

3D Elevation Program – The Industry Perspective

Amar Nayegandhi, CP, CMS, GISP
Vice President, Dewberry Engineers Inc.



Dewberry's Geospatial and Technology Services (GTS)

Industry-recognized thought leaders, geographers, certified GIS Professionals, photogrammetrists, analysts, application developers, consultants

Supporting USGS since 1998...

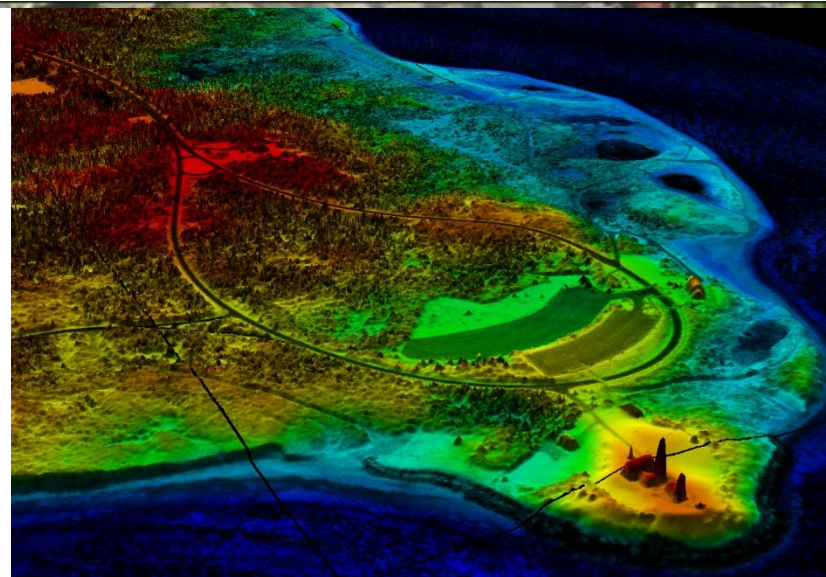
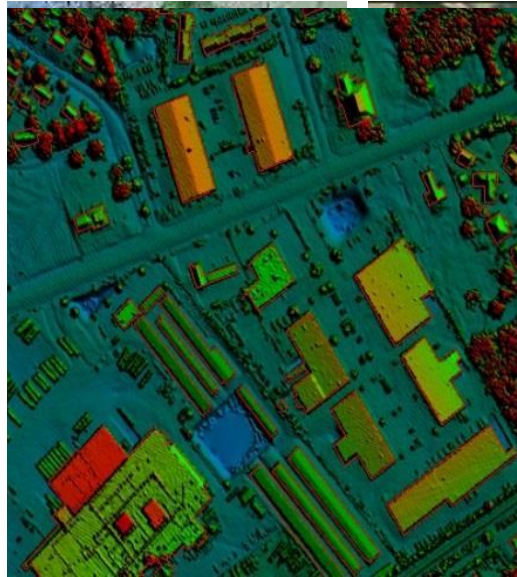
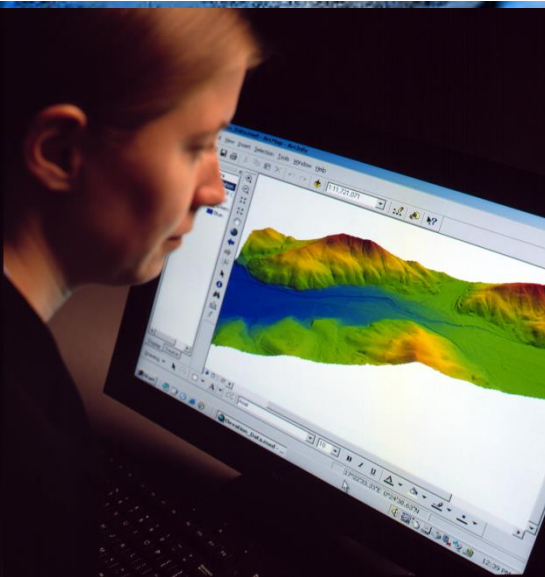
Elevation Mapping, Imagery Acquisition, QA/QC

USD 160M in geospatial support to USGS

1M sq km of topographic lidar data produced and **1.3M sq km** of lidar data

quality-checked for USGS; **1.6M sq km** of topographic ifsar data produced for USGS

Dewberry GTS received USGS's **Highest Quality Achievement Award** for
"Outstanding achievements in producing LIDAR products of the highest quality in timely manner."



Dewberry Geospatial - What we Do

- **Strategic Consulting**

- Strategic Planning
- Organizational Strategy and Design
- Process Optimization
- Staffing and Training

- **Enterprise Systems**

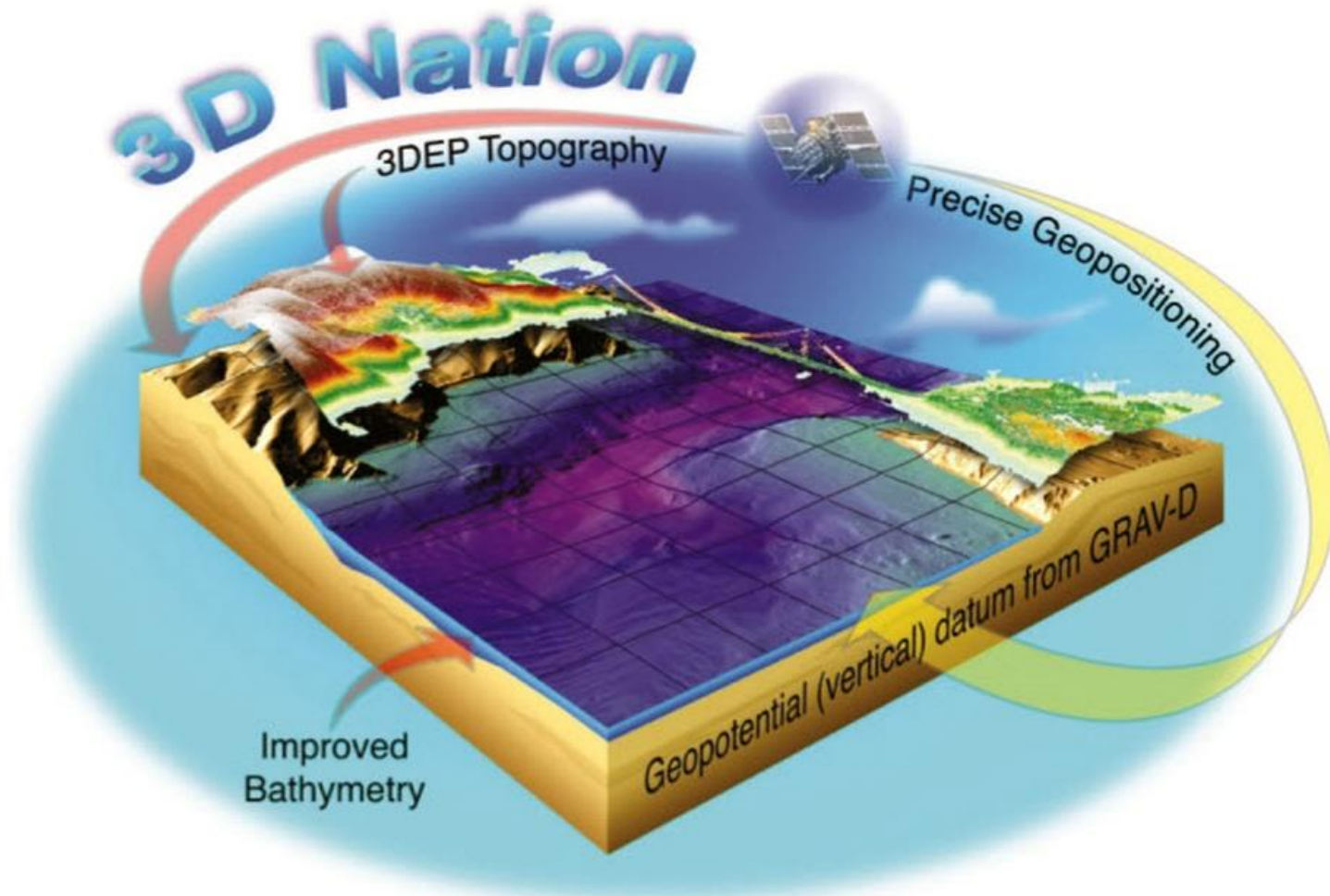
- Systems Integration
- Application Development
- Mobile Platform Development

- **Geospatial Data Services**

- Database Modeling and Design
- Data Collection and Development
- Remote Sensing
- Asset Inventory and Condition Assessment
- Data Analysis and Visualization

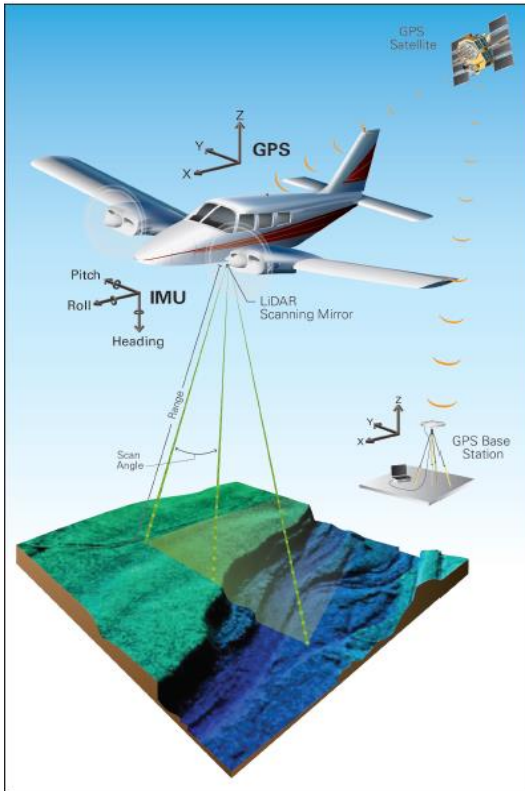


3D Nation Concept

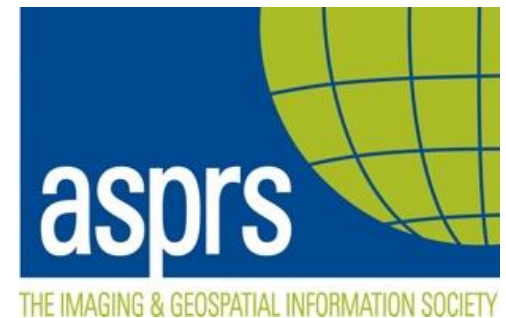
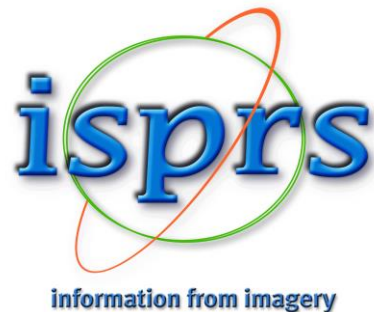


Elements of the 3D Nation concept.

Image courtesy RiegI, Inc.



US National 3D Elevation Program success through industry partnerships



Industry Representation through Professional Organization

MAPPS is the only national association of geospatial, mapping and photogrammetry firms in the United States with the following objectives:

- **Advocate** on Capitol Hill for sound geospatial policy and legislation
- **Expand** the geospatial market and create growth opportunities
- **Provide** professional recognition for innovation and projects
- **Increase** private sector use by government entities
- **Serve** as the voice of the private geospatial firms
- **Enhance** ability to participate in the free enterprise market
- **Promote** business interests and contest unfair competition
- **Offer** engaging business networking, professional knowledge exchange, and educational programs



American Society for Photogrammetry and Remote Sensing (ASPRS)

Society for setting standards and specifications

LAS 1.0 –May, 2003

ASPRS LIDAR Data Exchange Format Standard
Version 1.0
May 9, 2003

LAS 1.1 –March, 2005

LAS
Specification
Version 1.1
March 07, 2005

LAS 1.2 –Sept, 2008

LAS
Specification
Version 1.2

Approved by ASPRS Board 09/02/2008

LAS 1.3 –July, 2009



LAS SPECIFICATION
VERSION 1.3 – R10

Approved: JULY 14, 2009

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LAS 1.4 –July, 2013



LAS SPECIFICATION
VERSION 1.4 – R13
15 July 2013

Approved:
November 2011

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LAS SPECIFICATION
Version 1.4 R13

Page 1 of 28

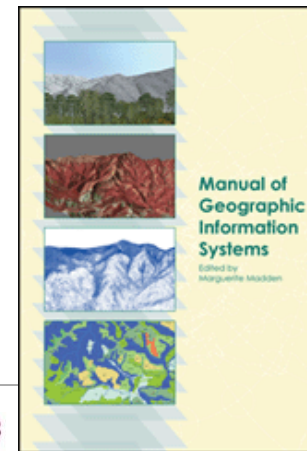
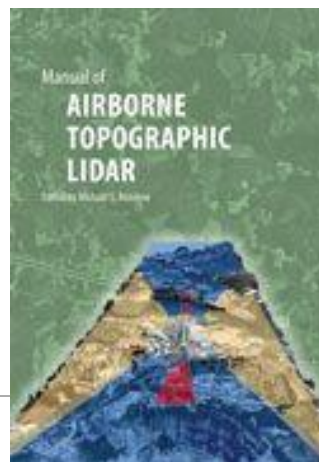
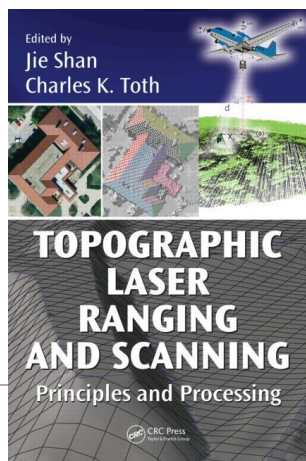
ASPRS Positional Accuracy Standards for Digital Geospatial Data (EDITION 1, VERSION 1.0 - NOVEMBER, 2014)

Foreword	A3
1. Purpose	A3
1.1 Scope and Applicability	A3
1.2 Limitations	A3
1.3 Structure and Format	A3
2. Conformance	A3
3. References	A4
4. Authority	A4
5. Terms and Definitions	A4
6. Symbols, Abbreviated Terms, and Notations	A5
7. Specific Requirements	A6
7.1 Statistical Assessment of Horizontal and Vertical Accuracies	A6
7.2 Assumptions Regarding Systematic Errors and Acceptable Mean Error	A6
7.3 Horizontal Accuracy Standards for Geospatial Data	A6
7.4 Vertical Accuracy Standards for Elevation Data	A6
7.5 Horizontal Accuracy Requirements for Elevation Data	A7
7.6 Low Confidence Areas for Elevation Data	A8
7.7 Accuracy Requirements for Aerial Triangulation and INS-based Sensor Orientation of Digital Imagery	A8
7.8 Accuracy Requirements for Ground Control Used for Aerial Triangulation	A8
7.9 Checkpoint Accuracy and Placement Requirements	A8
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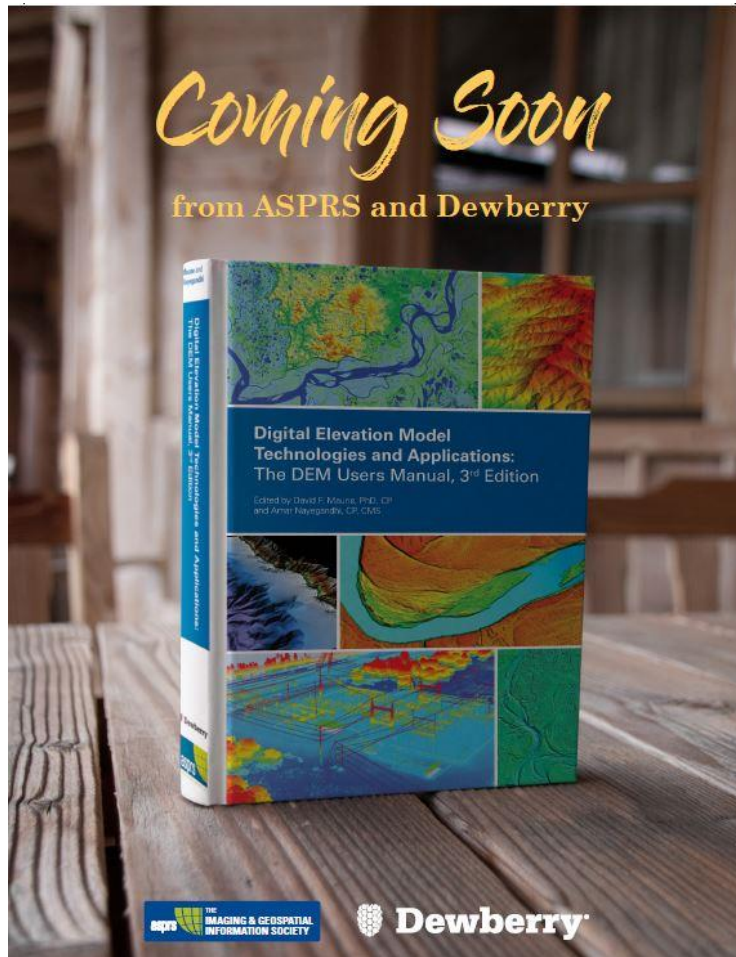
March 2015 A1

PHOTOGRAHMETRIC ENGINEERING & REMOTE SENSING



American Society for Photogrammetry and Remote Sensing (ASPRS)

Society for setting standards and specifications



The 3rd edition of the DEM Users Manual includes 15 chapters and three appendices. References in the eBook version are hyperlinked. Chapter and appendix titles include:

- | | |
|---|--|
| 1. Introduction to DEMs | 10. Airborne Lidar Bathymetry |
| 2. Vertical Datums | 11. Sonar |
| 3. Standards, Guidelines & Specifications | 12. Enabling Technologies |
| 4. The National Elevation Dataset (NED) | 13. DEM User Applications |
| 5. The 3D Elevation Program (3DEP) | 14. DEM User Requirements & Benefits |
| 6. Photogrammetry | 15. Quality Assessment of Elevation Data |
| 7. IfSAR | A. Acronyms |
| 8. Airborne Topographic Lidar | B. Definitions |
| 9. Lidar Data Processing | C. Sample Datasets |

This book is your guide to 3D elevation technologies, products and applications. It will guide you through the inception and implementation of the U.S. Geological Survey's (USGS) 3D Elevation Program (3DEP) to provide not just bare earth DEMs, but a full suite of 3D elevation products using Quality Levels (QLs) that are standardized and consistent across the U.S. and territories. The 3DEP is based on the National Enhanced Elevation Assessment (NEEA) which evaluated 602 different mission-critical requirements for and benefits from enhanced elevation data of various QLs for 34 Federal agencies, all 50 states (with local and Tribal input), and 13 non-governmental organizations. The NEEA documented the highest Return on Investment from QL2 lidar for the conterminous states, Hawaii and U.S. territories, and QL5 IfSAR for Alaska.

Chapters 3, 5, 8, 9, 13, 14, and 15 are "must-read" chapters for users and providers of topographic lidar data. Chapter 8 addresses linear mode, single photon and Geiger mode lidar technologies, and Chapter 10 addresses the latest in topobathymetric lidar. The remaining chapters are either relevant to all DEM technologies or address alternative technologies including photogrammetry, IfSAR, and sonar.

As demonstrated by the figures selected for the front cover of this manual, readers will recognize the editors' vision for the future – a 3D Nation that seamlessly merges topographic and bathymetric data from the tops of the mountains, beneath rivers and lakes, to the depths of the sea.

David F. Maune, PhD, CP
Amar Nayegandhi, CP, CSM
Co-Editors

Front cover figures courtesy of Dewberry

Lidar User Applications

Geologic Mapping

Seismic Fault Detection

Other Risk Analyses (Volcanoes and Landslides)

Soils Mapping and Engineering

Hydrologic & Hydraulic Modeling

Flood Risk Management

Sea Level Rise Mitigation

Sewer & Storm Water Planning

Post-Disaster Debris Estimation

Electric Reliability

Infrastructure Management

3D City Models

Line-of-Sight Analysis

Building Footprints

Renewable Energy Potential

Urban Planning

Forest Management

Change Detection

Aviation Safety

Route Planning

Precision Farming

Every dollar spent on LiDAR has a minimum of \$5 in benefits

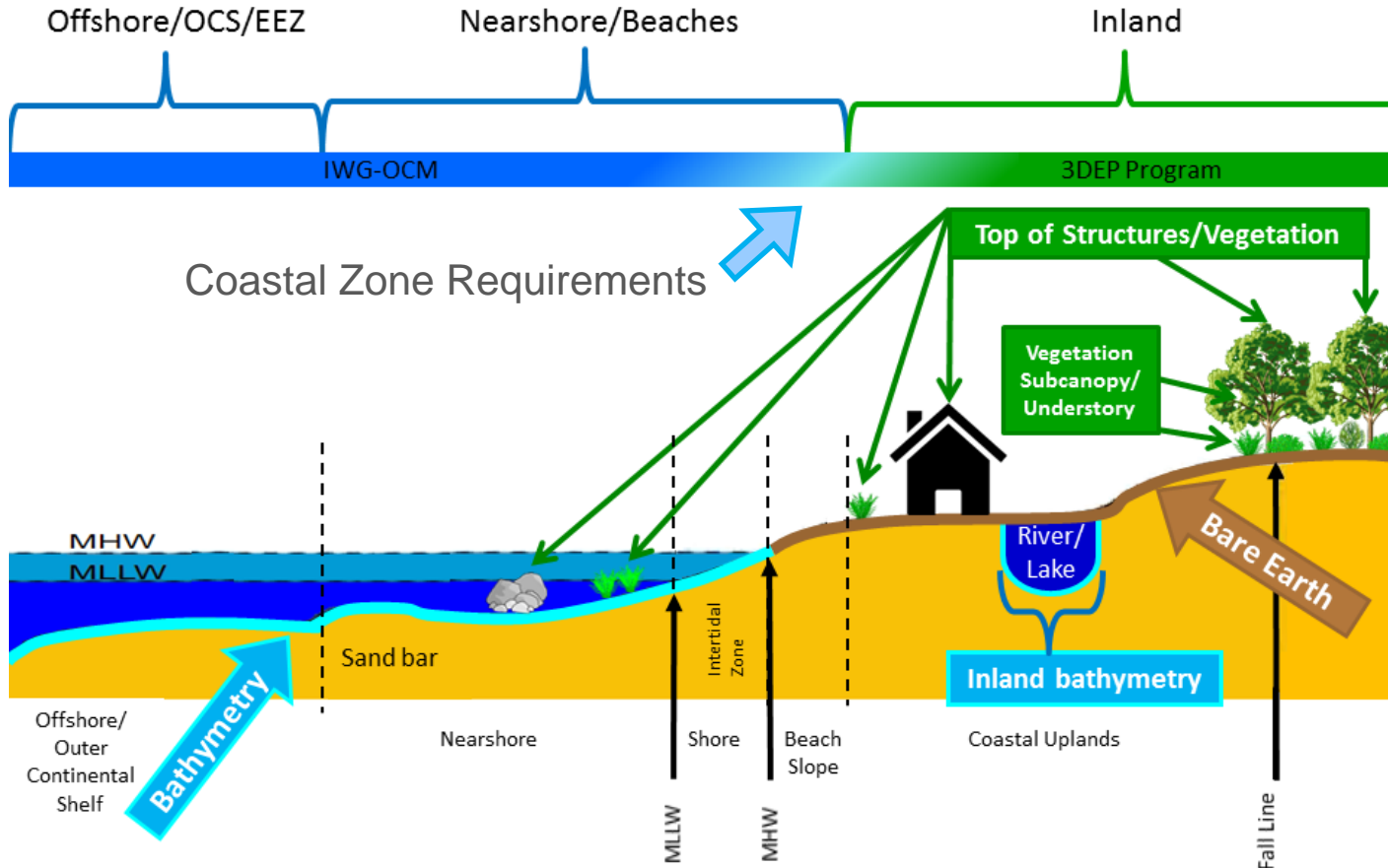
<http://www.dewberry.com/services/geospatial/national-enhanced-elevation-assessment>

NEEA Report for USGS 3DEP Lidar

Business Use		Annual Benefits	
		Conservative	Potential
Rank			
1	Flood Risk Management	\$295M	\$502M
2	Infrastructure and Construction Management	\$206M	\$942M
3	Natural Resources Conservation	\$159M	\$335M
4	Agriculture and Precision Farming	\$122M	\$2,011M
5	Water Supply and Quality	\$85M	\$156M
6	Wildfire Management, Planning and Response	\$76M	\$159M
7	Geologic Resource Assessment and Hazard Mitigation	\$52M	\$1,067M
8	Forest Resources Management	\$44M	\$62M
9	River and Stream Resource Management	\$38M	\$87M
10	Aviation Navigation and Safety	\$35M	\$56M
:			
20	Land Navigation and Safety	\$0.2M	\$7,125M
Total for all Business Uses (1 – 27)		\$1.2B	\$13B

NOAA/USGS 3D Nation Study (Ongoing)

Inland, Nearshore, Offshore and Topo, Bathy, Topo/Bathy

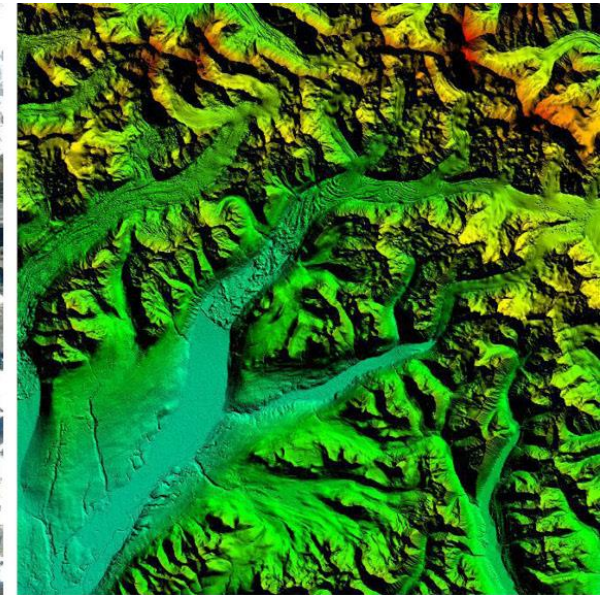
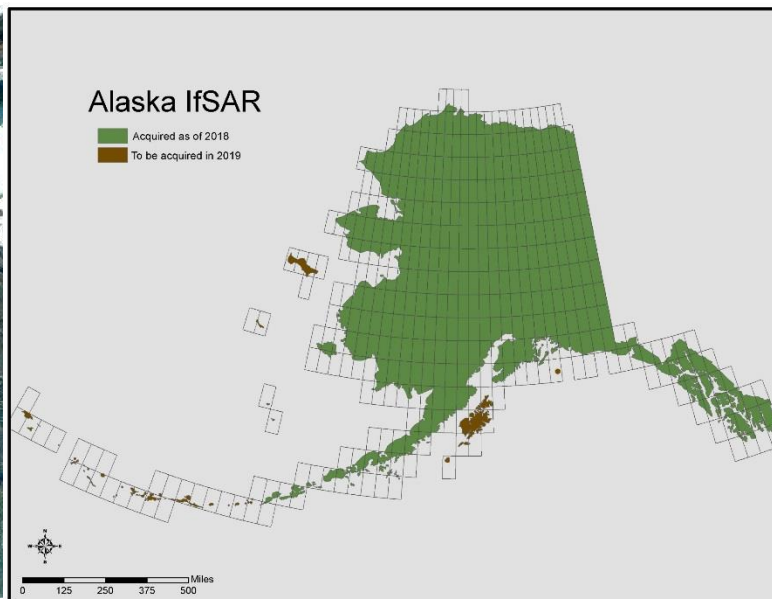


Technology Neutral Approach

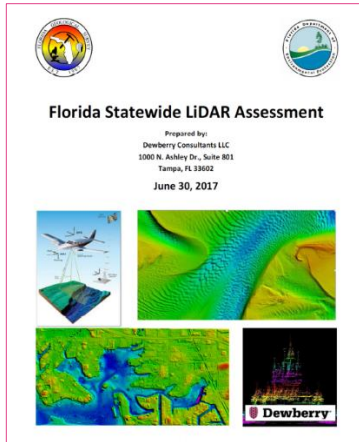
<https://coast.noaa.gov/data/docs/geotools/2017/presentations/Chappell.pdf>

Successful Statewide mapping initiatives – Alaska Airborne IfSAR

- Client: U.S. Geological Survey
- Employed interferometric synthetic aperture radar (IfSAR), a digital mapping technology ideal for Alaska, because it operates day and night and maps through clouds, ice, glaciers, and snow
- 660,000 sq miles; 1,689,000 sq km



Federal, State and Industry Partnerships – Florida Lidar Project



Florida Statewide Lidar Assessment
 Define specs, costs, and benefits for future projects



Ad hoc projects USGS, water management districts, counties, etc.

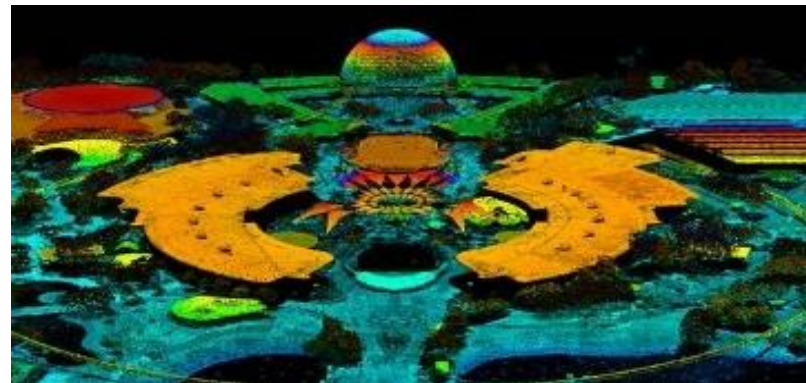
22,000
SQUARE MILES
 mapped since 2015



Hurricane Irma

- New mapping demands
- Federal/state legislative priority
- USGS / state awards contract to Dewberry

Epcot Center, Disney World, Osceola County



Other National Lidar Initiatives - Shoreline Mapping

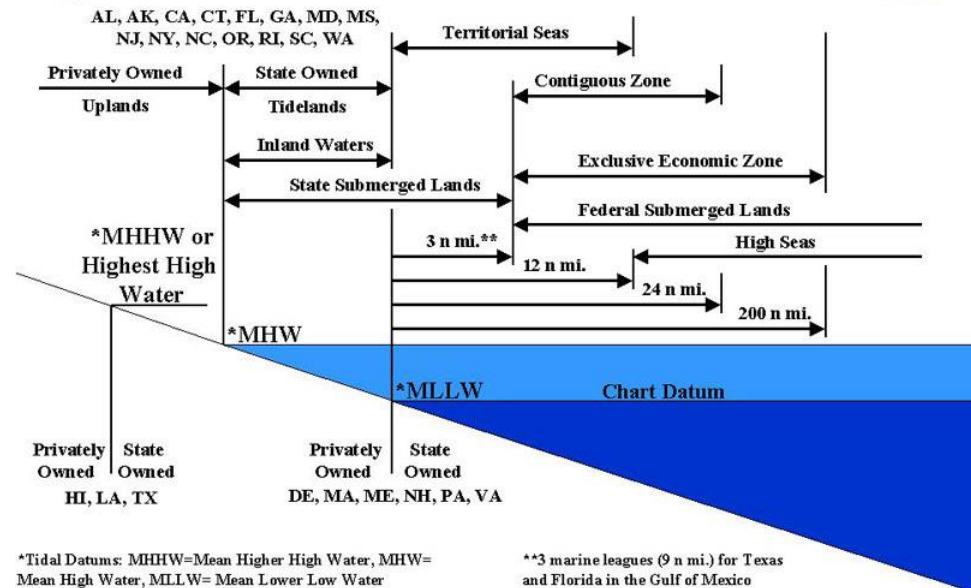
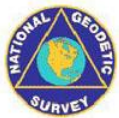
National Oceanic and Atmospheric Administration (NOAA)

National Geodetic Survey

- Define the National Shoreline
- Acquire Nearshore Elevation Data
- Support of other applications:
 - NOAA nautical charts
 - Used in defining the United States' territorial limits
 - Coastal resource management
 - Storm surge and coastal flooding modeling
 - Coastal geomorphology studies
 - GIS analysis
- Coastal Intelligence, Resiliency and Place-Based Conservation Applications
- *Integrated Ocean and Coastal Mapping : ! Map Once-Use Many Times !*



Importance of Shoreline



<https://shoreline.noaa.gov/>

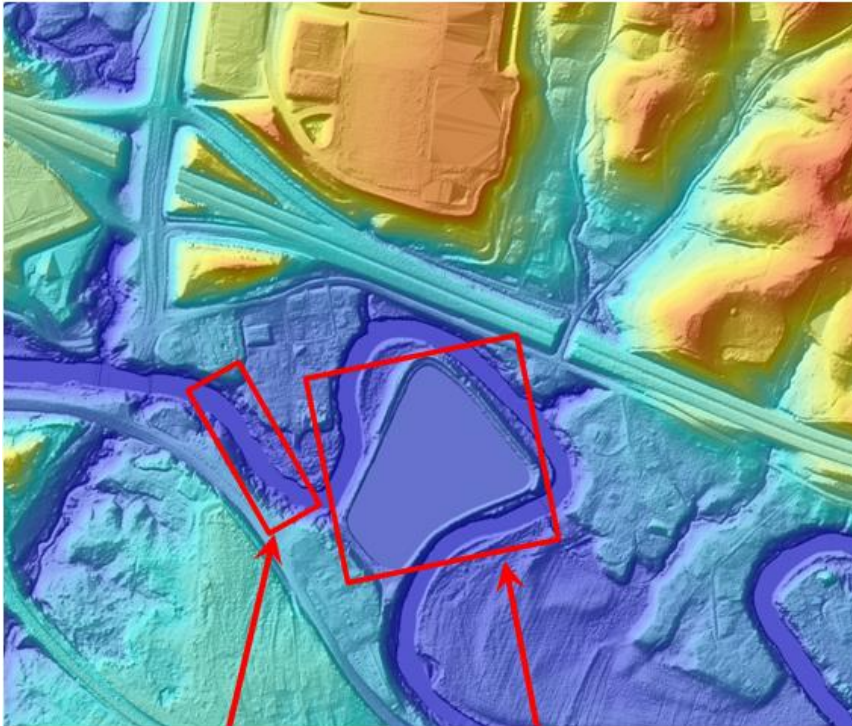
Big Data Processing, Analytics, and Applications

Benefits of Lidar - Bare Earth under dense vegetation



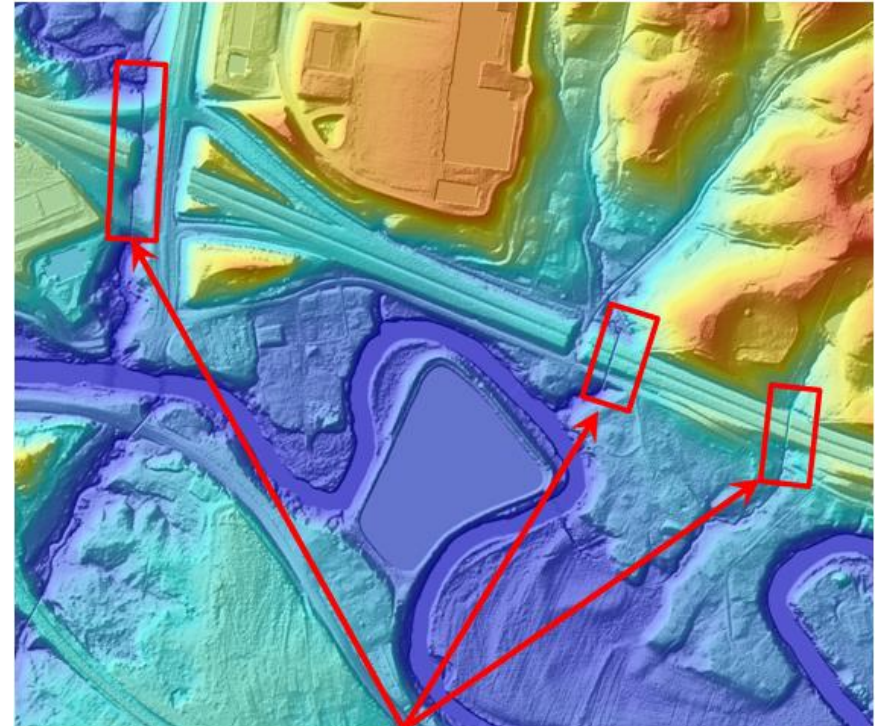
Hillsborough County, FL, USA

Water resources applications



Stream Waterbody

Hydro-flattened stream & lake w/bridge/overpass cut; a cartographic product.



Culverts Cut Through Roads

Hydro-enforced to include addition of culverts; a hydrologic modeling product.

Flood Risk Management



Old Flood Study

- Showed many houses outside Special Flood Hazard Area (SFHA) for 100-year flood that were mostly uninsured yet vulnerable to flooding



New Flood Study with LiDAR

- Shows houses in SFHA that require flood insurance
- Need to know true flood risk

NOAA Sea Level Rise (SLR) Viewer

Sea Level Rise and Coastal Flooding Impacts
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Sea Level Rise Confidence Marsh
Vulnerability Flood Frequency

Sea Level Rise ?
4 ft SLR

Legend
Water Depth
Low-lying Areas
Visualization Location

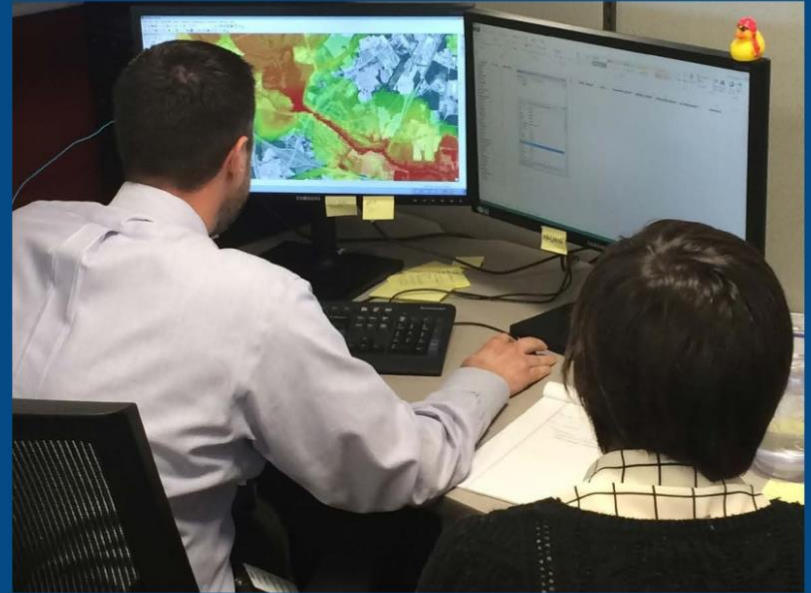
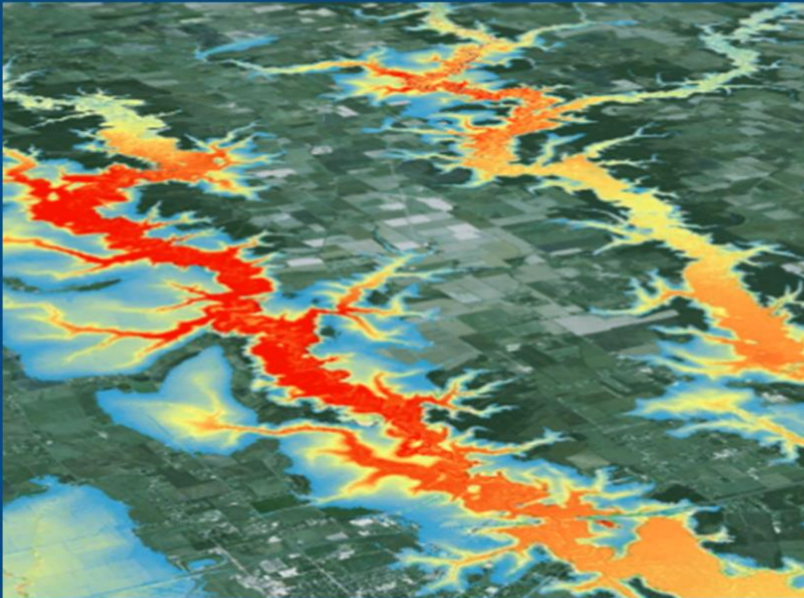
Overview
Use the slider bar above to see how various levels of sea level rise will impact this area.
Levels represent inundation at high tide. Areas that are hydrologically connected are shown in shades of blue (darker blue = greater depth).
Low-lying areas, displayed in green, are hydrologically "unconnected" areas that may flood. They are determined solely by how well the elevation data captures the area's hydraulics. A more detailed analysis of these areas is required to determine the susceptibility to flooding.

Understanding the Map
Additional Information

Texas Glossary Share
Imagery Streets
Galveston
West Bay
Offatts Bayou
Moody Gardens
Scholes Airport Terminal
Use the slider to view a simulation of sea level rise at this location.

The Sea Level Rise button allows users to see the impact of 4 foot SLR above MHHW in Galveston, TX. Local impacts of multiple SLR scenarios at local landmarks can be seen in simulation photos.

Response to Natural Disasters

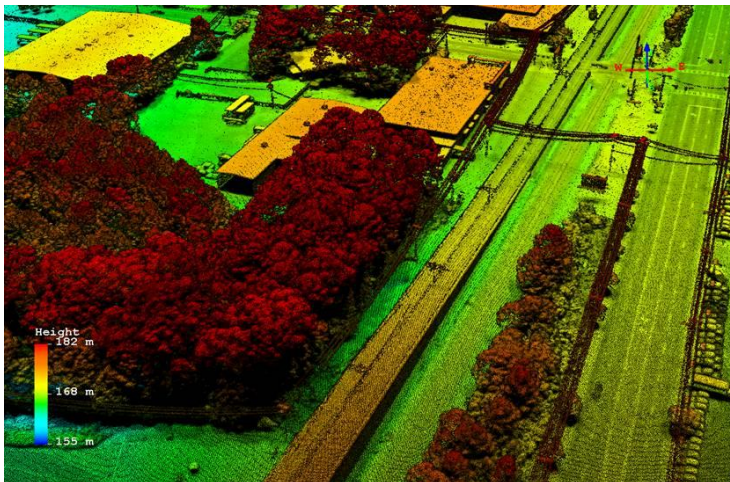


Infrastructure Management

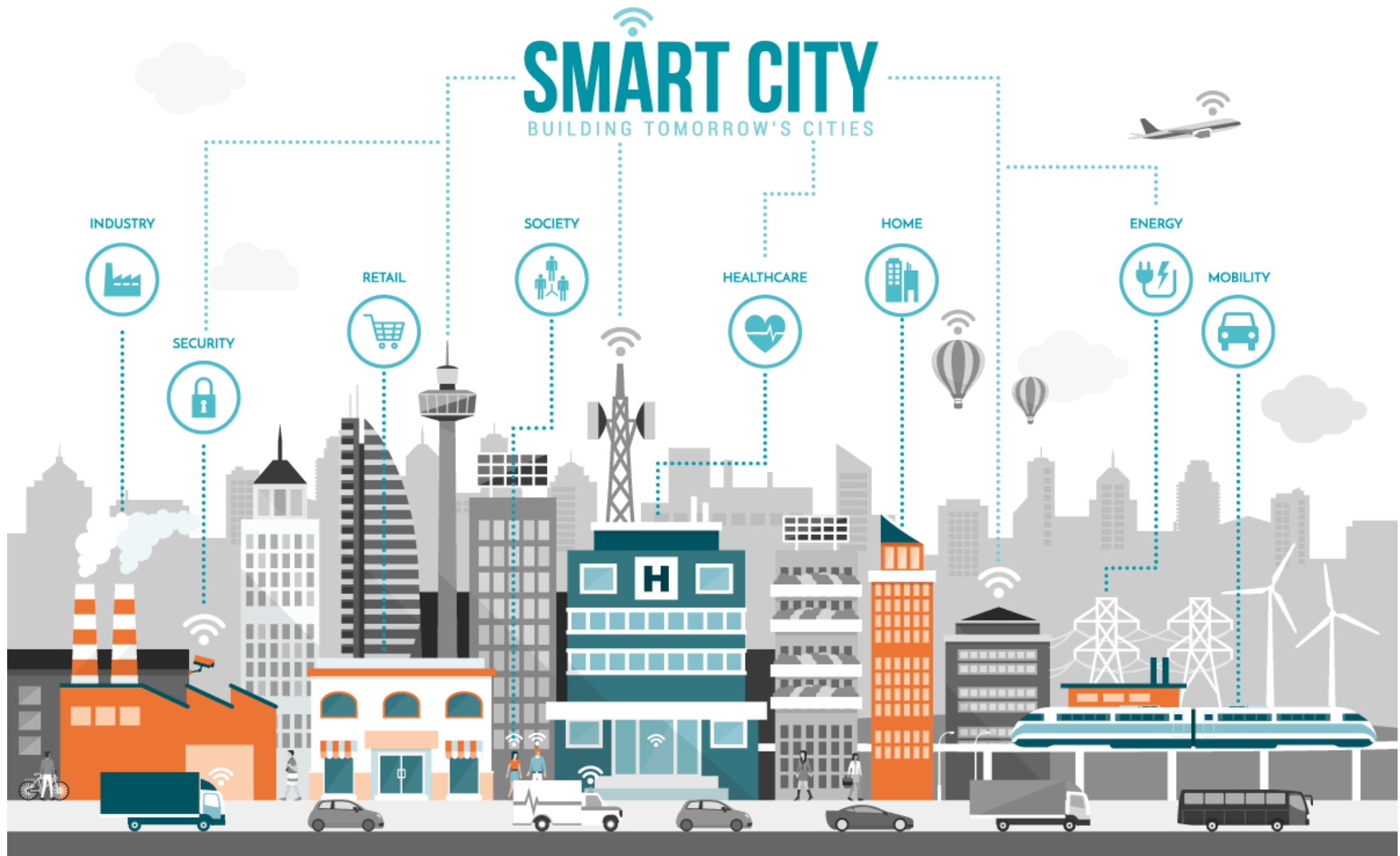


LiDAR is used for management of:

- Water and sewer treatment plants
- Overhead utility lines
- Roads and railroads
- Parks and trees
- Wildlife habitats
- Buildings of all types
- Emergency evacuations



3D City Models



Renewable Energy, Solar Potential

county.gov County Directory of Information & Services | Public Alerts | Public Information | County Contact Information

Los Angeles County **Solar Map**

Details | Got Solar! | Partners | Solar Resources | Incentives & Programs | Feedback

Switch Language: Español

Enter street address:
500 W Temple St, Los Angeles
Locate Address

Map Key

Solar Points

- Excellent (>4.9 kWh/Day)
- Good (4.0 to 4.9 kWh/Day)
- Poor (3.3 to 4.0 kWh/Day)
- Not Advisable (<3.3 kWh/Day)

(About the Rating)

Energy Projects

- Solar Electricity
- 3-D County Buildings
- Multiple

3154 77TH ST, LOS ANGELES CA

Property Summary

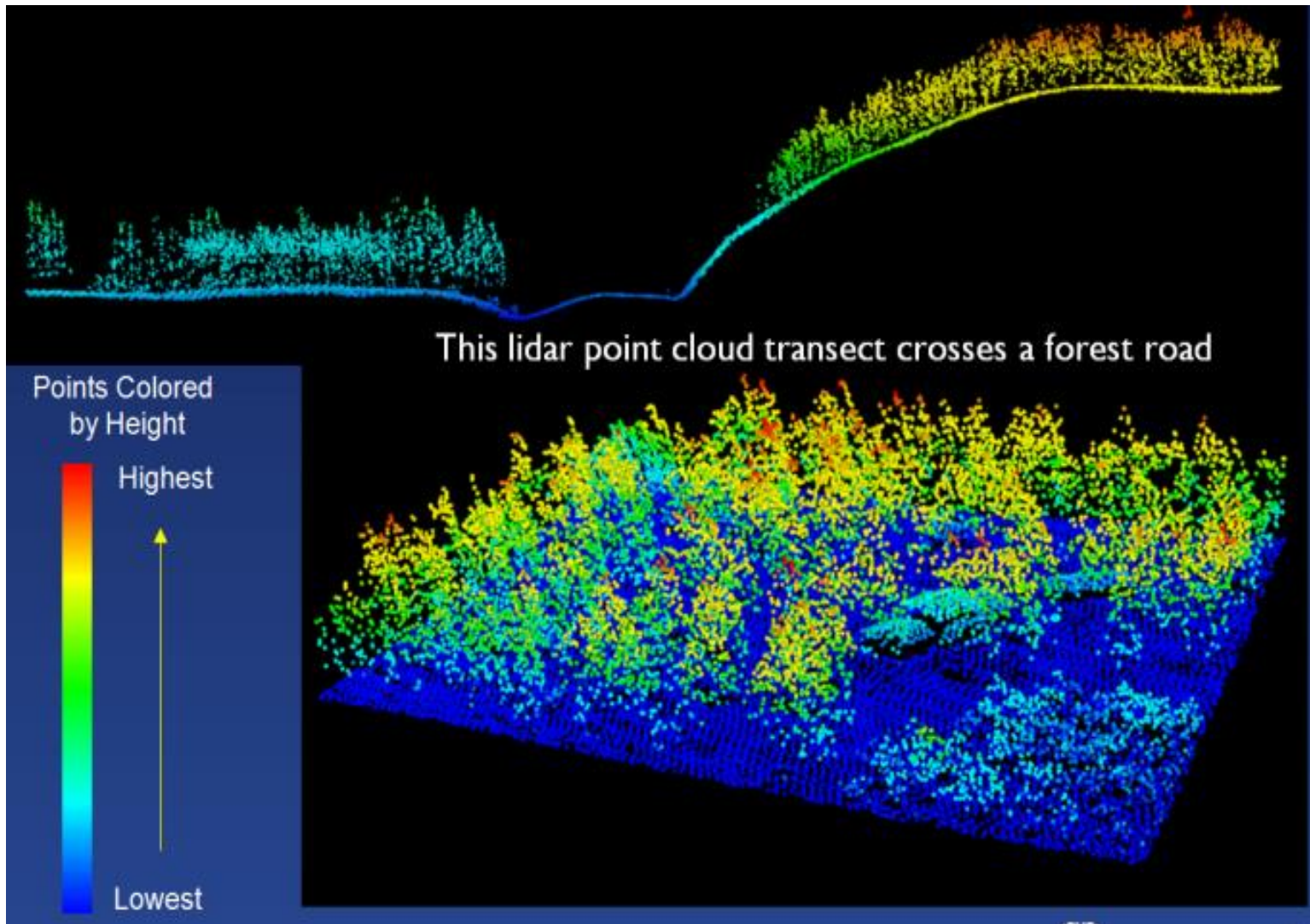
Total Roof Area: 2,268 Sq Ft
Electric Utility: Los Angeles Department of Water & Power

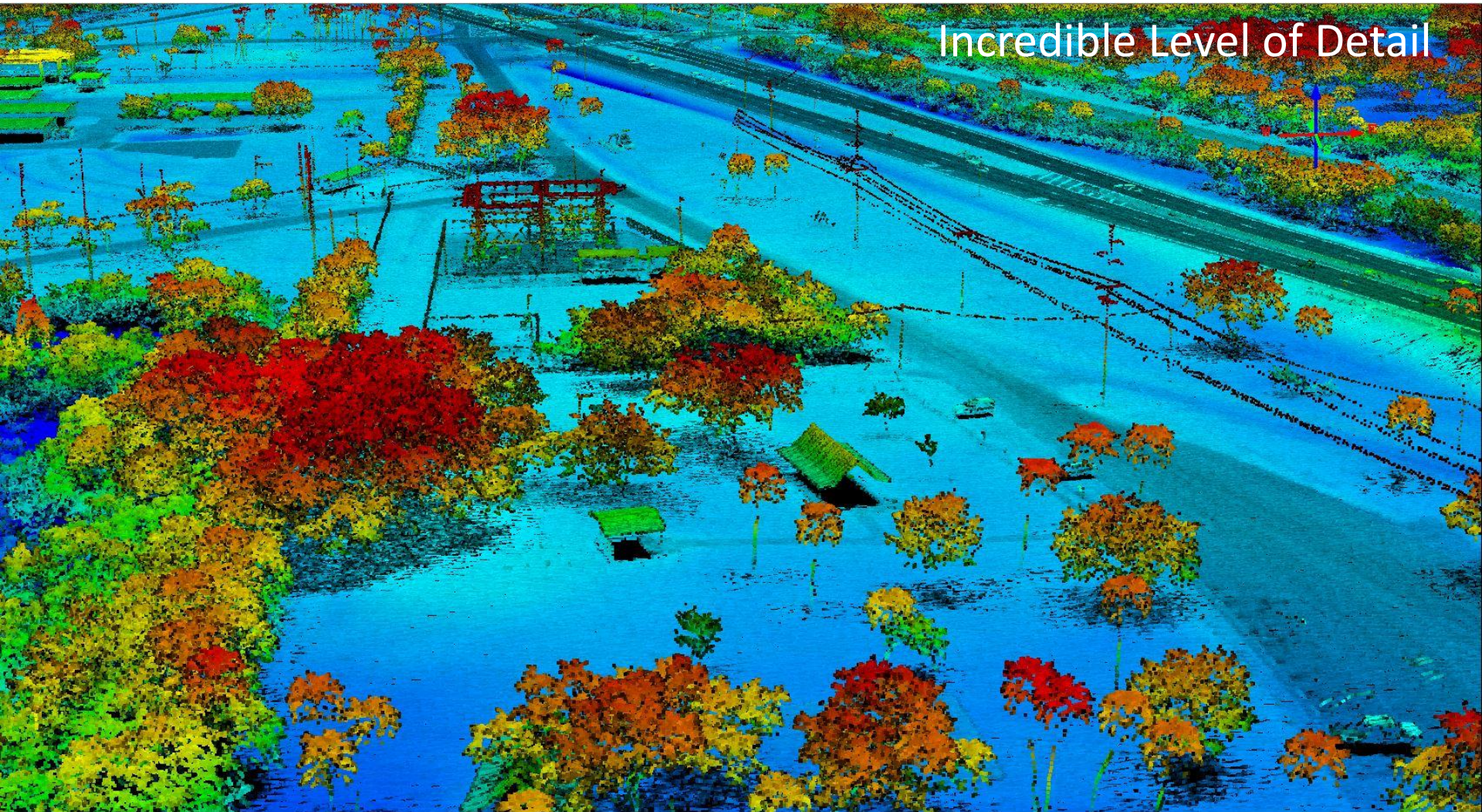
Solar Electric	Solar Hot Water
Area Suitable for Solar: 825 Sq Ft	Solar Water Heating Potential: 2,475 Therms/Year
Solar PV Potential: Up to 11.4 kW	Gas Savings: \$1,908 /Year
Electric Savings: Up to \$1,868 /Year	Carbon Savings: 33,279 lbs CO2/Year
Electricity Produced: 16,986 kWh/Year	Cost Estimates & Reports
Carbon Savings: 1,230 lbs/Year	Create a PDF Report for this Parcel
	Create Report

Los Angeles



Forest and Wildfire Management





Incredible Level of Detail

to support numerous applications that benefit the government and private sector

Advances in Lidar Technology

Market trends in airborne LiDAR

Decision-making that affects larger and larger areas requires more detailed and more consistent data demands frequent updates at manageable cost

Solutions

- Increase the number of points collected each second
- Increase the number of types of data per flight
 - XYZ
 - Intensity or Reflectivity
 - Spectral properties (RGB/NIR)
- Increase efficiency in data processing

Result: extreme pressure on cost per data point



Advances in Lidar Technology

- Linear and Photo-sensitive Lidar Sensors
 - Acquire data at higher altitudes and speed
 - Collect denser data
 - Collect topography and bathymetry data simultaneously



Leica SPL100 (single-photon)



Leica Terrain Mapper

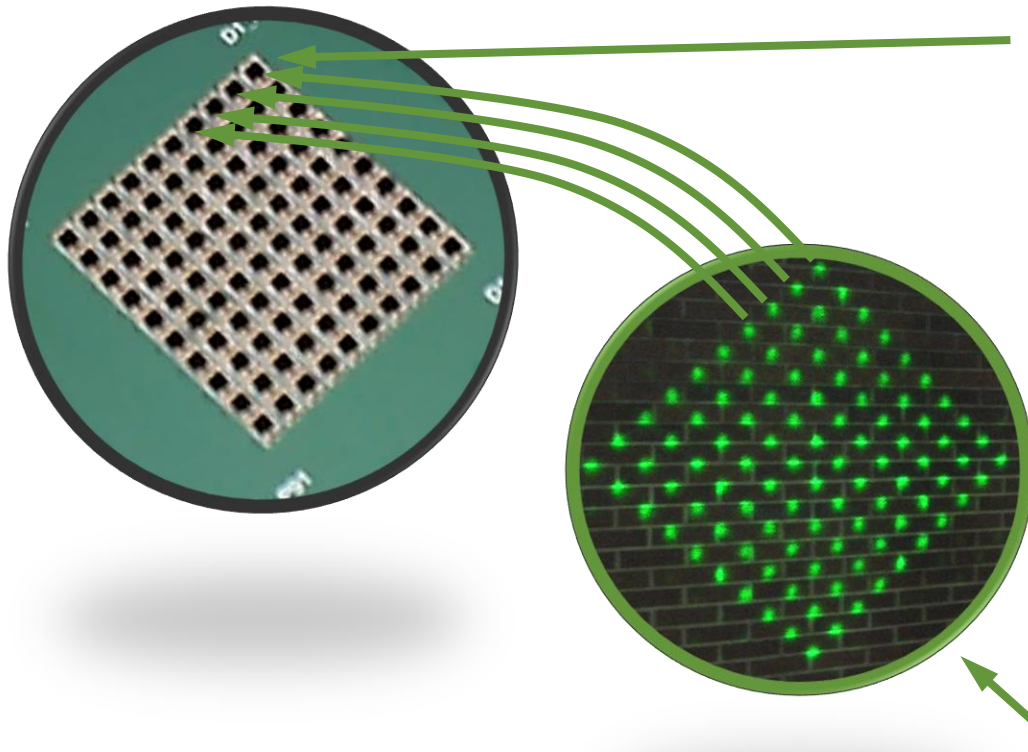


Riegl VQ-880-GH



Riegl VQ-1560i

Photon-sensitive Lidar



- Single-Photon Avalanche Diode (SPAD) detectors are far more sensitive than Avalanche Photo Diode (APD) detectors used in linear-mode LiDAR systems
- Less laser output required for detection of a target
- Output from a single laser pulse can be split to illuminate multiple locations on the ground, each illuminating an individual detector element



Photon-sensitive sensors can deliver 10x the effective pulse rate of linear-mode systems, with $\frac{1}{4}$ the laser output!

Future Trends in Geospatial Industry

10/5/2018

Geospatial Analytics Market Size, Share, Report, Analysis, Trends - Reuters



According to Statistics MRC, the Global Geospatial Analytics Market is expected to grow from \$38.65 billion in 2017 to reach \$174.65 billion by 2027 with a CAGR of 18.2%. Need for reducing operational and logistic costs by organizations, technology advancement in artificial intelligence (AI) and commoditization of geospatial information are some of the key factors driving the market growth. However, high cost for implementation and official issues & policies are restraining the market.



2

Singapore's Sirius Venture invests US\$3 million in Israeli food tech startup SuperMeat

Climate change adaptation is a response to global warming and climate change, that seeks to diminish the susceptibility of social and biological systems to comparatively sudden change and thus offset the effects of global warming. This growth can be attributed to the increasing awareness about climate change among organizations such as environment related organizations.

street address, postal code, or forest stand identifier as they are applied to geographic models. Geospatial analysts filter out related from unrelated data and apply it to conceptualize and imagine the order hidden within the apparent disorder of geographically sorted data.

Climate change adaptation is a response to global warming and climate change, that seeks to diminish the susceptibility of social and biological systems to comparatively sudden change and thus offset the effects of global warming. This growth can be attributed to the increasing awareness about climate change among organizations such as environment related organizations.

Pending

IPO

Startup

Asia-Pacific is expected to grow at the highest CAGR during the forecast period. The growth is due to rising acceptance and usage of geospatial analytics in high expansion industrial sectors. Infrastructure and smart city developments are also chief factors which are driving the market growth in this region.

Make an inquiry at: <http://www.strategymrc.com/report/geospatial-analytics-market>

Technologies Covered:

• Geographic Information System (GIS)

<https://www.reuters.com/brandfeatures/venture-capital/article?id=29591>

Thank you.
Questions?

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Vice President

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