Subsea LiDAR Metrology

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SUT
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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
- SL1 subsea LiDAR system launched in March 2013
- Track record; completed 10+ projects
- Recently completed second generation subsea LiDAR development; SL2
- Seeking partners who can bring the technology to the field
Agenda

Metrology workflows using Subsea LiDAR

• Instrument
• Collection Planning
• Operations
• Data Processing and Deliverables
INSTRUMENT OVERVIEW
SL1 and SL2 Subsea LiDAR Scanners

Time of flight (ToF) 532nm (green) LiDAR system built to offshore Oil and Gas requirements

Performance and accuracy are comparable to topside scanners

- 6mm single shot and 4mm positional accuracy in a single scene

SL1: Single canister, 3000m depth rating
    integrated pan

SL2: Dual canister, 1500m depth rating
    integrated pan and tilt

Offered as a service or lease
# Scanning Modes

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

Point Cloud

Bracket

Model
Fast Scan

Video

Point Cloud

Surface model and section cuts

ACAD Dimensioned drawing

0.0179
Mobile Scanning
Planning Parameters

- Accuracy/tolerances
- DC and field drawings
- Range
- Line of sight
- Height of platform
- Scan locations
- Currents
- Seabed
Subsea LiDAR Metrology Workflow

1. Place tripods and targets if needed
2. Sensor placed into position
   - ROV or Tripod
3. Run test scans
   - Range
   - Gain
   - Line of sight
4. Scan scene
5. QC data
6. Move to next position
7. Repeat workflow

7. Data preprocessed into point clouds
8. CAD elements extracted from point cloud (modeling)
9. Data QC’d and the deliverable is developed
### Range determines workflow

<table>
<thead>
<tr>
<th>Visibility</th>
<th>Range</th>
<th>Data collection</th>
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</thead>
<tbody>
<tr>
<td>Poor</td>
<td>2-4 meters</td>
<td>Small areas of interest from close range Difficult to register together Mobile an option</td>
</tr>
<tr>
<td>Fair</td>
<td>5-10 meters</td>
<td>&gt; 2 scan positions: accuracy $\approx$ 8-10 mm per registration</td>
</tr>
<tr>
<td>Good</td>
<td>10-25 meters</td>
<td>2 scan positions: accuracy $\approx$ 8-10 mm*</td>
</tr>
<tr>
<td>Very good</td>
<td>25-45 meters</td>
<td>Single setup: Accuracy $\approx$ 4-7 mm*</td>
</tr>
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*measuring a point to point distance at 35 meters
Single Scan Position (with redundancy)
Multiple Scan Positions

SP03 Structure scan 1
SP04 Registration scan 1
SP05 Structure scan 1

Reflective target
Spherical target
Registration Targets

Spheres

B/W Survey

Reflective
Line of Sight

By scanning the structures topside, the point clouds can be used as part of the data solution – snapped into the subsea scanned scene which mitigates the line of sight issue thus further reducing the collection time and complexity.
Single Scan Result
Top Side Scan
Register Topside into Subsea Model
OPERATIONAL CONSIDERATIONS
Deployment Options

SL1 TOP ROV Mounted

SL1 Tripod Mounted

SL2 AUV Mounted

SL1 DECK ROV Mounted
Platform Stability

Non stable ROV

Stable ROV
Particulates
Particulate Filter

No Particulate Filter

With Particulate Filter
Underwater LiDAR Best Practices

POST PROCESSING
Summary

• 3D at Depth have developed a subsea LiDAR platform
• End users have several options for deployment and collection
• Topside software and best practices can be used for subsea workflows
• We have developed some base applications and hope the community can define many more
• Building a business case to invest in the North Sea and support the region