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The 3D Elevation Program and America's Infrastructure

Infrastructure Connects Us All

Infrastructure—the physical framework of transportation, energy, communications, water supply, and other systems—and construction management—the overall planning, coordination, and control of a project from beginning to end—are critical to the Nation's prosperity. The American Society of Civil Engineers (2013) warns that, despite the importance of the Nation's infrastructure, it is in fair to poor condition and needs sizable and urgent investments to maintain and modernize it, and to ensure that it is sustainable and resilient.

Three-dimensional (3D) light detection and ranging (lidar) elevation data (fig. 1) provide valuable productivity, safety, and cost-saving benefits to infrastructure improvement projects and associated construction management (Dewberry, 2012). However, the acquisition of 3D elevation data primarily on a project-by-project basis can increase infrastructure project costs and risks, and distract management attention from project goals (Chang and others, 2012).

By providing data to users, the 3D Elevation Program (3DEP) of the U.S. Geological Survey (USGS) (Sugarbaker and others, 2014; see sidebar) reduces users' costs and risks and allows them to concentrate on their mission objectives. 3DEP includes (1) data acquisition partnerships that leverage funding, (2) contracts with experienced private mapping firms, (3) technical expertise, lidar data standards, and specifications, and (4) most important, public access to high-quality 3D elevation data.

The size and breadth of improvements for the Nation's infrastructure and construction management needs call for an efficient, systematic approach to acquiring foundational 3D elevation data. The 3DEP approach to national data coverage will yield large cost savings over individual project-by-project acquisitions and will ensure that data are accessible for other critical applications.

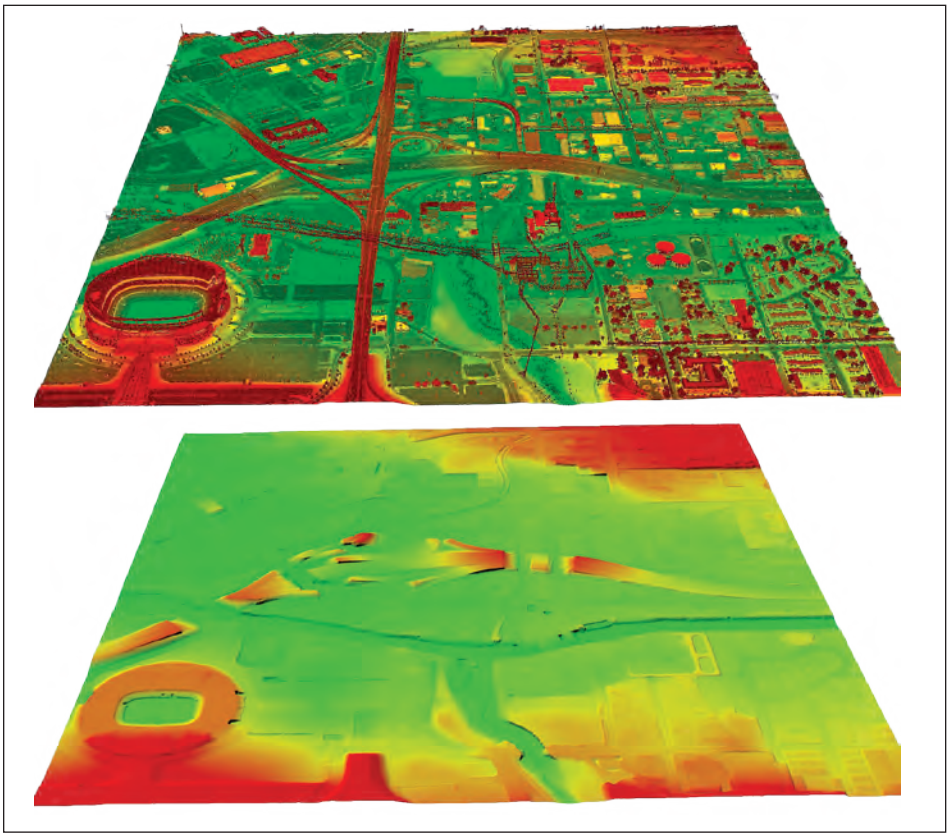

Figure 1. 3D elevation data for an area of Denver, Colorado, in the form of a lidar point cloud (top) and a derived bare-earth digital elevation model (bottom). These data along with other products provide valuable productivity, safety, and cost-saving benefits to infrastructure improvement projects. Image provided by Jason Stoker (USGS).

3D Elevation Program (3DEP)

The 3D Elevation Program (3DEP) is a national program managed by the USGS to acquire high-resolution elevation data (Sugarbaker and others, 2014). It produces point clouds, bare-earth digital elevation models (DEMs), and other products.

3DEP is backed by a comprehensive assessment of lidar, interferometric synthetic aperture radar (ifSAR), and related elevation data requirements (Dewberry, 2012) and is now an operational program. The goal of this high-priority cooperative program is to have complete coverage of quality level 2 lidar data for the conterminous United States, Hawaii, and the U.S. territories, and ifSAR data for Alaska, by the end of 2023.

Reduced Acquisition Costs and Risks

A funded national program will provide:

- *Economy of scale* by acquiring data for larger areas and reducing acquisition costs by 25 percent.
- *Predictable, efficient, and flexible Federal investments* that reduce costs for and allow better planning by Federal, State, Tribal, U.S. territorial, and local government partners, including the option of "buying up" to acquire higher quality data.
- *Consistent, high-quality, national coverage* that (1) provides data ready for applications that span project, jurisdictional, and watershed boundaries, (2) meets multiple needs, and (3) increases benefits to citizens.
- *Simpler data acquisition* that provides contracts, published data-acquisition specifications, and specialized quality assurance and information technology expertise. Partners reduce their risks and can concentrate on their business activities.

3DEP can conservatively provide new benefits of $690 million per year and has the potential to generate $13 billion per year in new benefits through applications that span the economy (Dewberry, 2012). The shared lidar, ifSAR, and derived elevation datasets would foster cooperation and improve decisionmaking among all levels of government and other stakeholders.

High-Quality Data

For the conterminous United States, Hawaii, and the U.S. territories, the USGS and its partners acquire quality level 2 or better lidar data. Quality level 2 data have a minimum nominal pulse spacing of 0.7 meters

Uses of 3D Elevation Data

Uses of 3D elevation data in infrastructure investments and construction management (Dewberry, 2012; Chang and others, 2012) include:

- Route, grade, line-of-sight, and utility surveys and corridor mapping.
- Terrain and other obstruction identification for aviation.
- Dam, levee, and coastal-structure failure modeling and mitigation.
- Hydraulic and hydrologic modeling.
- Evaluations of geologic, coastal, and other natural hazards, and geotechnical evaluations.
- Permit application and construction plan development and evaluation.
- Drainage issues and cut-and-fill estimate requirements.
- Vegetation, topographic, and geomorphologic feature analysis.
- As-built model development.
- Preliminary engineering, estimate development, and quantity estimation activities.
- Base-map and elevation model creation.

Mobile and stationary lidar and other survey data typically are used, if necessary, with 3D elevation data in site-specific applications.

Benefits of 3D Elevation Data

Benefits of using 3D elevation data in infrastructure projects (Chang and others, 2012) include:

- Improved personnel safety from reduced exposure to hazards in the field.
- Increased detail from the high density of point measurements captured.
- Improved productivity and reduced costs from rapid data-capture rates.
- Superior coverage of visible surfaces for large and inaccessible project areas.

For business uses related to infrastructure improvements, the value of *annual* new national benefits from 3DEP data are conservatively estimated to be $170 million (table 1). These estimates are 25 percent of the new annual national conservative benefits of $690 million (Dewberry, 2012; see sidebar) for all business uses of 3DEP data. If 3DEP data were used only for infrastructure projects and not made available for all other business uses, the Nation would forego 75 percent of the total annual benefits that it could accrue from all business uses. Dewberry (2012) also estimated that 3DEP data have the potential to generate $13 billion per year in new benefits through applications that span the economy.

Table 1. Conservative annual national benefits of 3DEP data related to infrastructure improvements and associated business uses (derived from Dewberry, 2012).

Business use	Conservative annual benefit (million dollars)
Infrastructure and construction management	95.8
Water supply and quality	54.8
Aviation navigation and safety	14.9
Renewable energy resources	2.6
Oil and gas resources	1.6
Land navigation and safety	0.04
Telecommunications	0.1
Total	**169.8**

Maximized Benefits and Minimized Risks

Working with the USGS on 3DEP offers opportunities to maximize benefits and minimize risks. 3DEP data that meet the needs of a project may already be available. Users benefit from previous investments by using the existing standardized point cloud or derived product data to ease the learning curve and begin project work immediately. Seamless standardized data offer flexibility to projects regardless of their shape or size.

If new 3D elevation data must be acquired, partnering with 3DEP offers:

- Reduced unit collection costs through the possibility of pooled funding with other partners and the economy of scale that 3DEP acquisition provides.
- Access to qualified and experienced firms under contract that acquire and process lidar data.
- Access to USGS technical expertise for data acquisition contracts and for distribution of point cloud and derived data products.
- Opportunity to "buy up" higher quality data for specialized applications.
- Opportunity to receive cost-share funding to acquire data on behalf of 3DEP.

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3D Elevation Program—Continued

and a vertical error of 10 centimeters, measured as root mean square error in the elevation (z) dimension ($RMSE_z$). Statewide for Alaska, quality level 5 ifSAR data are acquired that have a vertical error of 185 centimeters $RMSE_z$.

The data must have been acquired during the previous eight years. For more information see the Lidar Base Specification available at http://pubs.usgs.gov/tm/11b4/.

Point Cloud and Derived Products

Lidar data products include the all-return classified point clouds and derived bare-earth DEMs. Each DEM dataset is identified by its horizontal resolution and is produced to a consistent set of specifications. All DEMs represent the topographic surface of the Earth and contain flattened water surfaces. Nationally seamless DEMs are produced by blending only the highest quality project data into a continuous terrain surface for the United States, and are published at resolutions of 1/3 arc-second, 1 arc-second, and 2 arc-seconds. The standard 1-meter DEM dataset is seamless within collection projects but not across projects.

IfSAR data in Alaska include digital surface models, orthorectified intensity images, and 5-meter-resolution hydro-flattened DEMs.

The USGS integrates the elevation model data into its national elevation data coverage, as a component of The National Map. All 3DEP products to include an elevation-point query service and bulk-point query service are components of The National Map. Data are available, free of charge and without use restrictions. To download 3DEP products visit http://viewer.nationalmap.gov/basic/.

Ways to Participate

Partners may contribute funds toward data acquisition projects managed by the USGS, or they may receive cooperative funds to manage their own acquisition projects. The Broad Agency Announcement process is the primary mechanism used to establish agreements between partners. For more information see the 3DEP Web site at http://nationalmap.gov/3DEP/index.html. Organizations may also access the geospatial products and services contracts and quality control services managed by the USGS to acquire 3DEP data. Organizations may contribute existing elevation data that meet 3DEP specifications. More information about using USGS contracts or about other ways to contribute is available by request through http://nationalmap.gov/3DEP/3dep_feedback.html.

Learn More About 3DEP

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