The 3D Elevation Program: Overview

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A little history

USGS has a long, proud tradition of mapmaking
The changing times

• Mapping the breadth of the Nation in such meticulous detail has been a demanding challenge for USGS mapmakers since 1884.

• For 130 years, this ambitious goal has spurred USGS cartographers to invent new instruments, devise new methods, and apply the most modern technology to improve the accuracy, utility, and efficient production of geographic information.
The Topographic map

Art + Science

The United States Geological Survey is making a topographic map of the United States. This work has been in progress since 1882, and about one-fifth of the area of the country, including Alaska, has been mapped. The mapped areas are widely scattered, nearly every state being represented, as shown on the progress map accompanying each annual report of the Director.

This great map is being published in atlas sheets of conventional size, which are bounded by parallels and meridians. The transverse division of land corresponding to an atlas sheet is a quadsquare (a word used as specifically as possible in the survey of the public lands). The charts are of approximately the same size; the paper dimensions are 21 1/2 by 18 1/2 inches, the map occupying about 17 1/2 inches of height and 11 1/2 to 11 inches of width, the latter varying with latitude. These charts, however, are employed.

The largest scale is 1:12,500, or very nearly one mile to one inch, or one linear inch on the ground is represented by one linear inch on the map. This scale is used for the thickly settled or industrially important parts of the country. For the less populated parts of the country an intermediate scale of 1:25,000, or about two miles to one inch, is employed.

A third and still smaller scale of 1:50,000, or about four miles to one inch, has been used in the desert regions of the Far West. A few special maps on larger scales are made in limited areas in mining districts.

The sheets on the largest scale cover 15° of latitude by 12° of longitude; those on the intermediate scale, 30° by 20° of longitude; and those on the smallest scale, 1° of latitude by 1° of longitude.

The features shown on this map are, for convenience, classified in three groups: (1) water, including seas, bays, ponds, rivers and other streams, canals, estuaries, etc.; (2) relief, including mountains, hills, valleys, cliffs, etc.; (3) culture, i.e., the works of man, such as towns, cities, roads, railroads, boundaries, etc. The conventional signs used for most of these features are shown and explained in the marginal columns hereafter.

All water features are shown in blue, the rivers and creeks in full blue lines, and the larger streams, lakes, and the sea by blue water-coloring. Certain streams, however, which flow during only a part of the year, their beds being dry at other times, are shown by full lines, but by lines of dots. Ponds which are dry during a part of the year are shown by oblique parallel lines. Saltwater marshes are shown by horizontal ruling interspersed with tufts of blue, and fresh-water marshes and swamps by blue tufts with broken horizontal lines.

The land features of the relief, usually represented on maps by shading of some sort, with pen or brush, are here shown by contour lines. Each contour passes through those points which have the same altitudes. If one follows a contour on the ground one will go neither uphill nor downhill, but at a level. By the use of contours not only are the shapes of the plains, hills, and mountains shown, but also the elevations. The line of the coast itself is a contour line, the datum or zero of elevation being mean sea-level. The contour line at say, 30 feet above sea-level is the line that would be the sea if the sea water rose or fell to such a depth that it stood back as a level ground forward and toward the points of hills and spurs. On a gentle slope this contour line is far from the present coast line, while on a steep slope it is near it. Thus a succession of these contour lines for parts of the map indicates a gentle slope; if these are drawn together, a steep slope and if they run together in one line, as if such contour were running under the one above it, they indicate a cliff. In many parts of the country the depressions are hollows with no outlets. The contours of these hollows, however, are usually indicated by hachures, or short dashes, on the inside of the curve.

Certain contours, usually every 50th one, are accompanied by numbers showing elevation above sea-level. Many other heights, instrumentally determined, are also given, the number in each case being placed in close proximity to the point to which it applies.

The works of man are shown in black, in which color all hachured lines are painted. Boundaries such as county, city, town, grant, reservation, etc., are shown by broken lines of different black and colored. Roads are shown by thin double lines (full for the better roads, dotted for the inferior ones), trails by single dotted lines, and railroads by thick black lines with cross lines. Other cultural features are represented by conventions easily understood.

The sheets composing the topographic atlas are designated by the name of a principal town or of some prevalent natural feature within the district, and the names of adjoining published sheets are printed on the margins. The sheets are sold at five cents each when fewer than 100 copies are purchased, but when they are ordered in lots of 100 or more copies, whether of the same sheet or of different sheets, the price is two cents each.
The project was launched in late 2009, and the term “US Topo” refers specifically to quadrangle topographic maps published in 2009 and later.

These maps are modeled on the familiar 7.5-minute quadrangle maps of the period 1947-1992, but are mass-produced from national GIS databases on a repeating cycle.

US Topo maps repackage geographic information system (GIS) data in traditional map form; this benefits non-specialist map users, as well as applications that need traditional maps.
The National Map

One of the cornerstones of the U.S. Geological Survey's (USGS) National Geospatial Program

- The National Map is a collaborative effort among the USGS and other Federal, State, and local partners to improve and deliver topographic information for the Nation.

- USTopo is powered by The National Map

- The geographic information available from The National Map includes:
  - orthoimagery (aerial photographs),
  - geographic names
  - hydrography
  - boundaries
  - transportation
  - structures
  - land cover
  - elevation
Elevation Historically

Powered by the NED

For 15 years, the National Elevation Dataset (NED) has been the primary elevation data product produced and distributed by the USGS. The NED provides seamless raster bare earth elevation data of the conterminous United States, Alaska, Hawaii, and the island territories. The NED is derived from diverse source data sets that are processed to a specification with a consistent resolution, coordinate system, elevation units, and horizontal and vertical datums.

- The NED served as the elevation layer of The National Map, and provided basic elevation information for earth science studies and mapping applications in the United States.
Tying it all together- Historically

From NED to derivatives to TNM to USTopo currently
Bare earth DEMs from Lidar/Ifsar feed our Elevation Historically

From Lidar/Ifsar DEMs to NED to derivatives to TNM to USTopo

- Lidar
- Ifsar
- Bare Earth DEMs
- Point Clouds
- CLICK
- Earth Explorer
- TNM
Mapping has changed
Less art, more science

- With the proliferation of lidar and ifsar as our tools to collect elevation data, we are not really mapping anymore—we are now measuring elevation using remote sensing and GPS.

- 3-D information from these systems are being used for an incredible amount of applications.
  - We are not just measuring bare earth anymore, we are measuring vegetation, buildings, roads, streams, etc. in 3-D.

- 3-D information is considered more and more commonplace, and consumer technology is rapidly embracing this trend.
3-D

Commonplace in our lives now, and growing
3D Elevation Program (3DEP)

Applies groundbreaking lidar technology to acquire and distribute 3D data

Addresses a broad range of critical applications of national significance

- 3D data include surface elevations and natural and constructed features
- 3DEP increases the quality level of lidar being acquired to enable more accurate understanding, modeling, and prediction
- Goal to acquire national coverage in 8 years
What is the 3D Elevation Program?

3DEP is a call for community action to…

- Address the mission-critical requirements of Federal agencies, states, local governments, tribes, private and not-for-profit organizations
- Increase the overall investment in 3D data from about $45 M to $146 M annually to return more than $690 million annually in new benefits
- Leverage collaboration among Federal, states, local and tribal partners to systematically complete national 3D data coverage in 8 years
- Leverage the capability of private industry mapping firms, create jobs
- 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
3DEP 2012-2015
READY for a national, 8-year program

Developed 3DEP infrastructure

- Documented comprehensive requirements and benefits in the National Enhanced Elevation Assessment (NEEA)
- Designed 3DEP based on NEEA and to maximize return on investment
- Developed the NEEA inventory into the annual U.S. Interagency Elevation Inventory in partnership with NOAA and others
- Published plan for action based on extensive stakeholder input
- Issued the first Broad Agency Announcement in 2014, with funding partnerships with FEMA and NRCS
### 3D Elevation Program
#### Quality Levels – A New “Floor”

<table>
<thead>
<tr>
<th>Quality Level</th>
<th>Source</th>
<th>Vertical Accuracy RMSEz</th>
<th>Nominal Pulse Spacing (NPS)</th>
<th>Nominal Pulse Density (NPD)</th>
<th>DEM Post Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>QL1</td>
<td>Lidar</td>
<td>10 cm</td>
<td>0.35 m</td>
<td>8 points/sq. meter</td>
<td>0.5 meter</td>
</tr>
<tr>
<td>QL2</td>
<td>Lidar</td>
<td>10 cm</td>
<td>0.7 m</td>
<td>2 points/sq. meter</td>
<td>1 meter</td>
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<tr>
<td>QL3</td>
<td>Lidar</td>
<td>20 cm</td>
<td>2.0 m</td>
<td>0.7 points/sq. meter</td>
<td>3 meters</td>
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<tr>
<td>QL4</td>
<td>Imagery</td>
<td>139 cm</td>
<td>N/A</td>
<td>N/A</td>
<td>5 meters</td>
</tr>
<tr>
<td>QL5</td>
<td>Ifsar</td>
<td>185 cm</td>
<td>N/A</td>
<td>N/A</td>
<td>5 meters</td>
</tr>
</tbody>
</table>

**Now**

**Legacy**

**Alaska**
New products and services being made available in 2015 from The National Map

- 5 meter Alaska DEMs
- Lidar Point Cloud
- Alaska Ifsar ORIs
- 1 meter DEMs
- Alaska Ifsar DSMs
# 3DEP Products and Services

<table>
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<tr>
<th>Product</th>
<th>Planned coverage on release date</th>
<th>Sources</th>
<th>Planned product or service</th>
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<tbody>
<tr>
<td>1-meter DEM</td>
<td>Partial coverage—U.S. and some territories</td>
<td>Lidar</td>
<td>Tiles (TBD) by download</td>
</tr>
<tr>
<td>5-meter DEM</td>
<td>Partial coverage—Alaska</td>
<td>Ifsar</td>
<td>1-degree × 1-degree block by download</td>
</tr>
<tr>
<td>1/9 arc-second DEM—Legacy</td>
<td>Partial coverage—U.S. and some territories</td>
<td>Lidar, Ifsar, photogrammetry</td>
<td>15-minute × 15-minute block by download</td>
</tr>
<tr>
<td>1/3 arc-second DEM</td>
<td>CONUS, HI, some territories, parts of Alaska</td>
<td>Lidar, Ifsar, photogrammetry</td>
<td>1-degree × 1-degree block by download</td>
</tr>
<tr>
<td>1 arc-second DEM</td>
<td>CONUS, HI, AK, and U.S. territories</td>
<td>Lidar, Ifsar, photogrammetry</td>
<td>1-degree × 1-degree block by download</td>
</tr>
<tr>
<td>2 arc-second DEM</td>
<td>Alaska</td>
<td>Lidar, Ifsar, photogrammetry</td>
<td>1-degree × 1-degree block by download</td>
</tr>
<tr>
<td>Elevation-point query</td>
<td>CONUS, HI, some territories, AK</td>
<td>1/3 arc-second DEM, except 1 arc-second DEM in AK</td>
<td>Application service</td>
</tr>
<tr>
<td>Hillshade</td>
<td>CONUS, HI, some territories, AK</td>
<td>1/3 arc-second DEM, except 1 arc-second DEM in AK</td>
<td>Viewing service</td>
</tr>
<tr>
<td>Contours at 5 to 120 feet</td>
<td>CONUS, HI, some territories, AK</td>
<td>1/3 arc-second DEM, except 1 arc-second DEM in AK</td>
<td>1-degree × 1-degree block by download and viewing service</td>
</tr>
</tbody>
</table>
## 3DEP Products and Services

<table>
<thead>
<tr>
<th>Source data</th>
<th>Planned coverage on release date</th>
<th>Sources</th>
<th>Planned product or service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidar full point cloud—Unclassified</td>
<td>Partial coverage—U.S.</td>
<td>Lidar—QL1, QL2, QL3</td>
<td>Project areas by special request</td>
</tr>
<tr>
<td>Lidar full point cloud—Classified</td>
<td>Partial coverage—U.S.</td>
<td>Lidar—QL1, QL2, QL3</td>
<td>Project tiles by download</td>
</tr>
<tr>
<td>Ifsar digital surface model</td>
<td>Partial coverage—Alaska</td>
<td>Ifsar—QL5</td>
<td>Project tiles by download</td>
</tr>
<tr>
<td>Orthorectified ifsar intensity image</td>
<td>Partial coverage—Alaska</td>
<td>Ifsar—QL5</td>
<td>Project tiles by download</td>
</tr>
<tr>
<td>Source resolution DEM</td>
<td>Partial coverage—U.S. and some territories</td>
<td>Lidar, Ifsar</td>
<td>Project tiles by download</td>
</tr>
</tbody>
</table>
72 pre-proposals submitted, requested funds over $50M, 29 were funded

Total estimated committed = $9.8M, with a total estimated value of $26.5M (estimates will be refined)

The $9.8M is comprised of USGS, FEMA and NRCS funds

Total square miles is estimated at 94,114, with average project size of 3,245 sq mi

Additional selections may follow with remaining funding as project estimates are refined and FY15 funding is clarified
3DEP is Big Data

Data from Appendix H of NATIONAL ENHANCED ELEVATION ASSESSMENT FINAL REPORT
So what is the 3DEP mindset?

Need to change how you perceive elevation at USGS

From This:

Bare Earth DEMs

Lidar

Point Clouds
So what is the 3DEP mindset?

Need to change how you perceive elevation at USGS

To This:

- Bare Earth DEMs
- Contours/hillshades
Services in development

3DEP Point Clouds

Application

Application

Application

Application

Application

Application

WCS

Bare Earth DEMs

Stakeholders

Services

- Shaded Relief
- Slope
- Aspect
- Curvature

Delivery
From point cloud data to information
Questions?