



Know.

SEAlimited.com

3-D Modeling in Marine Accident Investigation and Reconstruction

Bryan R. Emond, P.E. C.M.I.
Discipline Lead, Maritime
S-E-A, Fort Lauderdale, Florida

April 21, 2022

Disclaimer



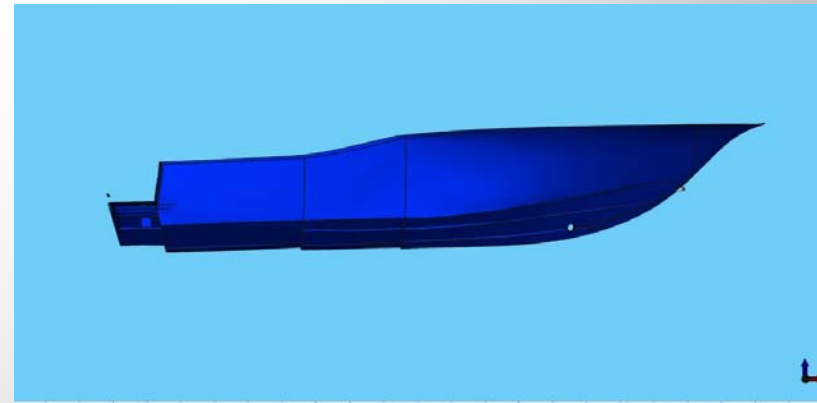
Know.

All discussions, opinions, comments, photographs, images, etc. made during the presentation are meant for general training and educational purposes, and shall not be considered a professional opinion regarding any specific claim or legal matter.



Presentation Objectives

- 3-D data collection technologies
- Data capture vs. Modeling
- Uses for 3-D Data and Modeling
- Strengths and limitations of 3-D Data and Modeling



Types of 3-D Data Collection

3-D Laser Scanning

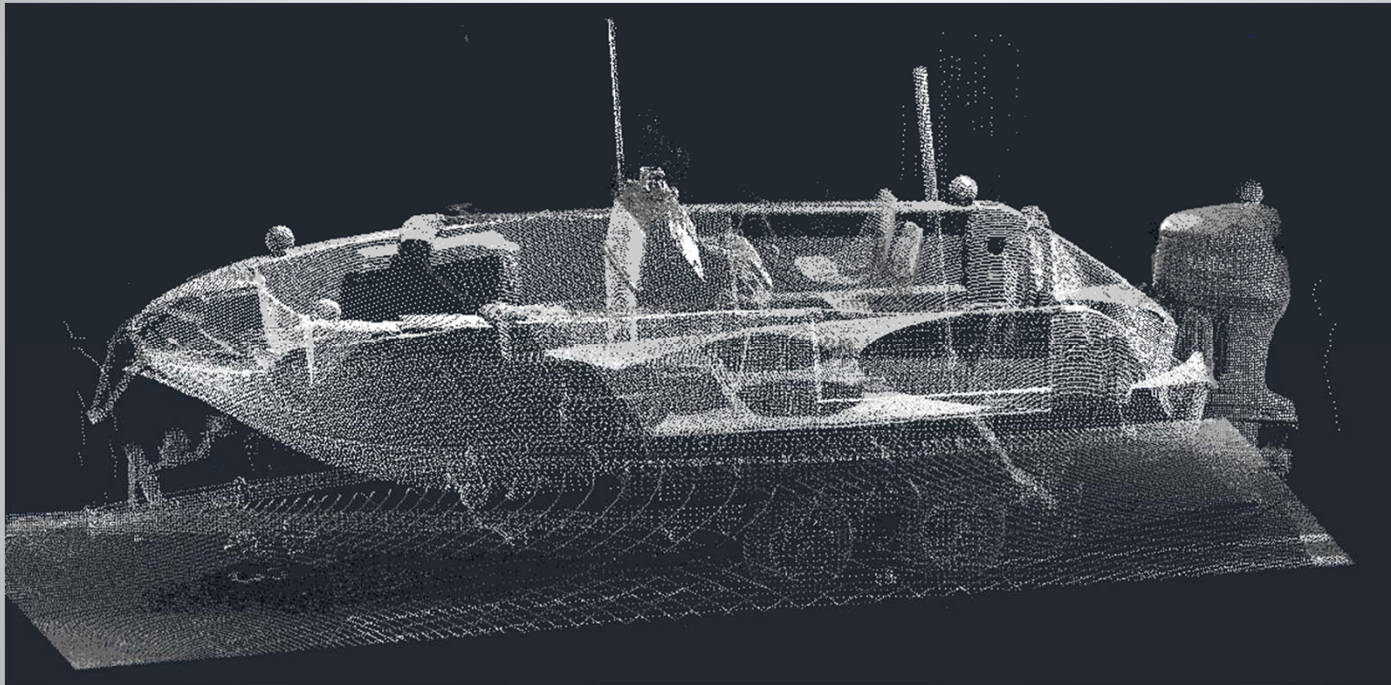


Know.



3-D Laser Scanning

- Point Cloud Data



Hundreds of Thousands to Millions of Points in a “Cloud”

3-D Laser Scanning

- Point Cloud Data



Cruise Ship Theater



- Documentation
- Measurement
- Preservation

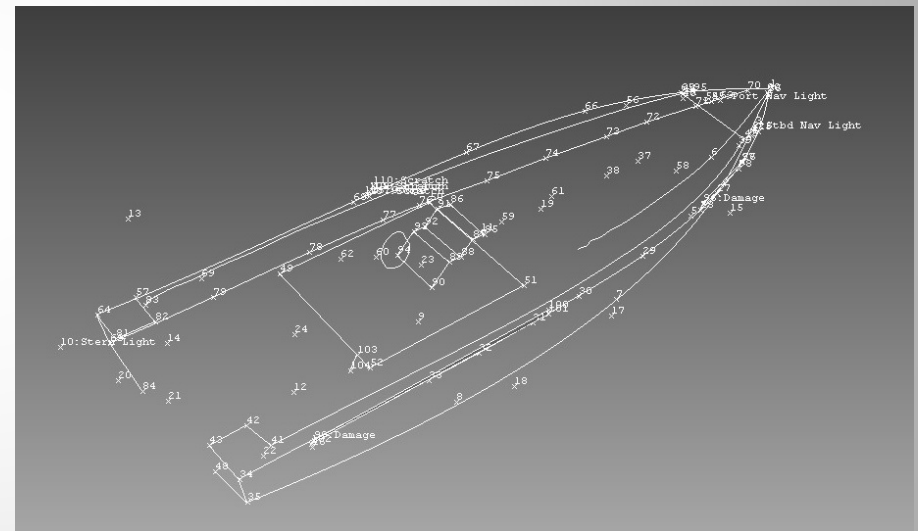


Know.

Types of 3-D Data Collection

Photogrammetry

- Measurement From Photographs
 - From Camera



Know.

Types of 3-D Data Collection

Photogrammetry

- Measurement From Photographs
 - From Drone Camera



Know.



Types of 3-D Data Collection

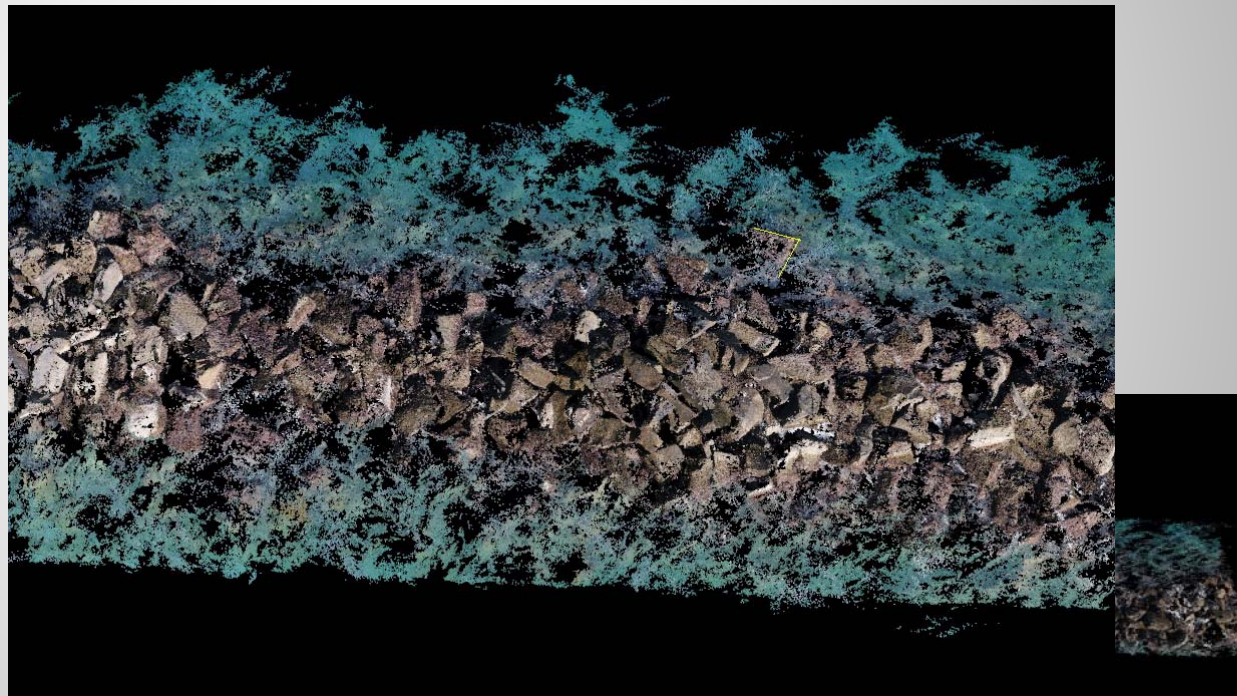
Photogrammetry

- Measurement From Photographs
 - From Drone Camera

3-D Data From Remote
& Large Areas



Know.

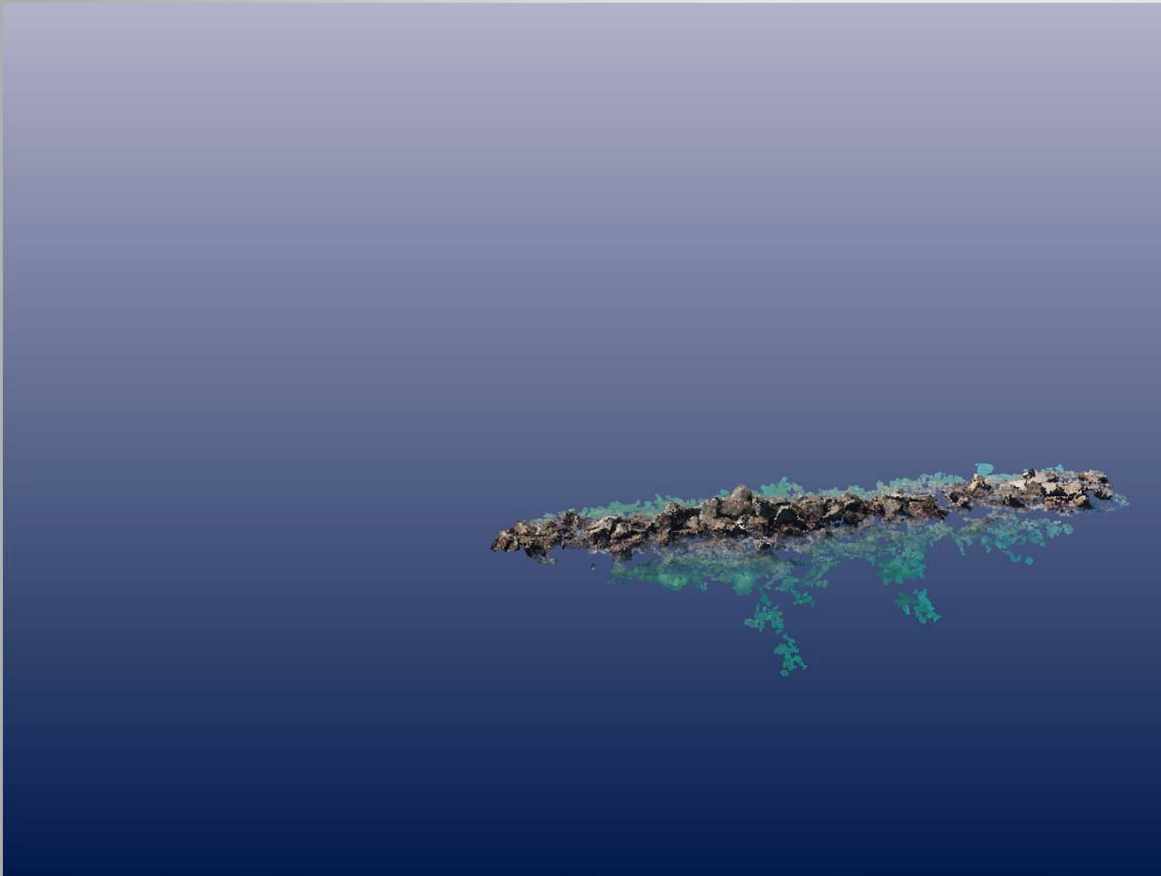


Types of 3-D Data Collection



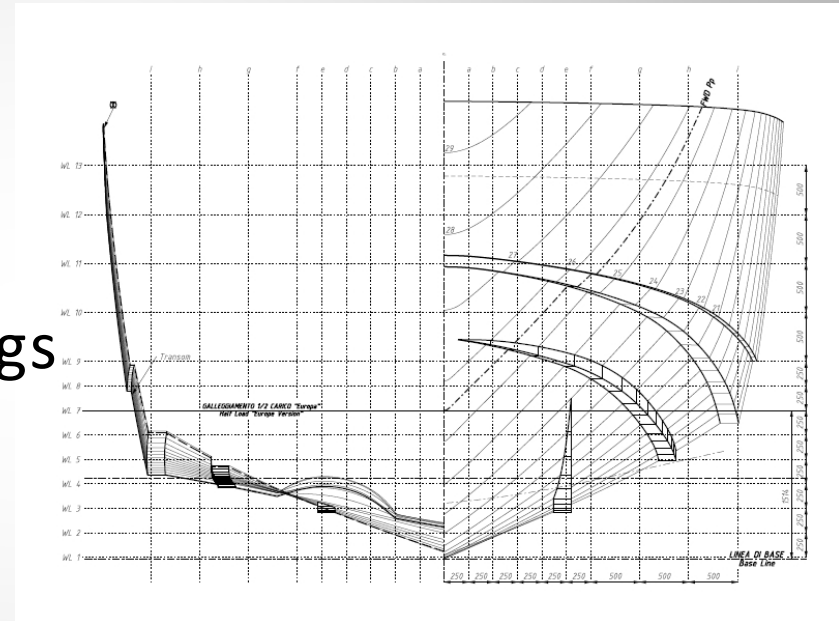
Know.

3-D Data From Remote & Large Areas



Types of 3-D Data Collection

- 3-D Laser Scanning
- Photogrammetry
 - Camera
 - Drone
- Pre-existing 3-D CAD Drawings
- 2-D Drawings
- Hand Measurement



Know.

What's the difference?

- 3-D Data are scaled position information
- 3-D Models are forms or shapes based on measured data
- Models can be used
 - to perform tests & analysis
 - Hydrostatics & Stability
 - Finite Element Analysis
 - Structural Analysis
 - To help explain a hypothesis (animation)
- “All models are wrong, but some are useful.” –George Box

3-D Data vs. Model

An Example...

Photographs...



Know.



Vessel 1



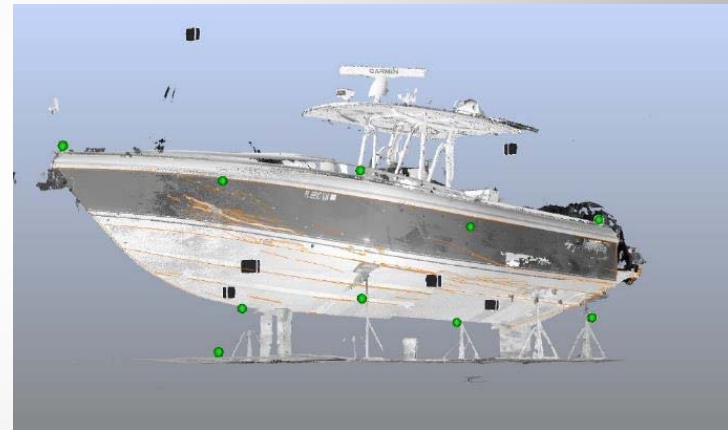
Vessel 2

An Example...

3-D Point Cloud from Laser Scan of Damaged Vessels...



Vessel 1



Vessel 2

An Example...



Know.

Models of Pre-Damaged Vessels...



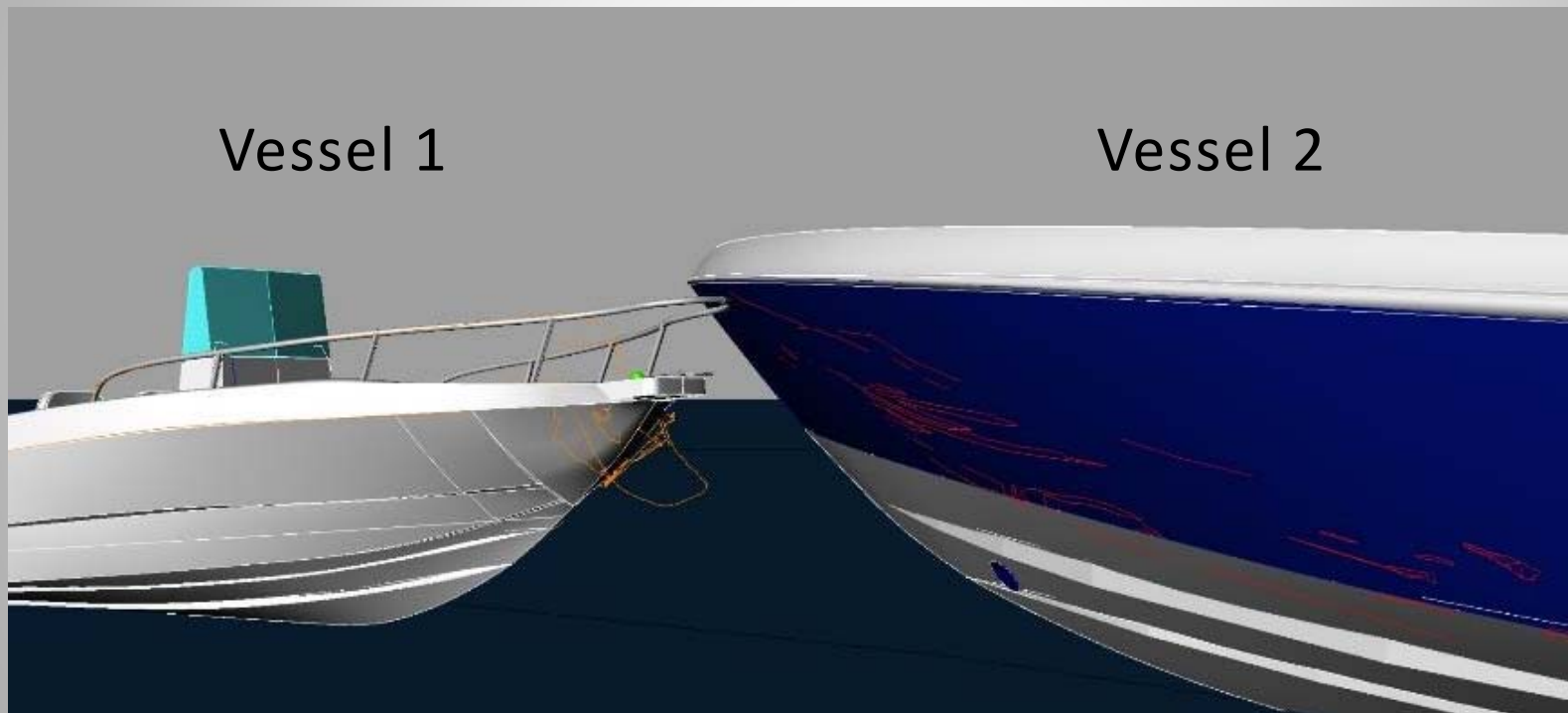
Vessel 1



Vessel 2

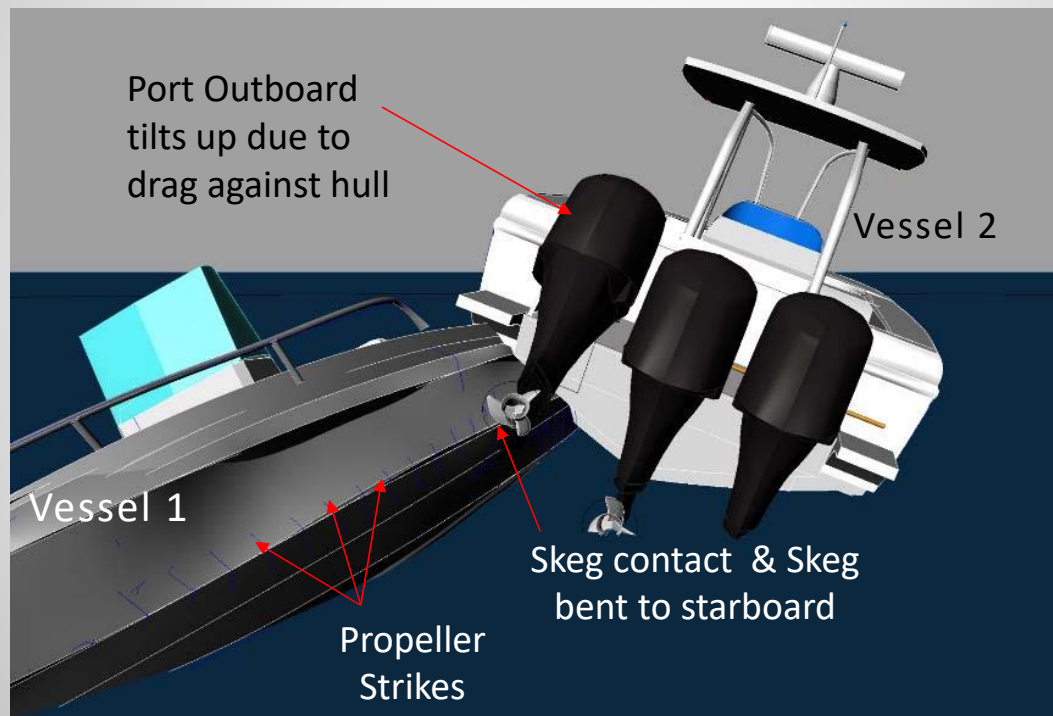
An Example...

3-D Models of Both Vessels to Explain Damage...



An Example...

3-D Models of Both Vessels to Explain Damage...





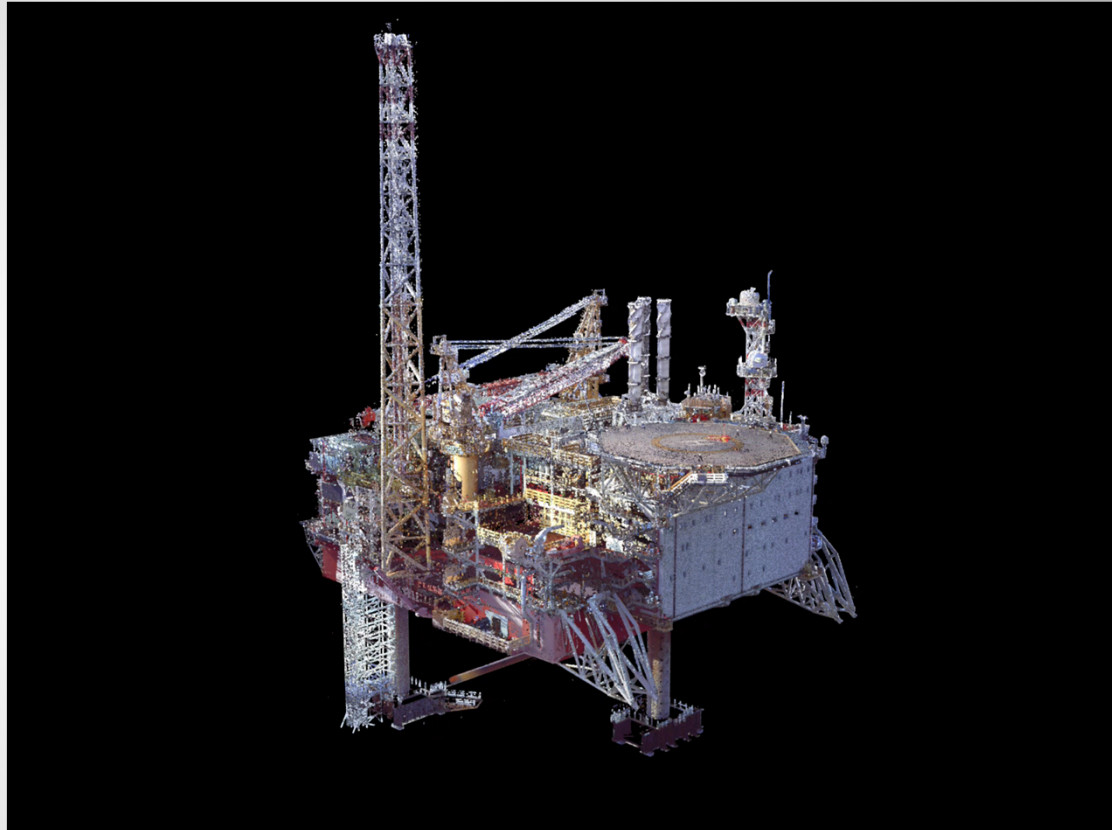
Case Study No. 1

Documentation of Offshore Oil Rig

Case Study No. 1 - Documentation

Offshore Oil Rig

- Background
- Purpose
 - Document Defects
 - Valuation

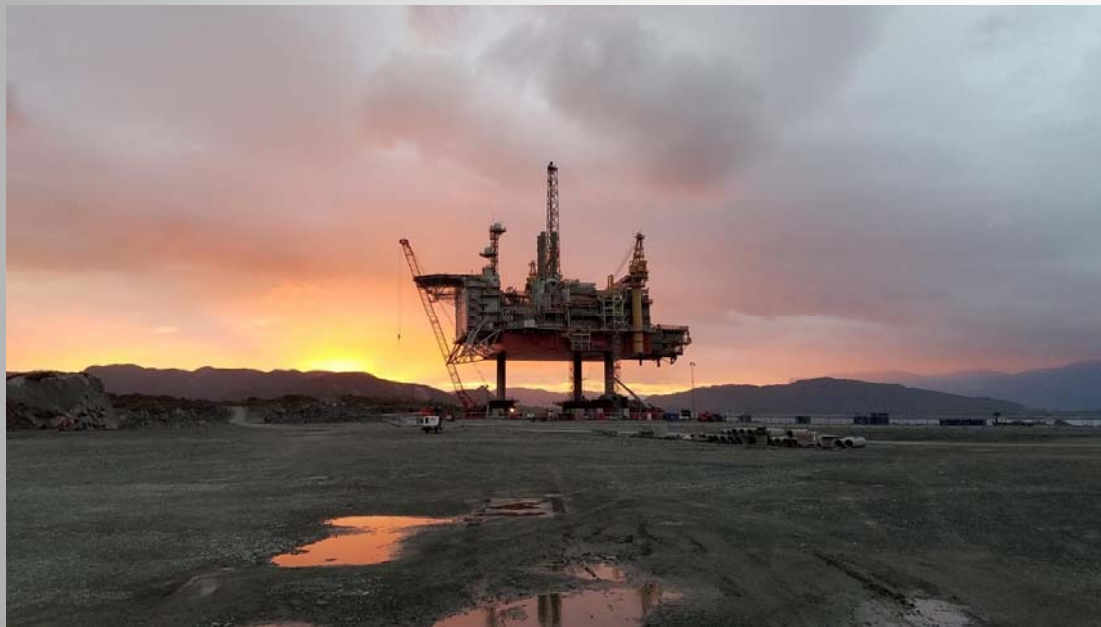


Know.

Case Study No. 1 - Documentation

Offshore Oil Rig

- Resources



Know.

Case Study No. 1 - Documentation



Know.



Case Study No. 1 - Documentation



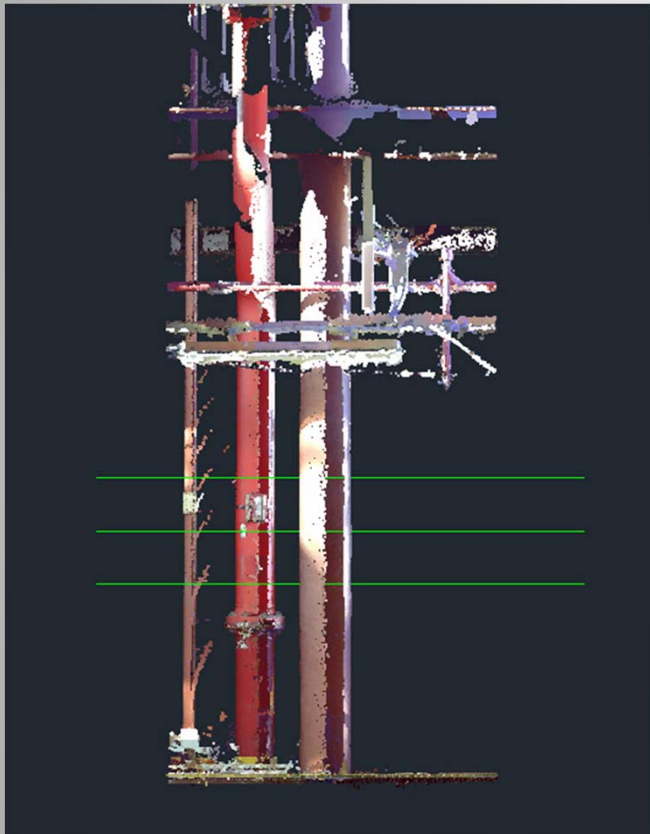
Know.



Case Study No. 1 - Documentation



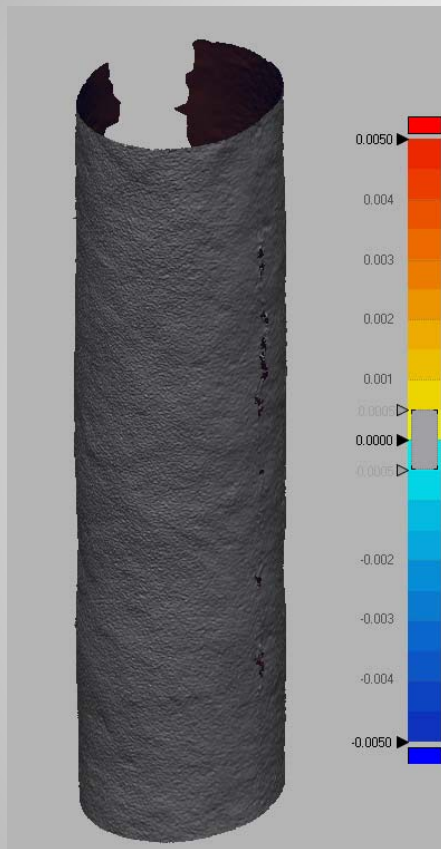
Know.



Case Study No. 1 - Documentation



Know.



Offshore Oil Rig



Know.

- Background
- Purpose
 - Document Construction Defects
 - Valuation
- Results
 - Information captured forever
 - Expert analysis still required





Case Study No. 2

Vessel Sinking Analysis

Case Study No. 2 - Vessel Sinking Analysis

Sinking at the dock

- Background
- Purpose
 - Why?
 - When?
 - Who?



Know.

Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan



Case Study No. 2 - Vessel Sinking Analysis

Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud

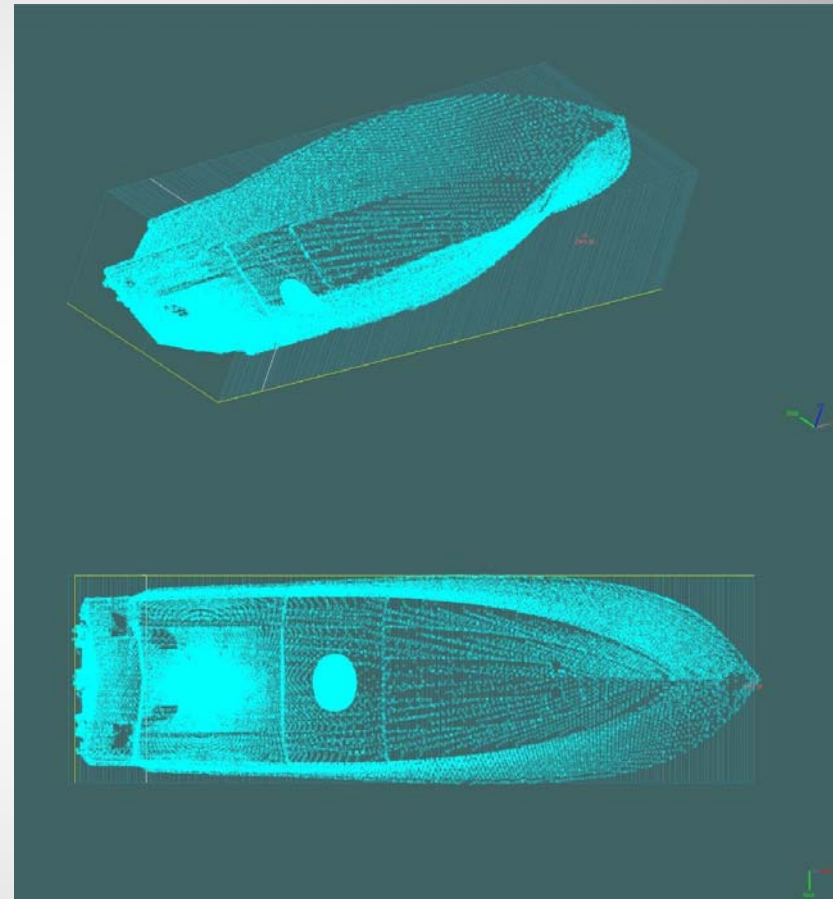


Know.



Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud
 - Build CAD Model

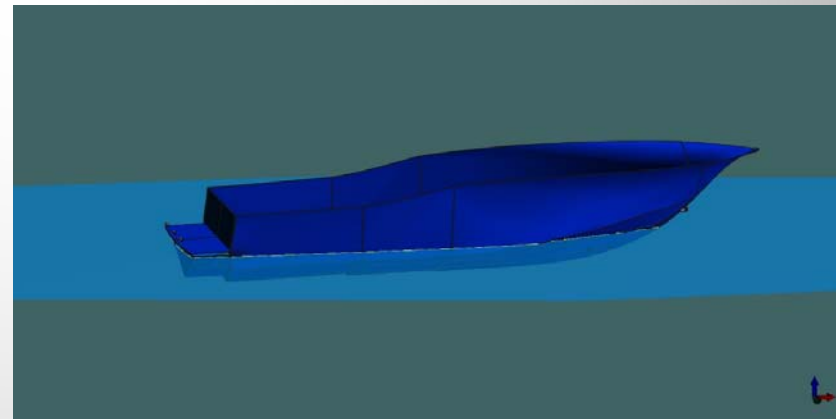
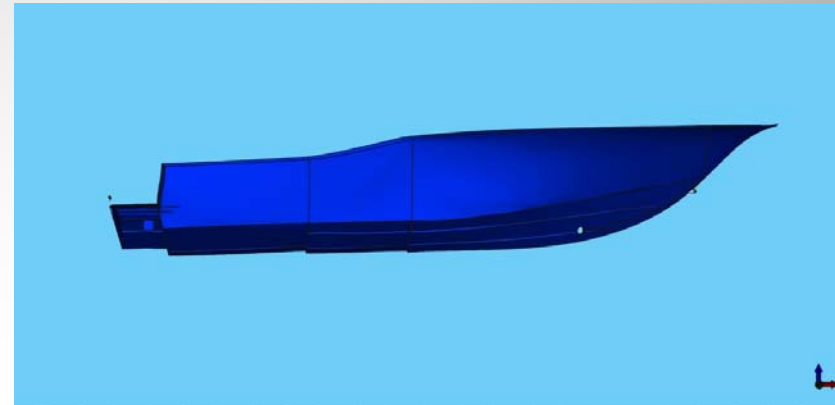
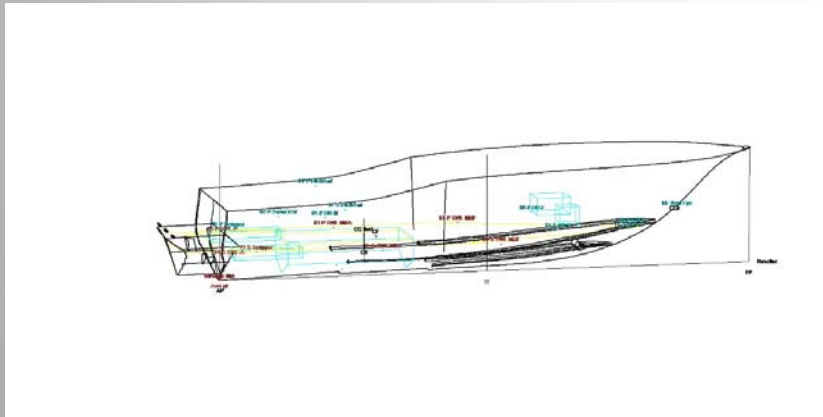


Know.

Case Study No. 2 - Vessel Sinking Analysis

Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud
 - Build CAD Model

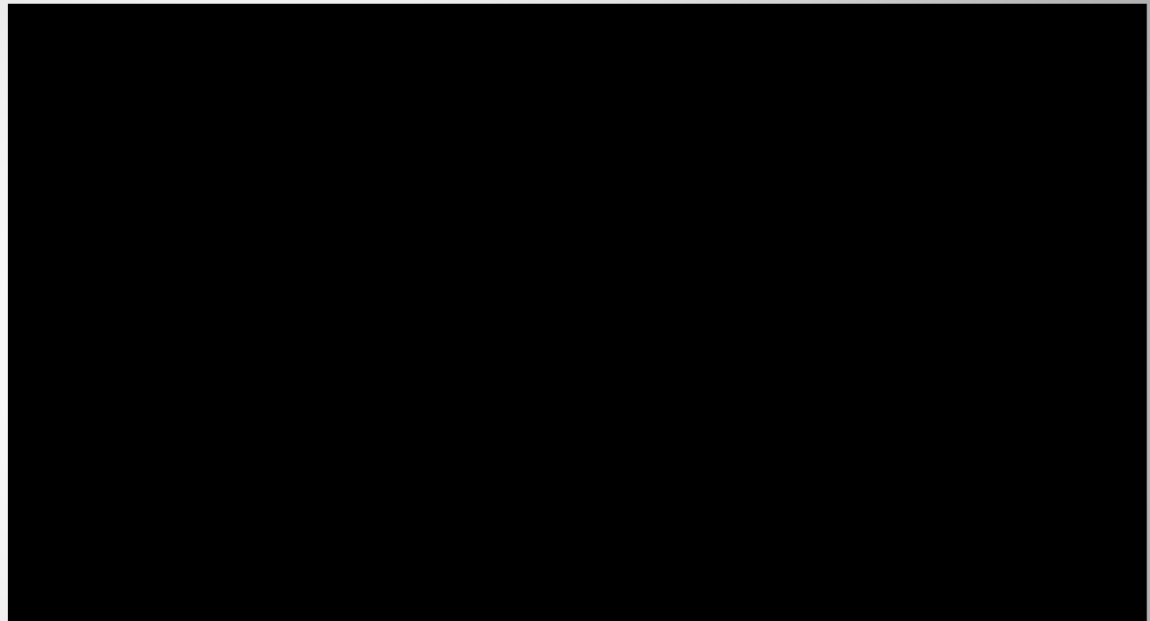


Know.



Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud
 - Build CAD Model



Sinking at the dock

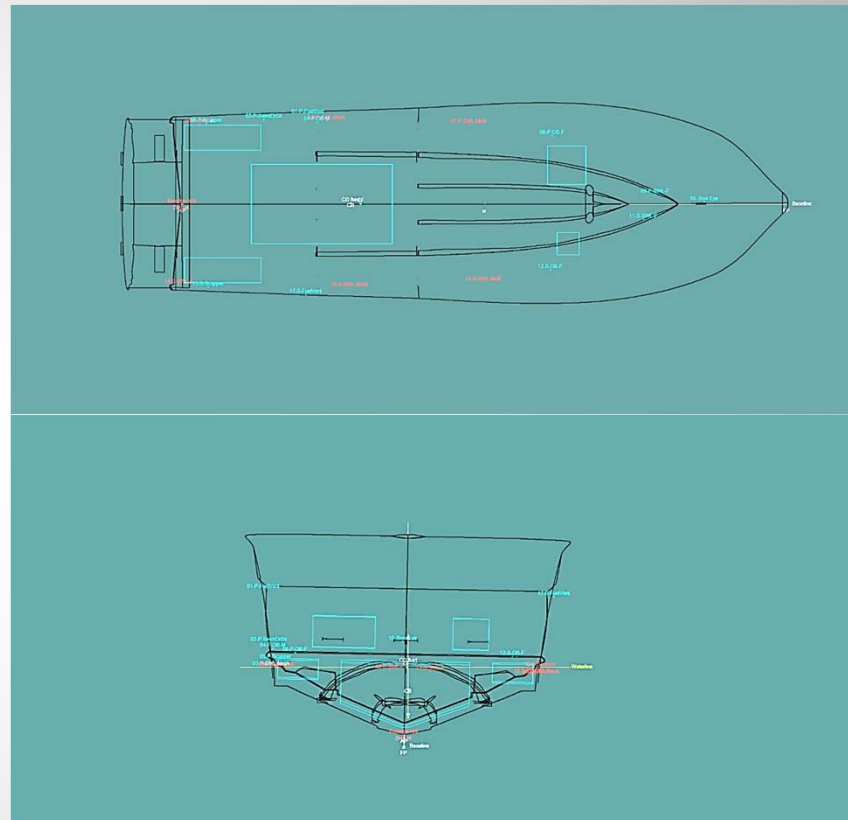
- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud
 - Build CAD Model
 - Establish Lightship Condition



Case Study No. 2 - Vessel Sinking Analysis

Sinking at the dock

- Methodology
 - Estimates/Calculations
 - 3-D Laser Scan
 - Develop Point Cloud
 - Build CAD Model
 - Establish Lightship Condition
 - Test Various Loading Conditions

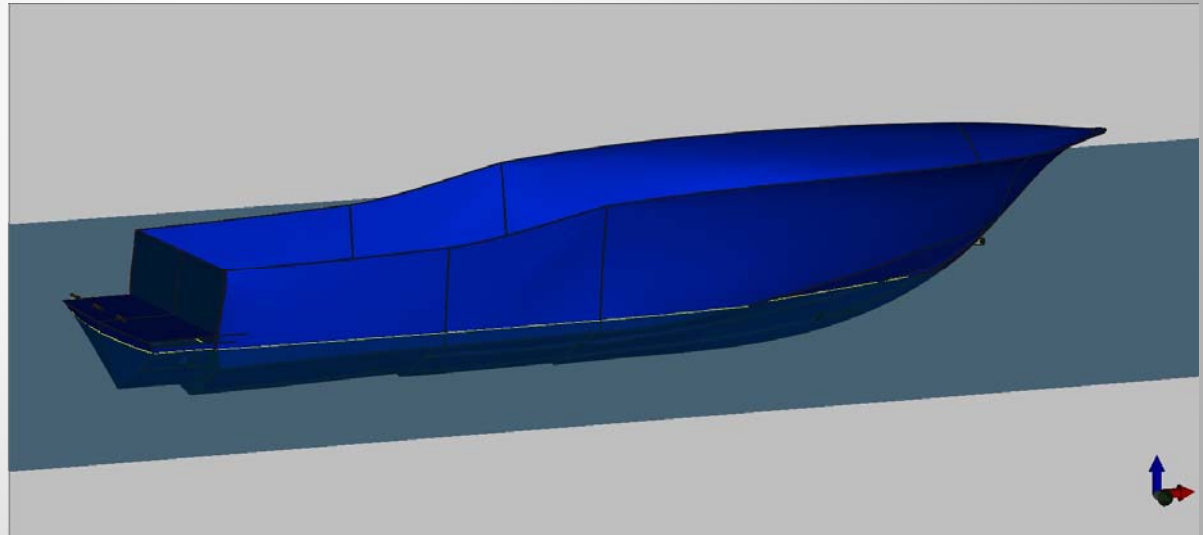


Know.

Sinking at the dock

- Results

- Change in freeboard due to water density
- Freeboard of vessel when left
- Down-flooding rate
- Bilge pump condition





Case Study No. 3

Post Hurricane Sinking

Case Study No. 3 – Post Hurricane Sinking

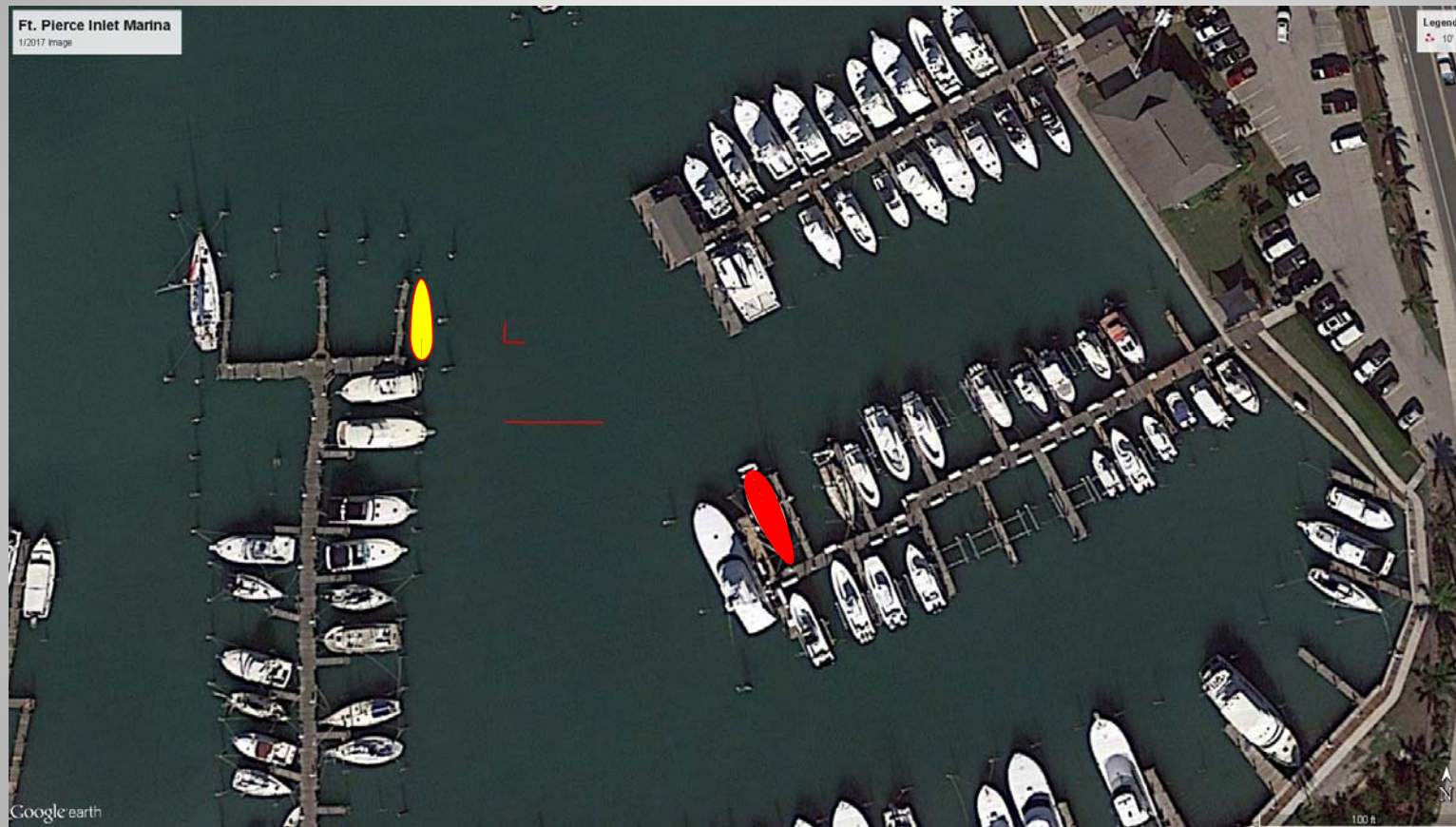
Who Dunnit?

- Background



Know.

Case Study No. 3 – Post Hurricane Sinking

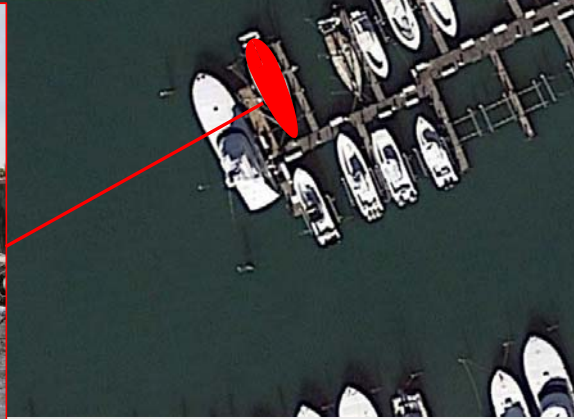
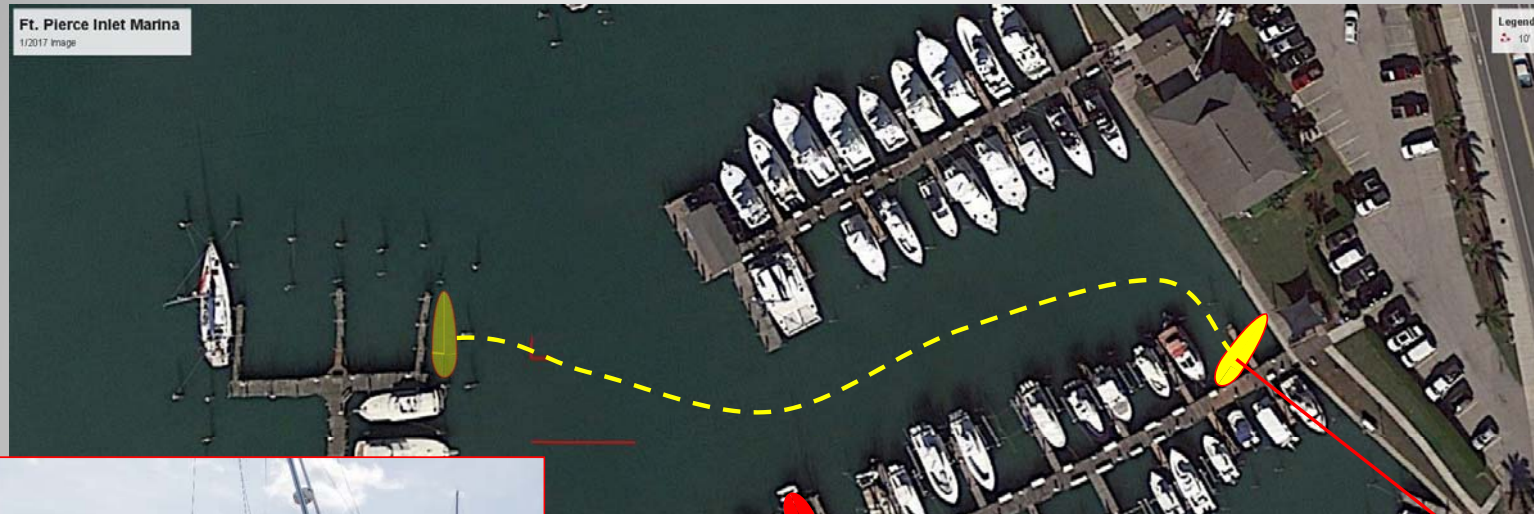


Know.

Case Study No. 3 – Post Hurricane Sinking



Know.



Case Study No. 3 – Post Hurricane Sinking



Know.



Case Study No. 3 – Post Hurricane Sinking



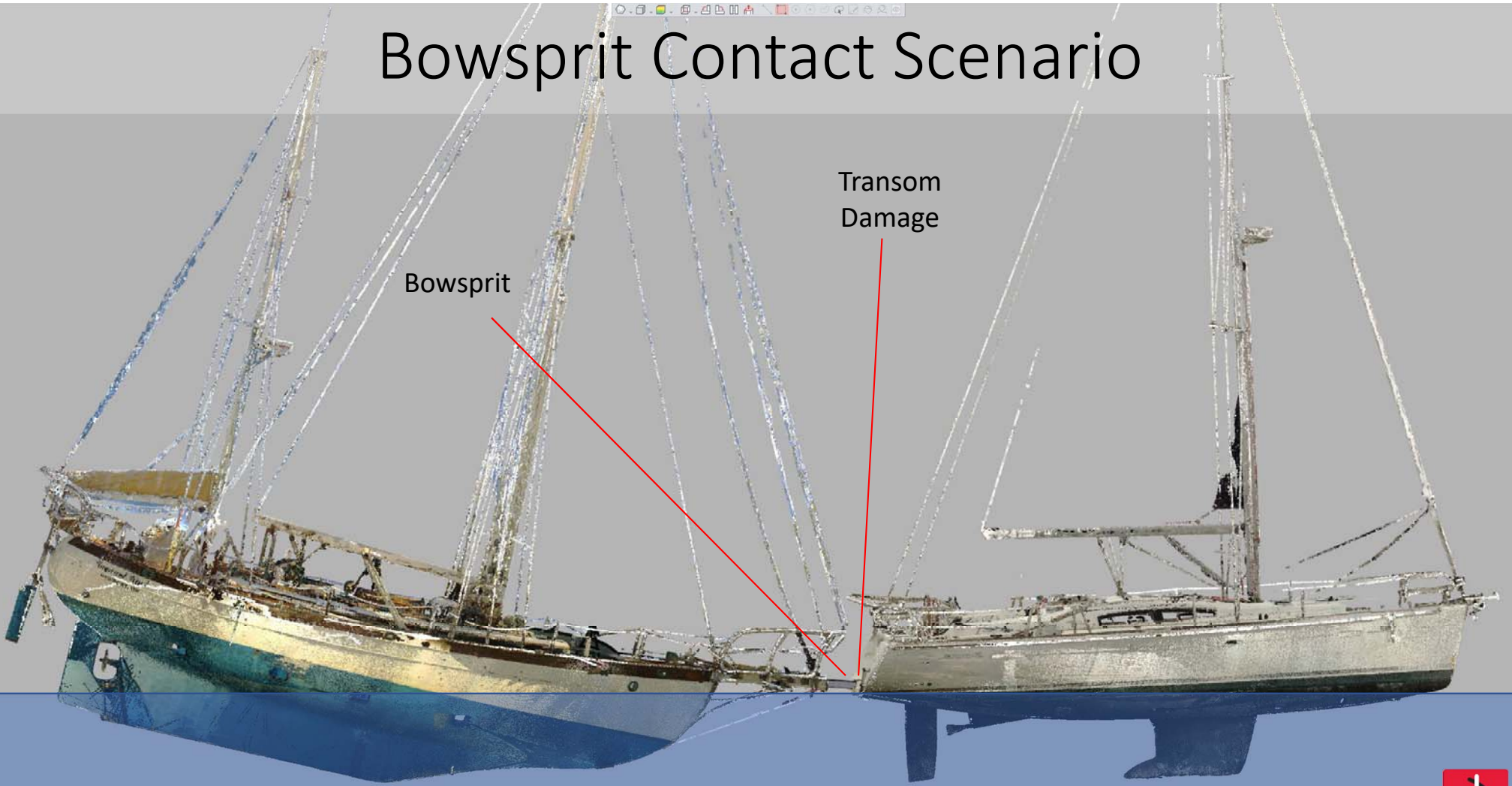
Know.



Bowsprit Contact Scenario

Bowsprit

Transom
Damage



Bowsprit Contact Scenario

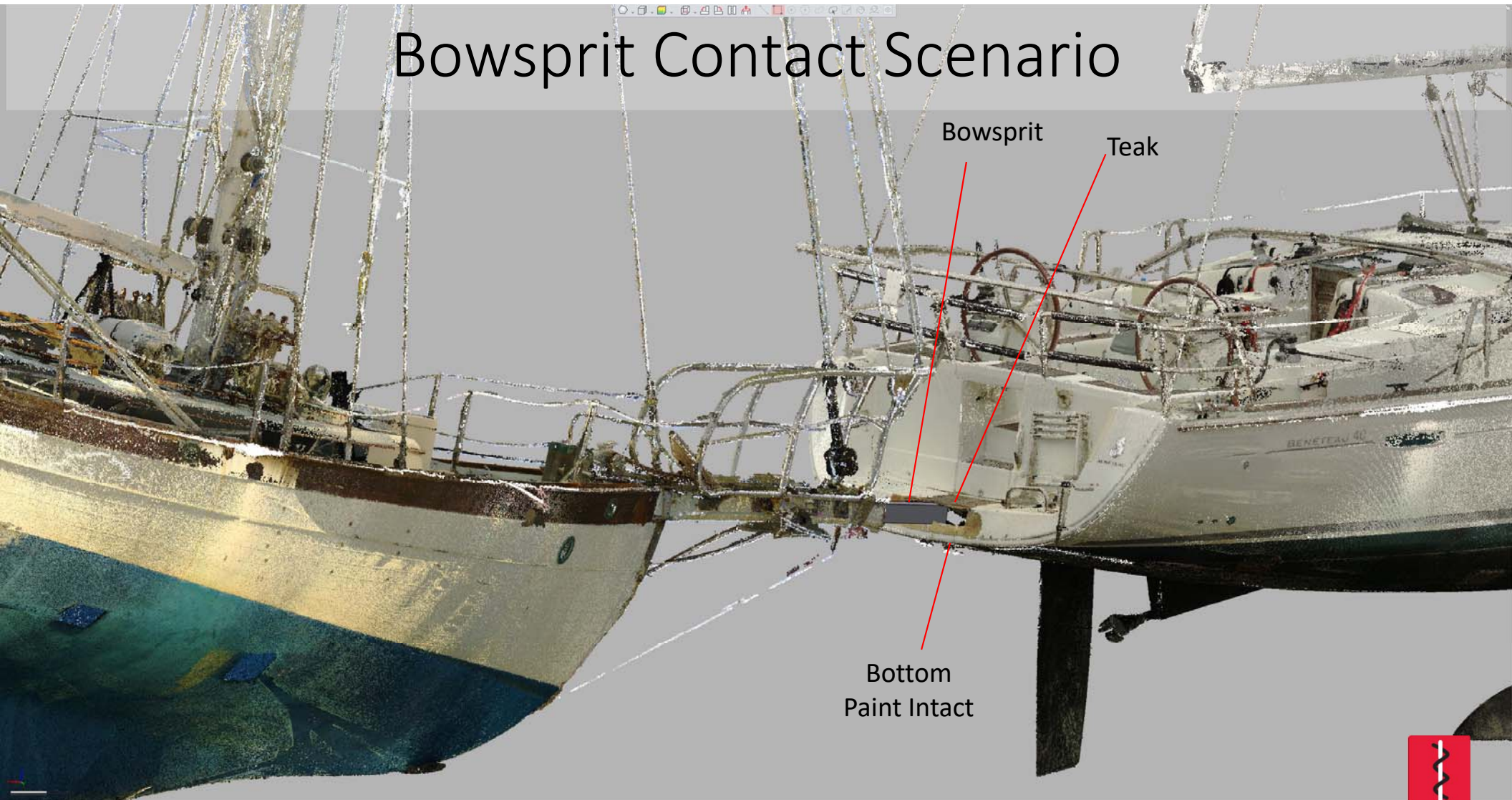
Bowsprit

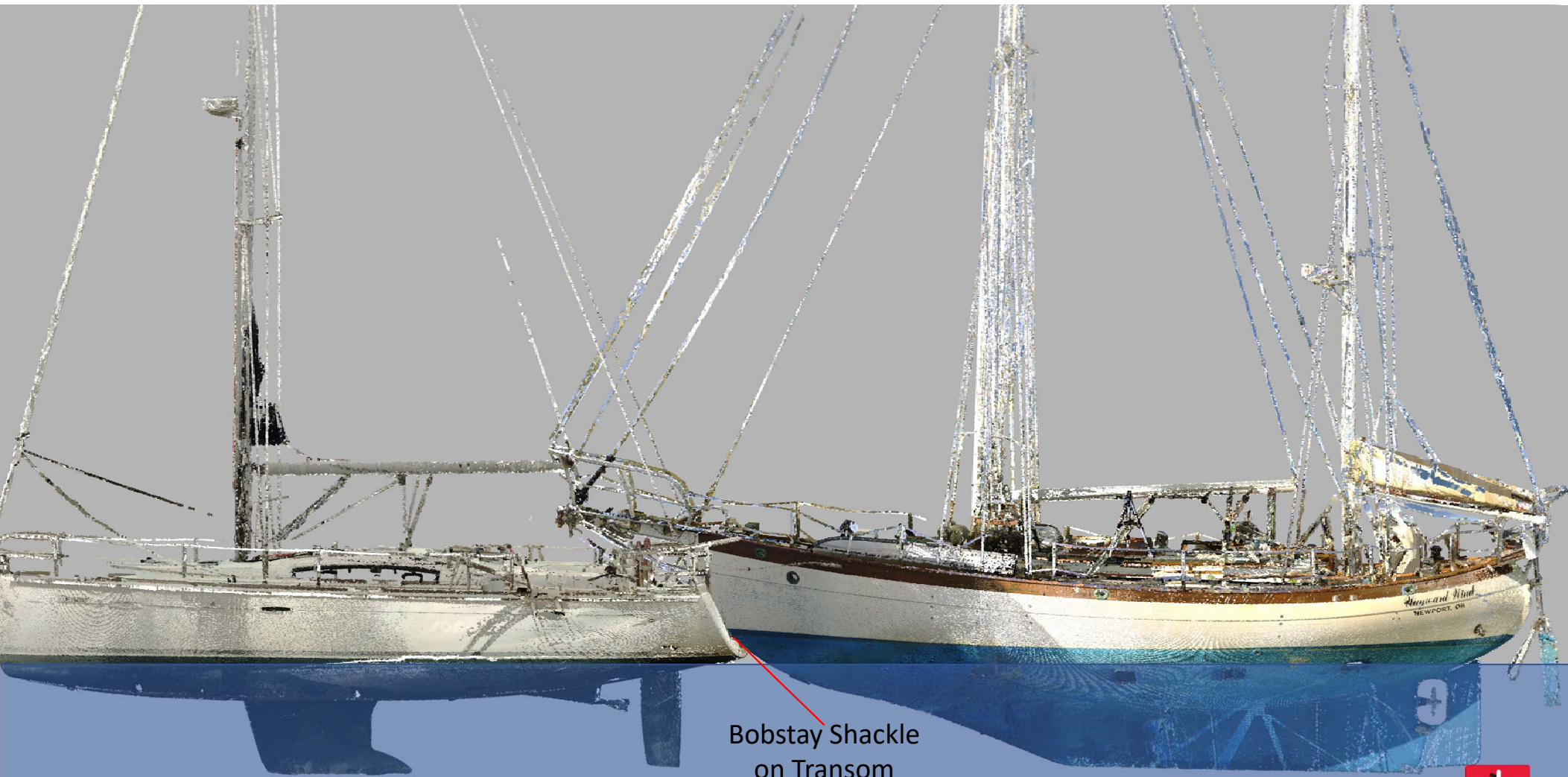
Forestay

Dodger
Frame

Railing

Bowsprit Contact Scenario

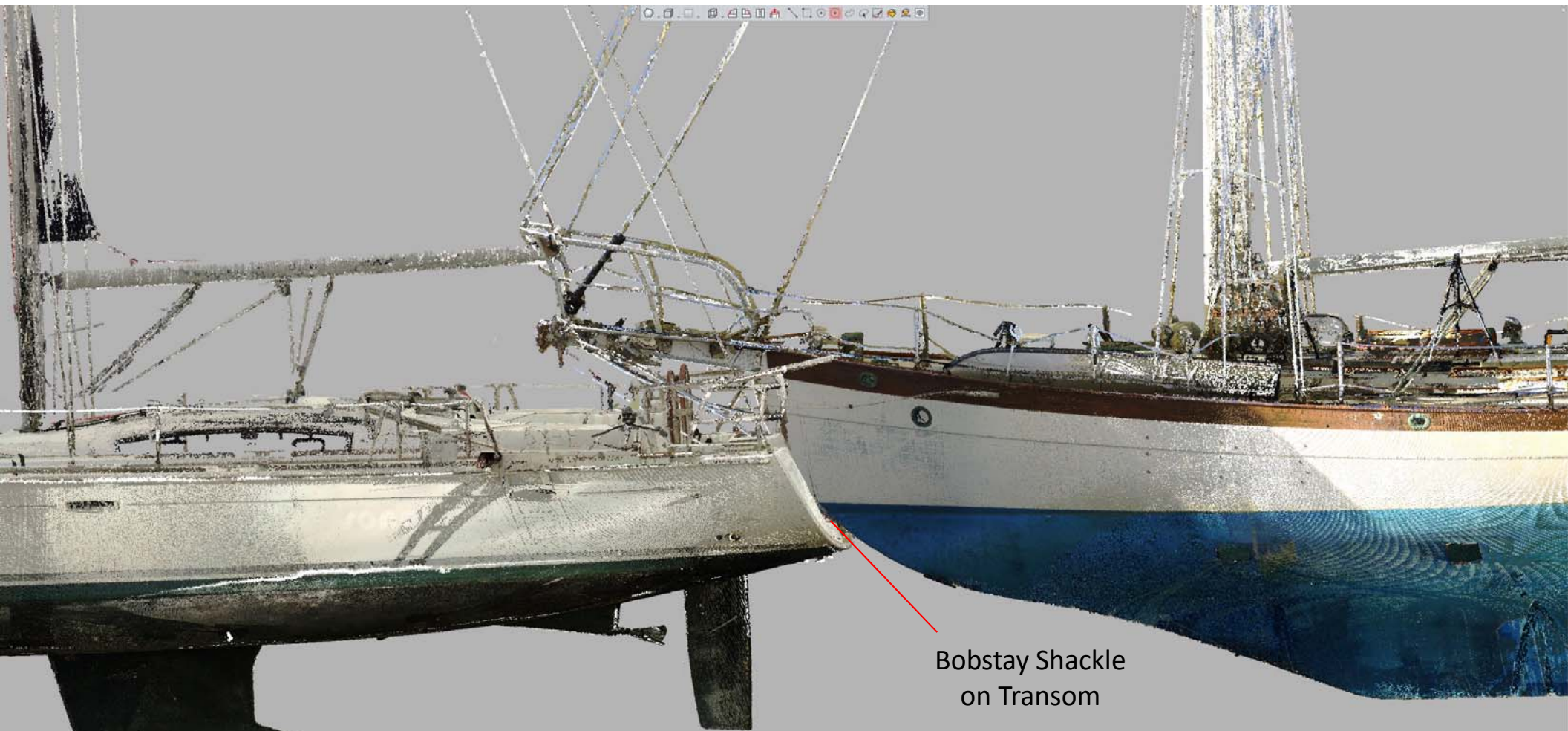




Bobstay Shackle
on Transom

Bobstay Shackle Contact Scenario



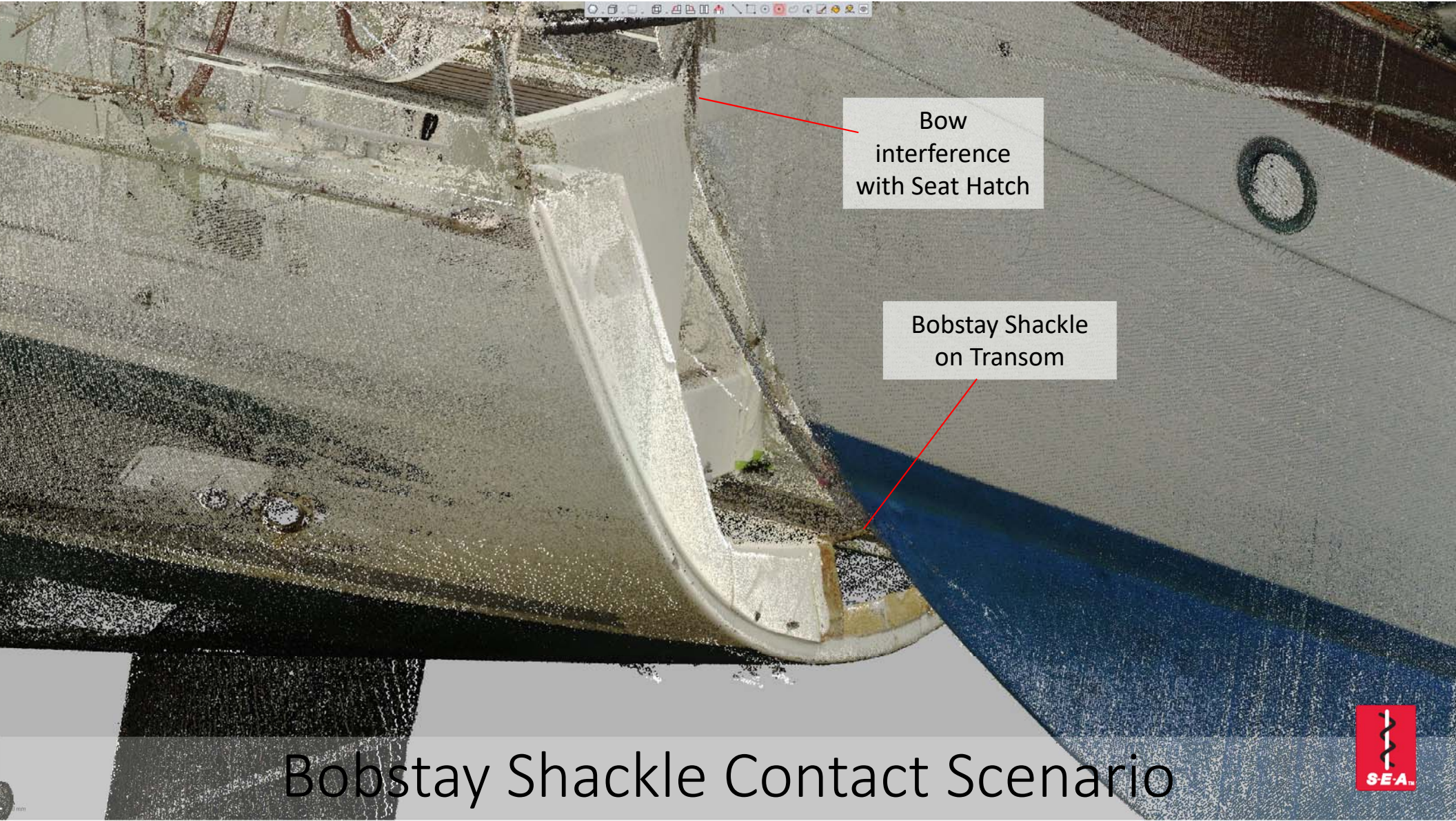


Bobstay Shackle
on Transom

Bobstay Shackle Contact Scenario



0.5 mm

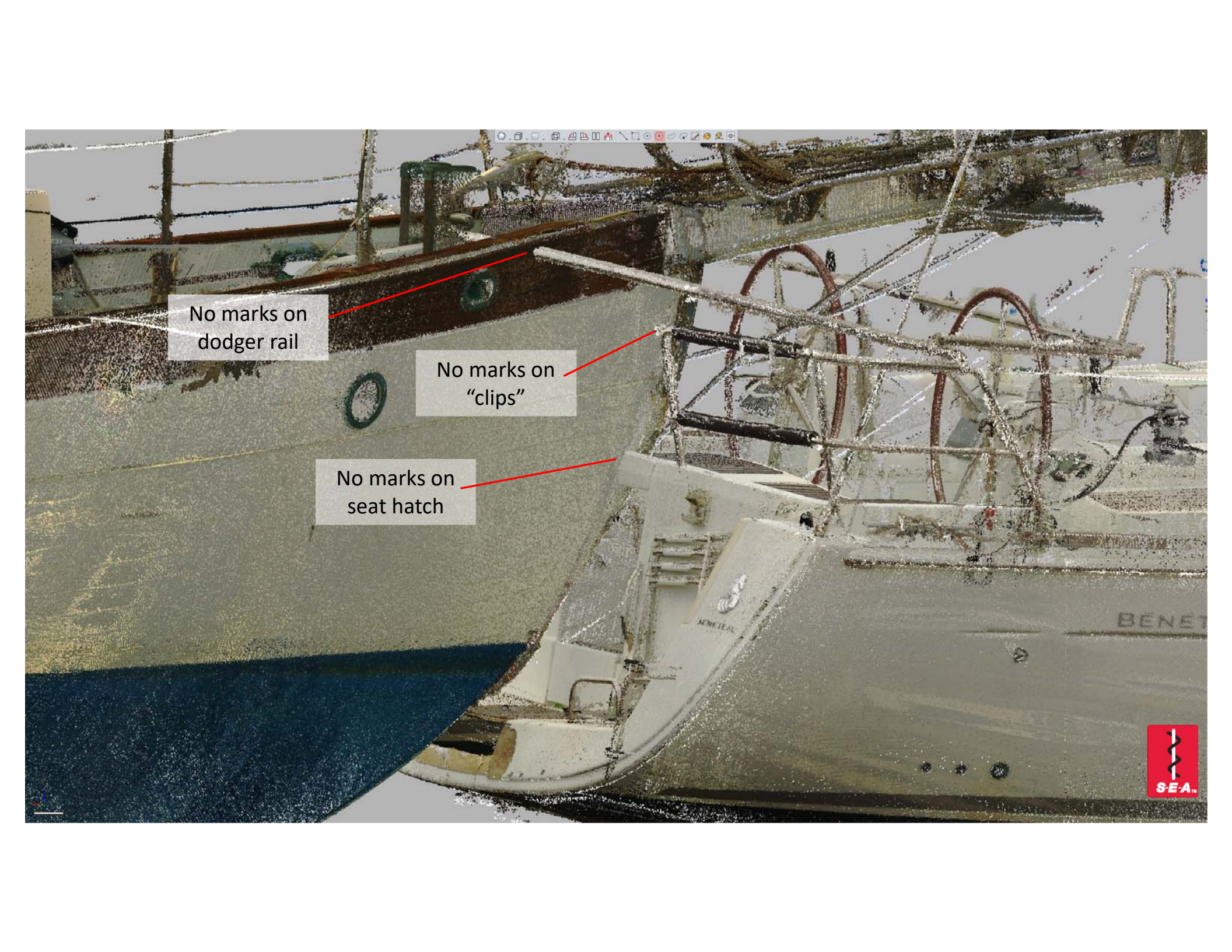


Bow
interference
with Seat Hatch

Bobstay Shackle
on Transom

Bobstay Shackle Contact Scenario



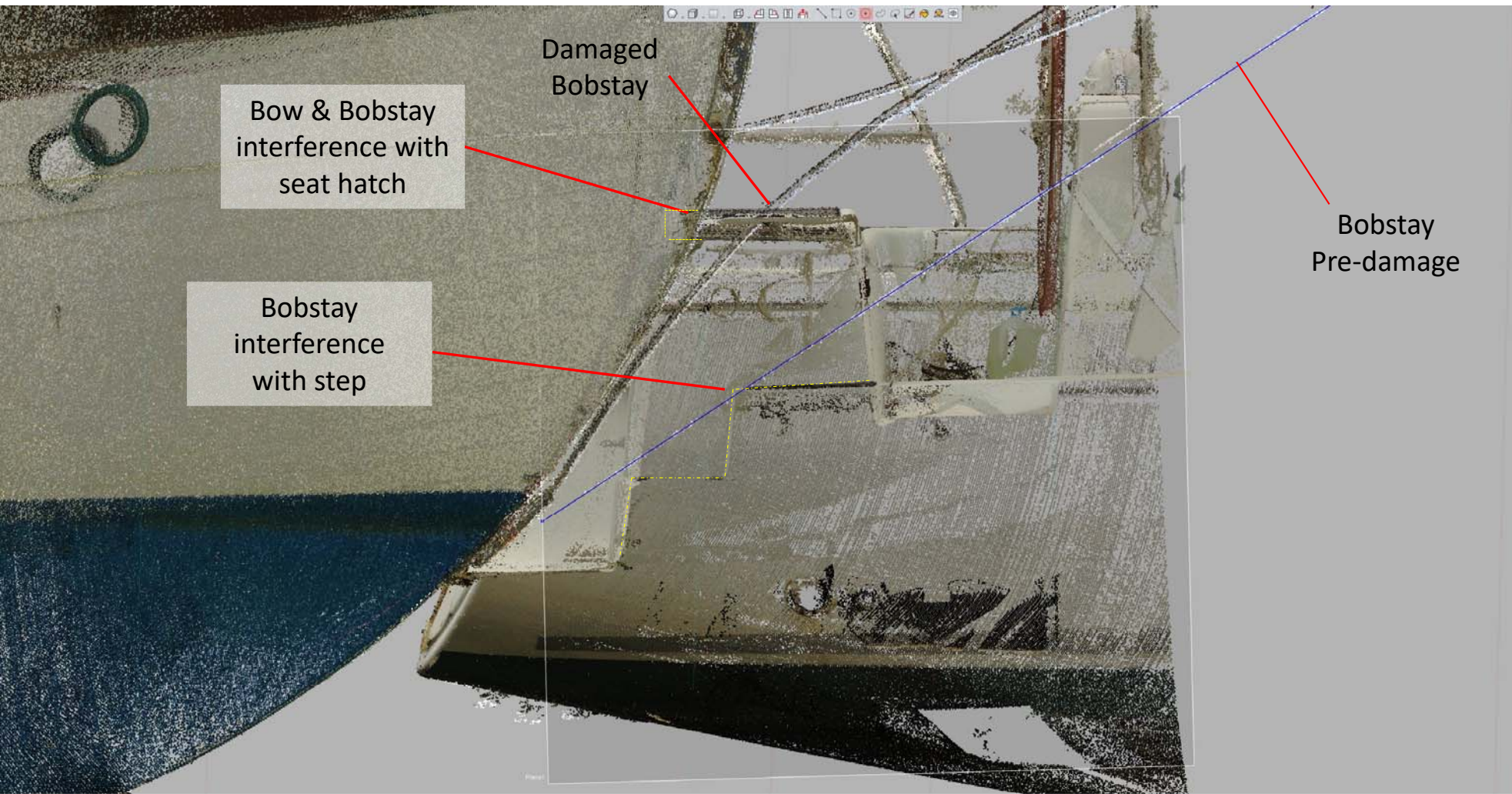


No marks on
dodger rail

No marks on
"clips"

No marks on
seat hatch





Bow & Bobstay
interference with
seat hatch

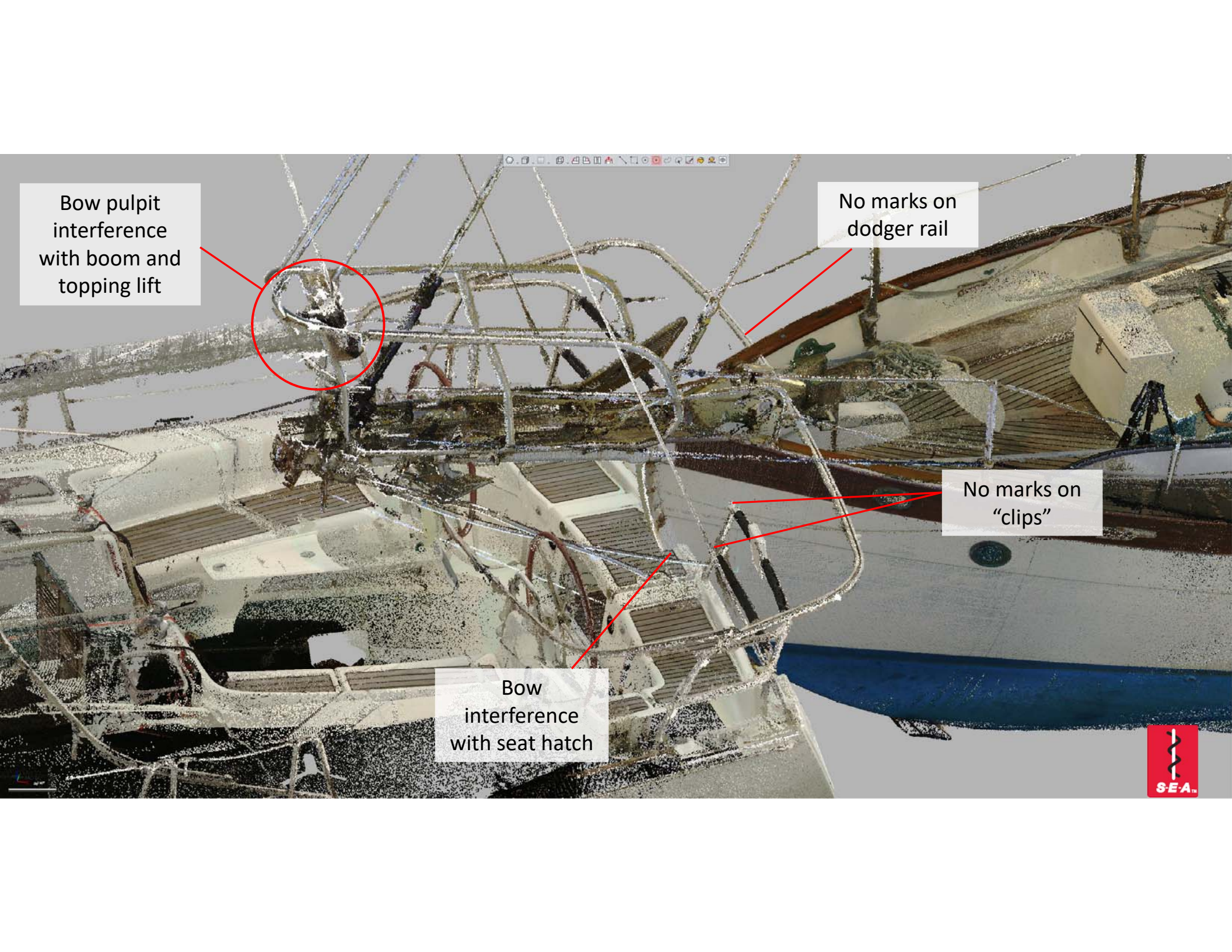
Bobstay
interference
with step

Damaged
Bobstay

Bobstay
Pre-damage

Bobstay Shackle Contact Scenario



A 3D point cloud model of a boat deck, showing the complex arrangement of railings, ropes, and structural elements. The model is rendered in a light grey color against a dark background. Several red circles and lines highlight specific areas of interest. A red circle highlights a point where a railing intersects with a boom and topping lift. A red line points to a section of the dodger rail. Another red line points to a section of the railing labeled as 'clips'. A red line points to the bow area where it meets a seat hatch. The text labels are in white boxes with black text. The SE-A logo is in the bottom right corner.

Bow pulpit
interference
with boom and
topping lift

No marks on
dodger rail

No marks on
"clips"

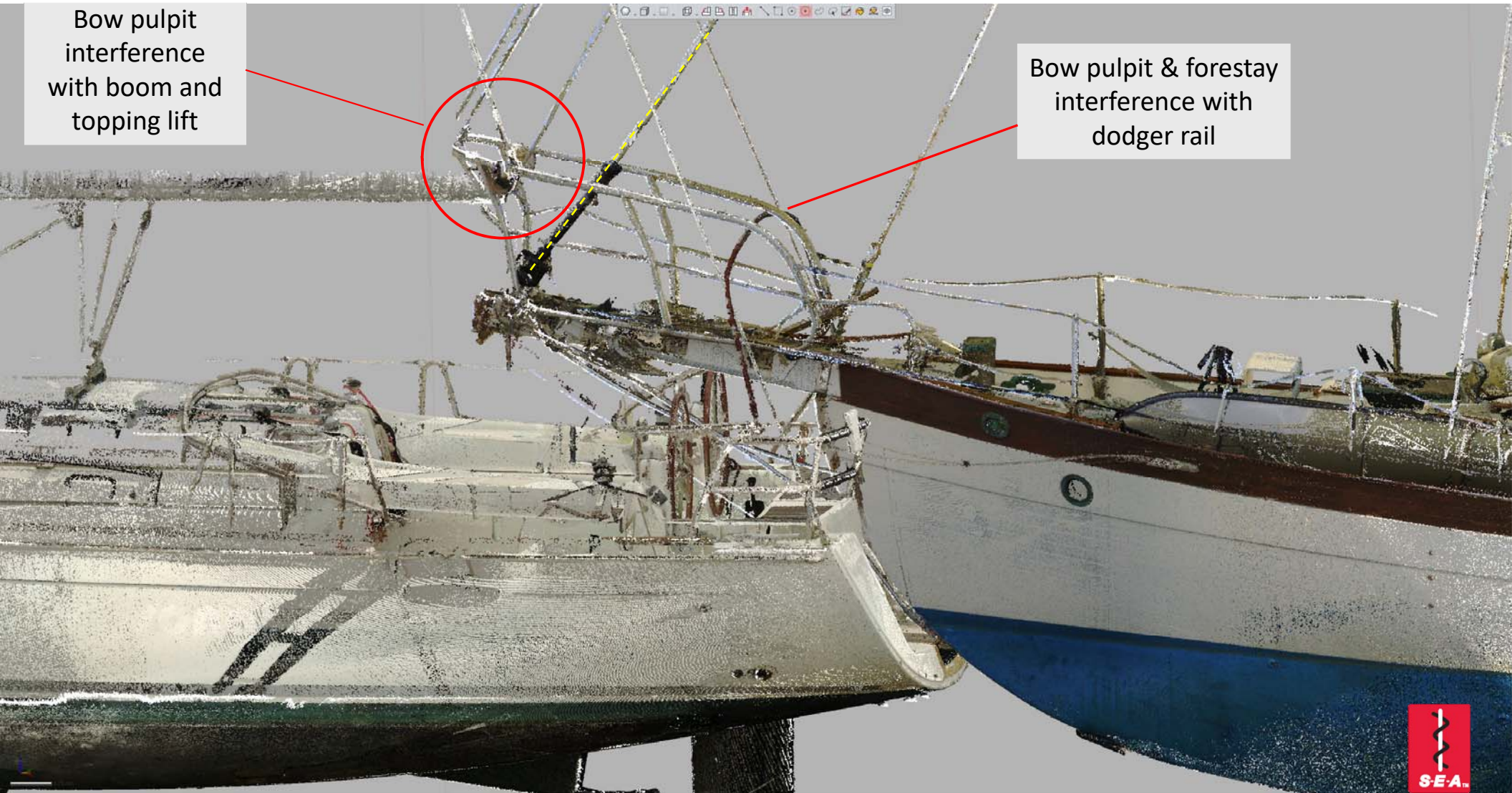
Bow
interference
with seat hatch

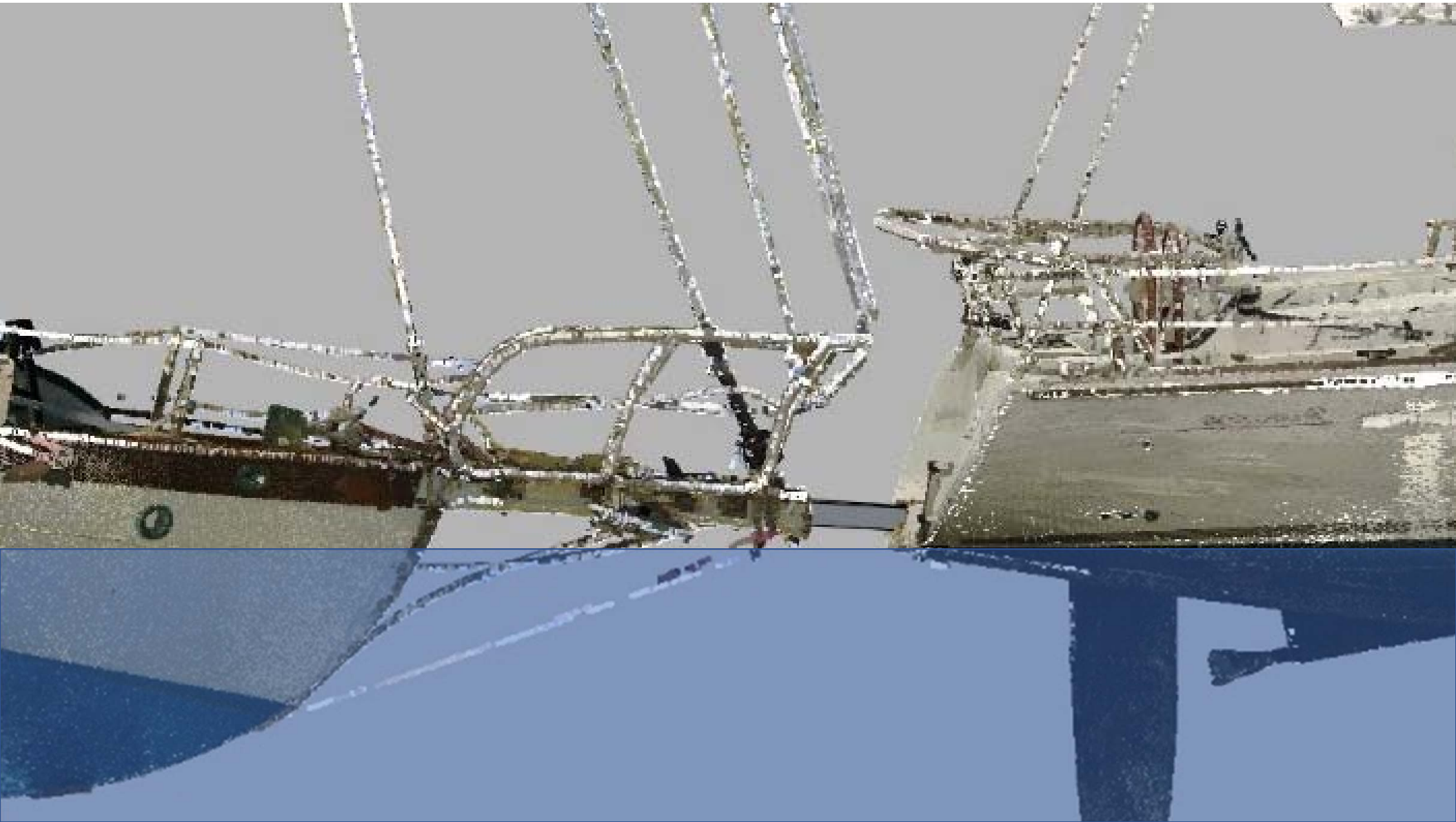


Maximum raised
position of
dodger rail

Bow pulpit
interference
with boom and
topping lift

Bow pulpit & forestay
interference with
dodger rail







Case Study No. 3 – Post Hurricane Sinking



Know.



Who Dunit



Know.

- Results

- Damage not consistent with being caused by suspect vessel
- Other plausible causes for the damage



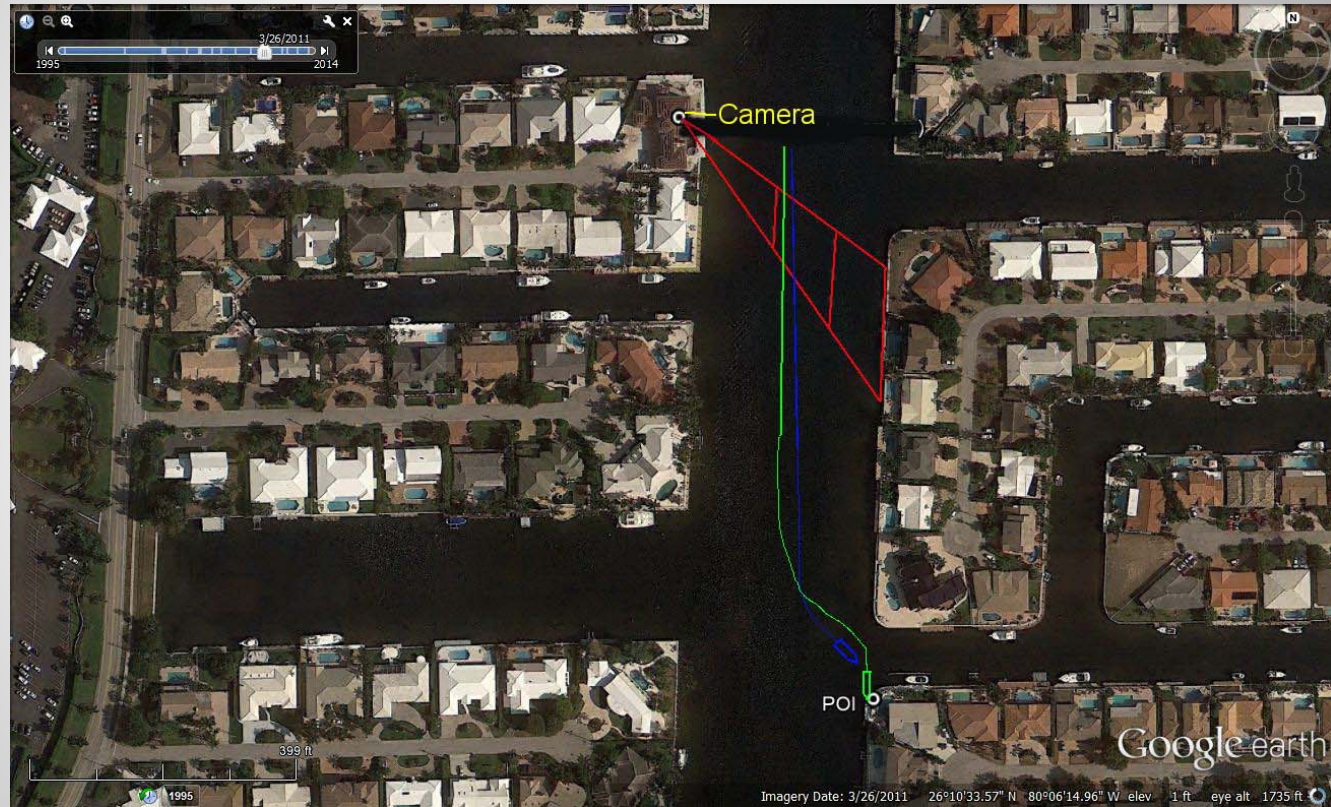
Case Study No. 4

Vessel Accident Reconstruction
Camera Matching

Case Study No. 5 – Vessel Accident Reconstruction

Camera Matching

- Background



Know.

Case Study No. 5 – Vessel Accident Reconstruction

Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?



Know.



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



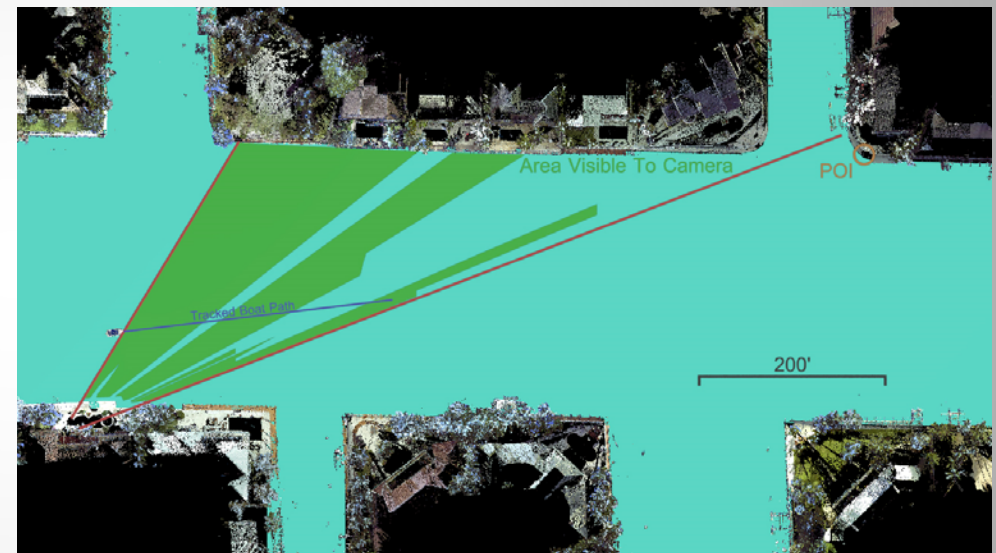
Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above



Camera Matching

- Background
- Issues:
 - How fast was the boat traveling?
- Methodology
 - 3-D laser scan of boat
 - 3-D laser scan of waterway
 - Lens Correction of CCTV
 - Combining the above





Case Study No. 5

Vessel Accident Reconstruction
Visibility Analysis

Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

- Background
- Issues:
 - What could the operator see?
- Methodology
 - 3-D laser scan,
 - GPS position data,
 - Instrumentation & Operational Testing
 - Modeling & Animation



Know.

Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis



Know.



Tee Top missing



Transfer marks
across console



Contact/
Transfer Marks
on port bulwark



Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis



Forward End – Point of Initial Contact

No marks or damage



No marks or damage



Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis



Gouge/Scrapes

Port Bow



Gouge/Scrapes

Starboard Bow

Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

3D Laser Scan of 54' Sports Cruiser



Know.



Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

3D Scan of Exemplar 19' Center Console



Know.



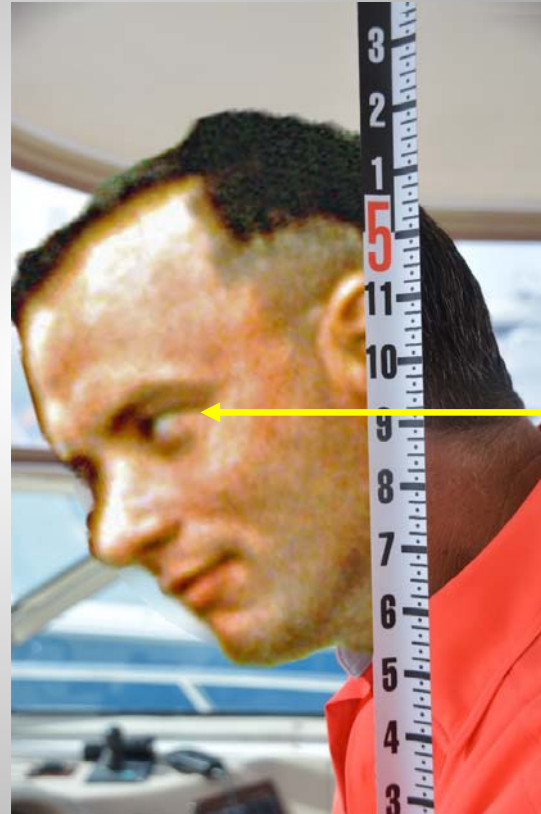
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

Determining operator's height of eye



Know.



Apx. 4' 9" Height of Eye

Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

On-water Testing of 54' Sports Cruiser

- Used VBOX data collection
- Measured Apx. Avg. 7.5° trim at 16-18 kts:
- 90% of trim angles between 5° and 9.5°



Know.

Visibility Analysis

On-water Testing of 54' Sports Cruiser

- Captured video at Height of Eye of the operator



- Example:
 - 5' Height of Eye
 - 16 Knots
 - 1-2 ft. Seas

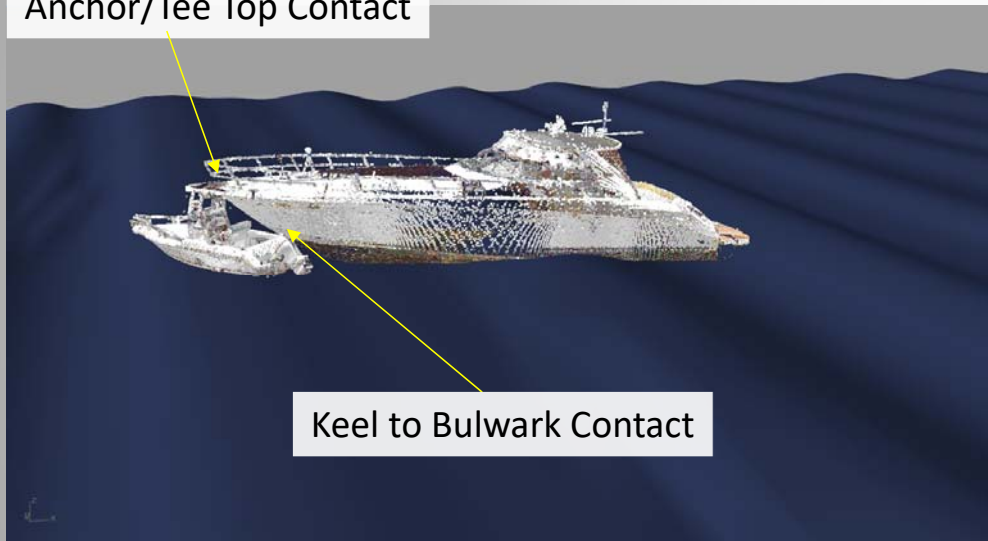
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis Test Accident Scenarios



Scenario A: Apx. 2 ft seas, 7.5° Trim, 54' vessel keel to 19' vessel bulwark Initial Contact

Anchor/Tee Top Contact



Keel to Bulwark Contact



7.5° deck angle in 2 ft. seas

Case Study No. 6 – Vessel Accident Reconstruction

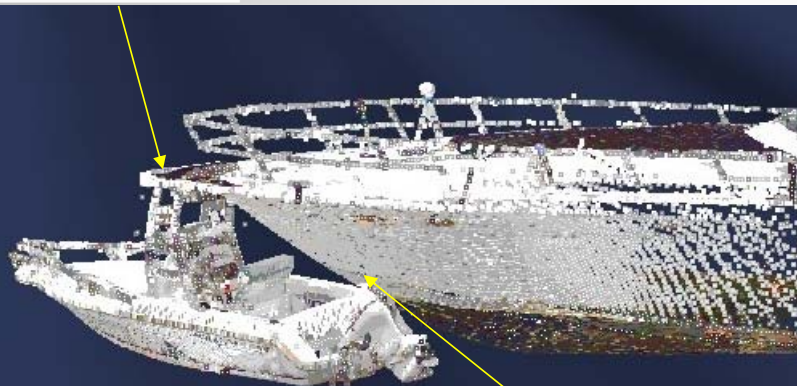
Visibility Analysis



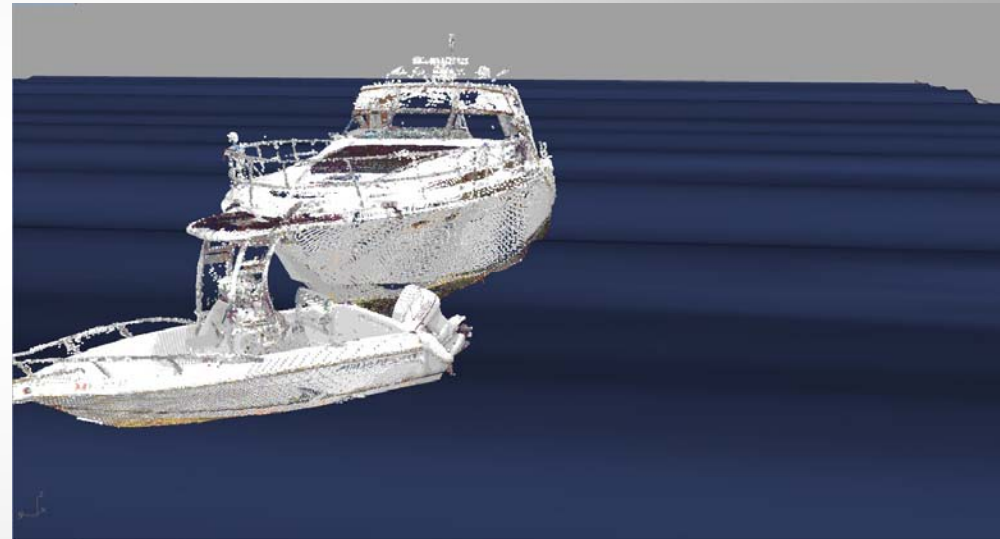
Know.

Scenario A: Apx. 2 ft seas, 7.5° Trim, Initial Contact- 54' vessel keel to 19' vessel bulwark

Anchor/Tee Top Contact



Keel to Bulwark Contact



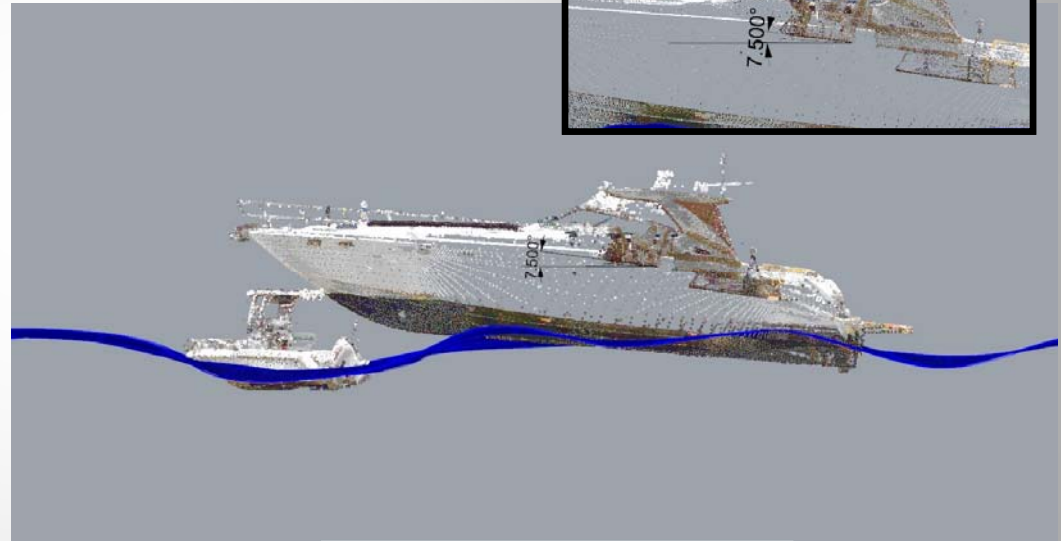
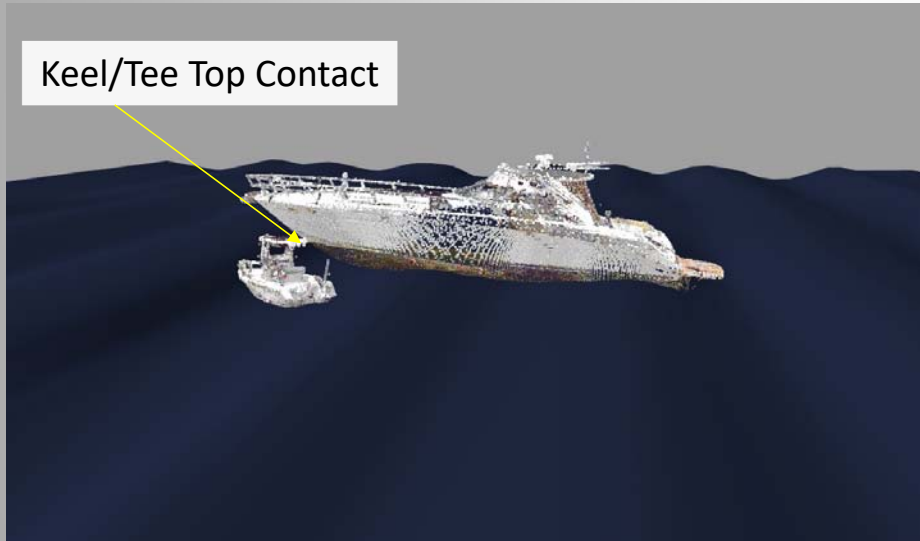
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis



Know.

Scenario B: Apx. 5 ft seas, 7.5° Trim, Initial Contact - 54' vessel keel to 19' vessel Tee-Top



7.5° deck angle in 5 ft. seas

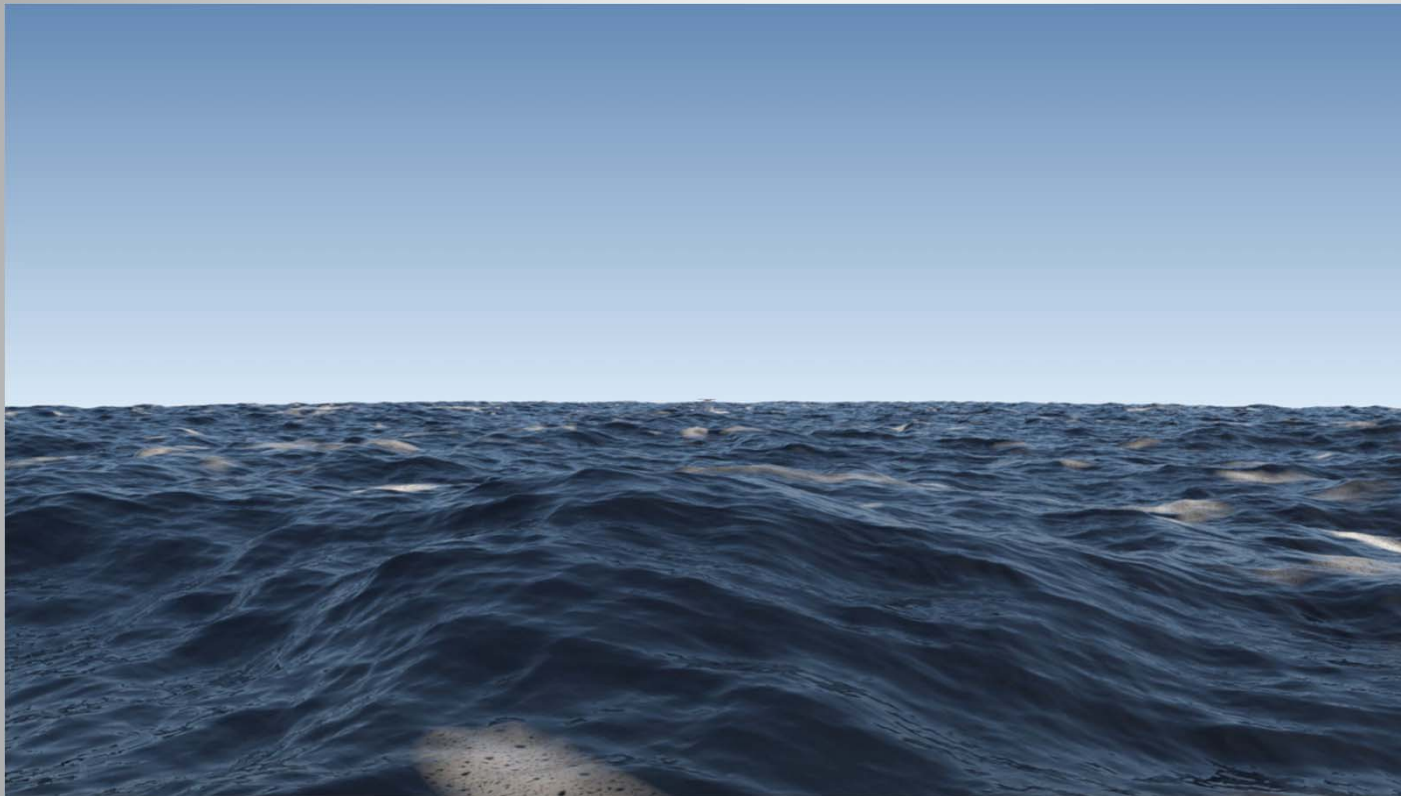
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

Scaled Animation



Know.



Height of Eye: 4' 9"
Vessel Speed: 17 knots
Seas : 2-6 ft.
Weather: Clear Skies
Trim: 5°-9°
Start Apx. 570 ft. apart

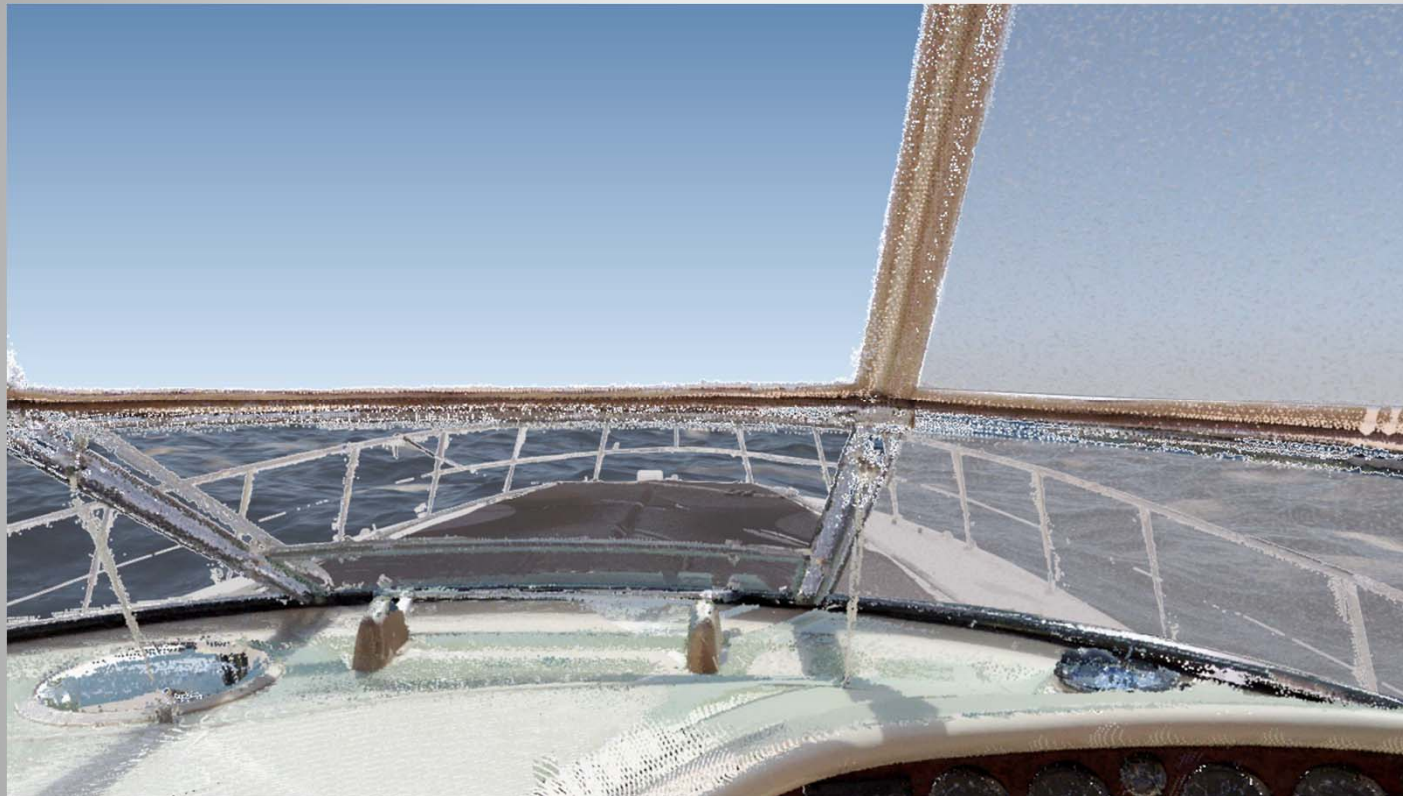
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

Scaled Animation



Know.



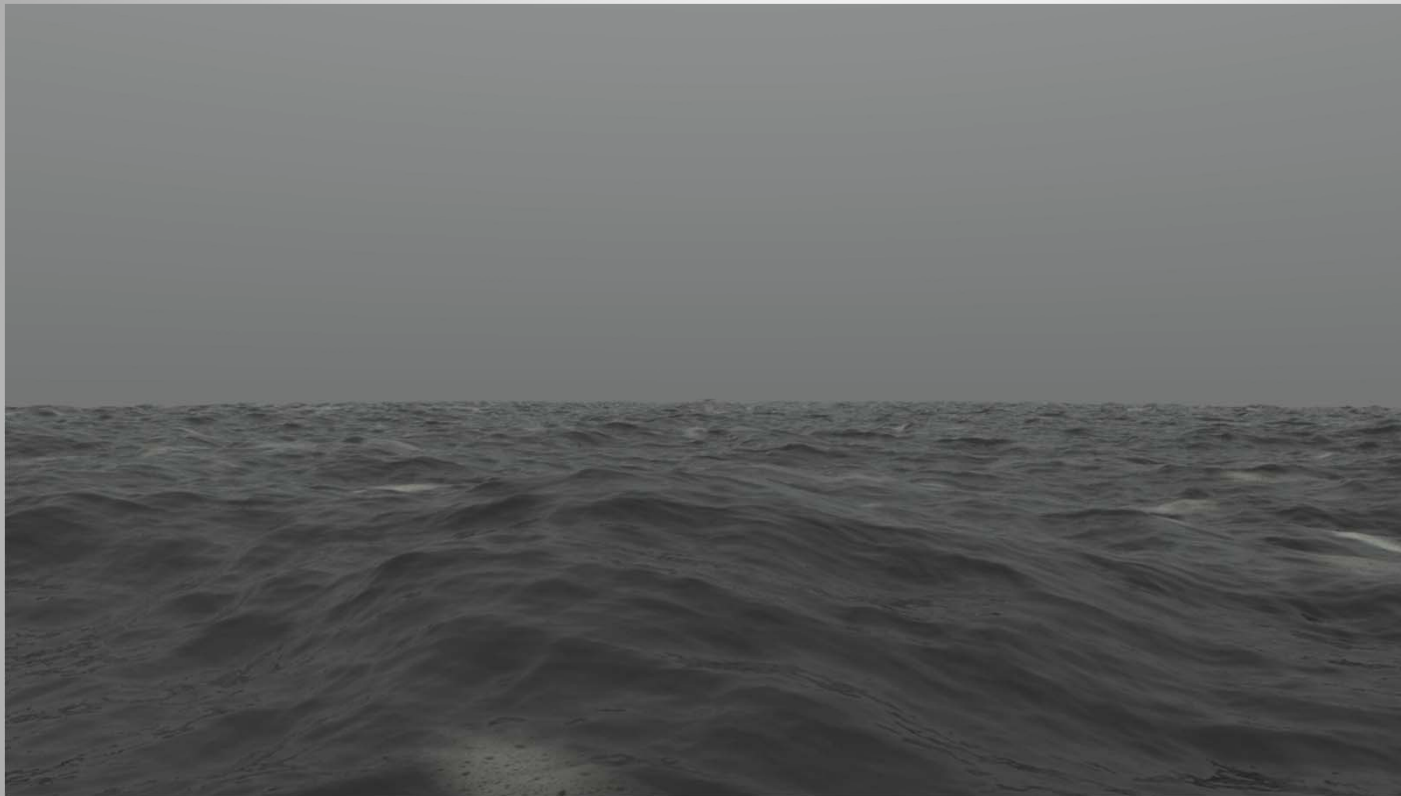
Height of Eye: 4' 9"
Vessel Speed: 17 knots
Seas : 2-6 ft.
Weather: Clear Skies
Trim: 5°-9°
Start Apx. 570 ft. apart

Visibility Analysis

Scaled Animation



Know.



Height of Eye: 4' 9"
Vessel Speed: 17 knots
Seas : 2-6 ft.
Weather: Cloudy
Trim: 5°-9°
Start Apx. 570 ft. apart

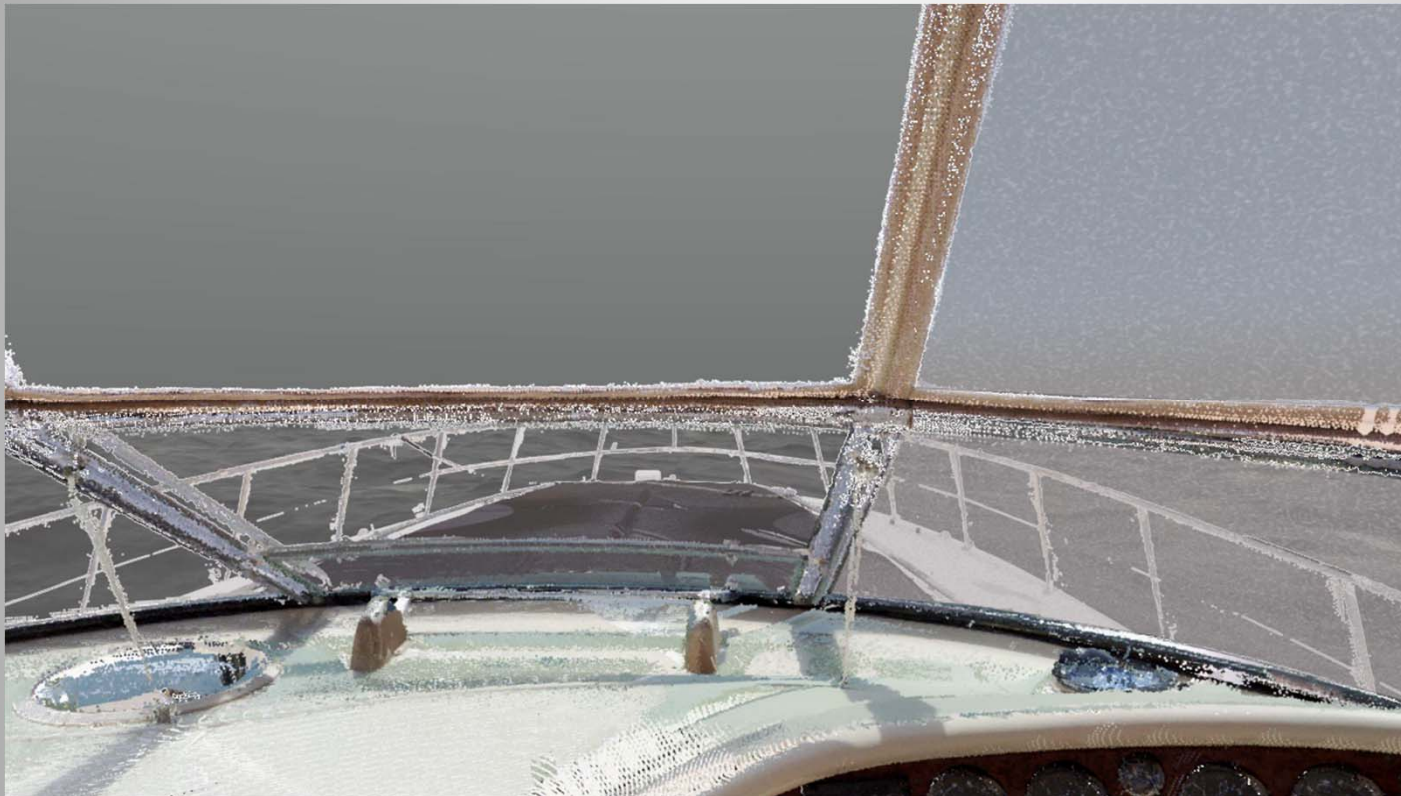
Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

Scaled Animation



Know.



Height of Eye: 4' 9"
Vessel Speed: 17 knots
Seas : 2-6 ft.
Weather: Cloudy
Trim: 5°-9°
Start Apx. 570 ft. apart

Visibility Analysis

- Background
- Issues:
 - What could the operator see?
- Methodology
 - 3-D laser scan,
 - GPS position data,
 - Modeling & Animation
 - **Virtual Reality**



Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis

Virtual Reality



Know.

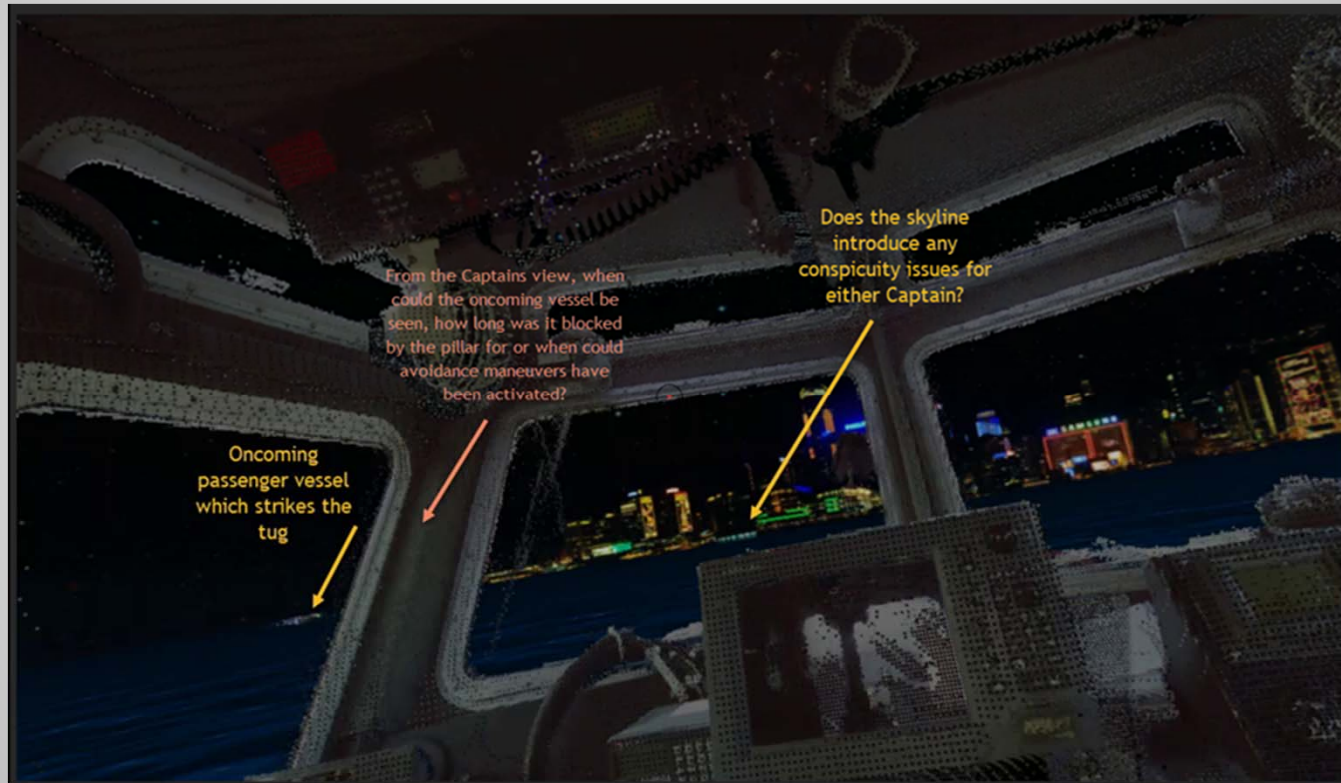


Case Study No. 6 – Vessel Accident Reconstruction

Visibility Analysis Virtual Reality



Know.



From the Captains view, when could the oncoming vessel be seen, how long was it blocked by the pillar for or when could avoidance maneuvers have been activated?

Does the skyline introduce any conspicuity issues for either Captain?

Oncoming passenger vessel which strikes the tug

Summary

3-D Modeling – Strengths & Limitations



Know.

• Data vs. Models

—3-D data

- Unaltered measurements
- Accuracy
- Measurement
- Scaled comparison

—3-D models

- Representations of data
- Variations (increased uncertainty)
- Turn back clock
- Admissibility in court
- Demonstrative aid



Summary

3-D Modeling – Strengths & Limitations



- VR

- Use for analysis
- Use in court
- Logistics
- Video game syndrome
- Visual communication
 - Of hypotheses
 - Of possible scenarios

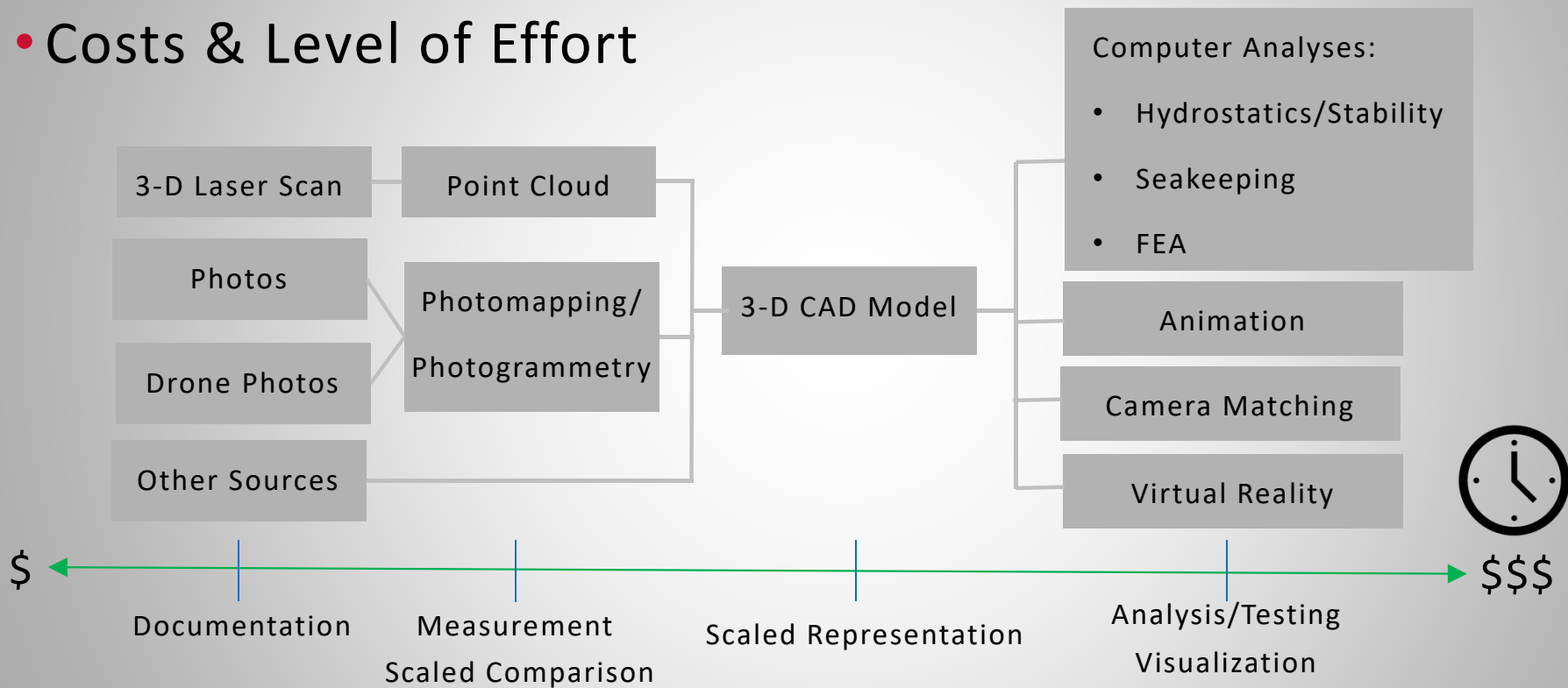


Summary

3-D Modeling – Strengths & Limitations



• Costs & Level of Effort





Know.

SEAlimited.com

Thank you for your attention.
Questions?

Bryan R. Emond, P.E., C.M.I.
bemond@SEAlimited.com

S-E-A, Fort Lauderdale Office
5410 NW 33rd Avenue
Suite 100
Fort Lauderdale, FL 33071

888.771.0591
954.777.4790

