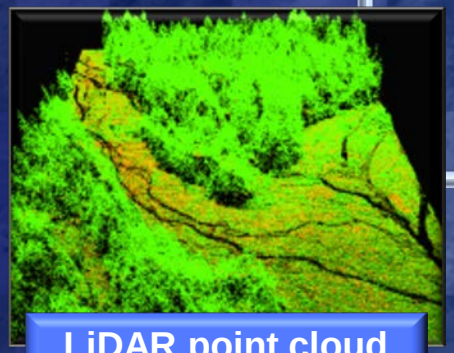
LiDAR Point Cloud

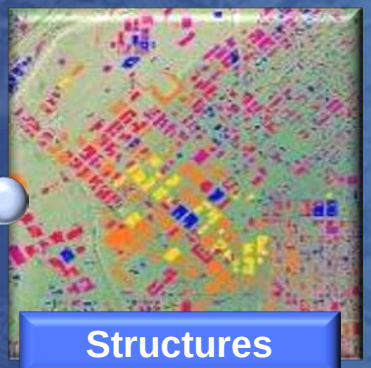
Supports derived elevation products and geospatial data integration



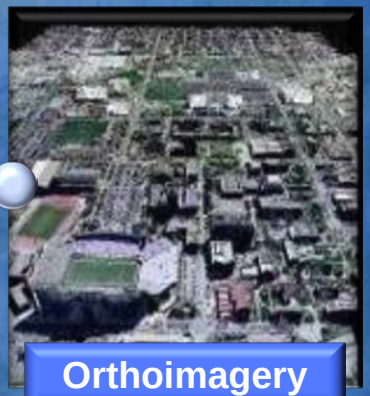
LiDAR point cloud

Land Cover

Elevation



Structures



Orthoimagery

Contours

Hydrology

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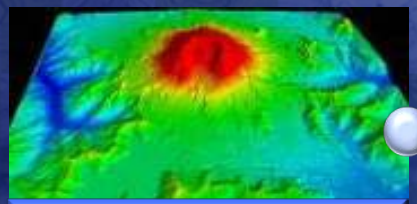
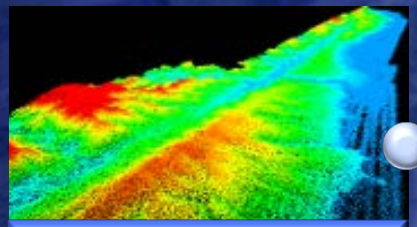
Concept for a National Enhanced Elevation Program

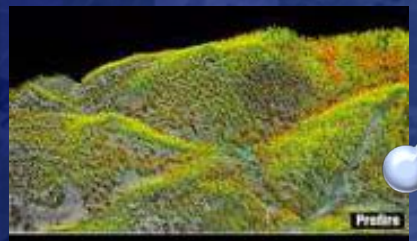
Supporting multiple operational and science needs

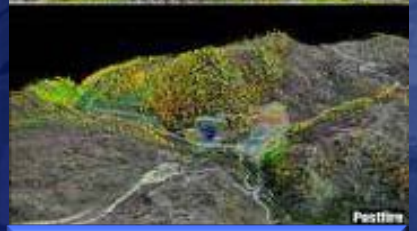


Volcano Monitoring

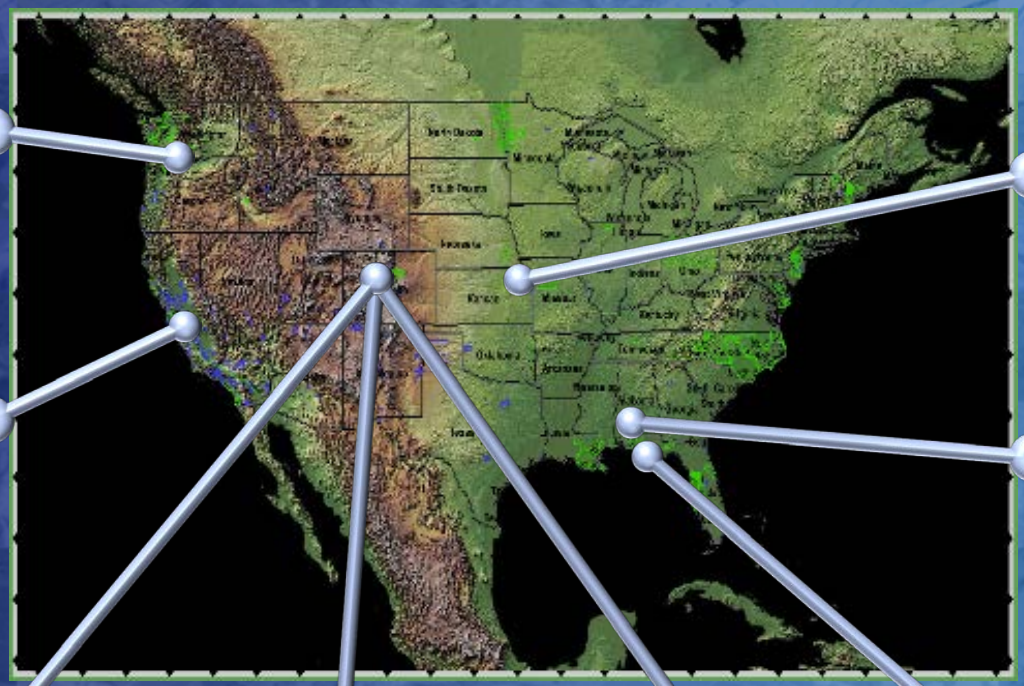


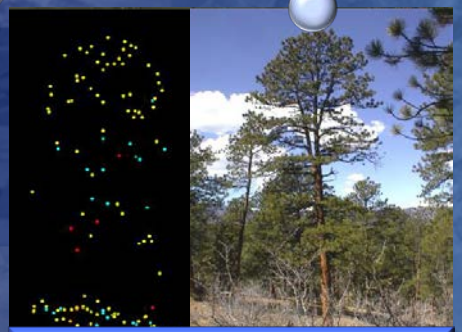
Earthquake Faults





Carbon/Disturbance



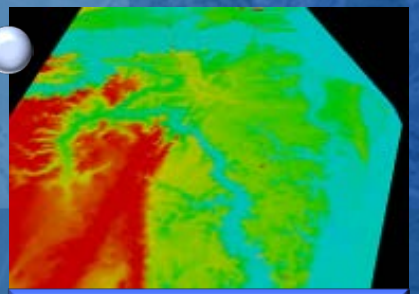


Biomass

Hydrologic Studies

Urban Response

Land Cover



Coastal Studies

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Elevation Data Must Scale to Address Large Area Requirements

- Biomass and Carbon estimates
- Fire fuels models
- Geologic fault mapping
- Floodplain modeling
- Homeland security line of site analysis
- Hydrologic network improvements
- Landslide prone areas mapped
- Land cover assessment and mapping
- Precision agriculture
- Property valuation
- Species and habitat assessments
- Structures mapped in 3-D
- Three dimensional GIS enabled
- Urban area planning
- Wetland inventory improvements
- Wind and solar energy assessments

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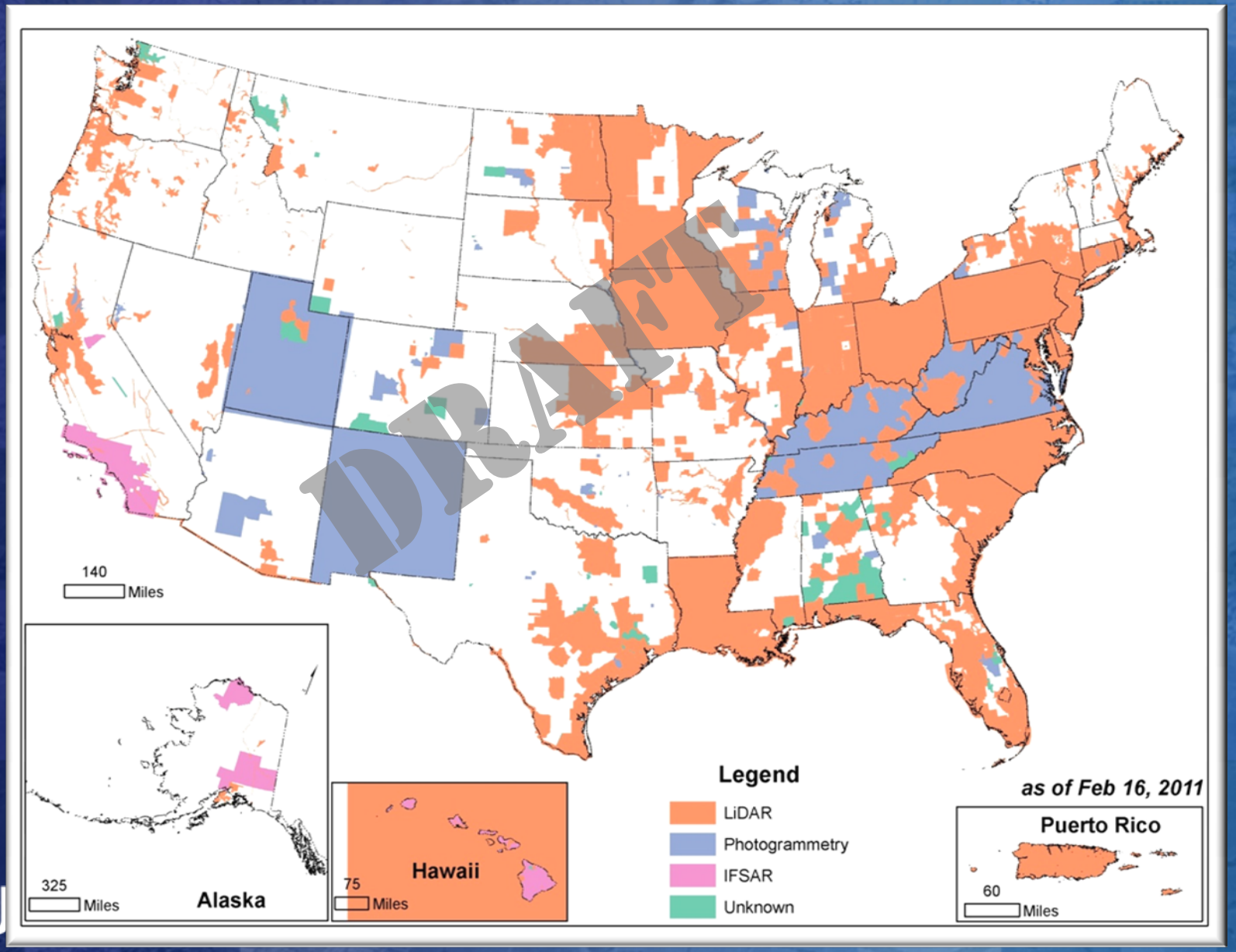
Enhanced Elevation Data Inventory



National Enhanced Elevation Assessment
Purpose

- Develop and refine requirements for a national program.
- Identify program implementation alternatives, costs and benefits of meeting priority Federal, State and other national needs.
- Quantify answers to key questions:
  - Is it more cost effective for the Government to manage these activities within the context of a national program?
  - Are there additional national or agency benefits derived from such a strategy?
  - What does the optimized program look like?

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National Enhanced Elevation Program

Idealized Goals and Schedule

- FY10
  - Established project team and management oversight
  - Initiated National Enhanced Elevation Assessment
  - Built on ARRA success and partnerships with FEMA, NGA, states and others
- FY11
  - National Enhanced Elevation Assessment
  - Begin Developing Multi-year National Enhanced Elevation Plan
- FY12
  - Develop supporting documents – alternatives analysis, design, implementation plan, etc.
  - Develop organizational approaches
- FY13
  - Implementation begins

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National Enhanced Elevation Assessment – Status of Ongoing Tasks

NOAA LiDAR Workshop
August 18, 2011

David Maune, PhD, CP, CFM
Project Manager

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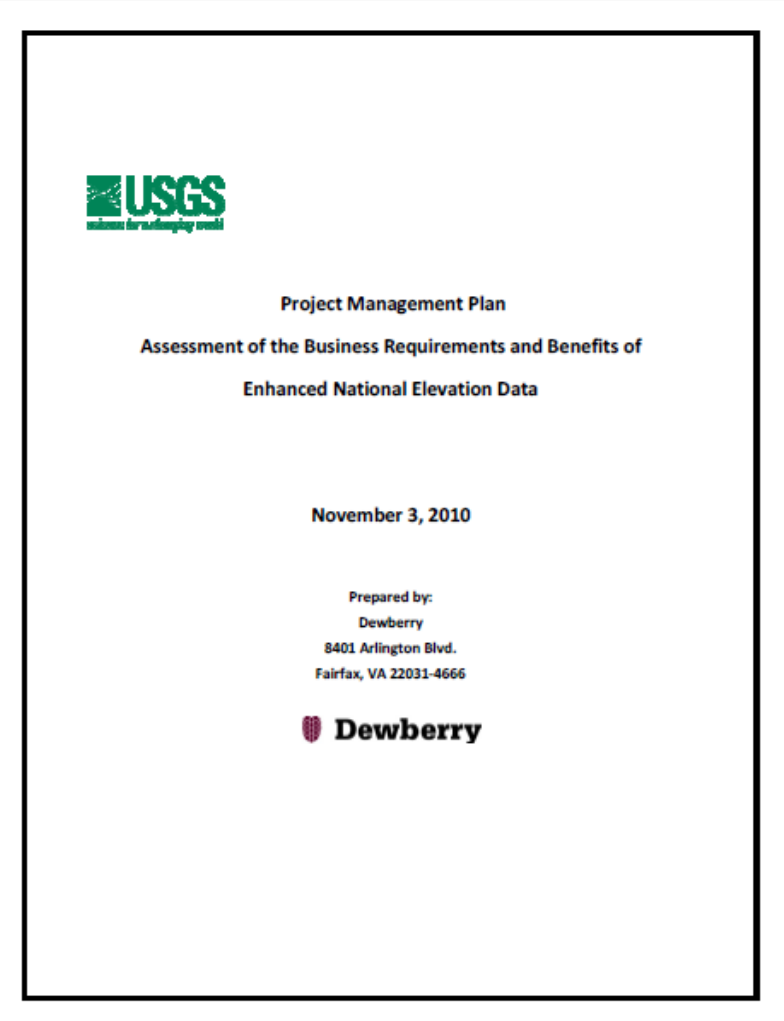
Project Management Plan



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Project Management Plan

Assessment of the Business Requirements and Benefits of

Enhanced National Elevation Data

November 3, 2010

Prepared by:
Dewberry
8401 Arlington Blvd.
Fairfax, VA 22031-4666

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- Overview, goals & objectives
- Requirements, costs & benefits information collection methodology:
  - Questionnaire process
  - Interview/Workshop process
  - Validation process
- Data aggregation/analyses
- Technology alternatives
- IT implementation scenarios
- Cost-benefit analyses
- Conclusions

Business Uses

1. Natural resources conservation
2. Water supply and quality
3. River & stream resource management
4. Coastal zone management
5. Forest resources management
6. Rangeland management
7. Wildlife and habitat management
8. Agriculture and precision farming
9. Geologic resource assessment and hazard mitigation
10. Resource mining
11. Renewable energy resources
12. Oil and gas resources
13. Cultural resources preservation and management
14. Flood risk management
15. Sea level rise and subsidence
16. Wildfire mgt, planning, response
17. Homeland security, law enforcement, disaster response
18. Land navigation and safety
19. Marine navigation and safety
20. Aviation navigation and safety
21. Infrastructure and construction management
22. Urban and regional planning
23. Health and human services
24. Real estate, banking, mortgage, insurance
25. Education K-12 and beyond
26. Recreation
27. Telecommunications

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Topographic Data Quality Levels

Quality Levels	Elevation Source	Horizontal Resolution Terms			Vertical Accuracy Terms	
		Point Density	Nominal Pulse Spacing	DEM Post Spacing	RMSEz in Open Terrain *	Equivalent Contour Accuracy
QL 1	LiDAR	8 pts/m^2	0.35 m	1/27 arc-sec (~1 m)	9.25 cm	1-ft
QL 2	LiDAR	2 pts/m^2	0.7 m	1/27 arc-sec (~1 m)	9.25 cm	1-ft
QL 3	LiDAR	1 – 0.25 pts/m^2	1 – 2 m	1/9 arc-sec (~3 m)	≤18.5 cm	2-ft
QL 4	Imagery	1 – 0.04 pts/m^2	1 – 5 m	1/3 arc-sec (~10 m)	46.3 cm – 139 cm	5 – 15 ft
QL 5	IFSAR	0.04 pts/m^2	5 m	1/3 arc-sec (~10 m)	92.7 cm – 185 cm	10 – 20 ft

* Vertical accuracy is reduced in vegetated land cover categories

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Bathymetric LiDAR Data Quality Levels

Three bathymetric LiDAR Quality Levels:

- Standard Quality Level (3-5 meter post spacing; RMSEz ~ 20 cm)
- Higher Quality Level (higher resolution/higher accuracy)
- Lower Quality Level (coarser resolution/lower accuracy)

Most bathymetric requirements submitted to Dewberry actually pertained to turbid waters for which bathymetric LiDAR is severely limited

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Update Frequency

- Annually
- 2-3 years
- 4-5 years
- 6-10 years
- >10 years
- Event driven; needs not met by a cyclic data acquisition program

NGA – Homeland Security and Disaster Response

Mission-Critical Requirements:

QL2 LiDAR of the 133 Urban Areas is required for disaster response, law enforcement, homeland security, research, and 3D modeling, simulation, and analyses.

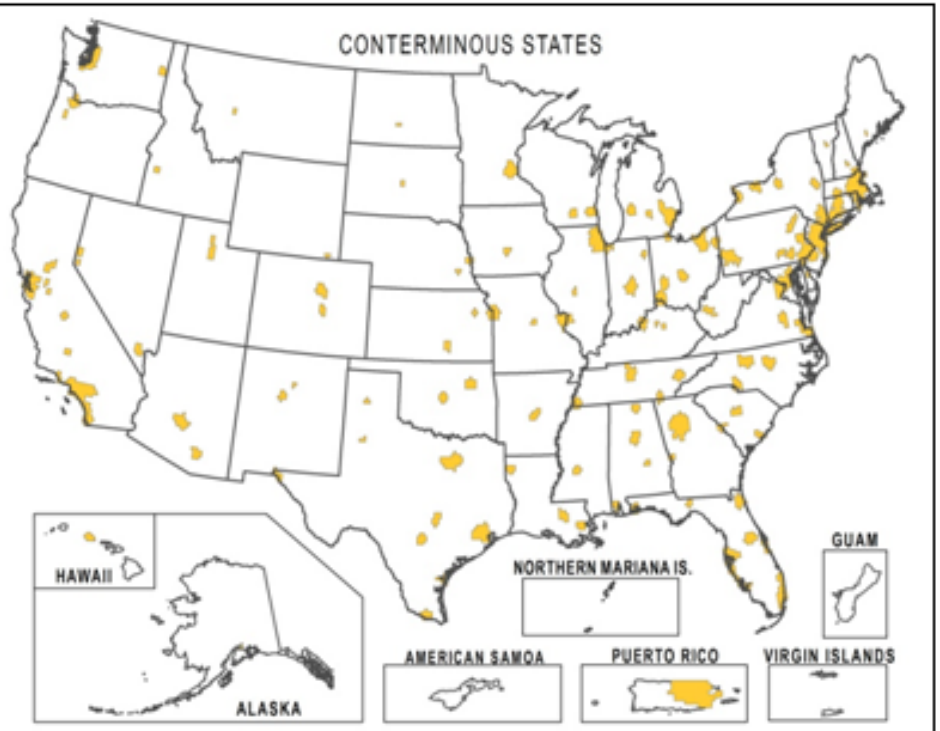
Update frequency: 4-5 years

Business Use: Homeland Security, Law Enforcement, and Disaster Response, BU#17

Estimated program budget: Cannot provide

Quantifiable Benefits of Enhanced Elevation Data:

No credible cost savings can be placed on the dollar value of infrastructure or lives protected from acts of terrorism or natural disasters.



Data Requirements

Quality Level

- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Agency: NGA

Functional Activity: Homeland Security and Disaster Preparedness

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NOAA – Advanced Hydrologic Prediction Service Static Inundation Mapping

Mission-Critical Requirements:

NOAA requires QL3 LiDAR for FEMA's high priority areas, QL4 DEMs from imagery for FEMA's mid priority areas, and QL5 IFSAR for FEMA's low priority areas. These data are required for hydrologic modeling, flood forecasting and warning, and flood inundation mapping of riverine areas nationwide for which NOAA provides advanced hydrologic prediction services.

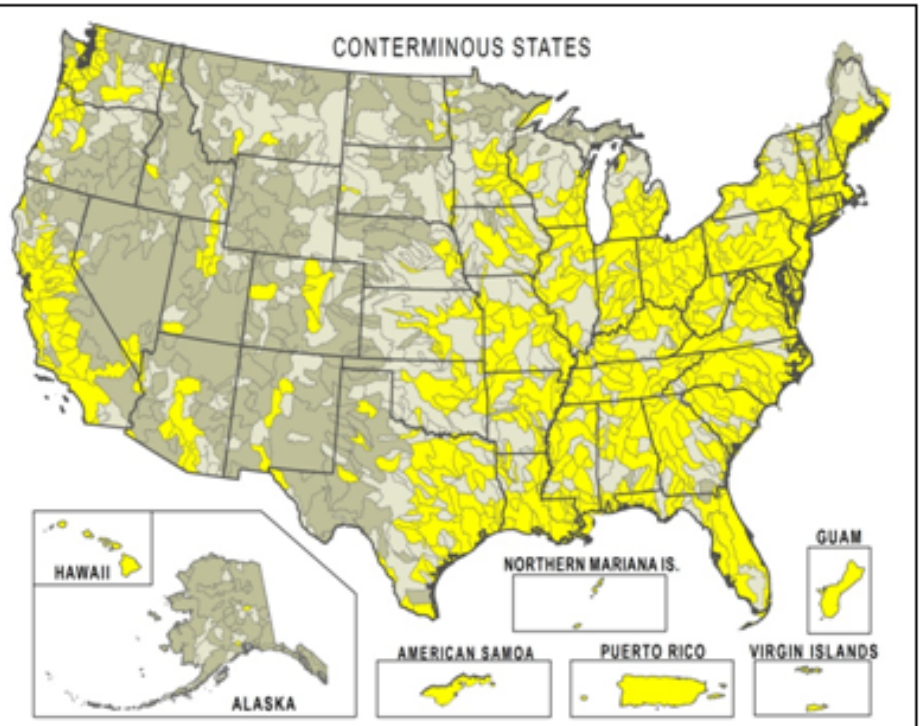
Update frequency: 4-5 years

Business Use: Flood Risk Management, BU#14

Estimated program budget: $400,000/yr

Quantifiable Benefits of Enhanced Elevation Data:

NOAA has estimated that the flood loss reduction benefits of the AHPS program can be estimated at $243M annually and 10% ($24.3M/yr) can be directly attributed to LiDAR data.



Agency: NOAA

Functional Activity: Advanced Hydrologic Prediction Service Static Inundation Mapping

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NRCS – Conservation Engineering and Practices

Mission-Critical Requirements:

Enhanced elevation data (QL2 LiDAR and QL5 IFSAR) for non-Federal lands, and a modernized IT infrastructure are mission-critical for a broad array of conservation engineering and practices for diverse Conservation Technical Assistance (CTA) programs managed by NRCS.

Update frequency: 6-10 years

Business Use: Multiple, but primarily Natural Resources Conservation, BU#1

Estimated program budgets supported by elevation data: ~$3B/yr

Quantifiable Benefits of Enhanced Elevation Data:

NRCS would save a minimum of $60M/yr from LiDAR, and possibly as much as $150M/yr if each Federal and state program was rigorously analyzed.

Data Requirements

Quality Level
- Quality Level 1
- Quality Level 2
- Quality Level 3
- Quality Level 4
- Quality Level 5

Agency: NRCS

Functional Activity: Conservation Engineering and Practices

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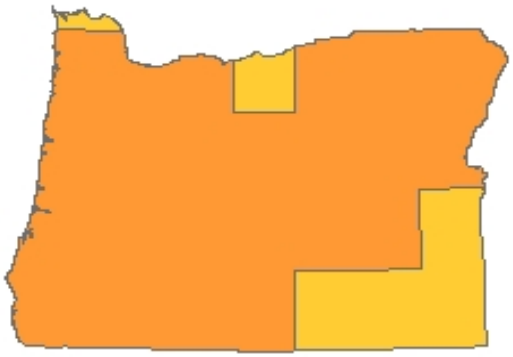
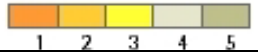
Oregon – Forest Resources Management

Program: Forest Management	Business Use: 5. Forest Resources Management



Quality Level: 

Update Frequency: 6-10 years

Bathymetric Data: No

Tide-Coordinated: No

Data Outside State Needed: No

Forest Management: Forest Management involves collecting and sharing information about the conditions of Oregon's forests, protecting forestlands and conserving forest resources. Intensity Image is also a required product.

Estimated Annual Operational Benefits: Major; $6,500,000

The single biggest impact of lidar technology on the science of forestry is that of forest inventory. Traditionally forest-wide inventories have been based upon samples taken within different vegetation strata across the landscape. Now forest managers are closer to being able to have a true inventory of the trees in any given area or ownership. Another benefit is that the design of new road layout is constrained by control points that the constructed road should avoid and areas of optimal grade and alignment. By using the bare earth hillshade it is possible to conduct preliminary engineering before making a field visit.

Estimated Annual Customer Service Benefits: Major; $6,500,000

The engineering uses of lidar data are impressive. In the past land managers used the best available topographic information available which was typically the 1:24,000 USGS topographic quadrangles. The contour lines on these maps were developed using photogrammetric methods, and due to the forest cover in western Oregon, the USGS was not able to certify that these maps met the national map accuracy standard of +/- ½ a contour interval (typically 40'). The lidar bare earth model is an accurate representation of the ground surface under the vegetation and can be used in many ways

Estimated Strategic Benefits: Major

1. Landslide and unstable slope identification to avoid issues resulting from improper road location.
2. Steep slope and operable lands identification.
3. Determining tractor ground versus cable ground and optimal landing locations.
4. Road design and layout including mass calculations for fills and cuts.
5. Determine yarding profiles and blind leads for cable systems.
6. Determination of landing placement.
7. The canopy layer is an efficient tool to help ODF biologists quickly identify potential marbled murrelet habitat and candidate trees.
8. The lidar derived hillshade is an extremely valuable tool for the identification of potential cultural resource areas, and specific historical activity locations.

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Michigan – Wildlife Management

Program: Wildfire vulnerability analysis	Business Use: 16. Wildfire Management, Planning, Response

Quality Level: 1 2 3 4 5

Update Frequency: 6-10 years

Bathymetric Data: Not Reported

Tide-Coordinated: No

Data Outside State Needed: Not Provided

Wildfire: Wildfire / Wildfire vulnerability analysis / Wildfire management planning and response. It is expected that these activities would be much improved by high-quality elevation and vegetative cover data.

Estimated Annual Operational Benefits: Moderate; Dollar Value Not Reported

1. Not certain that appropriate quality of required elevation data was selected - need a quality that allowed vegetative cover to be identified, ideally along with tree heights, as well as the identification of built structures in the area. 2. A statewide GIS analysis of that data could then allow wildfire risk areas to be identified, and wildfire vulnerabilities to be assessed, in order to identify and prioritize wildfire mitigation projects throughout the state.

Estimated Annual Customer Service Benefits: Moderate; Dollar Value Not Reported

Good elevation data, including forest types and tree height information as well as the identification of structure locations, would allow a great expansion of the quality and consistency of wildfire analyses throughout the state, both in local hazard mitigation plans and the state hazard mitigation plan. This would allow the identification and prioritization of wildfire mitigation projects to take place, and to justify the benefits of these projects for FEMA funding.

Estimated Strategic Benefits: Moderate

Good elevation data, including forest types and tree height information as well as the identification of structure locations, would allow a great expansion of the quality and consistency of wildfire analyses throughout the state, both in local hazard mitigation plans and the state hazard mitigation plan. This would allow the identification and prioritization of wildfire mitigation projects to take place, and to justify the benefits of these projects for FEMA funding. This would be expected to include enhanced life safety, infrastructure protection, transportation/emergency access, and economic/tourism benefits.

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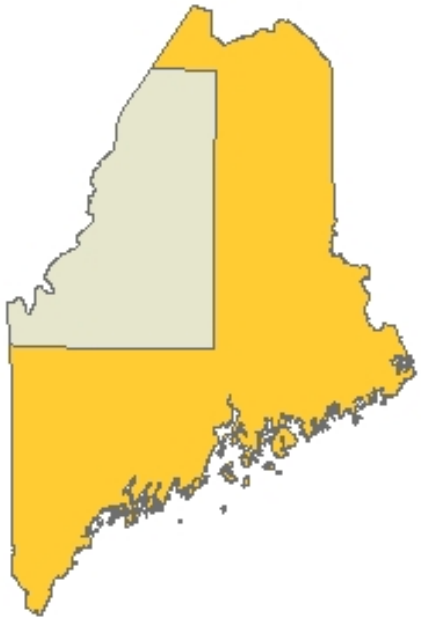
Maine – Geologic Resource Assessment and Hazard Mitigation

Program: Geologic hazard assessment	Business Use: 9. Geologic resource assessment and hazard mitigation



Quality Level: 1 2 3 4 5

Update Frequency: 2-3 years

Bathymetric Data: Yes

Tide-Coordinated: Yes

Data Outside State Needed: Not Provided

Geologic hazard mapping: Assessments of landslide hazards away from coastal areas including more accurate mapping of historic landslides in key areas.

Estimated Annual Operational Benefits: Not Reported; $200,000

Highly improved assessments on landslide hazards away from coastal areas. More accurate mapping of historic landslides in key areas.

Estimated Annual Customer Service Benefits: Major; Dollar Value Not Reported

Highly improved assessments on landslide hazards away from coastal areas. More accurate mapping of historic landslides in key areas.

Estimated Strategic Benefits: Major

Greater ease of identifying/mapping historic landslides - improved presentation to public.

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BU#1 – Natural Resources Conservation

Org.	Functional Activity	Qual. Level	Update
NRCS	Conservation Engineering & Practices (on non-Federal lands)	QL2 LiDAR QL5 IFSAR	6-10 years
NRCS	Specialized Mapping Applications nationwide	QL2/3 LiDAR QL5 IFSAR	6-10 years
USFS	Soil & Geology Inventory	QL2 LiDAR QL5 IFSAR	6-10 years
USFS	Wetlands Mapping and Characterization	QL2 LiDAR QL5 IFSAR	6-10 years
USGS	Mapping, Monitoring and Assessment of Biological Carbon Stocks	QL1/2 LiDAR	6-10 years
NOAA	Coastal and Marine Resources Conservation	QL2 LiDAR	4-5 years
EPA	Environmental Protection, Land Cover Characterization and Runoff Modeling	QL2 LiDAR QL5 IFSAR	4-5 years

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BU#1 – Natural Resources Conservation

Org.	Functional Activity	Qual. Level	Update
FWS	Landscape Conservation Cooperatives (LCCs)	QL1 LiDAR	6-10 years
NPS	Preservation and Protection of Natural and Cultural Resources	QL1/3 LiDAR QL5 IFSAR	6-10 years
BIA	Protection and Enhancement of American Indian Trust (AIT) Assets	QL3 LiDAR	6-10 years
USACE	Protection and Management of the Natural Environment	QL3 LiDAR	6-10 years
TVA	Natural and Cultural Resource Management and Conservation	QL3 LiDAR	2-3 years
TNC	Healthy Watersheds	QL2 LiDAR	6-10 years
Agren	Agricultural and Environmental Services	QL2 LiDAR	6-10 years

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BU#1 – Natural Resources Conservation

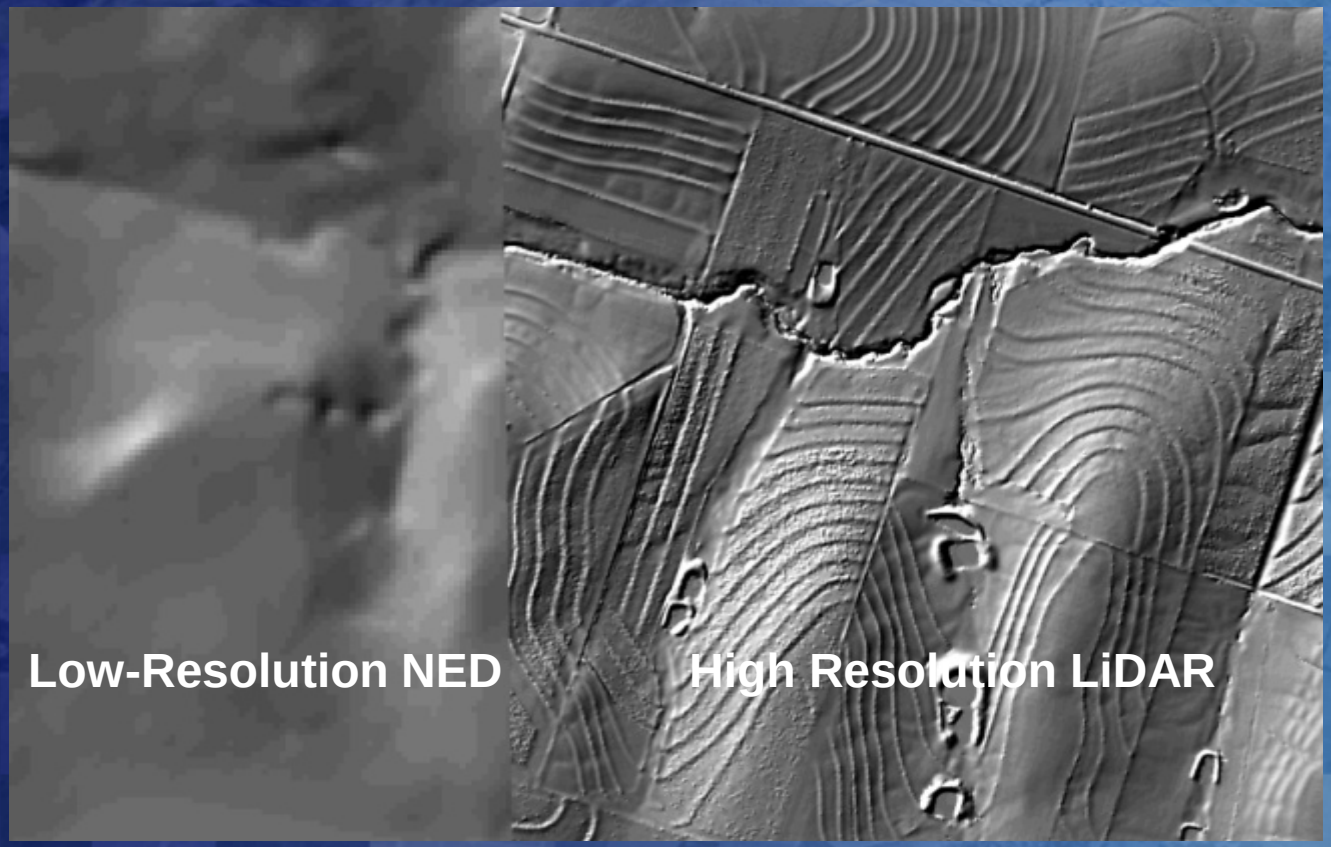

Image from NRCS

Conservation Engineering Practices require high-resolution DEMs as well as DEM derivatives (slope, aspect, curvature)

Slope, aspect & curvature are the three principal parameters for LiDAR Enhanced Soil Surveys (LESS)

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BU#2 – Water Supply and Quality

Image from Georgia Geospatial Advisory Council

Withlacoochee River Wastewater Treatment Plant near Valdosta, GA, located outside the FEMA SFHA, had to be relocated after flood of 2009 at cost of $94.5M

Elevations are critical for sewage treatment plants and water facilities

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BU#3 – River & Stream Resource Mgt

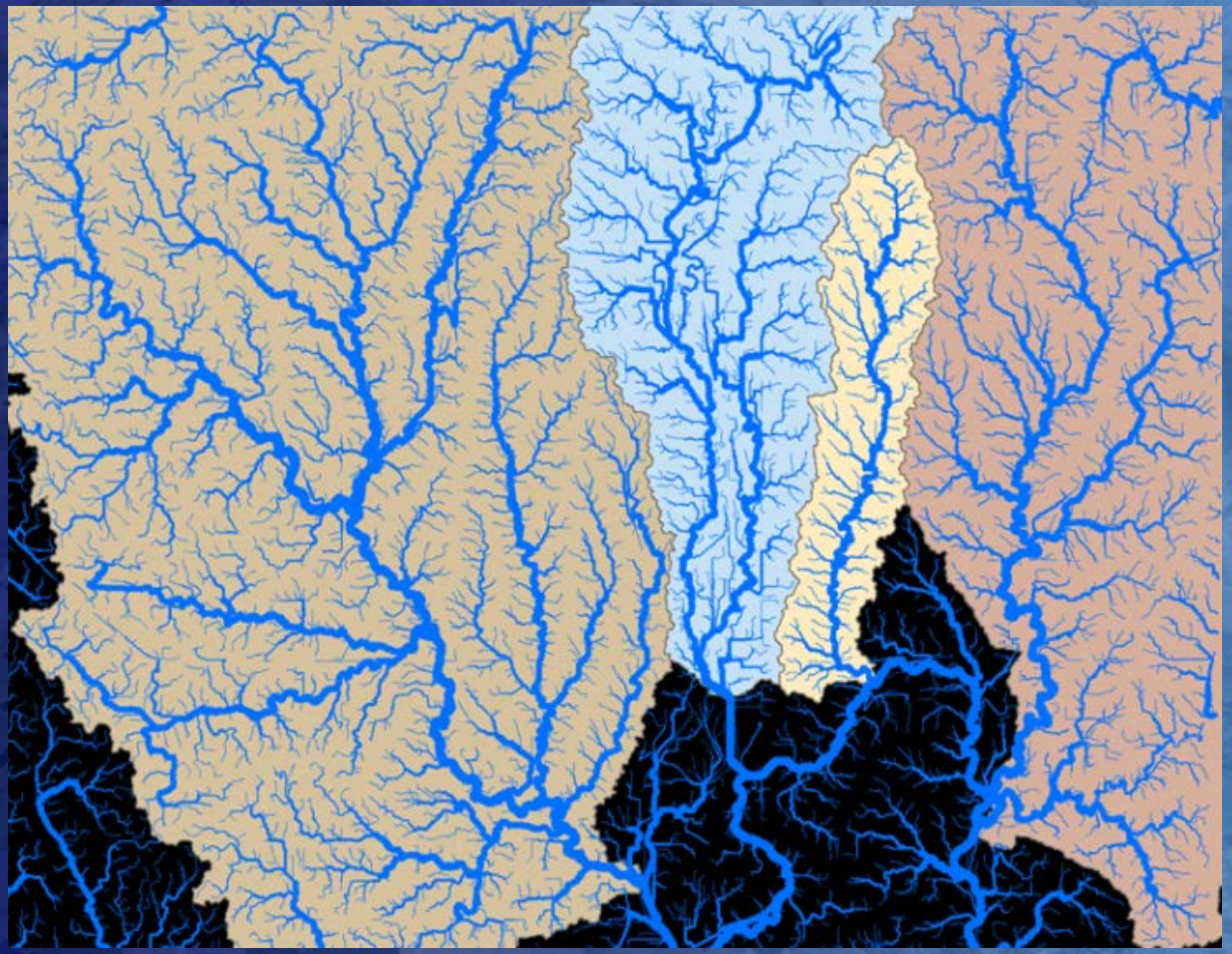

Image from USGS

Hydrologic modeling of watersheds, and hydraulic modeling of floodplains, are rightfully called "killer apps" for LiDAR

LiDAR is also seen as the solution to drainage problems nationwide

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BU#4 – Coastal Zone Management

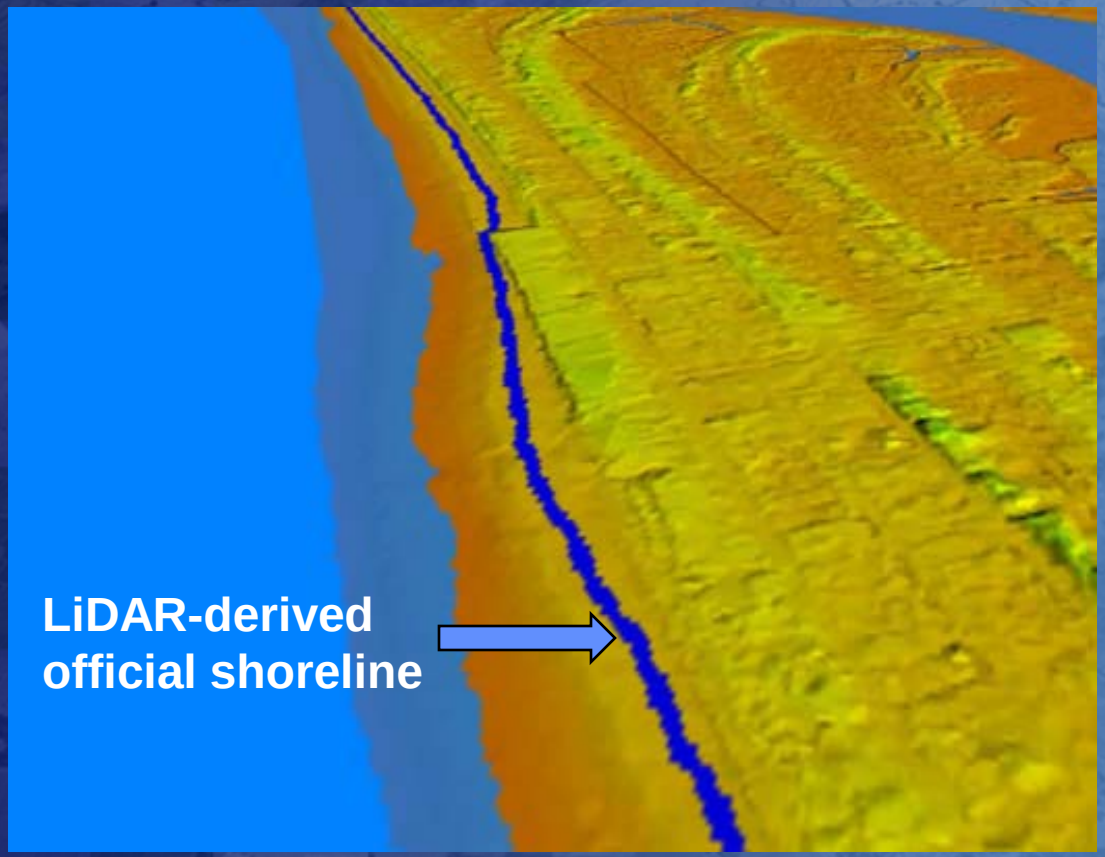

Image from NOAA

JALBTCX (NOAA, USACE, USGS, USN) has *Coastal Mapping & Charting Program* for topo/bathy LiDAR

NOAA's *Digital Coast* addresses timely coastal issues, including land use, coastal conservation, coastal hazards, marine spatial planning

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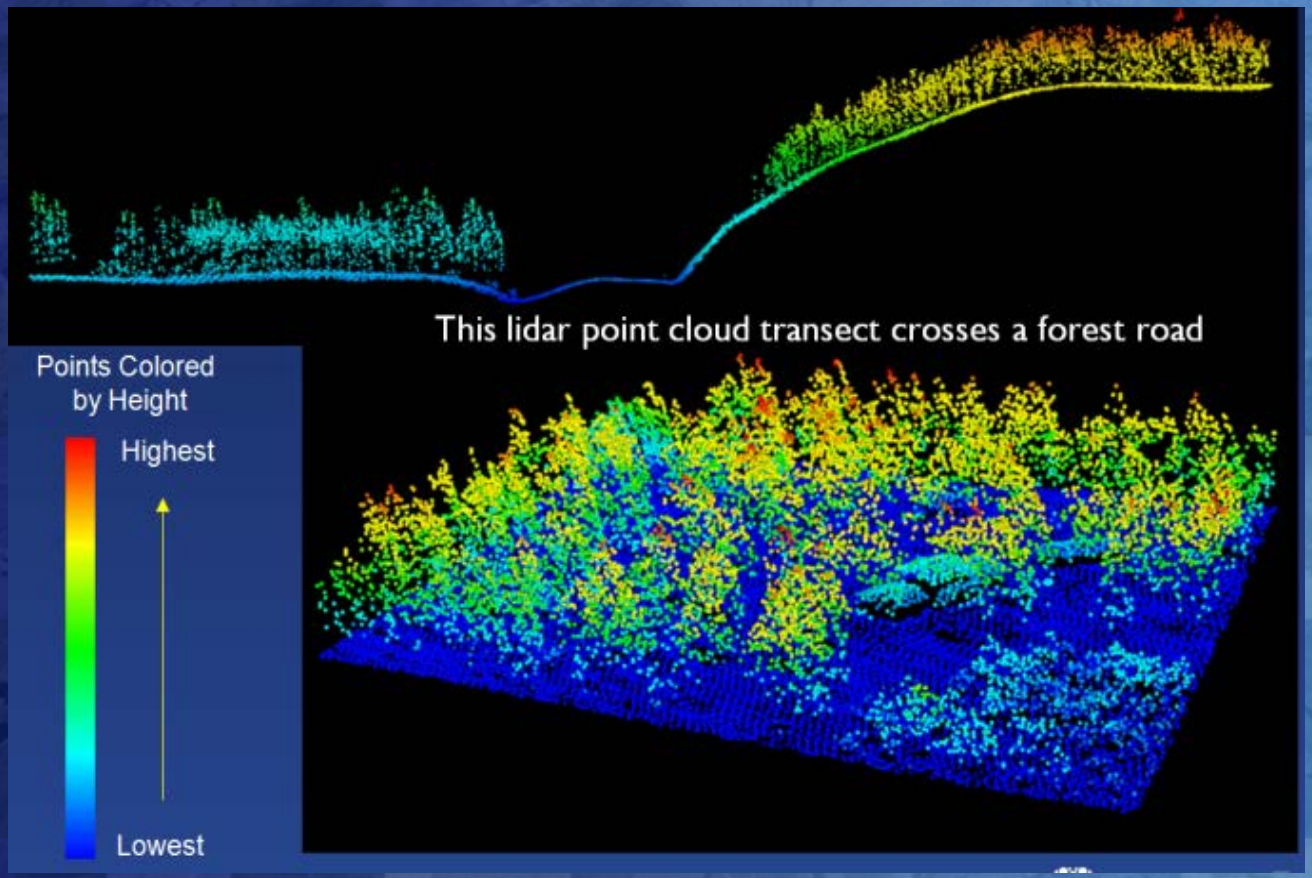
BU#5 – Forest Resources Management



LiDAR is vital for forest inventory and assessment, computation of forest metrics

Also used for assessment of forest health

Images from USFS

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BU#6 – Rangeland Management

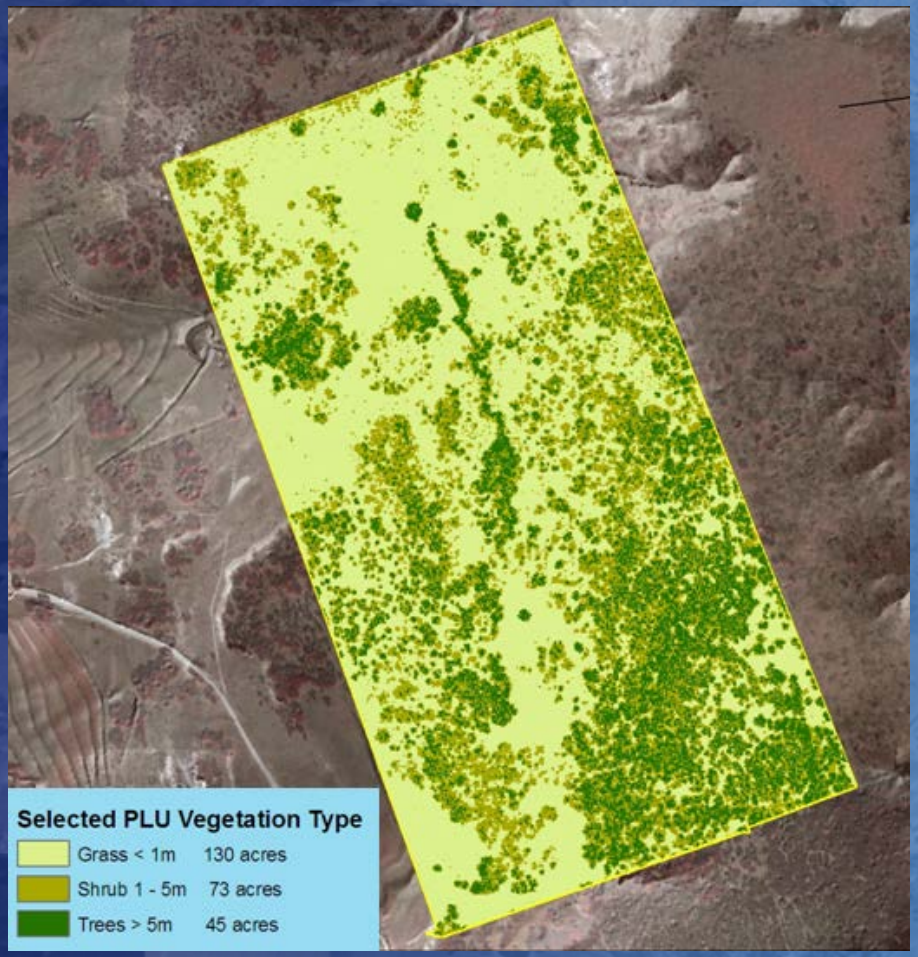

Image from NRCS

LiDAR used by NRCS for assessment of rangeland vegetation type by Planning Land Unit (PLU)

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BU#7 – Wildlife & Habitat Management

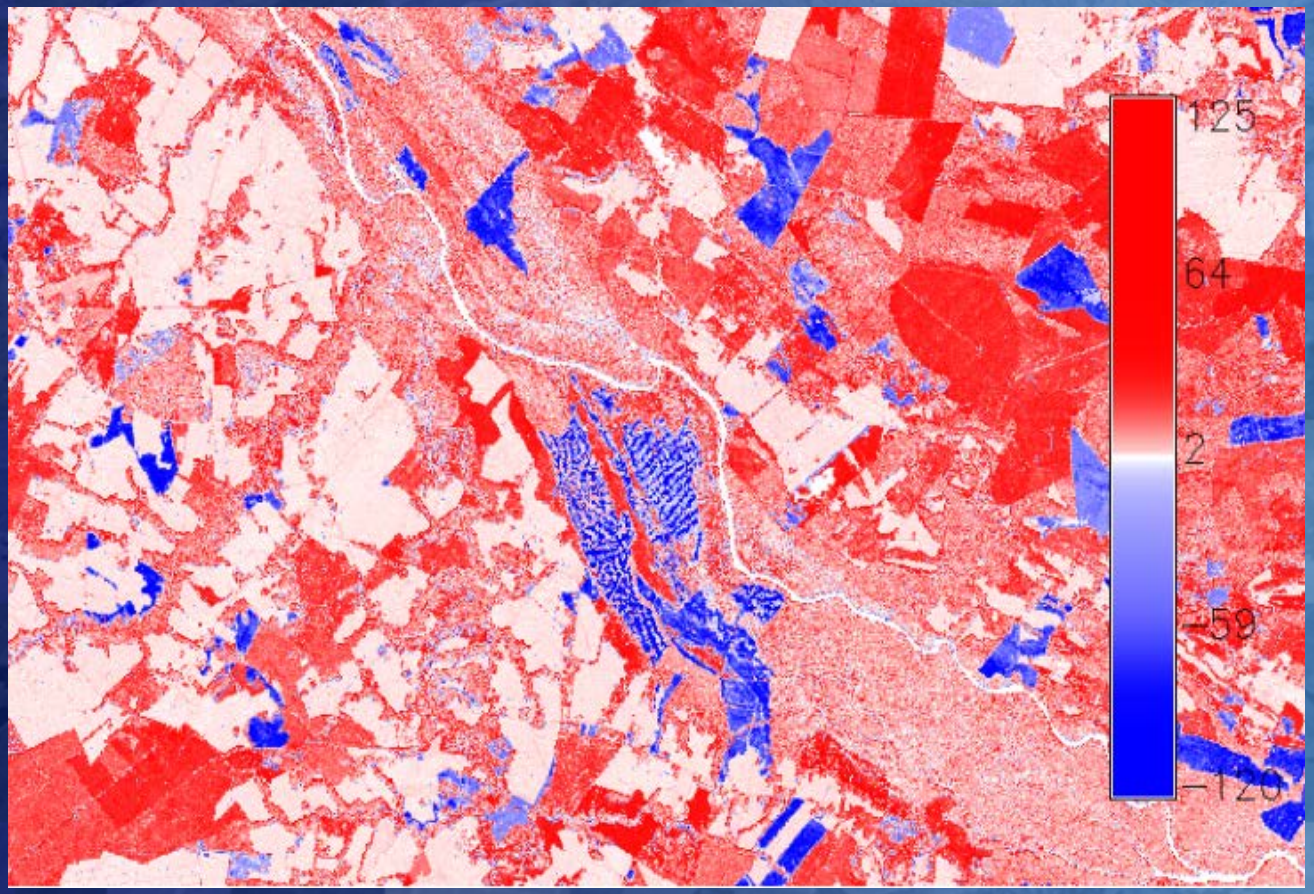

Image from FWS

Craven County, NC, LiDAR-derived differences in Loblolly pine canopy heights of ±120 ft in 6-year period, with major changes to wildlife habitat

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BU#8 – Agriculture & Precision Farming

Org.	Functional Activity	Qual. Level	Update
JR Simplot Company	Precision Agriculture	QL3 LiDAR	6-10 years
Ellingson Drainage	Agricultural Drainage Solutions	QL3 LiDAR	6-10 years
Agren	Agricultural and Environmental Services	QL2 LiDAR	6-10 years

USGS

Dewberry

BU#8 – Agriculture & Precision Farming

LiDAR is required for all agricultural land areas of the U.S. for topographic analysis of slope, aspect, curvature and soil wetness (surface and subsurface), and resultant site-specific application of seed, fertilizer, lime, pesticides and water to optimize farm yields.

Also used to reduce farm and pasture runoff that pollutes streams

Image from University of Missouri Extension

USGS

Dewberry

BU#9 – Geologic Resource Assessment & Hazard Mitigation

Org.	Functional Activity	Qual. Level	Update
USGS	Geologic Mapping	QL1 LiDAR	>10 years
USGS	Seismic Hazards	QL1 LiDAR	6-10 years
USGS	Landslide Hazards	QL1 LiDAR	4-5 years
USGS	Volcano Hazards	QL1 LiDAR	4-5 years
USFS	Soils and Geology Inventory	QL2 LiDAR QL5 IFSAR	6-10 years
NRC	Nuclear Power Plant Site Natural Phenomena Hazard Assessment and Risk Mitigation	QL1 LiDAR	6-10 years

Also BIA, BLM, NPS, NRCS as part of other Functional Activities

USGS

Dewberry

BU#9 – Geologic Resource Assessment & Hazard Mitigation

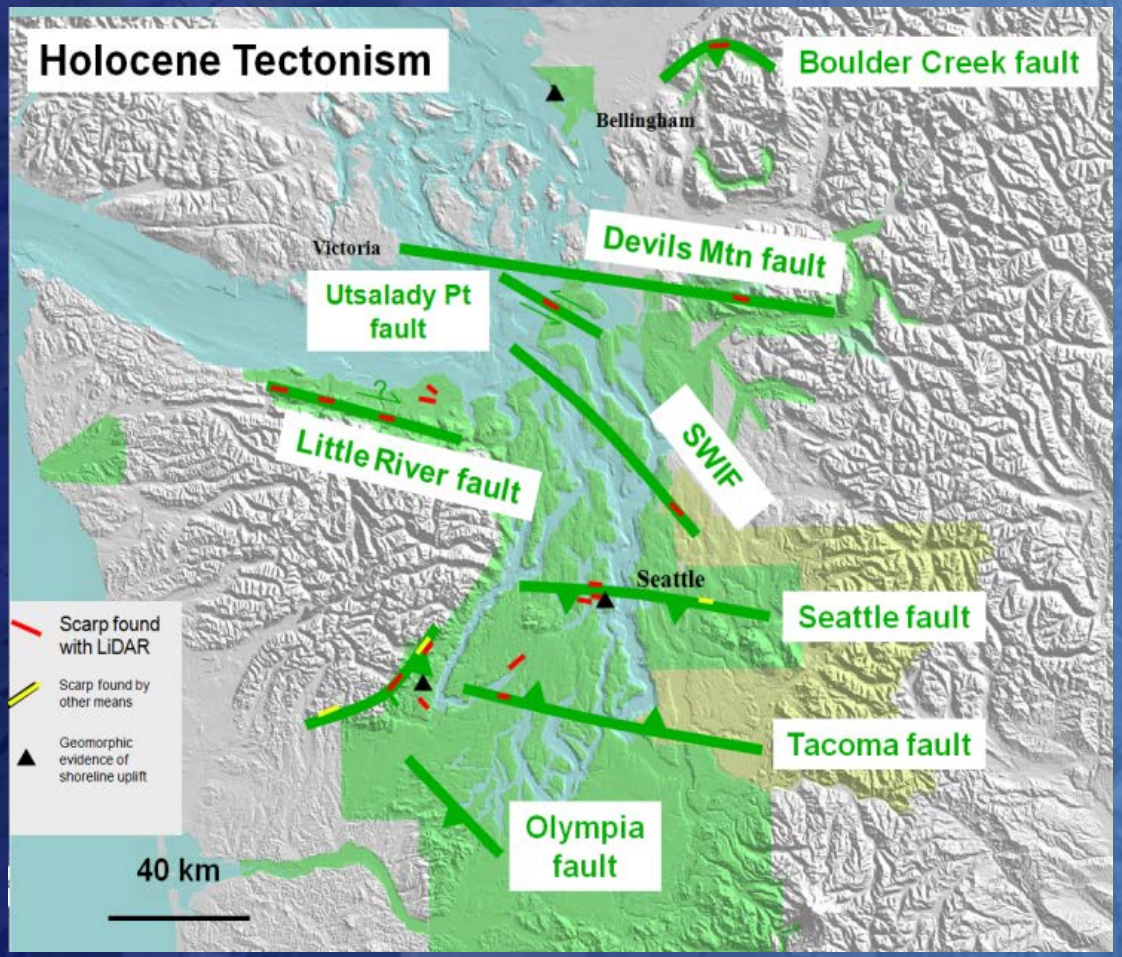


Image from USGS

LiDAR detected seismic faults near:

- **$12B nuclear waste treatment plant being built in Washington State**
- **$735M suspension bridge under construction across Tacoma Narrows**

USGS

Dewberry

BU#10 – Resource Mining

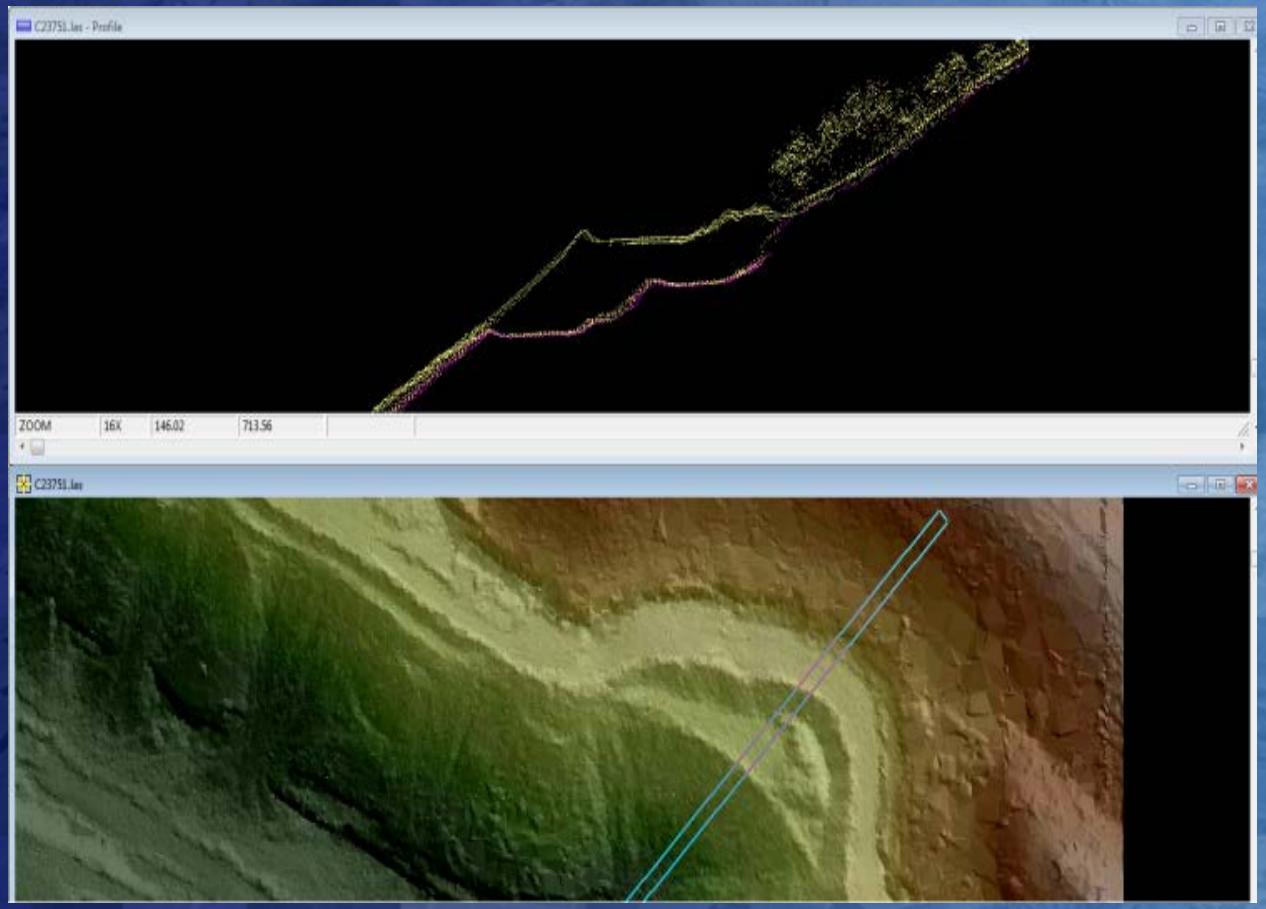


Image from Dewberry

LiDAR cross-section in Pennsylvania after only one month of mining.

LiDAR is ideal for evaluation of slopes for safe mining operations, environmental protection, and for comparisons between baseline surfaces (prior to mining) and final surfaces (after reclamation)

USGS

Dewberry

BU#11 – Renewable Energy Resources

Org.	Functional Activity	Qual. Level	Update
TVA	Siting of Wind and Solar Generation	QL4 Imagery	2-3 years
NextEra Energy	Wind Farm Siting and Design	QL5 IFSAR	2-3 years
Wind Logics	Solar Resource and Energy Assessments	QL3 LiDAR	6-10 years

Also BIA, BLM and other government land owners if wind or solar farms are allowed on Indian or government lands

USGS

Dewberry

BU#11 – Renewable Energy Resources

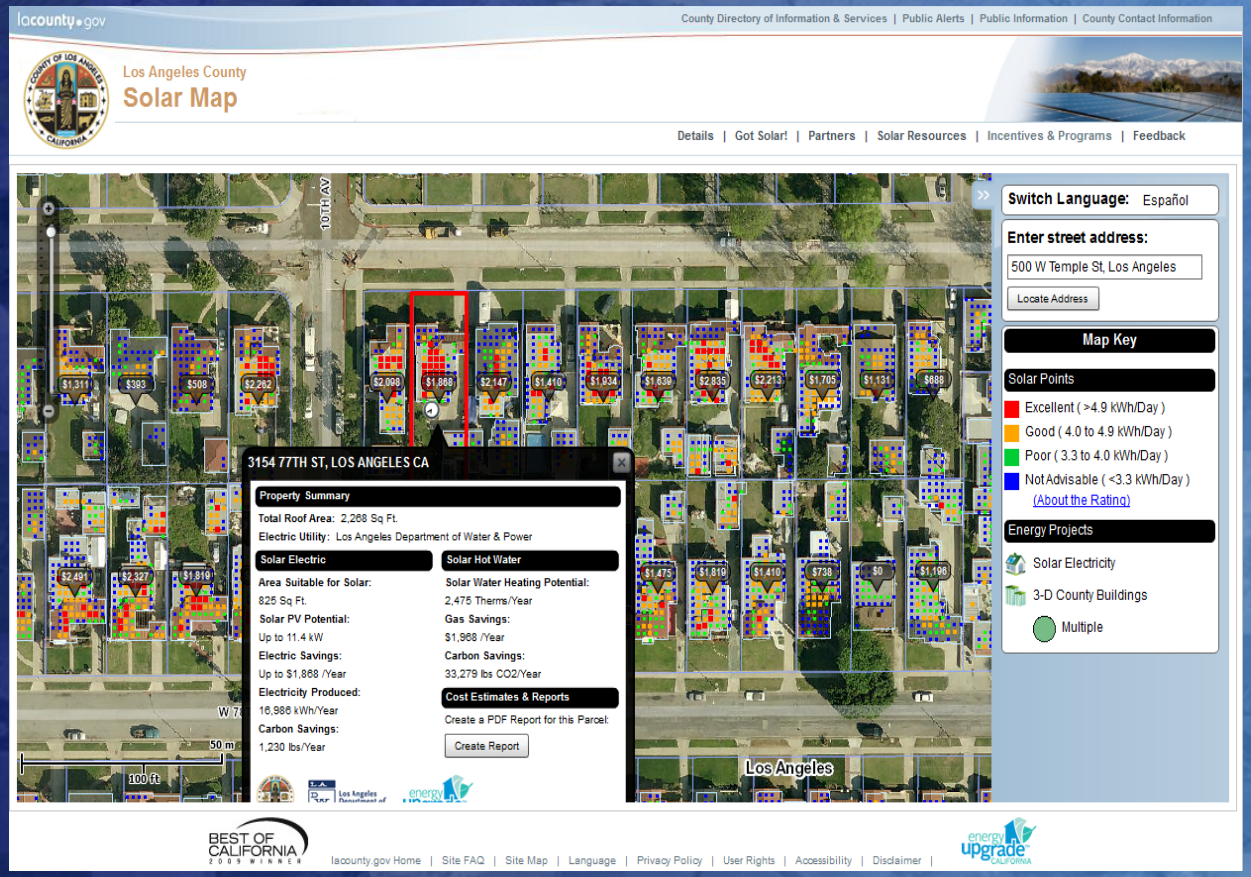


Image from Los Angeles County

Los Angeles and New York City are among major cities that use LiDAR data to enable home owners to print a report for their home/ property explaining its potential for solar energy and/or solar water heating, and potential cost savings and carbon savings

USGS

Dewberry

BU#12 – Oil and Gas Resources

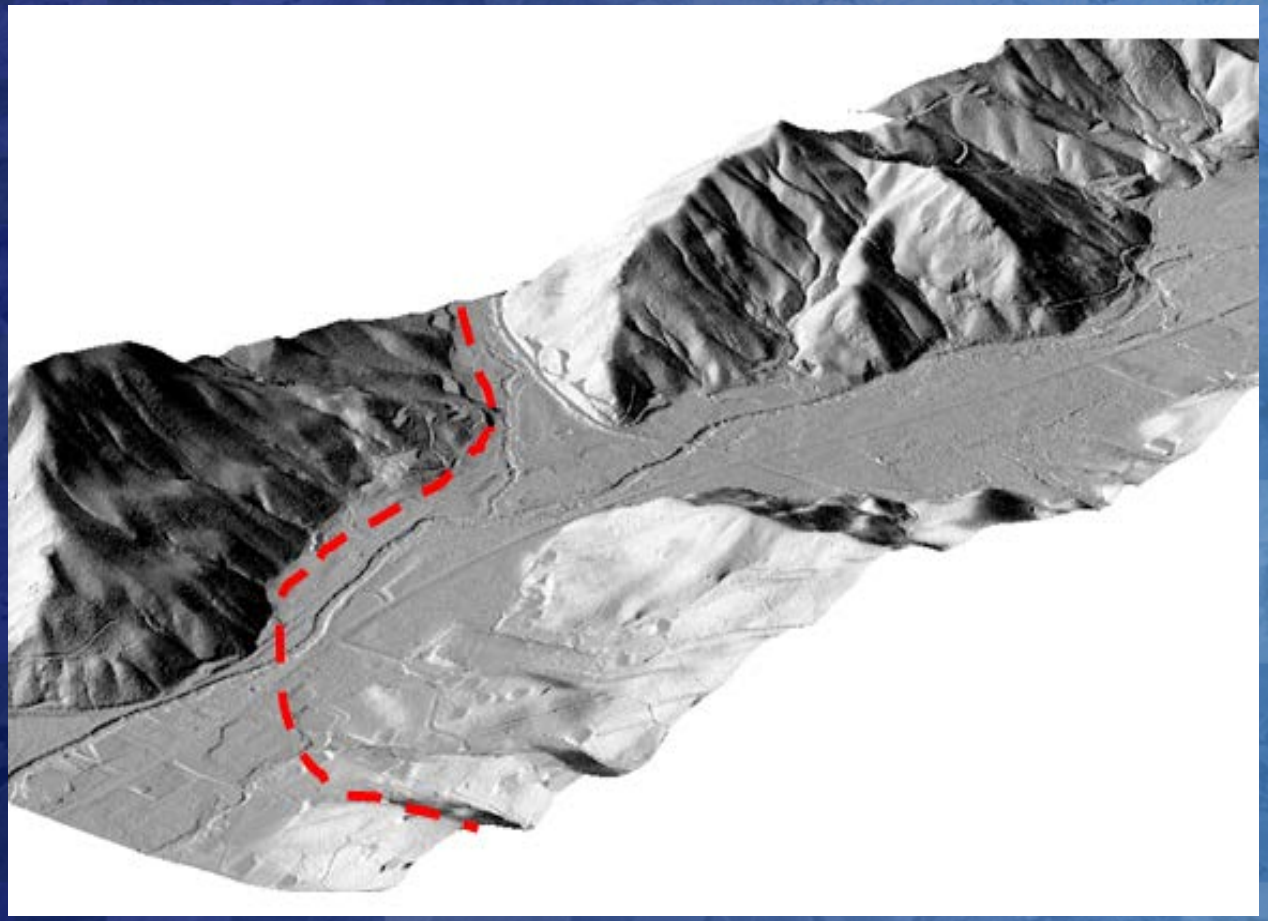


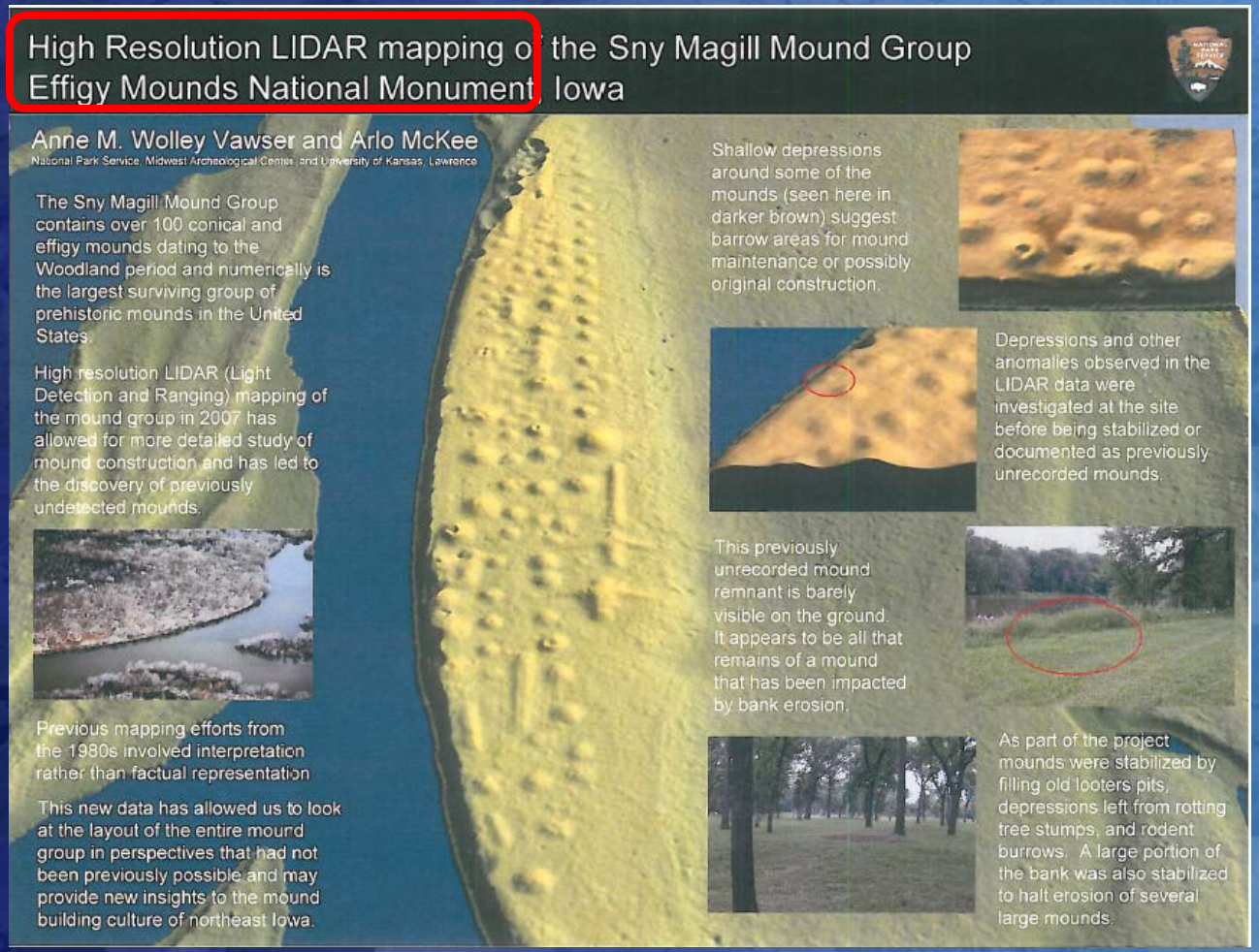
Image from Dewberry

LiDAR data is essential for pipeline routing across mountain ranges and beneath rivers, construction planning, encroachment control, estimation of timber removal, and asset inventories

USGS

Dewberry

BU#13 – Cultural Resources Preservation and Management



NPS brochure

Whereas these Native American artifacts in Iowa are obvious, other artifacts of ancient villages or trails are detectable by LiDAR, though not obvious when walking on the ground

USGS

Dewberry

BU#14 – Flood Risk Management

Org.	Functional Activity	Qual. Level	Update
FEMA	Flood Risk Analysis	QL3 LiDAR QL4 Imagery QL5 IFSAR	6-10 years
USACE	Flood Risk & Emergency Management	QL3 LiDAR	6-10 years
NOAA	Advanced Hydrologic Prediction Service Static Inundation Mapping	QL3 LiDAR	4-5 years
USGS	Flood Risk Management	QL3 LiDAR	4-5 years
IBWC	Flood Risk Management	QL2 LiDAR	4-5 years
USFS	Watershed Analyses	QL3 LiDAR	6-10 years
TVA	Navigation & Flood Risk Mitigation	QL1 LiDAR + bathy data	4-5 years

Also BIA, BLM, FERC, NPS, NRCS, USBR as part of other Functional Activities

USGS

Dewberry

BU#14 – Flood Risk Management

Before FIRM Revision

After FIRM Revision

Images from Georgia Geospatial Advisory Council

Whether structures are added to or removed from the Special Flood Hazard Area, it's critical that FIRMs accurately represent true flood risk, and LiDAR makes this possible.

USGS

Dewberry

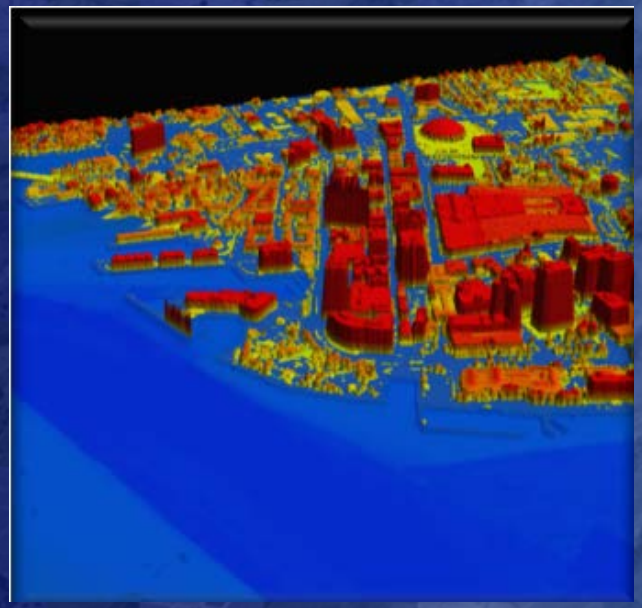
BU#15 – Sea Level Rise & Subsidence

Org.	Functional Activity	Qual. Level	Update
NOAA	Coastal Mapping and Modeling	Topo/bathy LiDAR	4-5 years
USGS	Coastal Zone Management, Sea Level Rise and Subsidence	Topo/bathy LiDAR	4-5 years
USACE NOAA	Coastal Mapping and Charting (JALBTCX)	Topo/bathy LiDAR	4-5 years
EPA	Sea Level Rise Vulnerability Assessments	QL2 LiDAR	6-10 years
The Nature Conservancy	Coastal Stewardship & Resiliency	QL2 LiDAR	4-5 years

USGS

Dewberry

BU#15 – Sea Level Rise (SLR) and Subsidence



LiDAR for multiple SLR scenarios

1m SLR & subsidence predictions for Southern Louisiana

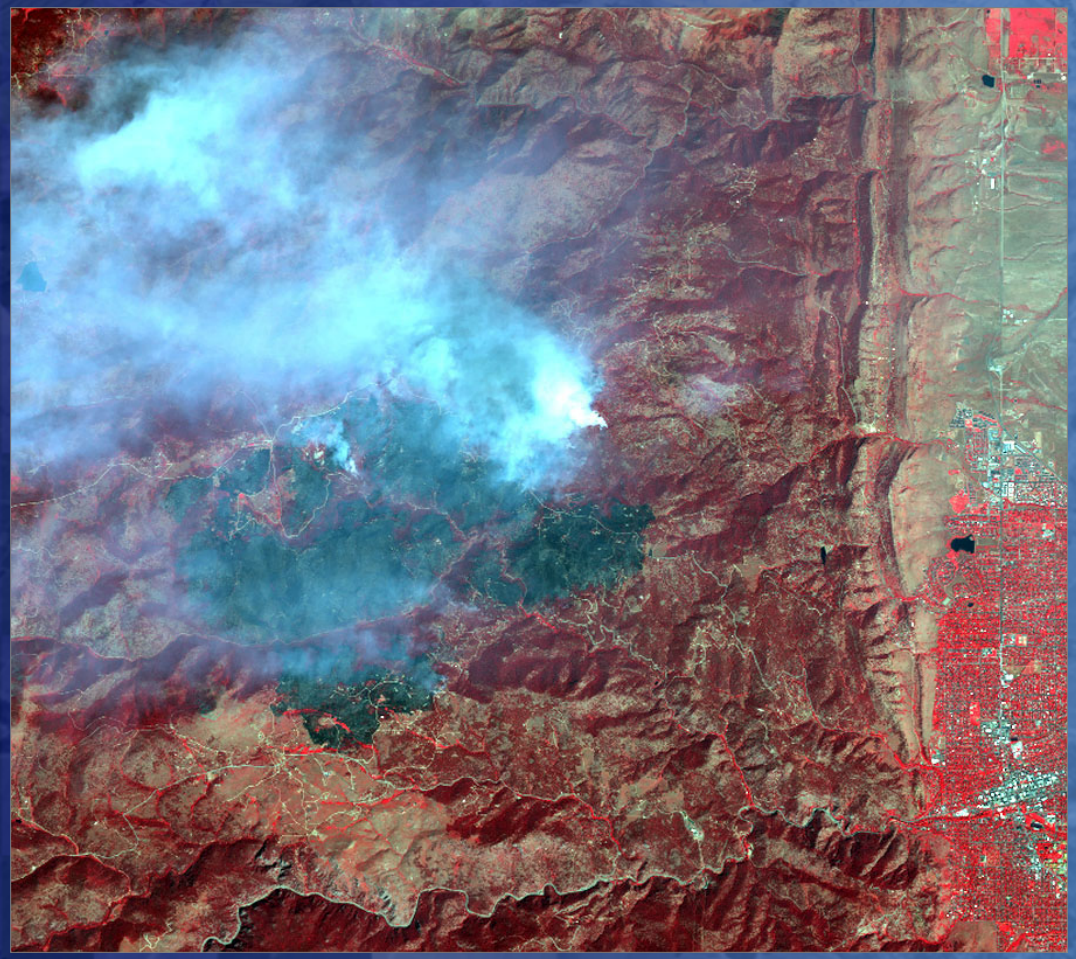
50 years of subsidence in California

Images from USGS and NOAA

USGS

Dewberry

BU#16 – Wildfire Management, Planning & Response



WV2 image from Digital Globe

Imagery can track the progress of wildfires

…but elevation data, including slope and biomass (fuel), wind and weather models predict when & where the fire will spread

…vital for planning fire-fighting strategies

USGS

Dewberry

BU#17 – Homeland Security, Law Enforcement & Disaster Response

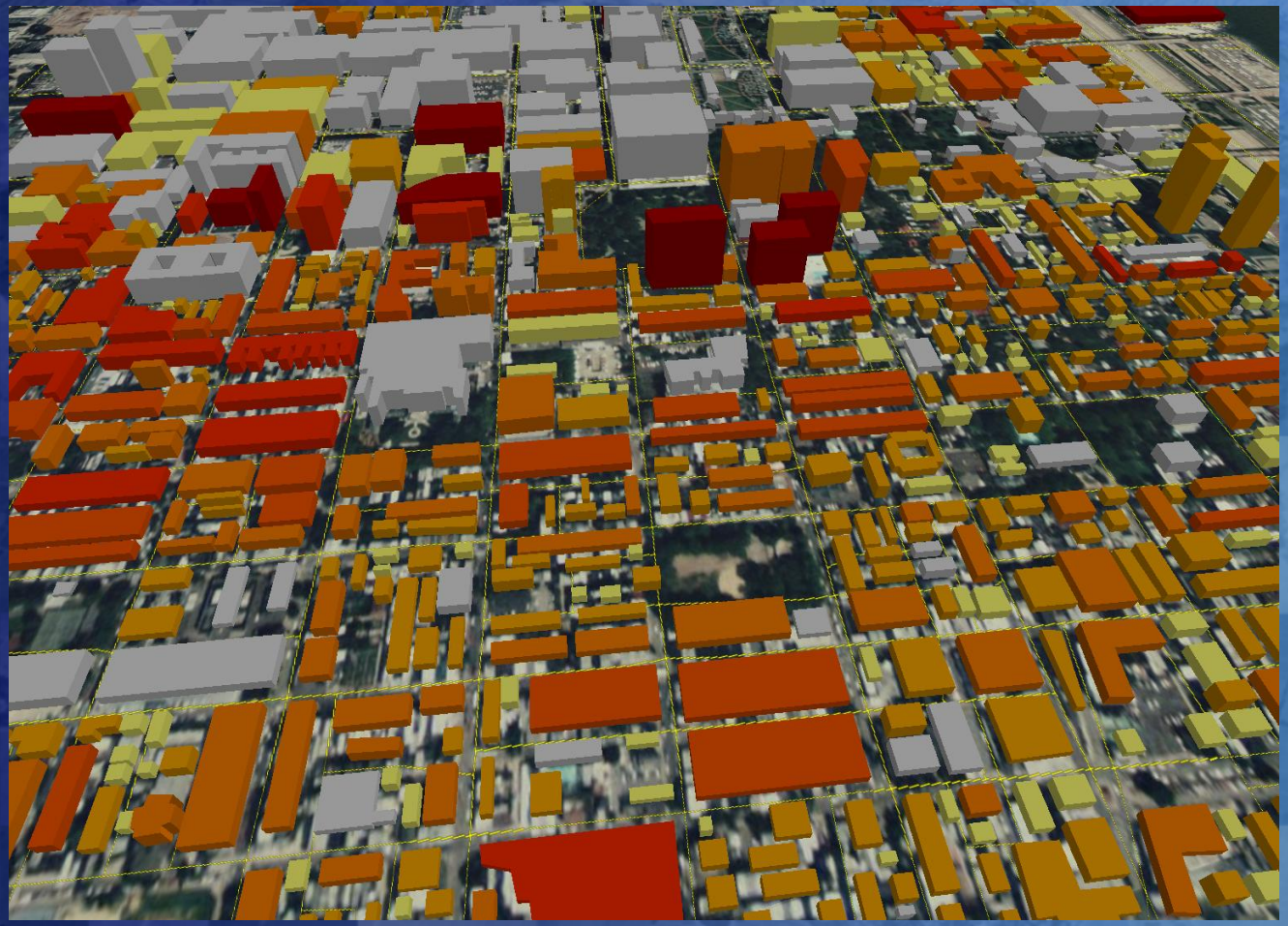


Image from DOE

- **LiDAR is used to determine number of floors and square footage of buildings**
- **Census & other data are used to determine average building occupancy for different building types**
- **Evacuation planning**

USGS

Dewberry

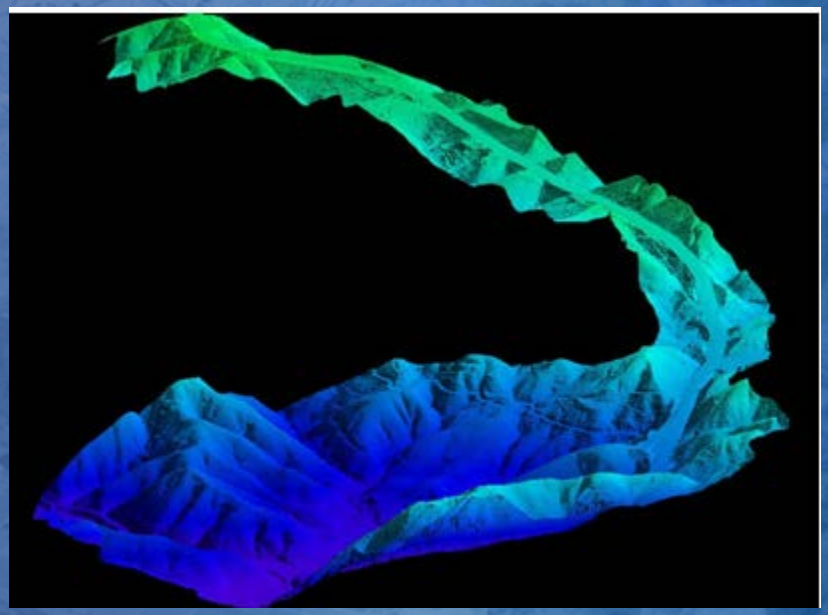
BU#18 – Land Navigation and Safety

Org.	Functional Activity	Qual. Level	Update
TomTom	Location and Navigation Services	QL2 LiDAR QL5 IFSAR	4-5 years
FRA	Safety for Railroad Grade	QL3 LiDAR	2-3 years

USGS

Dewberry

BU#18 – Land Navigation and Safety



Combined use of LiDAR and imagery for road surveys saves costs and minimizes surveyor hazards from passing cars

New cars & trucks will use LiDAR for transmission control; reduce fuel & emissions and provide driver fatigue warnings

Images from Tuck Mapping Solutions

USGS

Dewberry

BU#19 – Marine Navigation and Safety

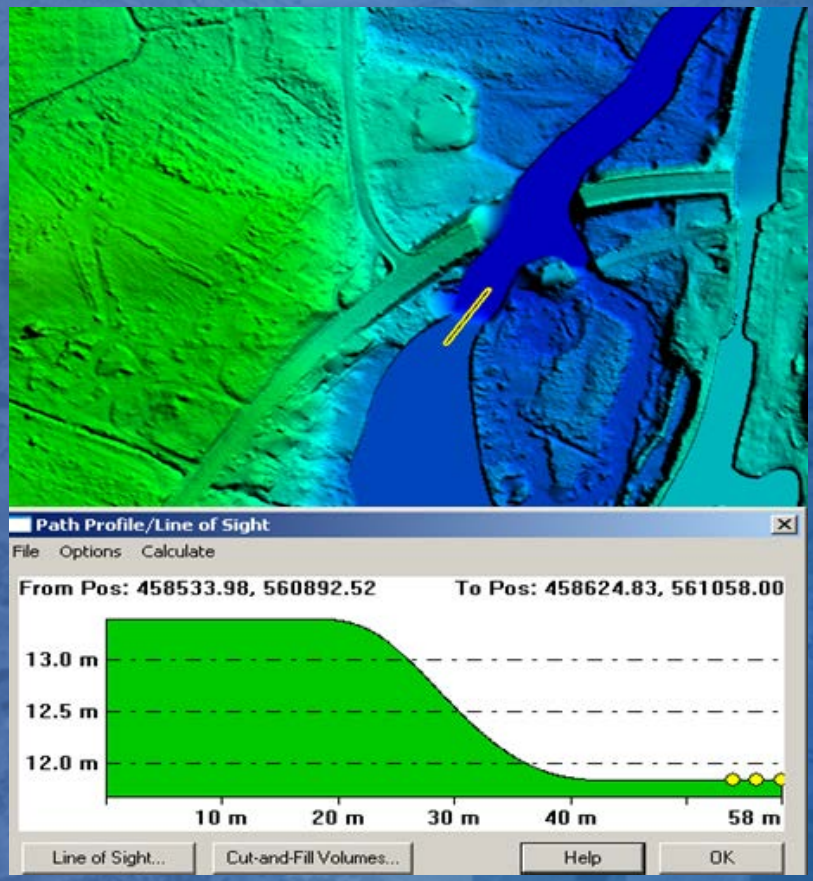
Org.	Functional Activity	Qual. Level	Update
USACE	Development and Management of the Nation's Water Resources	QL2 LiDAR	6-10 years
TVA	Navigation & Flood Risk Mitigation	QL1 LiDAR + bathy data	4-5 years
NOAA	Coastal Mapping and Modeling	Topo/Bathy LiDAR	4-5 years
DHS (USCG)	Coastal Search and Rescue	QL3 LiDAR	>10 years

USGS

Dewberry

BU#19 – Marine Navigation & Safety

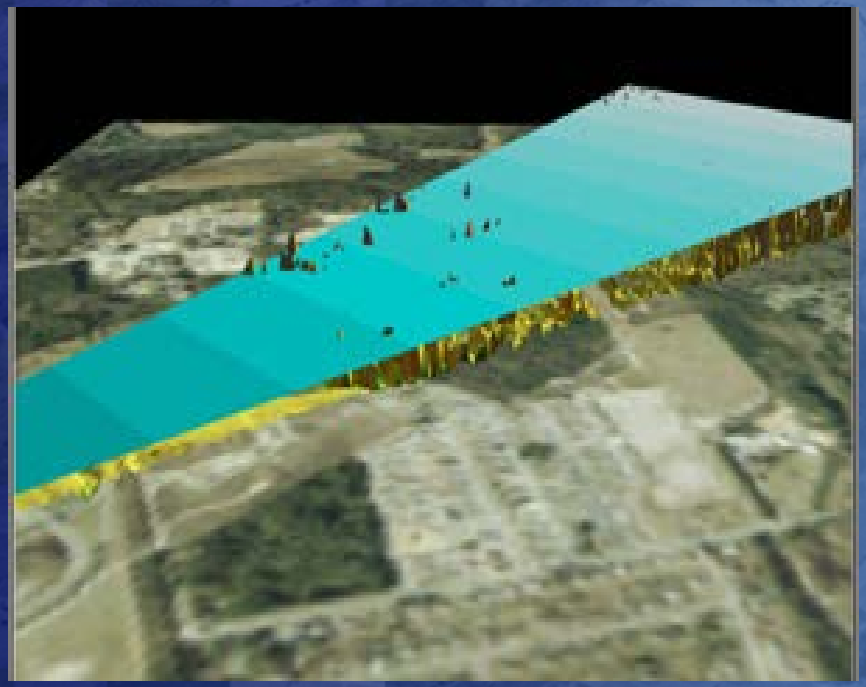
I need a better picture to demonstrate elevation data used for Marine Navigation and Safety



USGS

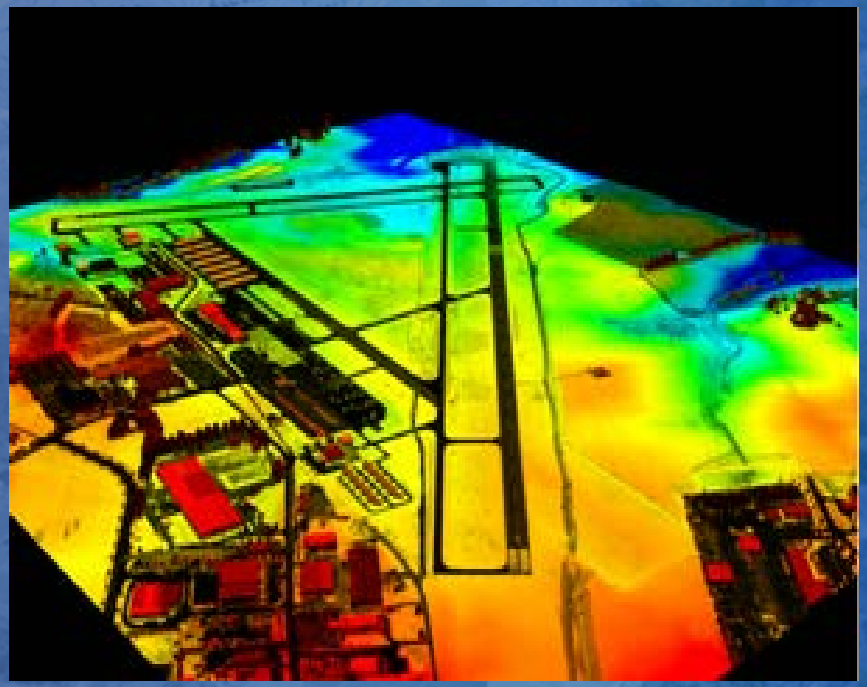
Dewberry

BU#20 – Aviation Navigation & Safety



LiDAR identifies obstacles that penetrate Obstruction Identification Surfaces (OIS)

Image from Fugro EarthData



LiDAR used for development of aviation instrument approach & departure procedures

Image from NOAA

USGS

Dewberry

BU#20 – Aviation Navigation and Safety

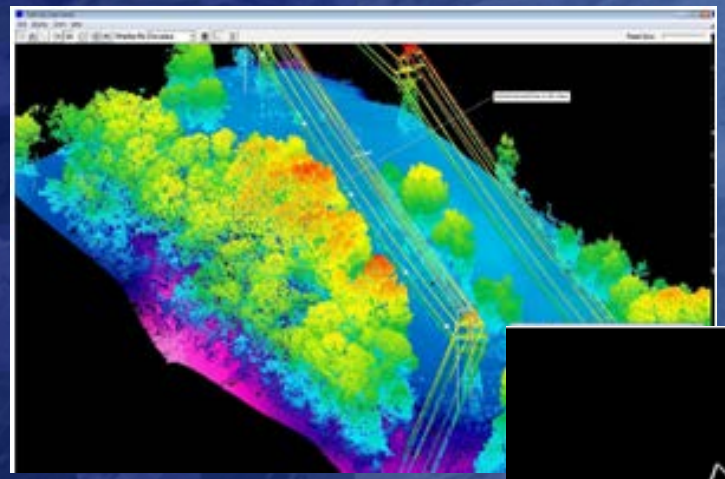
Pilots are trained on flight simulators using elevation data and imagery.
This is especially critical in Alaska where there is an urgent need to reduce Controlled Flight Into Terrain (CFIT) accidents.

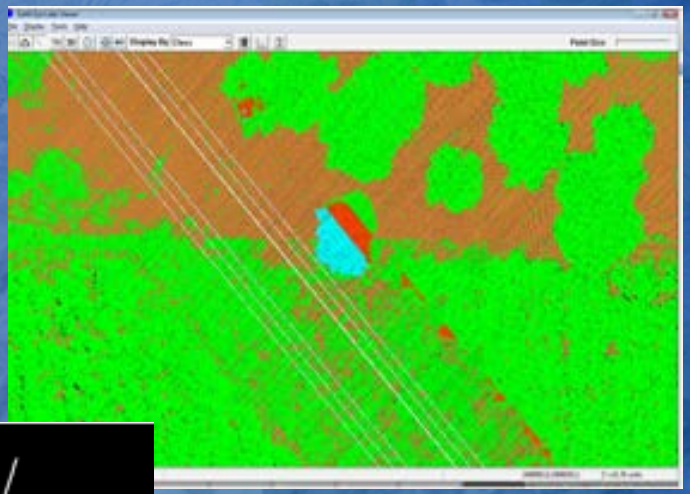
Image from E-Terra LLC

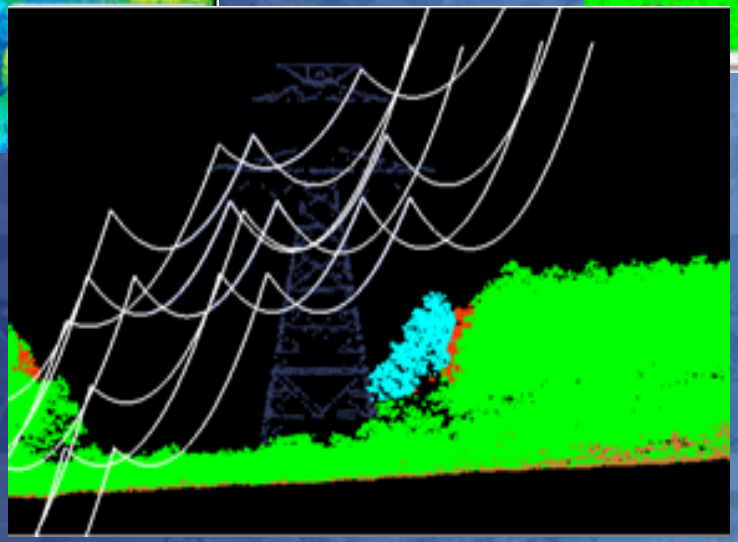
USGS

Dewberry

BU#21 – Infrastructure & Construction Management







LiDAR vital for compliance with North American Electric Reliability Corp (NERC) regulations

Grow-in vegetation growing into lines

Fall-in vegetation falling into lines

Inside & outside of Right of Way

Images from EarthEye

USGS

Dewberry

BU#22 – Urban and Regional Planning

LiDAR model of Baltimore, MD used for multiple applications, including viewsheds

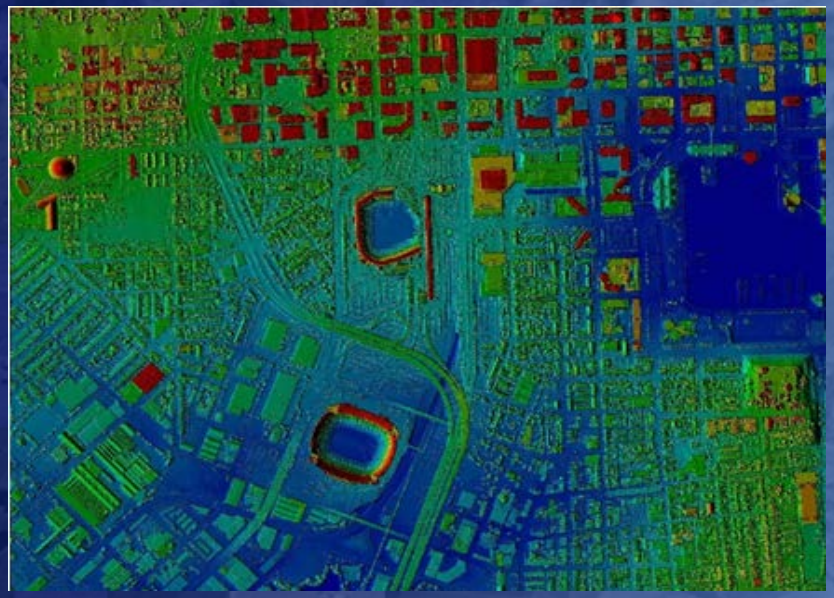


Image from ASPRS DEM Users Manual

LiDAR of Richland County, SC site saved $140K for development site planning

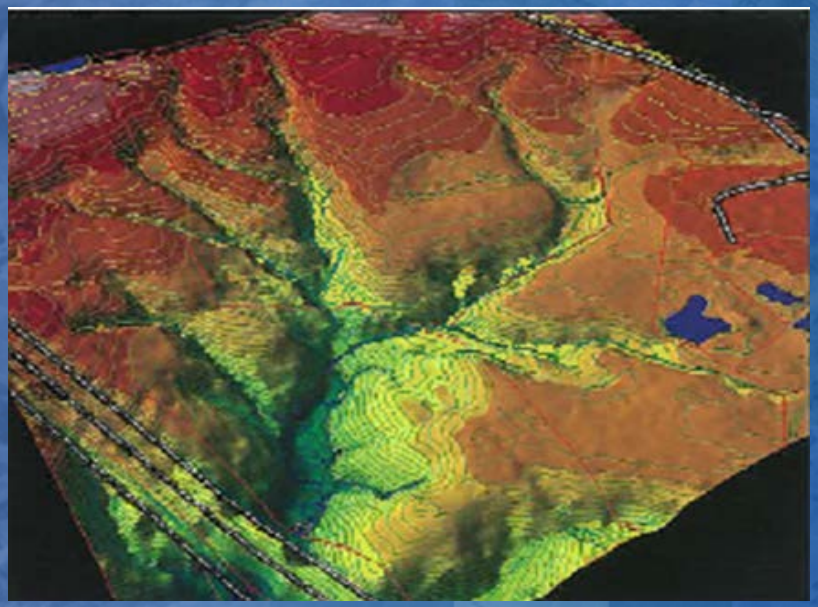


Image from ESRI's Measuring-Up : The Business Case for GIS

USGS

Dewberry

BU#23 – Health and Human Services

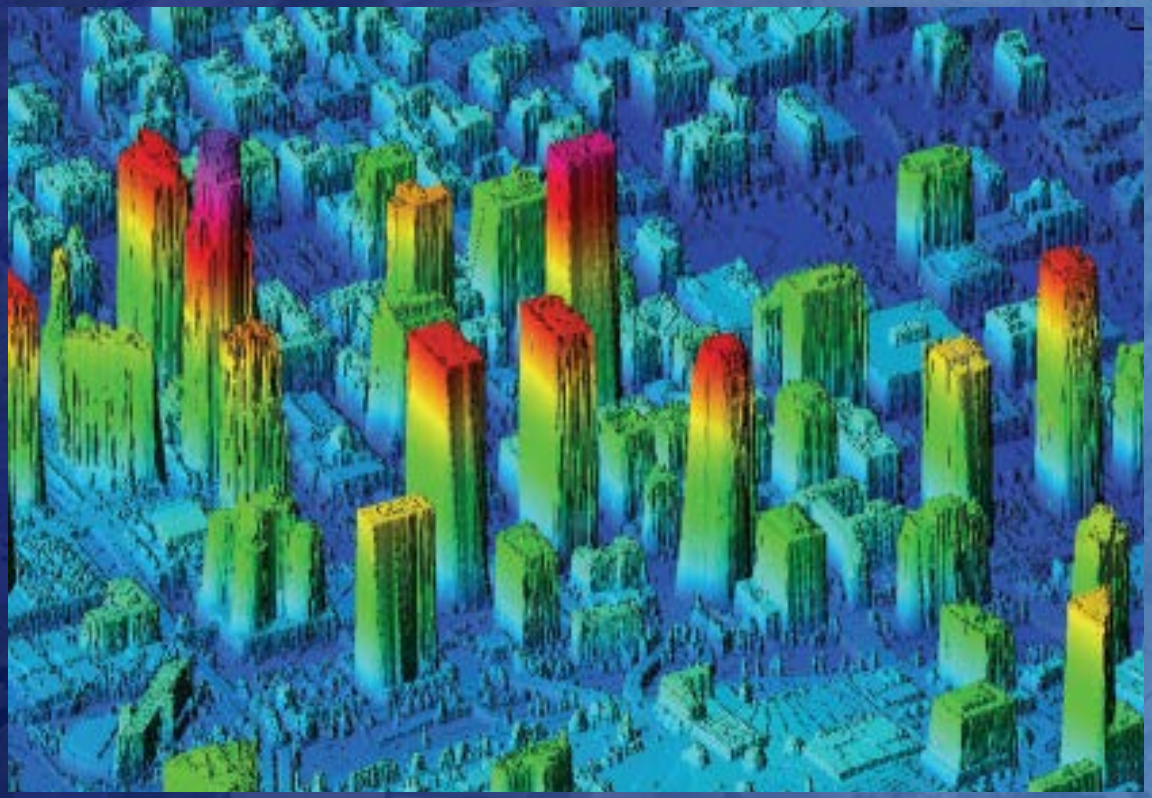


Image from ASPRS DEM Users Manual

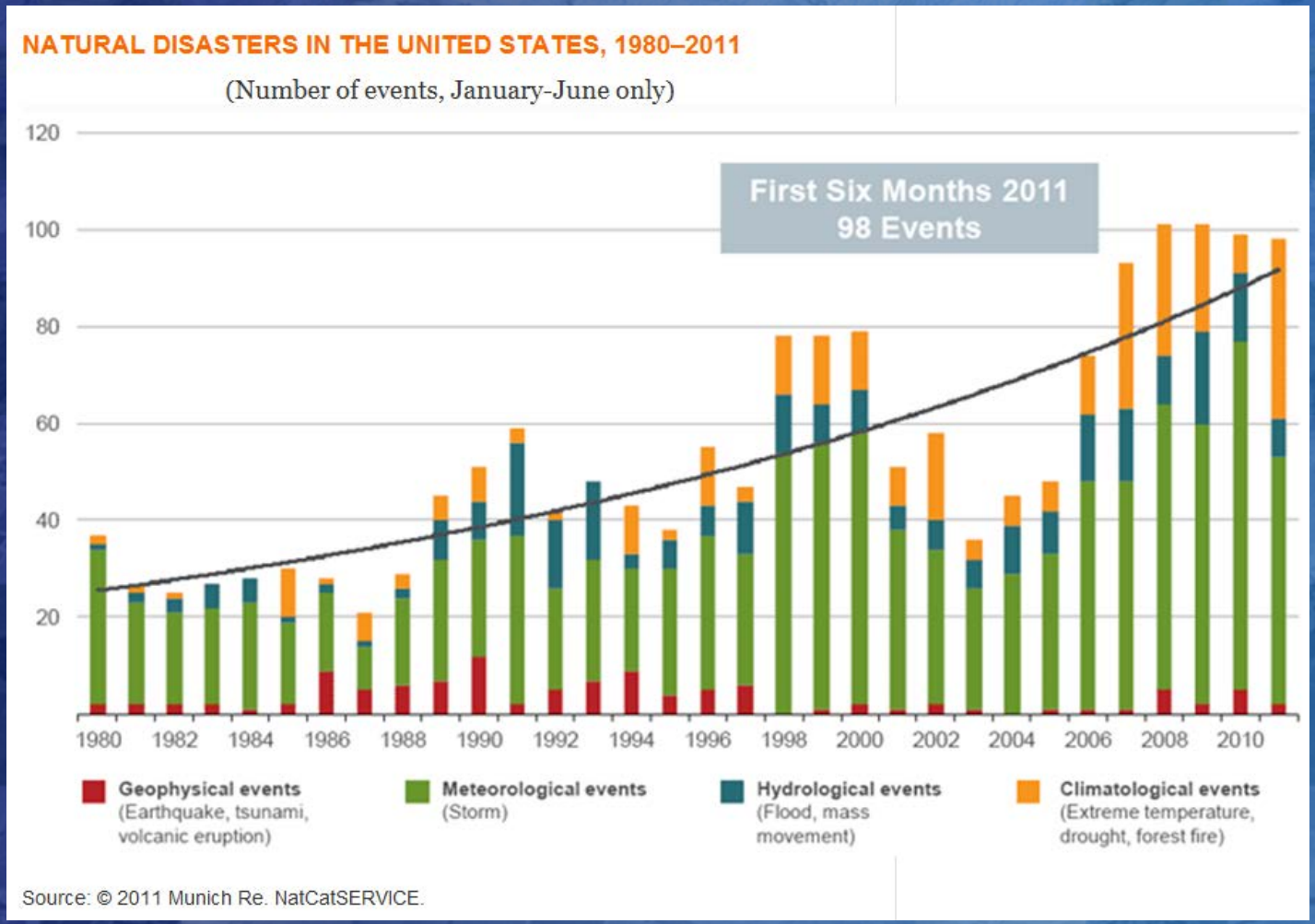
LiDAR 3D model of Los Angeles

Can model cities for smog as well as populations at risk from chemical, biological or radiological hazards, aerosols, or air-borne diseases

USGS

Dewberry

BU#24 – Real Estate, Banking, Mortgage, Insurance

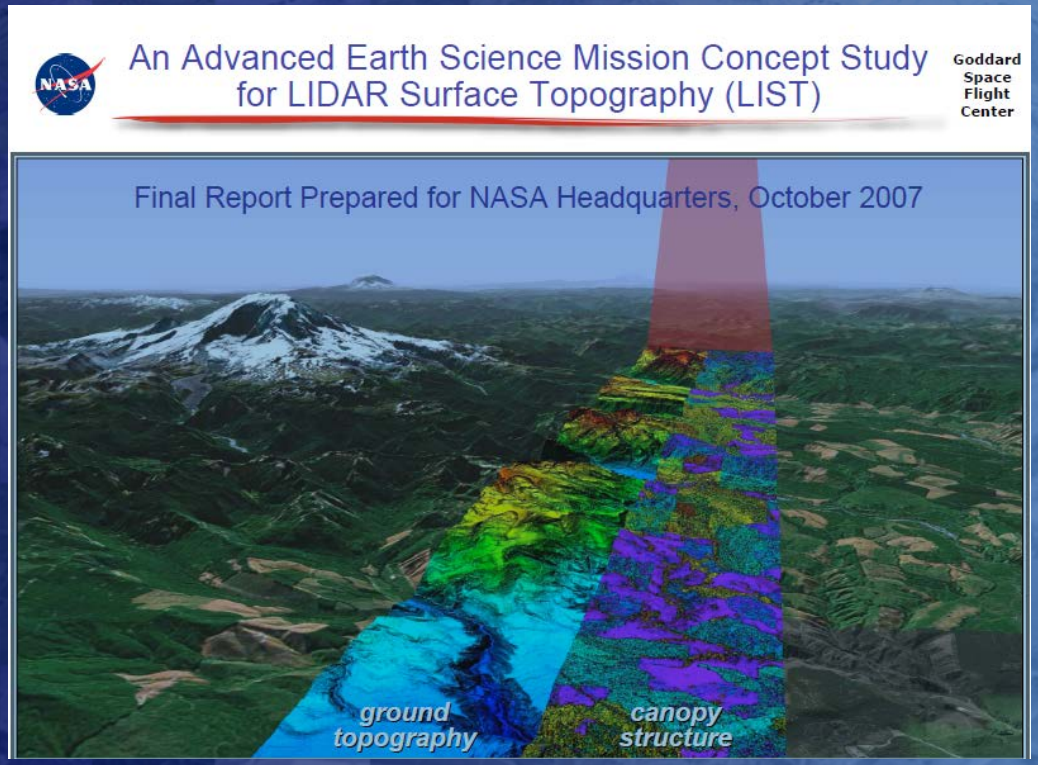


USGS

Chart from Munich Re

Dewberry

BU#25 – Education K-12 and Beyond



We have much yet to learn about the Earth on which we live for which ground topography and canopy structure are important components.

The science objective of NASA's LIST is to develop a scientific understanding of Earth's system and its response to natural and human induced changes."

The LIST will pioneer new global environmental observations to improve the operational services they provide to the nation. These services include weather forecasting, climate prediction, natural hazard assessment, prediction, and response, and environmental management."

Image from NASA

USGS

Dewberry

BU#26 – Recreation

Images from 3D Golf Course web site

LiDAR is used for design of professional golf courses and for simulators of those golf courses

USGS

Dewberry

BU#27 – Telecommunications

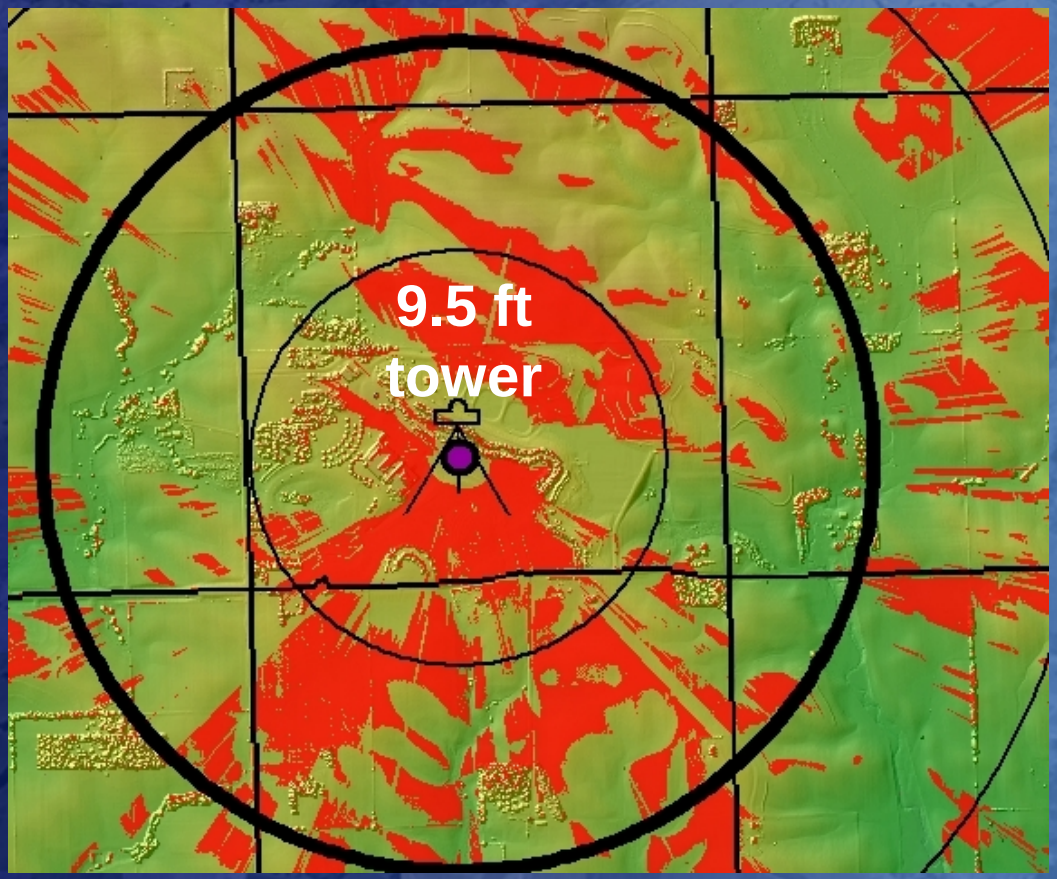


Image from USGS

Viewshed analyses for towers simulated at various heights to achieve desired coverage. Also vital for Homeland Security, e.g.:

- **Infrastructure Protection**
- **Border Protection**
- **Special Security Events**
- **Search & Rescue**

USGS

Dewberry

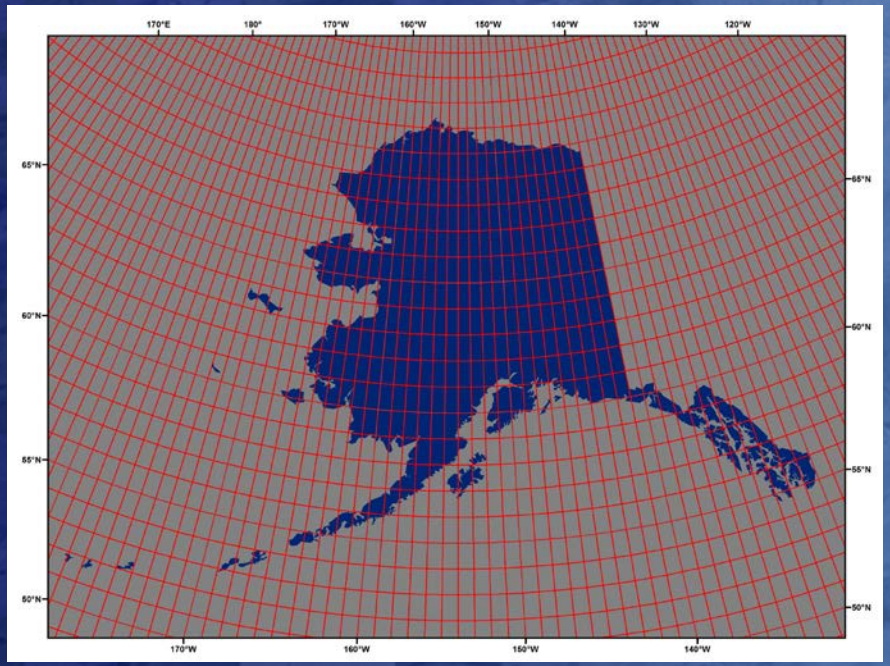
Analysis - Part B of Study

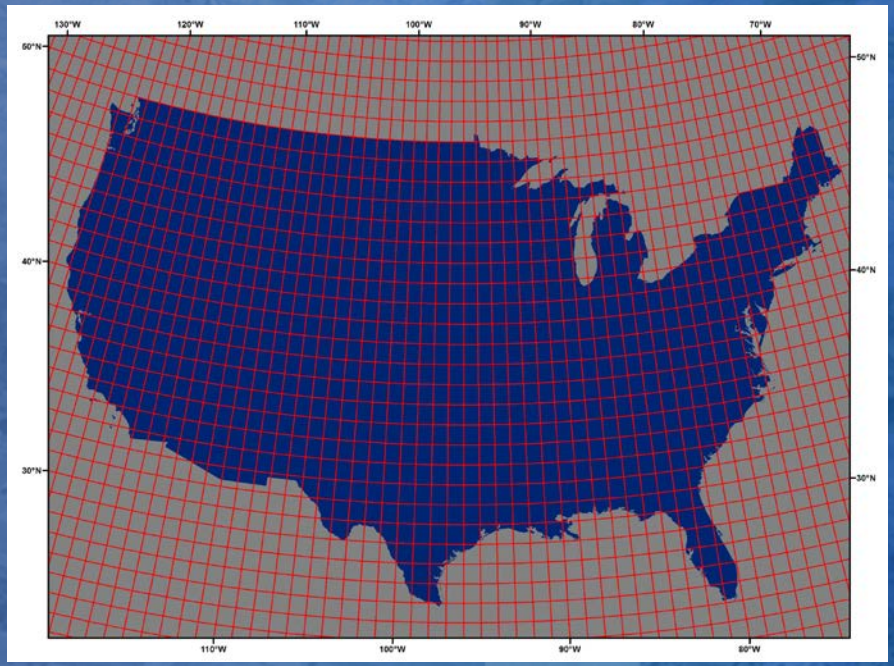
- For Federal, state and non-governmental users, aggregate, analyze, and validate geographic area requirements & benefits by Quality Level
- Estimate costs for candidate national datasets
- Evaluate technology trends, IFSAR, topo/bathy LiDAR
- Identify risks that could hamper consistent national implementation
- Develop/analyze enterprise IT infrastructure alternatives and program implementation scenarios
- Final report by December 15, 2011

USGS

Dewberry

Analyze requirements, benefits and costs by 1-degree cells; vary QL and update/freq





* Except for Hawaii & US Territories

QL1 LiDAR requirements are not satisfied by QL2 or QL3 LiDAR
QL2 LiDAR requirements are not satisfied by QL3 LiDAR
QL3 LiDAR requirements are satisfied by QL1, QL2 or QL3 LiDAR

USGS

Dewberry

Geodatabase-based Cost-Benefit Analysis Reduced Value Multipliers

	QL1	QL2	QL3	QL4	QL5
Annual					
2-3 years					
4-5 years					
6-10 years					
>10 years					

The biggest remaining issue is how to estimate dollar benefits when agencies say "Major Time/Cost Savings" but are unable to provide any values. Otherwise, their requirements and benefits won't count in analyses.

USGS

Dewberry

Elevation Products Used

- Digital Terrain Model (DTM) – 208
- Contours – 193
- Slope Data (Derived) – 153
- Hillshades (Derived) – 147
- LiDAR Full Point Cloud – 146
- Gridded DEM (Hydro-Enforced) –133
- Gridded DEM (No Hydro Processing) – 131
- Aspect Data (Derived) – 120
- Cross Sections –117
- Gridded DEM (Hydro Flattened) – 110
- Triangulated Irregular Network (TIN) – 109
- Breaklines – 108
- Digital Surface Model (DSM) – 106
- Curvature Data (Derived) – 68
- LiDAR Full Waveform – 45

USGS

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USGS

Dewberry 65