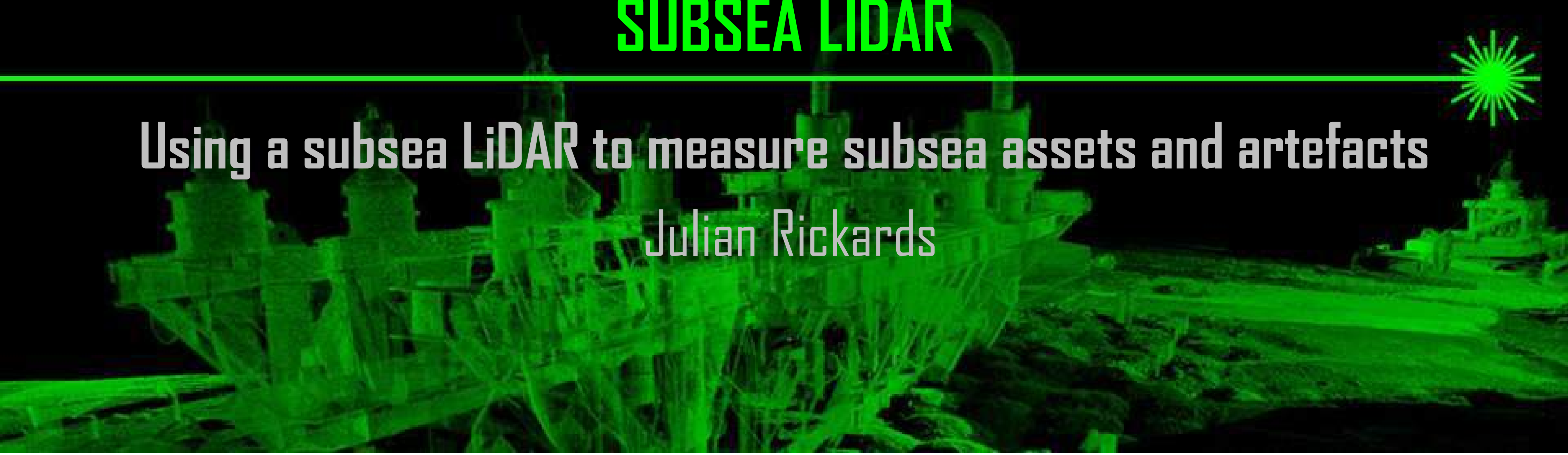
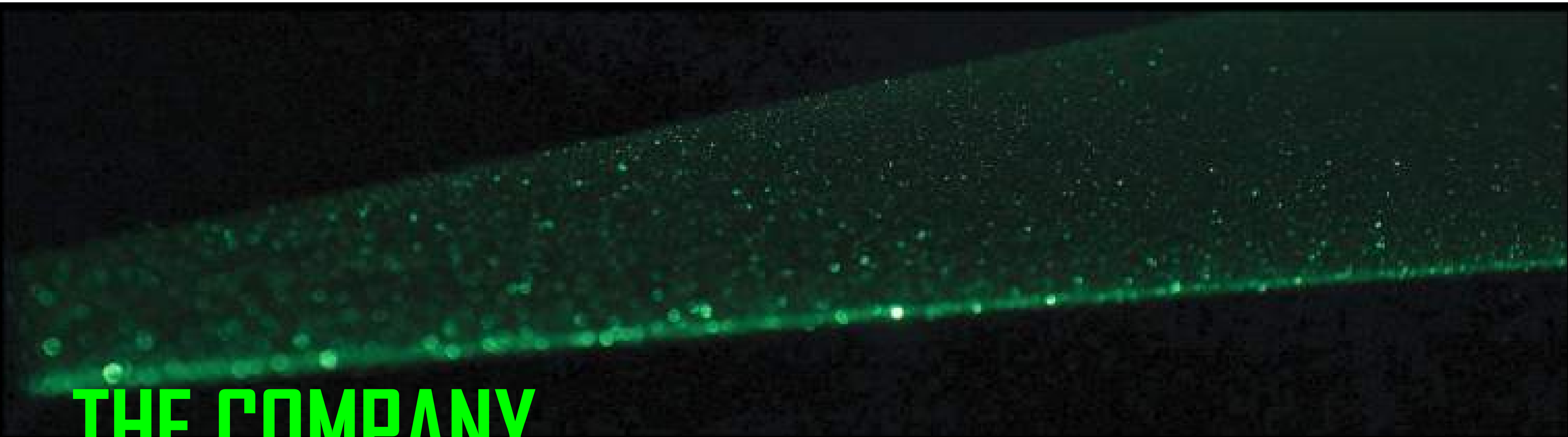
3D at Depth

SUBSEA LIDAR

Using a subsea LiDAR to measure subsea assets and artefacts

Julian Rickards





THE COMPANY

- Longmont, Colorado (HQ)
- Houston, Texas
- Norwich, UK
- Perth, Western Australia

LOCATION - NORWICH, UK

Located outside, Norwich at the new Scottow Enterprise Park and 10 minutes from Norwich airport. 3D at Depth has committed to establishing and employing staff from its European hub which also offers a global center of excellence within a centrally located time zone to support and assist on projects globally.

- Equipment storage and system integration/testing
- Training
- Project support/planning with client interaction
- Data processing
- Sales/Marketing
- Development

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2009 TO PRESENT DAY – DEVELOPMENT AND APPLICATION OF SUBSEA LIDAR

2009 - First demonstration of 3D at Depth underwater scanning LiDAR technology in a test tank in Boulder, CO

2012 - First underwater prototype demonstration integrated with a Schilling Robotics ROV in the Schilling Robotics test tank in Davis, CA / 1st US Patent awarded /Authorization to proceed on RPSEA/Lockheed contract for integrating a 3D subsea LIDAR on a Lockheed Autonomous Underwater Vehicle (AUV)

2013 - First open water test onboard a Technip ROV project / large tank validation at OHMsett / Lab demo of LDV based flow meter for expanded product portfolio / 2nd US Patent awarded

2014 – Commercial Revenue starts in parallel to development funding as business transitions into commercial market space. Technology wins Technip Jacques Franquelin award / MSA agreements form with large survey and Tier one contractors.

2015 – Commercial revenue growth is 3 times prior year / secured convertible note of $1M for expansion of short-term growth / Office space and headcount grown 3x. Joint development agreement with Technip signed / open 3D at Depth office in Australia. Client growth increased as market acceptance and exposure increased.

2016 – Improved and diversified new applications & sensor technology. Paid R&D projects increase and assist in short- and long-term growth.

2017 – Additional SAA with Schlumberger and expanded project team

2018 – Launch of SL3 and Real-time data collection, established 3D at Depth EAME

2019 – Over 410 metrologies delivered over 80 projects, an additional 55 projects providing Brown field services for decommissioning, subsea dim con for bypass work, in structure measurements, out of straightness.

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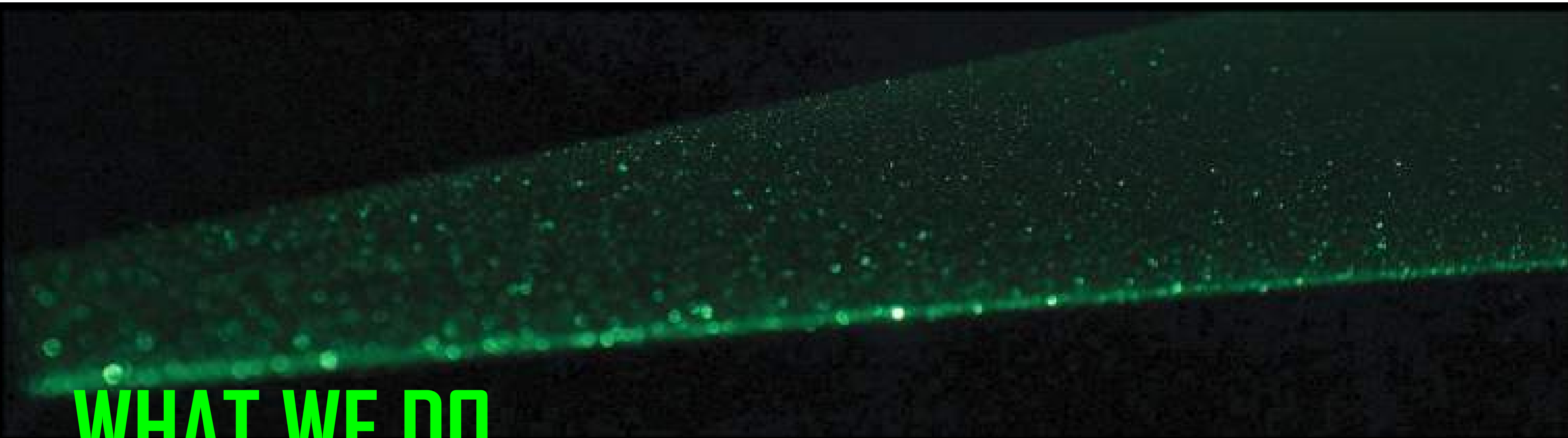
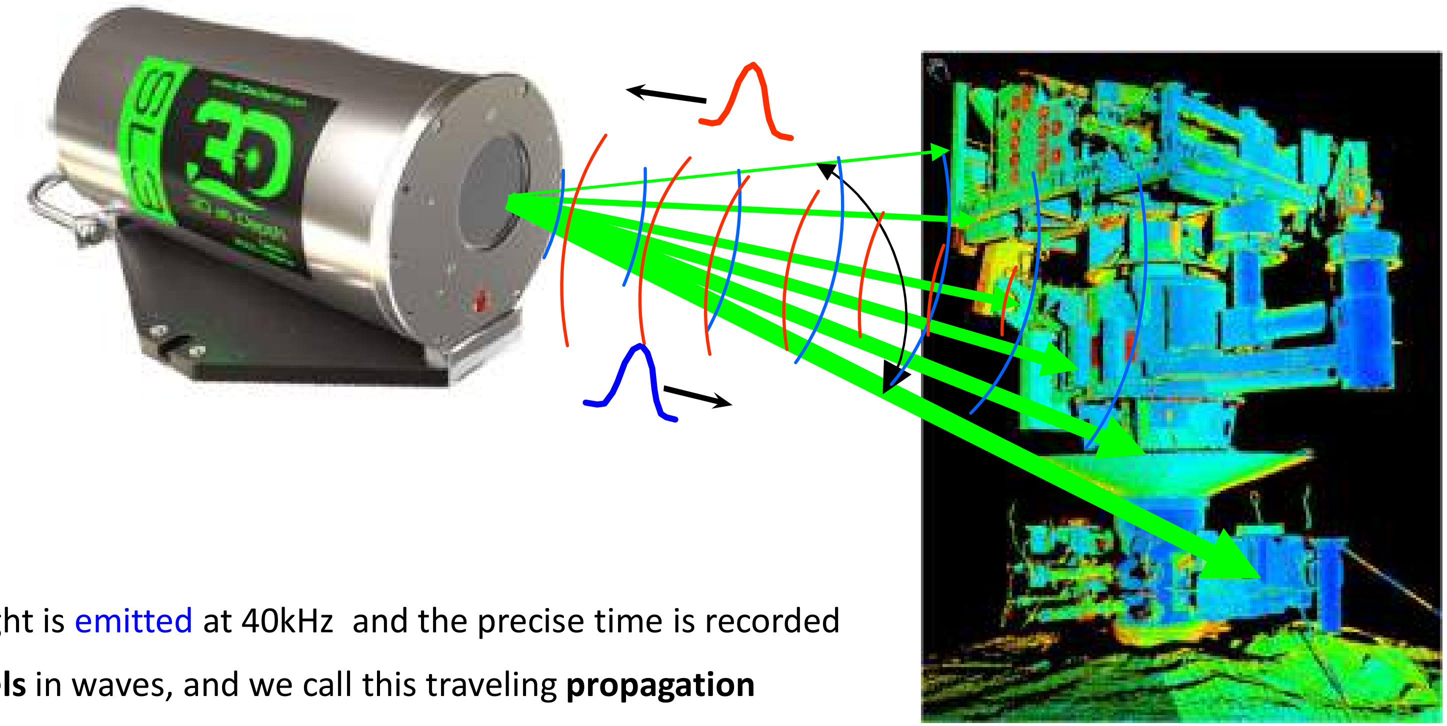


WHAT WE DO

WE DO THIS... UNDERWATER.

Depth

PRINCIPLES OF LIDAR



1) Pulse of light is emitted at 40kHz and the precise time is recorded
2) **Light travels** in waves, and we call this traveling **propagation**
3) The reflection of that pulse is detected and the precise time is recorded
4) Using the <u>constant speed of light</u>, the delay can be converted into a “slant range "distance.
5) Knowing the position and orientation of the sensor, the XYZ coordinate of the reflective surface can be calculated

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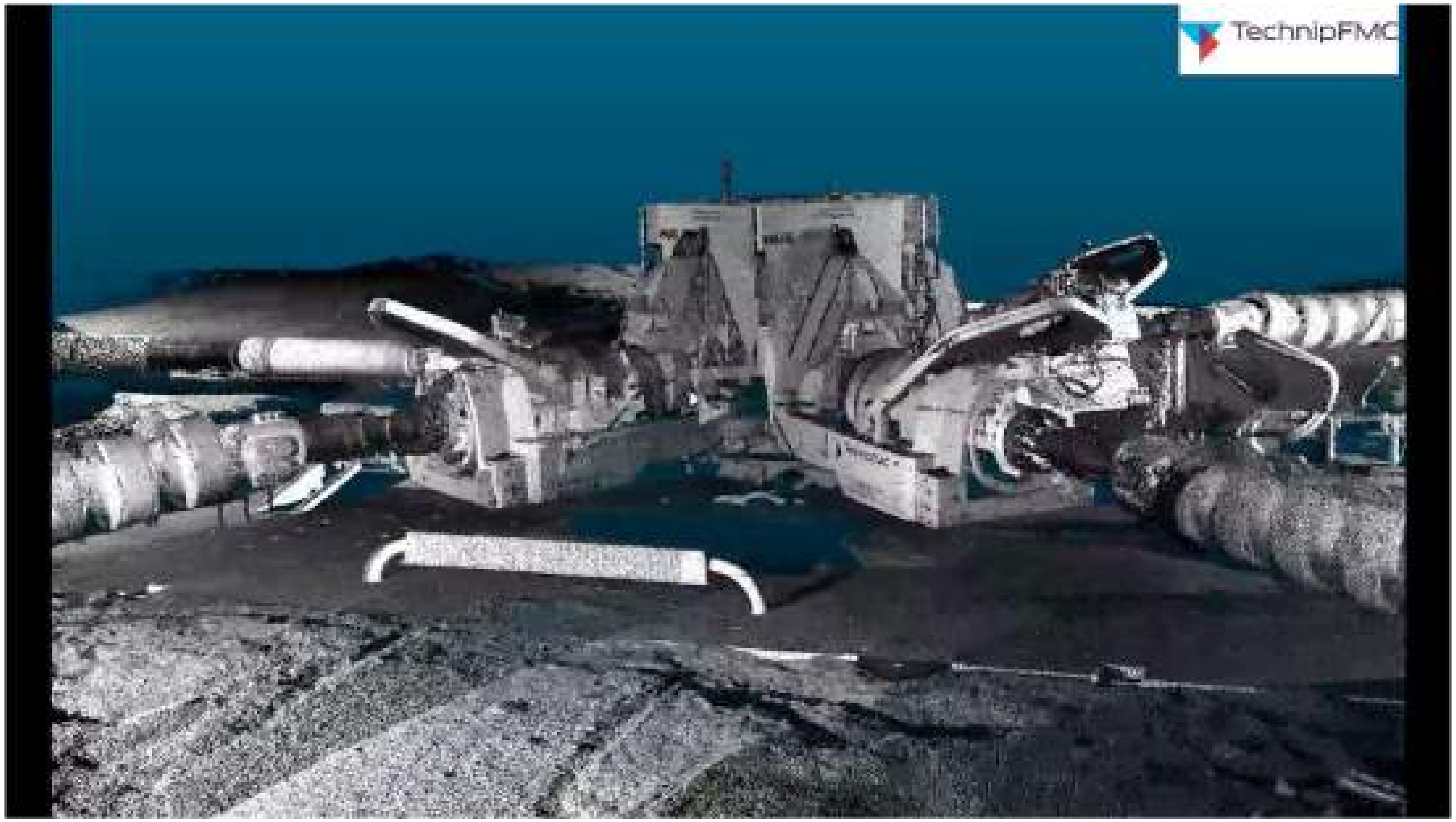
3D AT DEPTH – REAL-TIME



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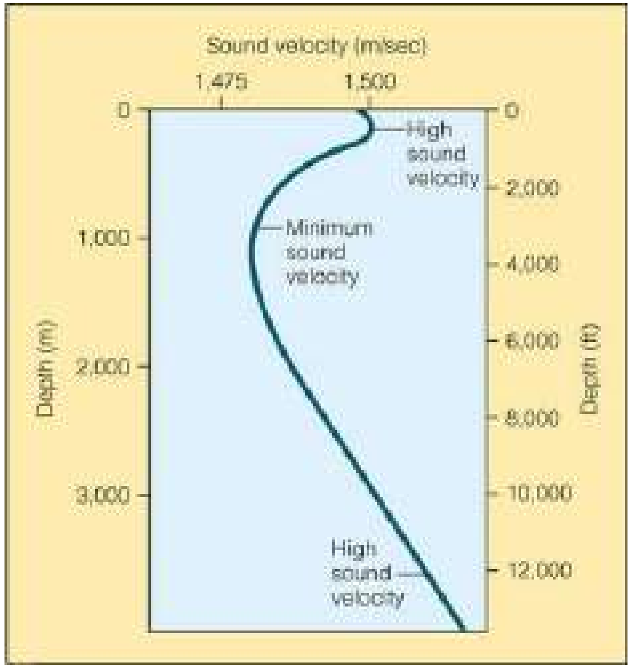
DATA QUALITY

NECESSITY OF CORRECTIONS – SONAR AND ACOUSTIC SURVEY

- Repeatable acoustic measurements are not possible without compensating for sound velocity through water.

- Average speed of sound in seawater is 5-times faster than air (1,500m/s).
- Increase in temperature or pressure will increase sound speed in water.
- Sound traveling through water of different temperature, salinity or pressure will bend; **(Refraction)**



- Repeatable optical measurements require the same compensation for **<u>index of refraction.</u>**

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APPLICATION OF CTD

- If water parameters change during acquisition, we can manage this in the same way as other established survey methods.
- Subsea LiDAR is the only optical measurement system that can apply these corrections with the same philosophy, as no imaging devices (i.e cameras) are required, thus the beam path has the same return as the outward path.

Water Parameters:
- **C**onductivity
- **T**emperature
- **P**ressure (≈Depth)

→ Sound Velocity
LBL, Sonar

→ Index of refraction
Subsea LiDAR

→ A traceable survey result with known consistency, accounting for changes in water parameters throughout.

- Subsea LiDAR measurements are not reliant on empirically derived data, such as known dimensions or characterizations of objects.

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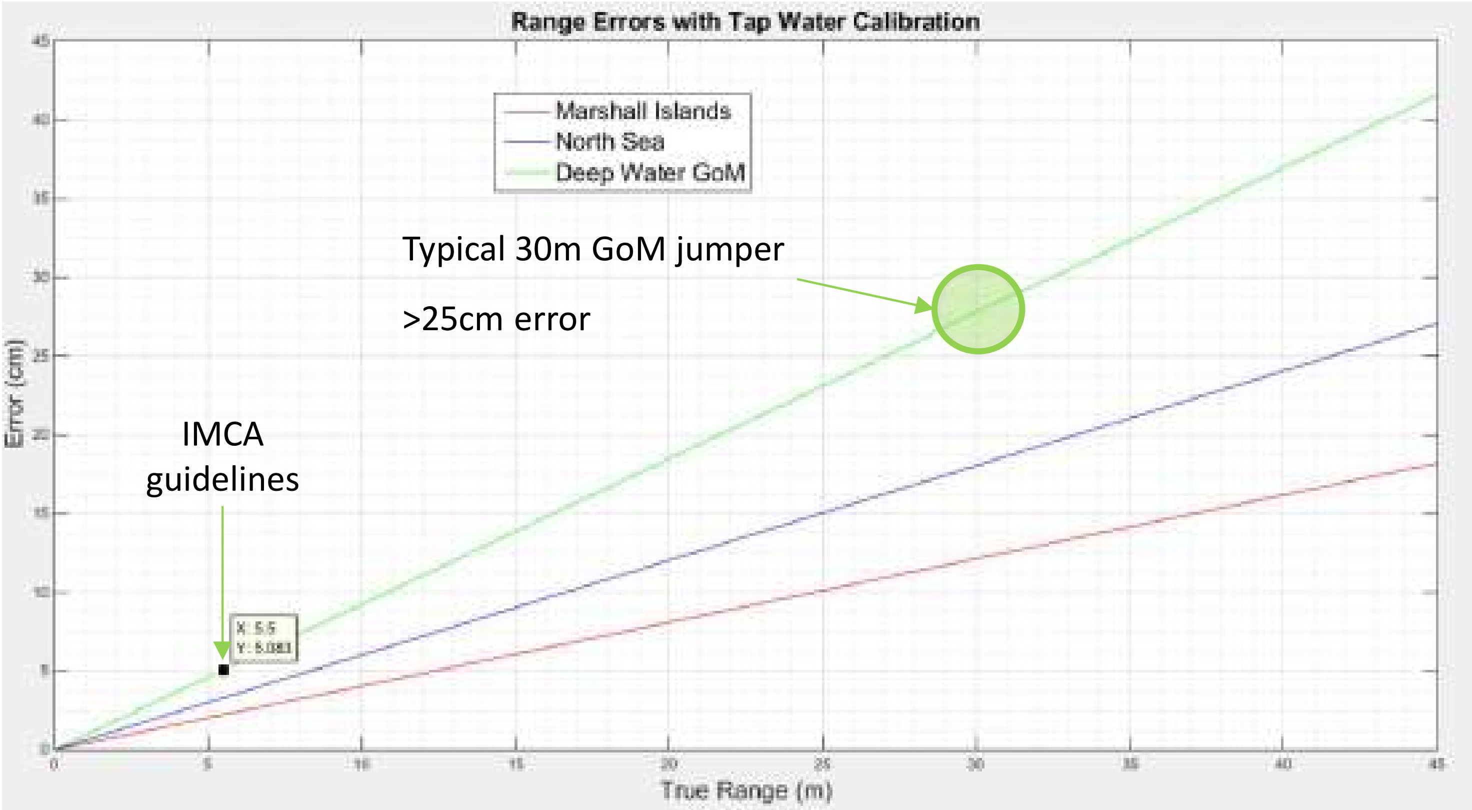
RANGE & ANGLE ERRORS DUE TO TAP WATER CALIBRATION IN LAB

- Assume you perform a calibration in the lab in tap water and then deploy the instrument in open water without applying index refraction correction.



Over 50mm range error at 5.5 meter range in the Gulf of Mexico (GoM)!

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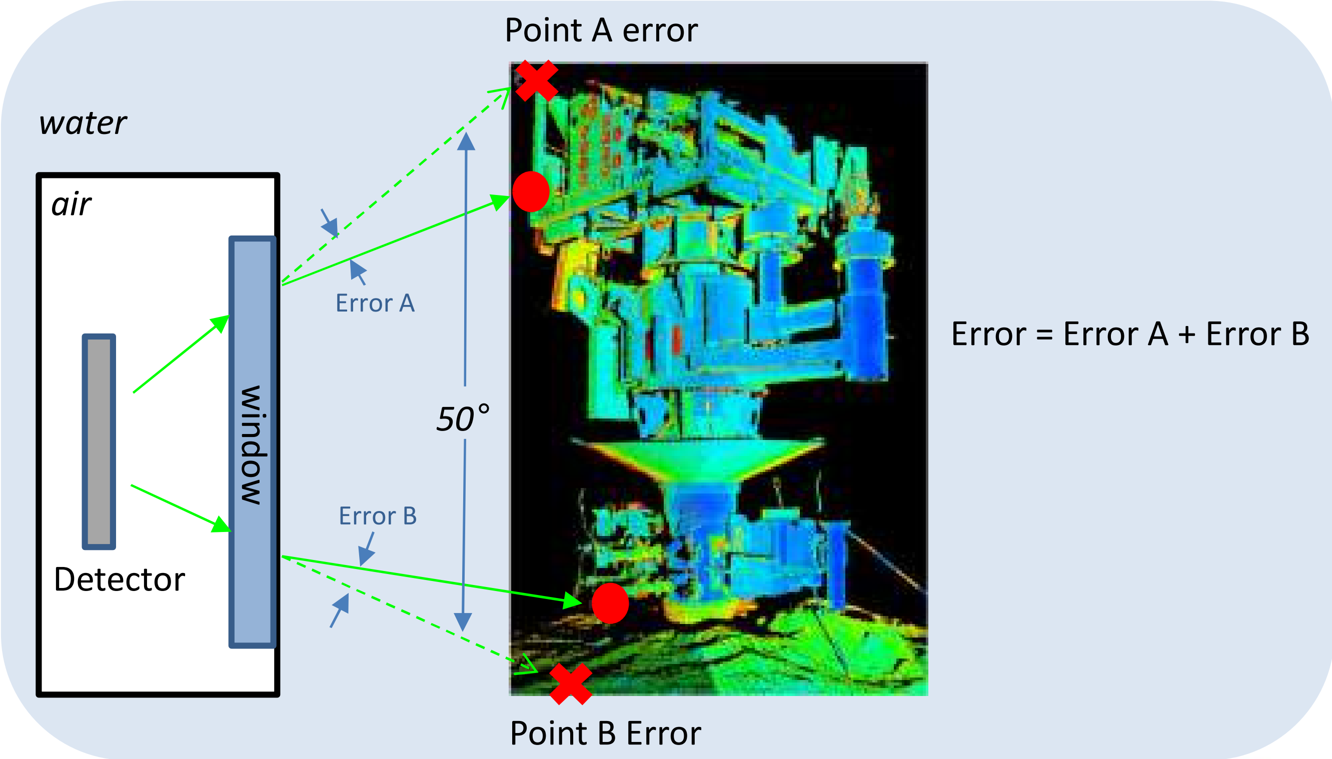
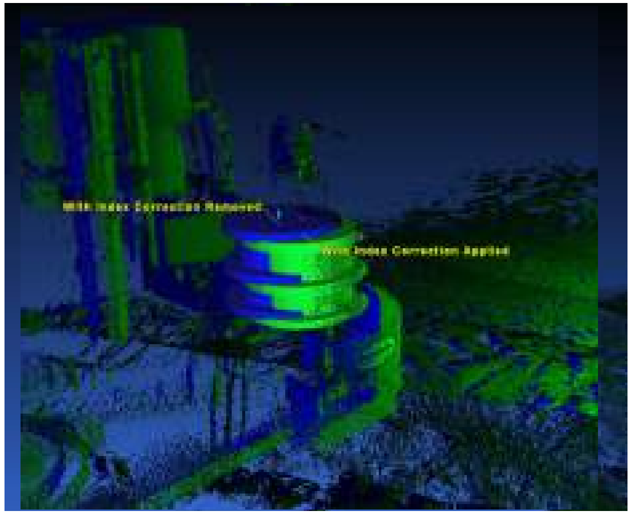
ANGULAR ERRORS WITH WATER CALIBRATION

- Assume you perform a calibration in the lab in tap water for an instrument with a 50° Field of View and then deploy the instrument. What is the error from Point A to Point B (*Simple example – assumes other dimension is correct)*



HOW DO THESE ERRORS IMPACT US IN THE REAL WORLD

FROM



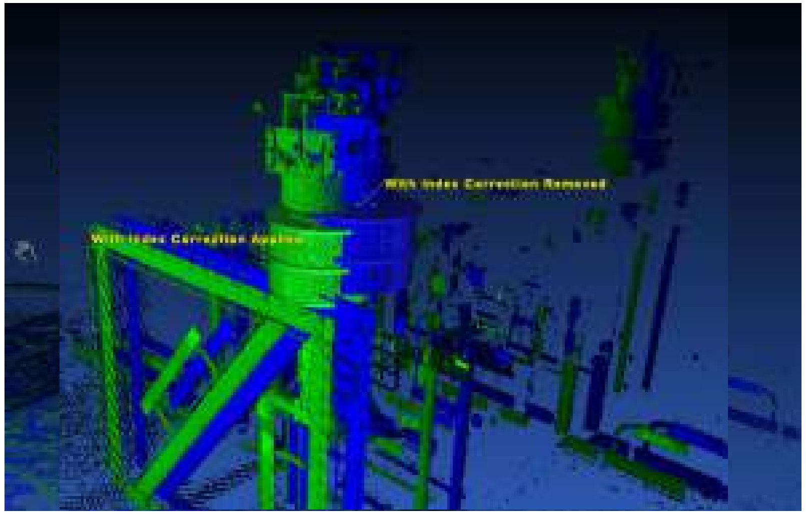
Center Hub to Scanner

With Index Correction Applied = 18.2m

With Index Correction Removed = 18.4m

Difference = 0.2m

TO



Center Hub to Scanner

With Index Correction Applied = 21.1m

With Index Correction Removed = 21.4m

Difference = 0.3m

- Resulting error increases as the distance from the scanner increases

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DEPLOYMENT PLATORMS

DIVER SPREAD – STATIC SCANNING

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SMALL TO LARGE PLATFORMS

Motion

WROV sit and scan.
3D at Depth only provide the sensor and supporting hardware.
Not the ROVs!

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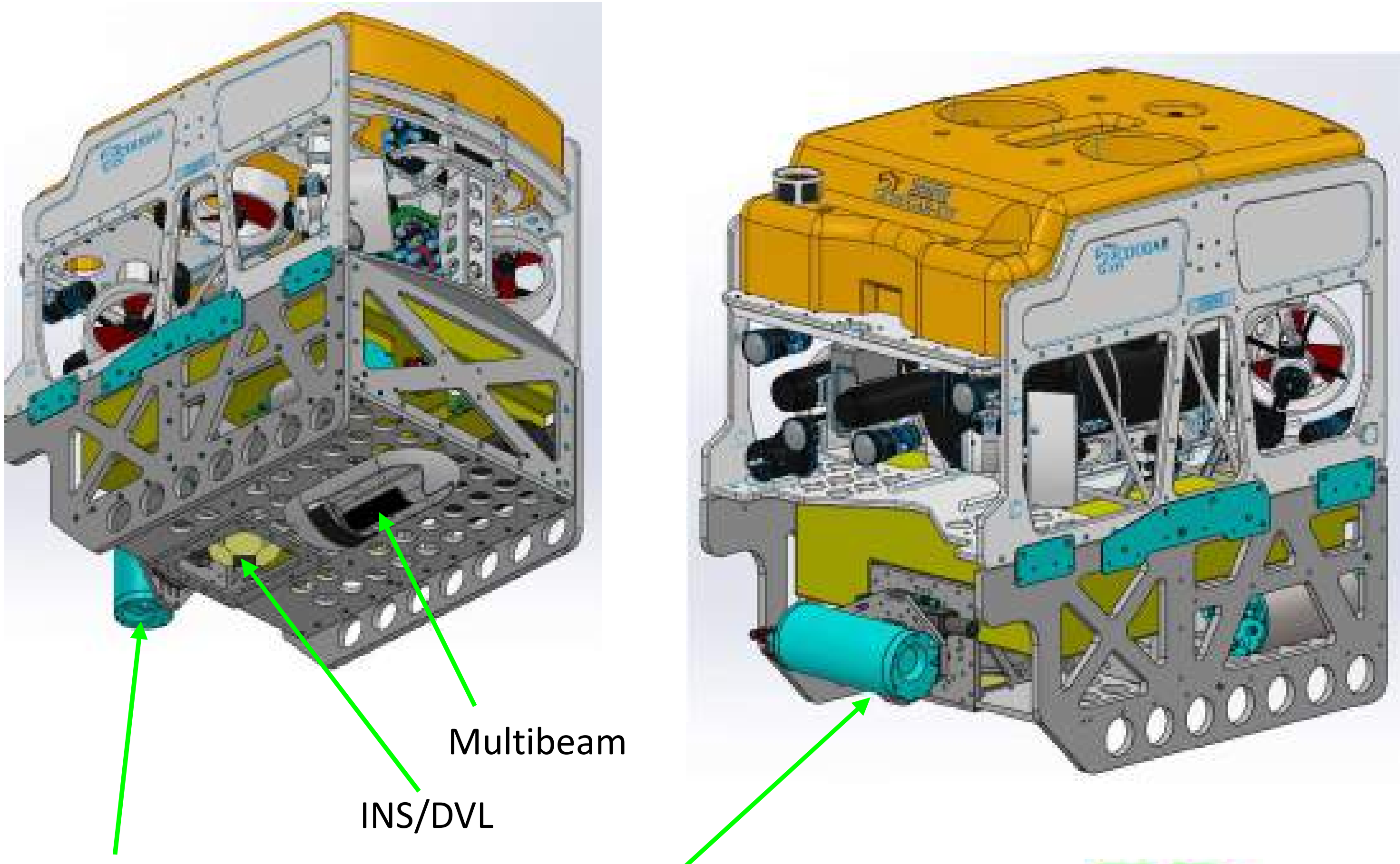
MOTION – (LIDAR AND MULTIBEAM)



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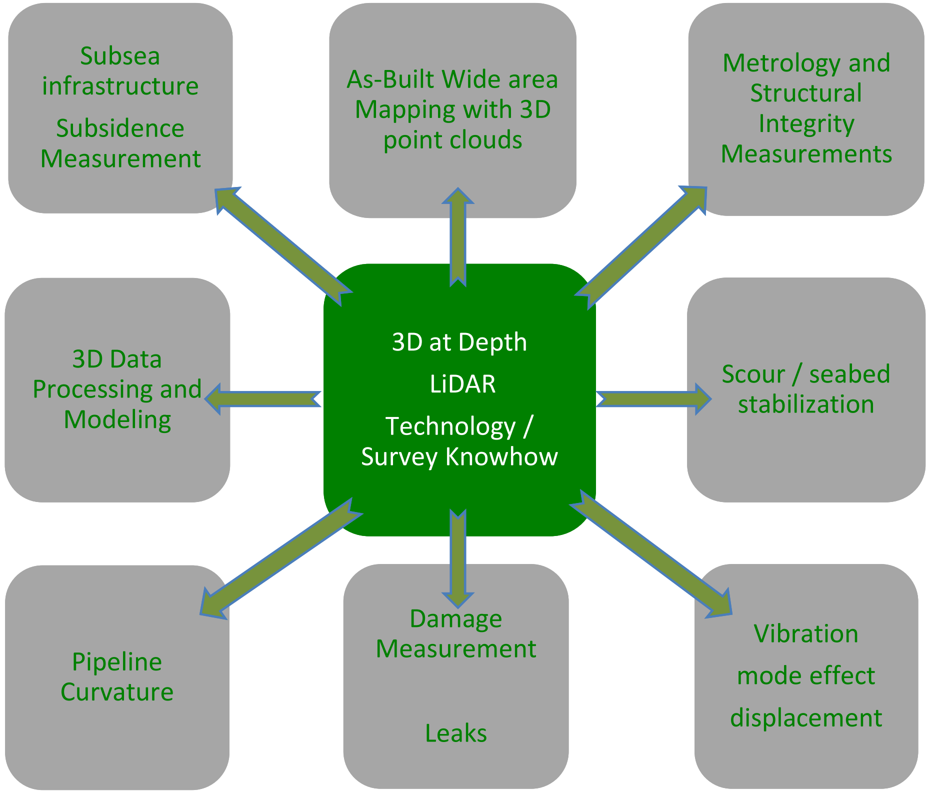
APPLICATIONS AND EXAMPLES

LIDAR APPLICATIONS



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DATA COLLECTION METHODS

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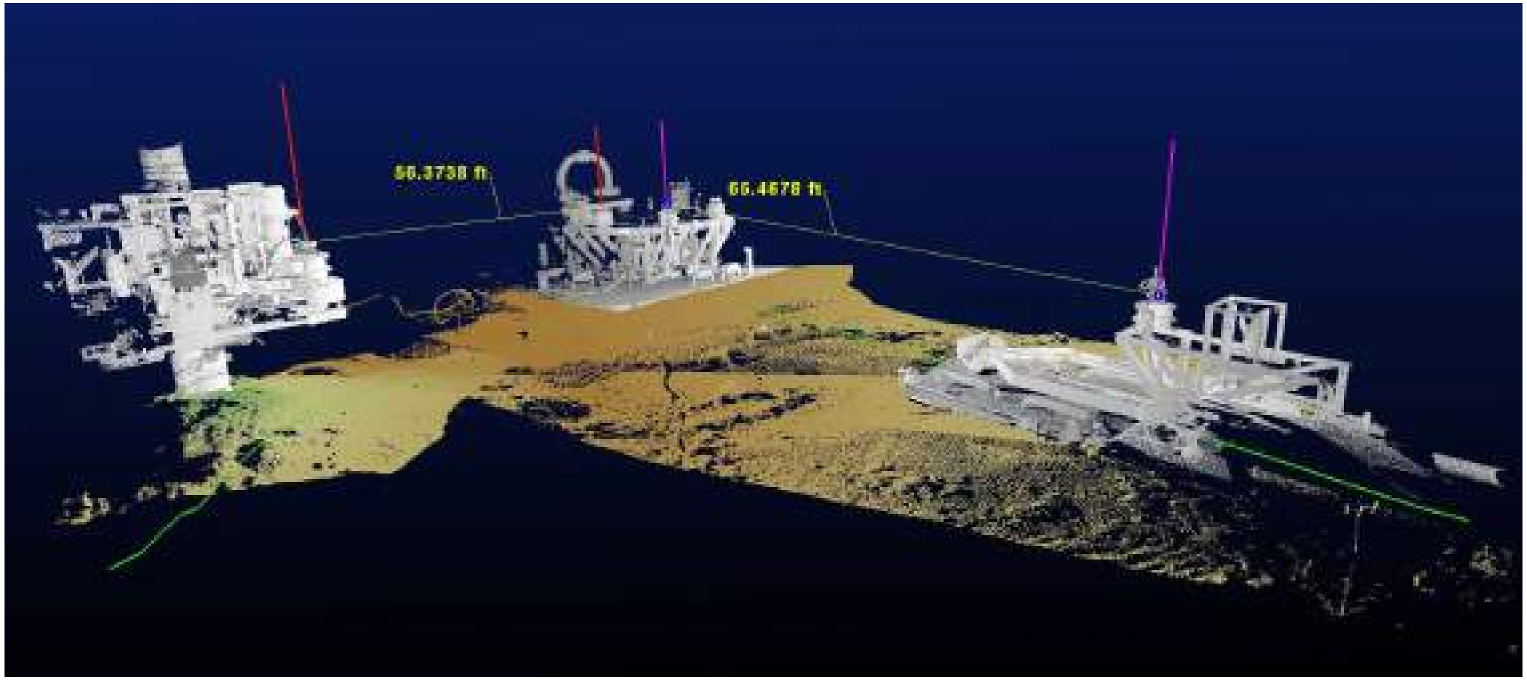
METROLOGIES

JUMPER METROLOGY



- Over 500 metrologies performed since Q2 2014
- All jumpers and spools successfully installed
- Average bottom time was only 2-3 hours per metrology
- Average time to complete metrology field report was 6 hours.

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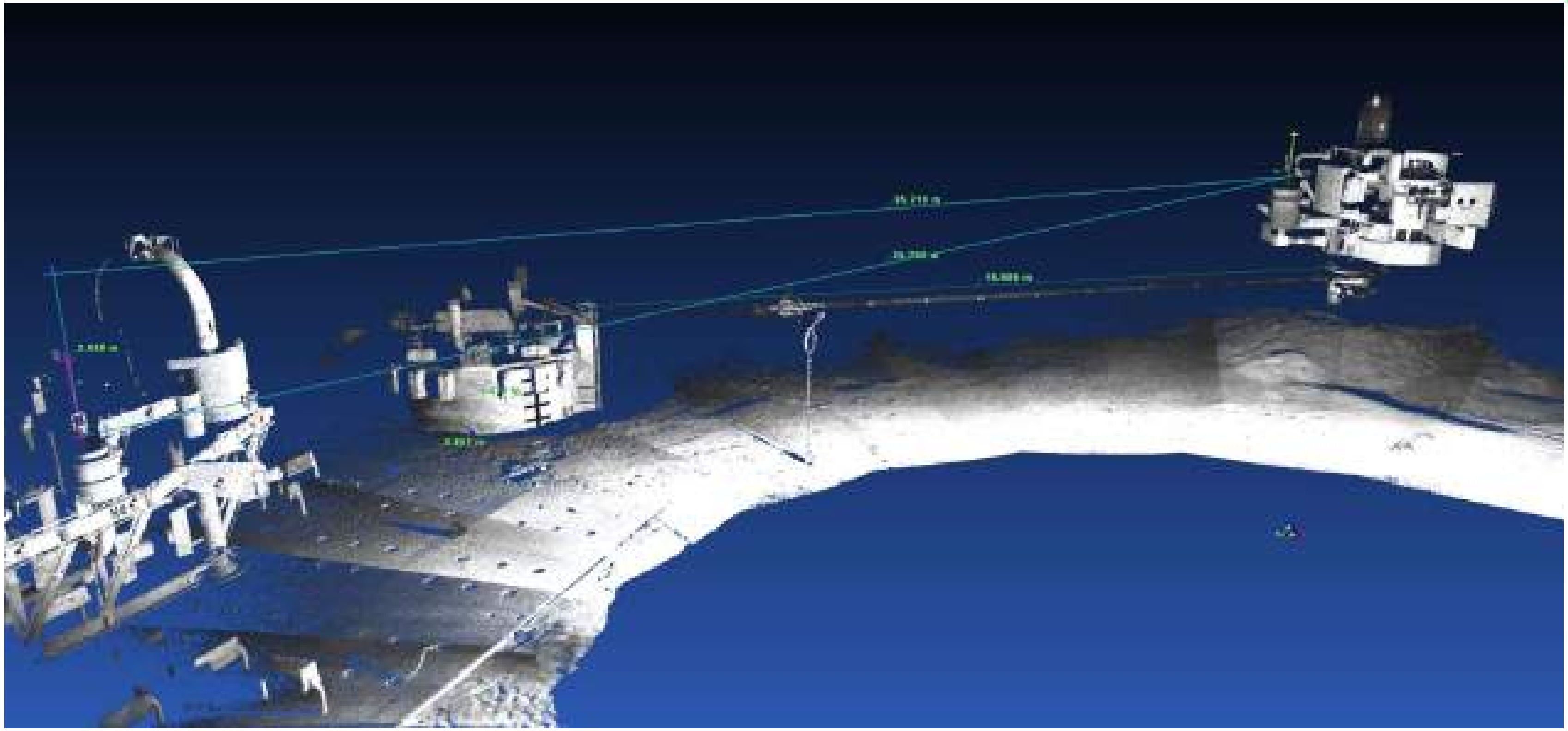
JUMPER METROLOGY



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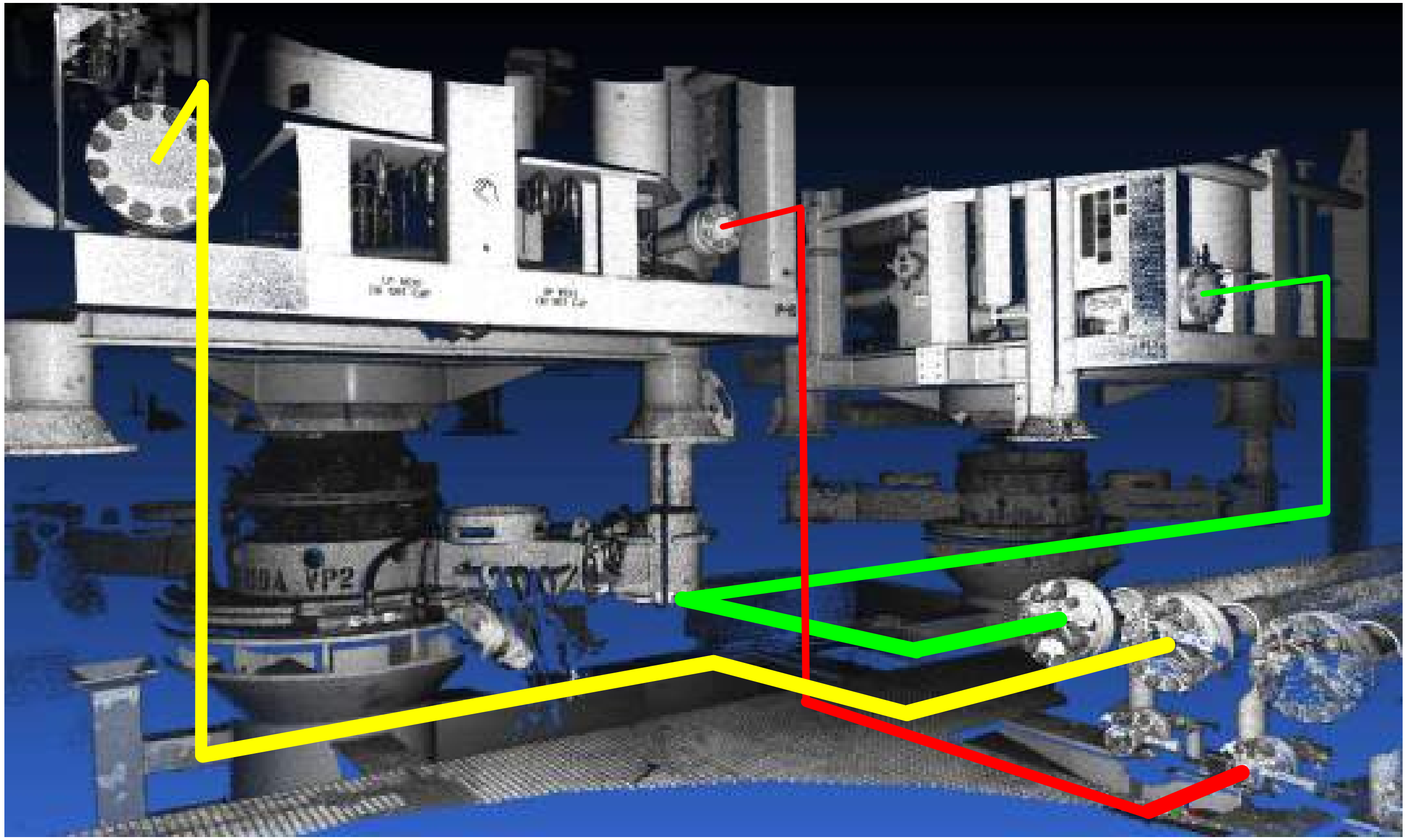
MULTIPLE METROLOGIES FROM SINGLE SCAN



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BENEFITS OF A LIDAR-BASED SOLUTION

Typical jumper connection

Non-typical Jumper connection with possible future issues

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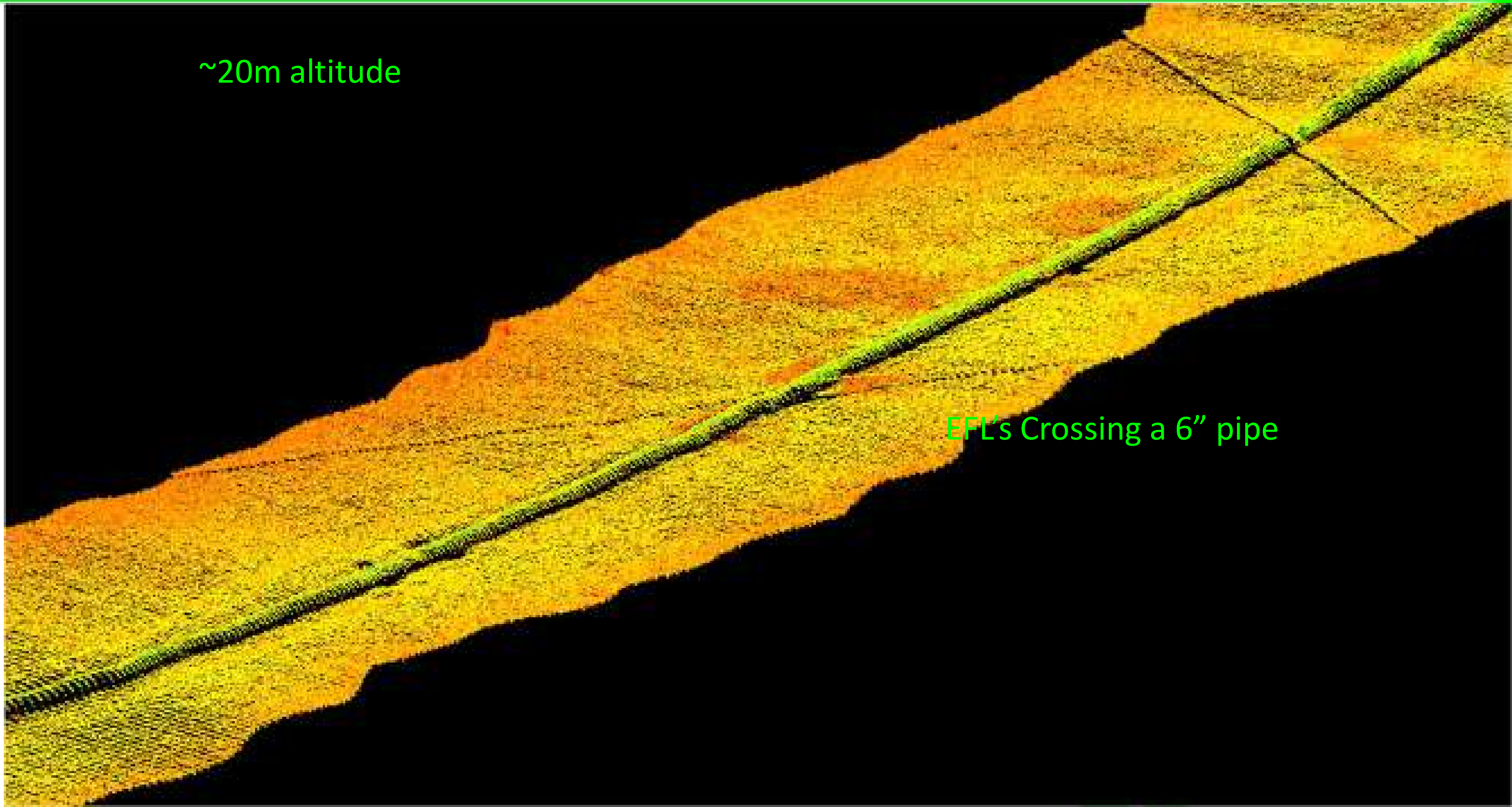
HIGH ALTITUDE / HIGH RESOLUTION



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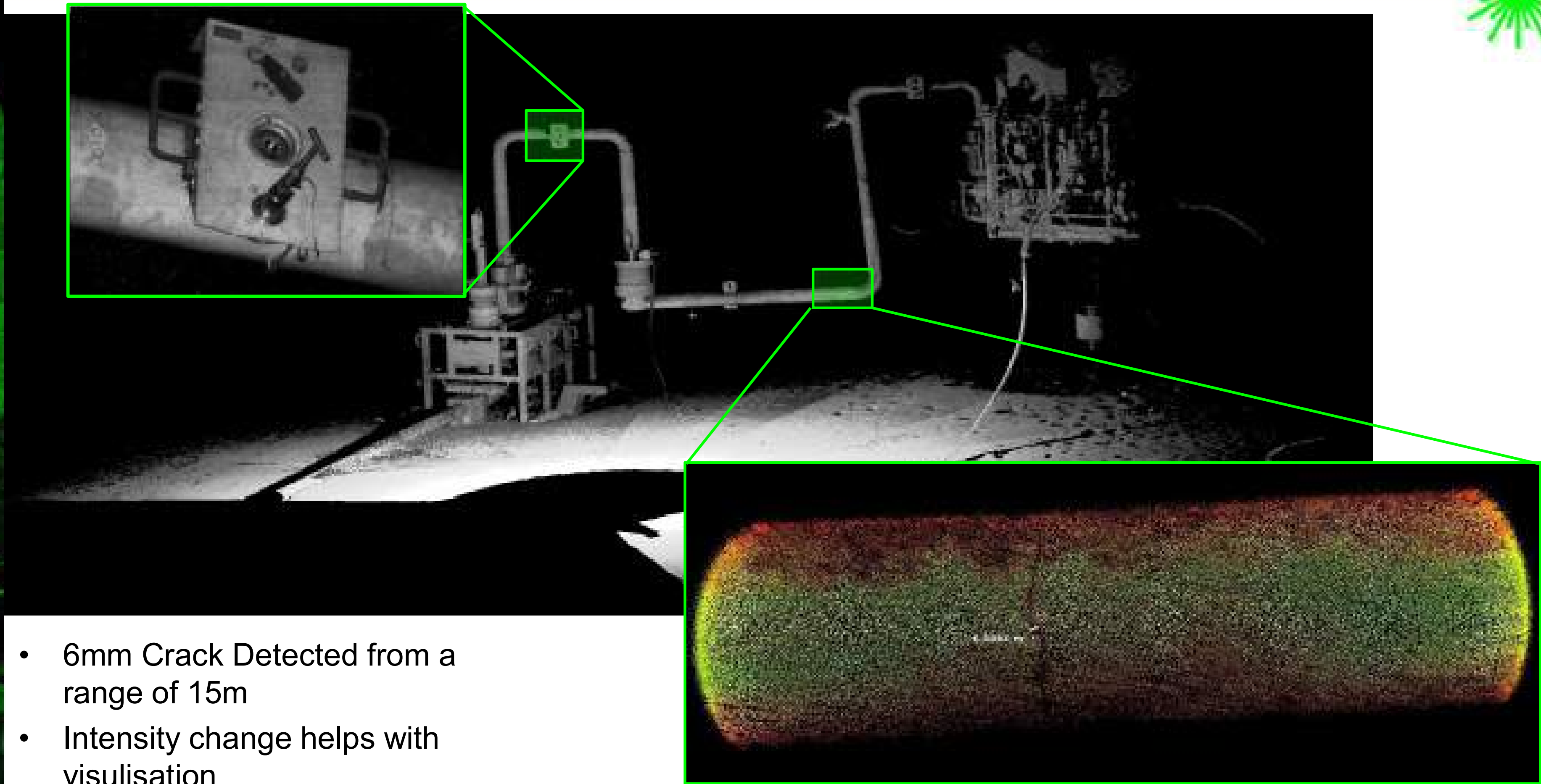
JUMPER / SPOOL / PIPELINE INSPECTION



- 6mm Crack Detected from a range of 15m
- Intensity change helps with visulisation

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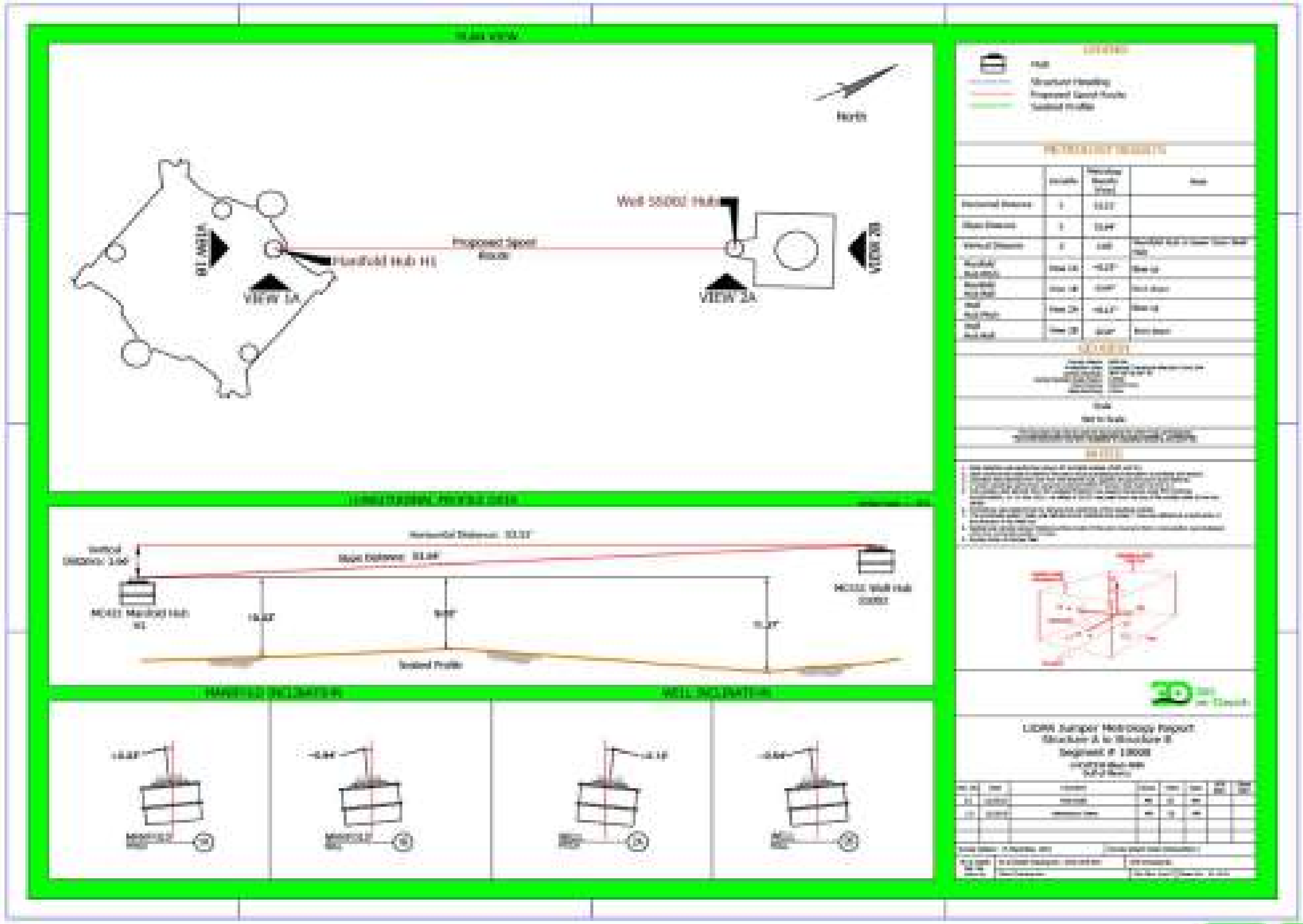
RESULTS –TRADITIONAL



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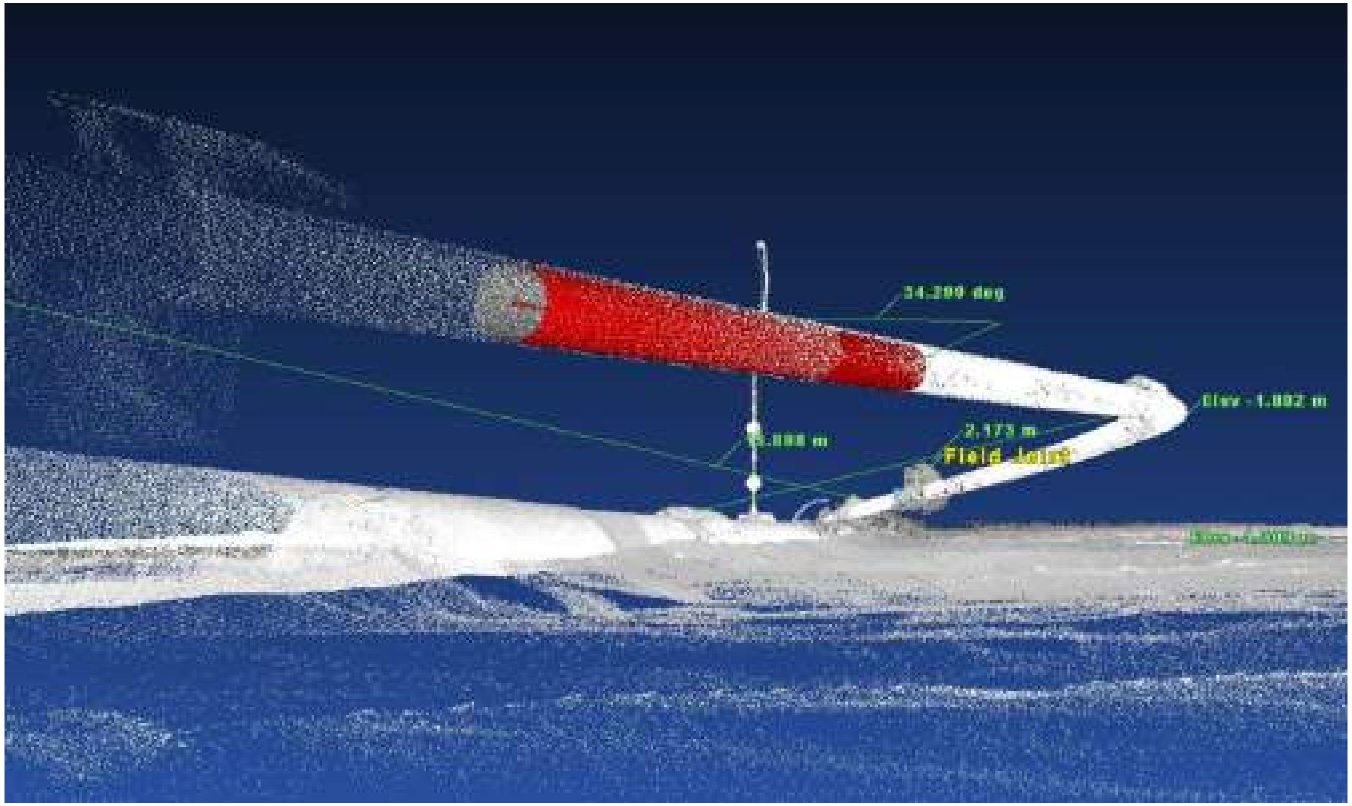
PIPELINE STATIC

PIPELINE DAMAGE ASSESSMENT



- Quantification of distances, angles and heights is straightforward.

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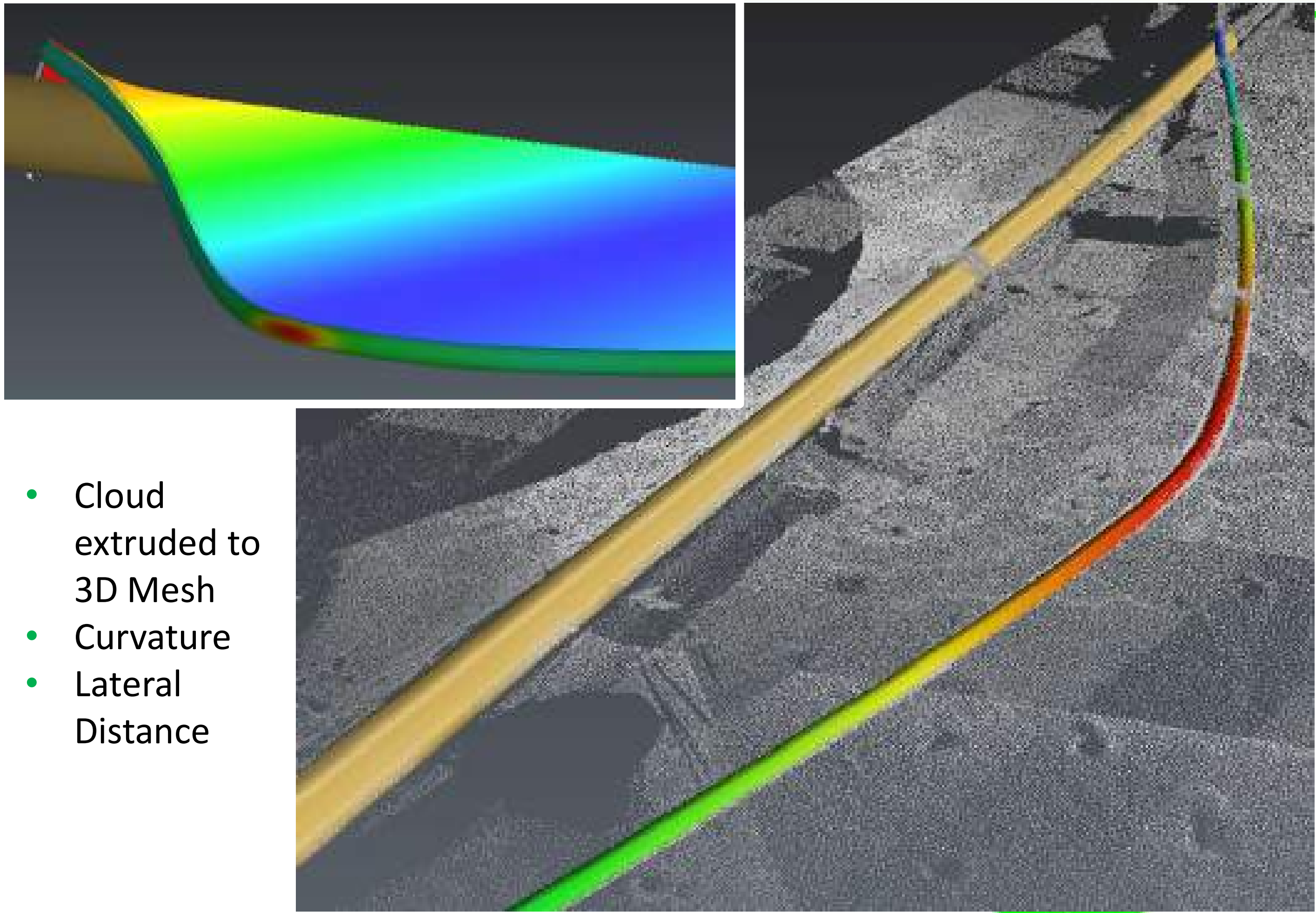
PIPELINE DAMAGE ASSESSMENT



- Cloud extruded to 3D Mesh
- Curvature
- Lateral Distance

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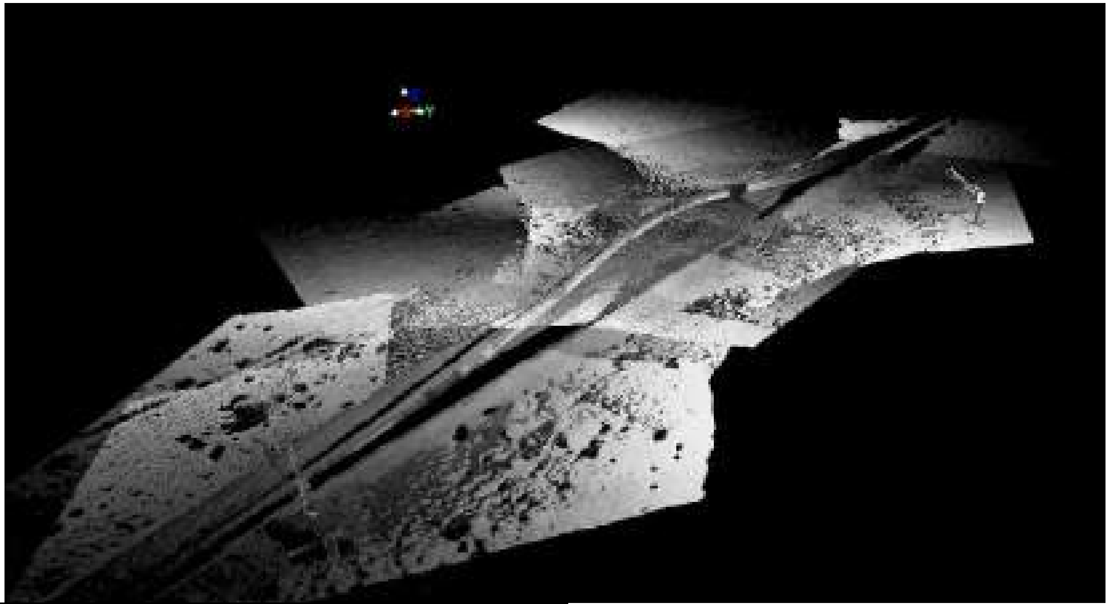
PIPELINE EXAMPLE - STATIC



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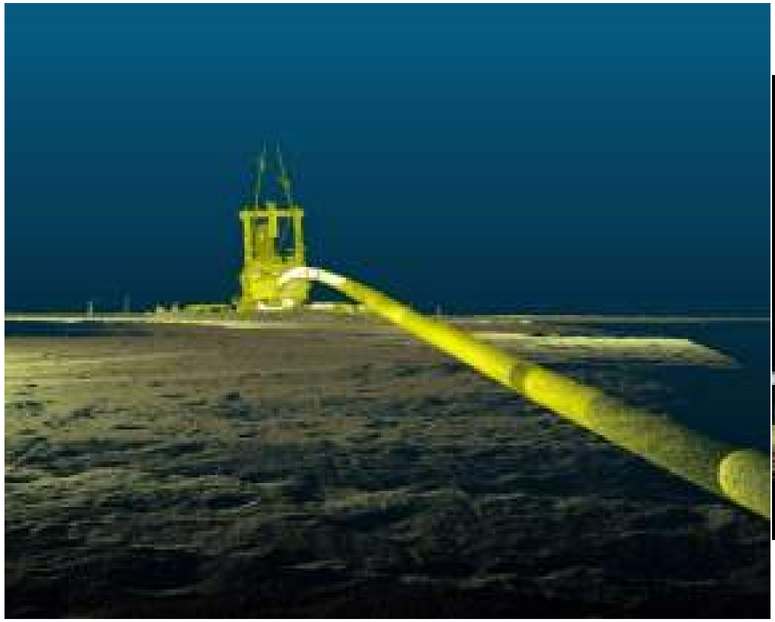
PIPELINE CURVATURE



Highly visible

Highly repeatable

Measurements you can reply on

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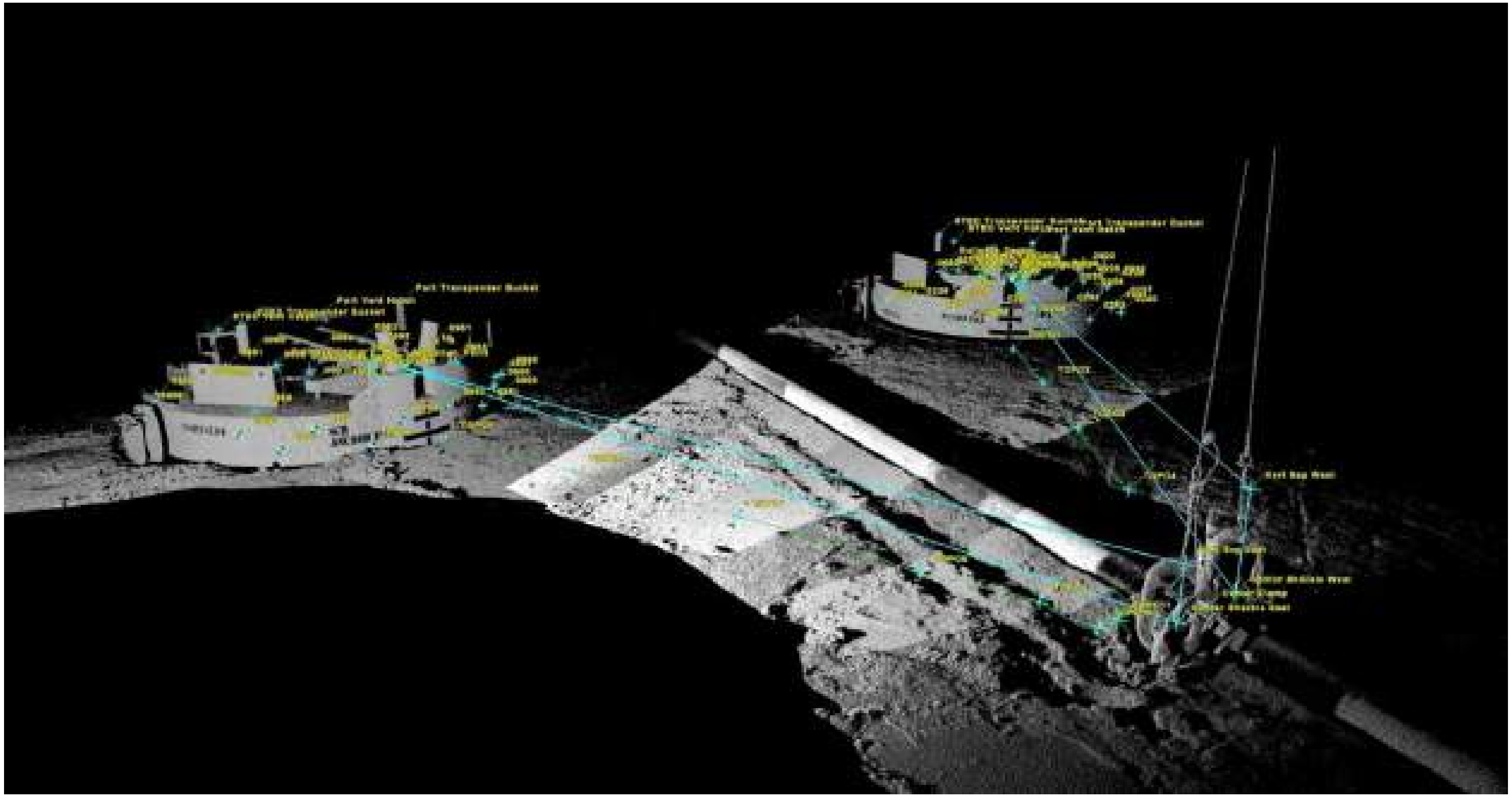
SLIP JOINT MONITORING



SUBSEA DIMENSIONAL CONTROL

PRE WELL WELL REMEDIATION SURVEY

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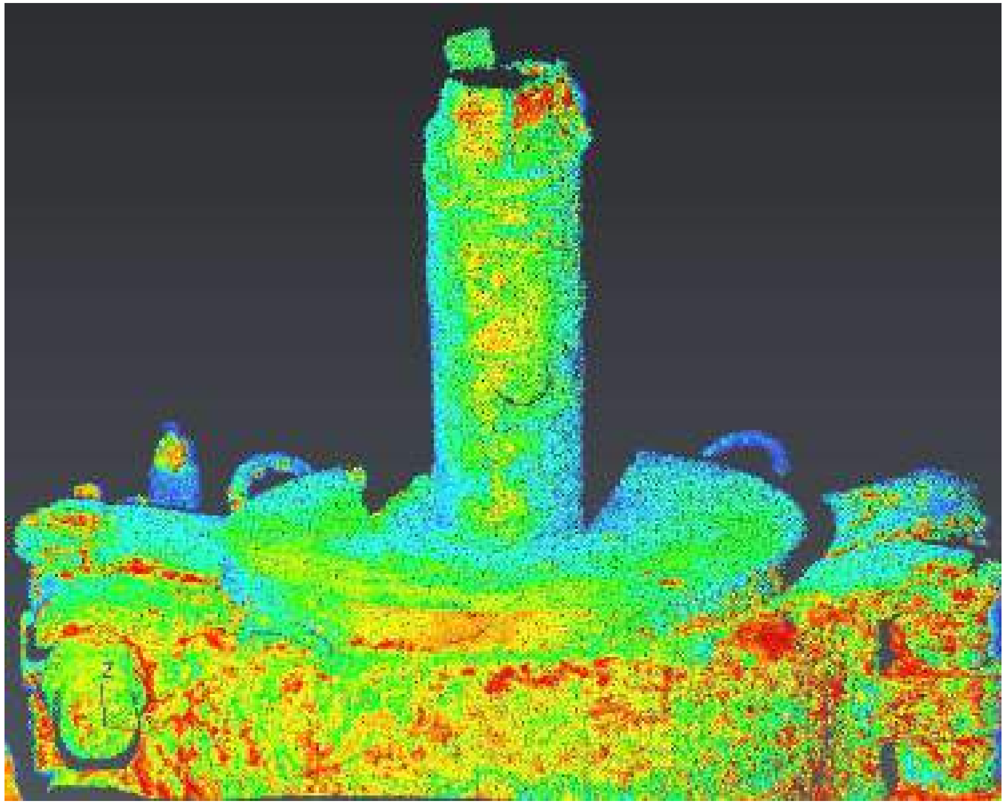
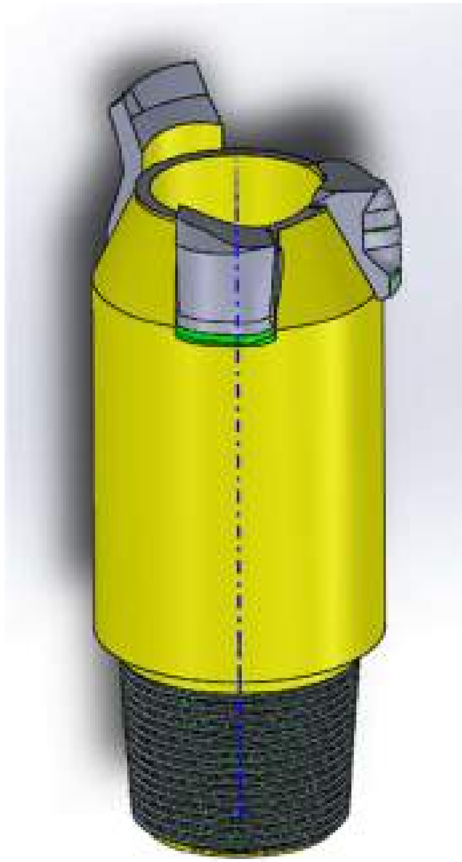
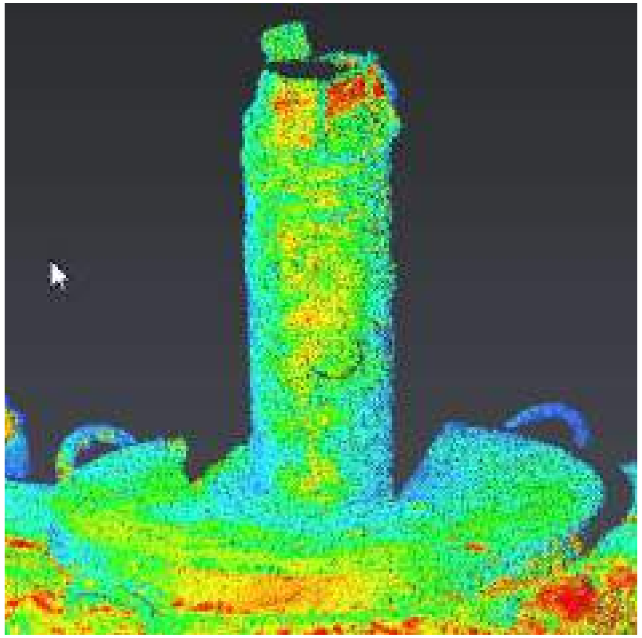
PROVIDING A REPLICA

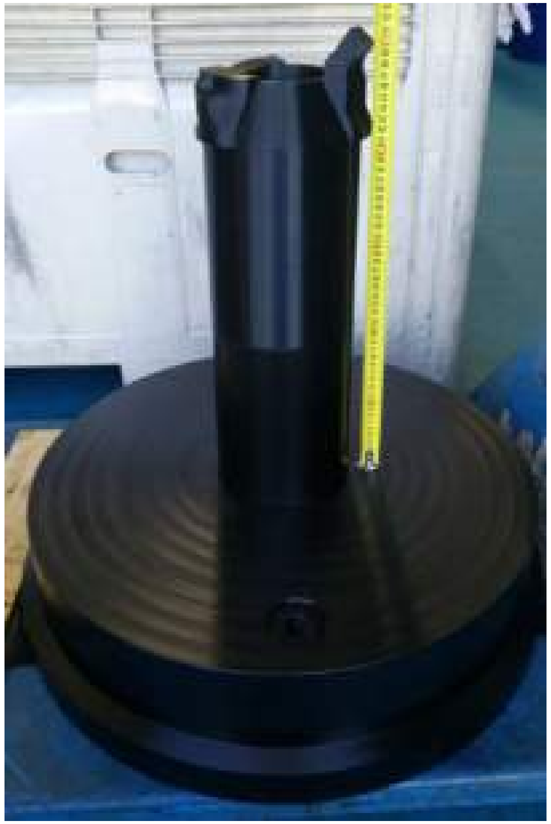




- A 3D CAD model was created from the point cloud.
- Thread was only information provided.

3D MODELLING, 3D PRINTING, REVERSE ENGINEERING





- From the 3D model, the physical part was 3D printed using Fused deposition modelling (*FDM*) technology.
- Assembled well cap shown on right 650mm diameter.

[Weblink : 3D replica of a wellhead]

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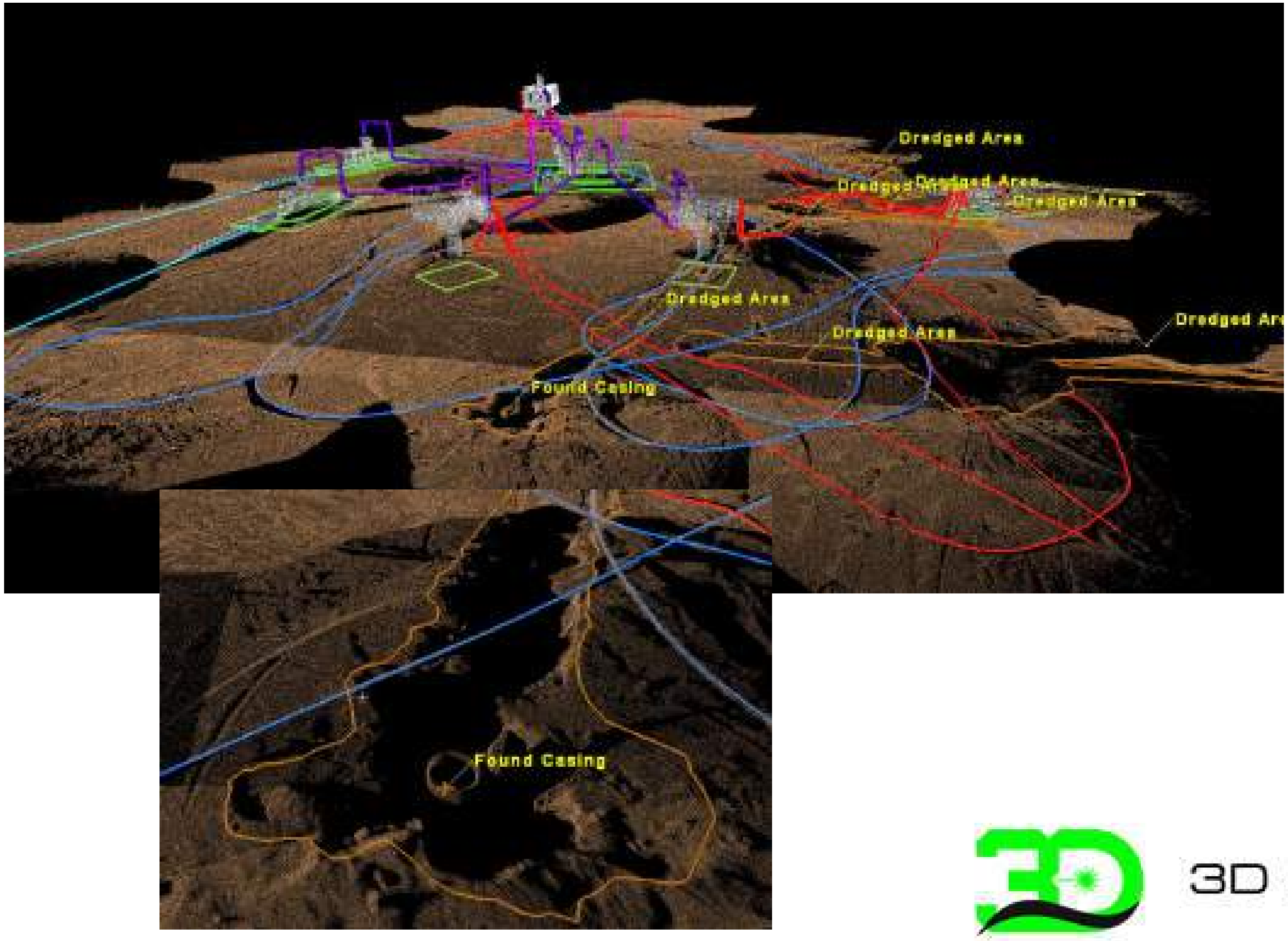
EXAMPLE – GENERAL FIELD SCAN



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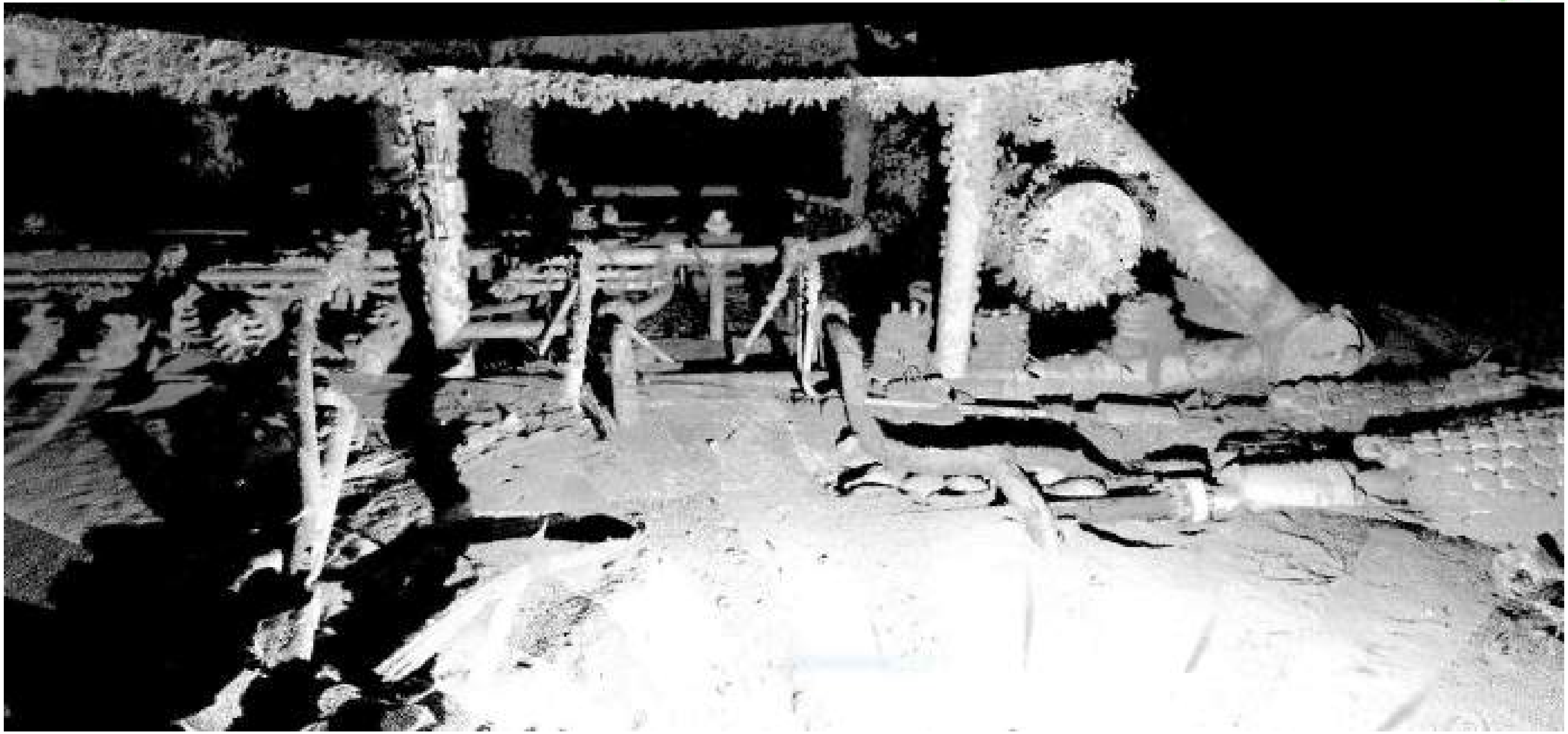
DIMCON OF OLD ASSETS



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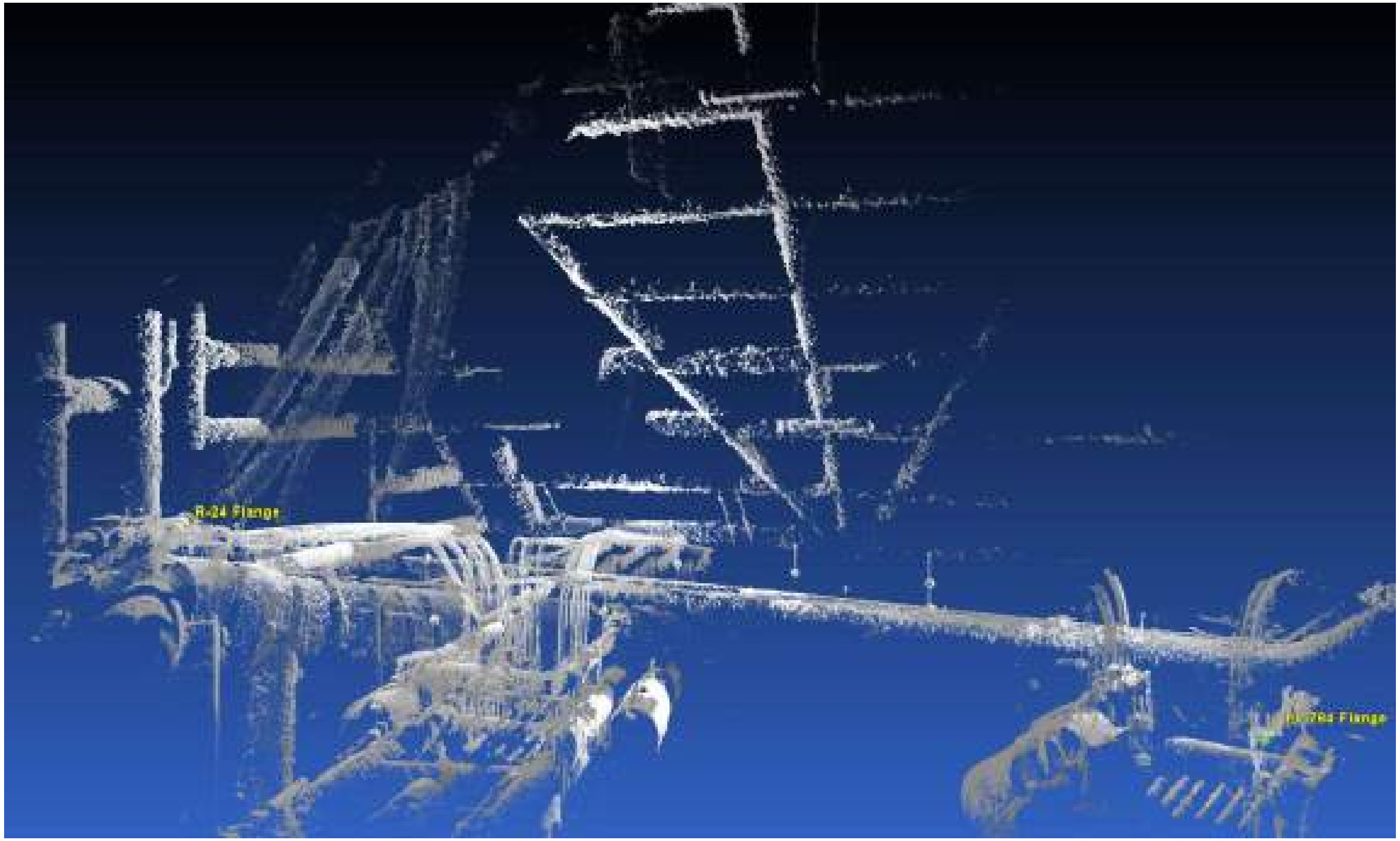
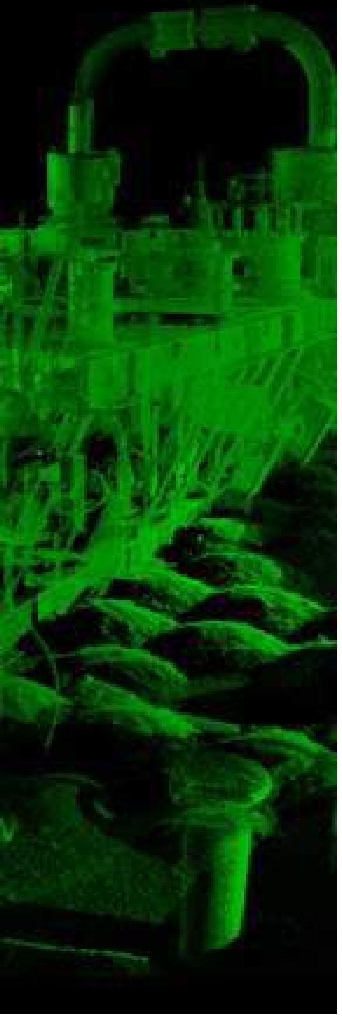
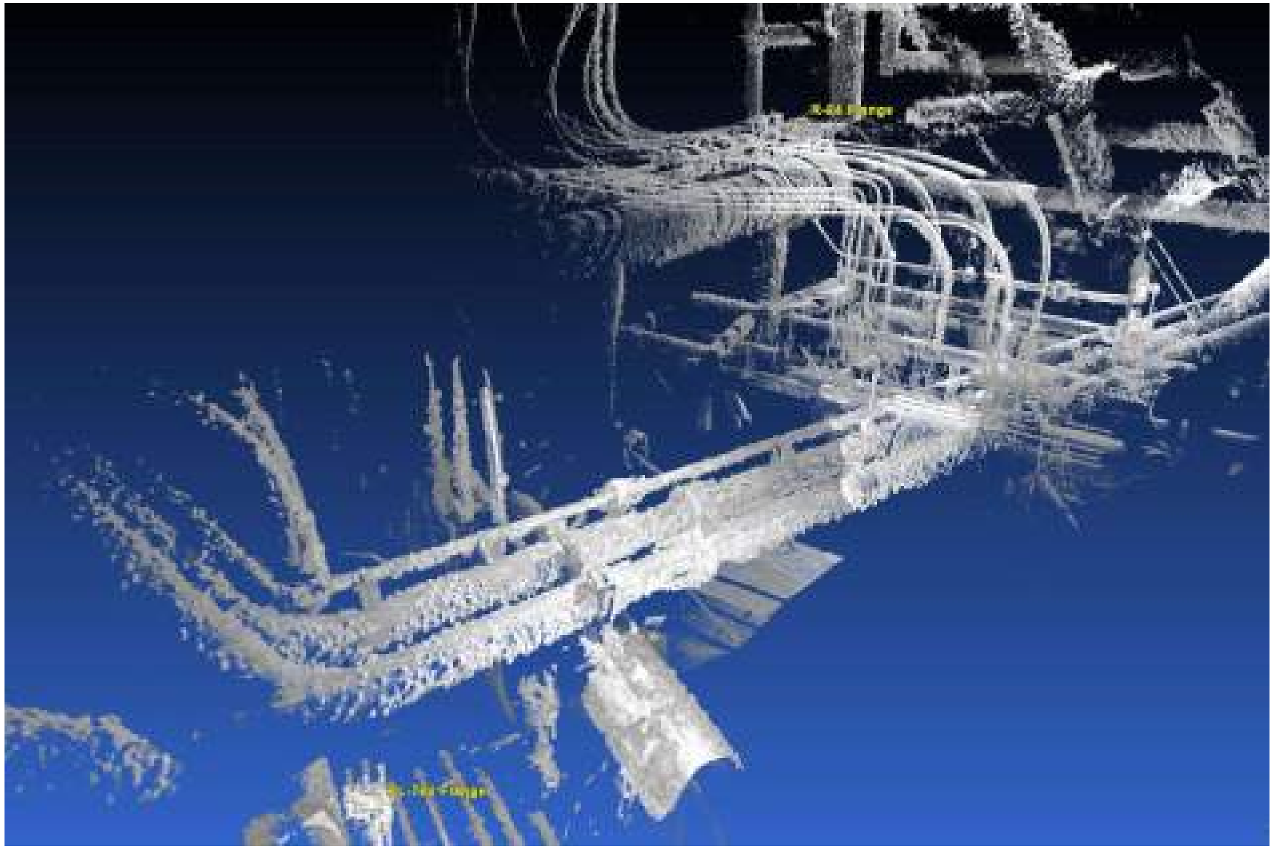
RECONFIGURATION



DIMCON OF OLD ASSETS





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NEW SPOOLS = NEW LIFE INTO AN OLD ASSET

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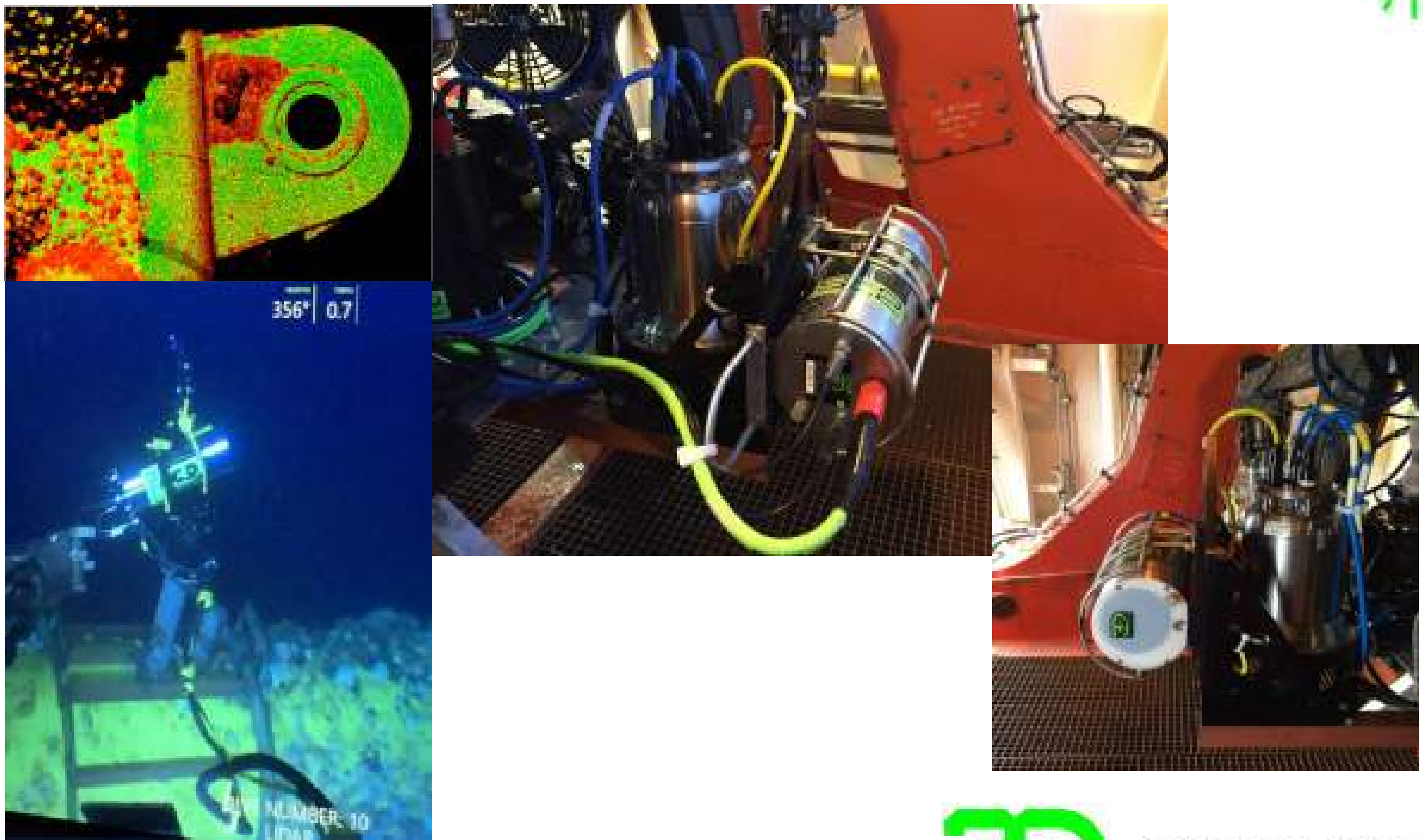
SIDE LOOKING MOTION SCANNING



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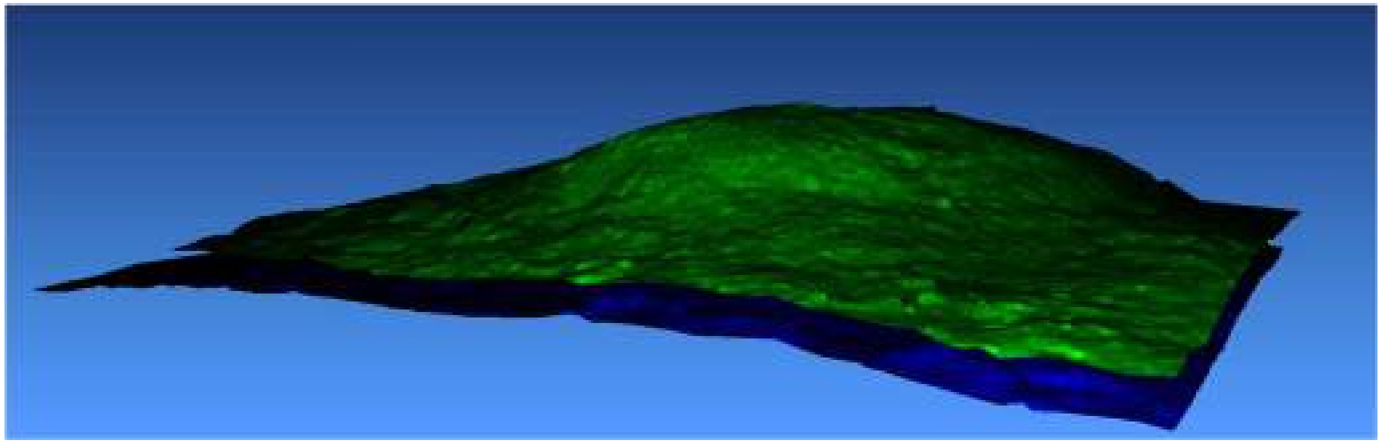
VOLUMETRIC SEABED CALCULATIONS



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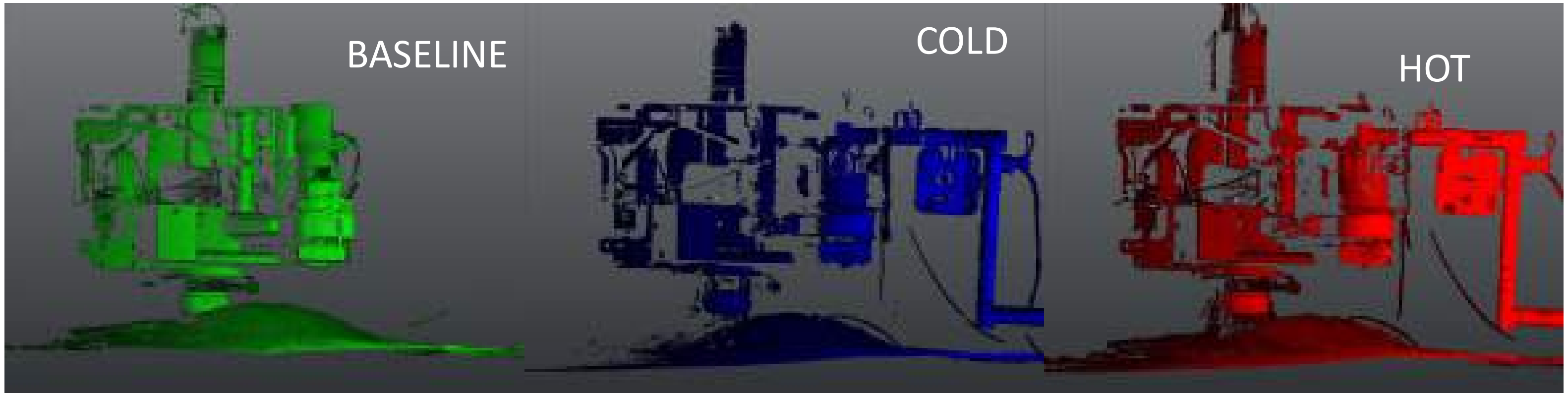
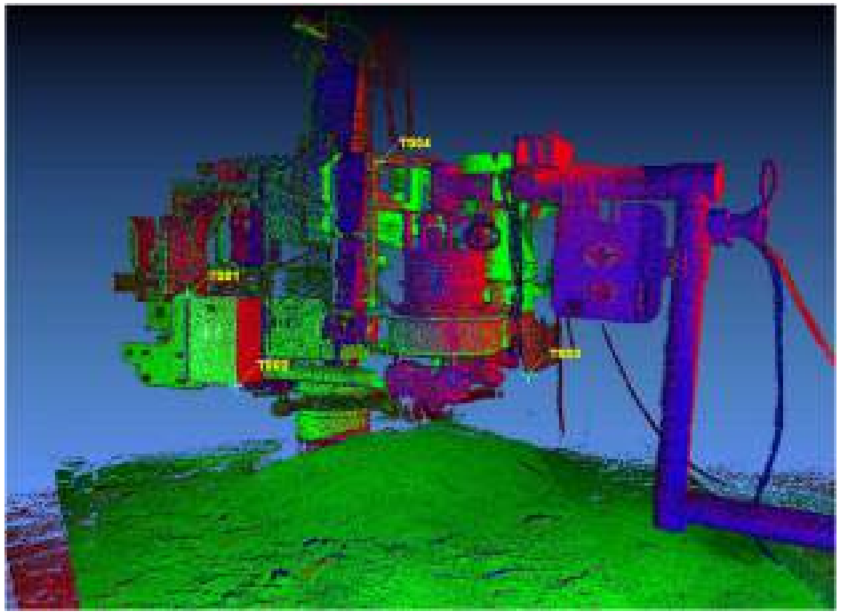
THERMAL TREE GROWTH





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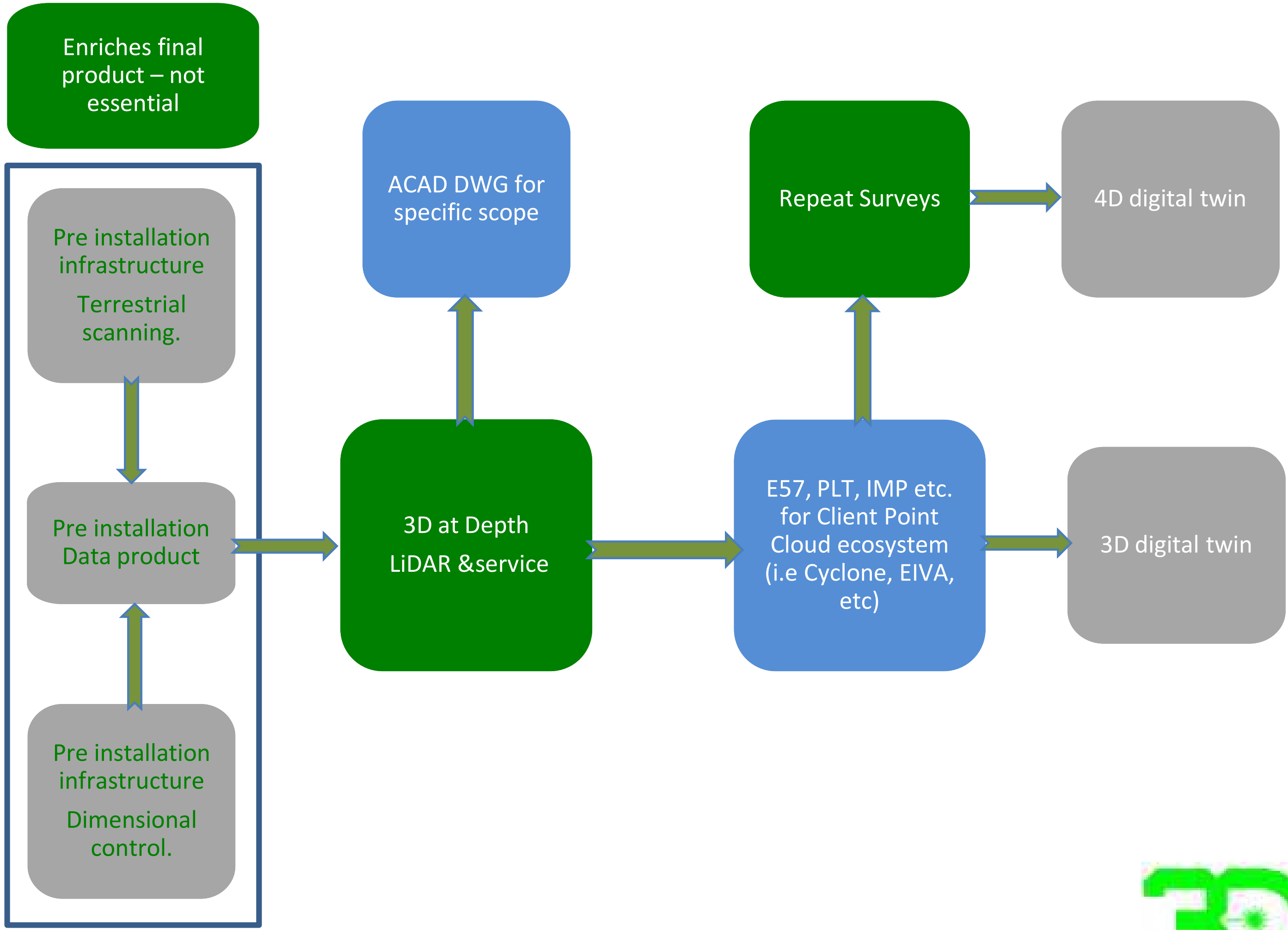
DATA FUSION



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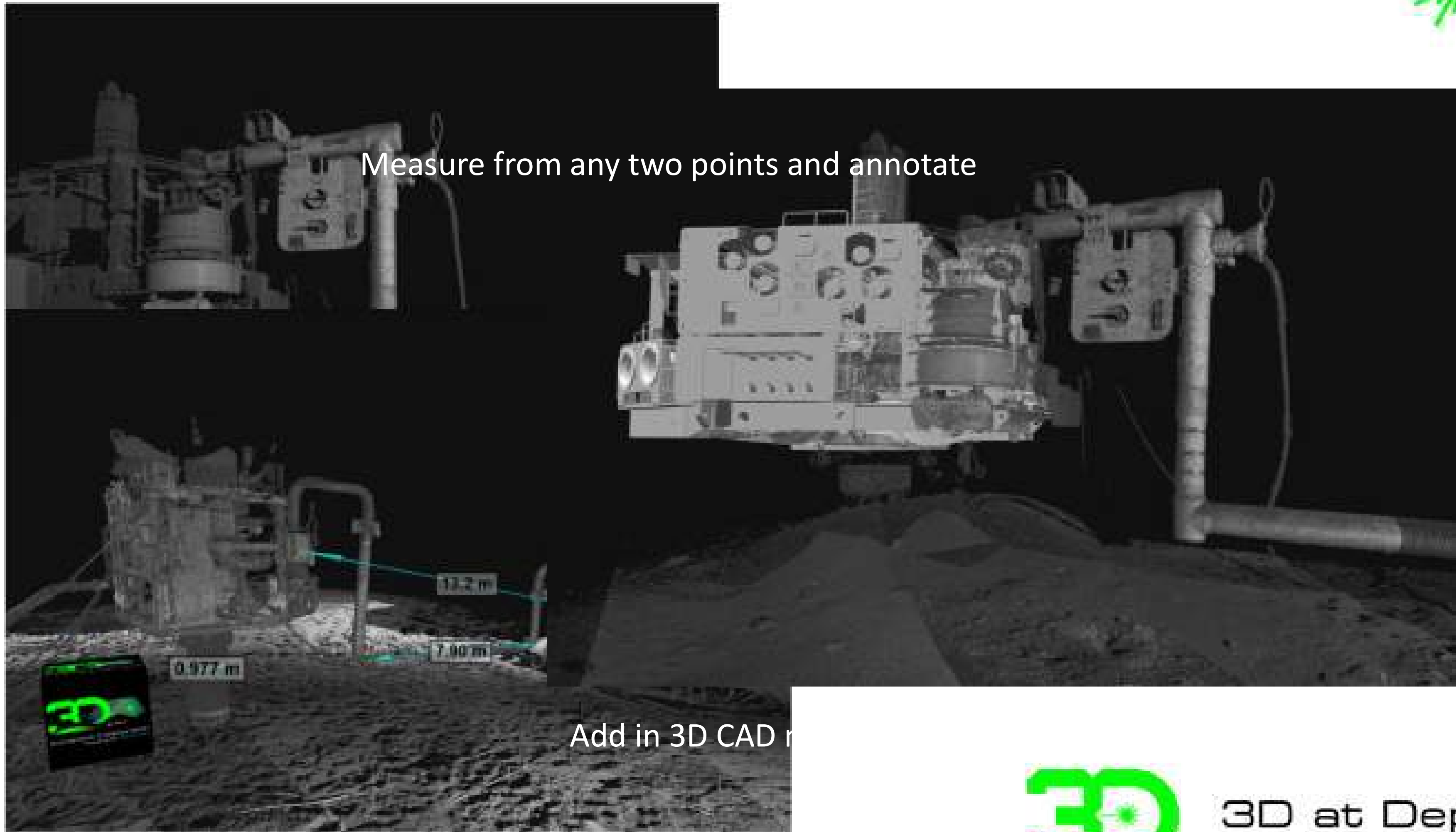
VISUALIZE MEASURE AND SIMULATE



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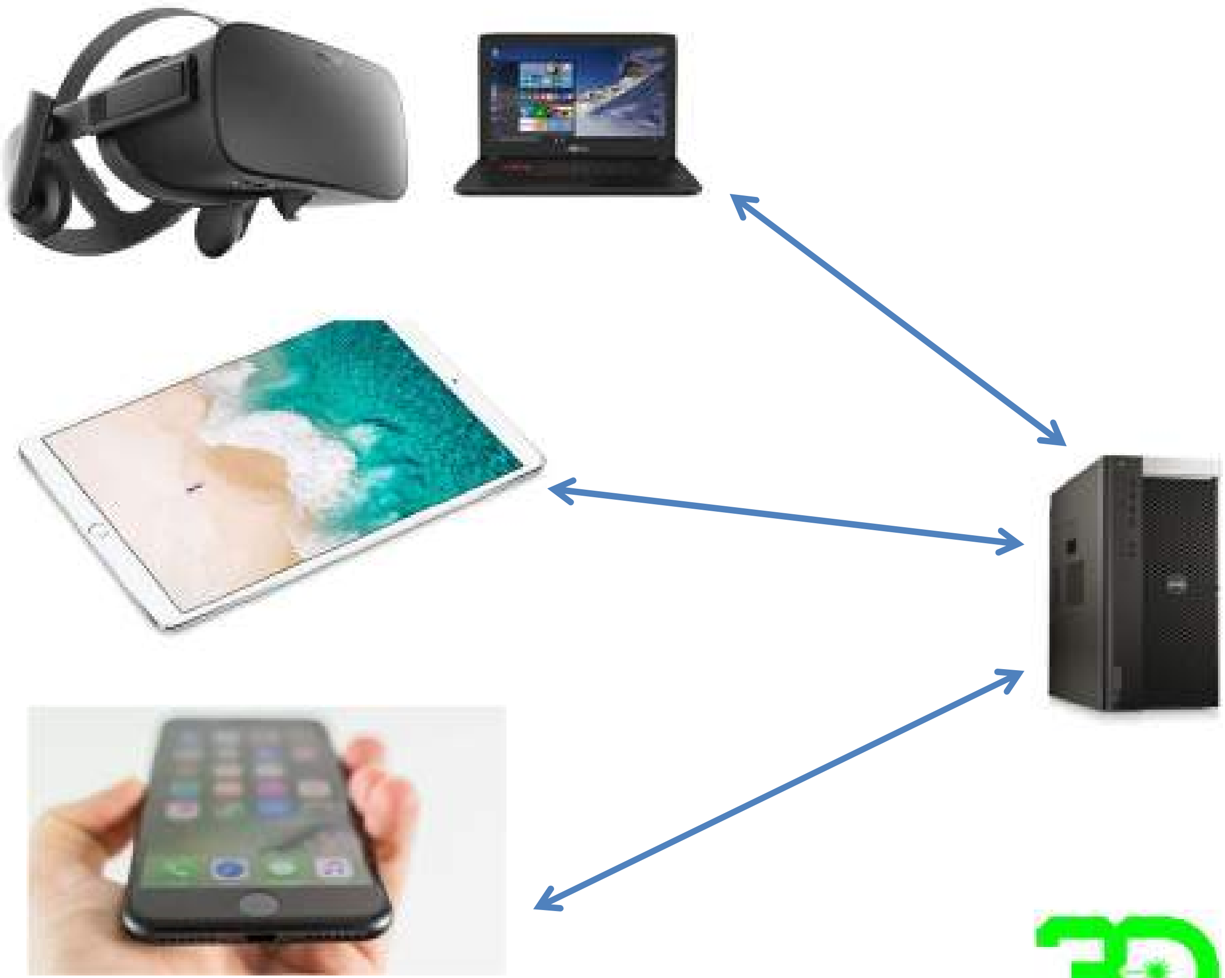
FAST MOVING DATA



3D at Depth

Sponsor - Air Sea Heritage Foundation

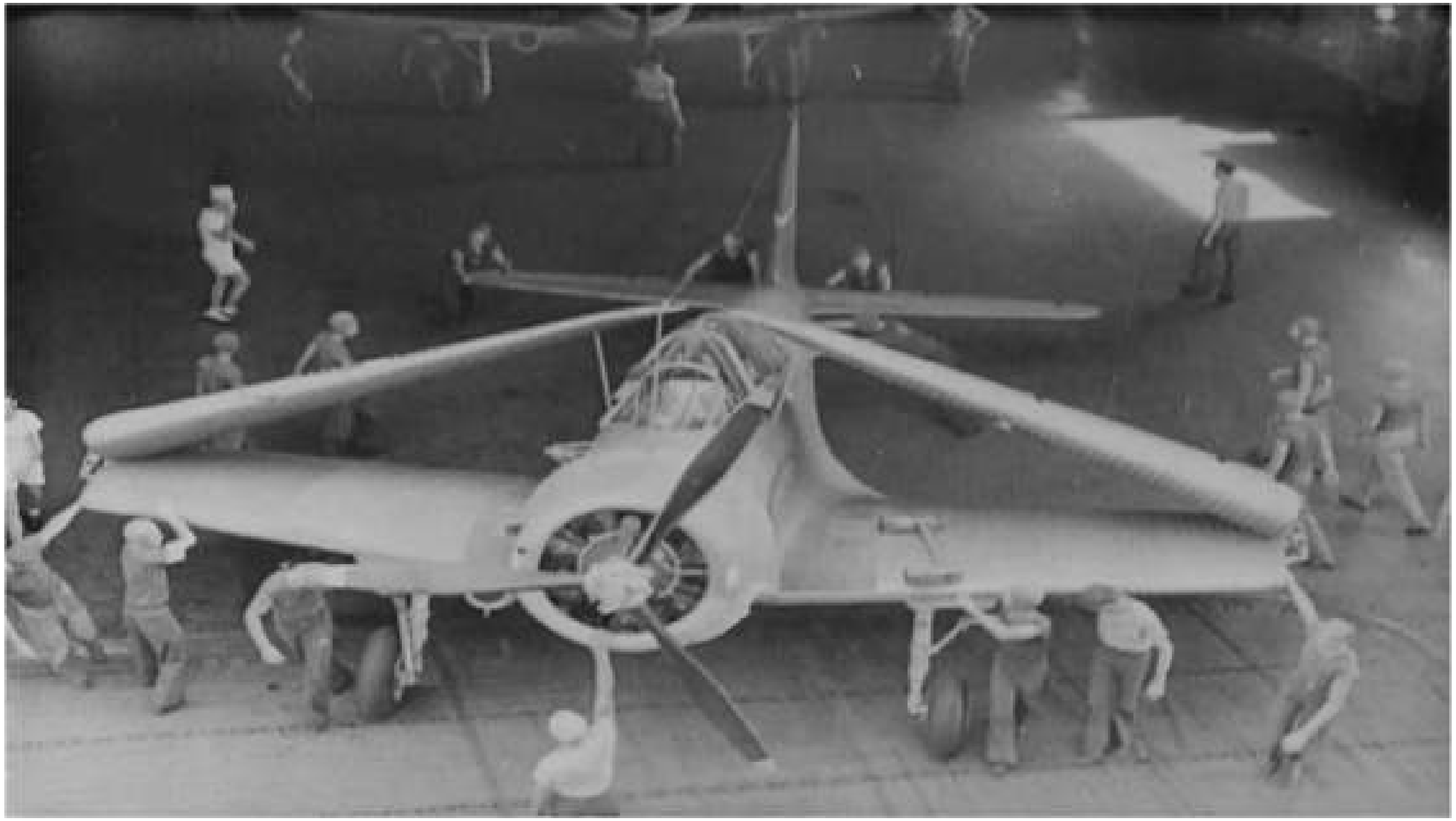
THE MISSION

- October 2018
- US Marshall Islands
- Jaluit Atoll

- TOTAL OF 6 DAYS ONBOARD

- Collect Millimetric repeatable measurements using SL (Subsea LiDAR) and onboard *patented index of refraction correction algorithms*

THE AIRCRAFT – TBD DEVASTATOR



Intro link for PDF version

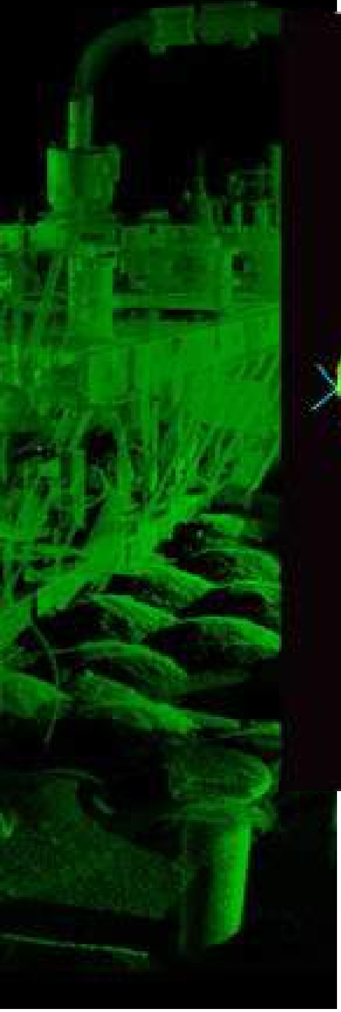
3D at Depth

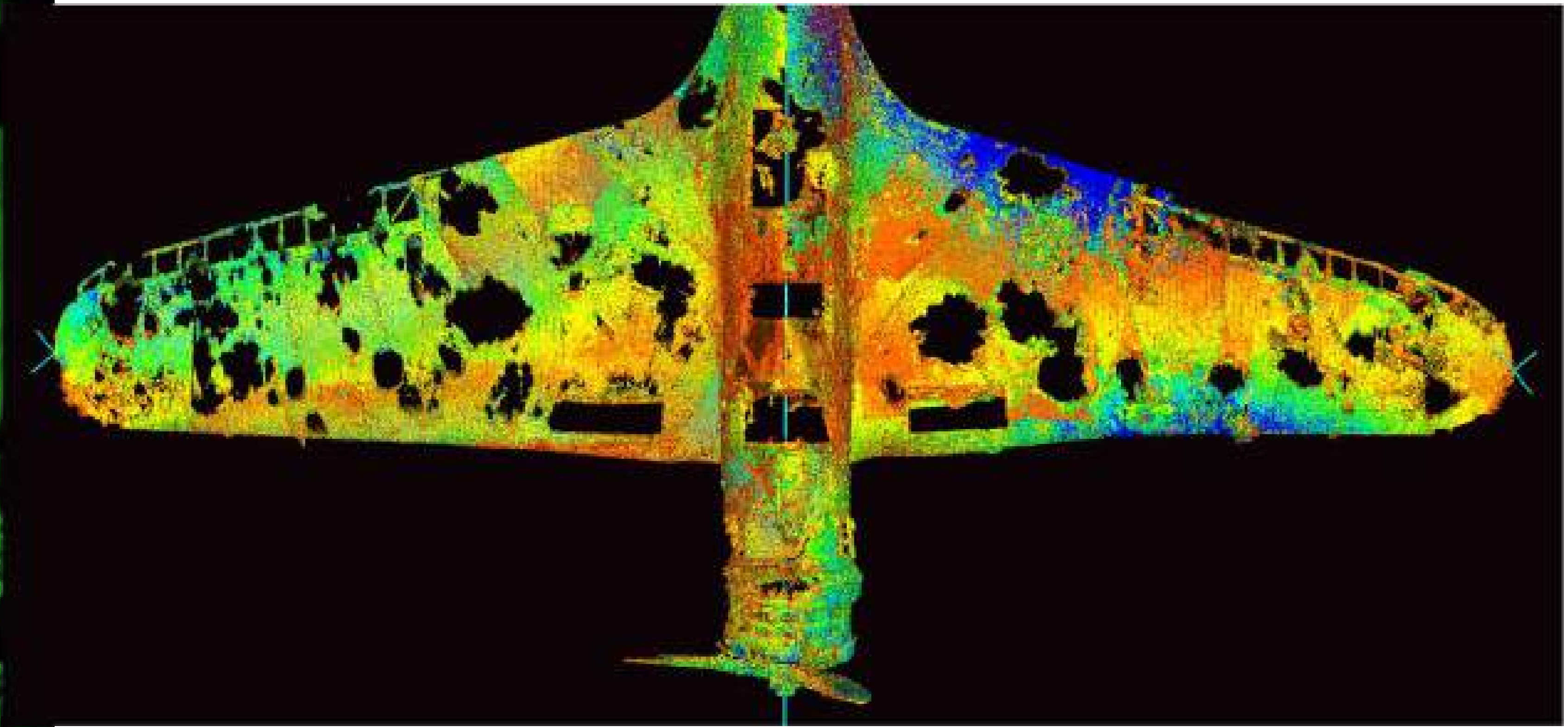
SL3 AND THE DEVASTATOR (1515)

Link for PDF version

3D at Depth

ABOUT A 50FT WING SPAN (15.24M METERS)





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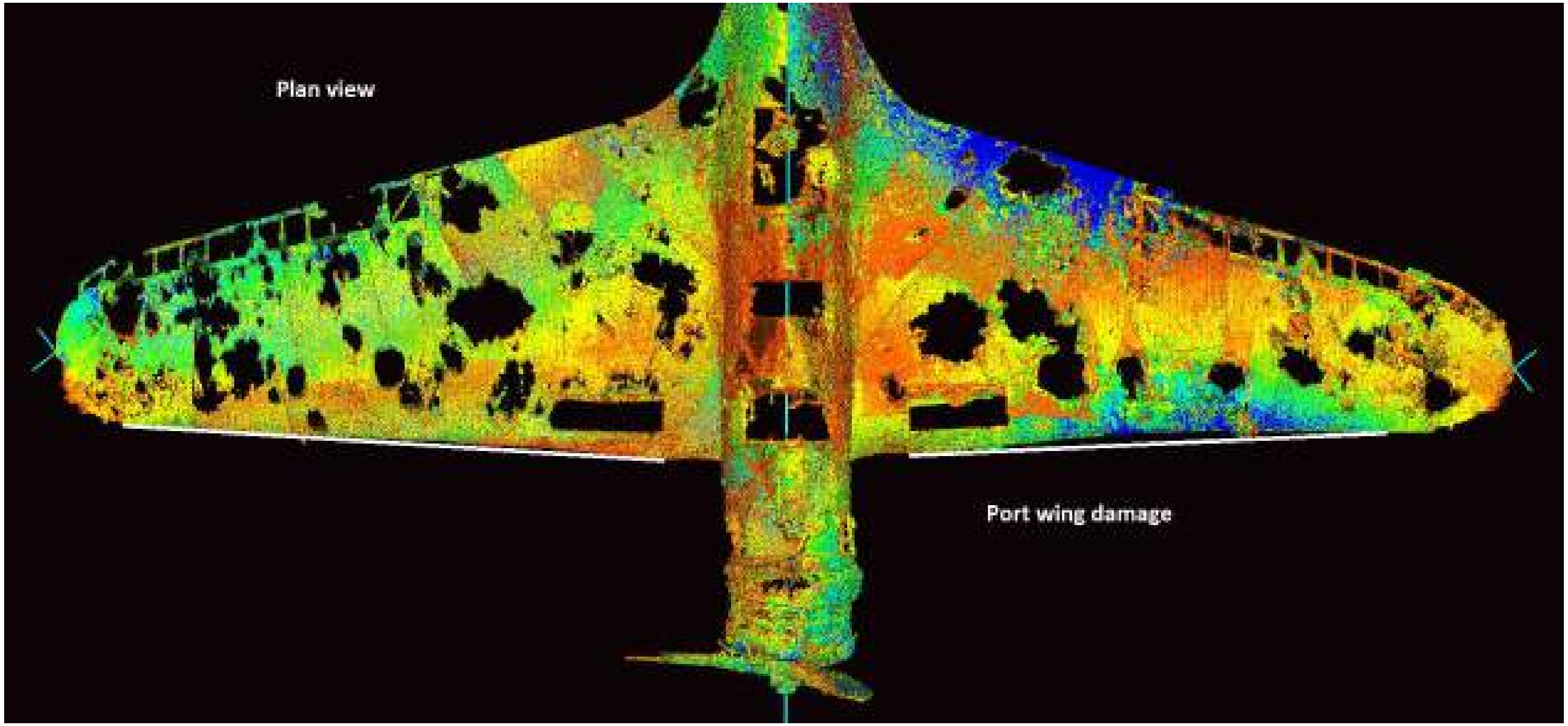
HOW ABOUT 48' 8" (14.834 METERS)



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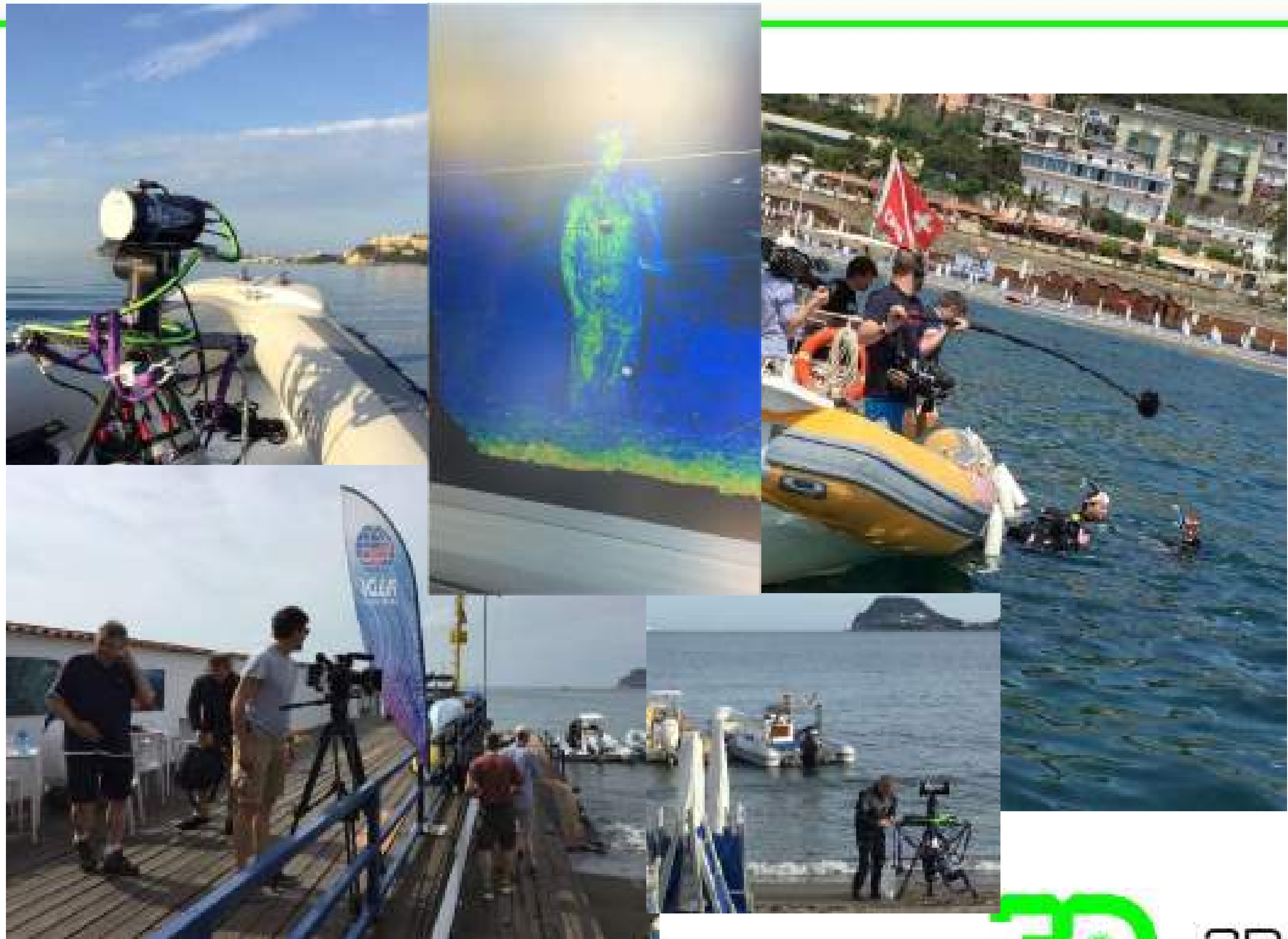
ITALY WITH THE BBC



3D at Depth

ITALY WITH THE BBC

THANK YOU!

3D at Depth