Based in the technology hub of Boulder, Colorado, 3D at Depth is dedicated to the development of underwater laser measurement sensors and software

- Patented subsea LiDAR technology
- 6 full time working systems with 100% redundancy
- Track record; completed 90+ projects
- Two Subsea LiDAR systems SL1 & SL2
- Developing the SL3
- Office locations in Boulder, CO / Houston, TX / Perth, WA
WHAT IS LIDAR?

- Light Detection and Ranging (ToF) – Time of Flight
- Has been around since 1960’s
- Used for aerial surveys
- Measure Range to Satellite's
1) Laser pulse transmitted at 40kHz

2) Pulse reflected from target

3) Portion of Scattered Light Collected by sensor

4) Beam is moved to cover the target using servo mirrors

**Phased Array Sonar**
- Beam divergence angle: 0.5°
- Beam diameter at 10m: 8.7cm
- Beam diameter at 20m: 17.5cm

**3D at Depth Subsea LiDAR**
- Beam divergence angle: 0.02°
- Beam diameter at 10m: 3.6mm
- Beam diameter at 20m: 7.3mm
TRIANGULATION VS LIDAR (TOF)

- Triangulation Laser
  - Range limited by geometry
  - High Resolution at short ranges (<3m)
  - Exponential error growth with range

- LiDAR is not fundamentally range limited by geometry
- Highly accurate timing circuitry
- 1mm = 3.3 picoseconds

Triangulation vs LiDAR
3km or 1.5km Rated ROV
Mountable Pan and Tilt unit
30° X 30° SECTOR SCANS

- Sector Scanner
- Pan/Tilt and scan
- 2.1m points per sector in Hi-Res mode
- 0.05° Pan & Tilt
MAIN SOFTWARE TOOLS

3D Collect – Scanning Interface

2D QuickView – QA Verification

Cloud – RAW to LAS & E57

LAS Viewer / CG / Leica Cyclone
# Subsea Lidar - 3 Modes of Operation

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
<th>Parameters</th>
</tr>
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<tbody>
<tr>
<td>Survey</td>
<td>Sensor is placed in a stationary location and moved into several scan positions for large areas.</td>
<td>• High resolution&lt;br&gt;• 3-5 minutes per scan&lt;br&gt;• Registration of multiple scan through targets</td>
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<tr>
<td>Fast</td>
<td>Steady platform but not stationary; mid water ROV</td>
<td>• Lower resolution&lt;br&gt;• 1-2 seconds per scan&lt;br&gt;• Snapshots</td>
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<tr>
<td>Mobile</td>
<td>Sensor integrated with a moving ROV, AUV or boat and integrated with an INS for motion compensation</td>
<td>• Single axis scanning&lt;br&gt;• Line scan or bowtie pattern&lt;br&gt;• Time stamped to INS feed</td>
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FAST SCAN & STATIC SURVEY SCAN

Fast Scan top of well
ROV mid water

Data Collection Time – 1.5s

Static Scan of Well
ROV landed “On bottom”

Data Collection Time – 3 to 5mins

Fast Scan top of well
ROV mid water

Data Collection Time – 1.5s
• Red point clouds were collected with the ROV on the seabed using survey mode (3 to 5 mins)

• Greyscale point cloud was collected while the ROV was mid water using fast scan mode (1 to 2 secs)

• The two datasets are easily merged.
MOBILE MODE SCANNING

• Successfully mapped the seafloor from a 22 meter range.

• Successfully captured 8 continuous hours of laser scan data with navigation data at 2900m depth.

• Currently working on improving the tightly coupled integration of laser and INS.
Single 30° x 30° scan.

±4mm Accuracy Point to Point distance measurement
Anywhere in the field of view

Pan & Tilt ±0.05°.

Full scan position – 18 Scans ±4mm to ±8mm accuracy. For distances Anywhere in the field of view.

Multiple registered scan positions add a mean absolute error of approx. 5 to 15mm across all the registered scans.
REGISTRATION TARGETS

- **Spheres**
- **B/W Survey Targets**
- **Reflective Targets**
SPOOL PIECE METROLOGY – SHORT < 30M

- Over 120 metrologies performed since Q2 2014
- All jumpers and spools successfully installed
- Average bottom time was only 3 hours per metrology
- Average time to complete metrology field report was 4 hours.
• 10 Long Spool metrologies performed in 2015
• Results were within project specification tolerances
• Significant time savings are possible over full LBL array deployment
• These results in relatively shallow water ~200m, more time can be saved in deeper water.
• Method Robust and Flexible, 2hrs per scan location.
• Hybrid Method used with both Acoustics and laser.
Terrestrial Scanned Structure
Registered into the subsea point cloud

Terrestrial Scanned Structure
Dimensional Control with Total Station
- Quantification of distances, angles and heights is straightforward.
PIPELINE DAMAGE ASSESSMENT

- Cloud extruded to 3D Mesh
- Curvature
- Lateral Distance
Calculate Pipeline Ovality at the Apex
A 3D CAD model was created from the point cloud.
• From the 3D model, the physical part was 3D printed using Fused deposition modelling (FDM) technology.

• Assembled well cap shown on right 650mm diameter.
AS BUILT SURVEYS
ITALY WITH THE BBC
THANK YOU
ANY QUESTIONS?

3D at Depth

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