

# The 3D Elevation Program—Summary for Puerto Rico

## Introduction

Elevation data are essential to a broad range of applications, including forest resources management, wildlife and habitat management, scientific research, national security, recreation, and many others. For the Commonwealth of Puerto Rico, elevation data are critical for flood risk management, landslide mitigation, natural resources conservation, sea level rise and subsidence, coastal zone management, infrastructure and construction management, and other business uses. Today, high-density light detection and ranging (lidar) data are the primary sources for deriving elevation models and other datasets. Federal, State, Tribal, U.S. territorial, and local agencies work in partnership to (1) replace data that are older and of lower quality and (2) provide coverage where publicly accessible data do not exist. A joint goal of State and Federal partners is to acquire consistent, state-wide coverage to support existing and emerging applications enabled by lidar data.

The National Enhanced Elevation Assessment (NEEA; Dewberry, 2011) evaluated multiple elevation data acquisition options to determine the optimal data quality and data replacement cycle relative to cost to meet the identified requirements of the user community. The evaluation demonstrated that lidar acquisition at quality level 2 (table 1) for the conterminous United States, Hawaii, and selected U.S. territories, and quality level 5 interferometric synthetic aperture radar (IFSAR) data (table 1) for Alaska, all with a 6- to 10-year acquisition cycle, provided the highest benefit/cost ratios. The 3D Elevation Program (3DEP) initiative (Snyder, 2012a,b) selected an 8-year acquisition cycle for the respective quality levels. 3DEP, managed by the U.S. Geological Survey (USGS), the Office of Management and Budget Circular A-16 lead agency for terrestrial elevation data, responds to the growing need for high-quality topographic data and a wide range of other three-dimensional (3D) representations of the Nation's natural and constructed features.

### 3DEP in Puerto Rico by the Numbers

Expected annual benefits	\$0.53 million
Estimated total cost	\$2.22 million*
Payback	4.2 years
Quality level 1 buy-up estimate	\$1.50 million

\*USGS-estimated acquisition cost (2015)



**Figure 1.** Map of the Commonwealth of Puerto Rico showing existing and planned-with-funding publicly available lidar data. Approximately 95 percent of the quality level 2 data is in the planned-with-funding category. Information source is the United States Interagency Elevation Inventory, fall 2015 (<http://coast.noaa.gov/inventory/>), which is updated annually. Quality level 2 or better lidar data meet 3DEP requirements. See table 1 for quality level information.

## 3D Elevation Program Benefits for Puerto Rico

The top 10 Puerto Rico business uses for 3D elevation data, which are based on the estimated annual conservative benefits of the 3DEP initiative, are shown in table 2. The NEEA survey respondents in the Commonwealth of Puerto Rico estimated that the national 3DEP initiative would result in at least \$0.53 million in new benefits annually to the Commonwealth. In 2015, the cost for such a program was estimated at \$2.22 million (Diane Eldridge, USGS, written commun., May 2015), resulting in a payback period of 4.2 years and a benefit/cost ratio of 1.9 to 1 over an 8-year period. Because monetary estimates were not provided for several major reported benefits, the total benefits of the 3DEP to Puerto Rico are likely to be much higher. On the basis of the NEEA survey results, all levels of government and many organizations in Puerto Rico could benefit from access to Commonwealth-wide high-resolution elevation data.

For Puerto Rico, approximately 84 percent of the identified business use requirements will be met in flood risk management, natural resources conservation, sea level rise and subsidence, and coastal zone management uses, as shown in table 2. The status of publicly available lidar data in Puerto Rico is shown in figure 1. Lidar with planned funding will be collected at quality level 2 to the extent possible, given limitations of current airborne lidar technology. The dense vegetation in parts of the islands may impact the accuracy over those areas.

By enhancing coordination between 3DEP and various government and private

## 3D Elevation Program

3DEP is a national program managed by the USGS to acquire high-resolution elevation data. The initiative is backed by a comprehensive assessment of requirements (Dewberry, 2011) and is in the early stages of implementation. 3DEP will improve data accuracy and provide more current data than is available in the National Elevation Dataset (NED). The goal of this high-priority cooperative program is to have complete coverage of the United States by the end of 2022, depending on funding and partnerships. 3DEP can conservatively provide new benefits of \$1.2 billion/year and has the potential to generate \$13 billion/year in new benefits through improved government services, reductions in crop and homeowner losses resulting from floods, more efficient routing of vehicles, and a host of other government, corporate, and citizen activities (Dewberry, 2011). A shared, common elevation dataset would foster cooperation and improve decision-making among all levels of government and other stakeholders.

### Benefits of a Funded National Program

- Economy of scale—Acquisition of data covering larger areas reduces costs by 25 percent.
- A systematic plan—Acquisition of data at a higher quality level reduces the cost of “buying up” to the highest levels needed by State, Tribal, U.S. territorial, and local governments.
- Higher quality data and national coverage—Ensure consistency for applications that span State, Tribal, U.S. territorial, and watershed boundaries and meet more needs, which results in increased benefits to citizens.
- Increase in Federal agency contributions—Reduces State, Tribal, U.S. territorial, and local partner contributions.
- Acquisition assistance—Provided through readily available contracts and published acquisition specifications.

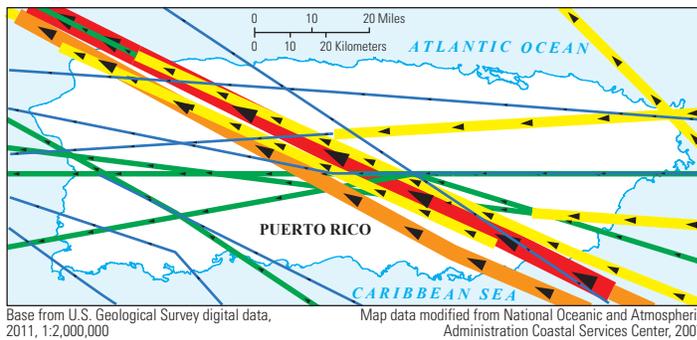
organizations in Puerto Rico, it may be possible to realize more than the cited conservative benefits and attain the higher potential benefits for many business uses.

The following examples highlight how 3DEP data can support business uses in Puerto Rico: (1) Enhanced elevation data provide more accurate bare-earth digital elevation models to enable dynamic modeling efforts for a variety of critical topics, including water resources management and conservation, understanding risks from sea level rise and storm surges, and understanding the vulnerability of shallow tidal-water habitats to climate change. With improved elevation data and topographic maps, organizations can more effectively engage in detailed vulnerability planning and mitigation pertaining to coastal natural resources, buildings, transportation infrastructure, and cultural assets at risk from hurricanes (fig. 2), tsunamis, storm runoff, sea level rise, landslides, debris flows, and storm surge. Additionally, a more complete assessment of beach morphology and sand volume change could help identify sand budgets in decline, which pose threats in the form of increased erosion and endangerment of infrastructure,

property, and lives. (2) An enhanced elevation dataset using the most current vertical datum (NAVD 88, GEOID 12B) would enable the generation of seamless bathymetry-to-topography coastal coverage (emerged relief mesh) to support modeling of sea level rise, storm surge, and wave runup.

## References Cited

- Dewberry, 2011, Final report of the National Enhanced Elevation Assessment (revised 2012): Fairfax, Va., Dewberry, 84 p. plus appendixes, <http://www.dewberry.com/Consultants/GeospatialMapping/FinalReport-NationalEnhancedElevationAssessment>.
- Snyder, G.I., 2012a, National Enhanced Elevation Assessment at a glance: U.S. Geological Survey Fact Sheet 2012–3088, 2 p., <http://pubs.usgs.gov/fs/2012/3088/>.
- Snyder, G.I., 2012b, The 3D Elevation Program—Summary of program direction: U.S. Geological Survey Fact Sheet 2012–3089, 2 p., <http://pubs.usgs.gov/fs/2012/3089/>.



**Figure 2.** Map showing the tracks of a sampling of hurricanes between 1852 and 1998 that have affected Puerto Rico. Colors represent strength categories according to the Saffir-Simpson hurricane wind scale. Blue is category 1 (least intense); red is category 5 (most intense). Arrowheads show direction of hurricane path. Large storms can have profound geomorphic (land-changing) consequences. Graphic by Sheila Murphy (USGS).

**Table 2.** Conservative benefits estimates for the top 10 business uses of the proposed 3DEP data identified in the National Enhanced Elevation Assessment for Puerto Rico (Dewberry, 2011).

Rank	Business use	Annual benefits (thousands)
1	Flood risk management	\$163.78
2	Natural resources conservation	130.34
3	Sea level rise and subsidence	84.38
4	Coastal zone management	74.26
5	Infrastructure and construction management	42.85
6	Oil and gas resources	9.38
7	Land navigation and safety	8.40
8	Aviation navigation and safety	8.20
9	Geologic resource assessment and hazard mitigation	7.12
10	Forest resources management	4.72
	Other	3.41
	Total	536.84

## 3D Elevation Program—Continued

The USGS and its partners will acquire quality level 2 or better (table 1) 3D lidar data over the conterminous United States, Hawaii, and the U.S. territories. Interferometric synthetic aperture radar (IfSAR) data are being collected at quality level 5 (table 1) in Alaska. The data will be acquired over an 8-year period and will be made available to the public. By using this acquisition scenario, a number of high-quality elevation-data products can be created to serve a wide range of business uses in government and the private sector.

**Table 1.** Data quality levels and related accuracies for the 3D Elevation Program (3DEP) initiative as provided on page 6 in USGS Circular 1399 (<http://dx.doi.org/10.3133/cir1399>). These data quality parameters for the 3DEP initiative approximate those used in the National Enhanced Elevation Assessment (Dewberry, 2011).

[RMSE<sub>(z)</sub>, root mean square error in the z (elevation) dimension; n/a, not applicable]

Quality level	Nominal pulse spacing (meters)	Vertical error as RMSE <sub>(z)</sub> (centimeters)
1	0.35	10
2	0.7	10
3	1.4	20
4	n/a	139
5	n/a	185

## Next Steps for Implementing 3DEP

Accomplishing the 3DEP initiative's goal of national coverage in 8 years depends on the following factors:

- Increased partnerships among Federal, State, Tribal, U.S. territorial, and local governments.
- Partnerships that acquire elevation data to the program's specifications across larger project areas.
- Increased communication about and awareness of the program's benefits and goals.
- Support for the program from government and other stakeholders.

## For Further Information:

Michael A. Tischler, Director  
USGS National Geospatial Program  
12201 Sunrise Valley Drive, MS 511  
Reston, VA 20192  
Email: [3DEP@usgs.gov](mailto:3DEP@usgs.gov)

Louis Driber  
The National Map Liaison  
2639 North Monroe Street, Suite A–200  
Tallahassee, FL 32303  
Email: [ldriber@usgs.gov](mailto:ldriber@usgs.gov)

<http://nationalmap.gov/3DEP/>

By William J. Carswell, Jr.

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