The following was presented at DMT’12 (May 20-23, 2012).

The contents are provisional and will be superseded by a paper in the DMT’12 Proceedings.

See also earlier Proceedings (1997-2011) http://ngmdb.usgs.gov/info/dmt/
3-D Elevation Program
May 22, 2012
Larry Sugarbaker
Senior Advisor, National Geospatial Program

The National Map
National Elevation Dataset
A Rich History

Lithographic Section preparing stone blocks used in the printing of topographic maps. USGS, 1917

Cartographer Yutaka Hamamoto working on a Wild A-7 stereoplanigraph. USGS, 1968
Two Modern Technologies of Choice

**Light detection and ranging (LiDAR)**
- System with a laser and detector (range), scanning mirror (laser direction), GPS (location), and IMU (orientation).
- 300,000+ laser pulses per second
- 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
What Does LiDAR Measure?

- Ground
- Roads and other surface features
- Vegetation
- Structures

LiDAR return data colored by height

Courtesy USFS
LiDAR Improves Data Quality

Ten meter resolution

Two meter resolution

Courtesy of NRCS
LiDAR Point Cloud and Derived Elevation Products
Supports Data Development and Geospatial Data Integration
Current Status of the Nation’s Elevation Data
NEEA Inventory Results

- 28% coverage - 49 states
- 15% coverage – Alaska
- 30+ year replacement cycle
- Program is well coordinated – less than 10% overlap of coverage
- Data quality variable

Why is this a problem?
- Remaining 72% coverage is 30 or more years old.
- Alaska – very poor quality
- Meets 10% of reported needs
- Current and emerging needs require higher quality data

Map depicts public sources of LiDAR in all states plus IfSAR data in Alaska

1996 - 2011

- 28% coverage - 49 states
- 15% coverage – Alaska
- 30+ year replacement cycle
- Program is well coordinated – less than 10% overlap of coverage
- Data quality variable
National Enhanced Elevation Assessment

At a Glance

- Sponsored by the National Digital Elevation Program (NDEP) and funded by USGS, NGA, FEMA, NRCS and NOAA to:
  - Document national requirements for improved elevation data from technologies such as LiDAR and IfSAR
  - Estimate the benefits and costs of meeting these requirements
  - Evaluate multiple national enhanced program scenarios

- 602 mission-critical activities that require enhanced elevation data were identified by:
  - 34 Federal agencies
  - 50 states
  - A sampling of local governments, tribes, private and not-for profit organizations

- A national program has the potential to generate $1.2 billion to $13 billion in new benefits each year when fully operational
Oil and Gas Resources

LiDAR slope data is essential for pipeline routing across mountain ranges and beneath rivers (as shown here) construction planning, encroachment control, and asset inventories.

From NEEA Study, 2011
Detecting Faults

Scarp found with LiDAR
Scarp found other means
Geomorphic evidence of shoreline uplift

Seattle
Victoria
Olympia

Holocene Tectonism PI: Ralph Haugerud, USGS
+ Landslide Inventory
Landslides mapped using LiDAR imagery
Seattle, Washington
## Data Quality Levels

<table>
<thead>
<tr>
<th>Quality Levels</th>
<th>Data Source</th>
<th>Horizontal Resolution</th>
<th>Vertical Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Point Density</td>
<td>RMSEz in Open Terrain</td>
</tr>
<tr>
<td>QL 1</td>
<td>LiDAR</td>
<td>8 points/m²</td>
<td>9.25 cm</td>
</tr>
<tr>
<td>QL 2</td>
<td>LiDAR</td>
<td>2 points/m²</td>
<td>9.25 cm</td>
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<tr>
<td>QL 3</td>
<td>LiDAR</td>
<td>1 – 0.25 points/m²</td>
<td>≤18.5 cm</td>
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<tr>
<td>QL 4</td>
<td>Imagery/LiDAR</td>
<td>1 – 0.04 points/m²</td>
<td>46.3 – 139 cm</td>
</tr>
<tr>
<td>QL 5</td>
<td>Imagery/IFSAR</td>
<td>0.04 points/m²</td>
<td>92.7 – 185 cm</td>
</tr>
</tbody>
</table>
Example: Geologic Resource Assessment and Hazards Mitigation (3 of 9 USGS activities)

**Mission critical use:** Identify areas, level of activity and risk associated with earth hazards to reduce losses and increase public safety

**Update frequencies:** 4-10 years

**Expected combined benefits:** $31.25M/year

**Data requirement:** Predominantly quality level 1

**Example applications:**
- Identify faults/landslides under thick vegetation
- Enhance infrastructure engineering design
- Estimate size, speed and effects of landslides
- Create loss mitigation strategies
- Provide maps and models to emergency planners
3-D Elevation Program (3DEP)
Recommended Uniform Quality Level 2

Partnership Funding Model with costs shared by benefiting Federal agencies and other State and local government cooperators

Scenario 3: 8 year acquisition

Avg. Annual Costs: $146M
Avg. Annual Benefits: $690M
Avg. Annual Net Benefits: $544M
B/C Ratio: 4.7:1
Total Possible Benefits Satisfied: 58%

Proposed program includes Quality Level 5 IfSAR data for Alaska