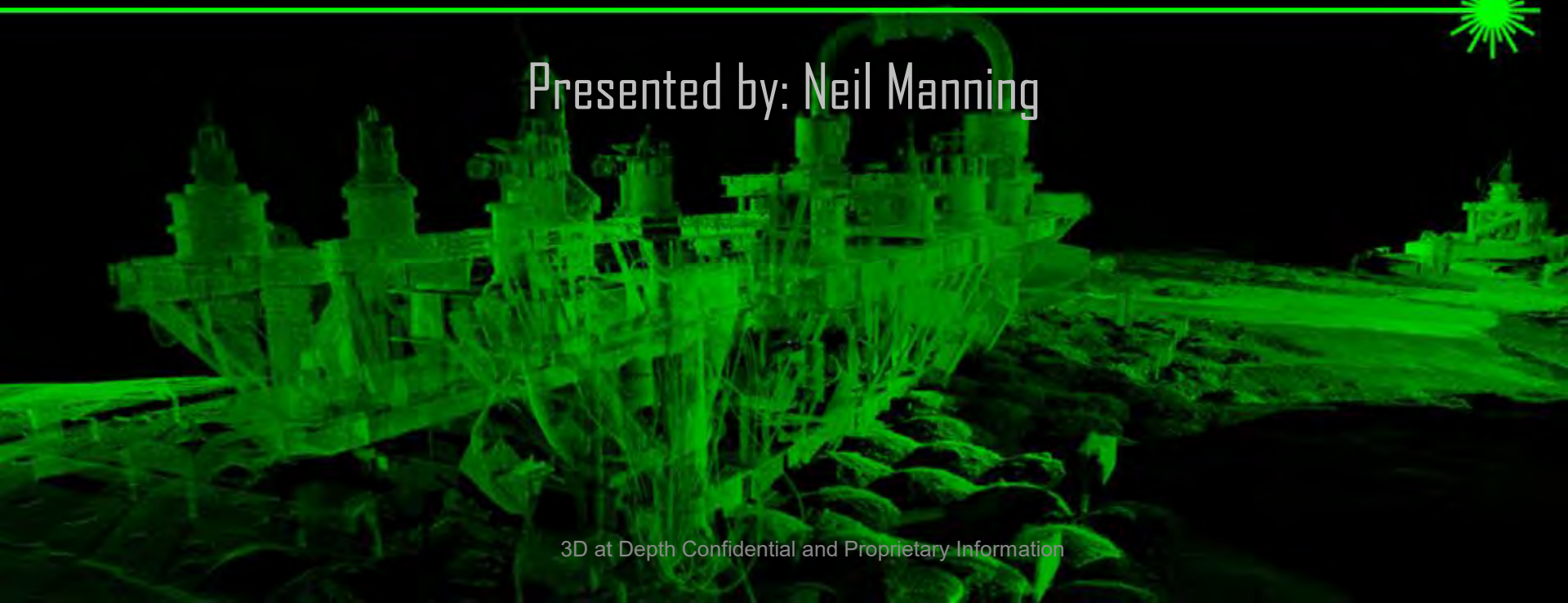
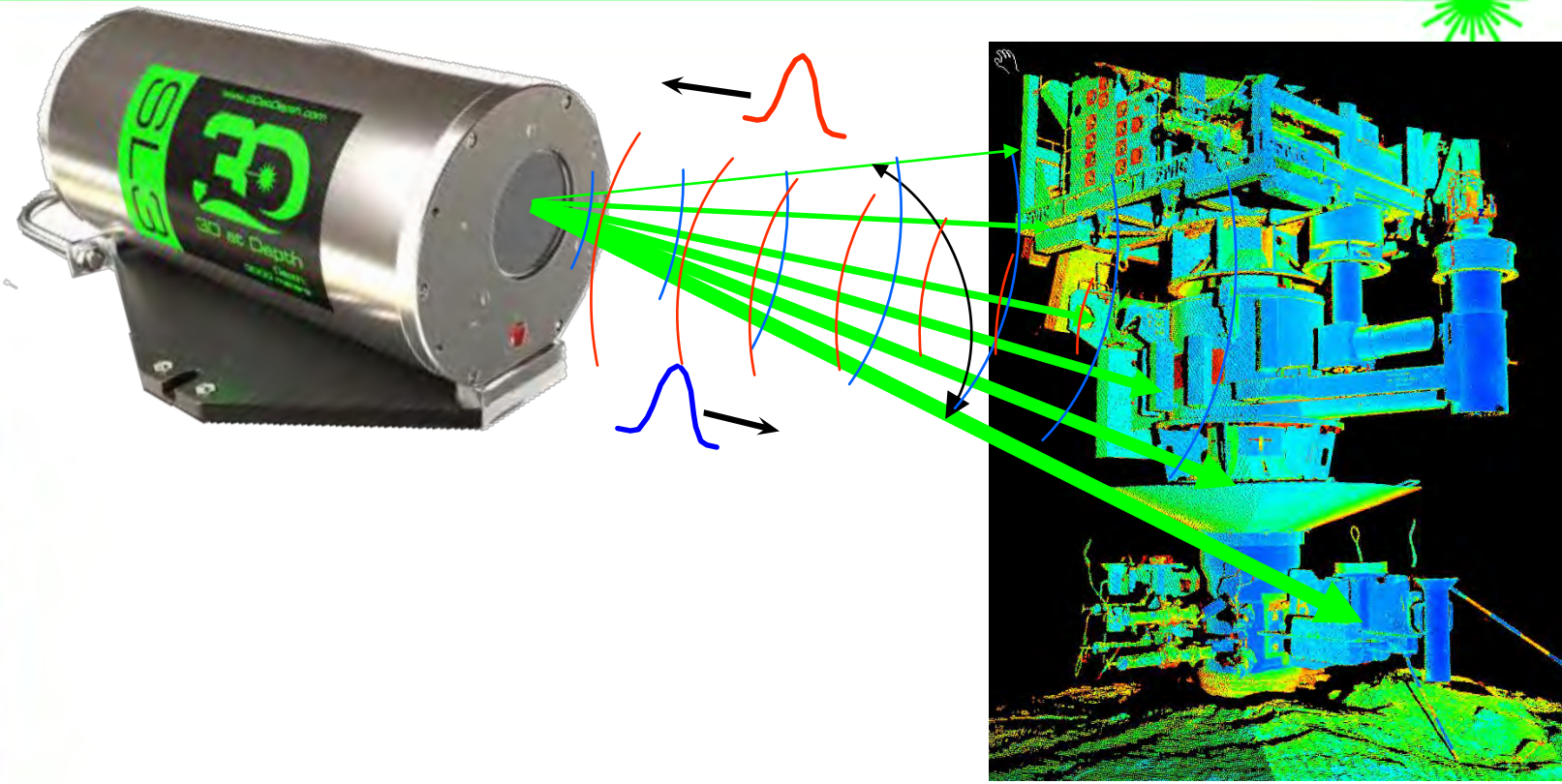
3D at Depth

SUBSEA LIDAR



Presented by: Neil Manning

PRINCIPLES OF LIDAR



1) Pulse of light is emitted at 40kHz and the precise time is recorded

2) **Light travels** in waves **(propagation)**

3) The reflection of that pulse is detected and the precise time is recorded

4) Using the constant speed of light, 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

TERRESTRIAL TRENDS – TAKEN SUBSEA

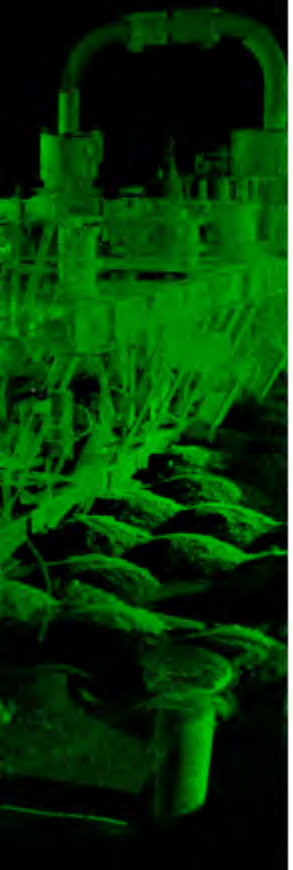
LIDAR APPLICATIONS

THE COMPANY

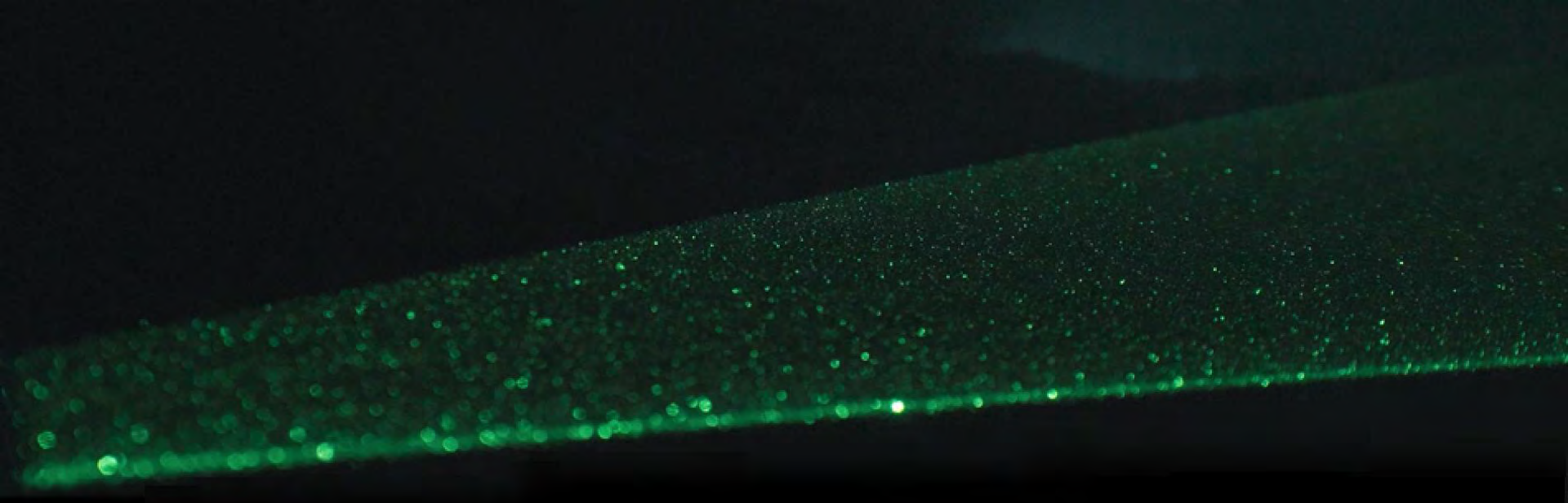
- Longmont, Colorado (HQ)
- Houston, Texas
- Norwich, UK
- Perth, Western Australia

WHO WE WORK FOR

Below is a list of repeat customers and IOC's whom have used the technology on more than a single occasion.



3D at Depth



DIFFERENTIATING TECHNOLOGY

INDEX OF REFRACTION

WHAT IS INDEX OF REFRACTION

- The ratio of the speed of an electromagnetic wave (light) in a vacuum to that in matter is known as the Refractive Index, or Index of Refraction

$$n = \frac{c}{v}$$

Where;

n = the index of refraction

c = the speed of light in a vacuum,

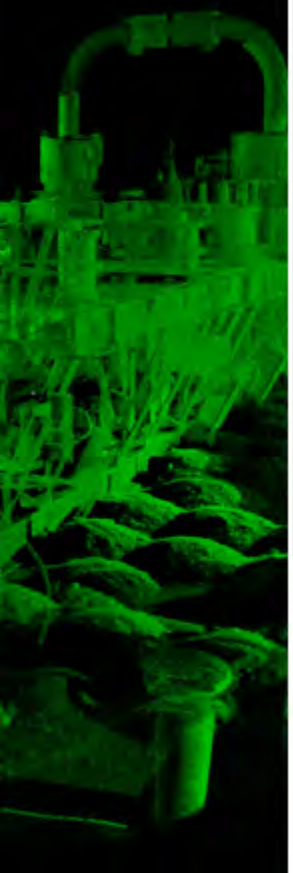
v = the phase velocity of light in the medium (matter)

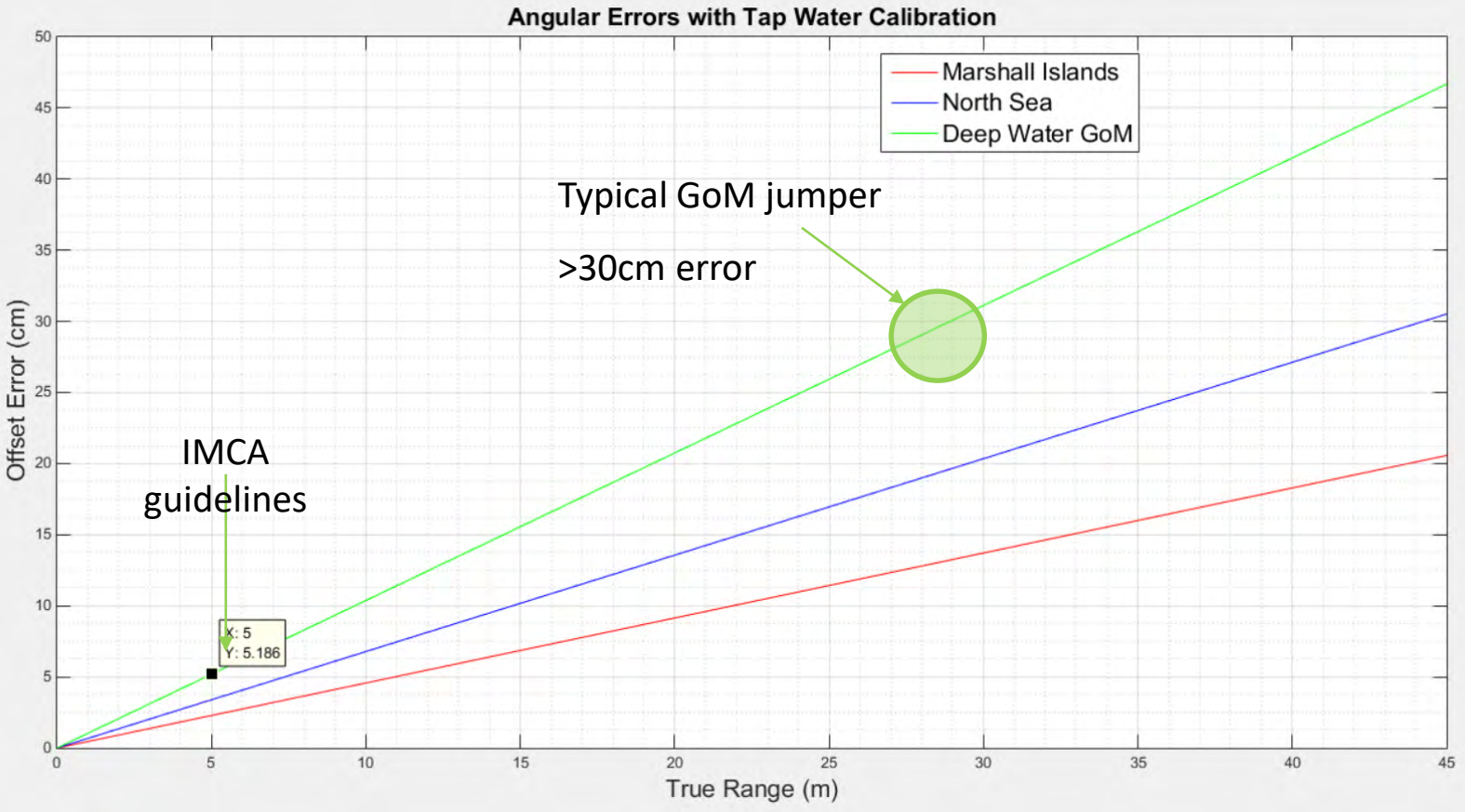
As the speed of light is faster in a vacuum than in matter, the refractive index is larger than 1.

- The speed of light in a vacuum is approximately 299,792.5 km / sec
- The index of refraction for the atmosphere is approximately n = 1.00029 at standard atmospheric temperature and pressure
- **Just like sound velocity, the index of refraction is dependent upon the temperature, pressure, and salinity of the water, along with the wavelength of light.**

Thomas Young was presumably the person who first used, and invented, the name "index of refraction", in 1807.

ANGULAR ERRORS IN A SINGLE DIMENSION DUE TO TAP WATER CALIBRATION IN LAB – ASSUMES OTHER DIMENSION IS CORRECT





Over 51 mm error at 5 meter range in the Gulf of Mexico (GoM) when assuming error in only one dimension

PATENT PROTECTED

3D at Depth owns two issued patents on methods for compensating for the index of refractions when making measurements in water

Issued US Patents

- 8,184,276 Continuous index of refraction compensation method for measurements in a medium
- 8,467,044 Continuous index of refraction compensation method for measurements in a medium

US008184276B2

(12) **United States Patent**
Embry

(10) **Patent No.: US 8,184,276 B2**
(45) **Date of Patent: May 22, 2012**

(54) **CONTINUOUS INDEX OF REFRACTION COMPENSATION METHOD FOR MEASUREMENTS IN A MEDIUM**

5,309,288	A	5/1994	Kahre
5,34			
5,44			
5,45			

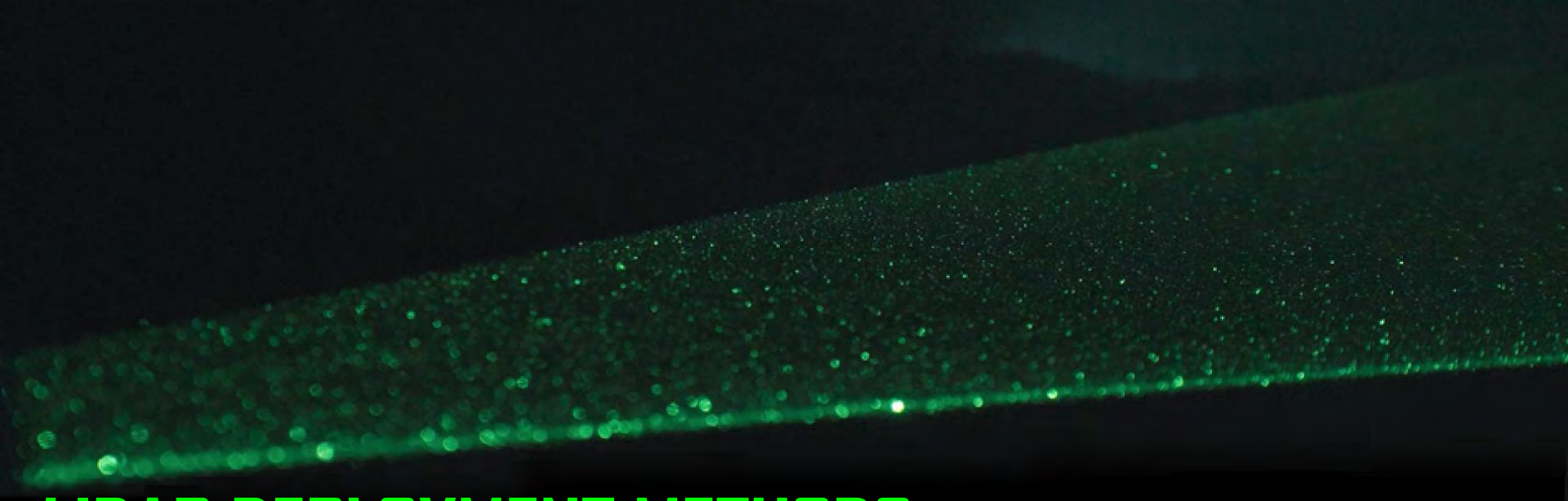
US008467044B2

(12) **United States Patent**
Embry

(10) **Patent No.: US 8,467,044 B2**
(45) **Date of Patent: Jun. 18, 2013**

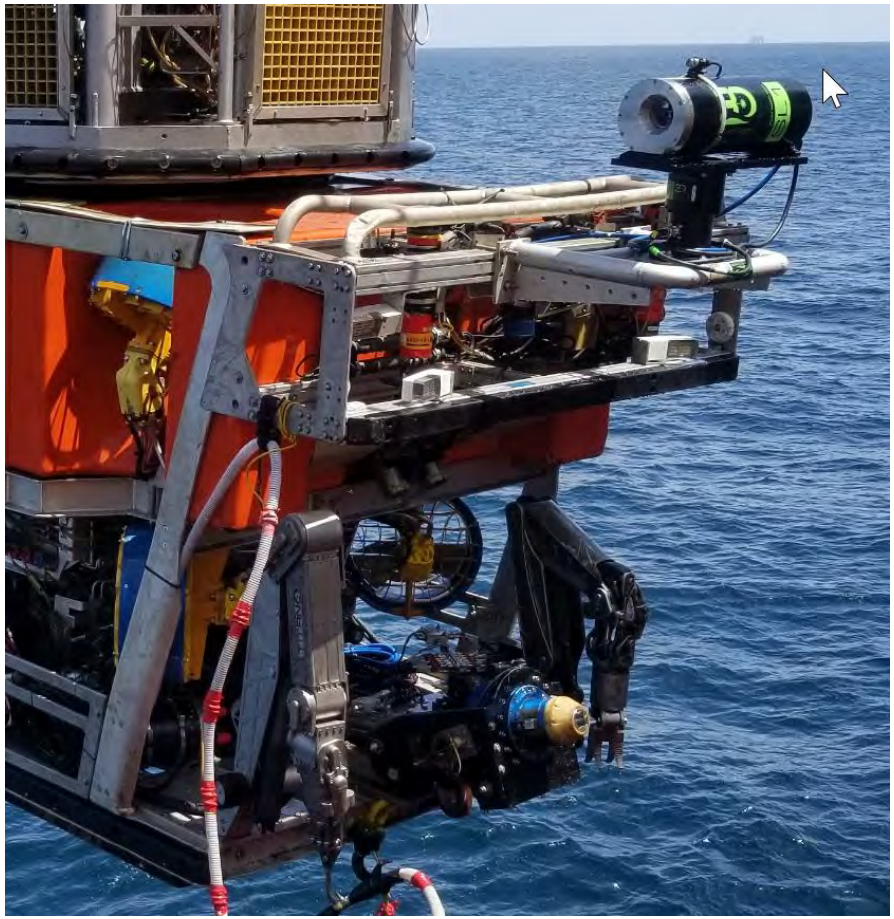
(54) **CONTINUOUS INDEX OF REFRACTION COMPENSATION METHOD FOR MEASUREMENTS IN A MEDIUM**

5,309,288	A	5/1994	Kahre
5,343,284	A	8/1994	Keeler et al.
5,446,529	A	8/1995	Stettner et al.
5,457,639	A	10/1995	Ulich et al.



LIDAR DEPLOYMENT METHODS

ROV & DIVER DEPLOYED SOLUTIONS (STATIC)



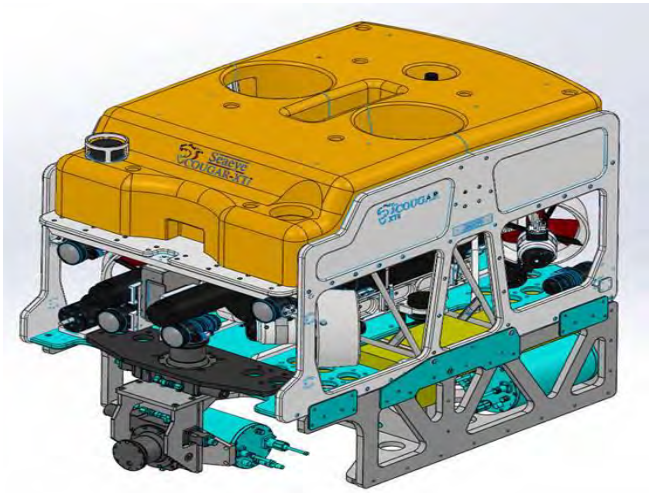
Working Class ROV

Diver Frame with
250m Umbilical

SMALL TO LARGE PLATFORMS (DYNAMIC AND STATIC)

AUV (Autonomous Underwater Vehicle)

Inspection Class ROV

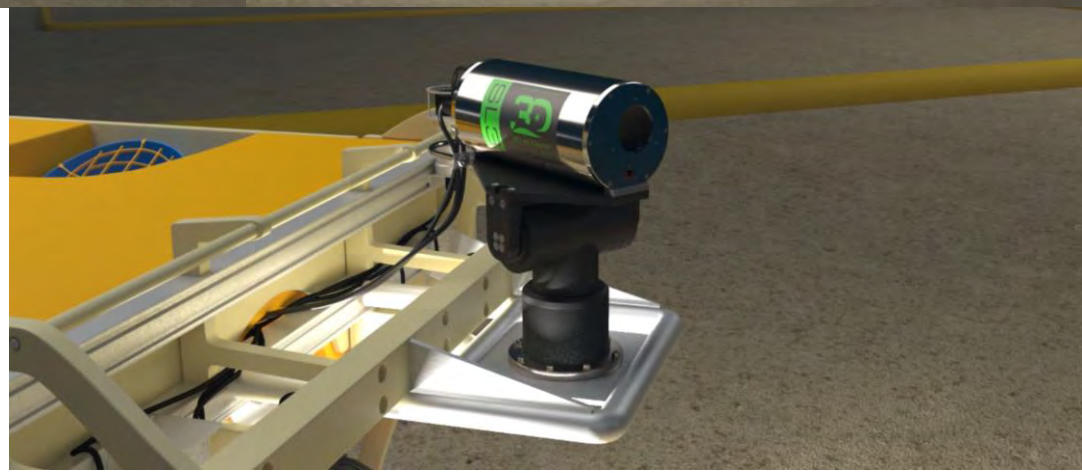


3D at Depth

COLLECTION METHODS

STATIC LIDAR ACQUISITION METHOD

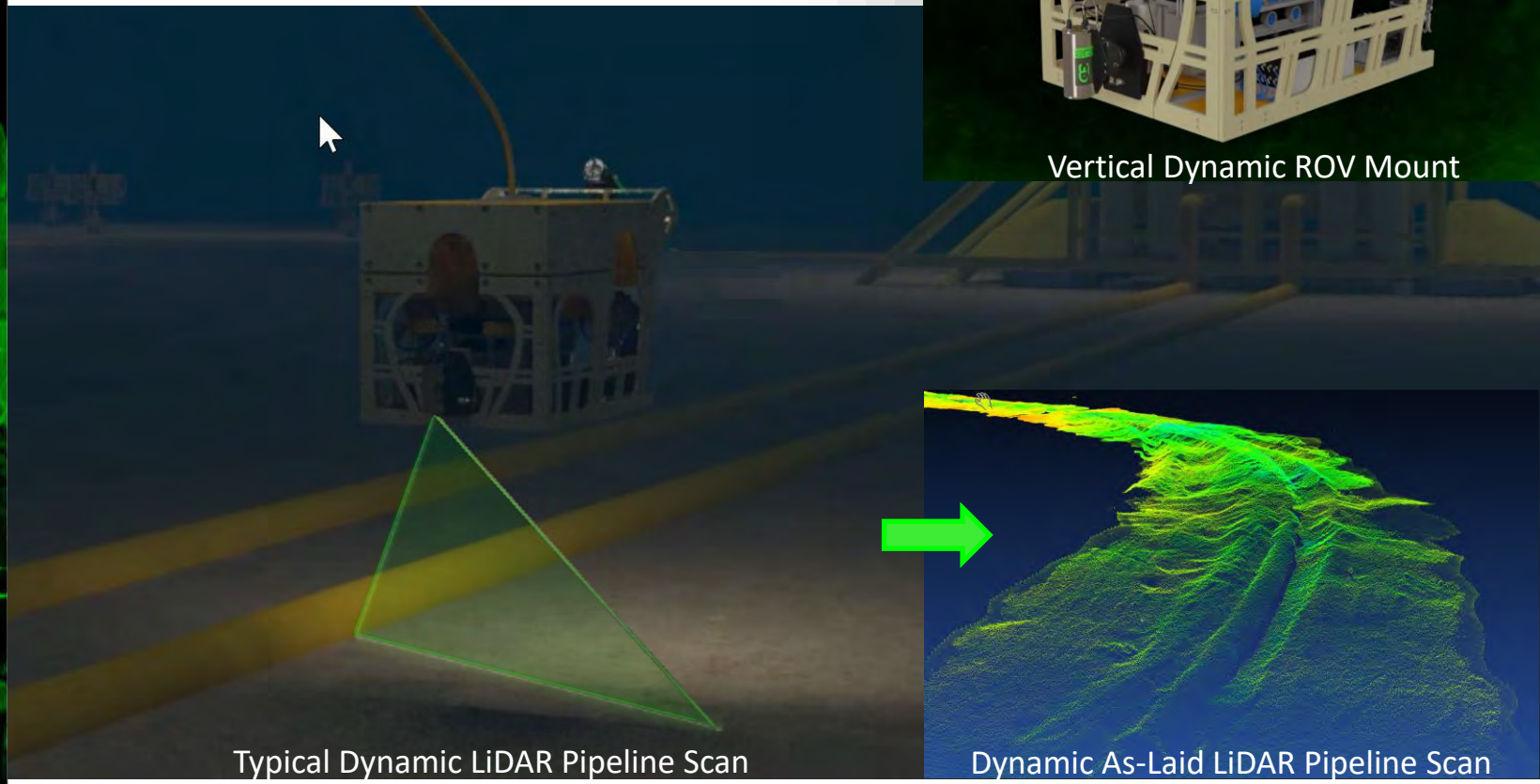
- **Static Scanning (ROV)**
  - Stationary and Touchless
  - Stable platform
  - No corrections needed
  - No external sensors required
  - Limited Range but higher point density



DYNAMIC LIDAR ACQUISITION METHOD

- **Dynamic Scanning (Motion)**
  - Mobile and Touchless
  - Unlimited data collection
  - Greater coverage / less collection time
  - Additional sensors required (INS, DVL & USBL/LBL)

Vertical Dynamic ROV Mount

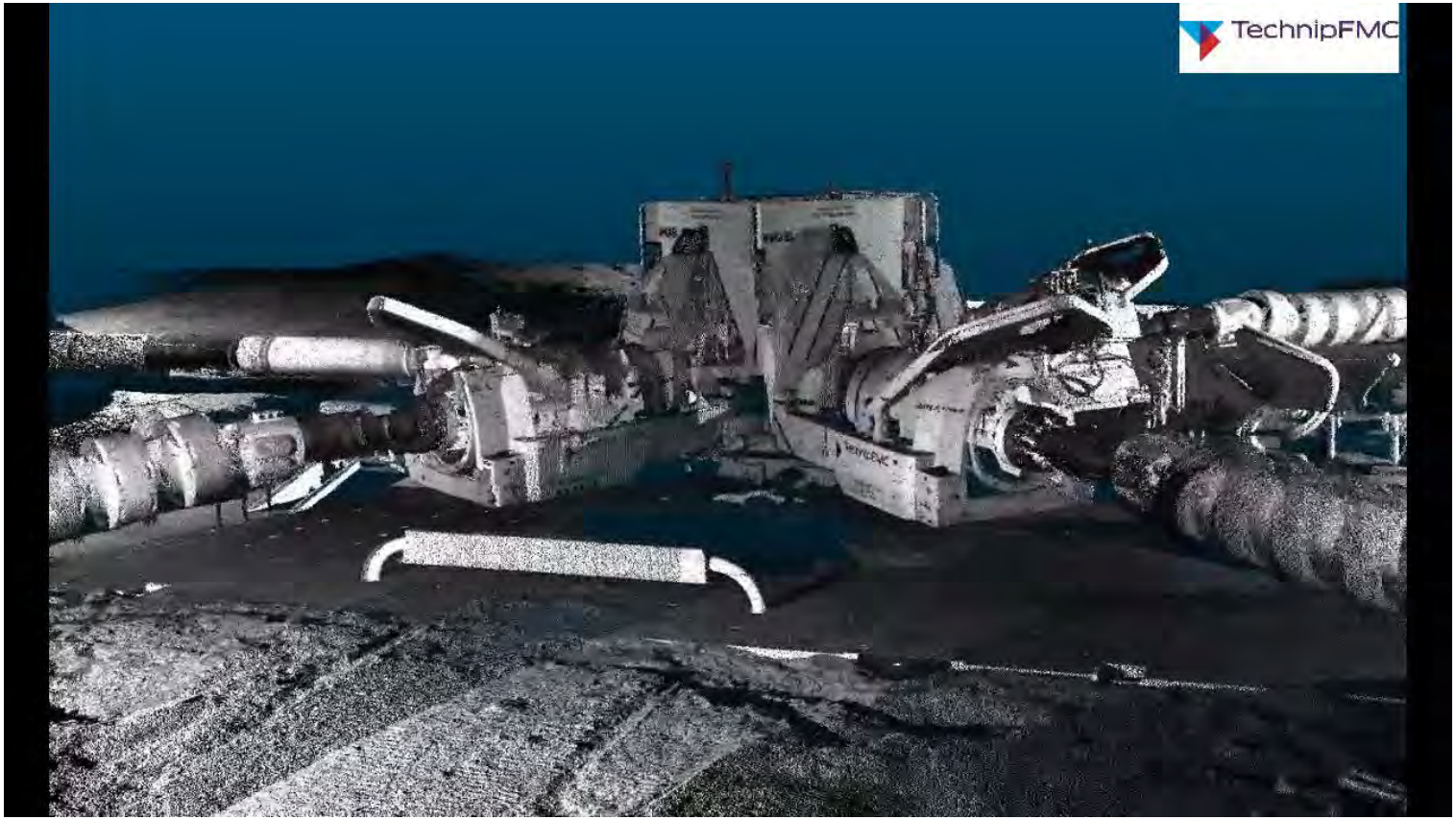


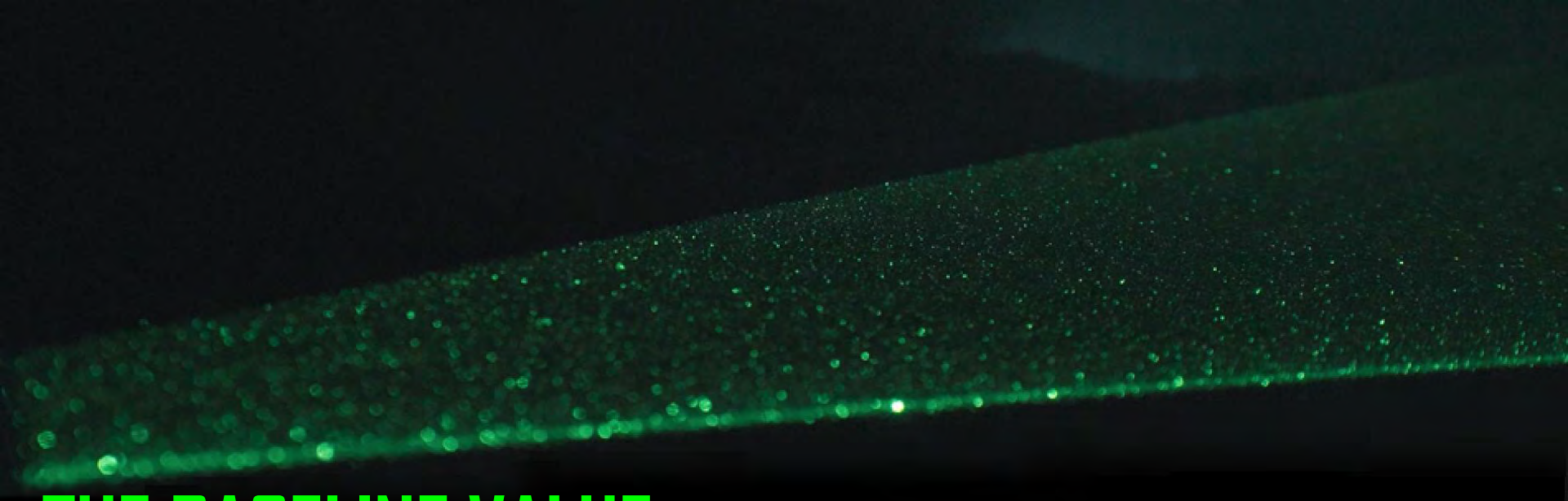
Typical Dynamic LiDAR Pipeline Scan

Dynamic As-Laid LiDAR Pipeline Scan

STATIC AND DYNAMIC DATA COLLECTION

3D AT DEPTH – REALTIME

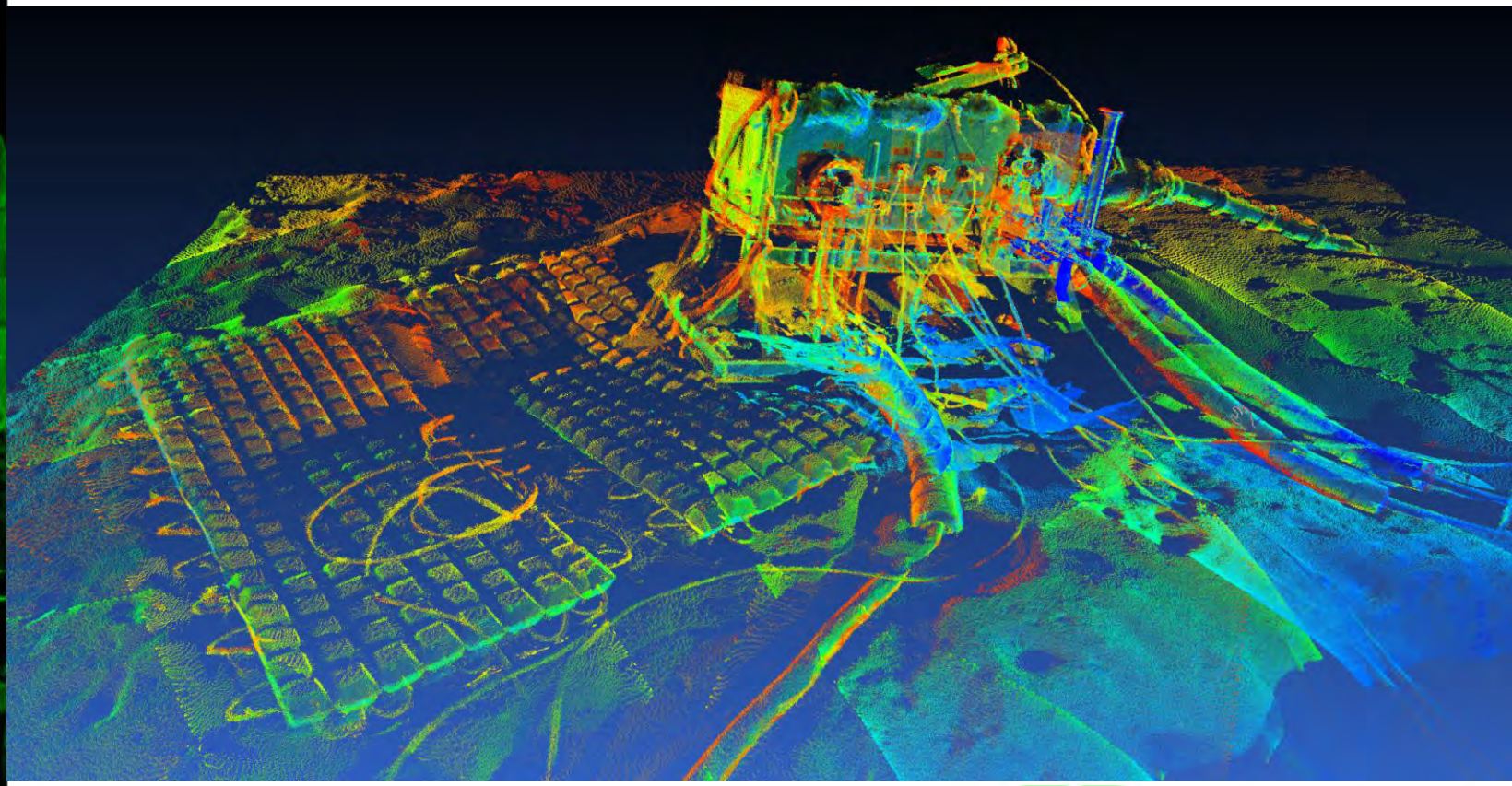




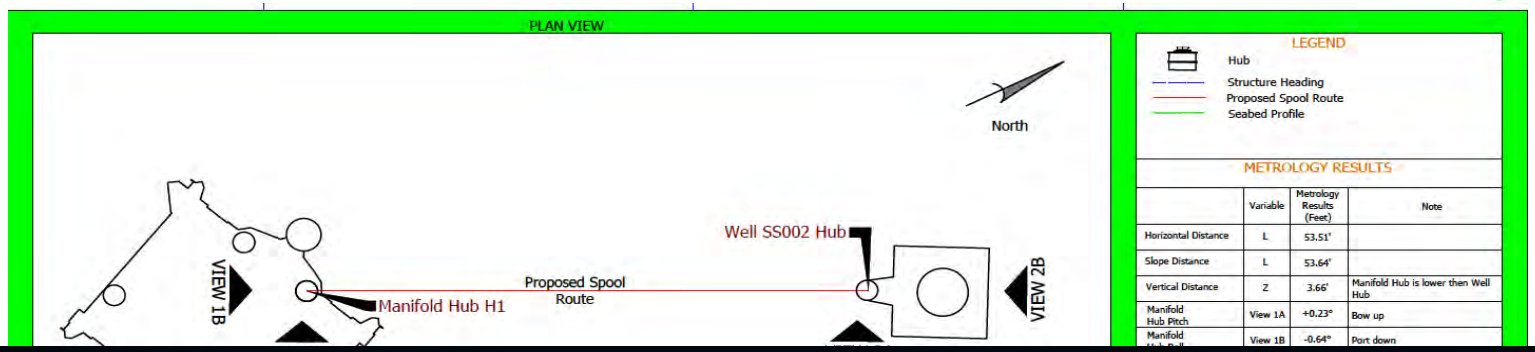
THE BASELINE VALUE

BENEFITS OF A LIDAR-BASED SOLUTION

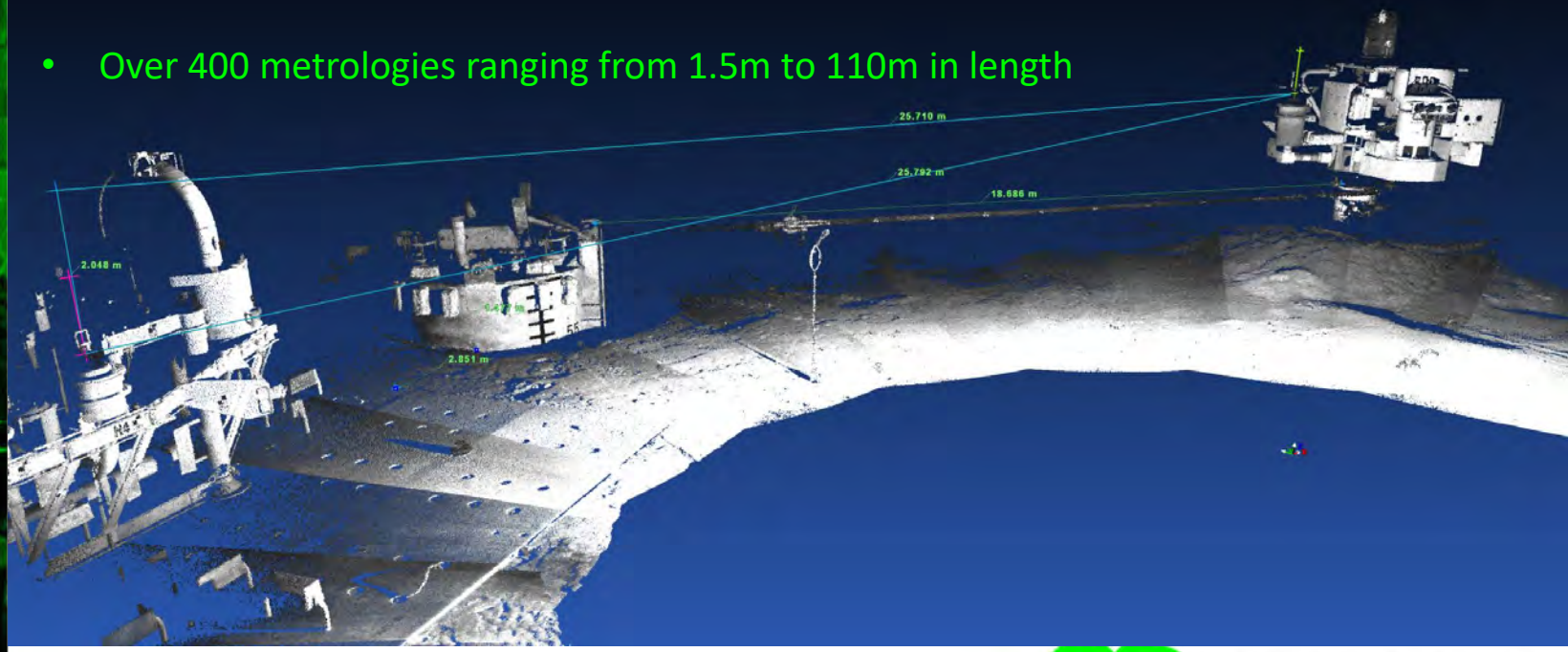
- Unparalleled accuracy in subsea imaging
- Faster turnaround of project data
- Increased safety to assets due to zero exposure to damage
- Decreased disruption of project environment “Touchless”
- Create Baseline Point Cloud Maps for annual movement/settlement comaprison



TRACK RECORD – OFFERING VISIBLE VALUE TO COMPLEX MEASUREMENTS

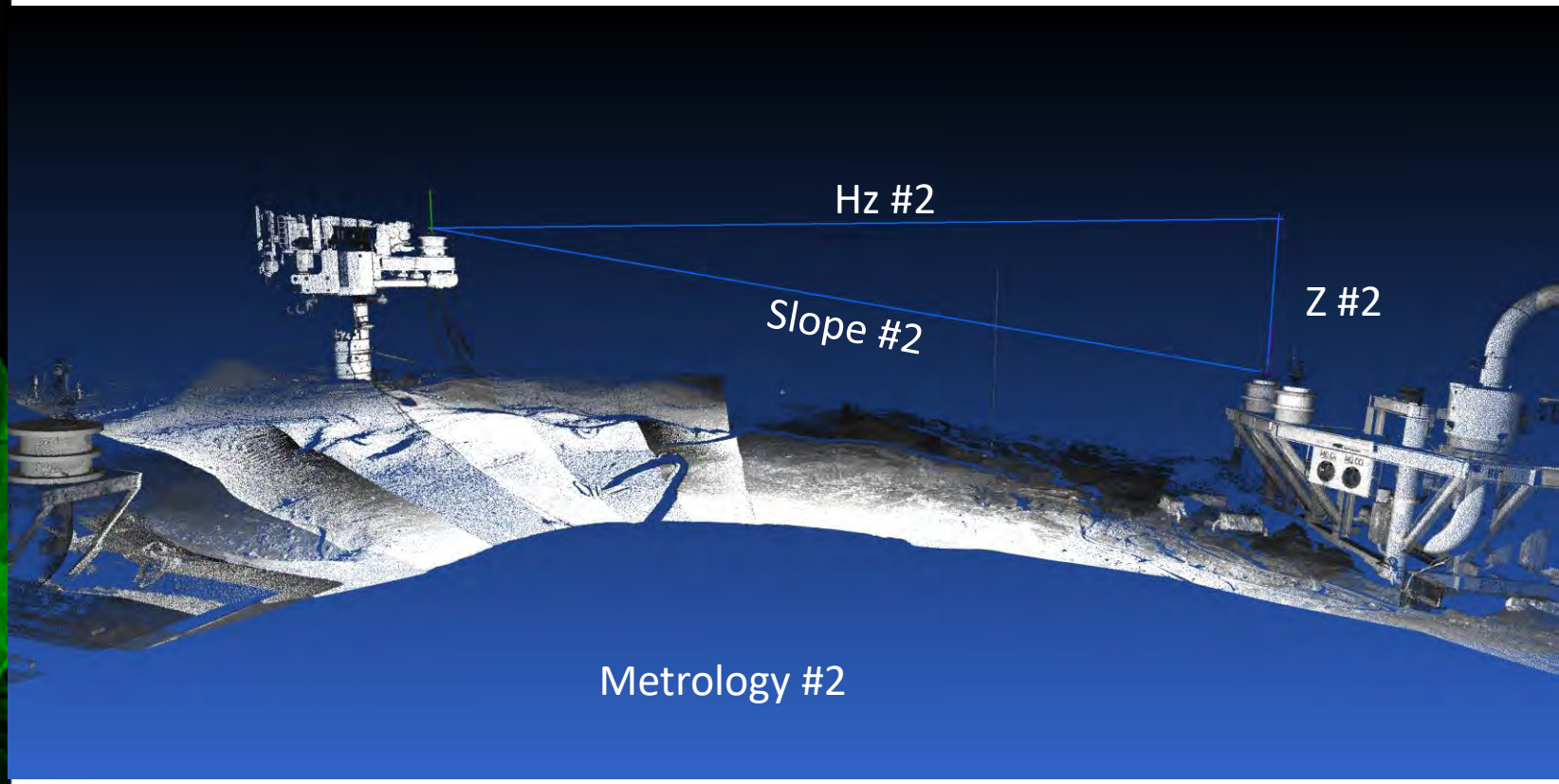


- 200 individual offshore projects ranging from 9m to 4000m water depths
- Over 400 metrologies ranging from 1.5m to 110m in length



3D at Depth

LONGER RANGE EQUALS MORE DATA COLLECTED

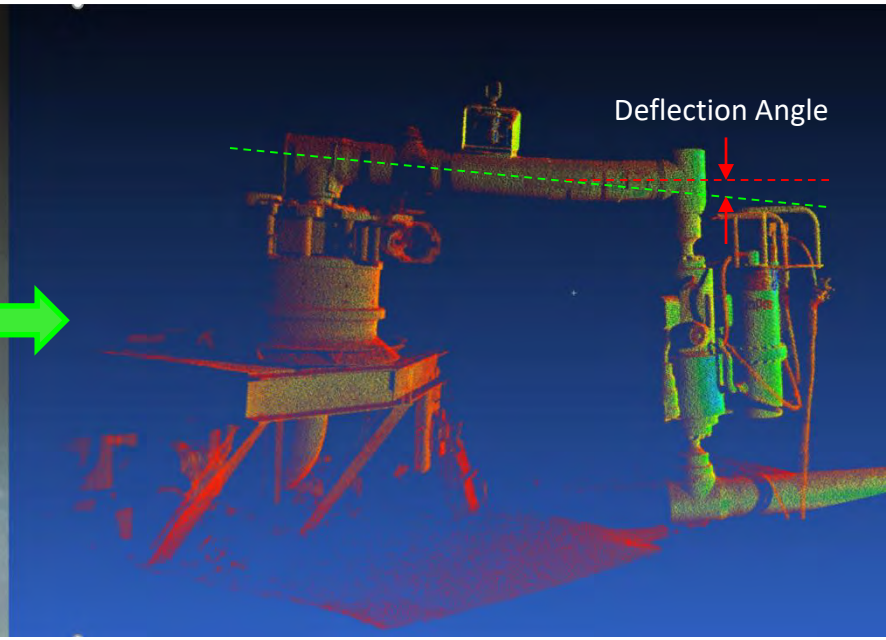


ONE SCAN POSITION / 2 X METROLOGY COLLECTED IN 1.5 HOURS

3D at Depth

DATA ANALYTICS

- Measurable data available to engineers to help analyze and form corrective actions
- Allows for accurate analysis from quantifiable data rather then “best guessing” from ROV video and photographs.

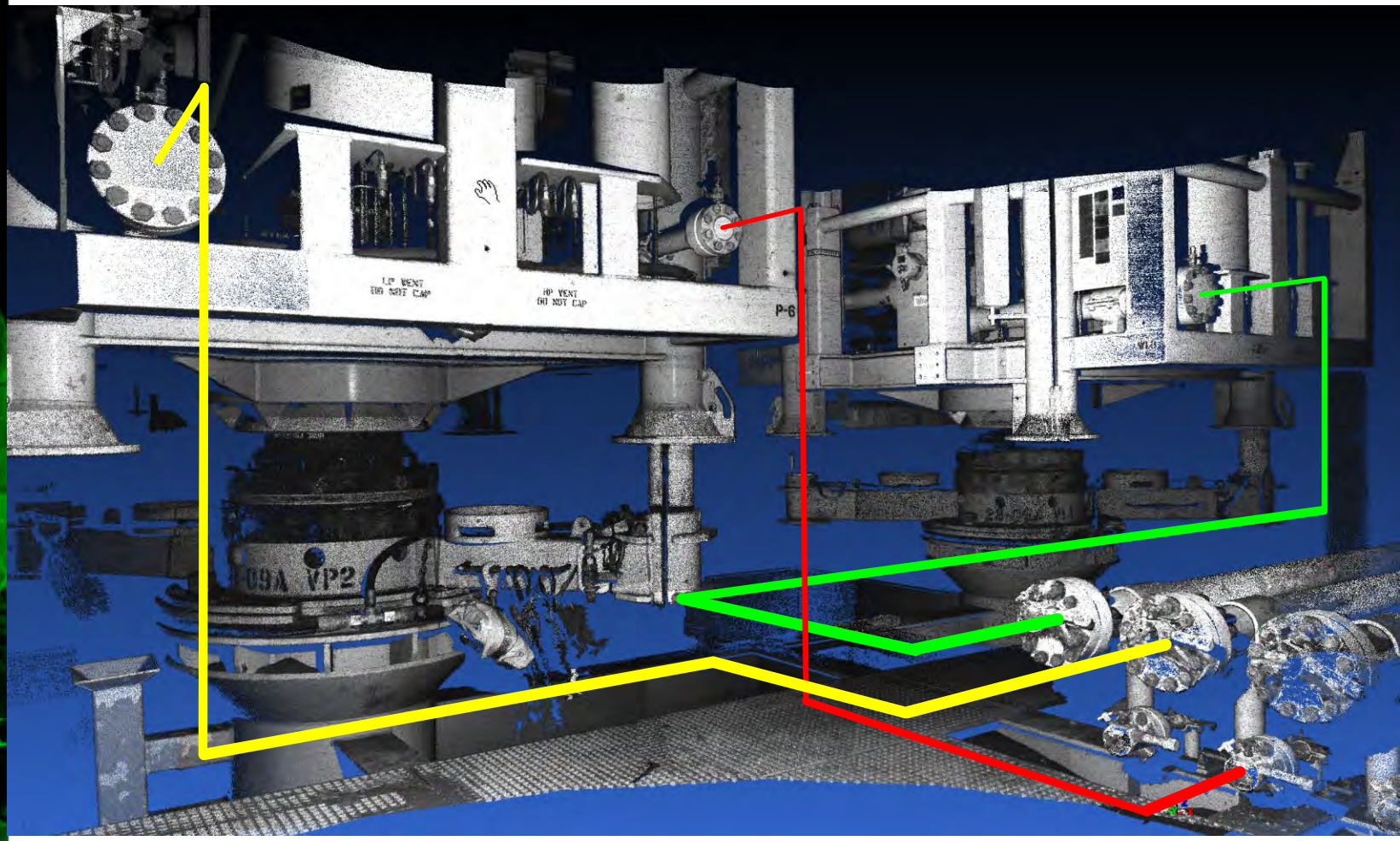


ROV Video

LiDAR derived point-cloud

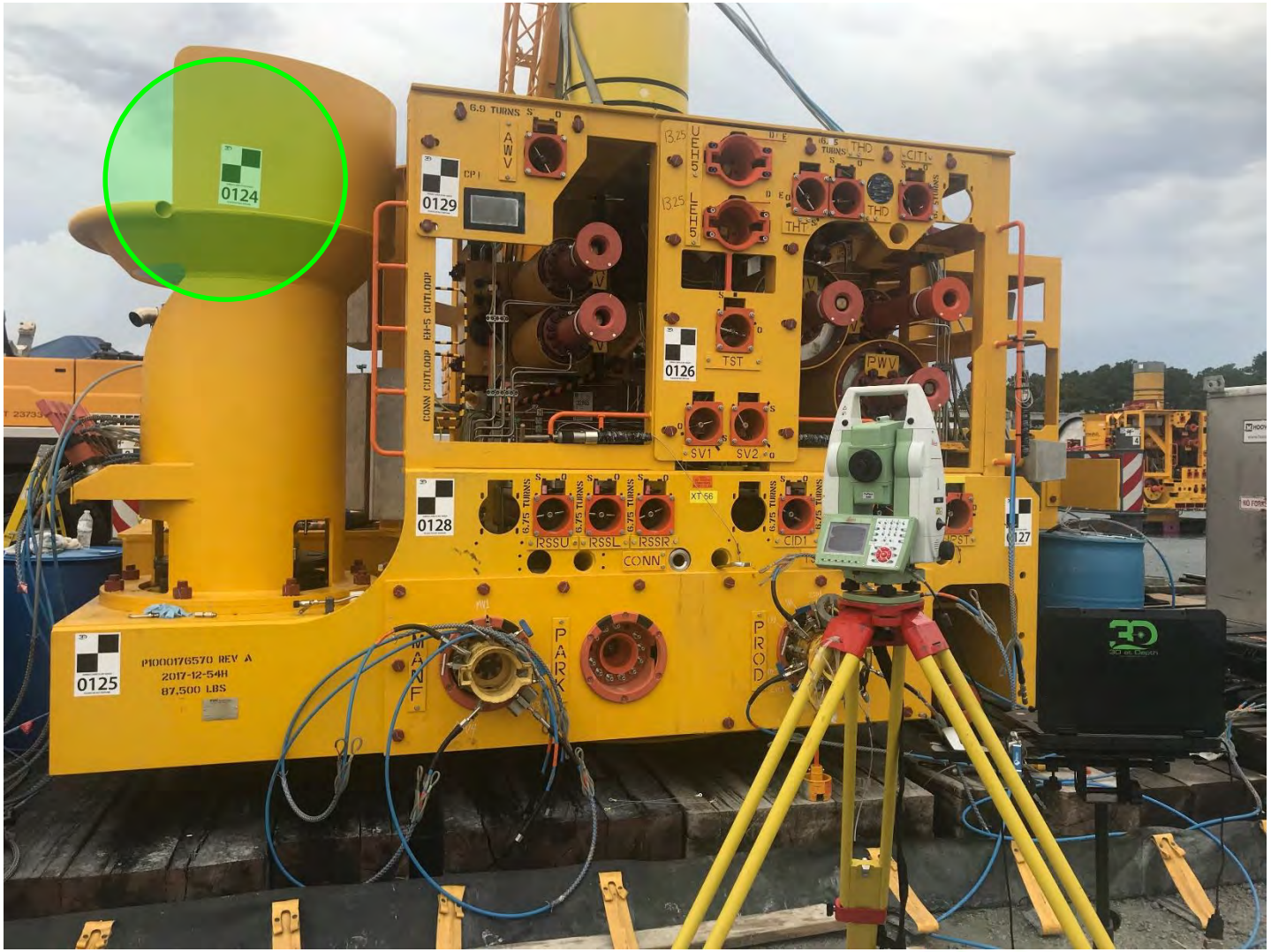
3D at Depth

MULTIPLE MEASUREMENTS FROM A SINGLE SCAN



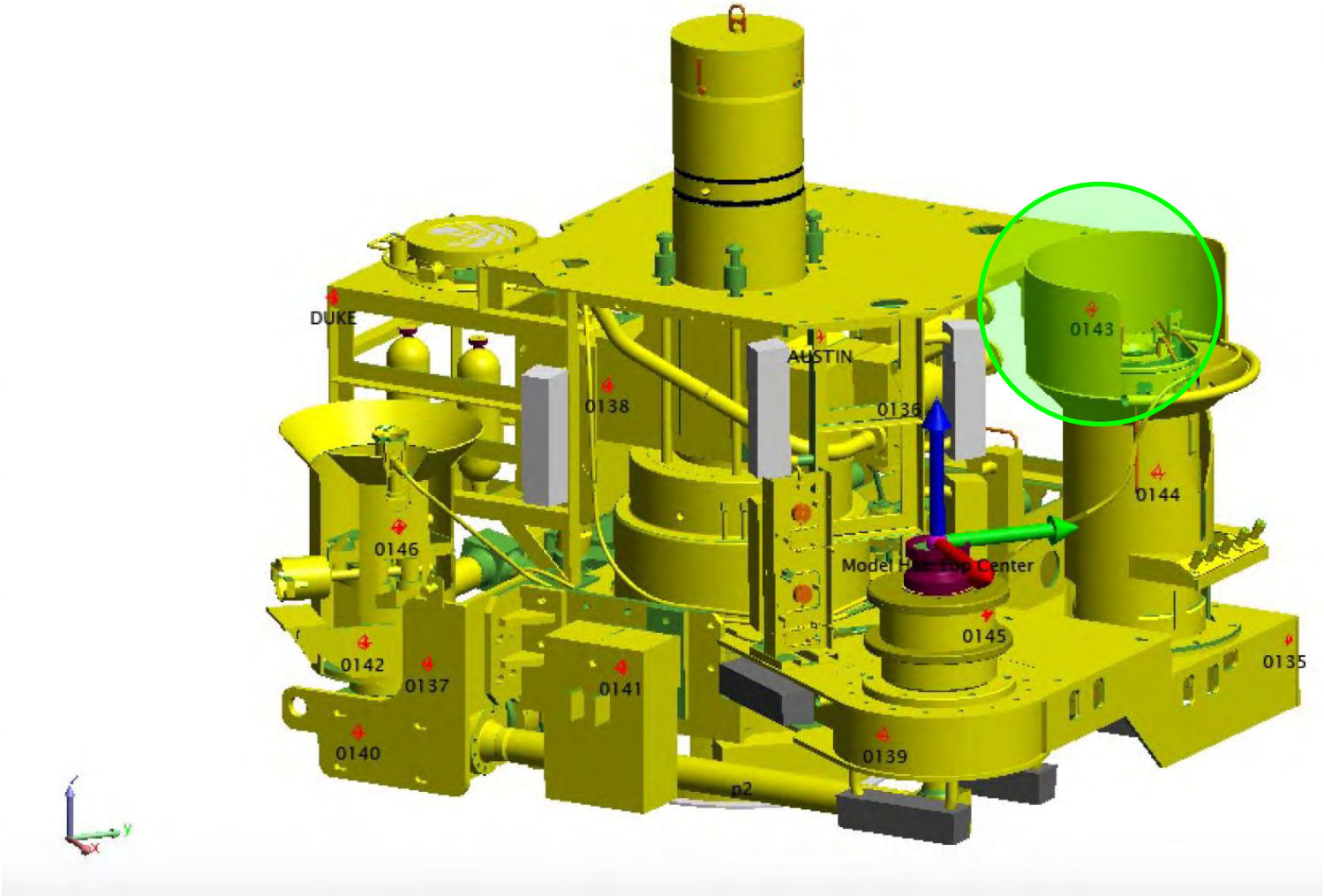
DIMENSIONAL CONTROL

TERRESTRIAL DIMENSIONAL CONTROL

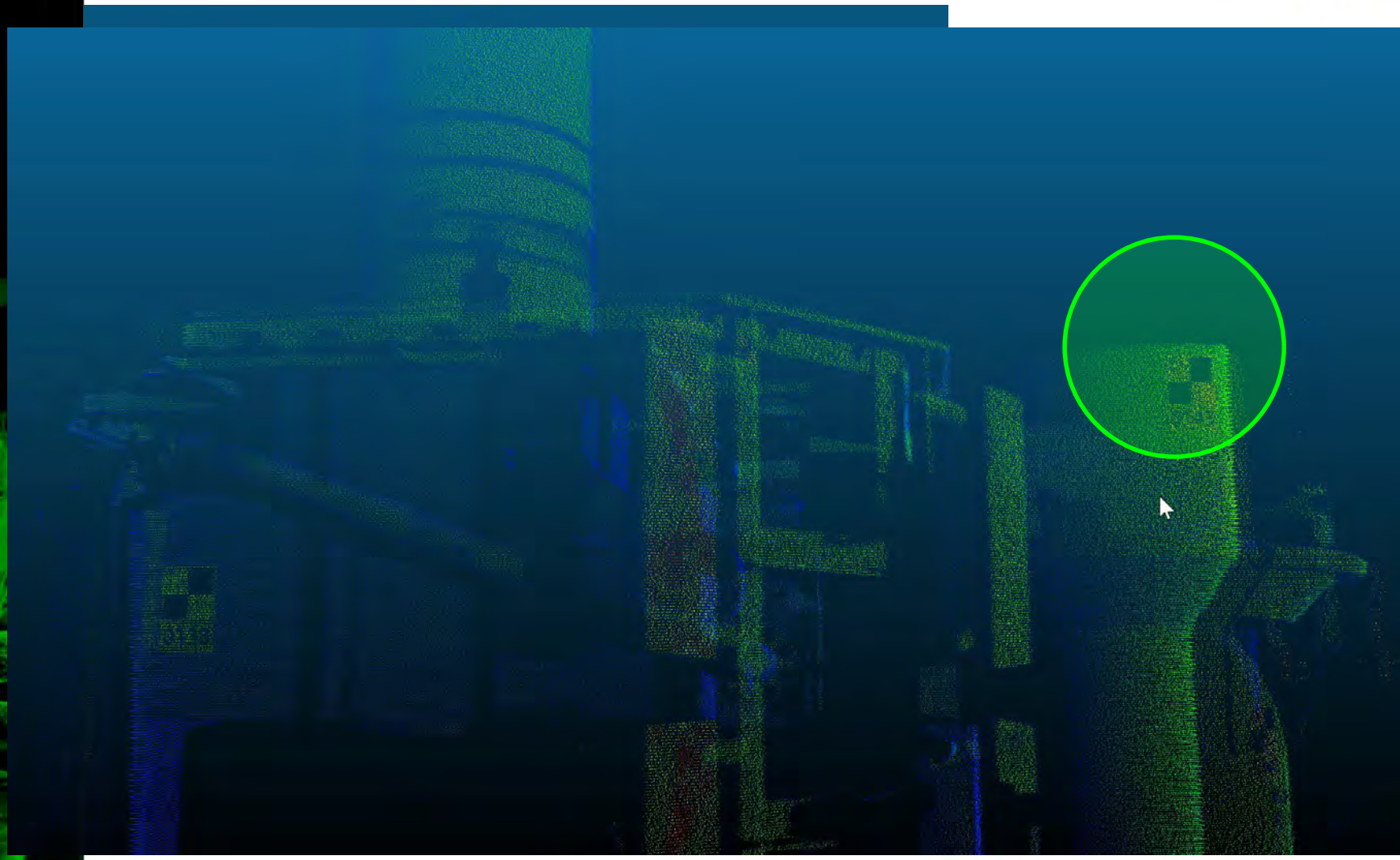


3D at Depth

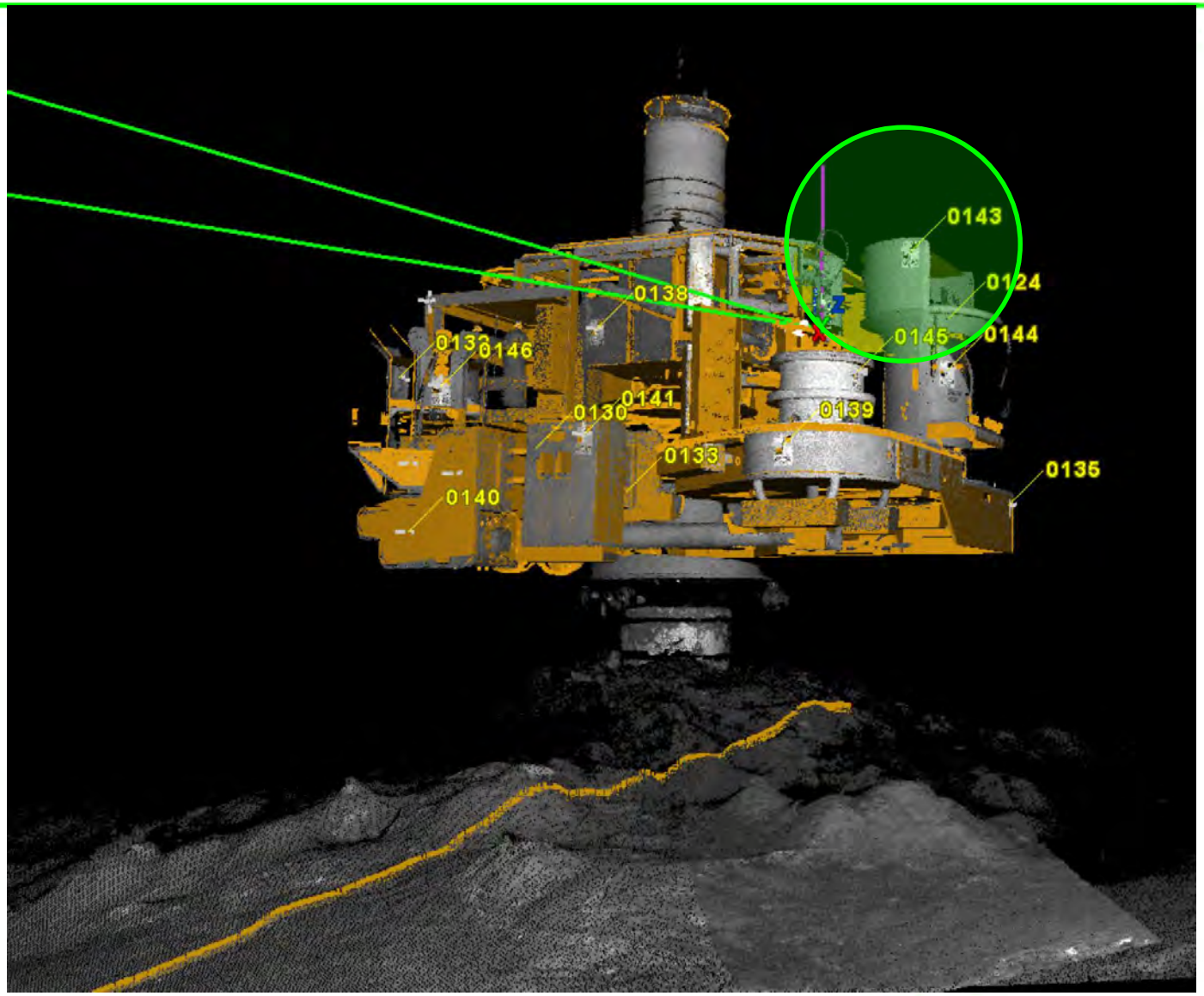
DC POINTS ADDED TO 3D CAD MODEL



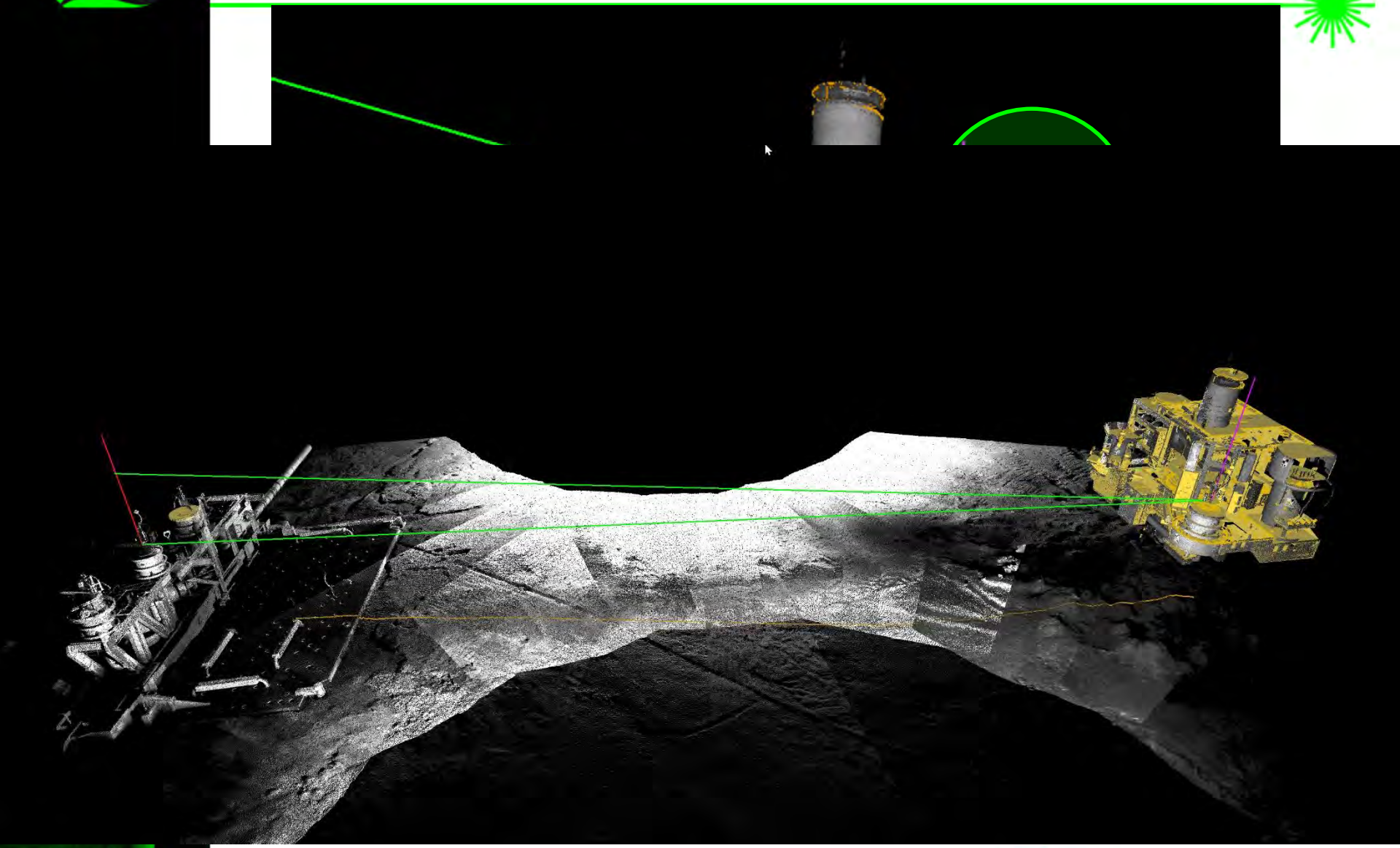
CONTROL POINTS SUBSEA LIDAR SCAN



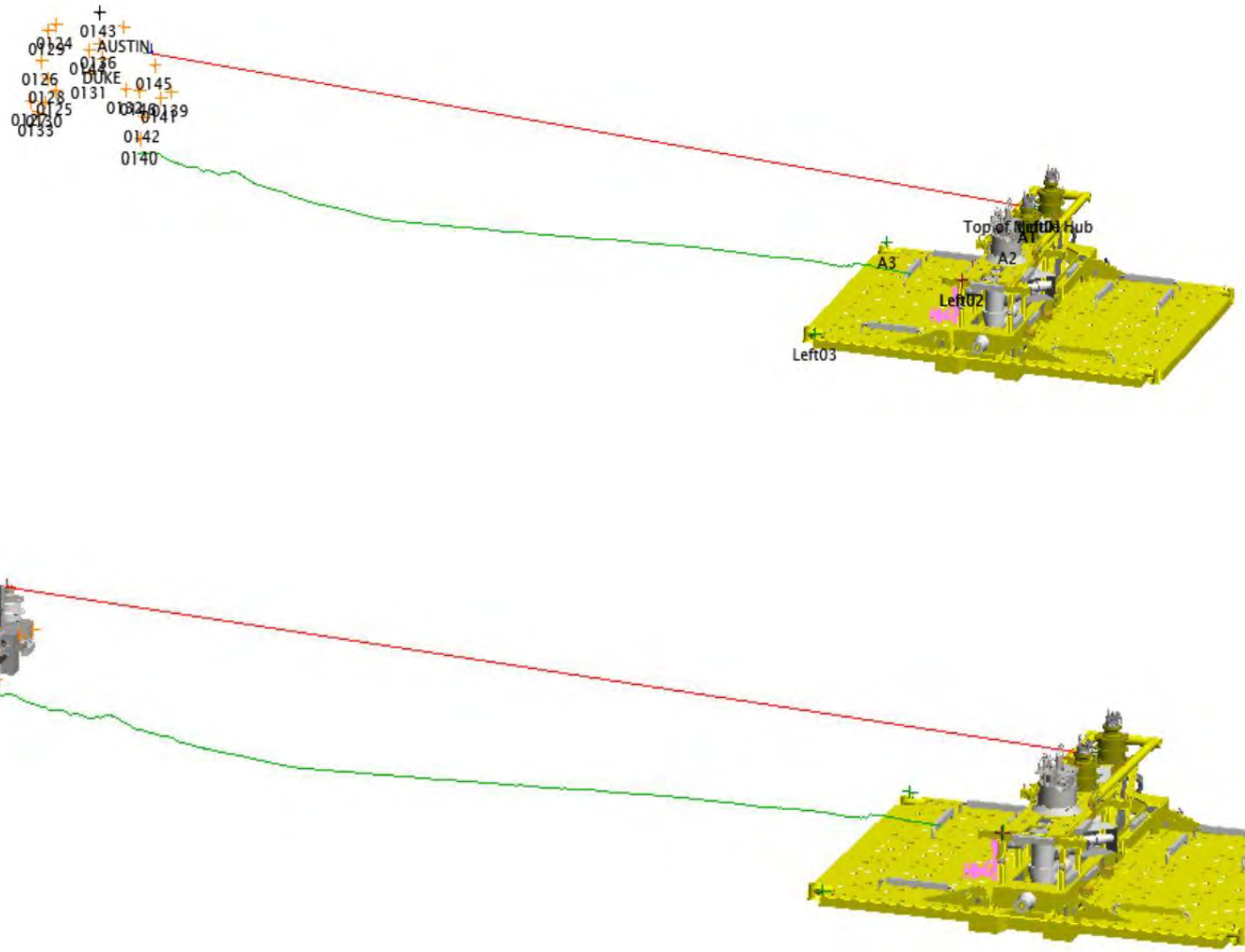
3D CAD TO POINT CLOUD REGISTERED



3D CAD TO POINT CLOUD REGISTERED

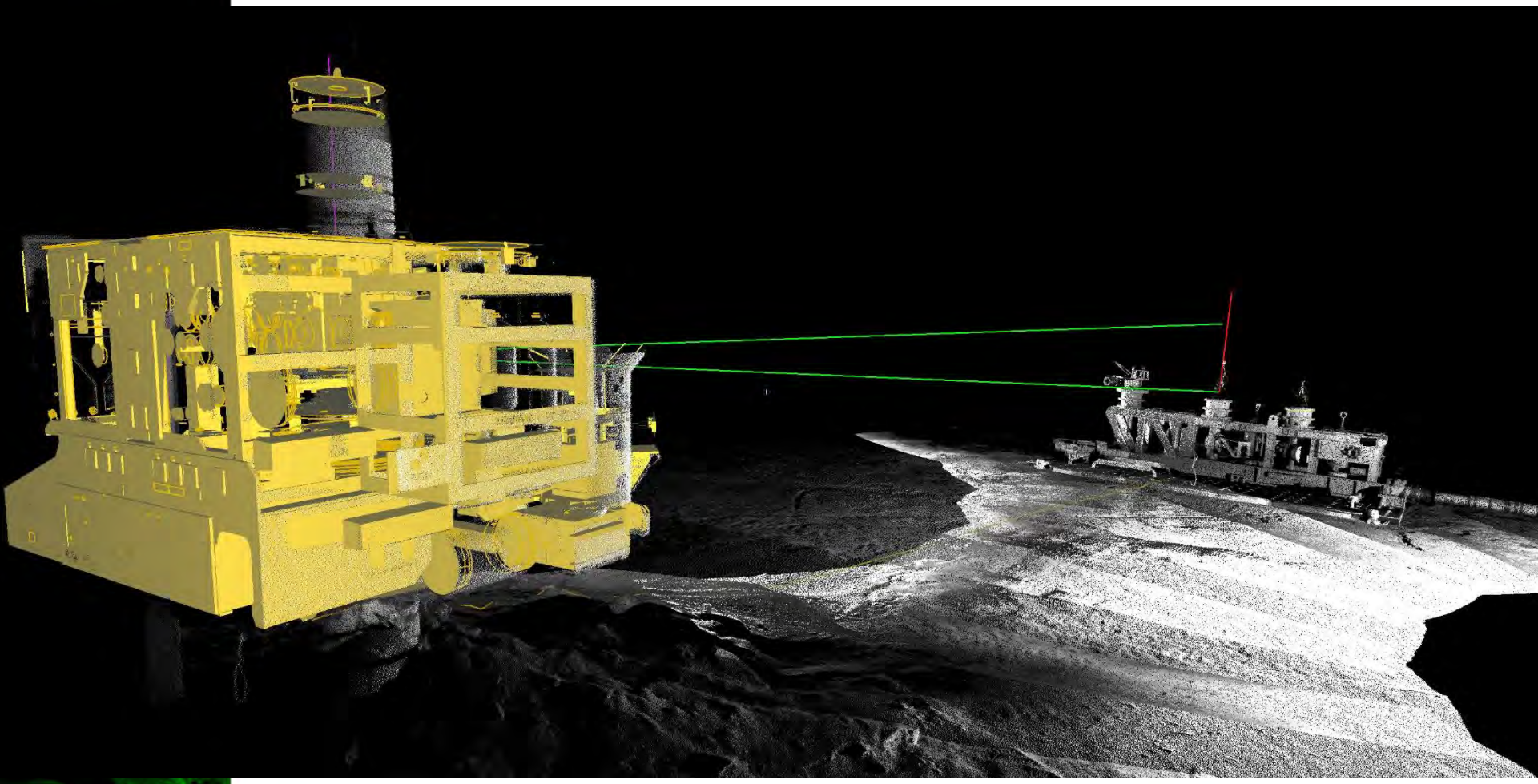


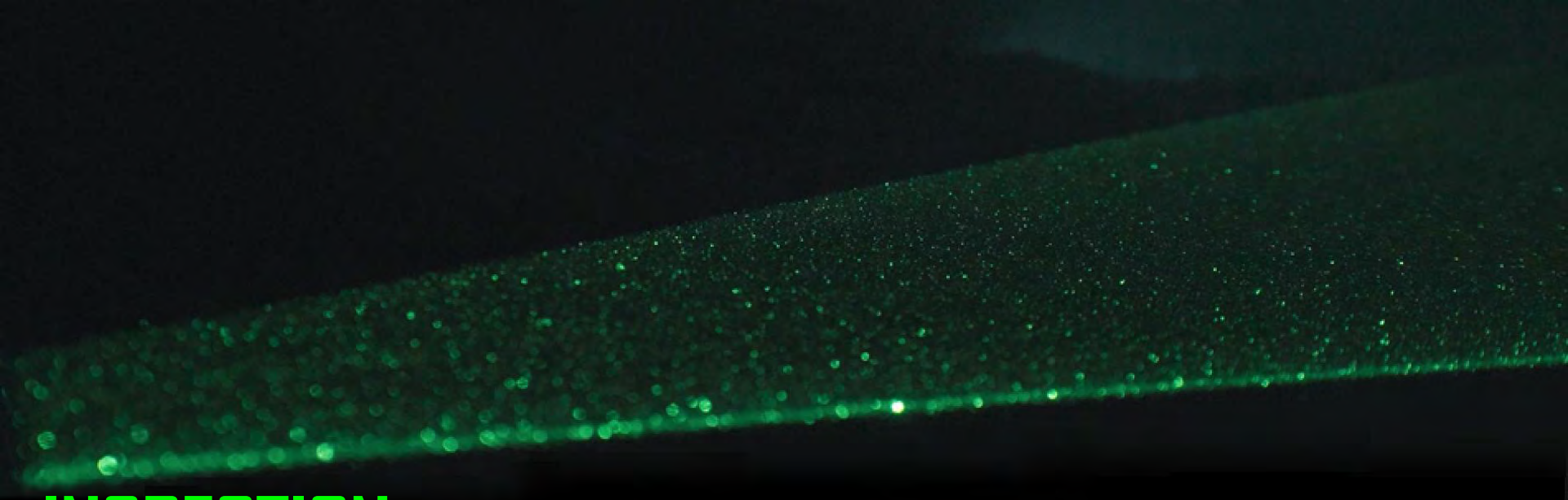
DIMCON POINTS GEO LOCATED WITH PROFILE



3D at Depth

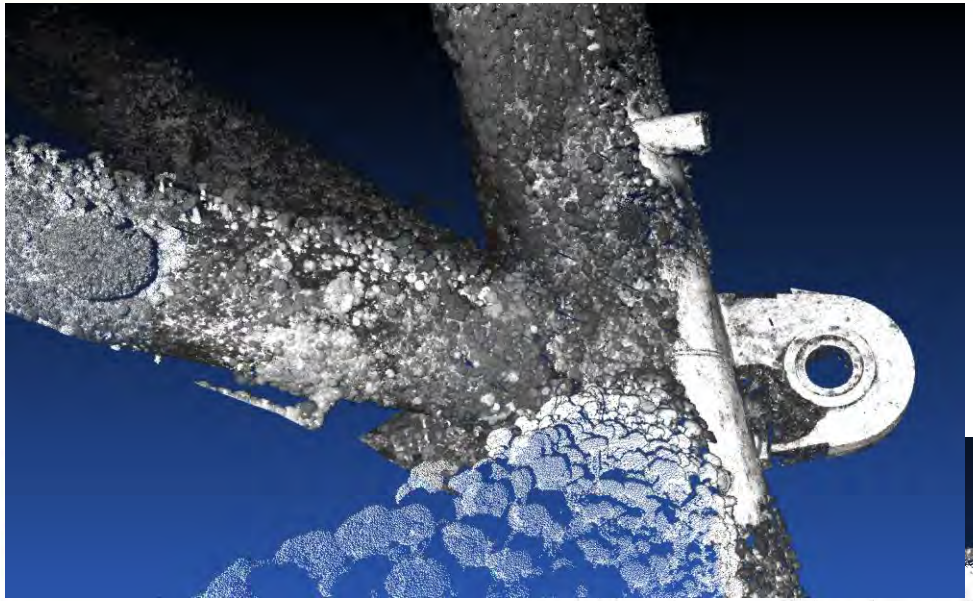
MOVING TO A DIGITAL TWIN





INSPECTION

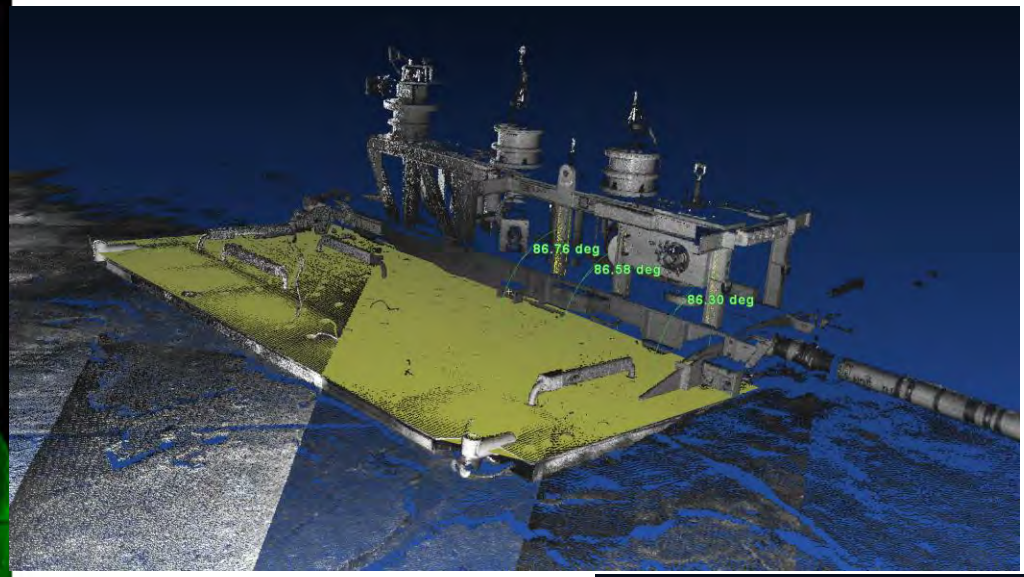
DETAILED POINT CLOUDS



- Millimetric measurements for any engineering requirement

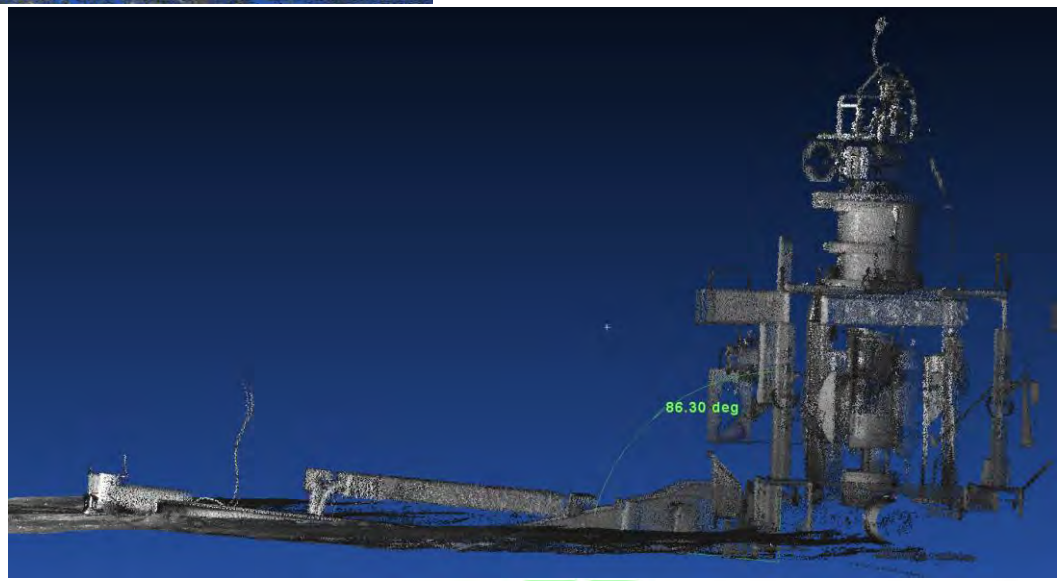
- Marine growth
- Anode life
- Debris location
- Asset settlement
- Damage assessment

ANGULAR MEASUREMENTS FROM ANY LOCATION

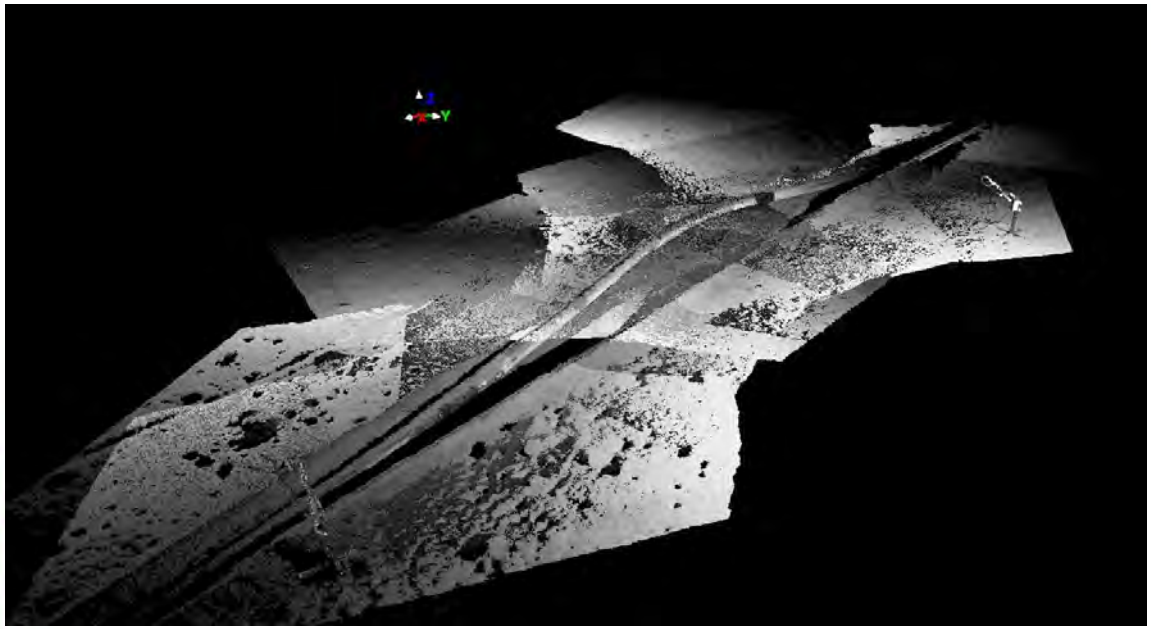


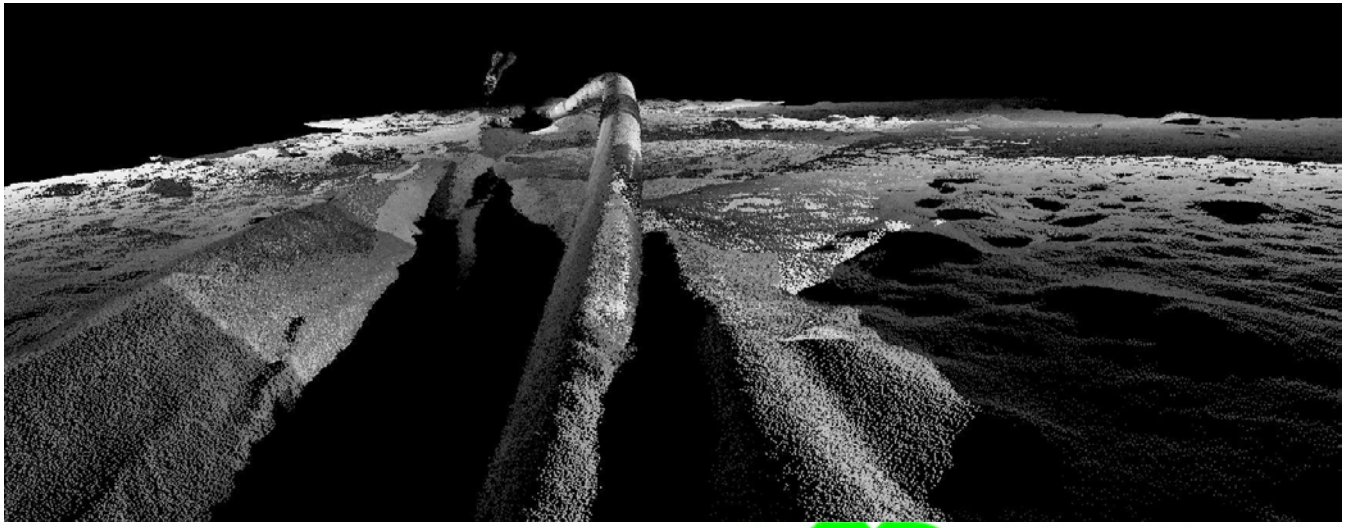
- Repeatable and accurate measurements

- Measurements you can rely on

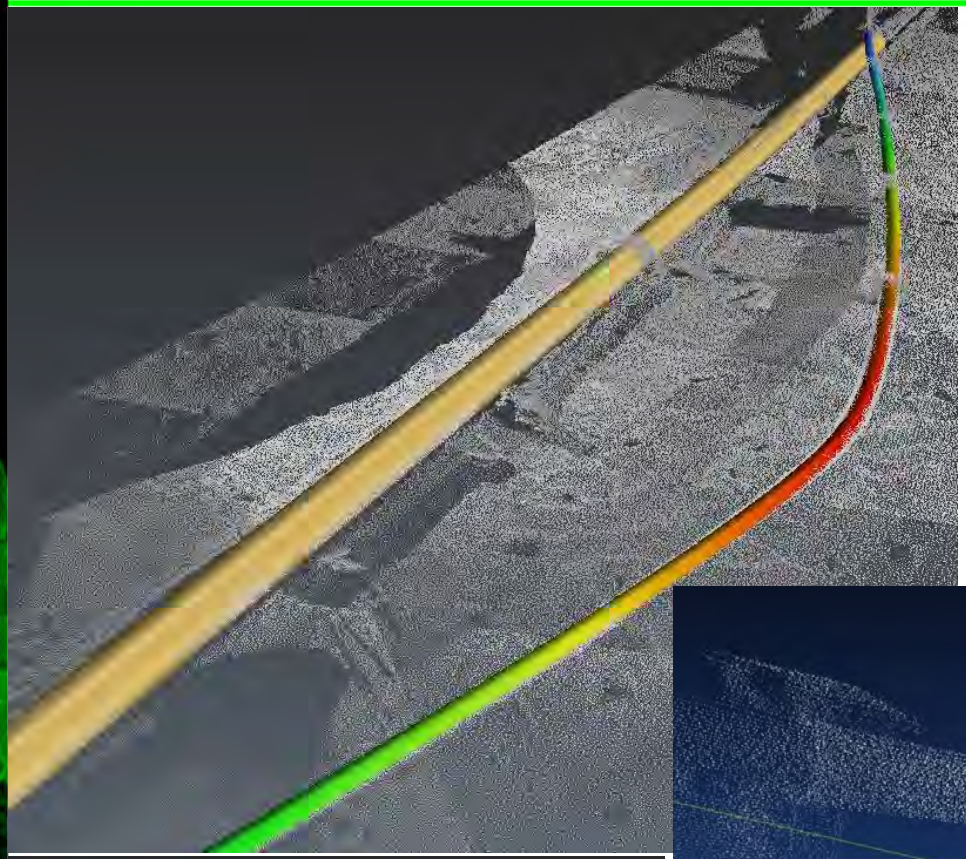


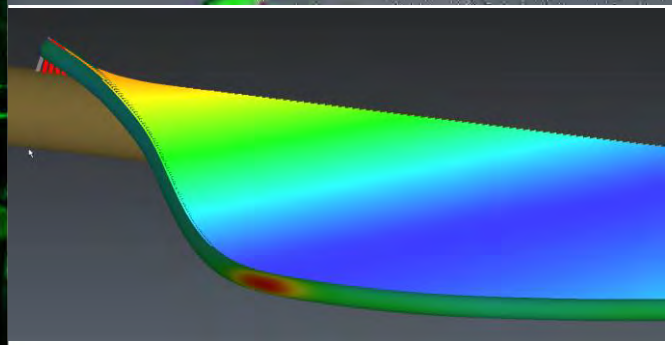
PIPELINE BUCKLE MEASUREMENT

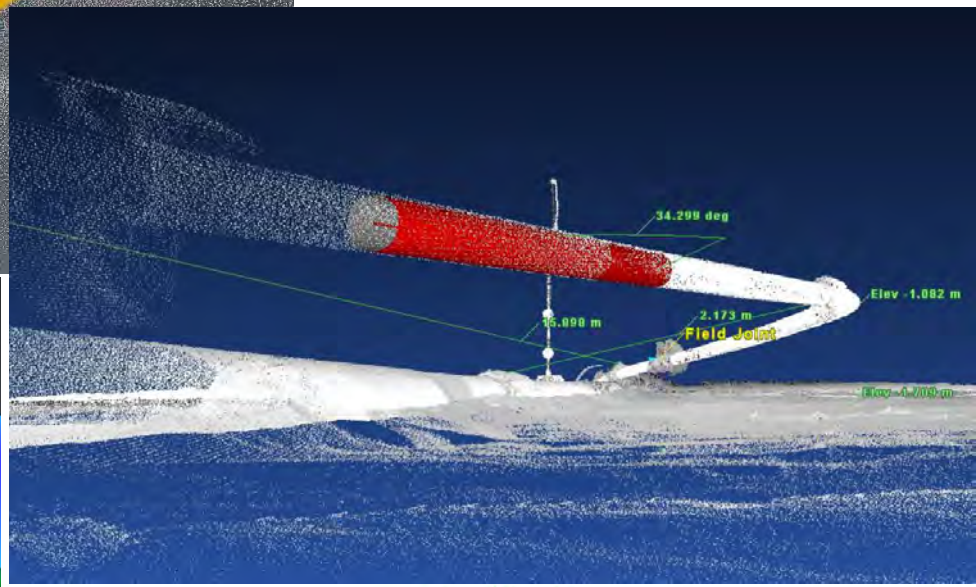




PIPELINE CURVATURE ANALYSIS

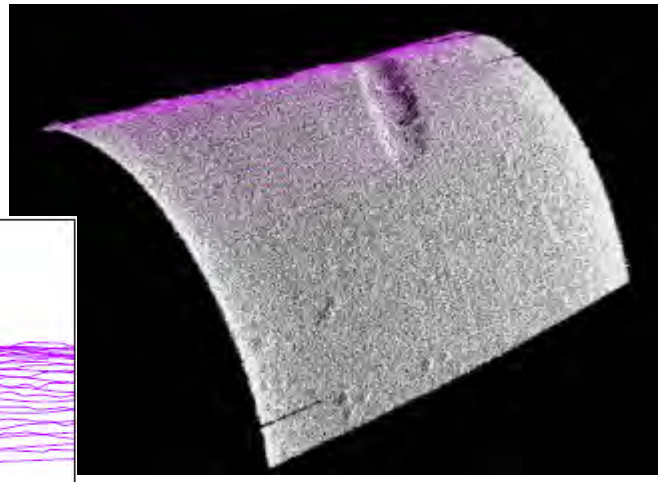


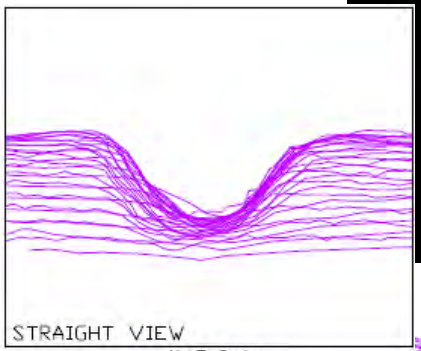


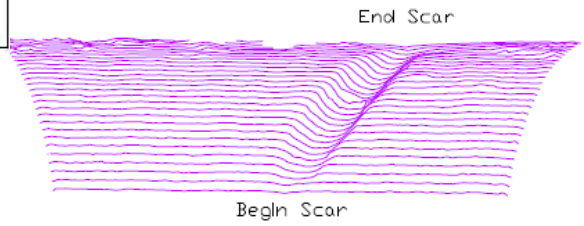


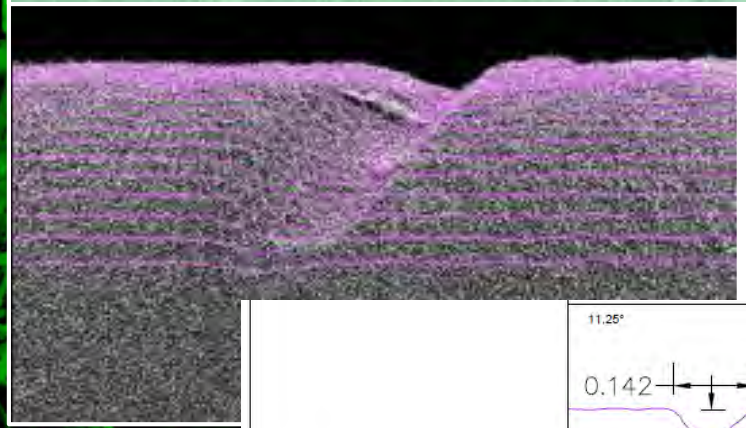
- Cloud extruded to 3D Mesh
- Curvature
- Lateral Distance
- Quantification of distances, angles and heights is straightforward.

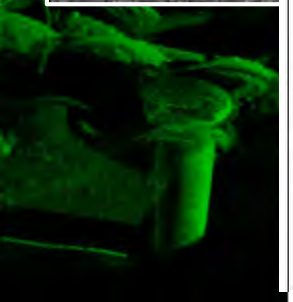
PIPELINE DAMAGE ASSESSMENT

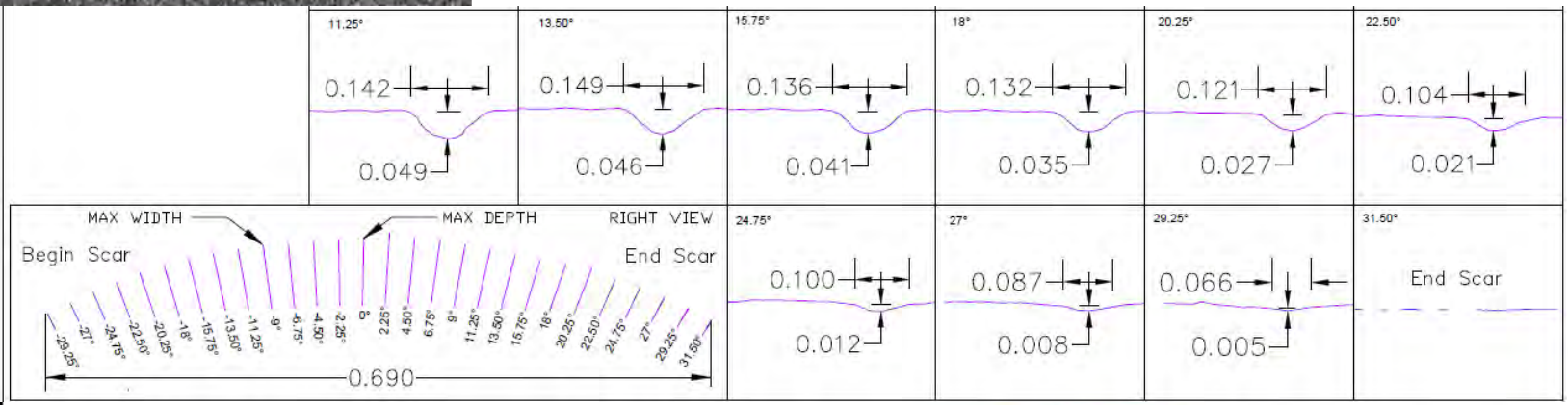




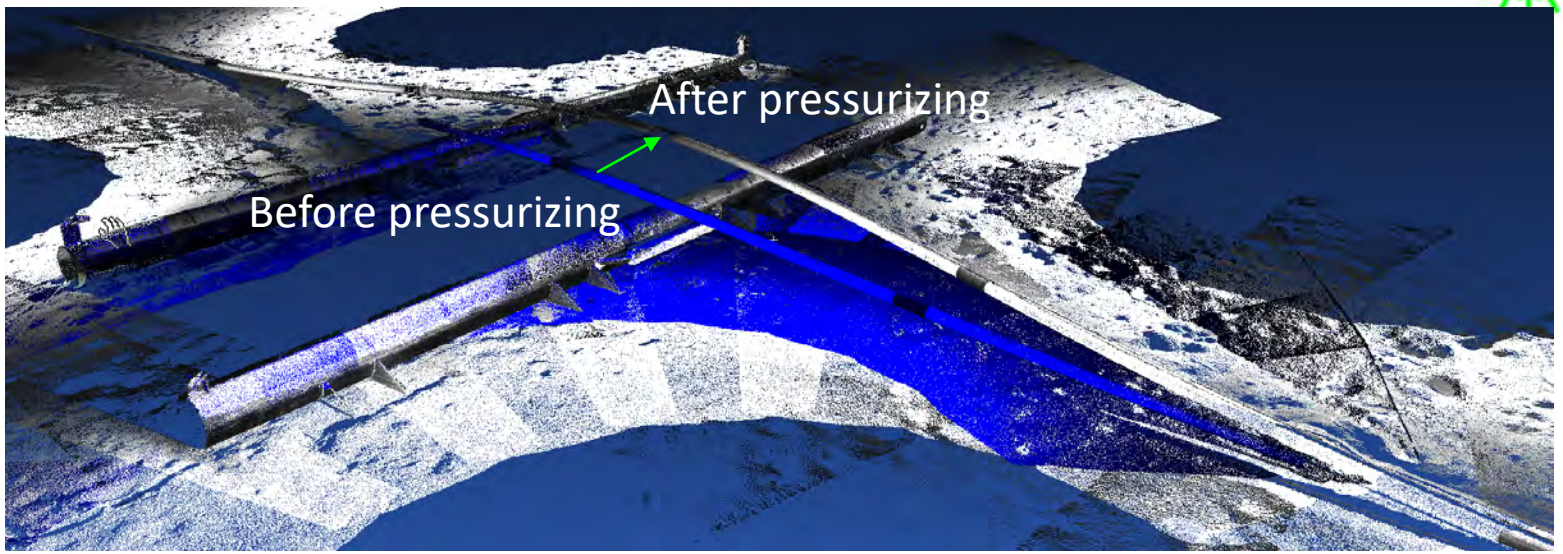


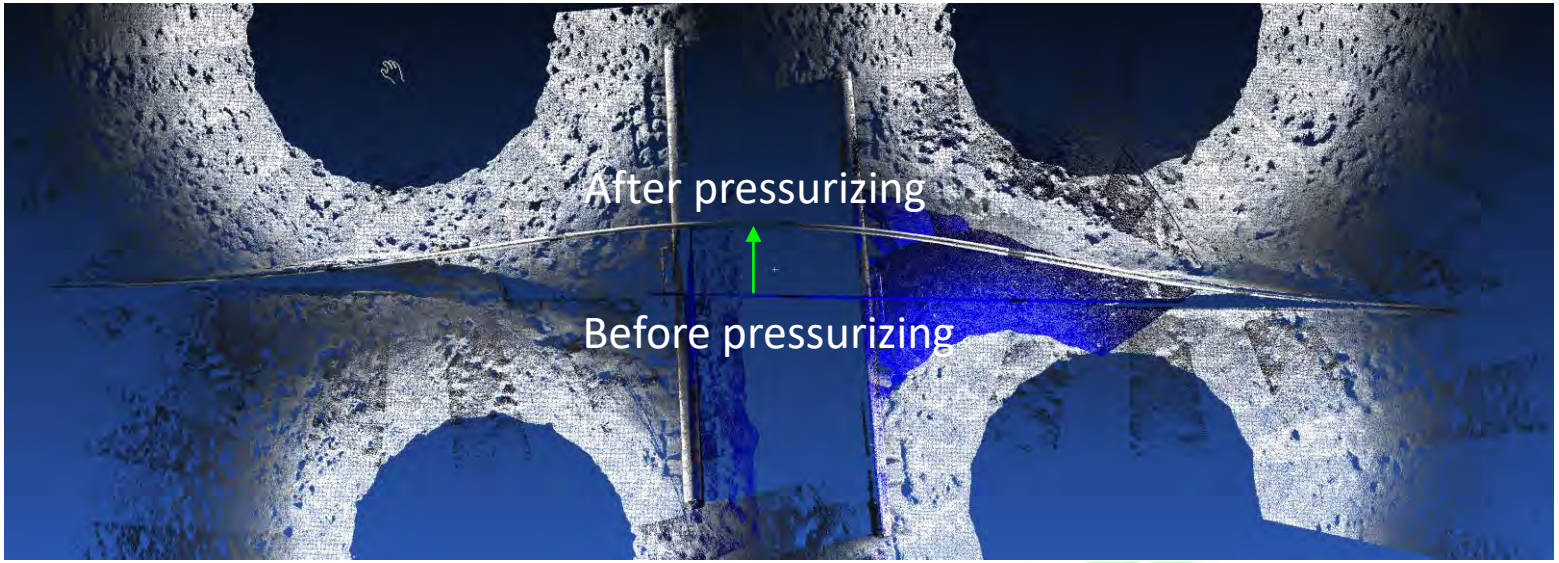






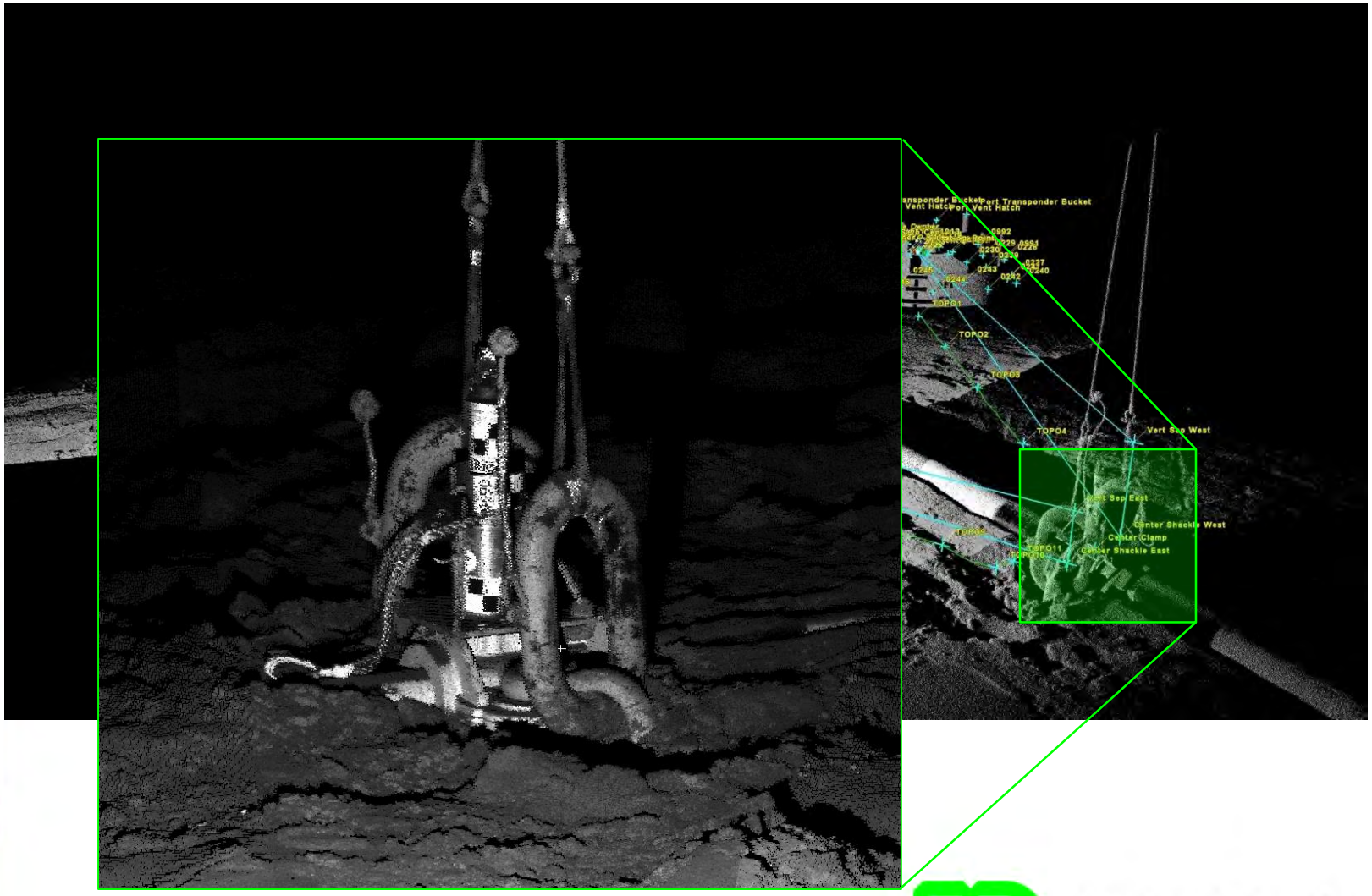
PIPELINE MOVEMENT – HOT VS. COLD



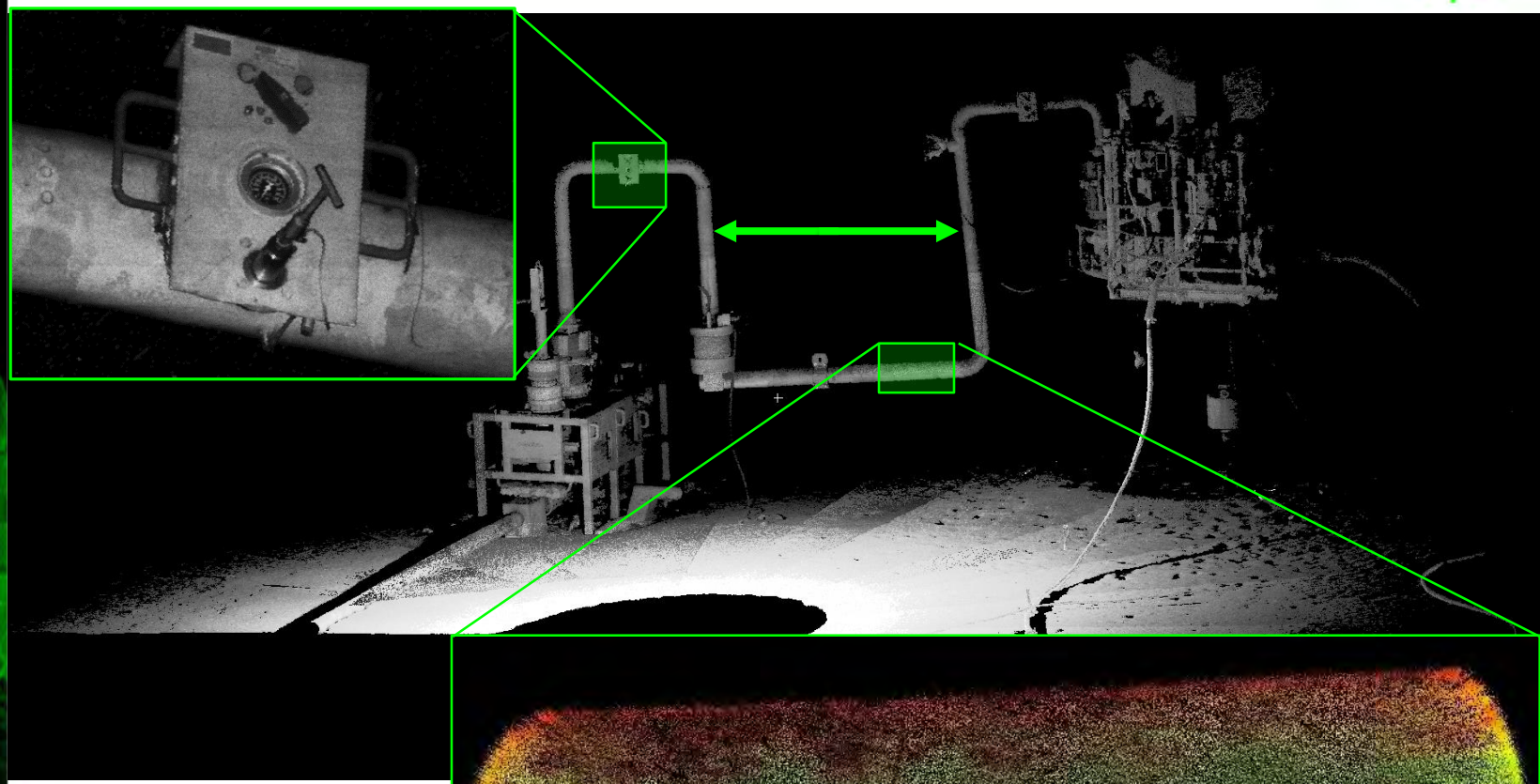


SLIP JOINT MONITORING

- Sediment disturbance measured to increase awareness for engineering prognosis

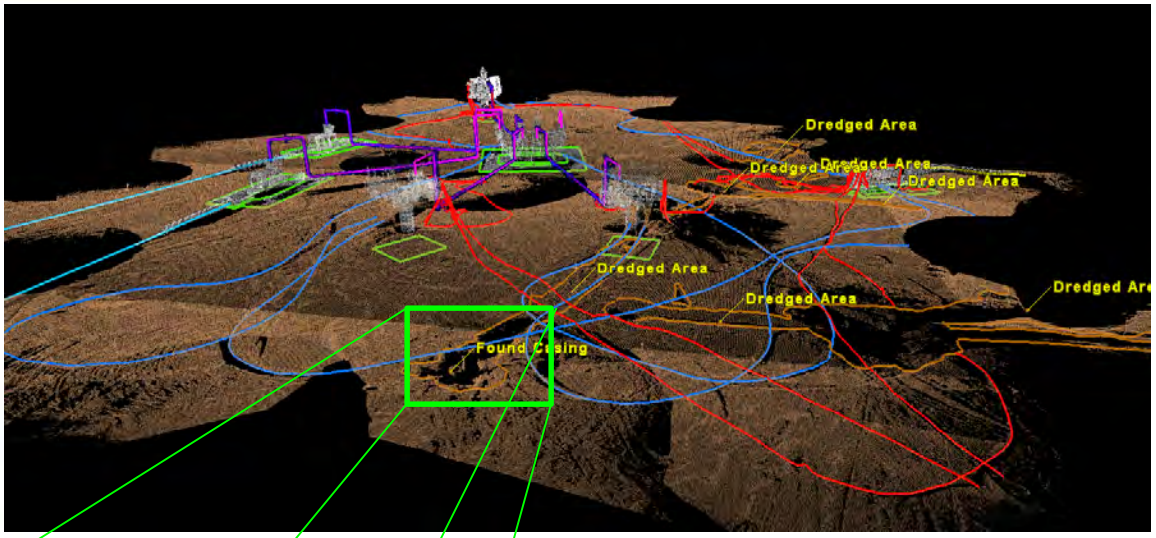


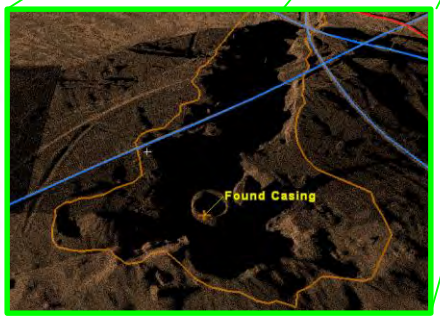
JUMPER / SPOOL / PIPELINE INSPECTION

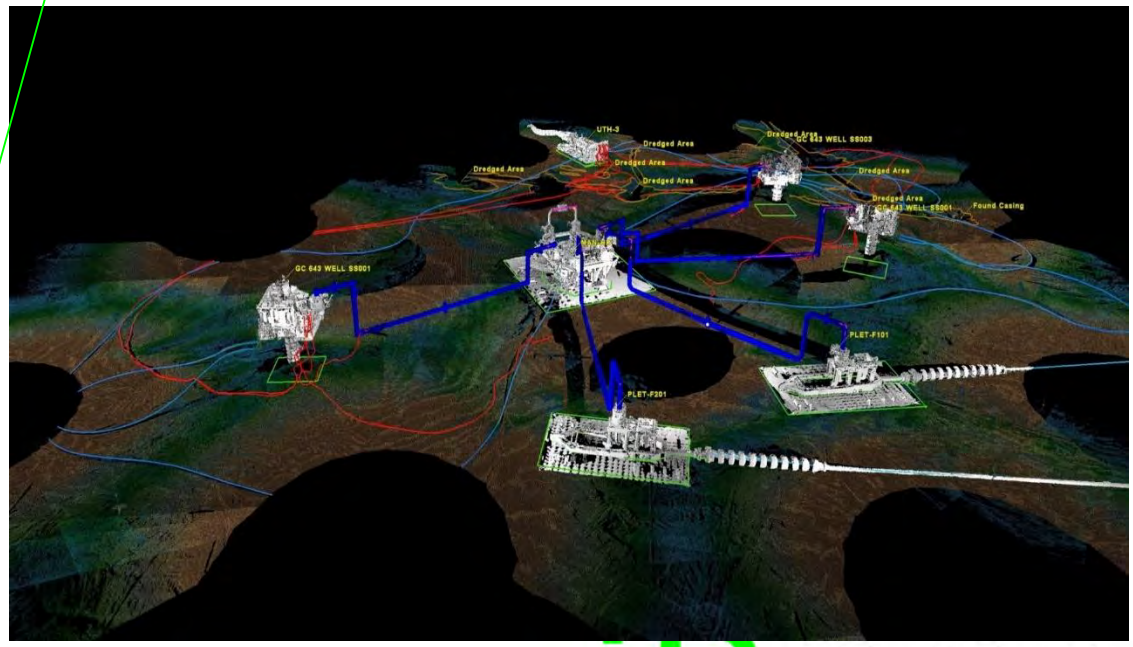


- 6mm Crack Detected from a range of 15m
- Intensity change helps with visulisation

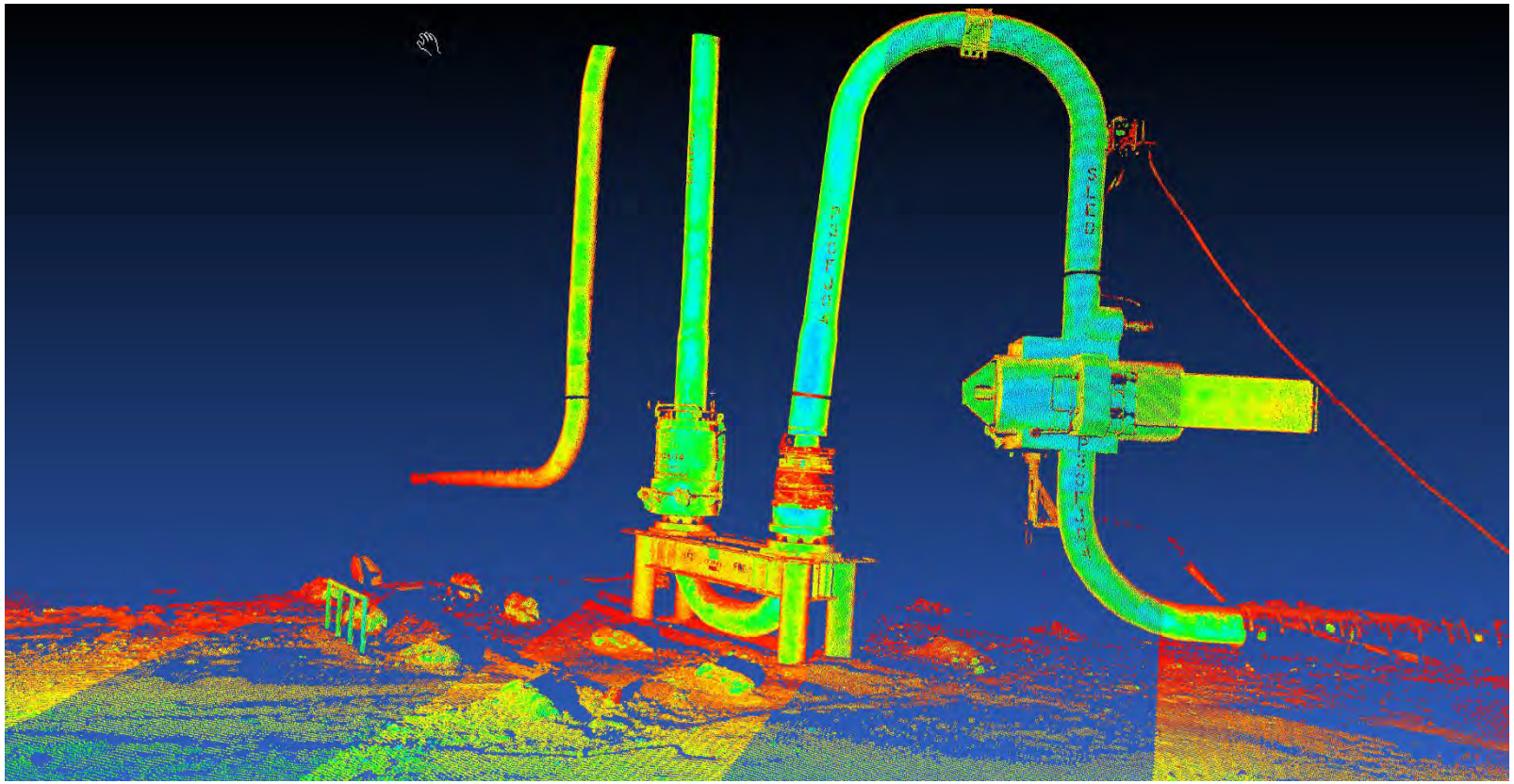
DRILL CENTER - FIELD SCAN



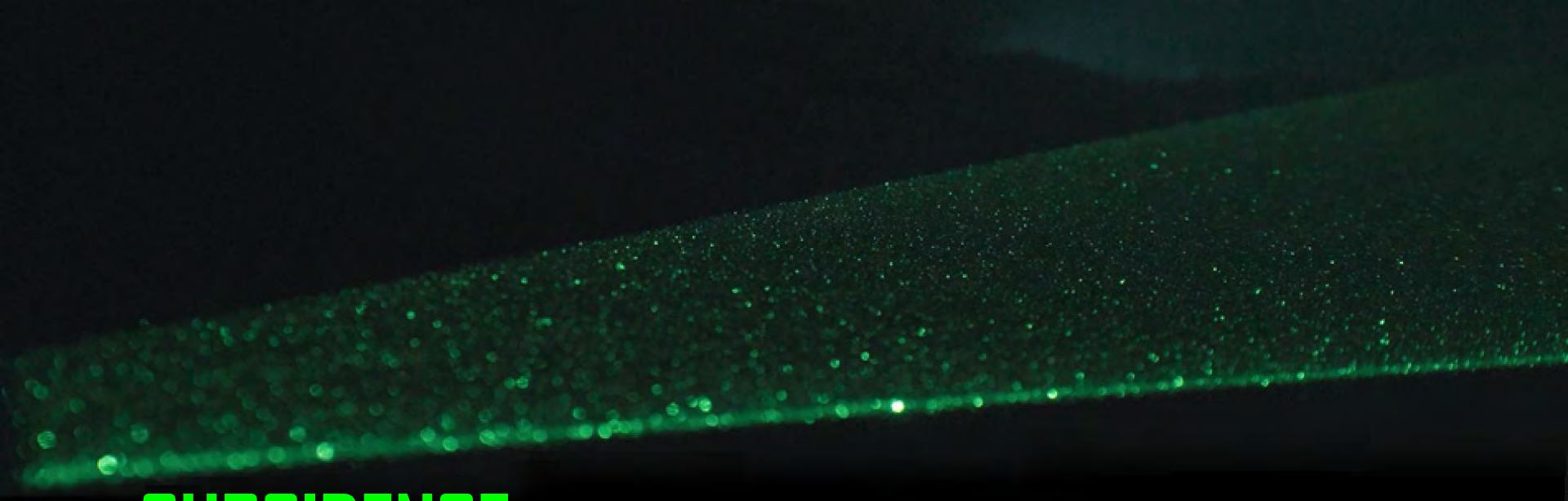




MORE THAN A MEASUREMENT



- Visual evidence of existing conditions to back-up numerical findings
- Actionable corrective planning without the need for additional trips
- Archivable data for comparison measurements



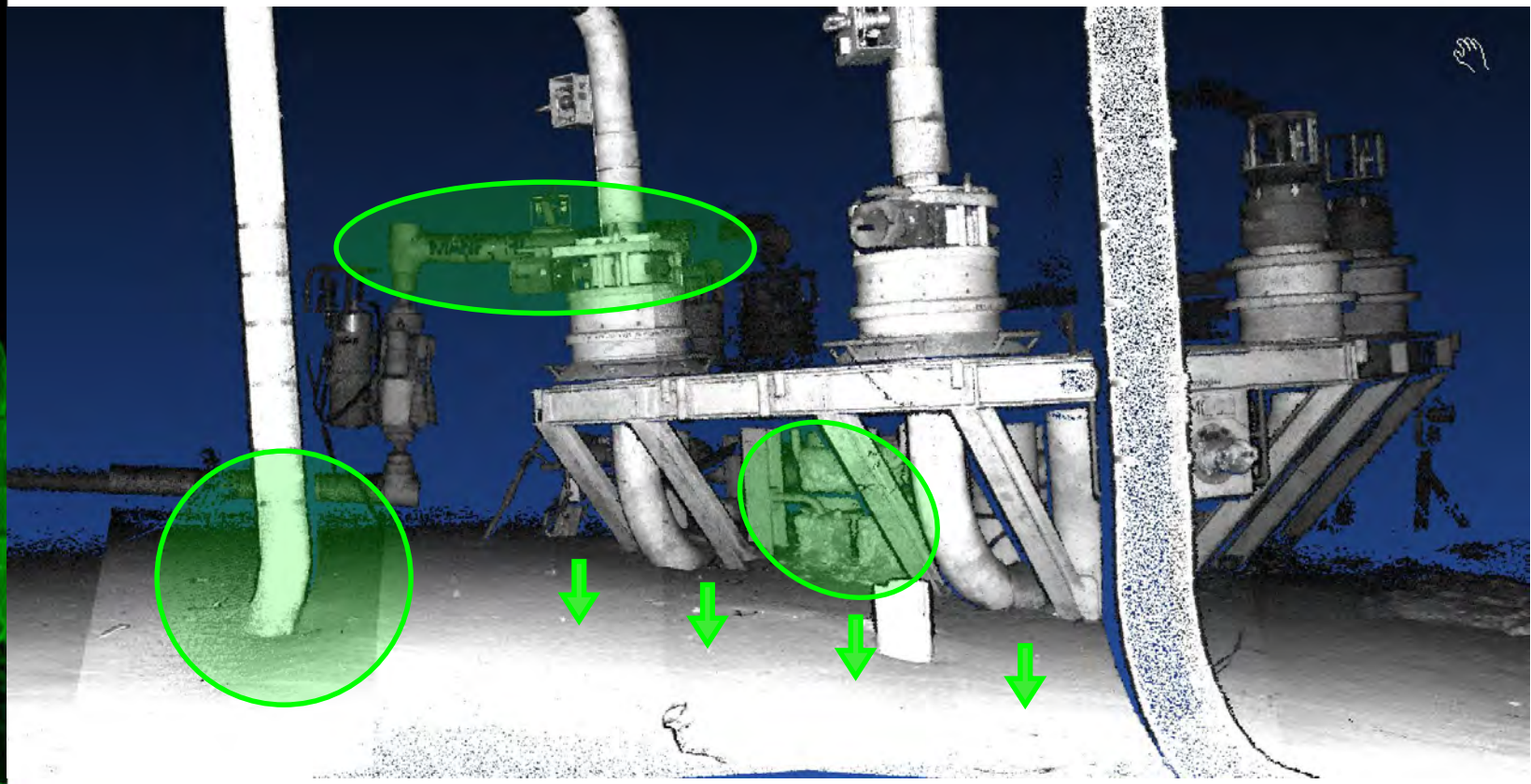
SUBSIDENCE

PRO-ACTIVE VERSUS RE-ACTIVE

Typical jumper connection

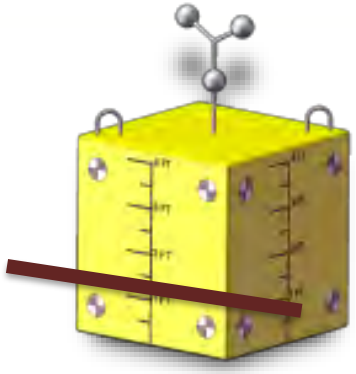
Non-typical Jumper connection with possible future issues

LIFE OF FIELD

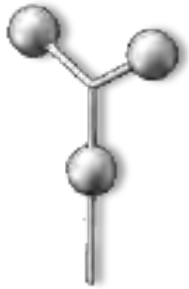


- Can you find any issues with this manifold?

SUBSIDENCE – STRUCTURE MOVEMENT

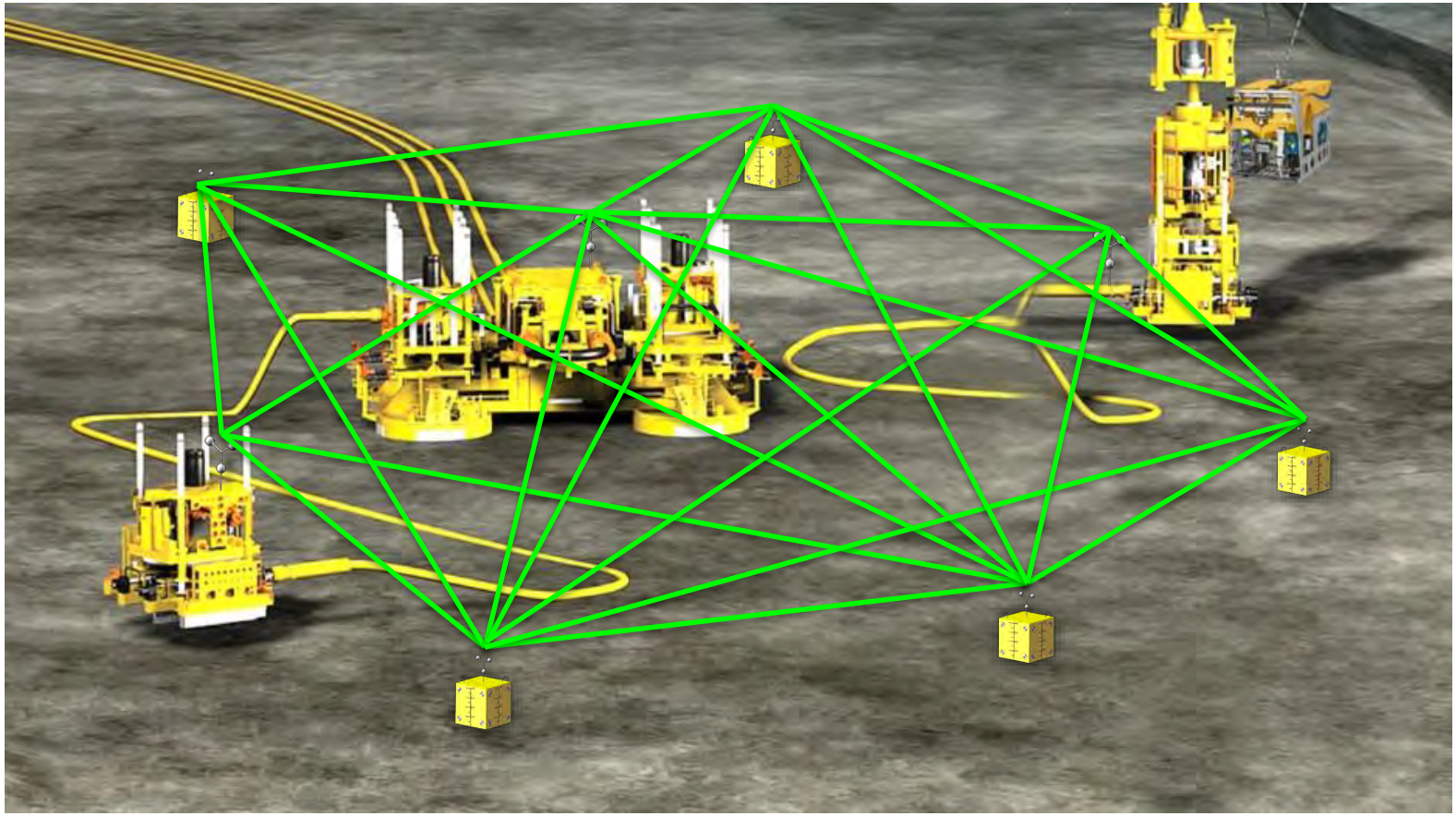


- Seafloor Mounted reference targets – designed to suit soil conditions and local currents



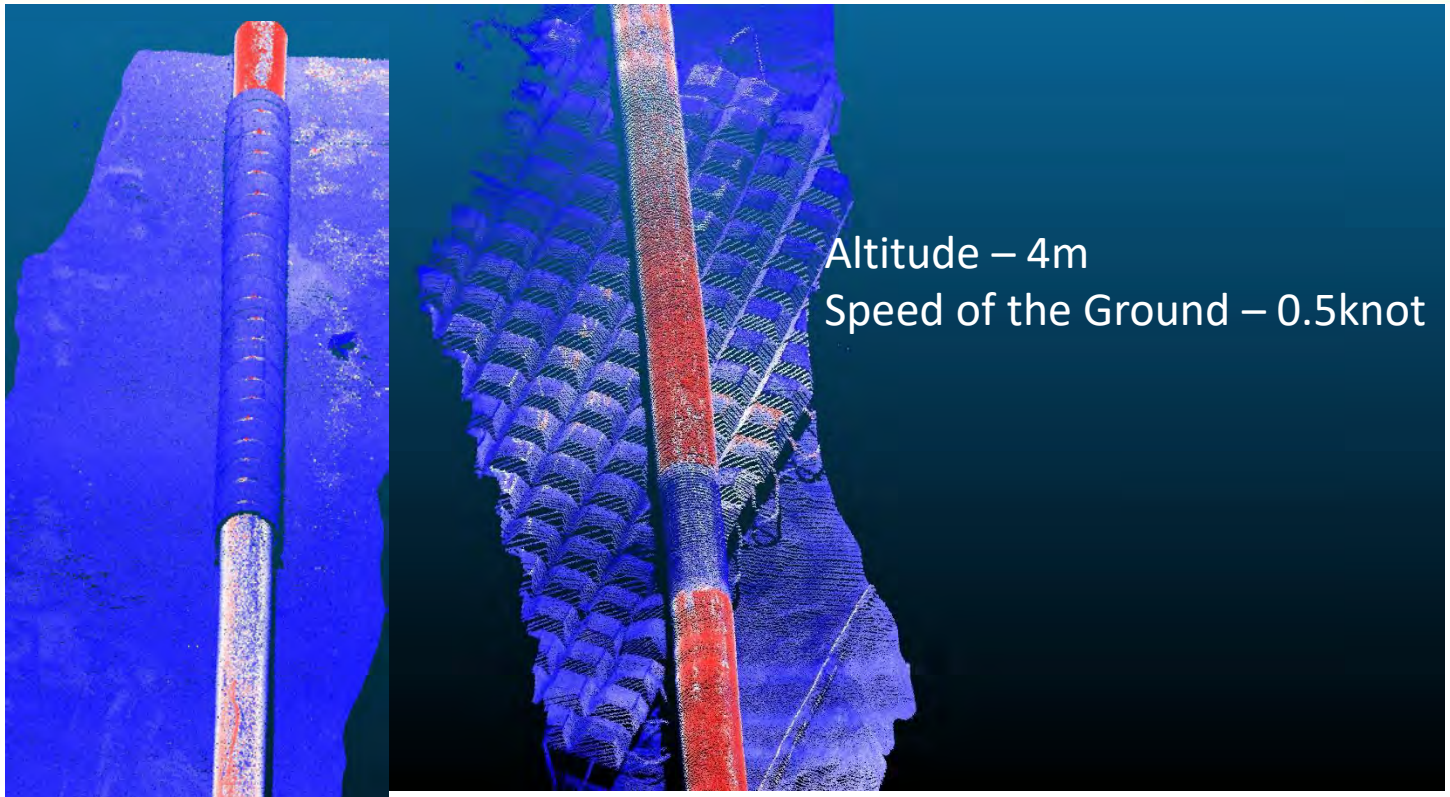
- Structure mounted spheres to aid in pitch / roll and heading references

CHECK FOR CHANGE X, Y, Z MEASUREMENTS



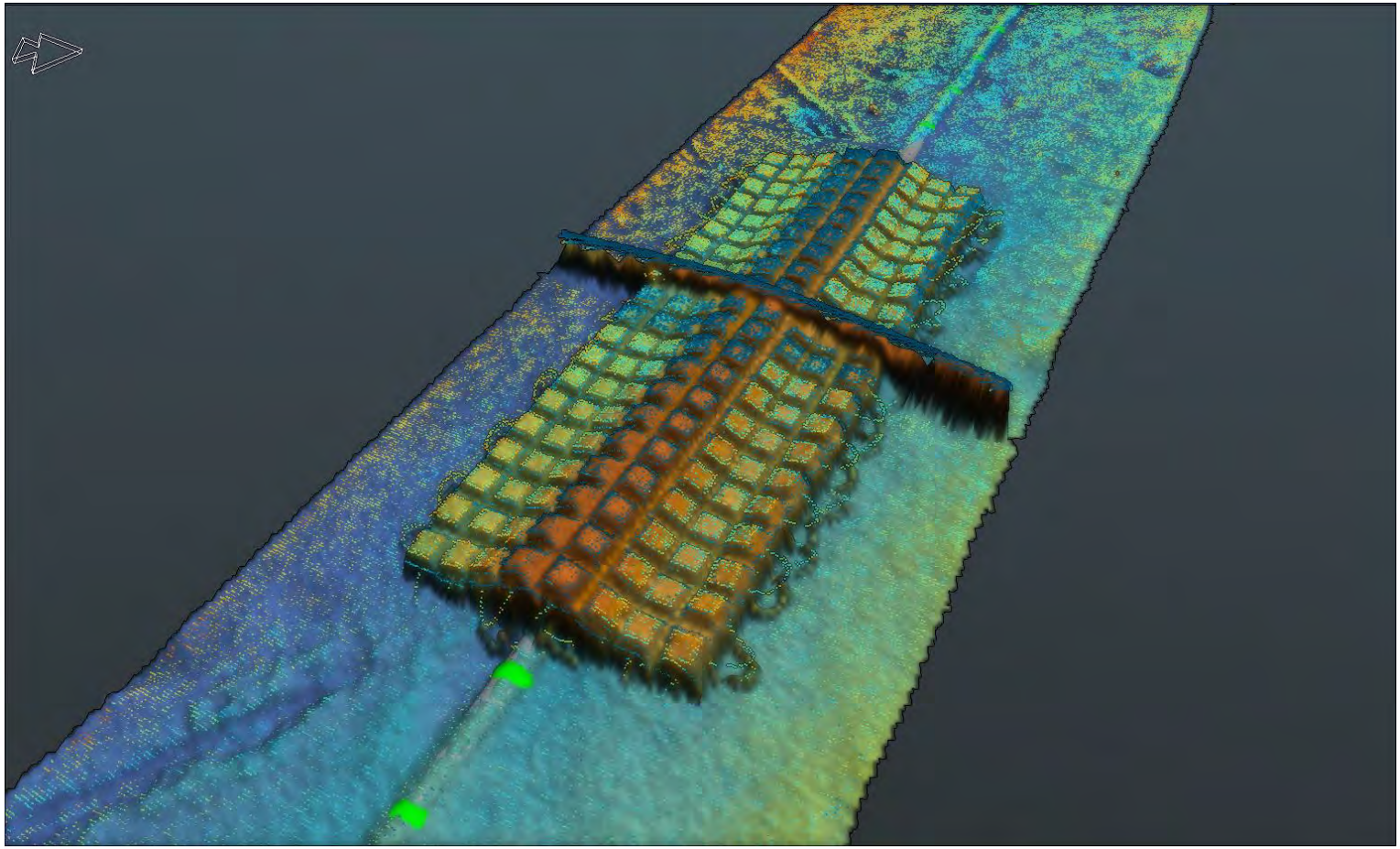
LIGHT IN MOTION (DYNAMIC LIDAR)

PIPELINE SURVEY USING MOTION BASED COMPENSATION

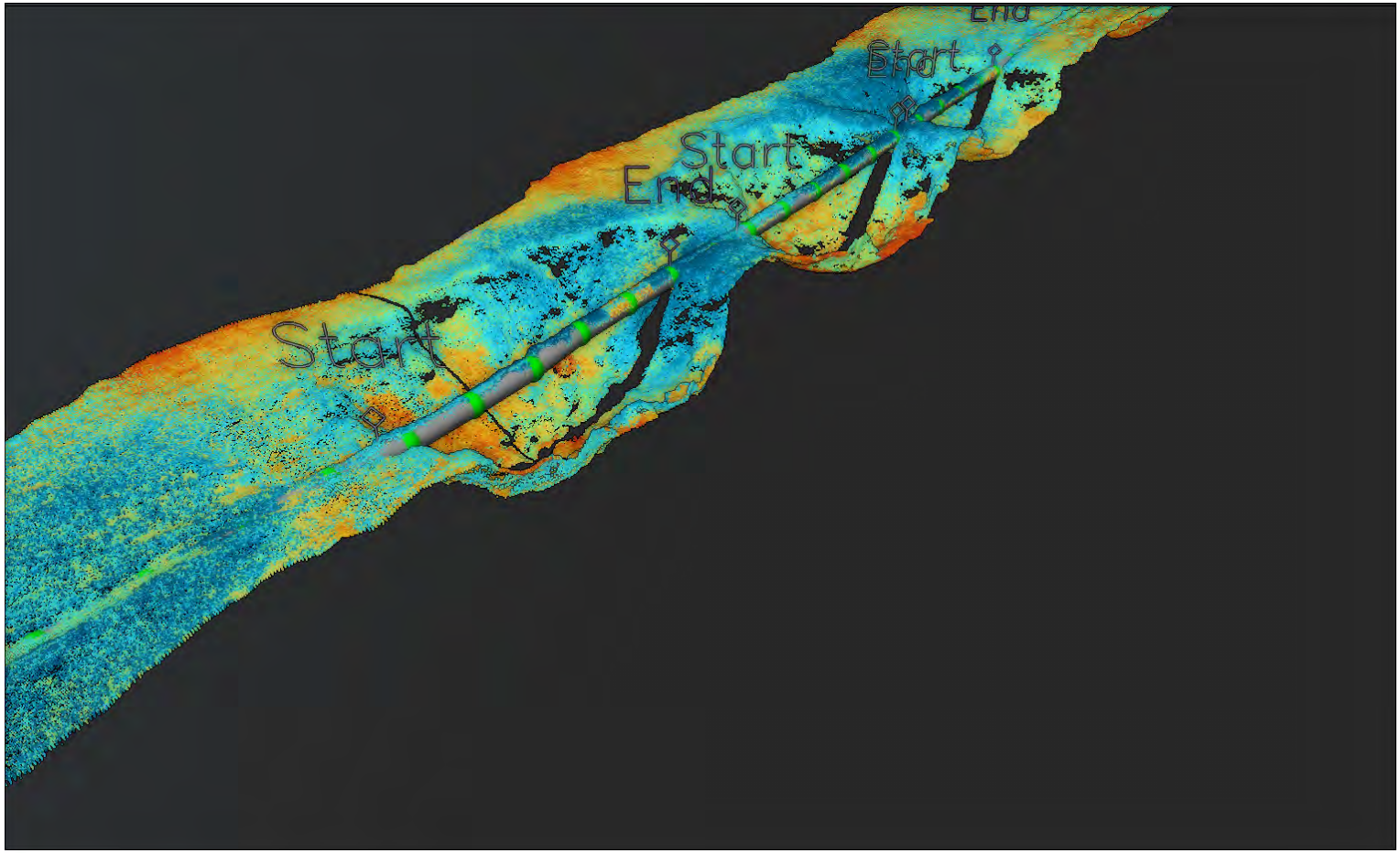


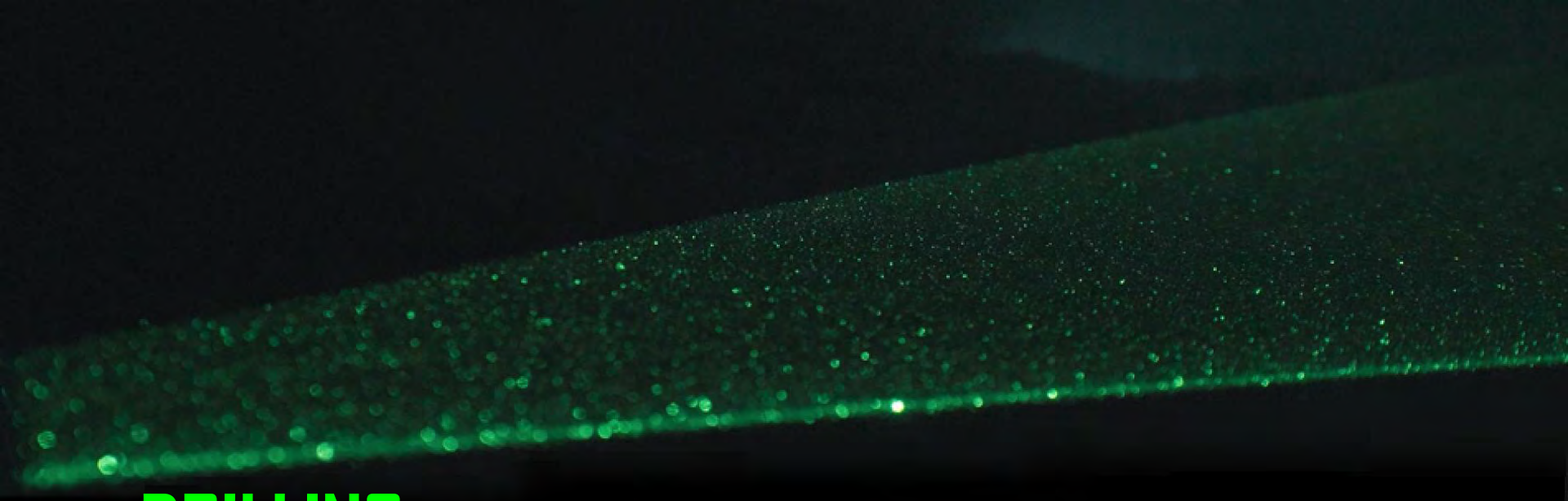
Altitude – 4m
Speed of the Ground – 0.5knot

CONCRETE MATTRESS & CROSSING



10" RISER TOUCHDOWN AND FREE SPAN DETAILS



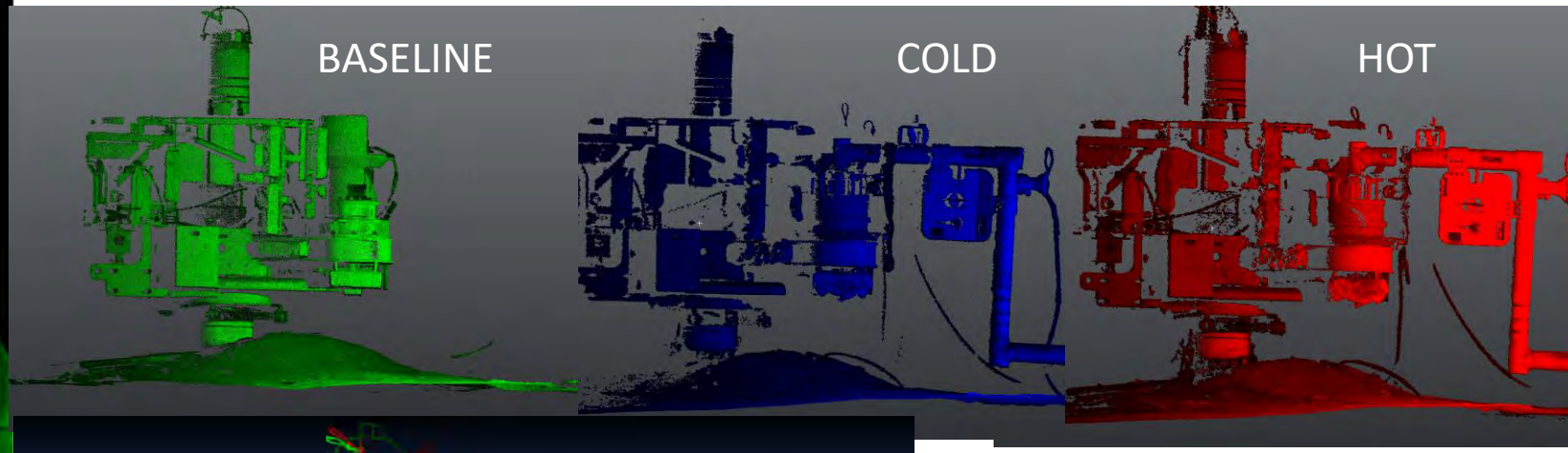


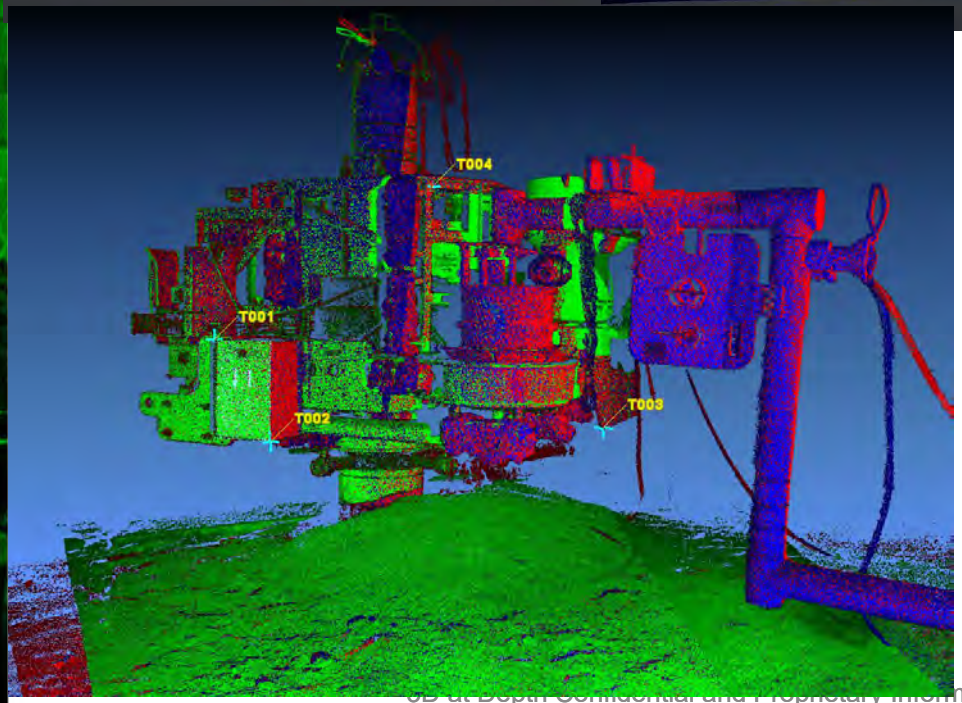
DRILLING

NON TOUCH - DRILLING APPLICATIONS

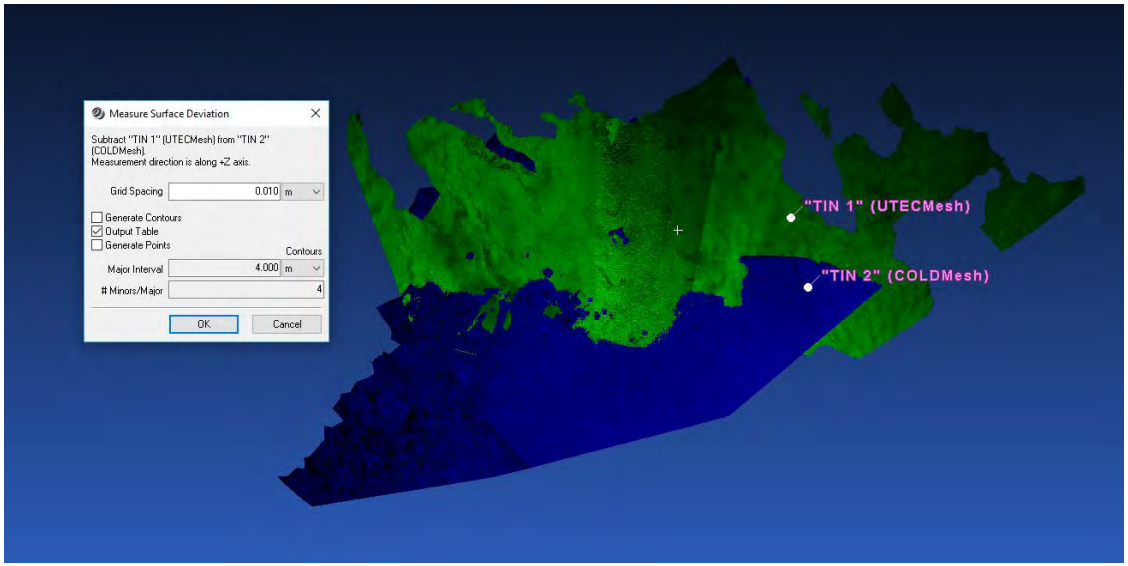
- Vortex induced Vibration monitoring – movement measurements of the Subsea tree
- Subsea pump Vibration measurements from one or more static or moving Laser transmitter and receiver.
- **Hydrocarbons, drilling fluids and other fluids such as glycol and hydraulic fluids used to operate and test subsea infrastructure for leaks.**
- Gas kick detection and vibration during drilling and production.
- Water Hammer kick detection during drilling and production.
- Top hat structure rotational alignment monitoring.
- Seabed volume measurement for Drill cuttings and or subsidence.
- Reservoir over pressure from well injection and stimulation the seafloor for cracks / deformation as well as seepage from methane gas bubbles and other hydrocarbon.
- Single or multiple scanners to be time sync'd or independent measurement devices

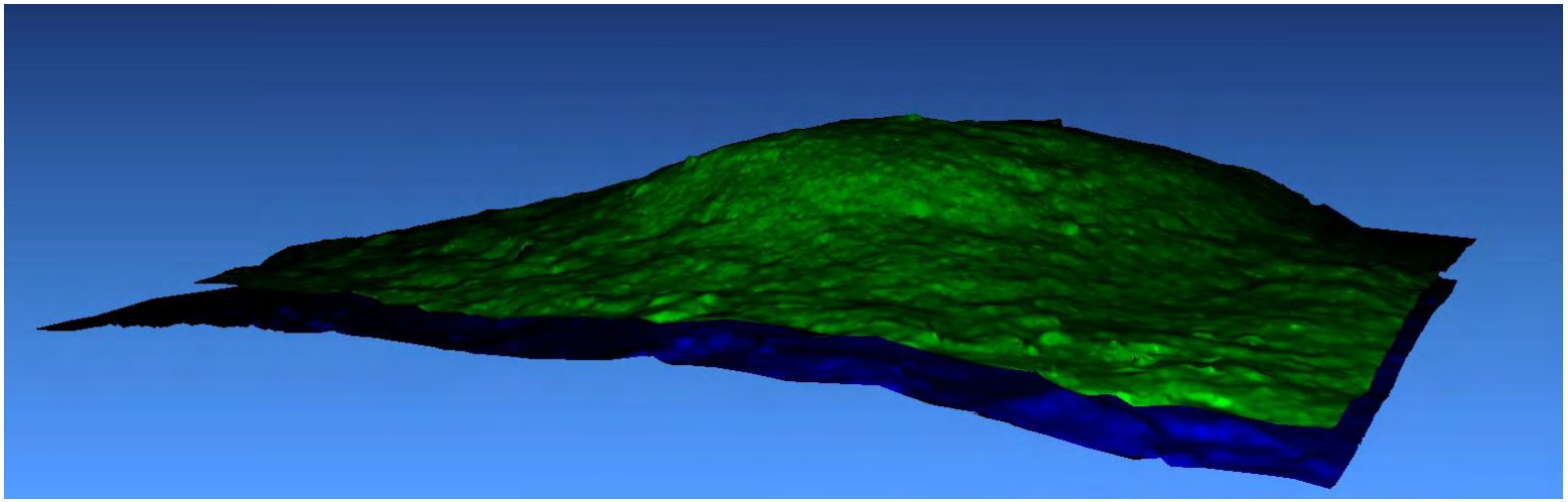
THERMAL TREE GROWTH



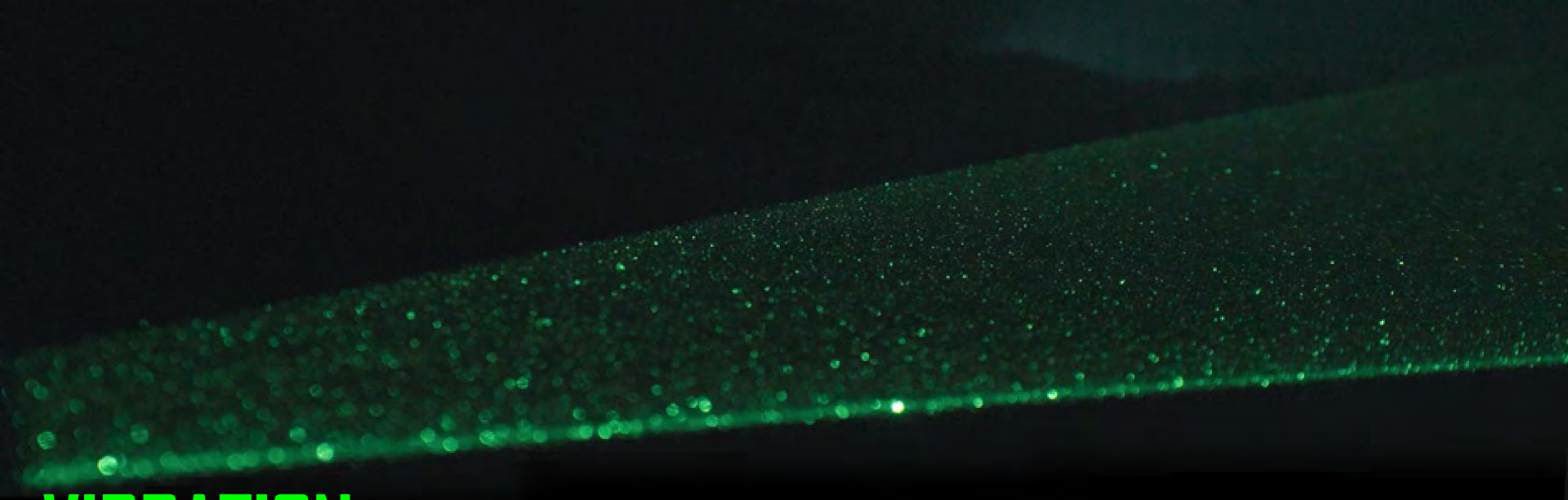


VOLUMETRIC TREE CUTTING CALCULATIONS



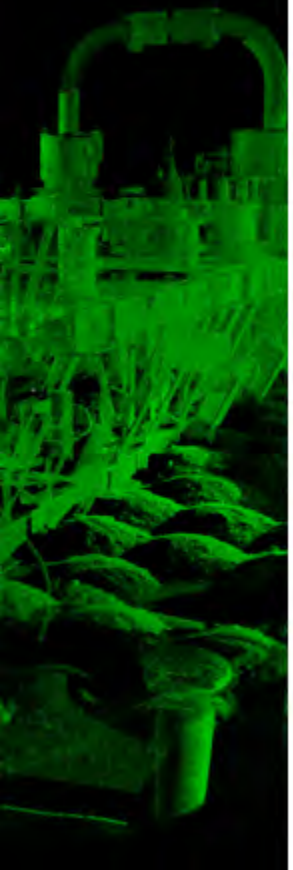


3D at Depth



VIBRATION –
DURING DRILLING OR WORKOVER ACTIVITIES

COMMON APPLICATIONS

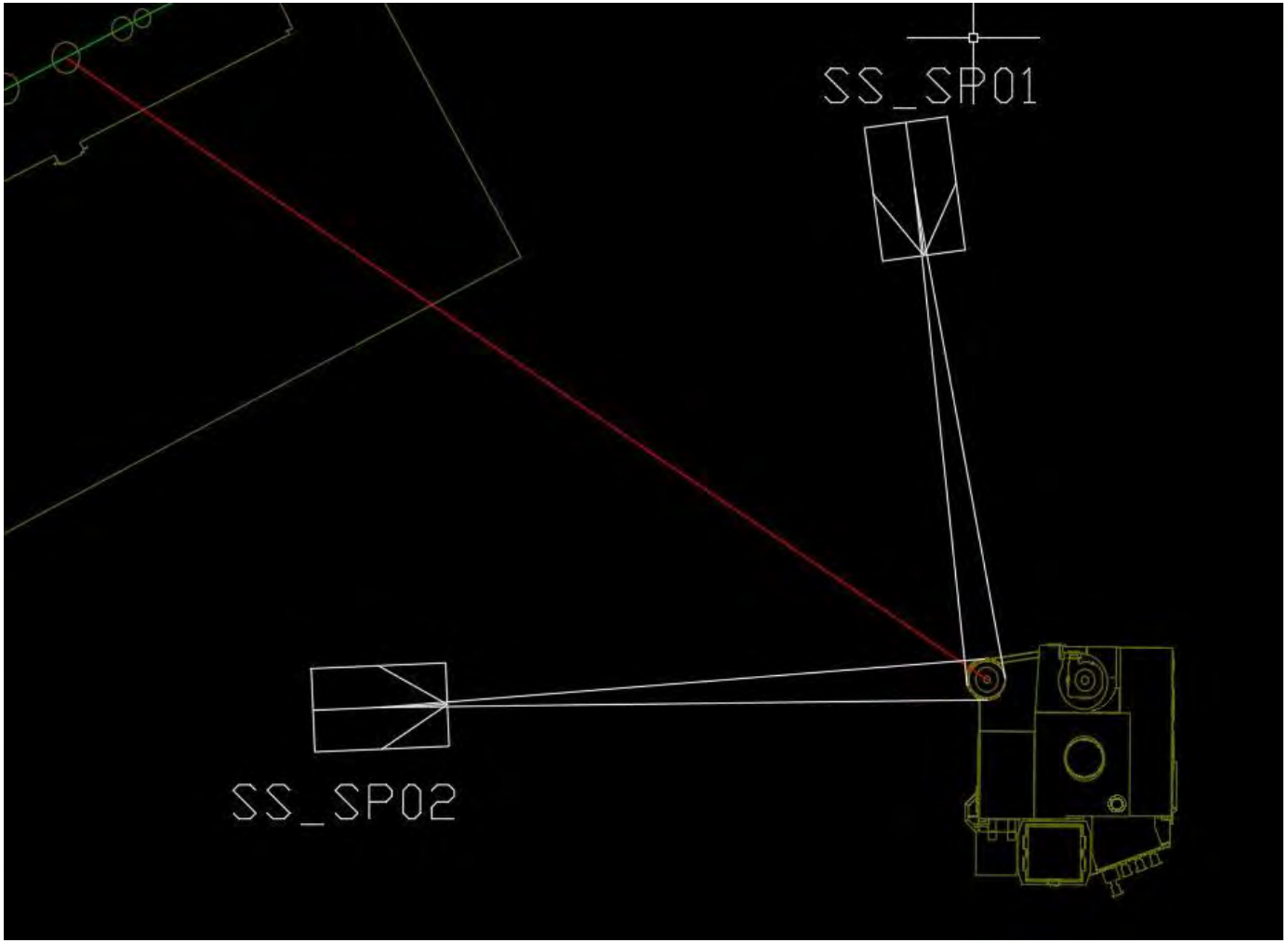


- Drilling and well intervention work over operations
- Subsea pumping & production systems
- Subsea pipeline
- Well injection / P&A
- Production start up

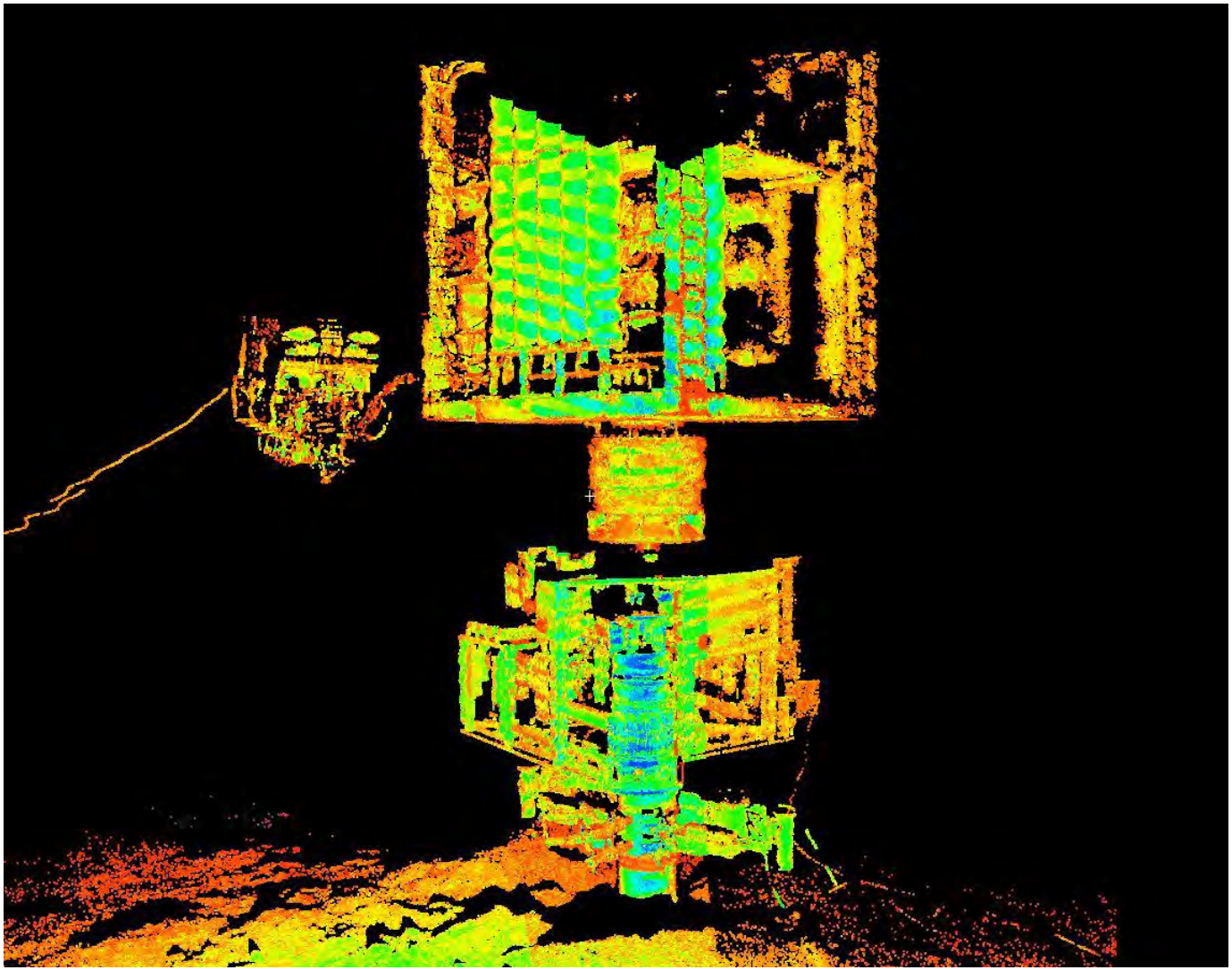
Rapid Deployment

- ROV Deployable from drill support or other inspection host vehicles
- Remote sensing

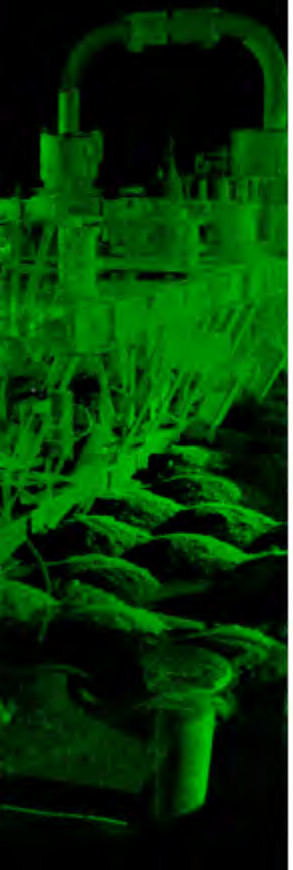
SCANNING – WE NEED TO BE PERPENDICULAR

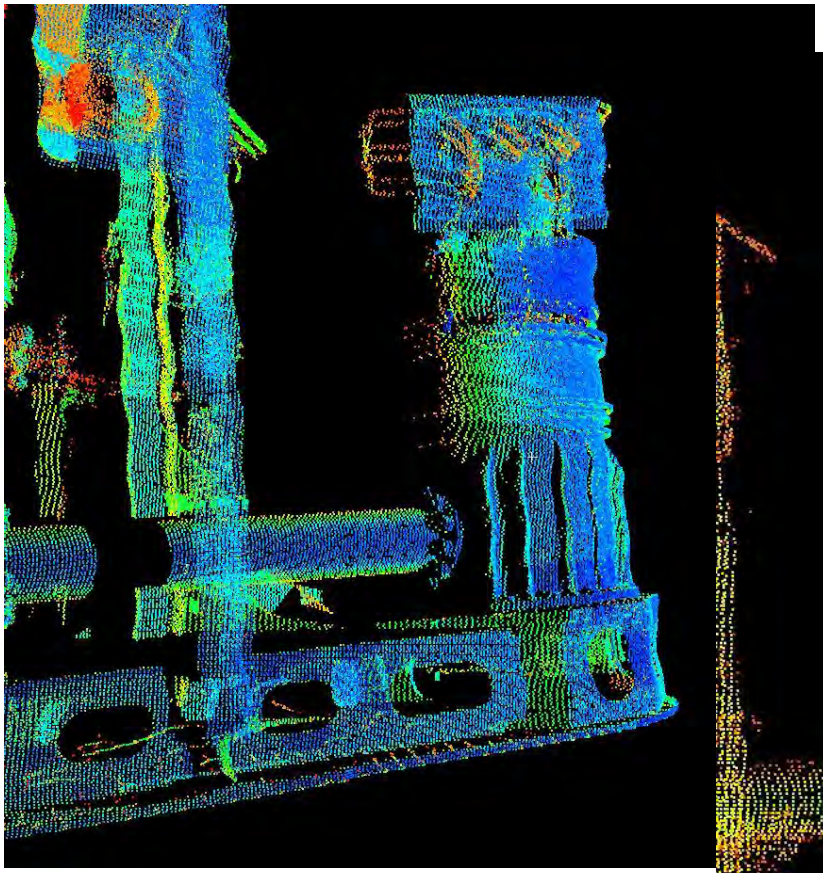


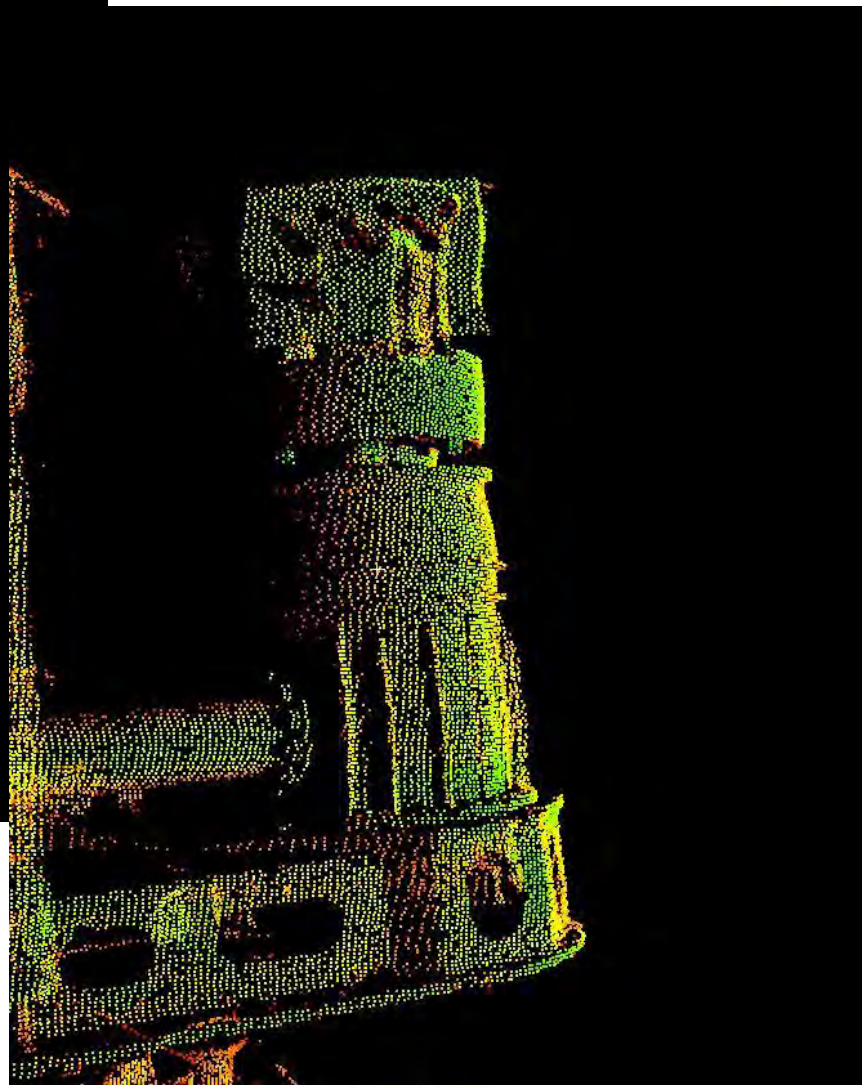
WAVY / BANDING



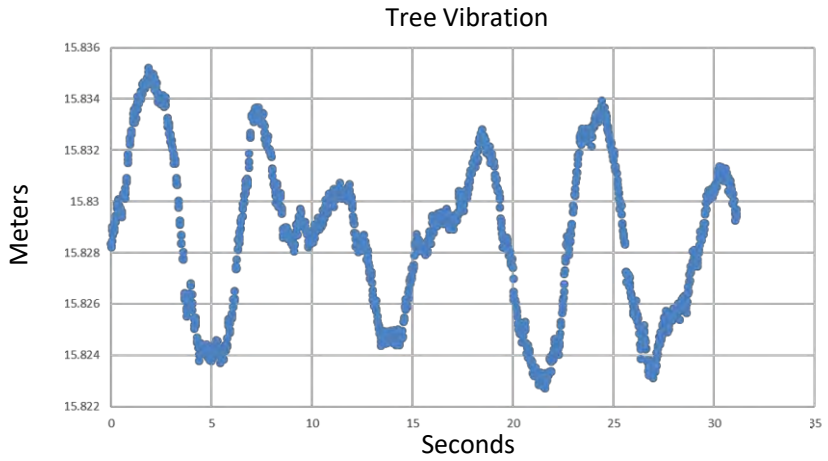
WAVY DATA



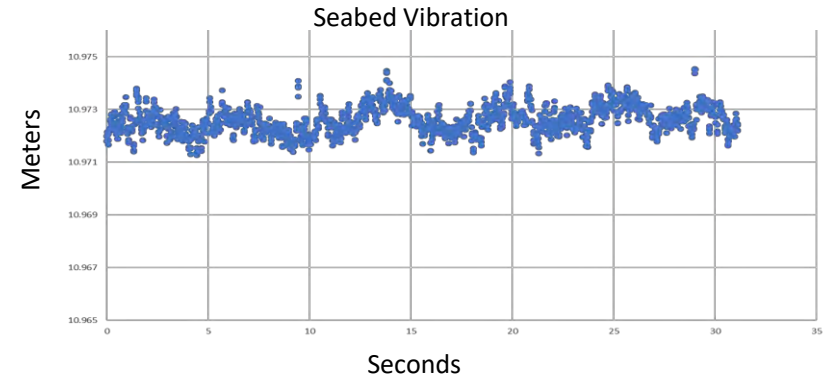




GOM TREE VIBRATION THIS WEEK

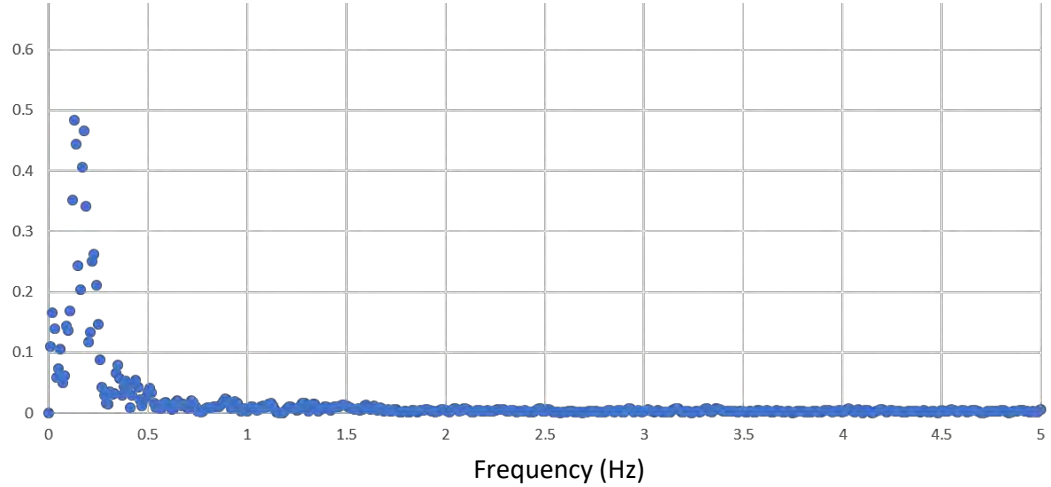


~ 11mm of movement from tree

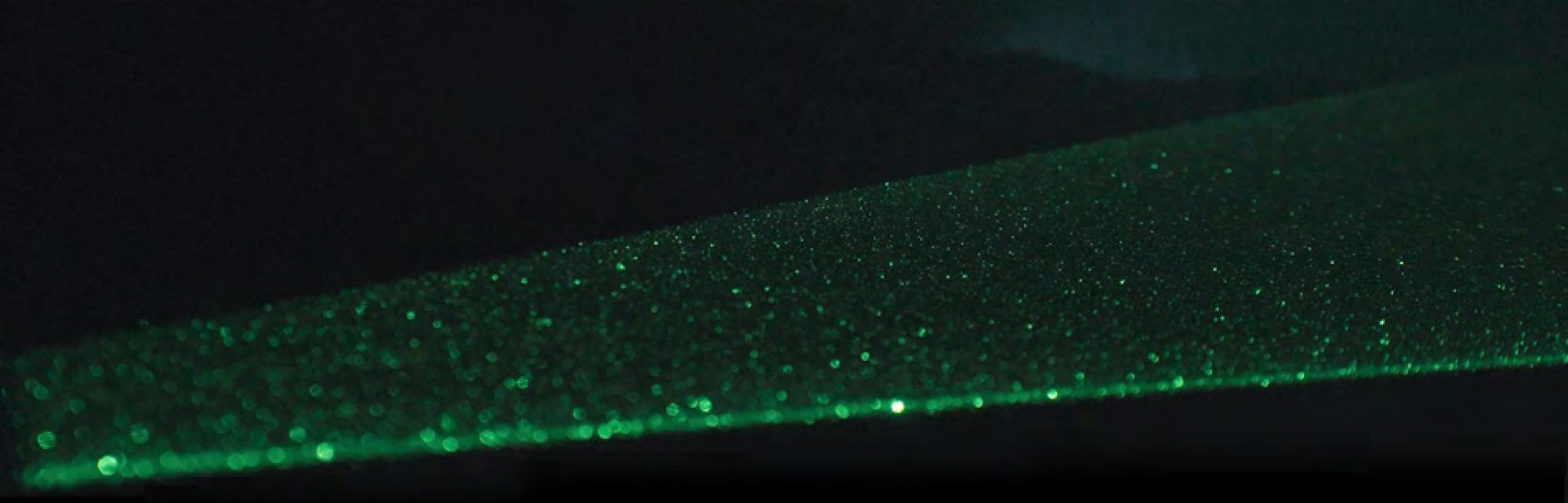


~ 2mm of movement when looking at seabed (ROV or other movement)

GOM TREE VIBRATION THIS WEEK



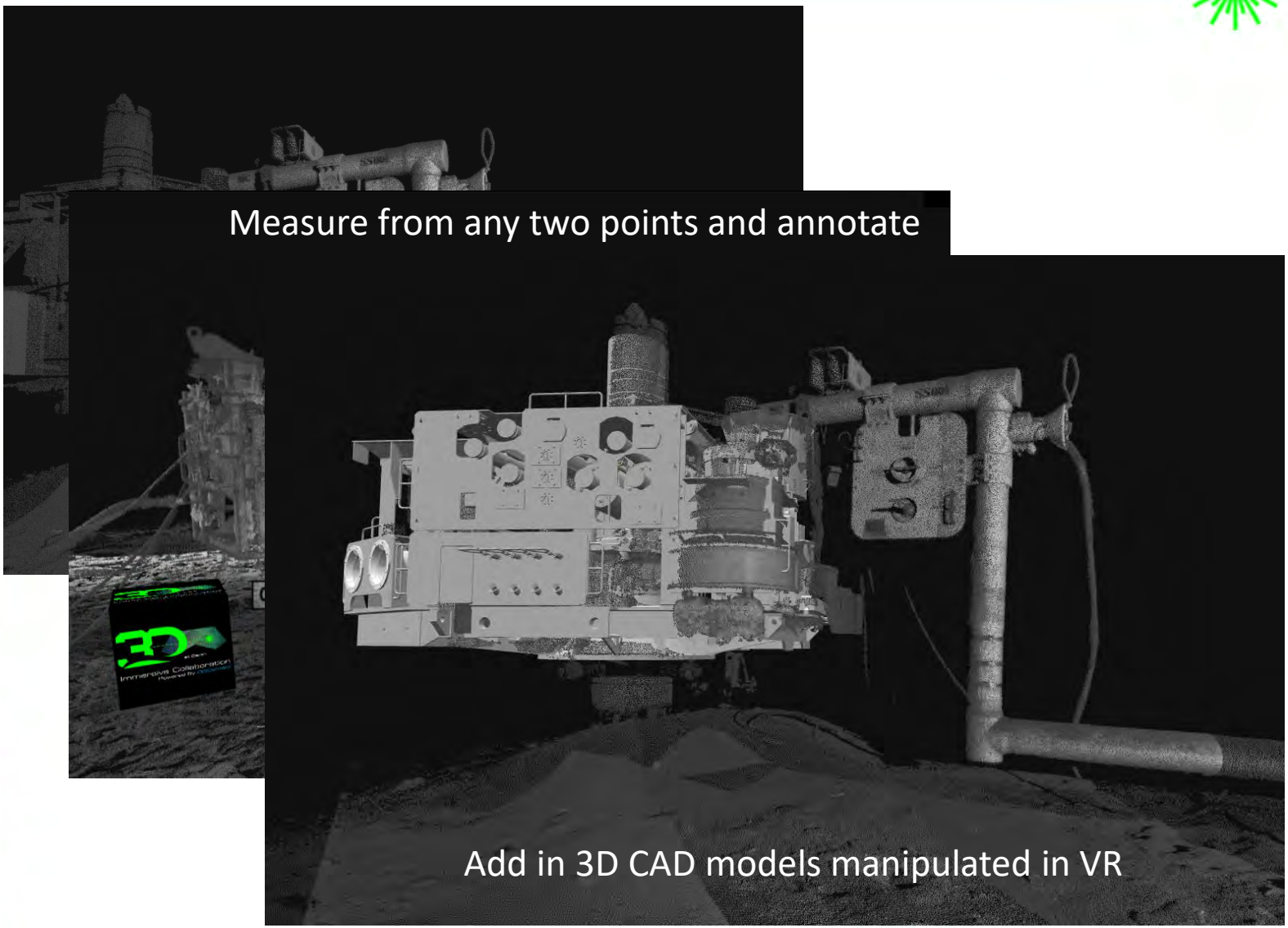
~ 0.14Hz frequency of movement



A DIGITAL TWIN

DATA VISUALIZATION - IMMERSED

VISUALIZE MEASURE AND SIMULATE



FAST MOVING DATA