

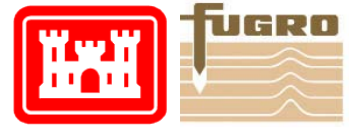
[illegible]

Innovations for the detection of pipelines

- **Diver-deployed hand-held devices**
 - Detect pipelines in up to 10' water depth
 - Send signal down the pipeline from shore (shore)
 - Theoretically detect and depth of burial up to 10'
- **Seabed crawler devices**
 - Tracked ROV drives the subsea line



5 W's and H



Who?

- USACE LA District
- Fugro

What?

- 4 breakwater surveys in Southern California

Where?

- Dana Point Harbor and Port of Los Angeles/Port of Long Beach

When?

- 3 separate programs between 2009 and 2010

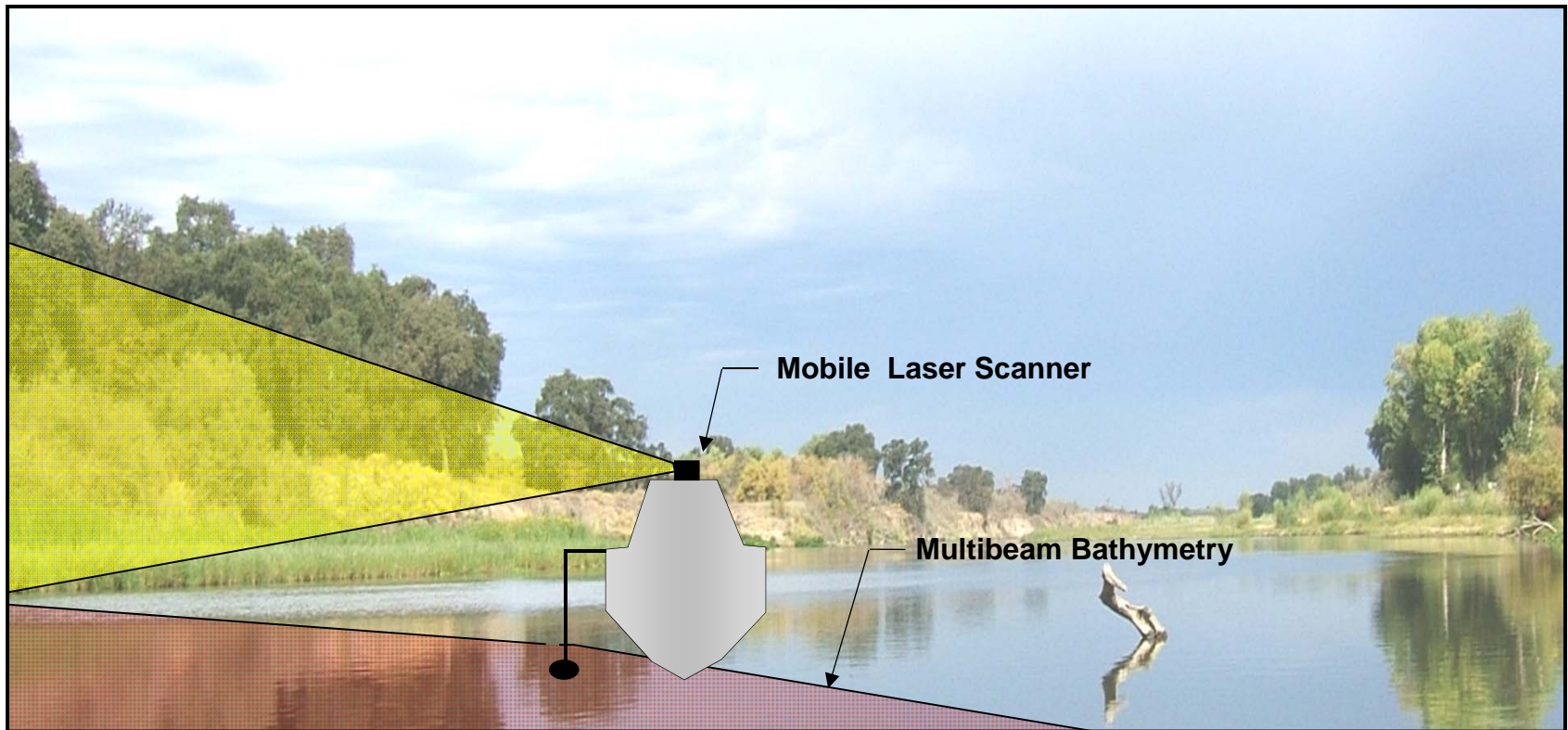
Why?

- Several benefits in terms of safety, efficiency and detail

How?...

Integrate bathymetry with a topographic data to close the gap between surface and underwater topography.

Complete survey crossing the water/land interface.



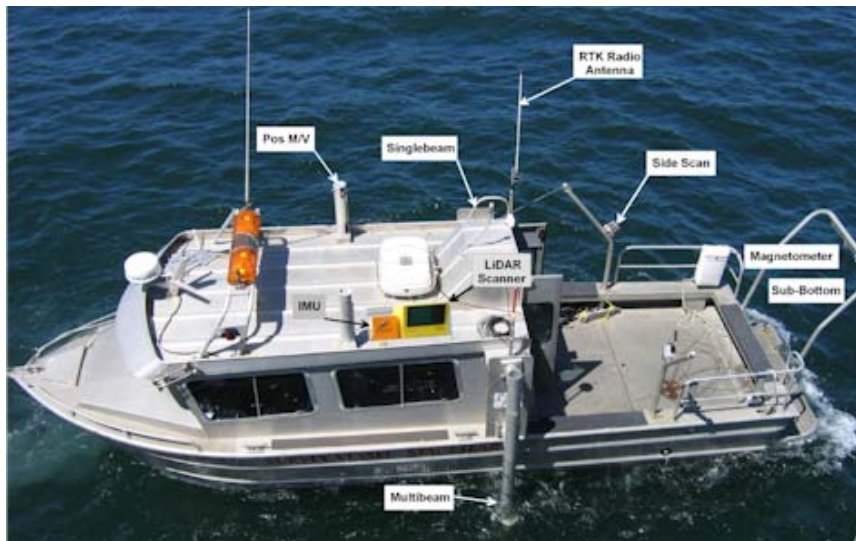


Key Components:

1. **GPS (GNSS) Positioning**
2. **Inertial Navigation (IMU)**
3. **Laser Scanner (LiDAR) (Topography)**
4. **Multibeam Bathymetric Echosounder (MBES) (Underwater)**
5. **Side-Scan Sonar (Underwater Imaging)**

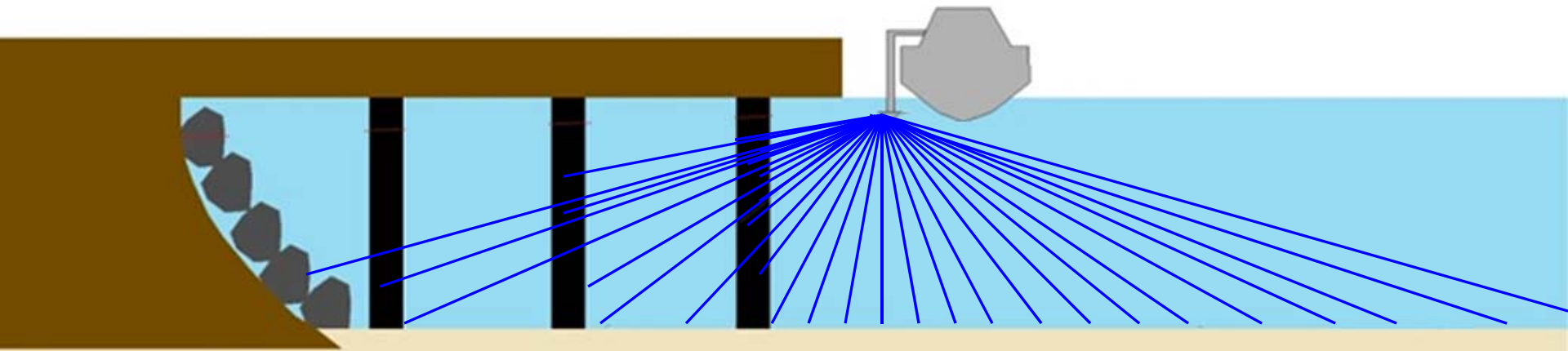
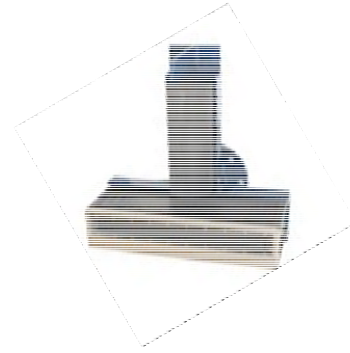
How it works:

- Use laser scanning (LiDAR) for above water survey
- Use sonar echosounding (multibeam) for underwater survey
- Uses GPS and Precision Inertial Navigation for Positioning
- Sonar Imaging also collected



Multibeam bathymetric echosounder (MBES):

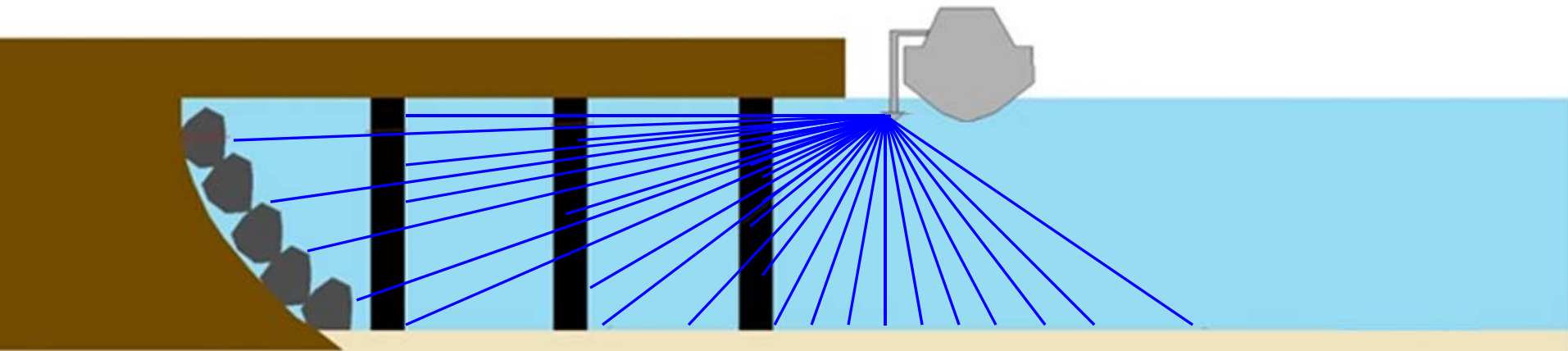
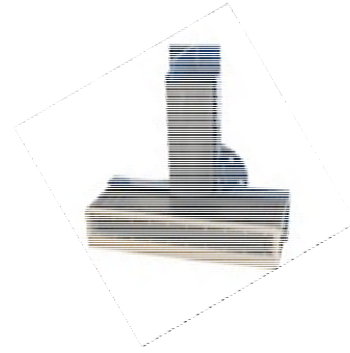
- Creates swathes of survey data (not just a single beam)
- Creates continuous seafloor map
- Variable swath width (width vs. detail) and can be rotated



Multibeam Sensor in standard orientation

Multibeam bathymetric echosounder (MBES):

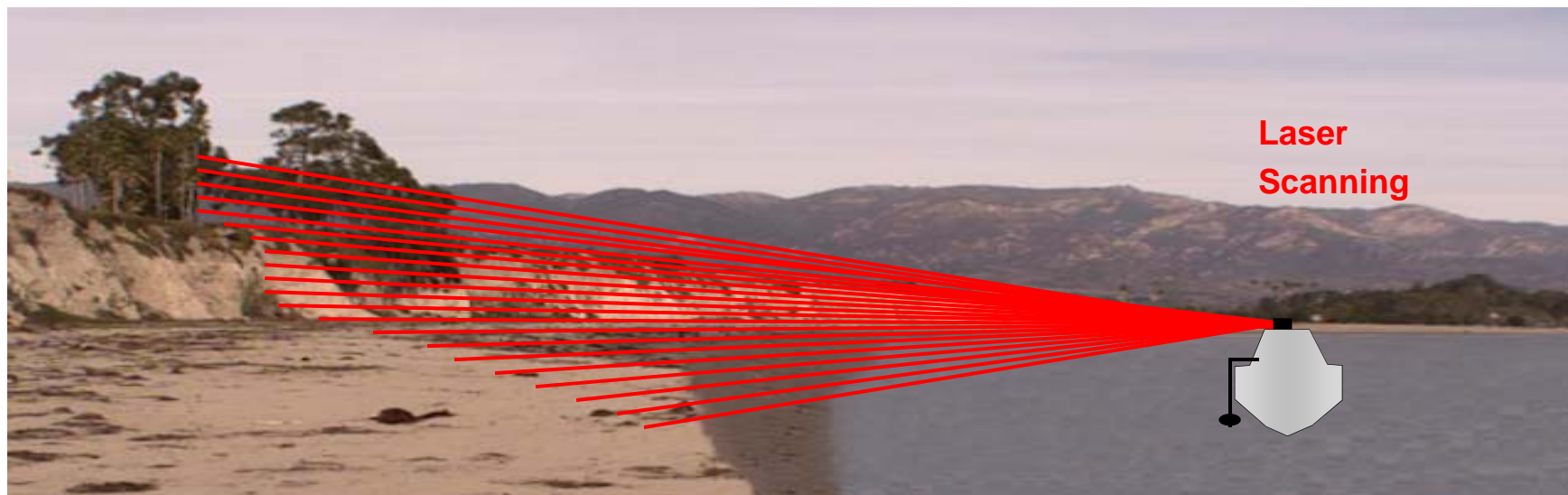
- Creates swathes of survey data (not just a single beam)
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- Variable swath width (width vs. detail) and can be rotated



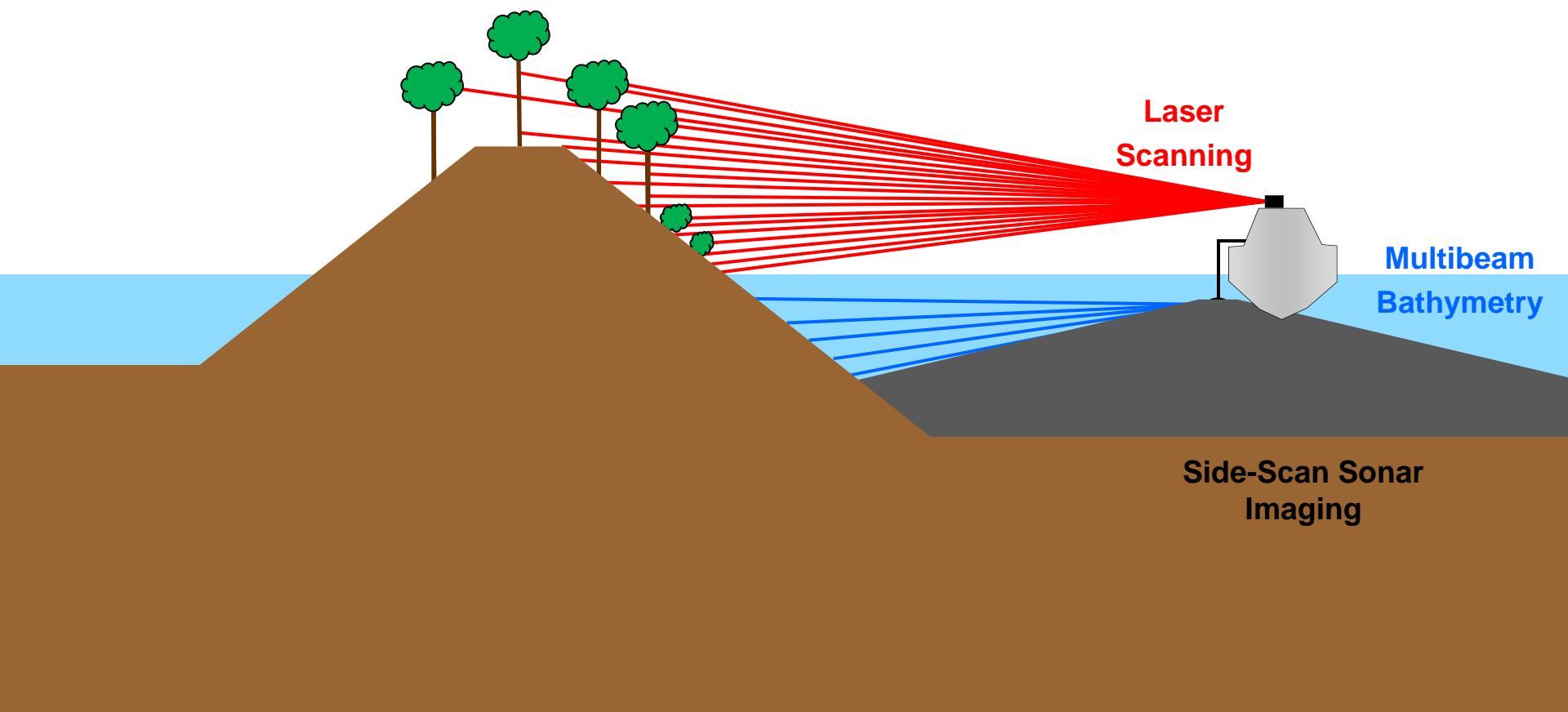
Rotated Multibeam Sensor for surveying laterally to the waterline

MLS similar to multibeam (and airborne LiDAR)

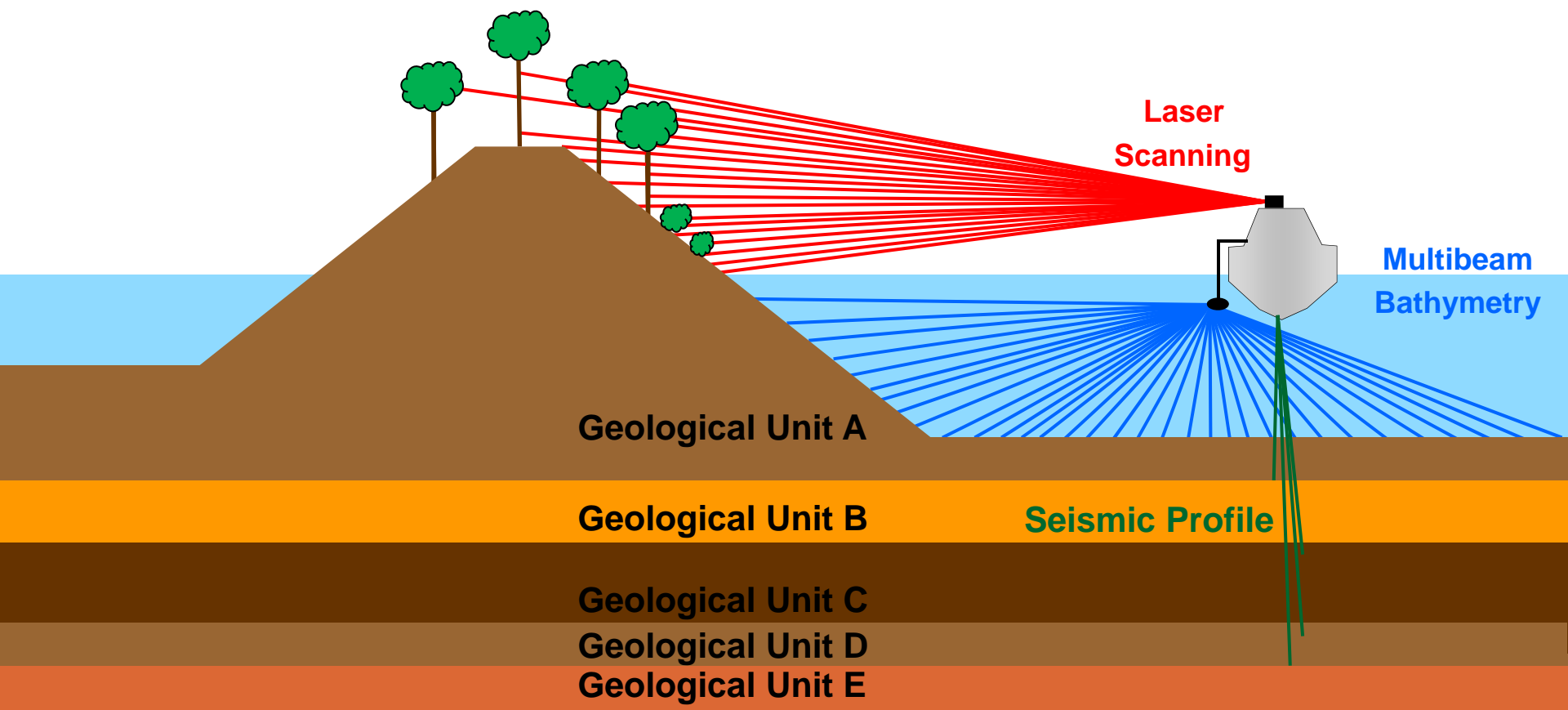
- Use lasers for ranging
- Often longer ranging laser required, especially in dangerous waters
- Some projects require supplementing capture from land



A survey that integrates bathymetry with a topographic data can close the gap between surface and underwater topography.

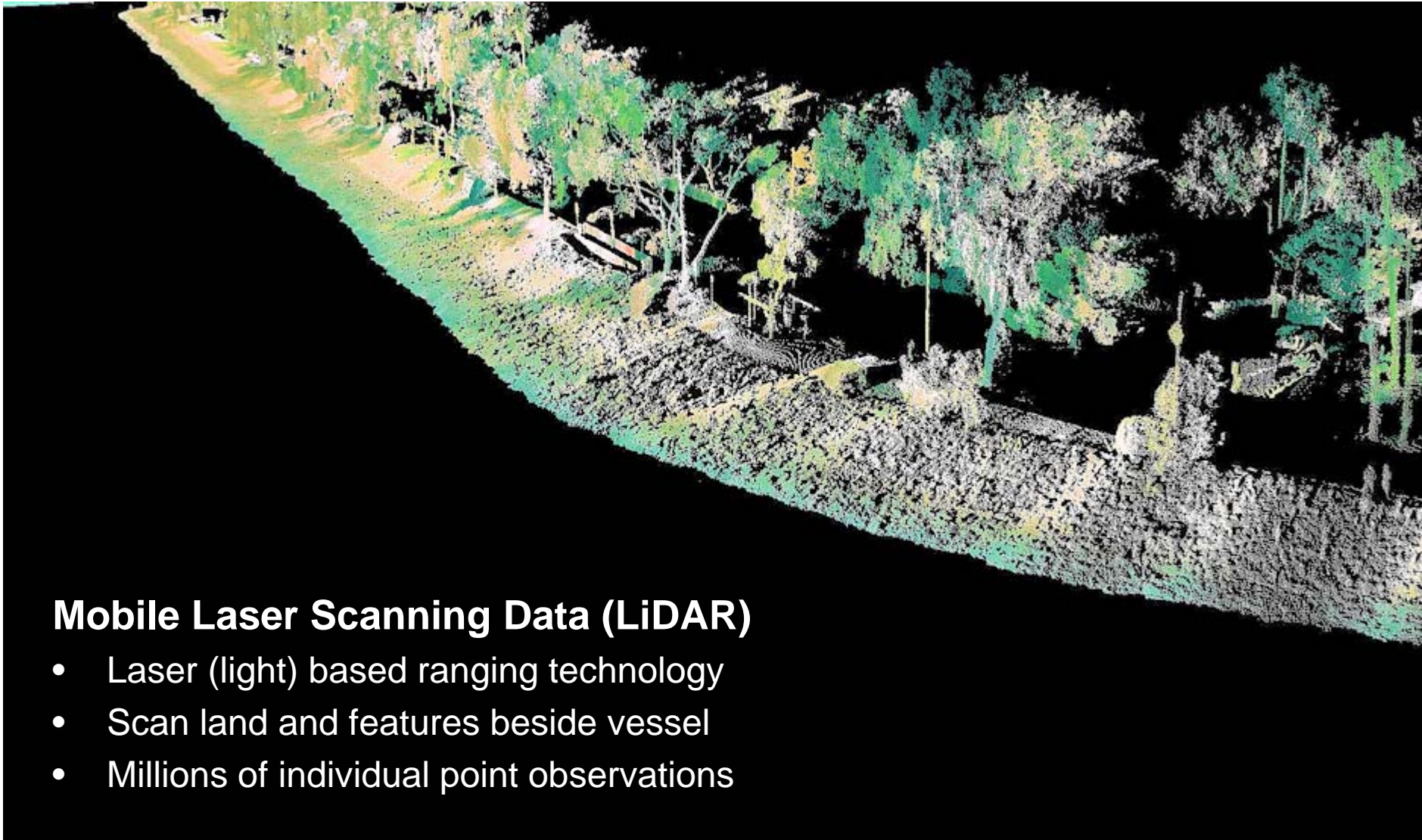


Although not used here, some applications require investigation of the subsurface using seismic profiling.



Multibeam Bathymetry Echosounder (MBES) Data

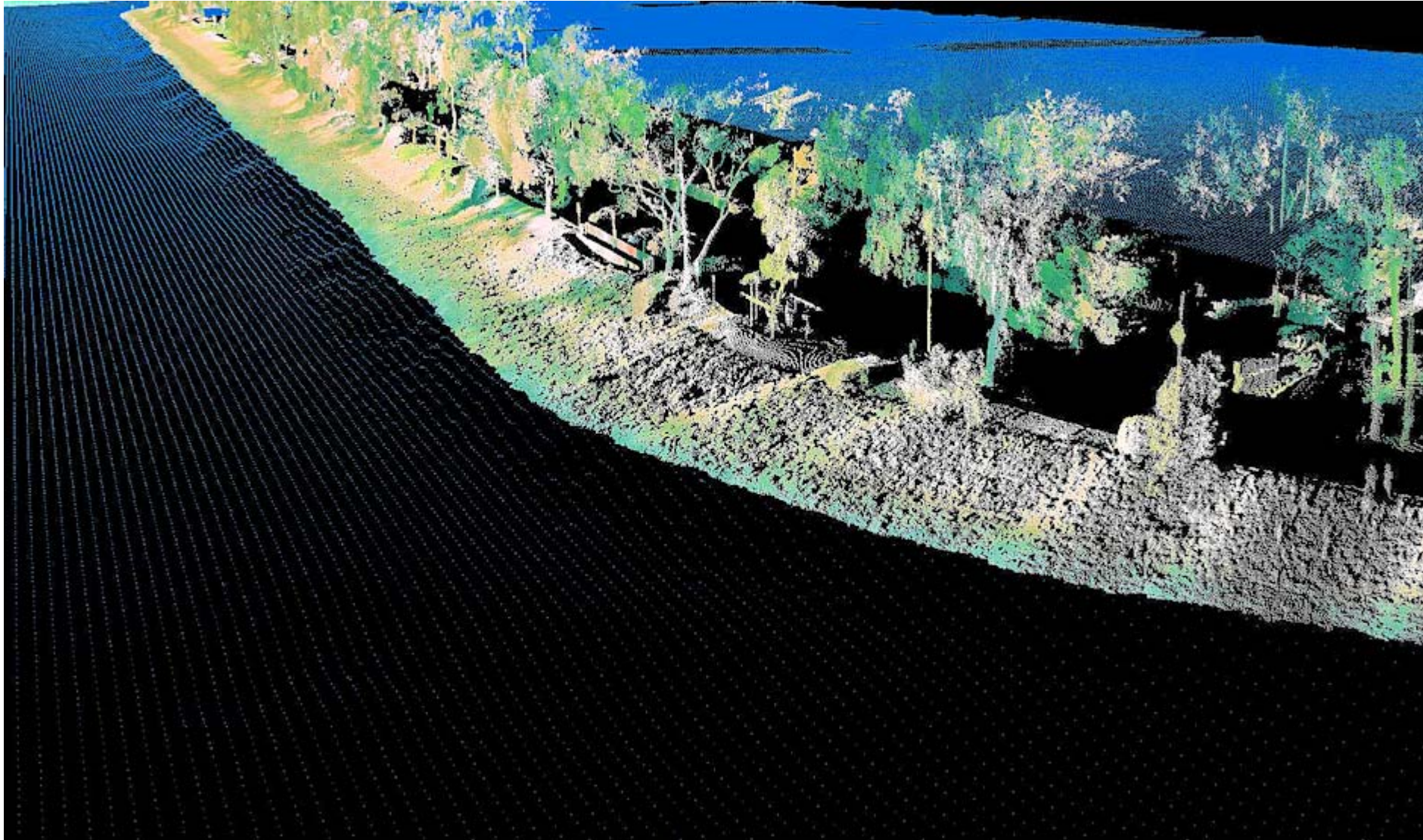
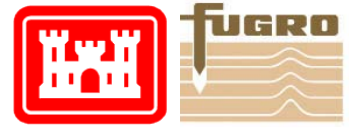
- Sonar (sound) based ranging technology
- Wide coverage on both sides of vessel
- Millions of individual point observations



Mobile Laser Scanning Data (LiDAR)

- Laser (light) based ranging technology
- Scan land and features beside vessel
- Millions of individual point observations

Integrating Bathymetry and Laser Scanning

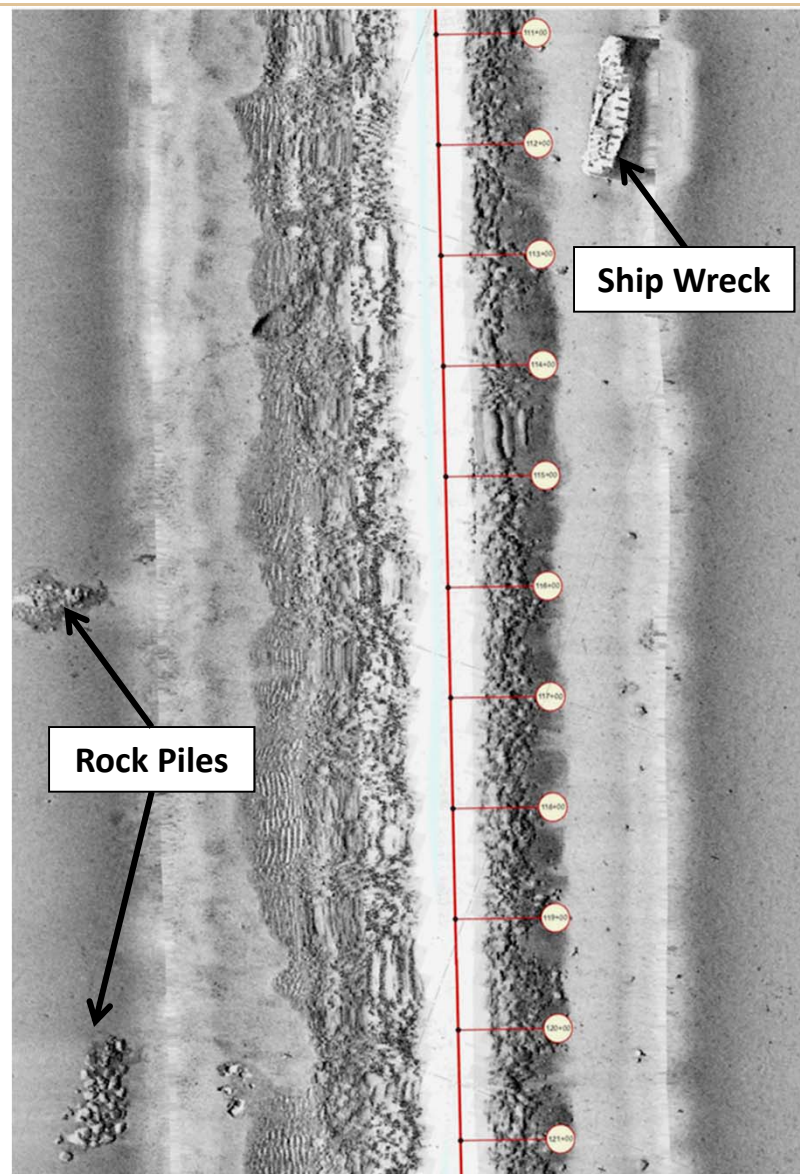


Sonar Backscatter Imaging (Side-Scan or Snippets)

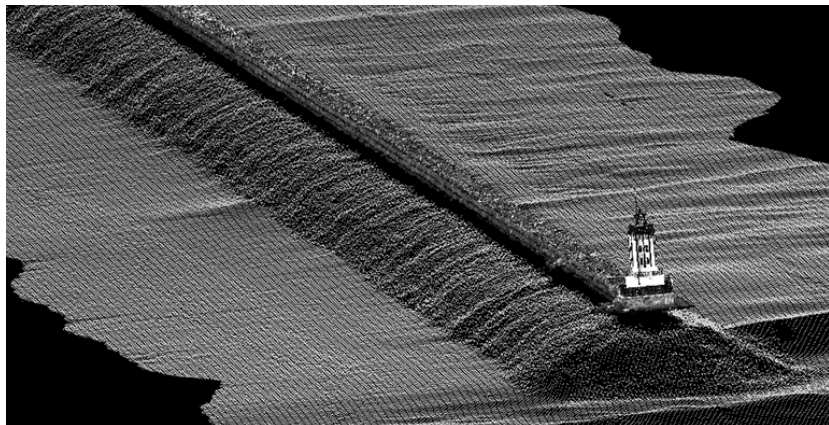
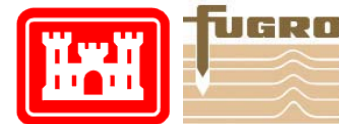


Side-scan sonar (or snippets) can be utilized for creating an image of the floor of the water body/water course.

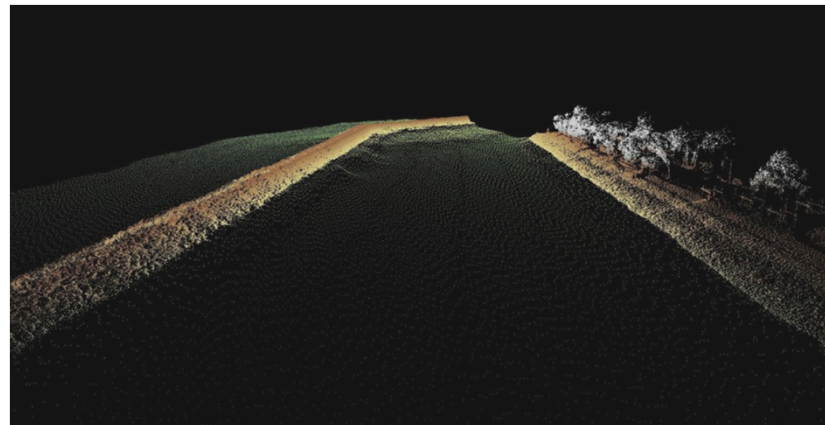
Data collected can help identify the composition and texture of the seabed/lakebed/riverbed.



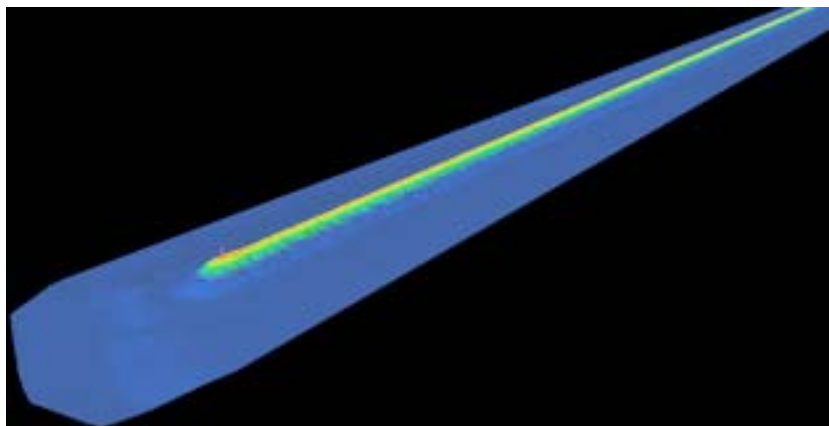
Four Breakwaters, Two Sites



San Pedro Breakwater



Dana Point West Breakwater

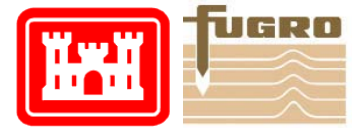


LA/LB Middle Breakwater

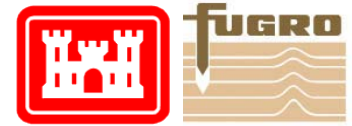


Dana Point East Breakwater

Four Breakwaters, Two Sites



Four Breakwaters, Three Sites



Dana Point Harbor

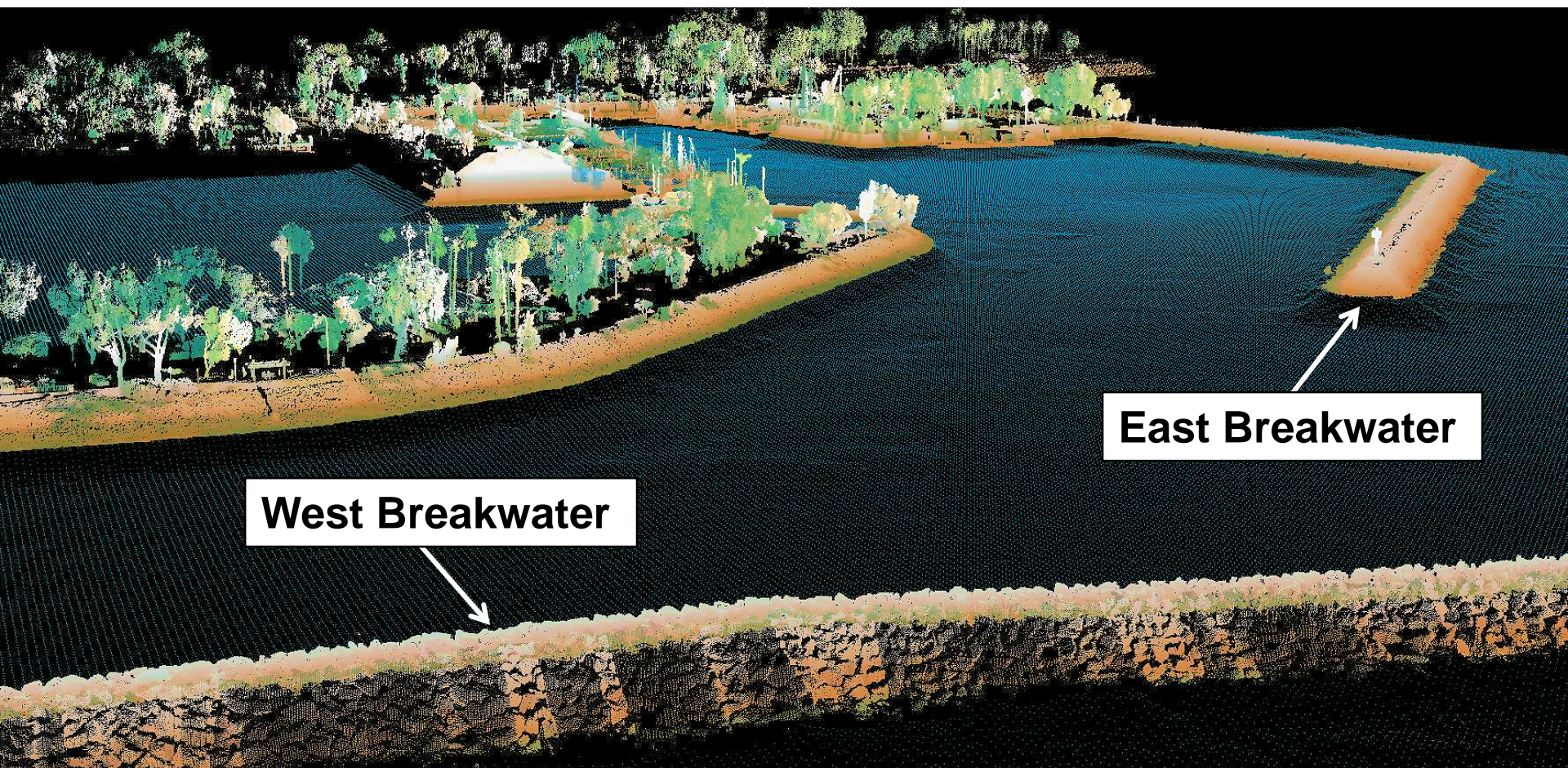
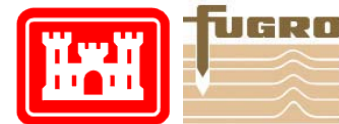
West Breakwater

East Breakwater

Evaluate:

- Channel depth and shoal risks
- Sediment scour and deposits
- Breakwater integrity
- Port/Harbor charts
- Profiles/cross-sections
- Hydro modeling

Harbor & Breakwater Survey: Dana Point



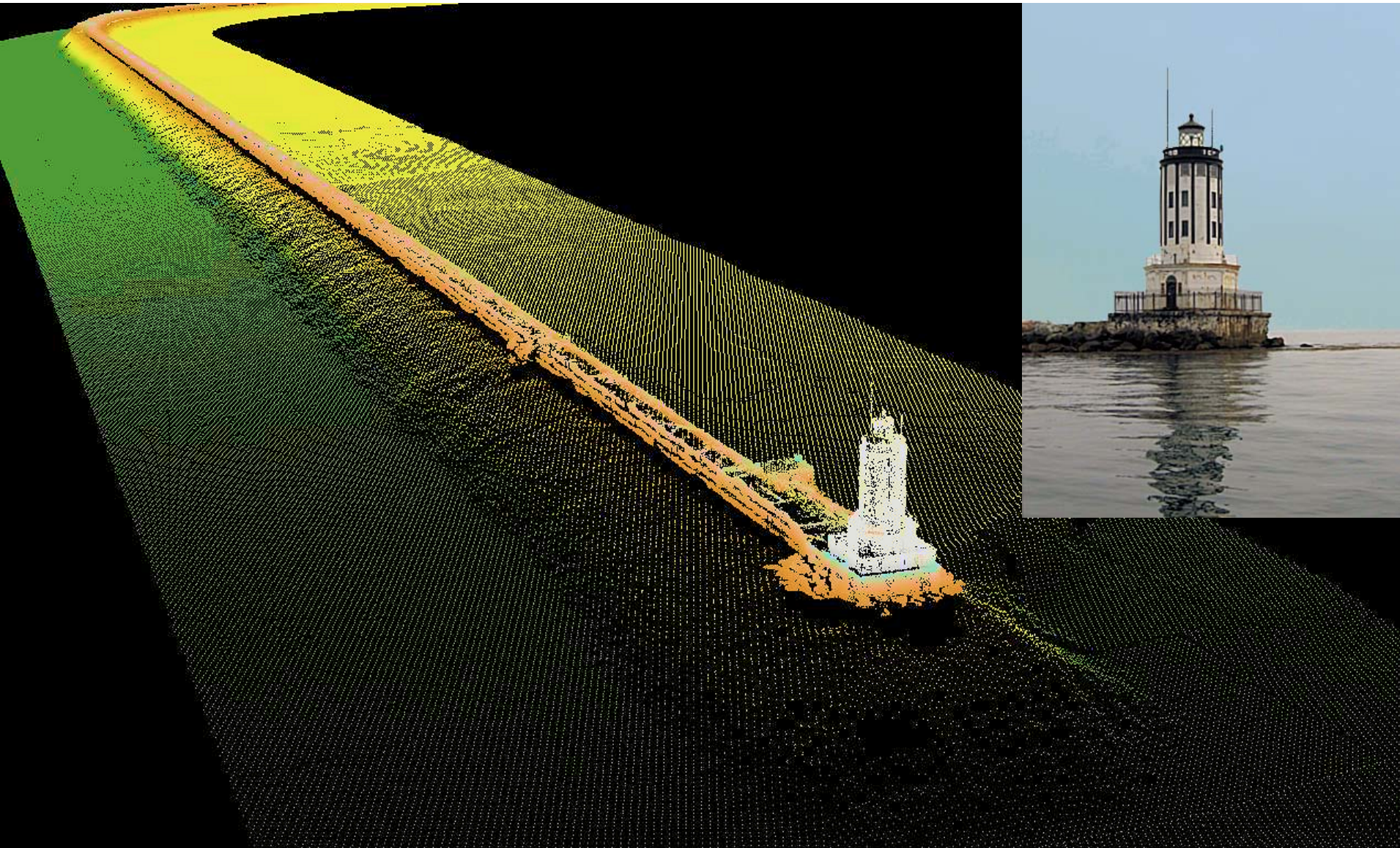
Data density:

Scanner:
Horizontal = 0.10m
Vertical = 0.05 m
Survey speed = 2.5 – 3.5 knt

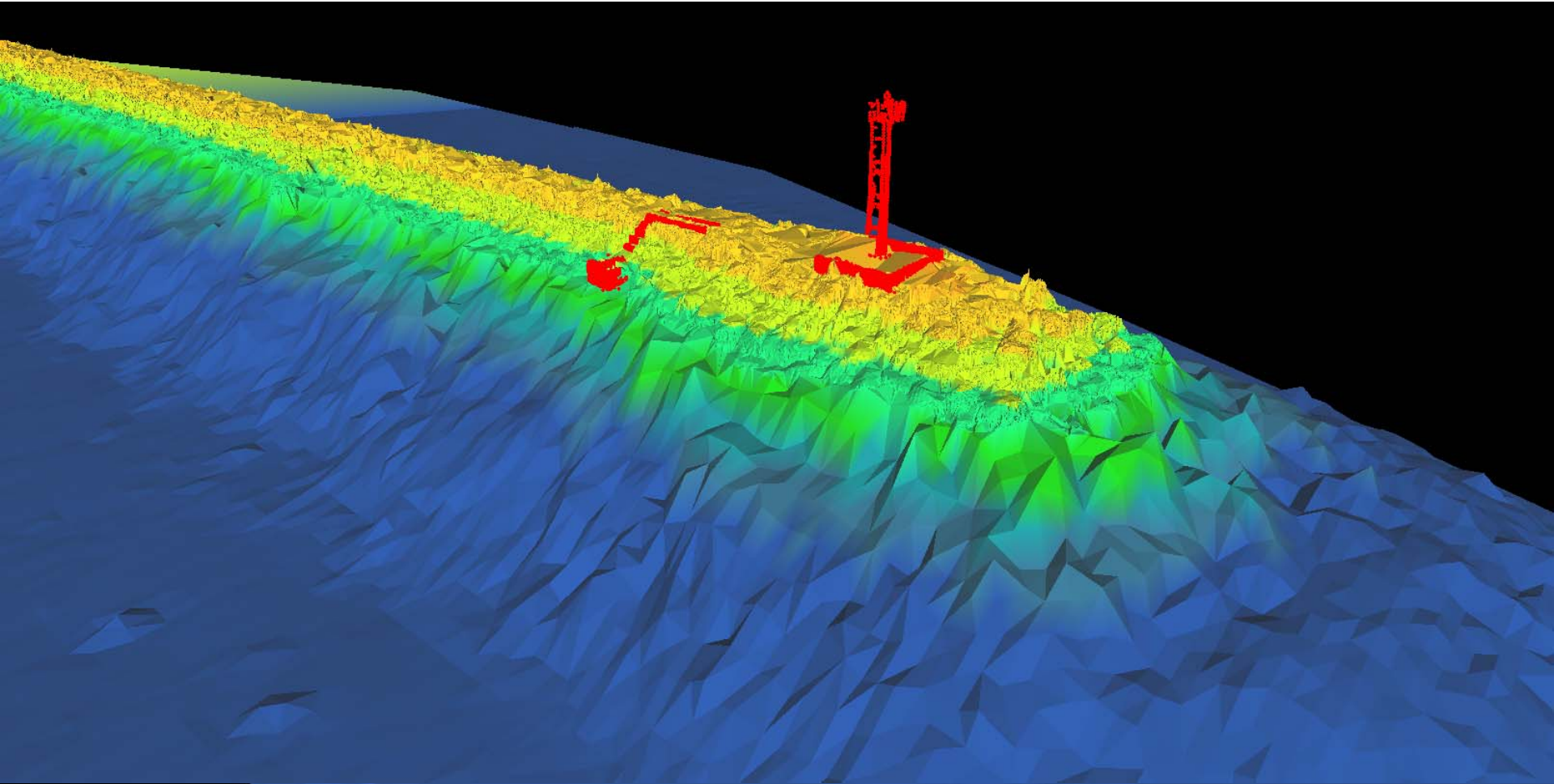
Multibeam:
Horizontal Resolution = 1m

Survey speed = 4.5 knt

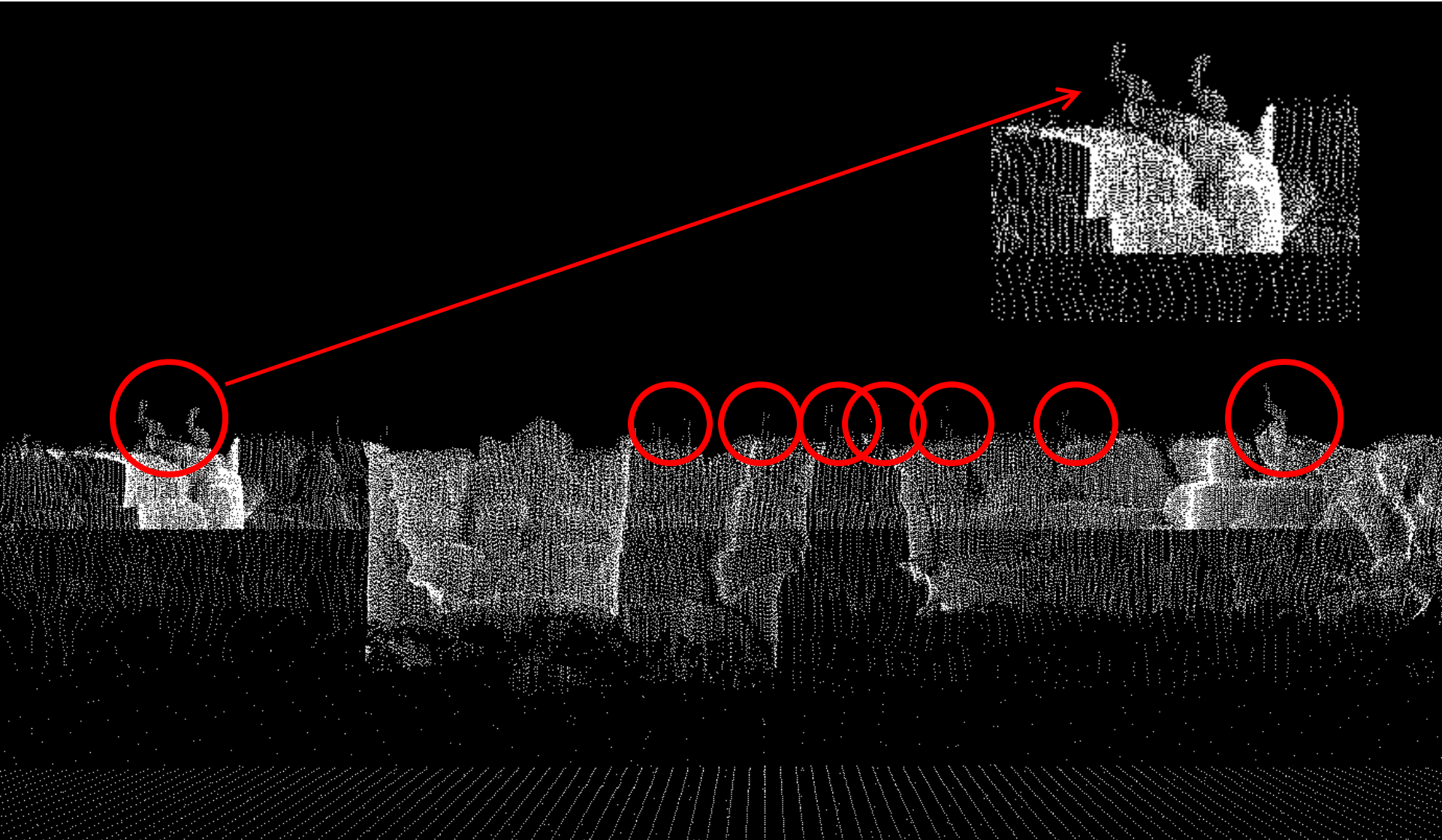
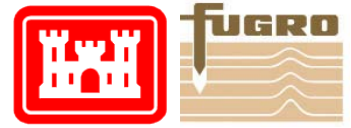
Breakwater Survey: San Pedro, California

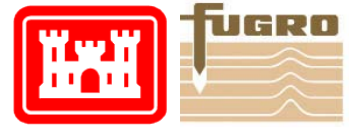


Breakwater Survey: Middle Breakwater



Editing Point Cloud to Create the Surface





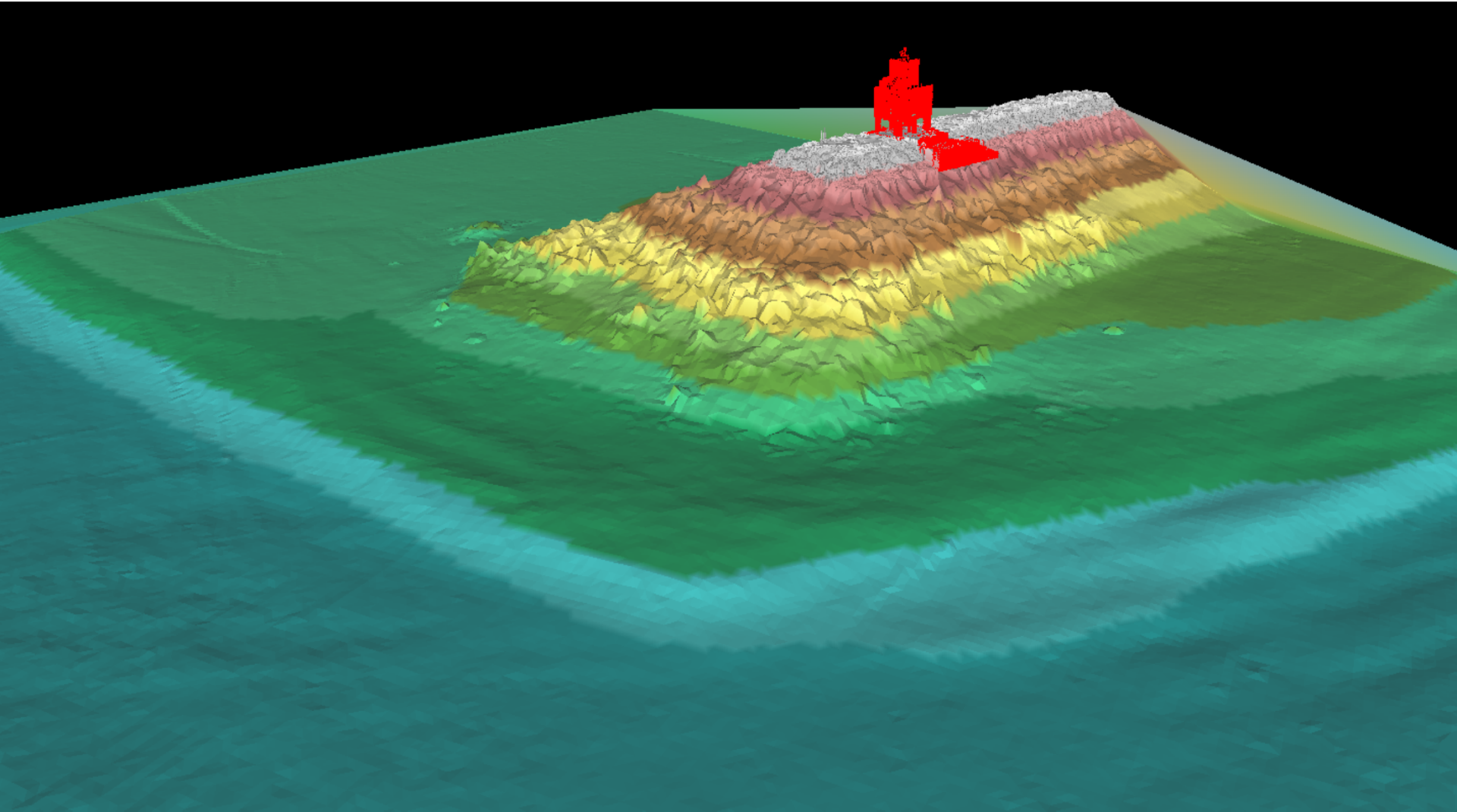
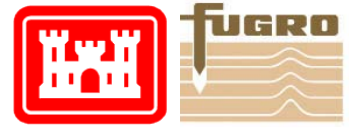
Pretty pictures but how is this data applied?

- Point Cloud Files (X,Y,Z) for entire survey
- Back-scatter image mosaics
- Contour models
- High-resolution profile extraction at any frequency along water channel
- Gridded surface model for easy use in ESRI ArcGIS
- Render and/or fly through data

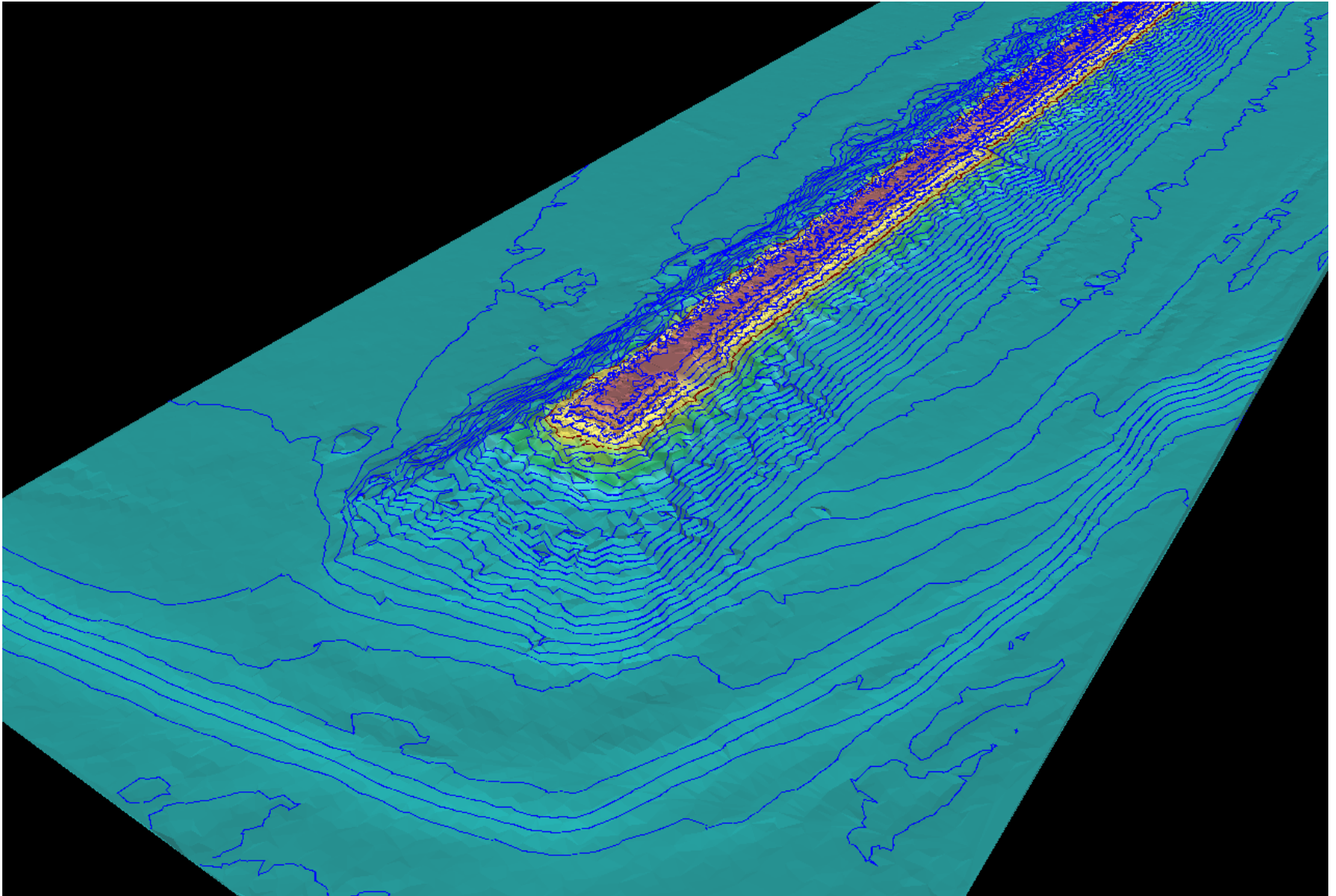
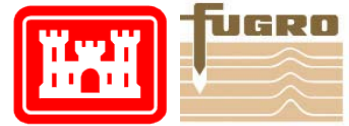
Dana Point Harbor w/ Multibeam and Scanner Data



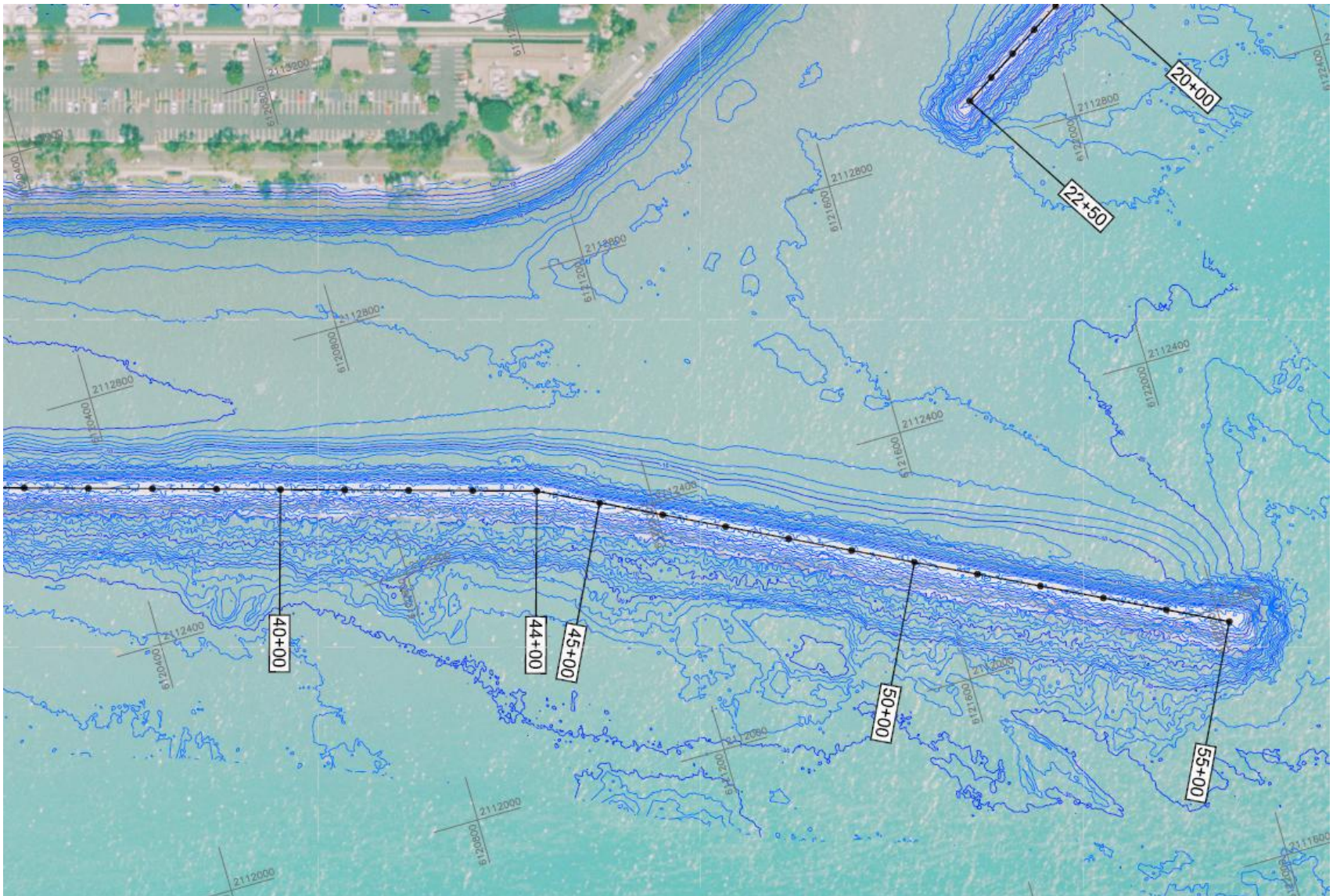
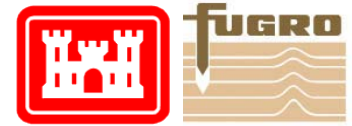
Breakwater Surface Model



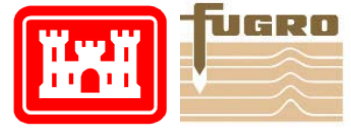
Breakwater Contours (3-foot / 1-meter)



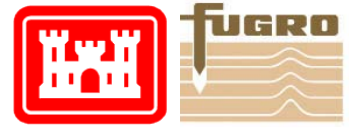
Produce Breakwater and Harbor Chart



Backscatter Sonar Image Mosaic



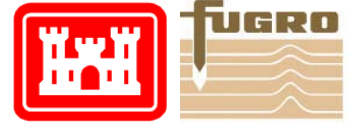
BOAT-MAP Data merged with Aerial Imagery



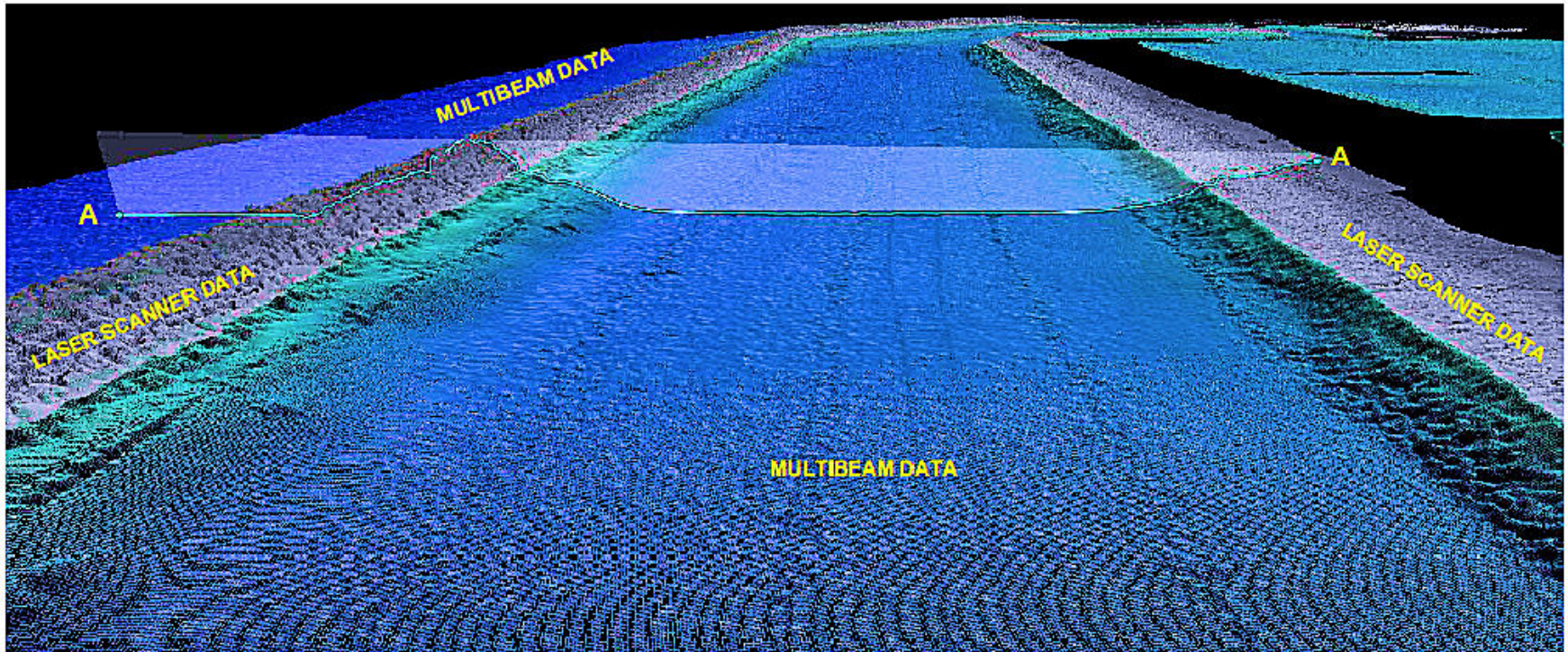
Integrated Data:

- Mobile Laser Scanning
- Multibeam Bathymetry
- Aerial Imagery

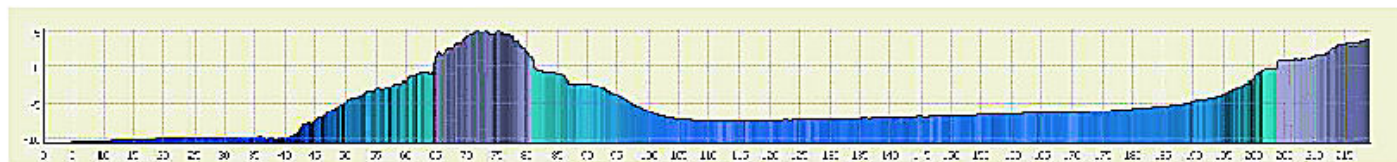
Cross-Section Extraction: at any interval/frequency



Dana Point - Cross Section Through Main Channel

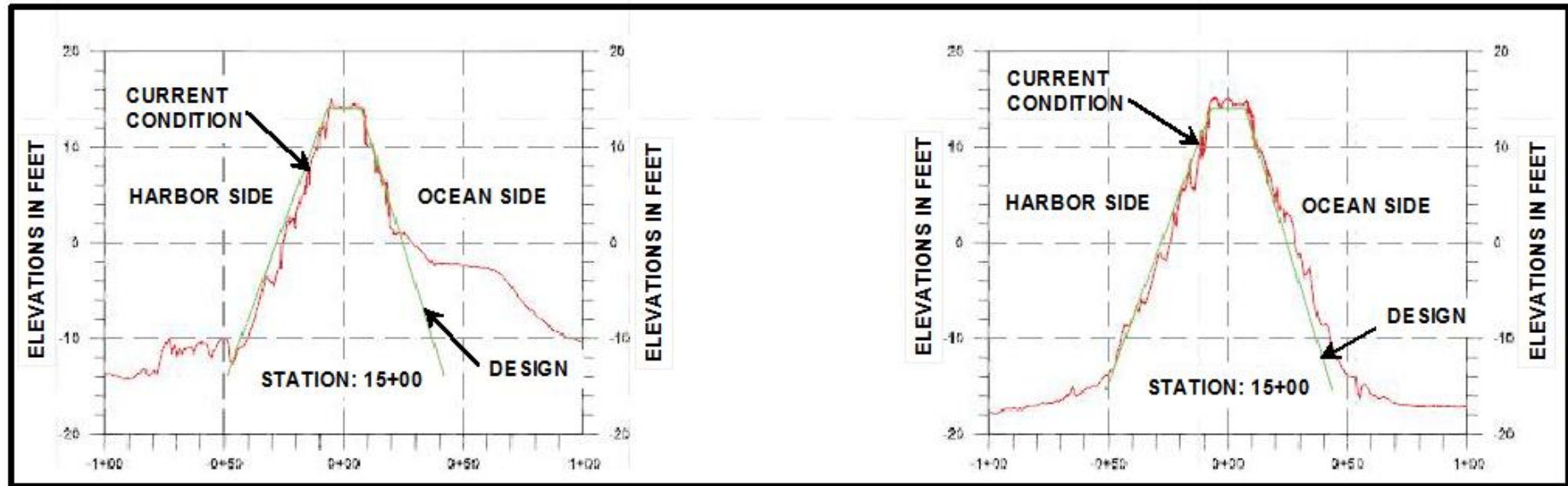
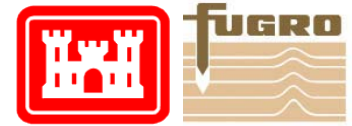


- Notes:
1. Elevations in meters
 2. Vertical datum: MLLW
 3. Distances in meters



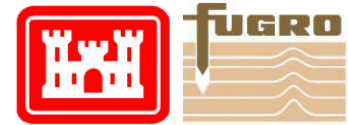
SECTION A-A'

Cross-Section Comparisons: Condition vs. Design

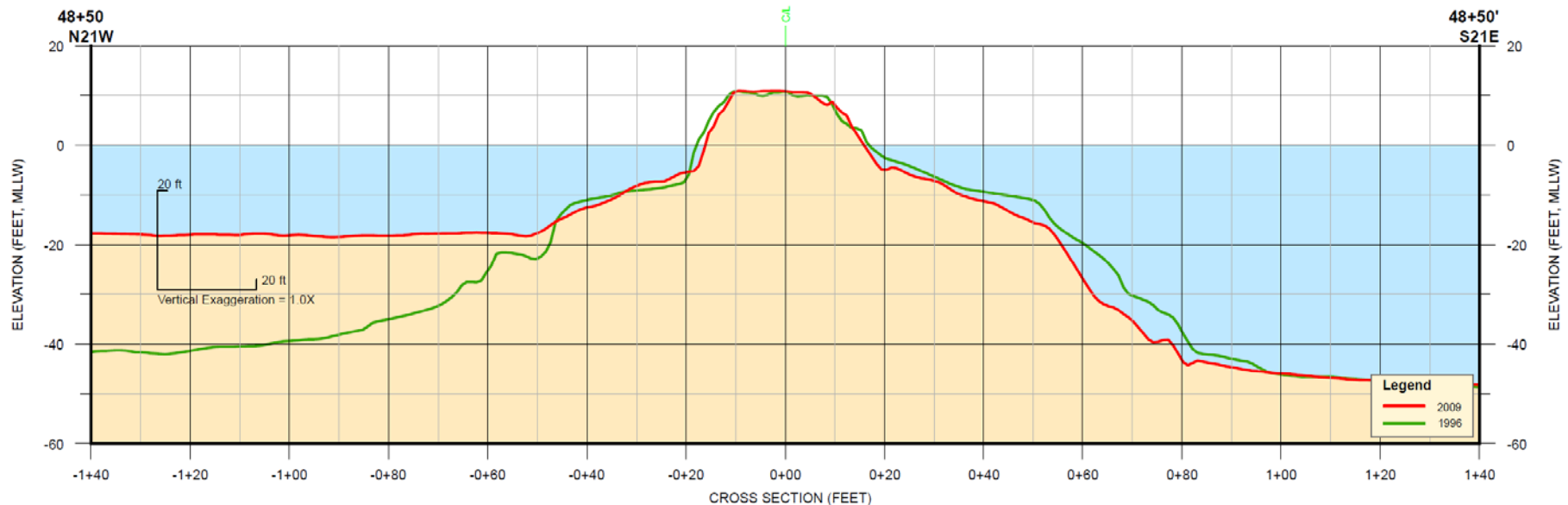
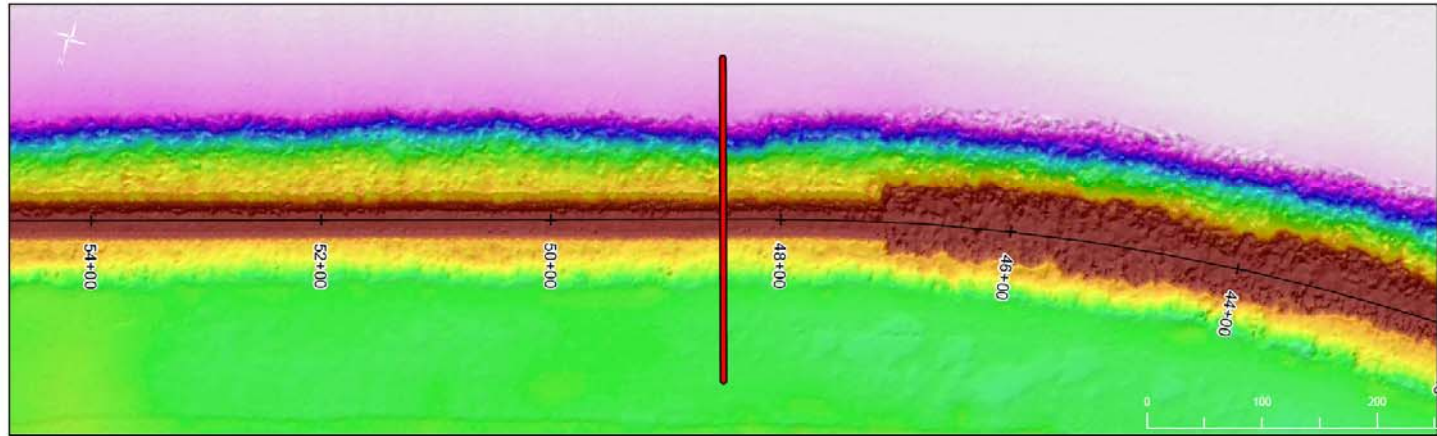
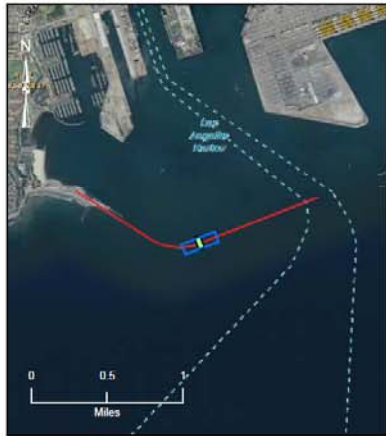


**BREAKWATER CROSS SECTION
CURRENT CONDITION AND CONSTRUCTION DESIGN**

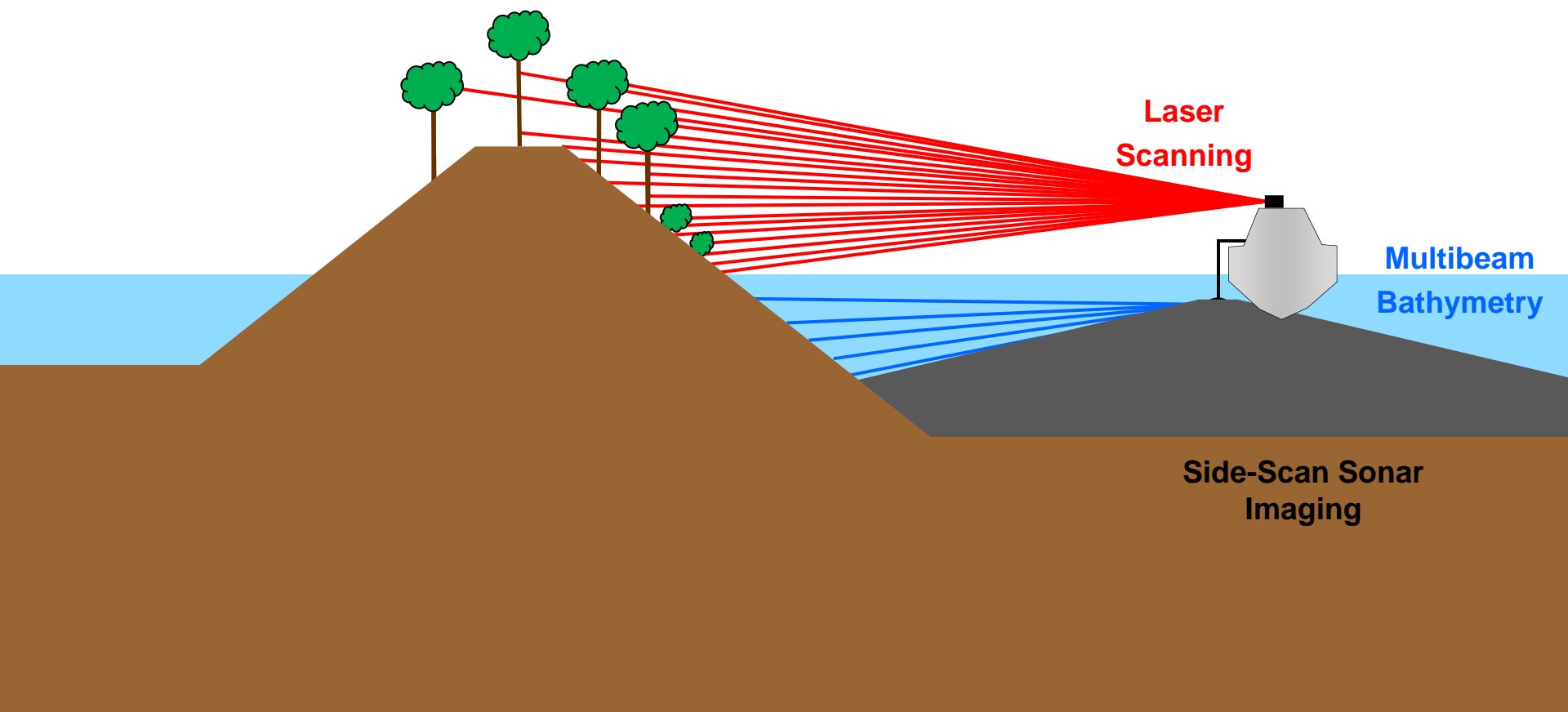
Cross-Section Comparisons: Present vs. Historical

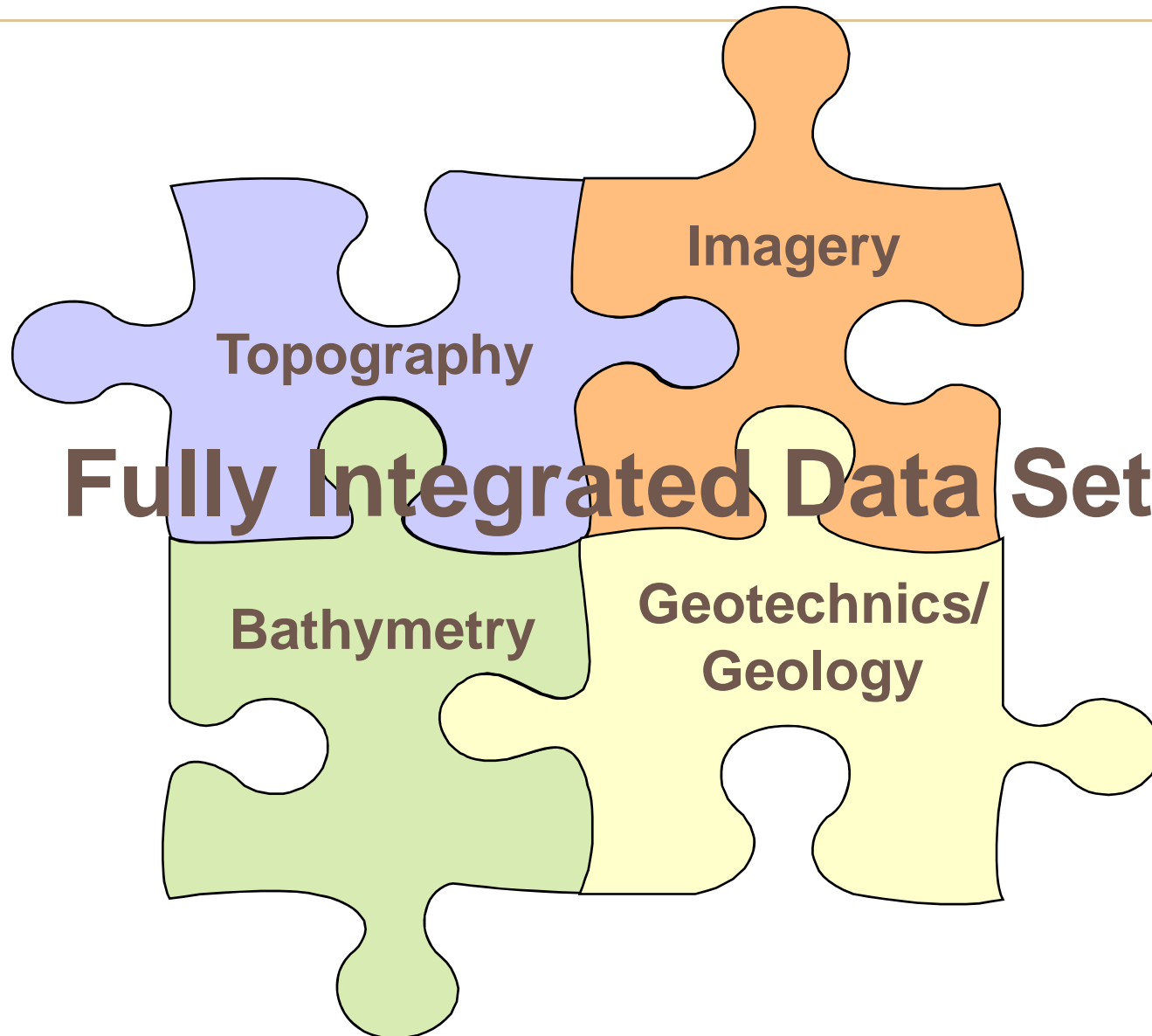


USACE SAN PEDRO BREAKWATER COMPREHENSIVE CONDITION SURVEY
STATION NUMBER 48+50



A survey that integrates bathymetry with a topographic data can close the gap between surface and underwater topography.





A large, 3D point cloud visualization of a bridge pier or structure, rendered in a yellowish-orange color against a black background. The structure is elongated and tapers towards the right, with a small, white, vertical object visible near its center. The point cloud is composed of many small dots, giving it a textured appearance.

Thank-you for Your Time

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