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3-D Modeling in Marine Accident Investigation and Reconstruction

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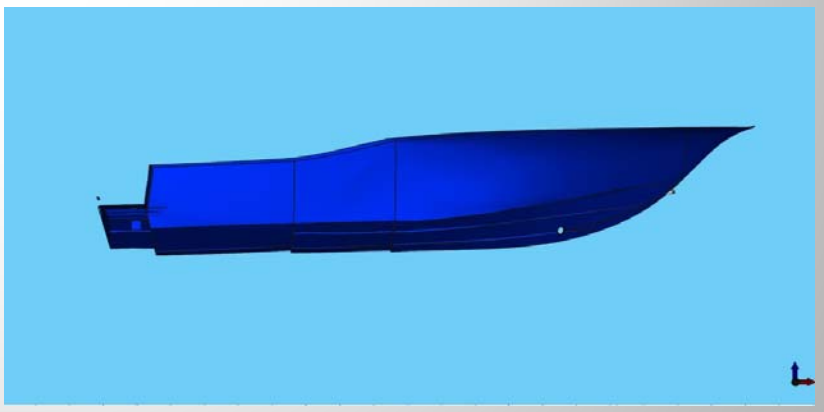
Disclaimer

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

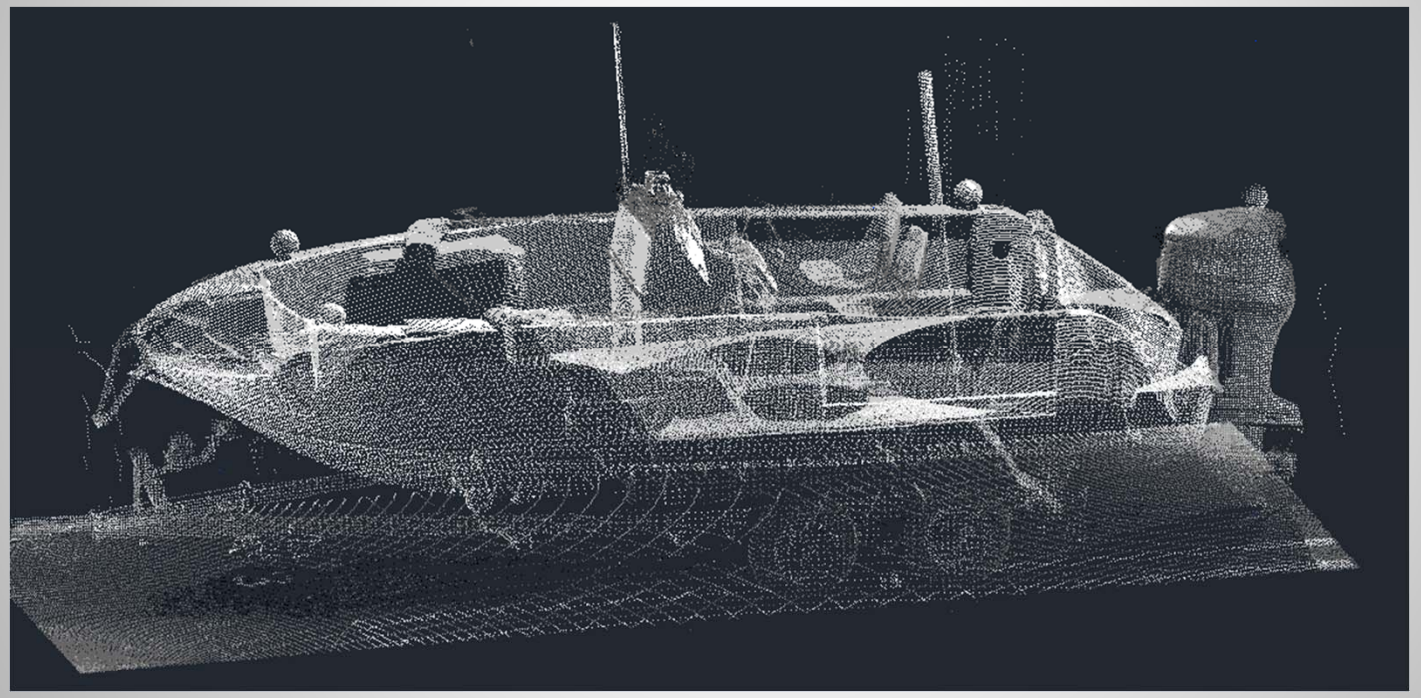
- 3-D data collection technologies
- Data capture vs. Modeling
- Uses for 3-D Data and Modeling
- Strengths and limitations of 3-D Data and Modeling



3-D Laser Scanning

3-D Laser Scanning

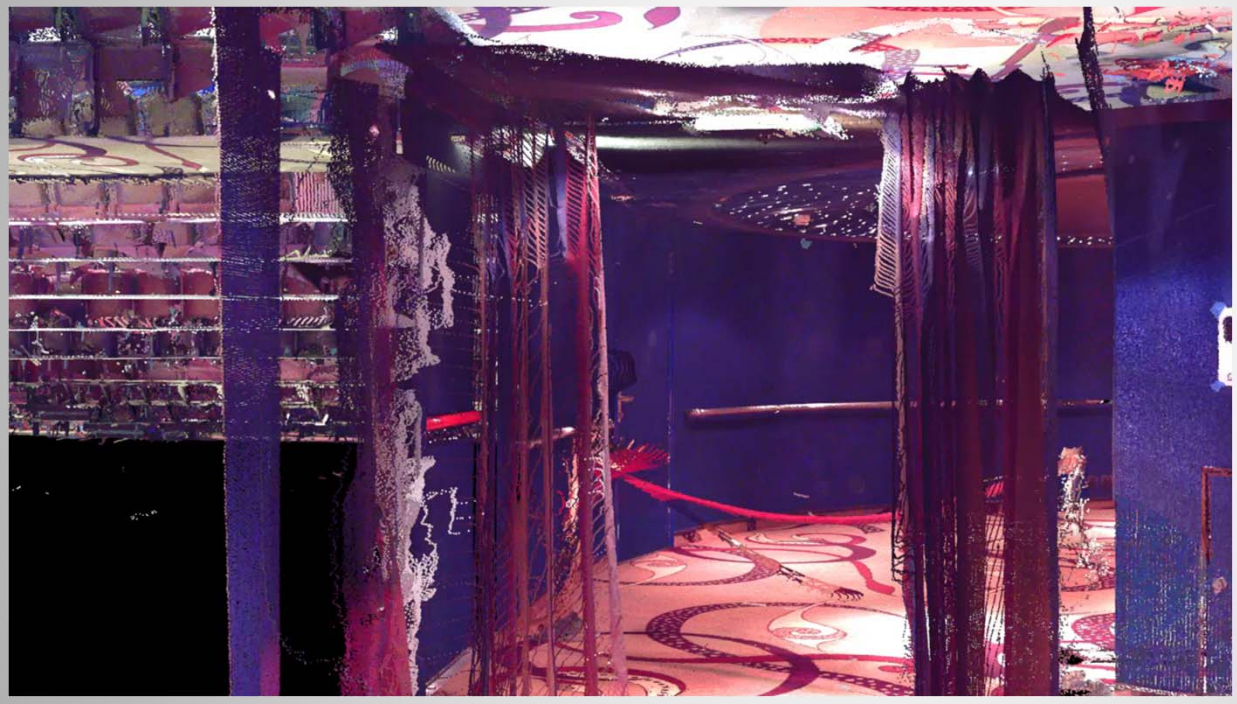
- Point Cloud Data



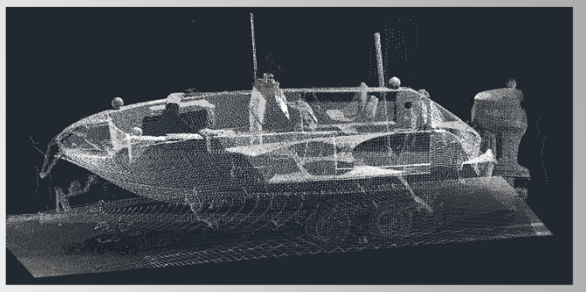
Hundreds of Thousands to Millions of Points in a “Cloud”

3-D Laser Scanning

- Point Cloud Data



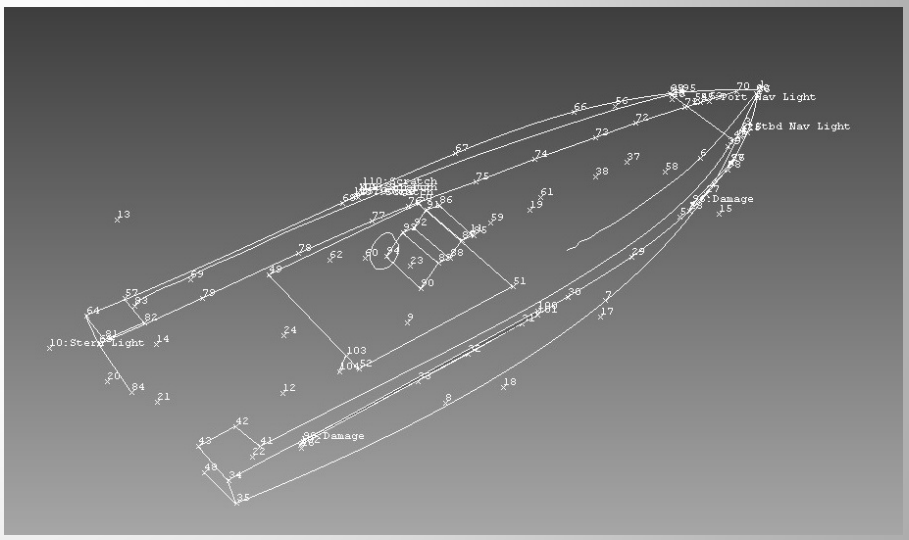
Cruise Ship Theater



- Documentation
- Measurement
- Preservation

Photogrammetry

- Measurement From Photographs
  - From Camera



Photogrammetry

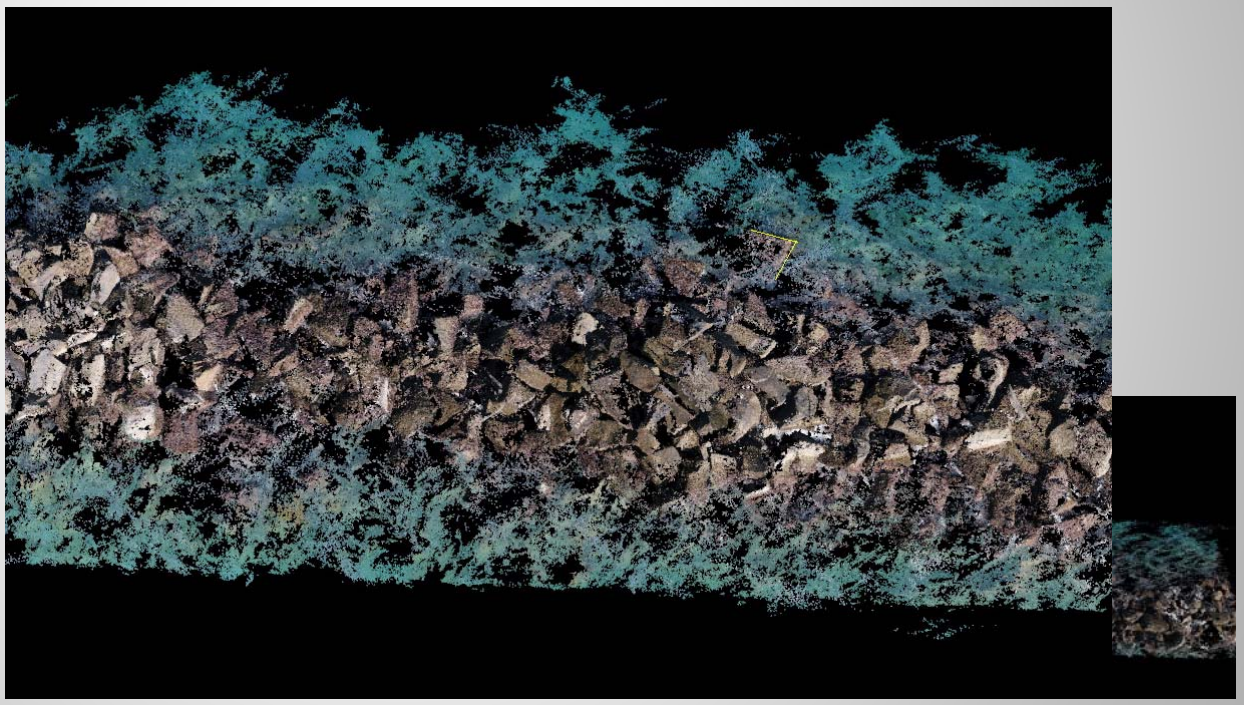
- Measurement From Photographs
  - From Drone Camera

Photogrammetry

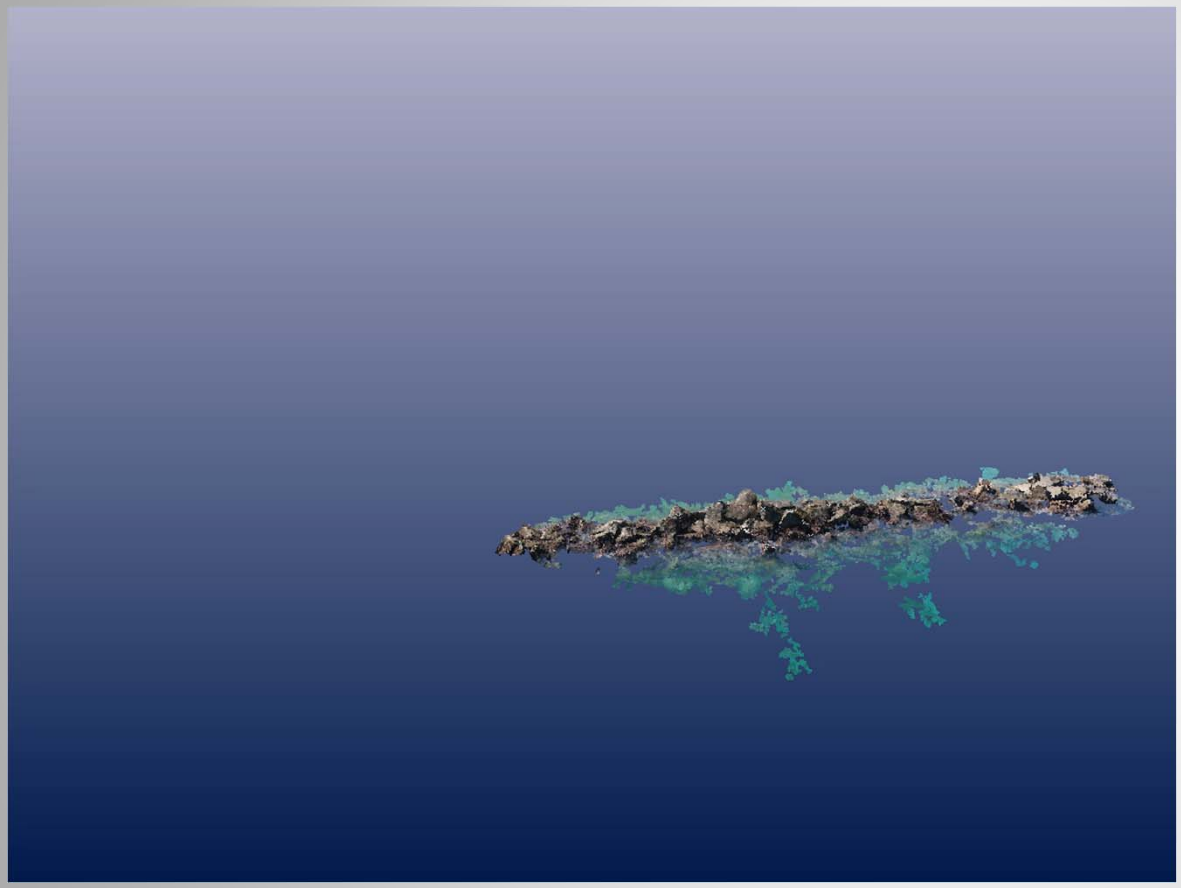
- Measurement From Photographs
  - — From Drone Camera

3-D Data From Remote

& Large Areas



Types of 3-D Data Collection

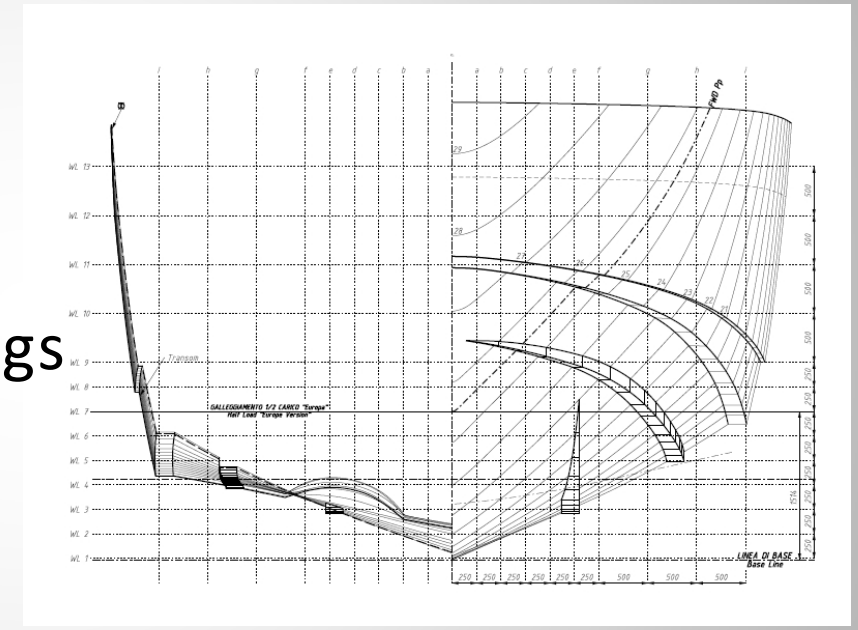


3-D Data From Remote

& 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



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

An Example…

Photographs…

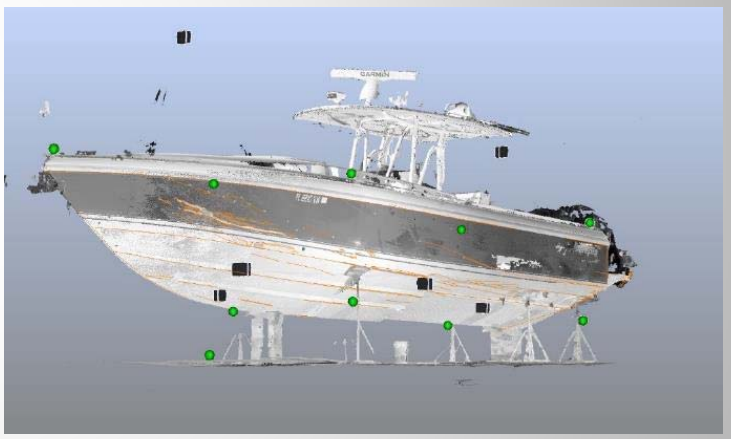
Vessel 1

Vessel 2

An Example…

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

Vessel 1



Vessel 2

An Example…

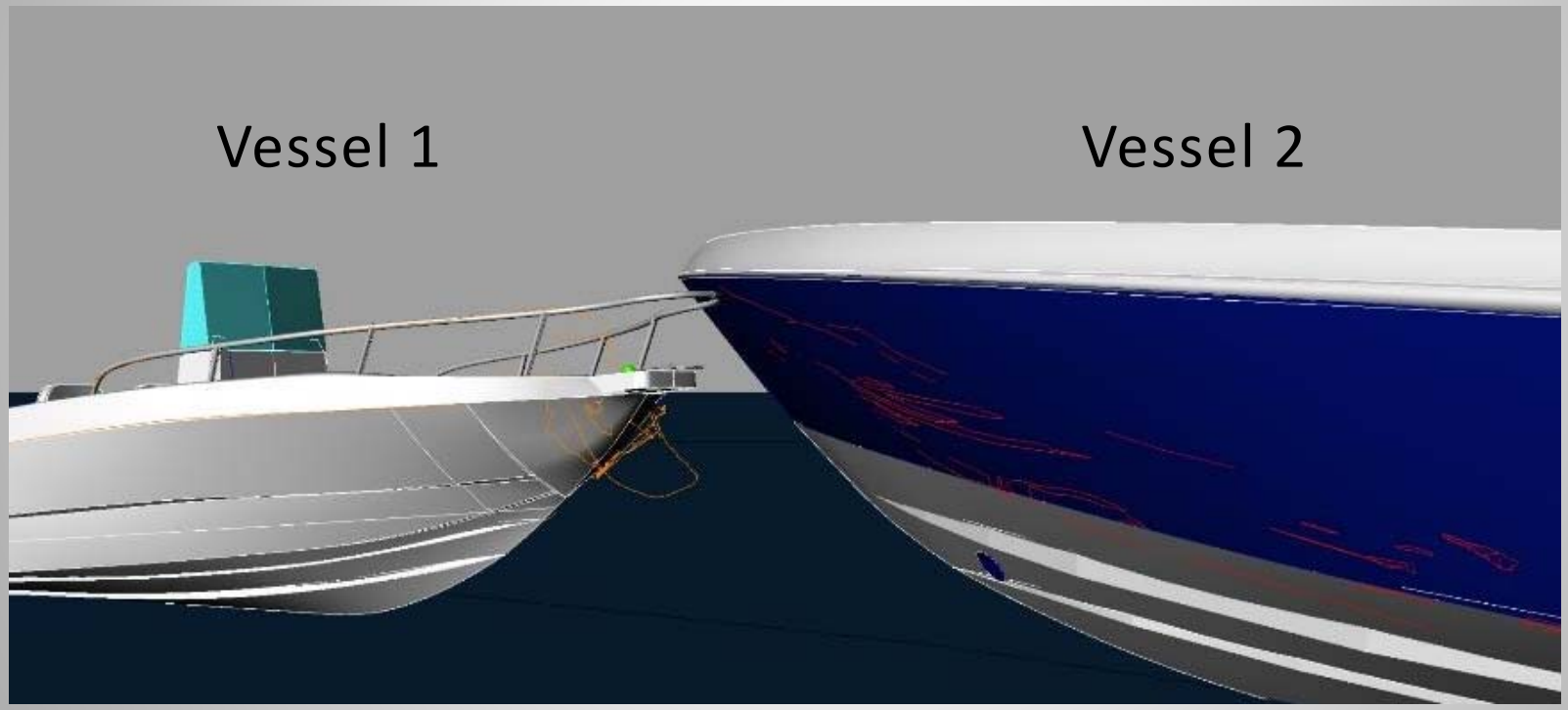
Models of Pre-Damaged Vessels…

Vessel 1

Vessel 2

An Example…

3-D Models of Both Vessels to Explain Damage…



An Example…

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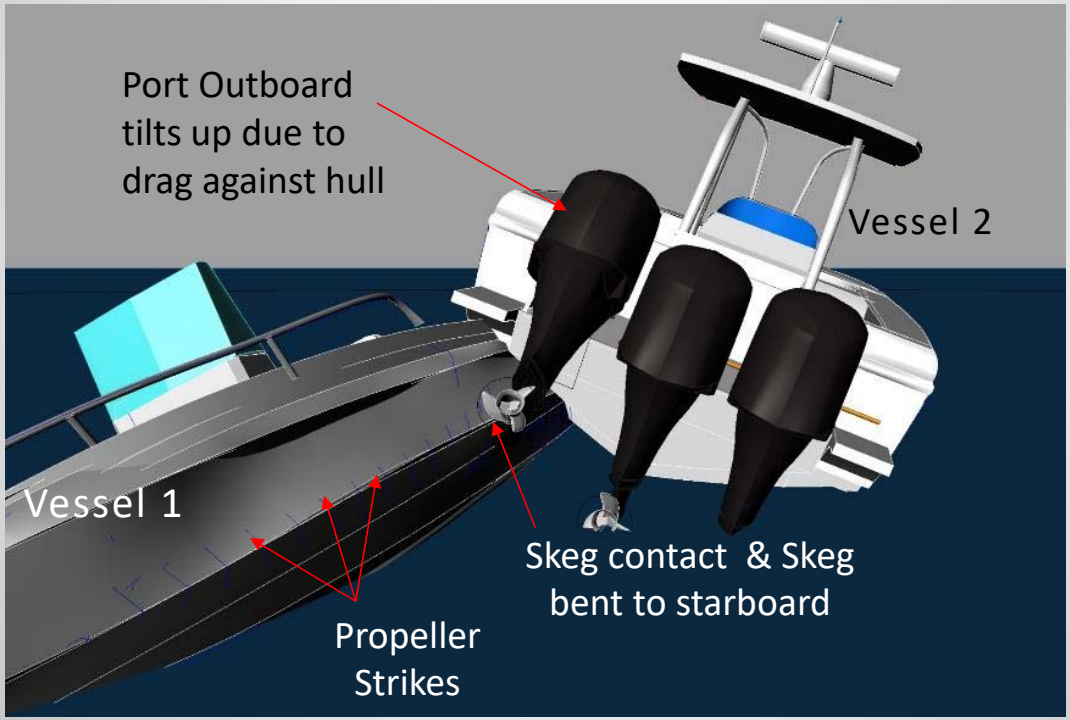
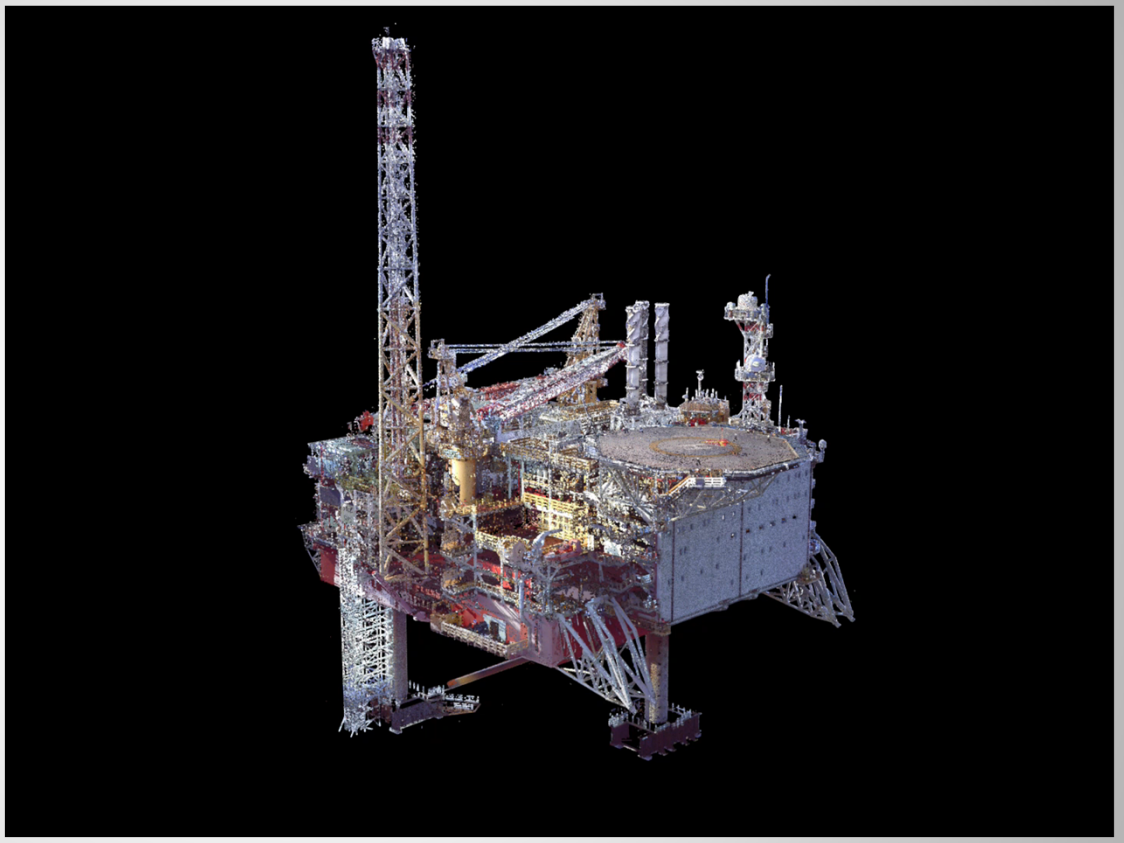


Case Study No. 1

Documentation of Offshore Oil Rig

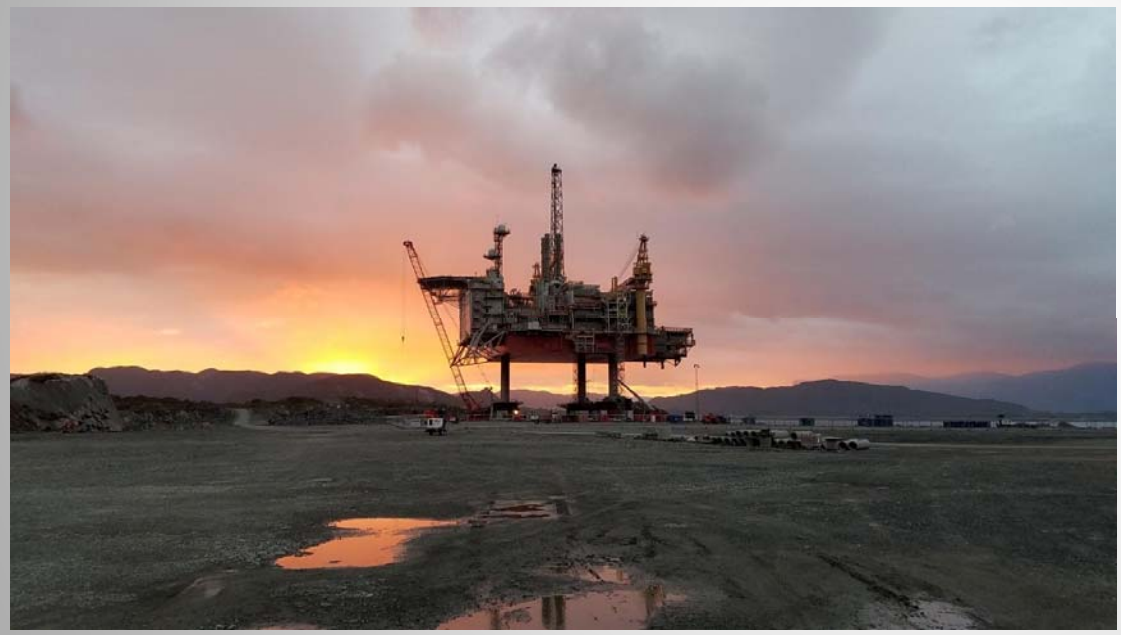
Offshore Oil Rig

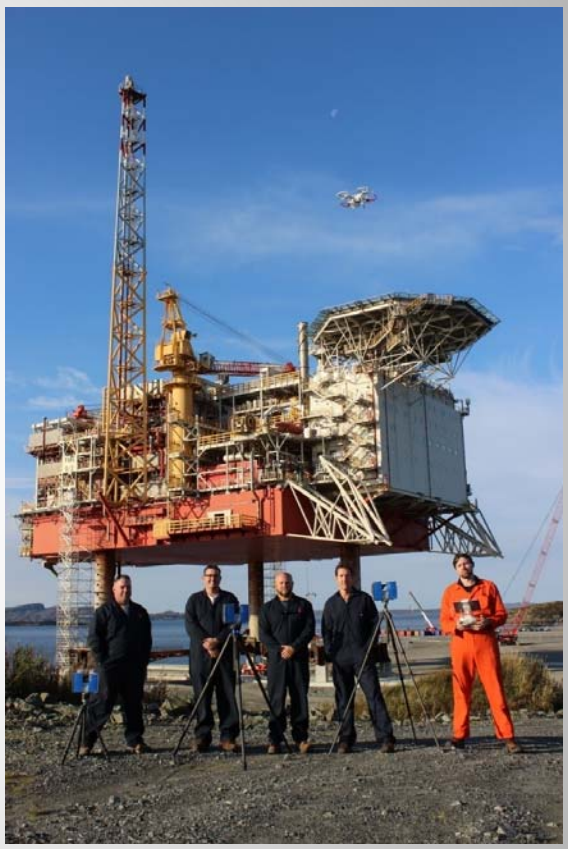
- Background
- Purpose
  - —Document Defects
  - —Valuation



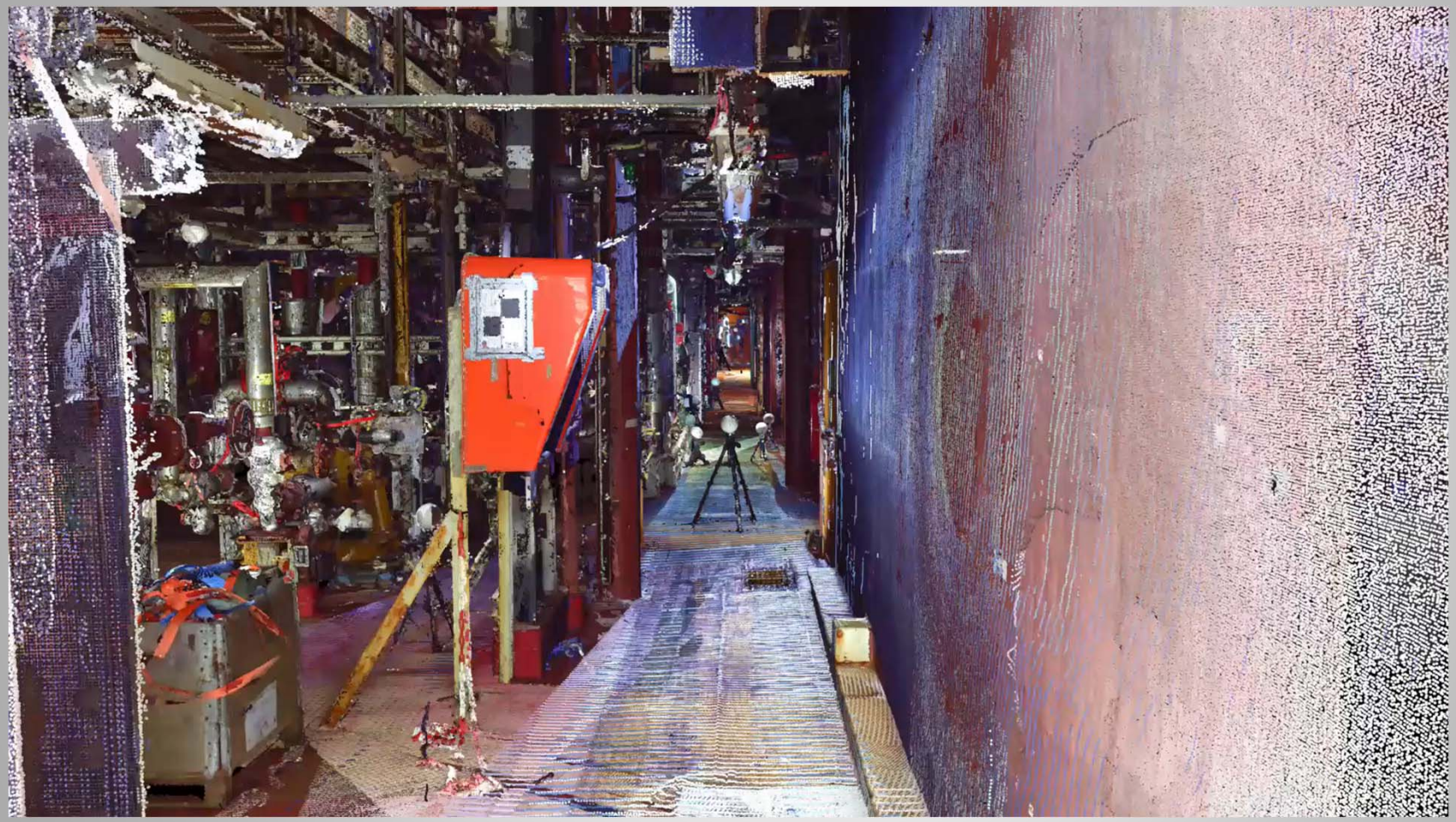
Offshore Oil Rig

- Resources





Case Study No. 1 - Documentation



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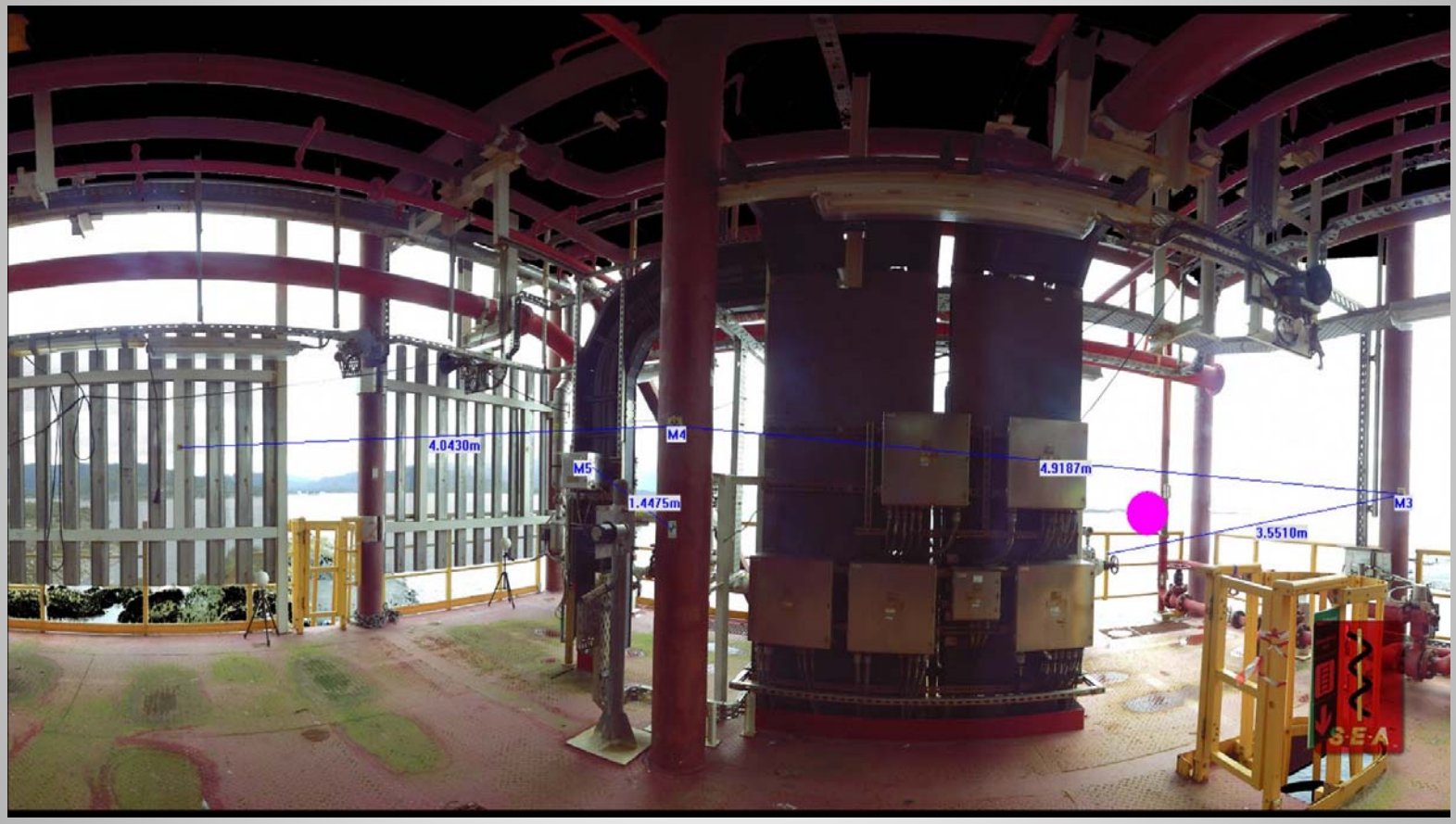

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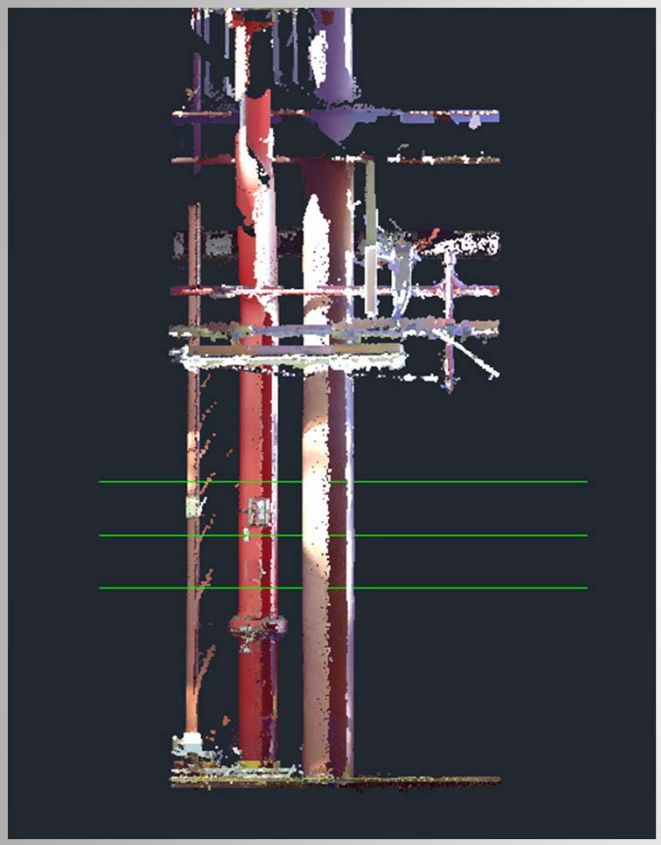

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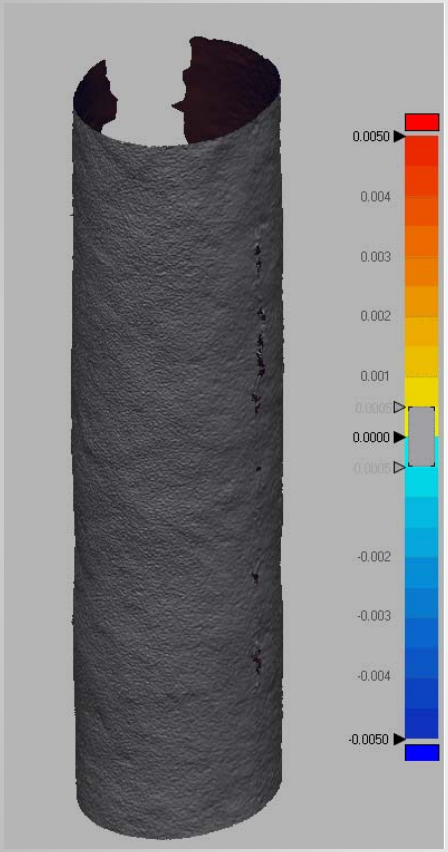
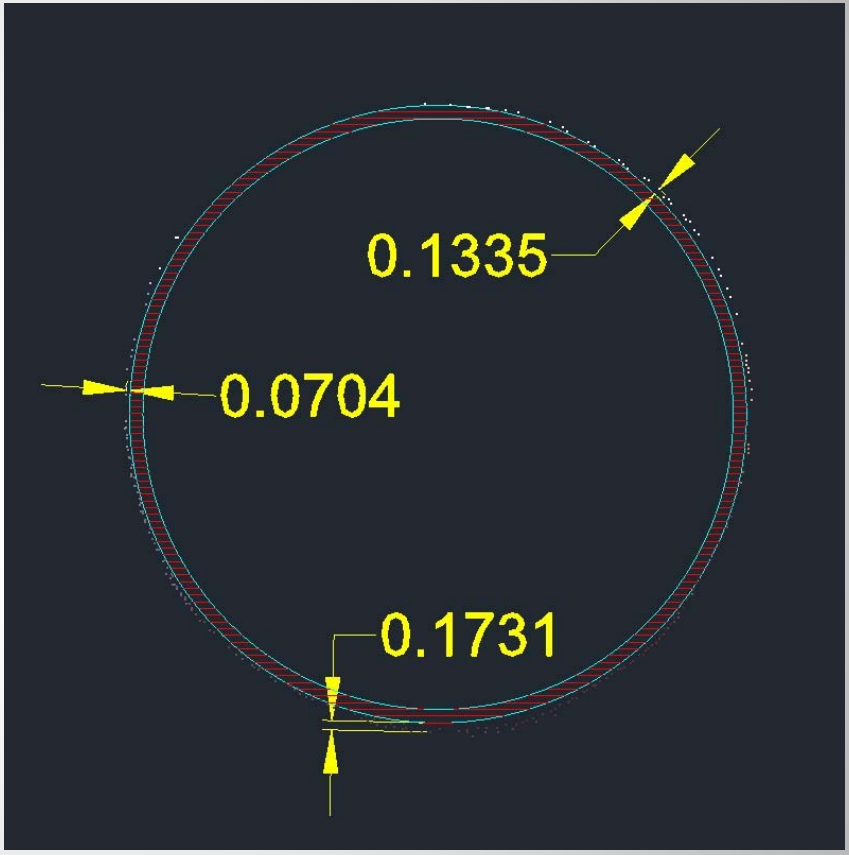




Offshore Oil Rig

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

Case Study No. 2

Vessel Sinking Analysis

Sinking at the dock

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

Sinking at the dock

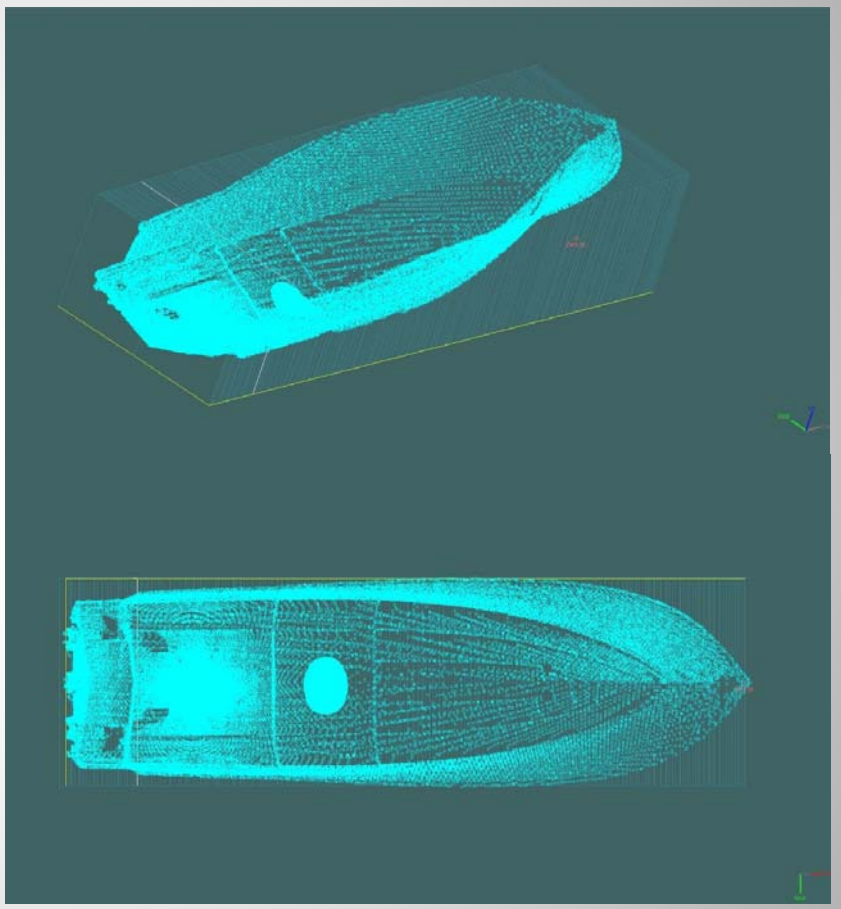
- Methodology
  - —Estimates/Calculations
  - —3-D Laser Scan

Sinking at the dock

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

Sinking at the dock

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



Sinking at the dock

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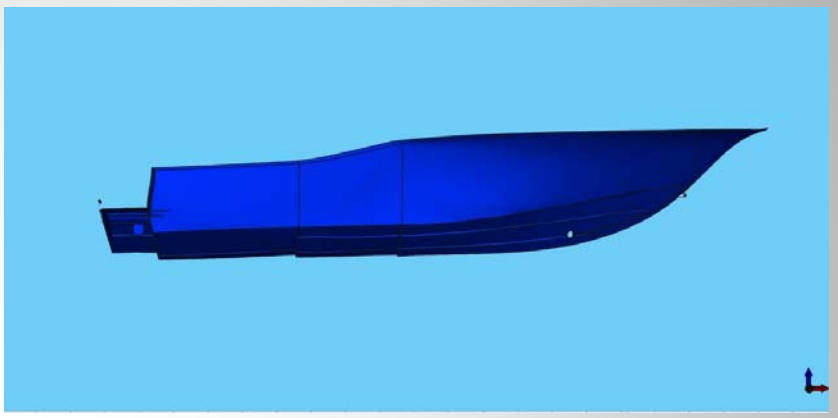
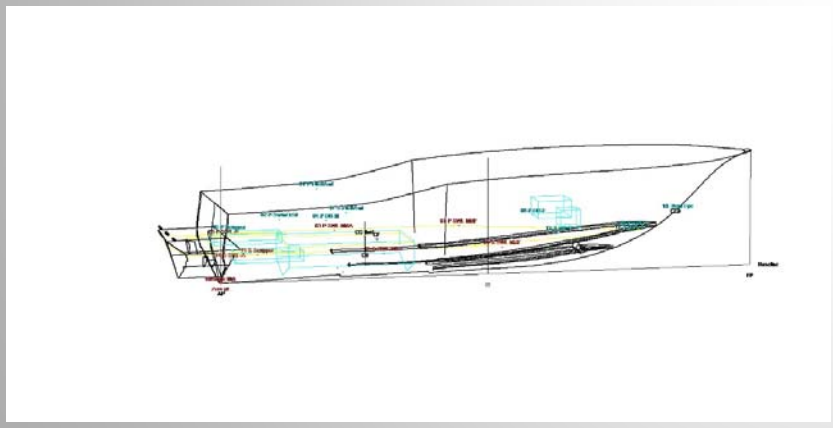
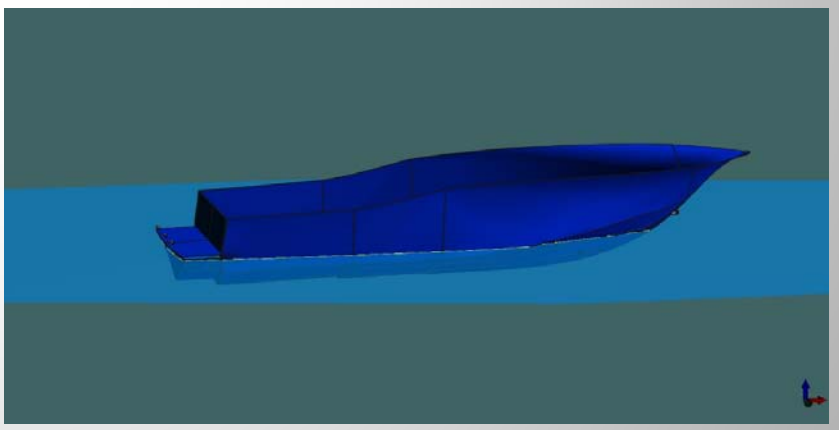






Sinking at the dock

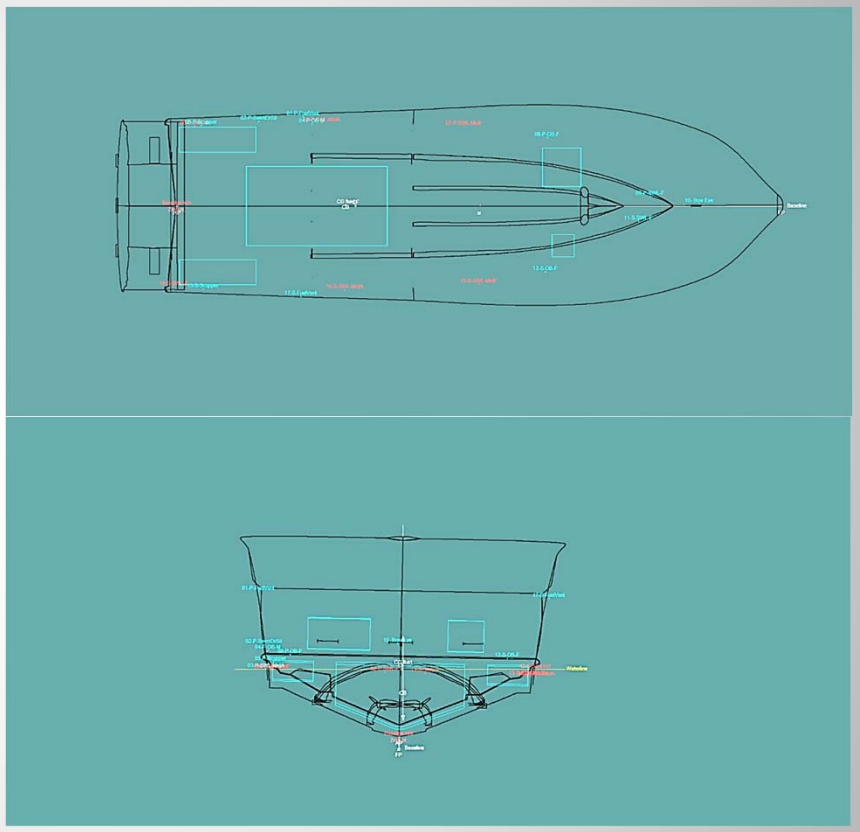
- Methodology
  - —Estimates/Calculations
  - —3-D Laser Scan
  - —Develop Point Cloud
  - —Build CAD Model

Sinking at the dock

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

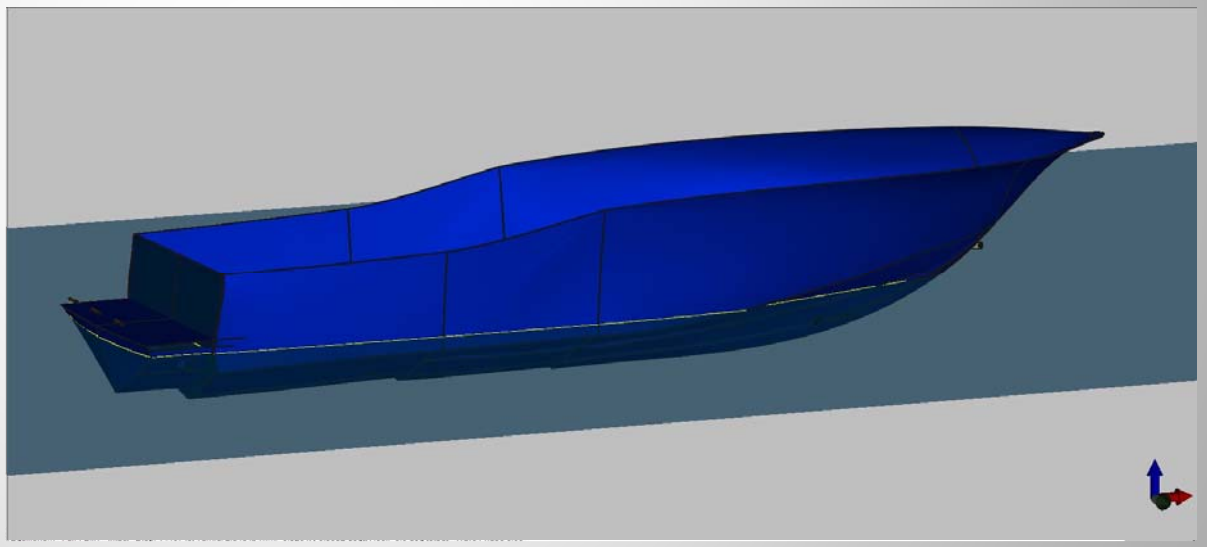
Sinking at the dock

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



Sinking at the dock

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



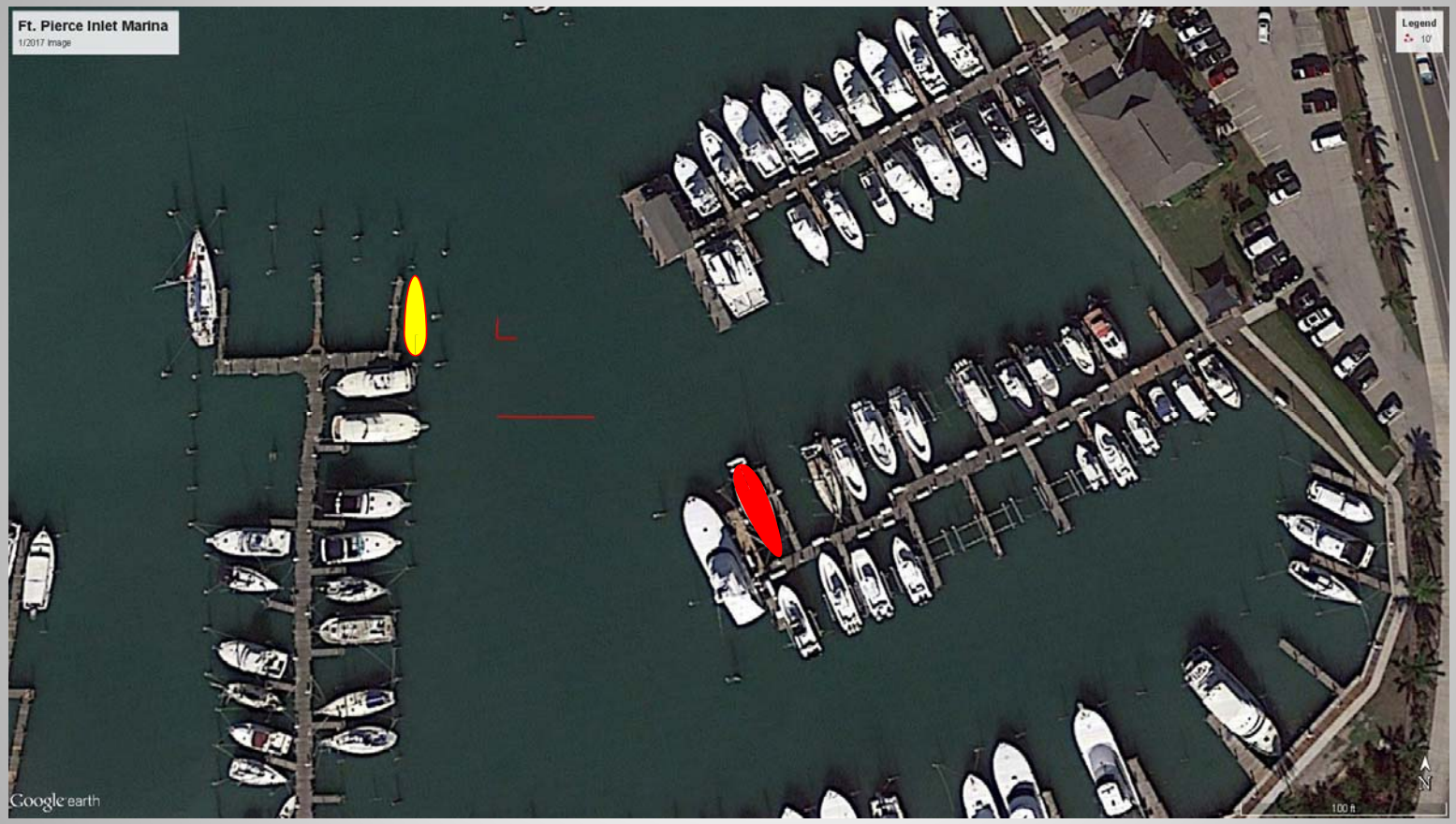
Case Study No. 3

Post Hurricane Sinking

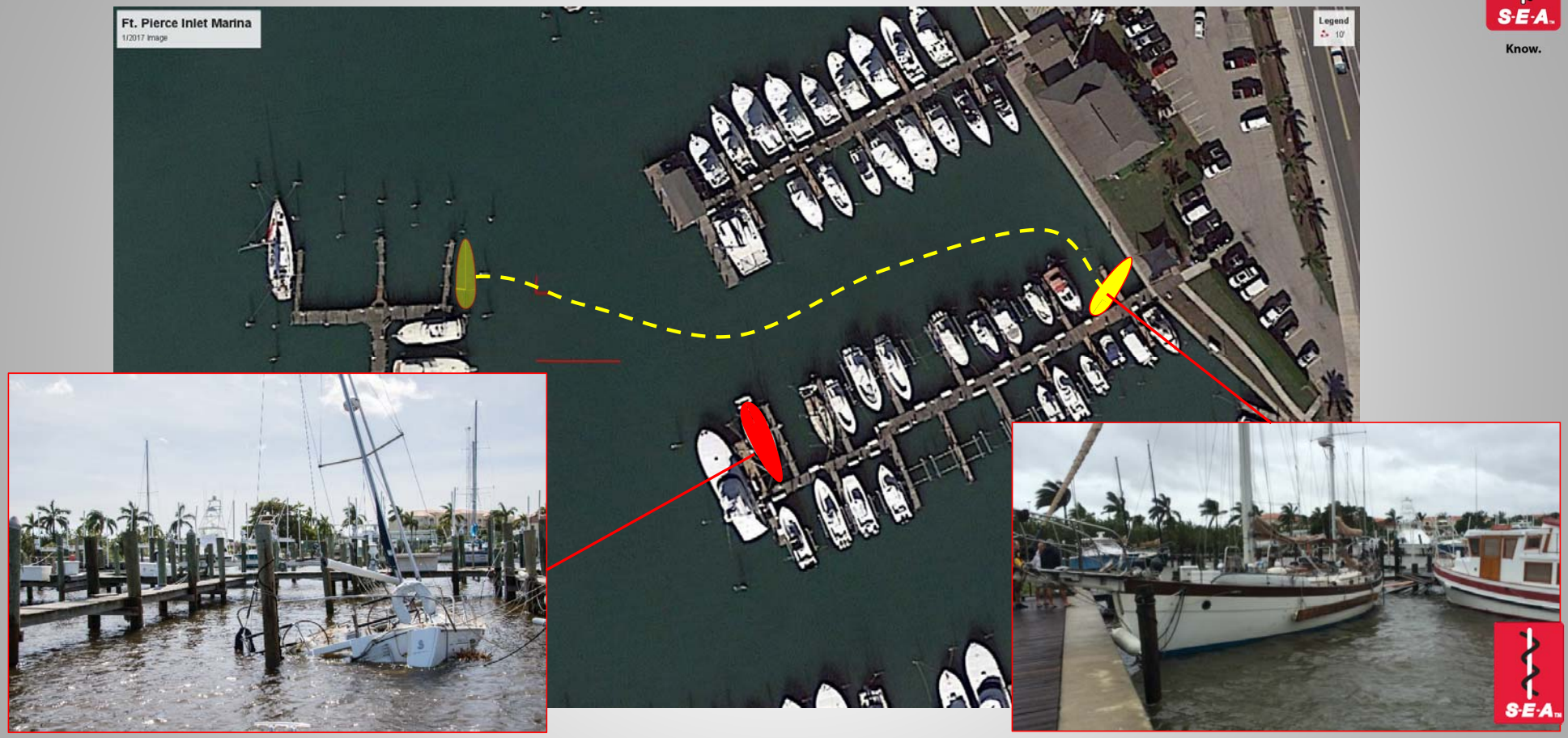
Who Dunnit?

- Background

Case Study No. 3 – Post Hurricane Sinking



Case Study No. 3 – Post Hurricane Sinking



Case Study No. 3 – Post Hurricane Sinking

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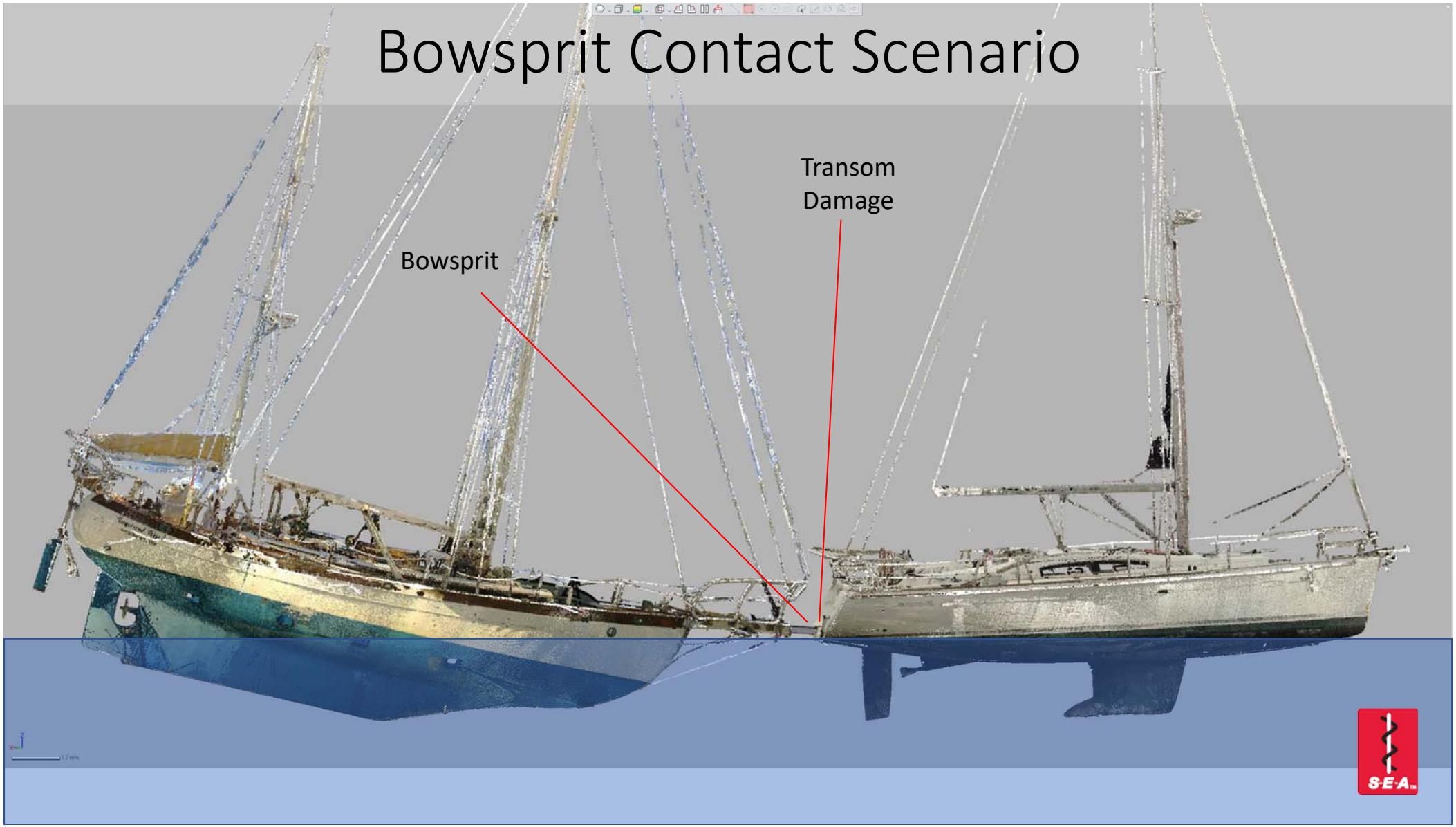
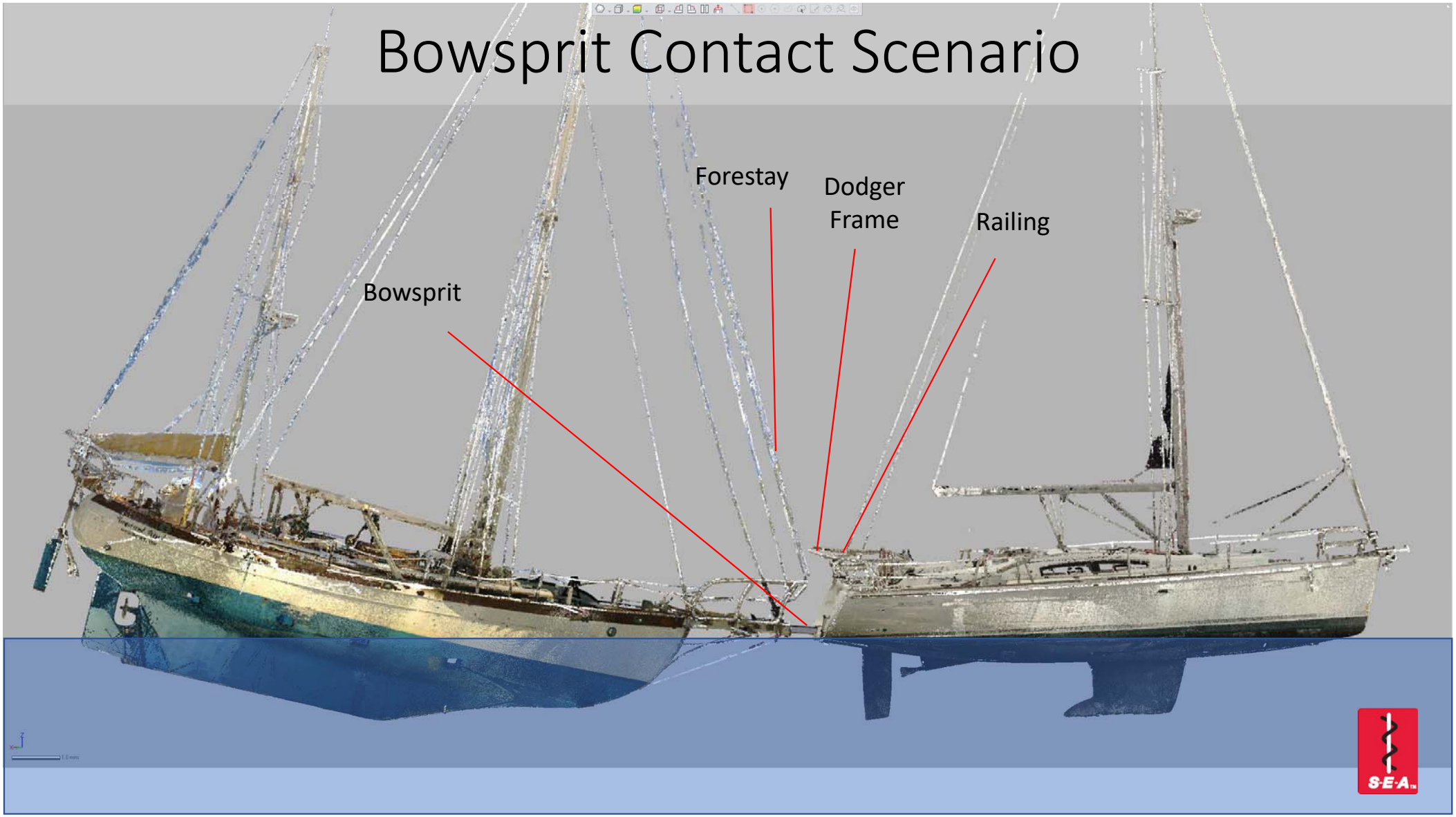
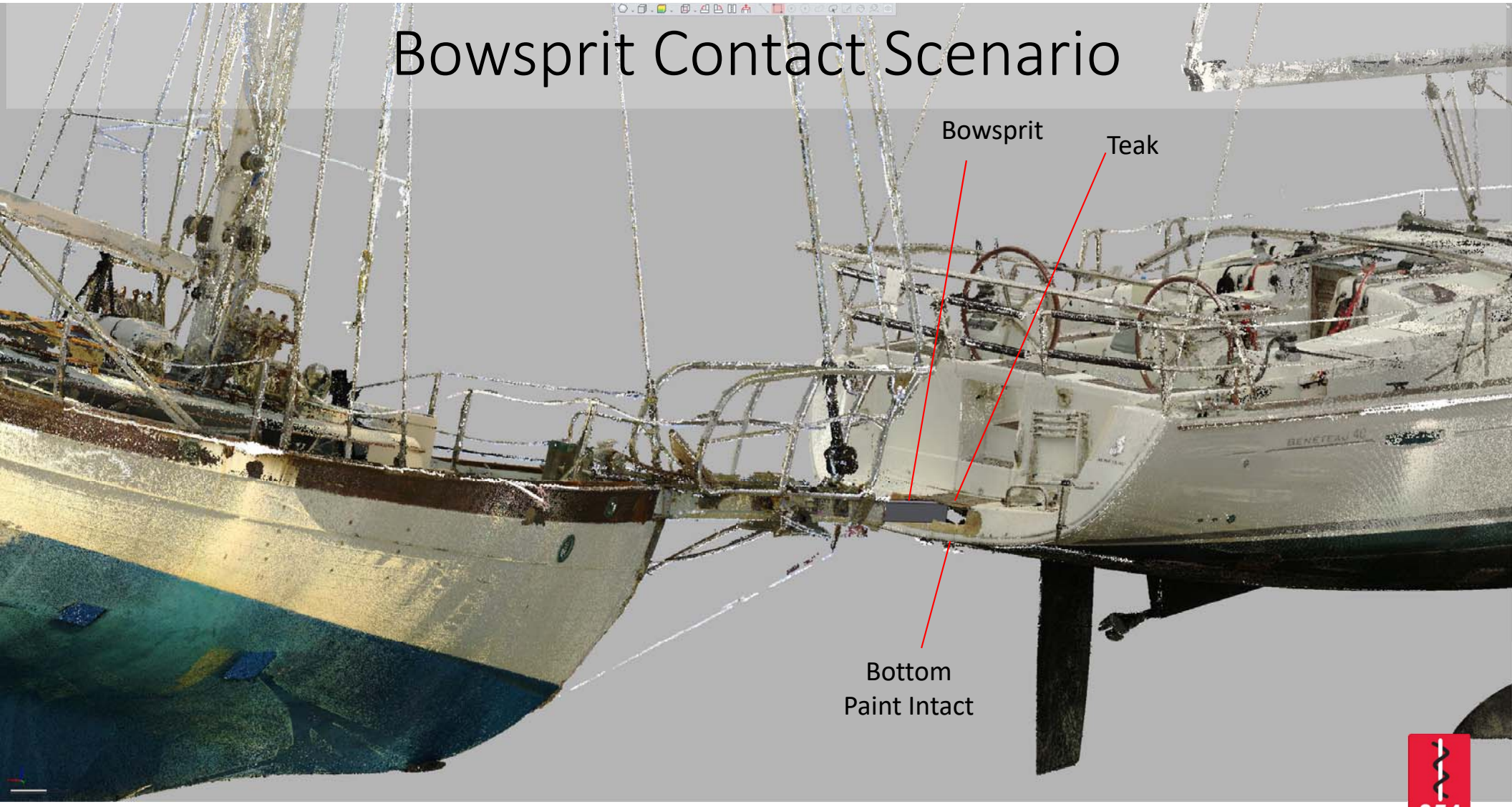
Bowsprit Contact Scenario

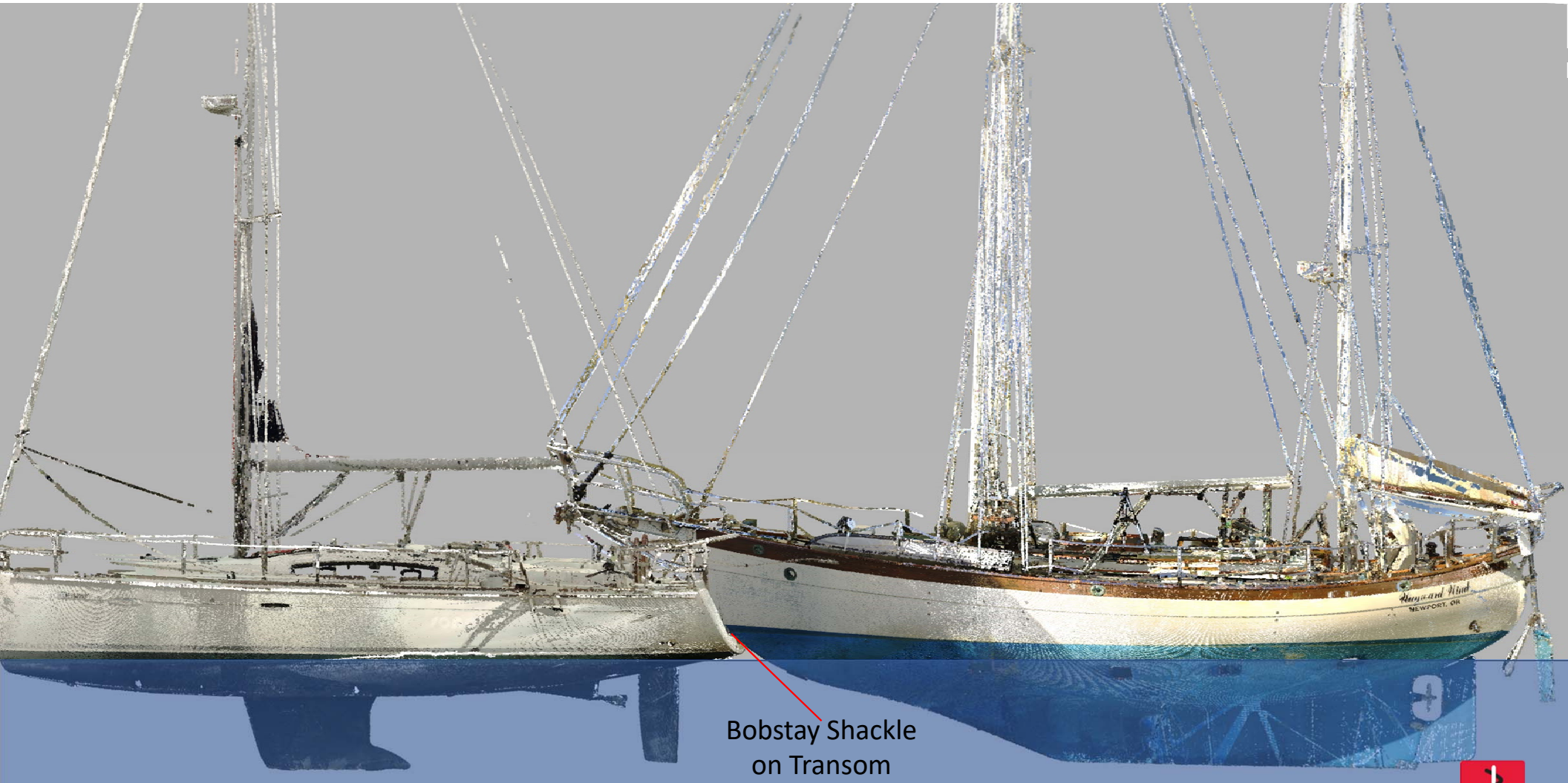


Bowsprit Contact Scenario



Bowsprit Contact Scenario





Bobstay Shackle Contact Scenario

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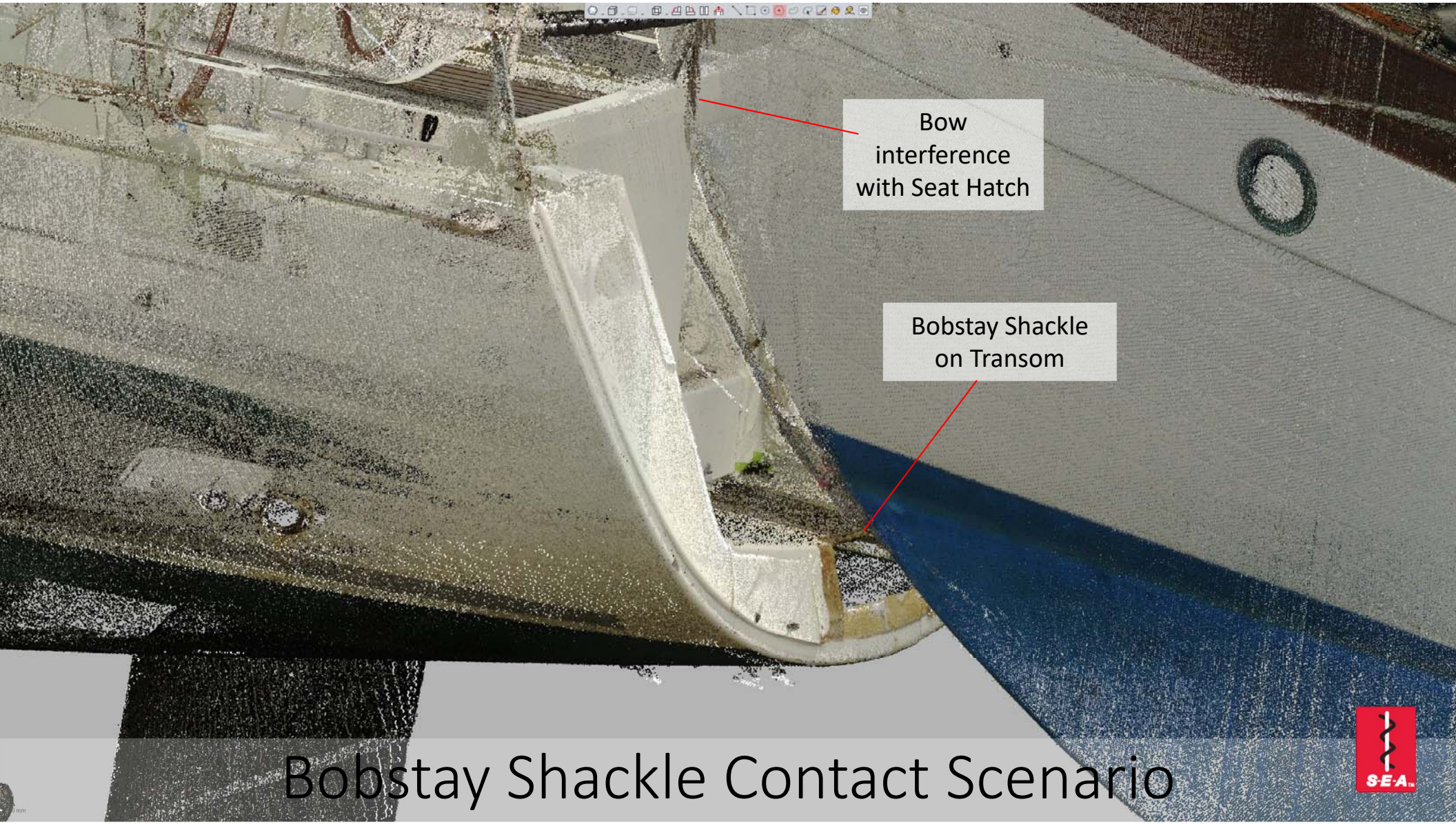

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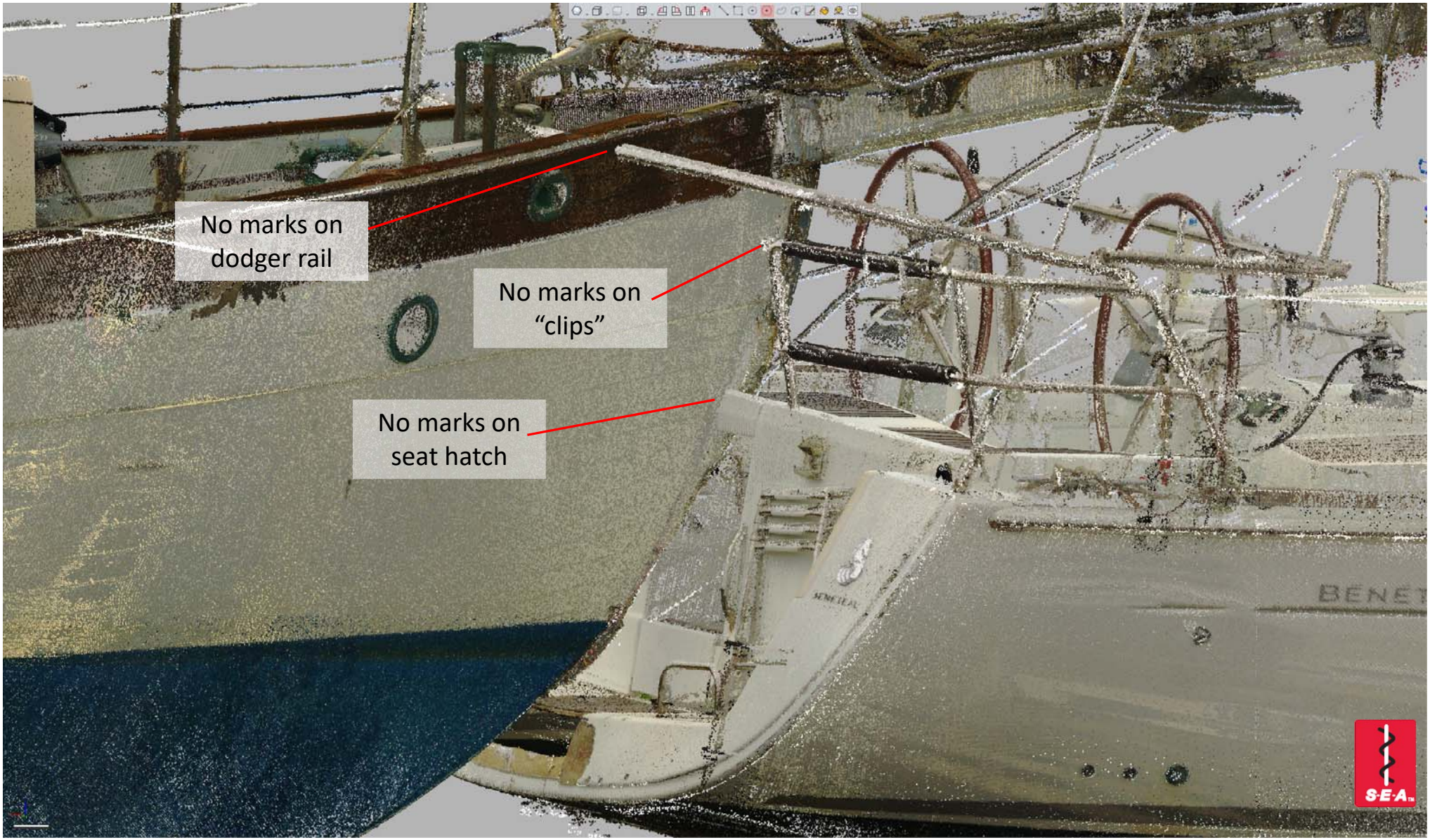
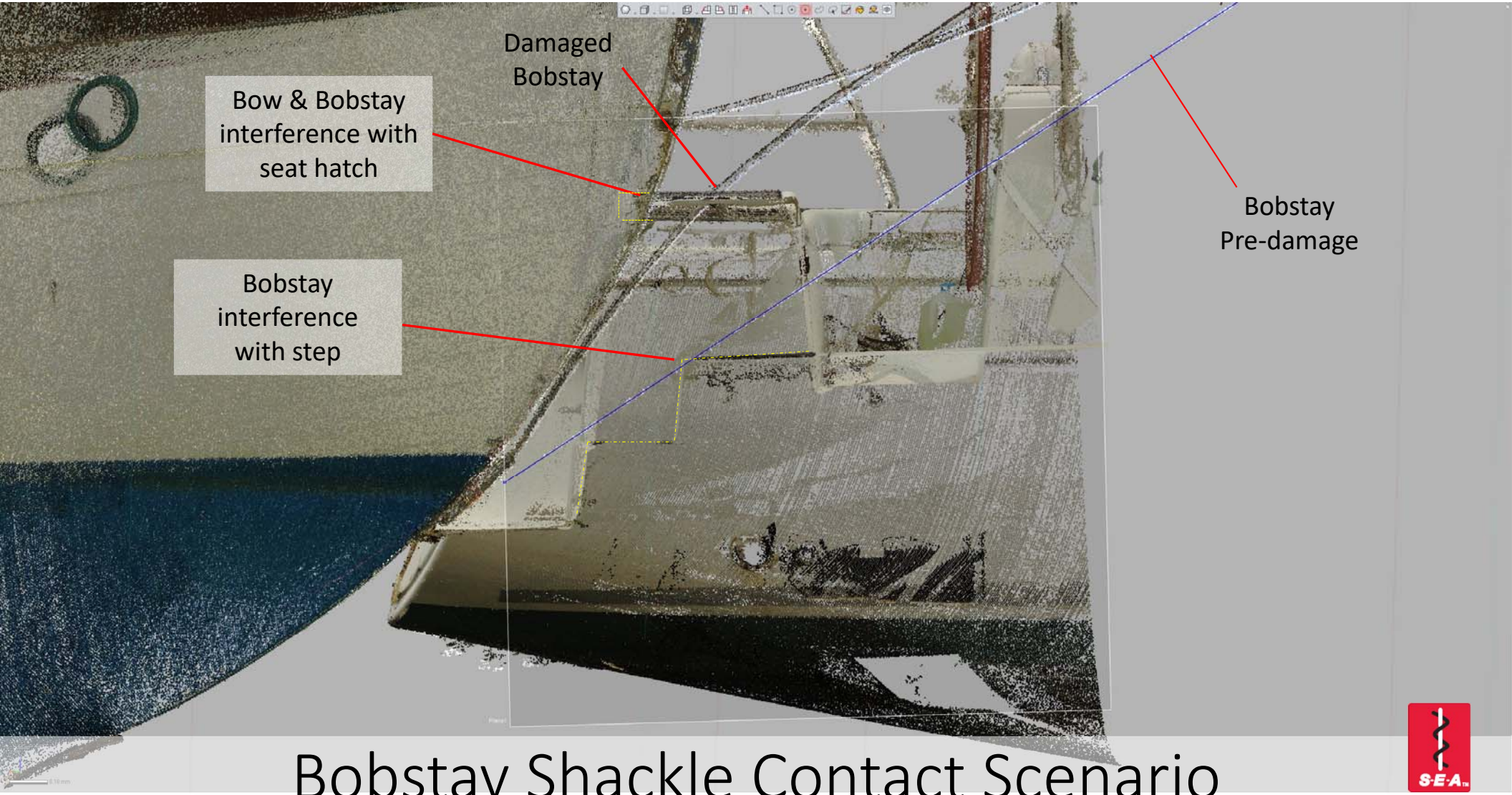

No marks on dodger rail
No marks on “clips”
No marks on seat hatch



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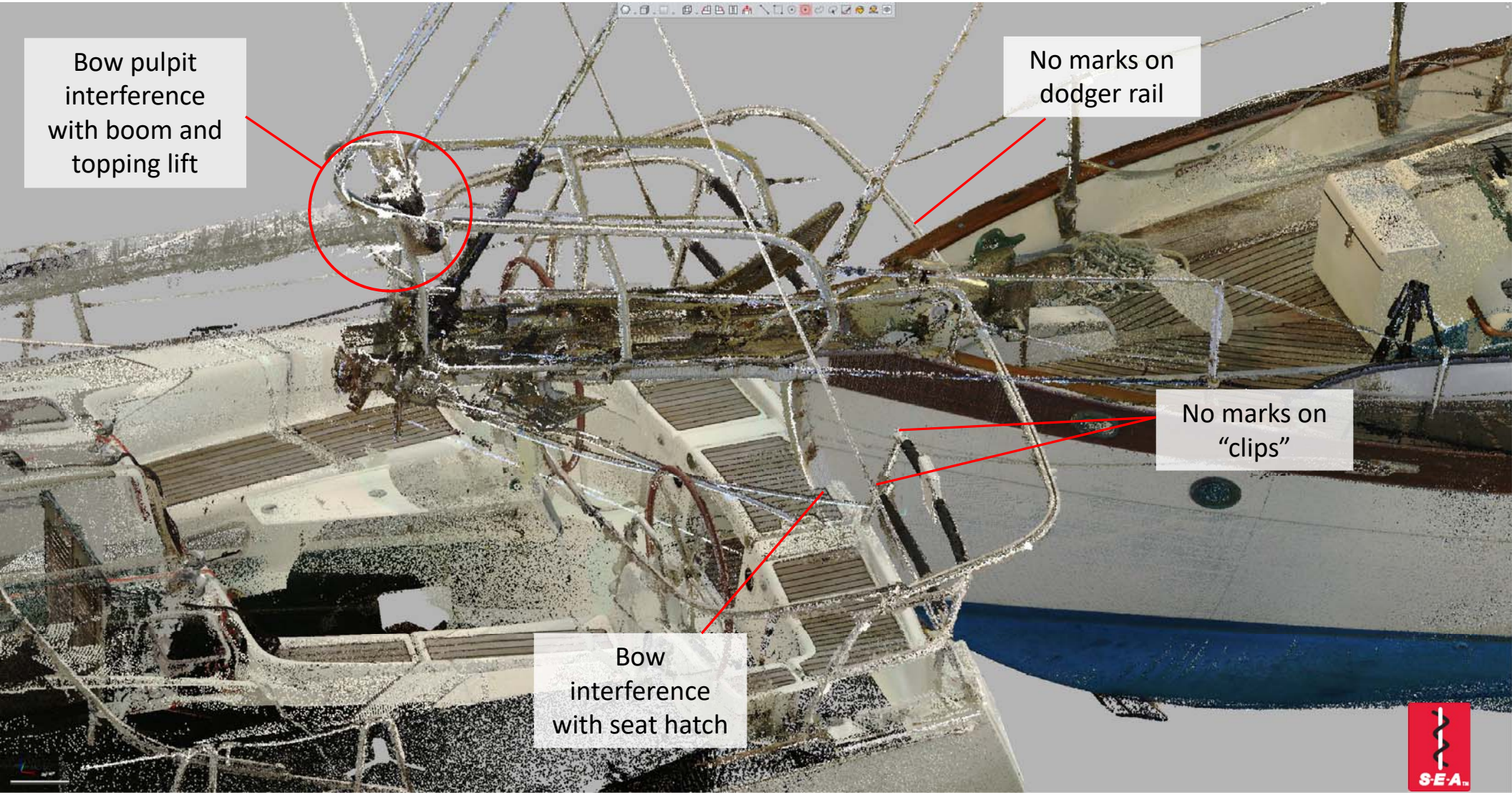
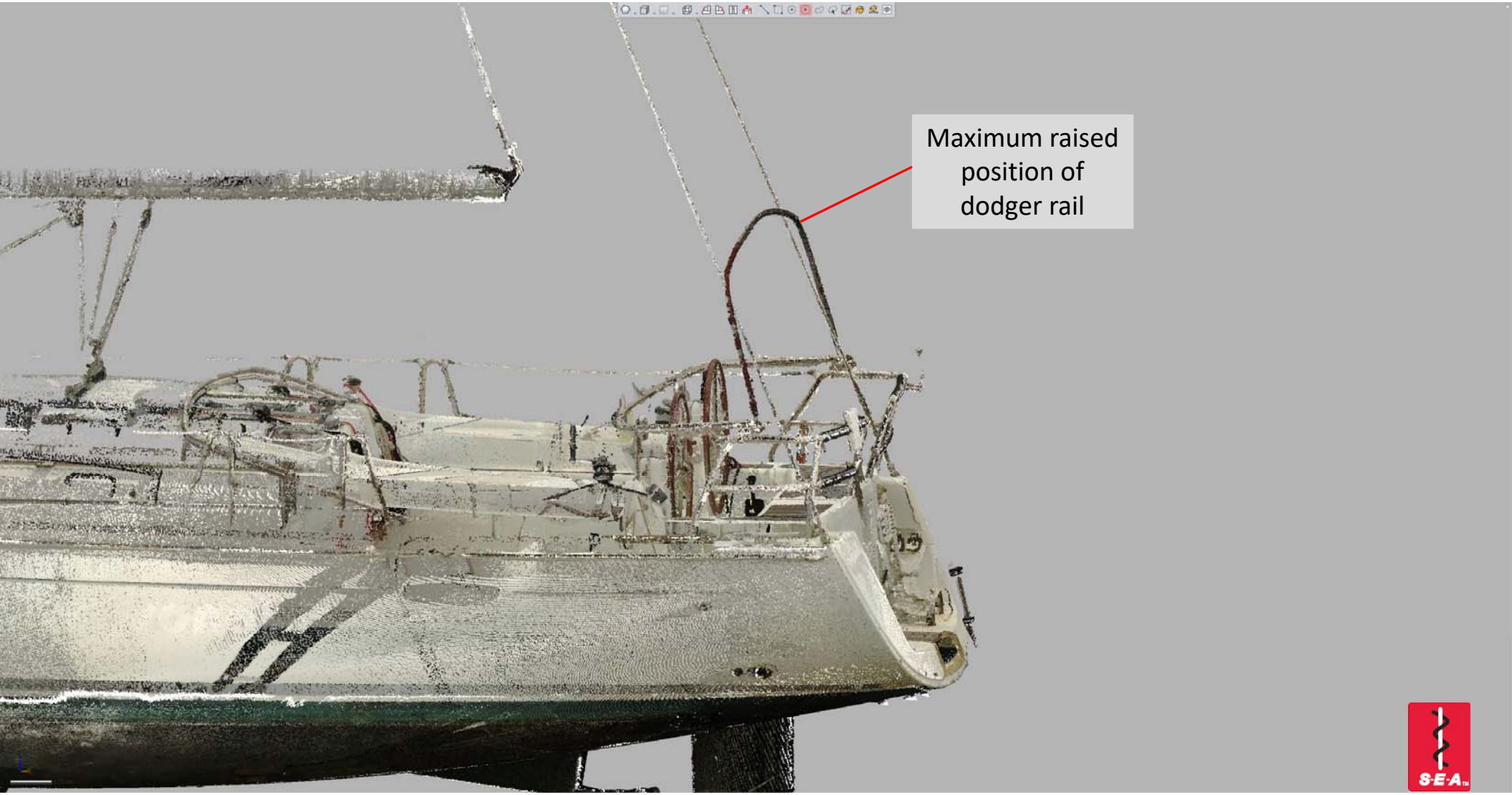
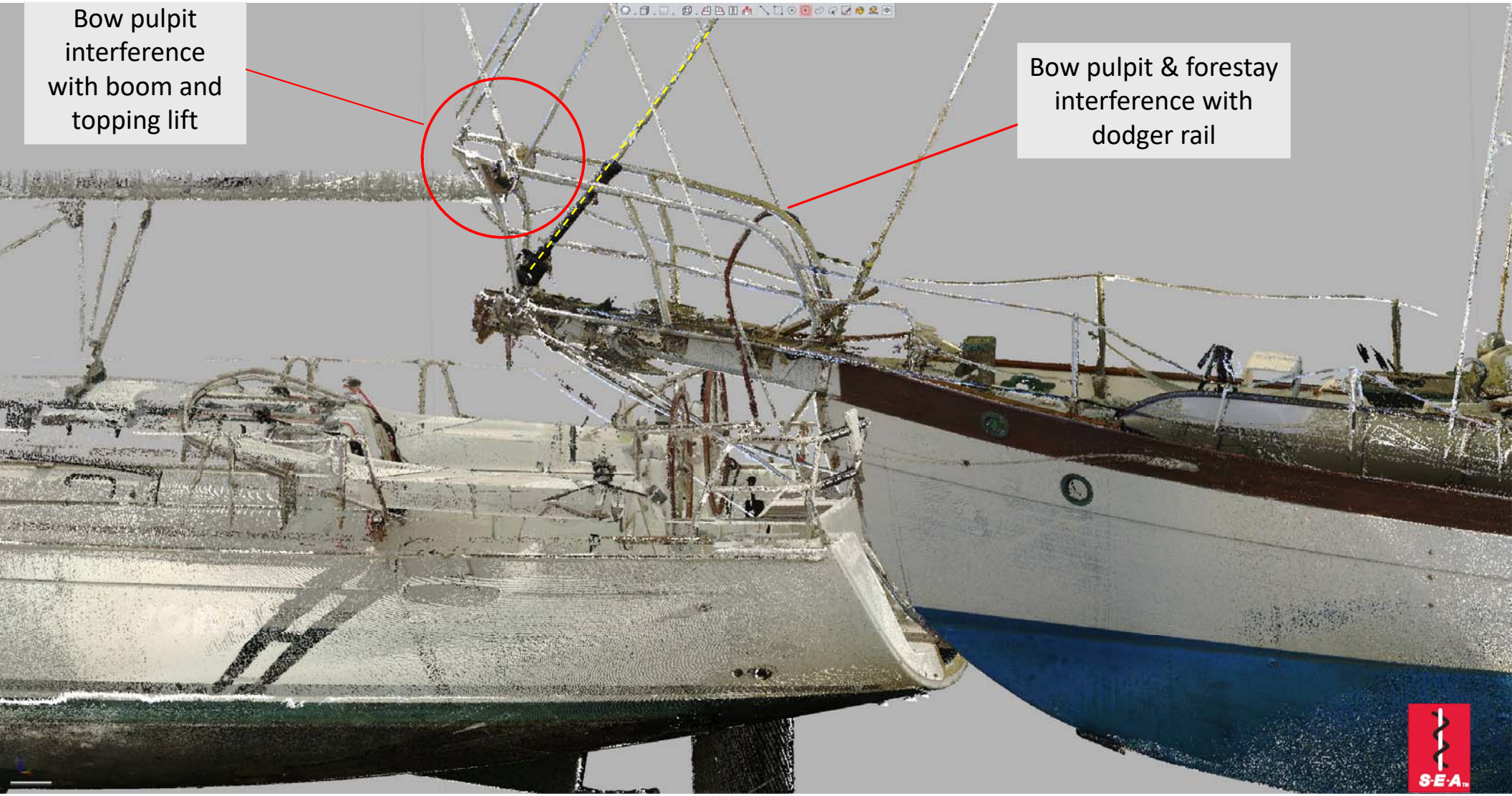
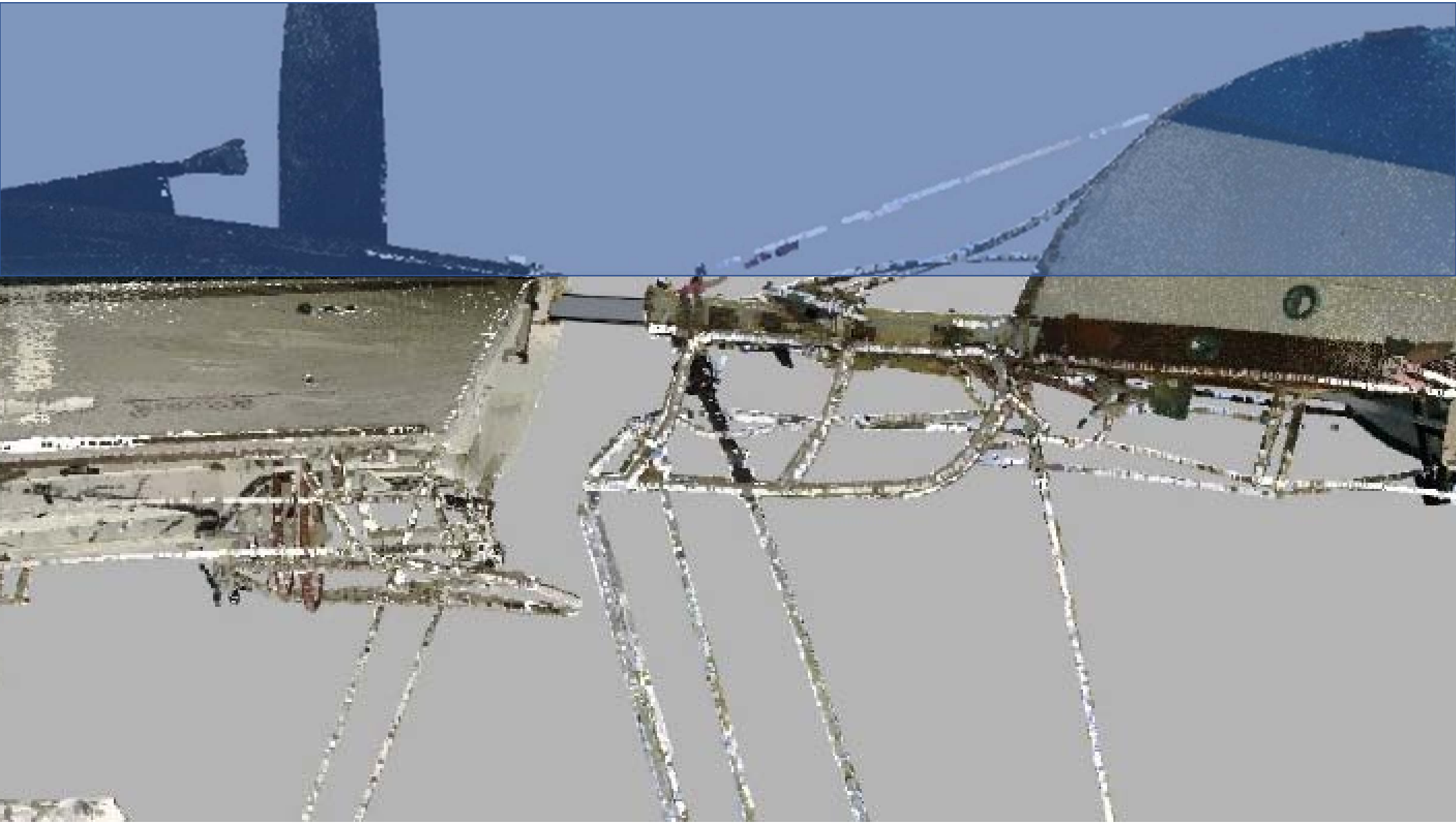
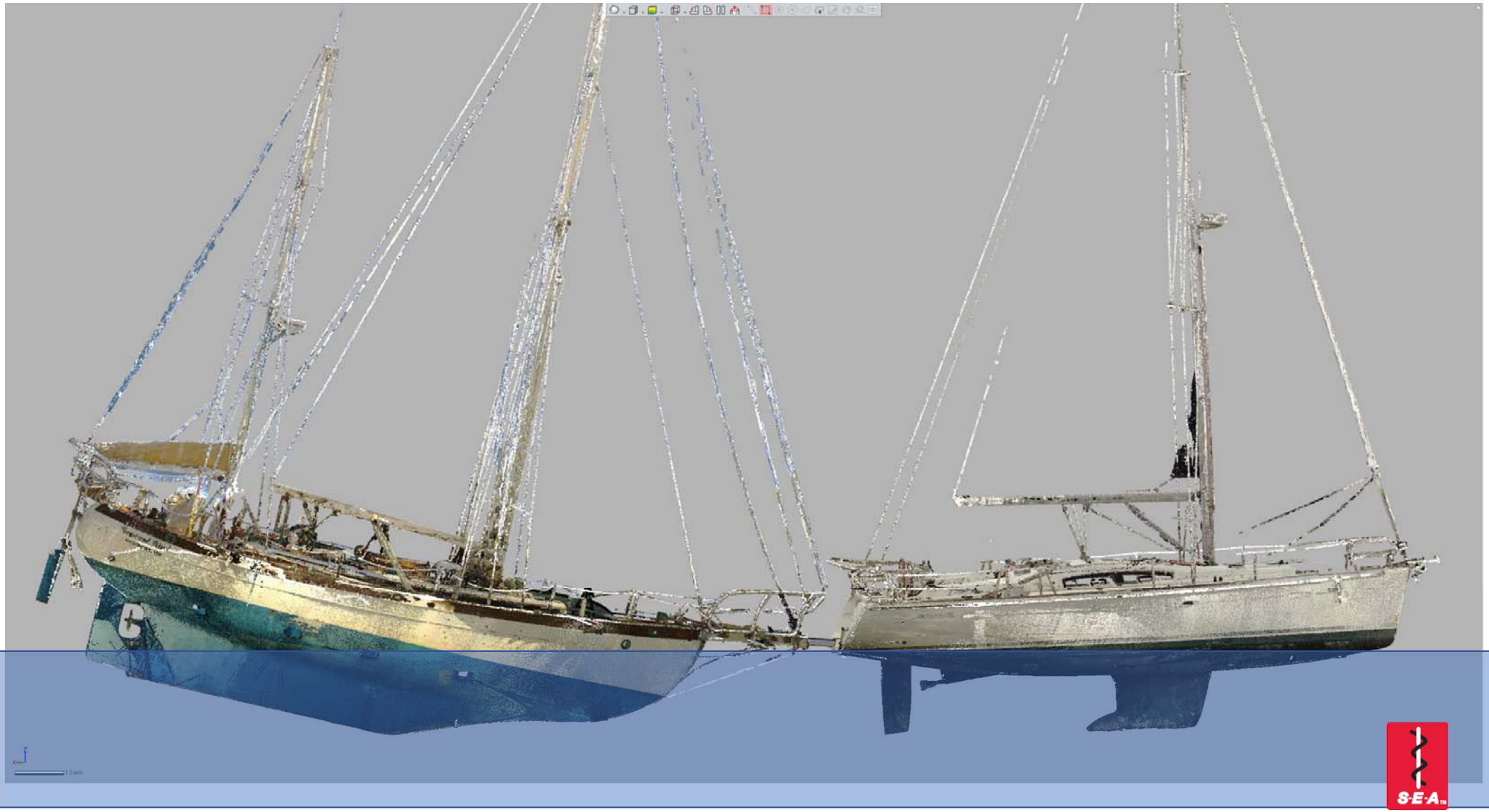

Bow pulpit interference with boom and topping lift
No marks on dodger rail
No marks on “clips”
Bow interference with seat hatch
S·E·A

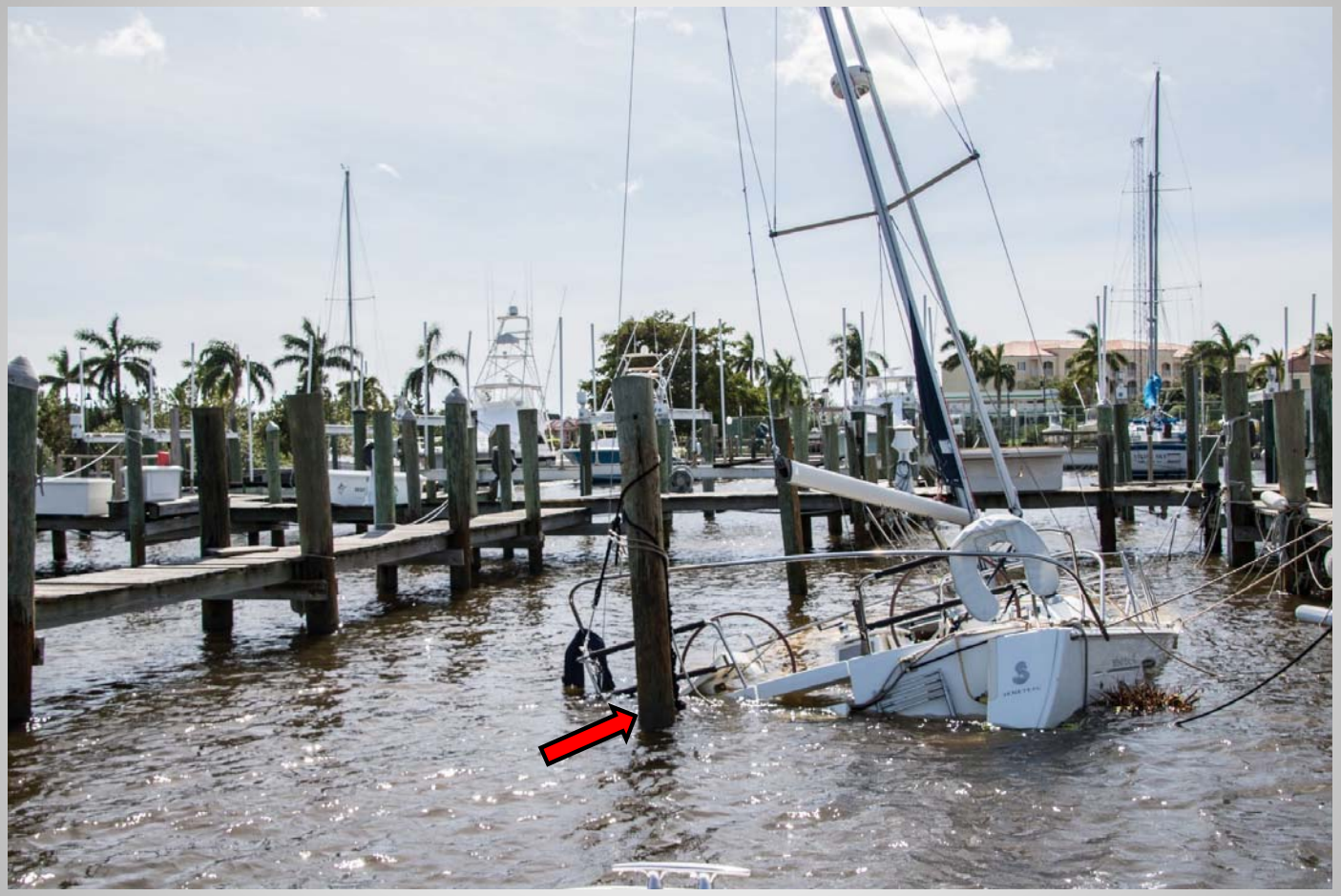

Maximum raised position of dodger rail


Bow pulpit interference with boom and topping lift
Bow pulpit & forestay interference with dodger rail





Case Study No. 3 – Post Hurricane Sinking



Who Dunnit

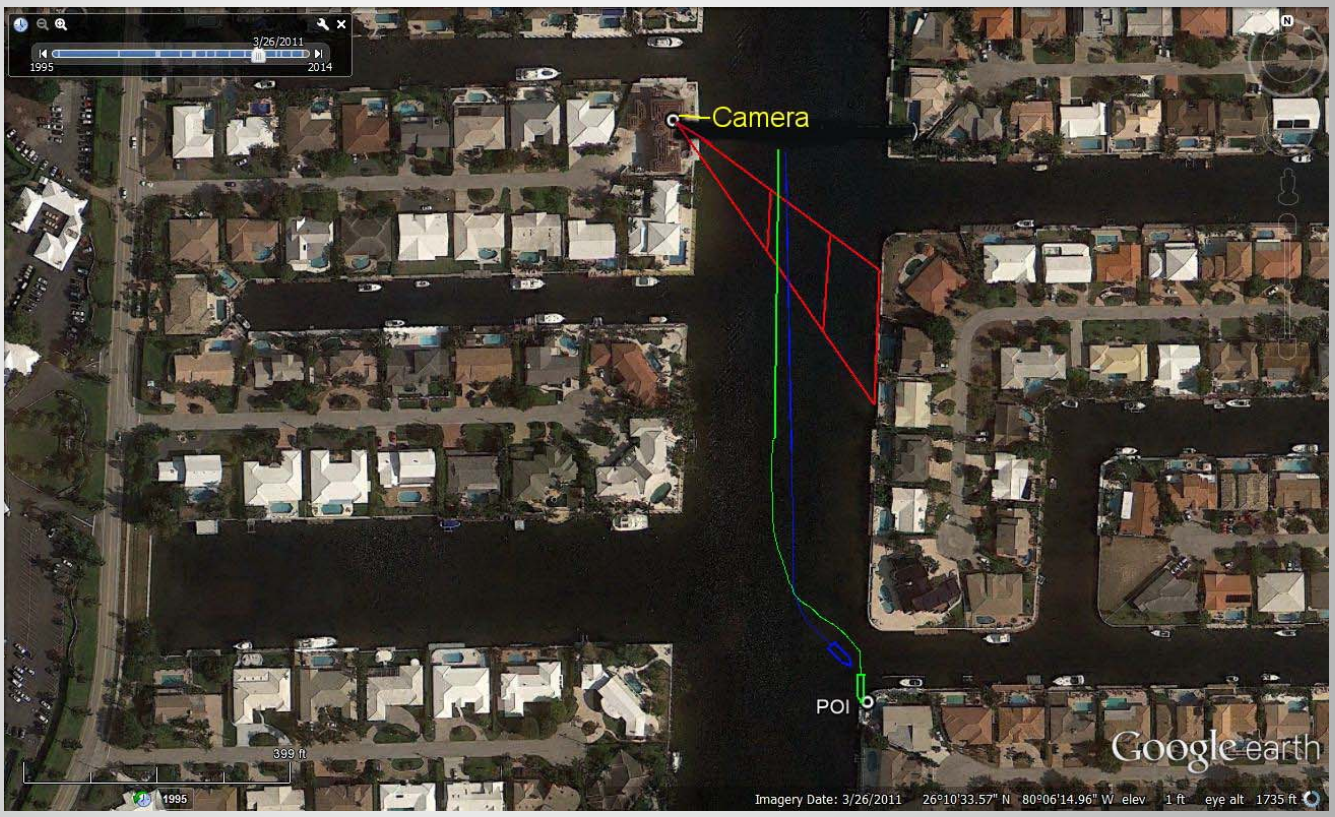
- Results
  - —Damage not consistent with being caused by suspect vessel
  - —Other plausible causes for the damage

Case Study No. 4

Vessel Accident Reconstruction
Camera Matching

Camera Matching

- Background



Camera Matching

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

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

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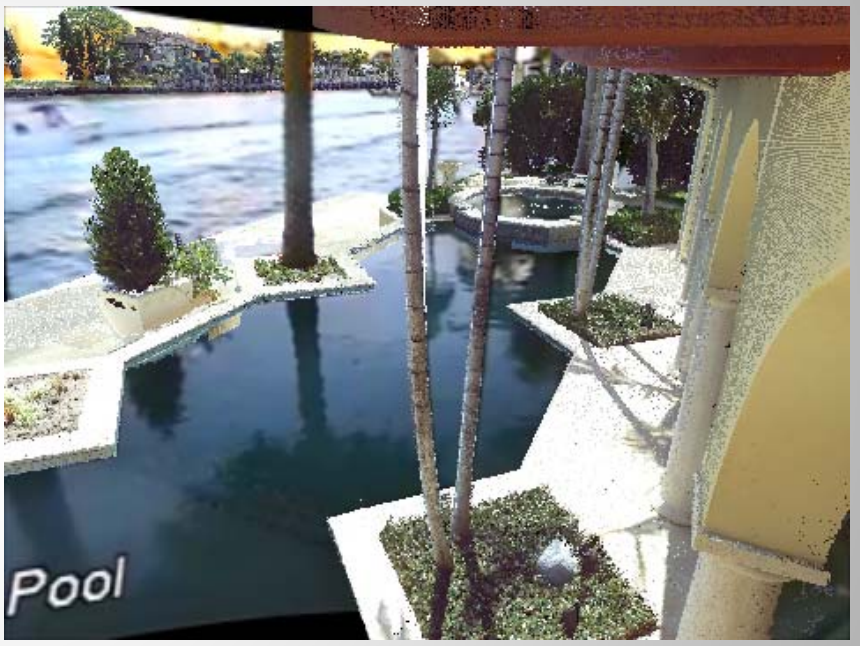

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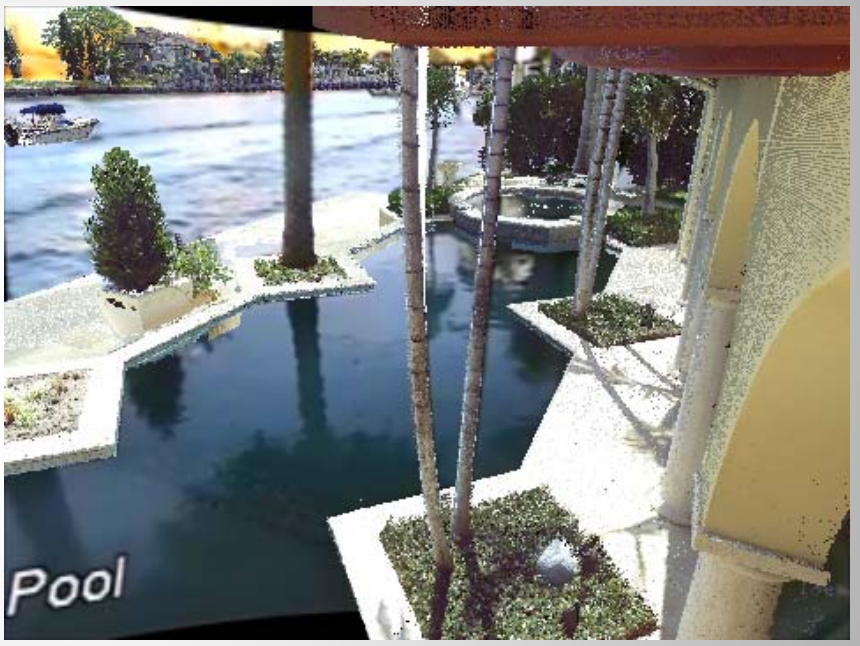

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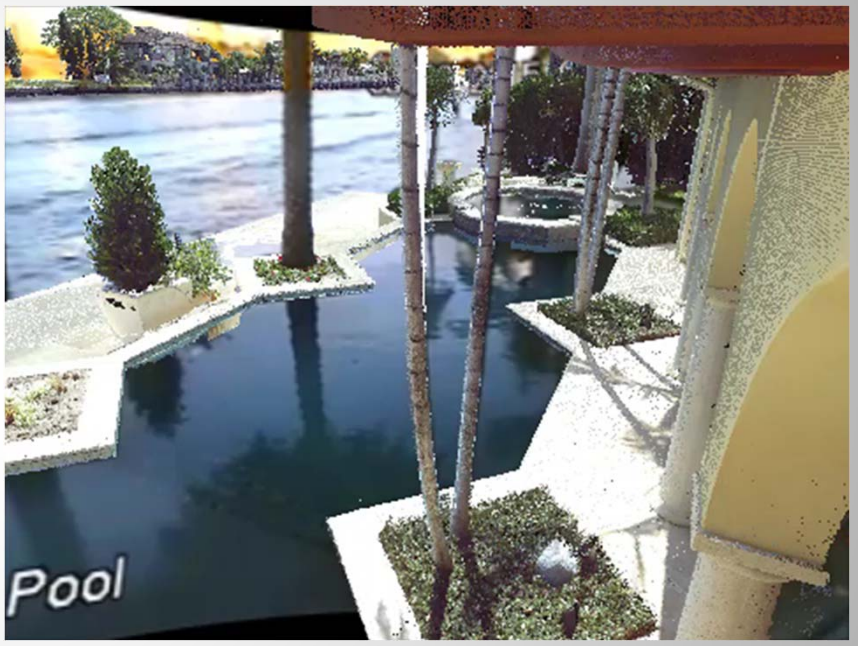

Camera Matching

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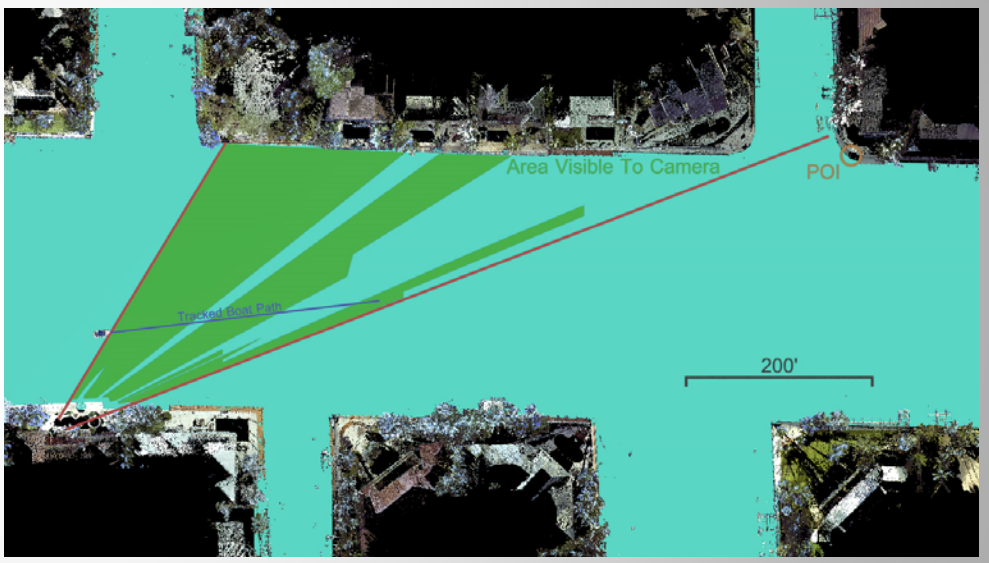
  - Lens Correction of CCTV
  - Combining the above

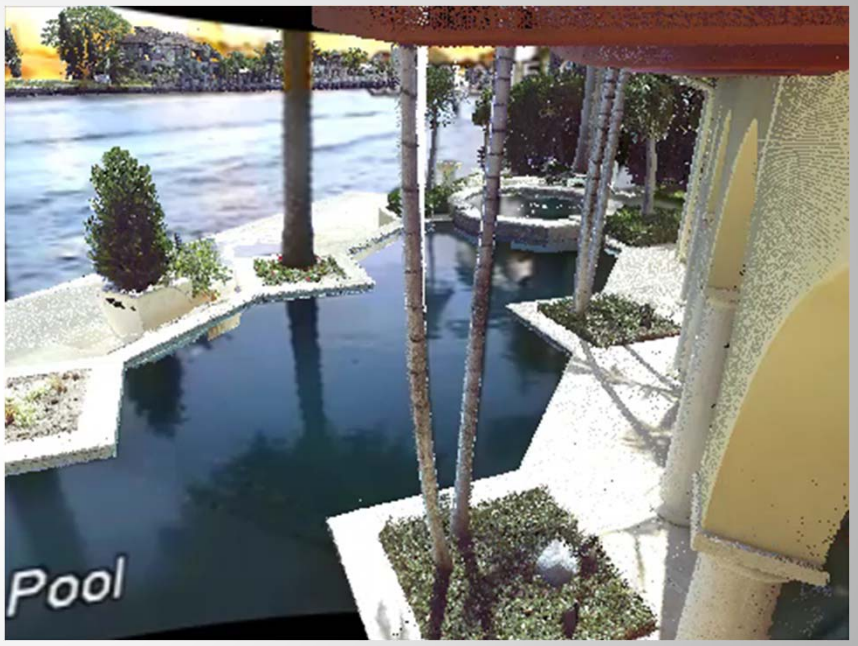


Camera Matching

- 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



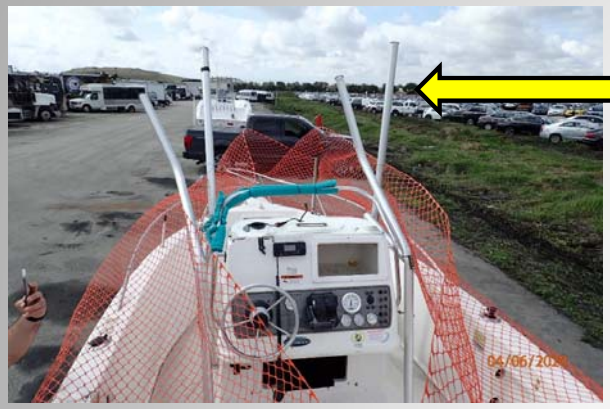
Case Study No. 5

Vessel Accident Reconstruction
Visibility Analysis

Visibility Analysis

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

Visibility Analysis



Tee Top missing

Transfer marks across console

Contact/ Transfer Marks on port bulwark

Visibility Analysis

Forward End – Point of Initial Contact

No marks or damage

No marks or damage

Visibility Analysis

Port Bow

Starboard Bow

Visibility Analysis

3D Laser Scan of 54’ Sports Cruiser

Visibility Analysis

3D Scan of Exemplar 19’ Center Console

Visibility Analysis

Determining operator's height of eye

Apx. 4' 9" Height of Eye

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°

Visibility Analysis

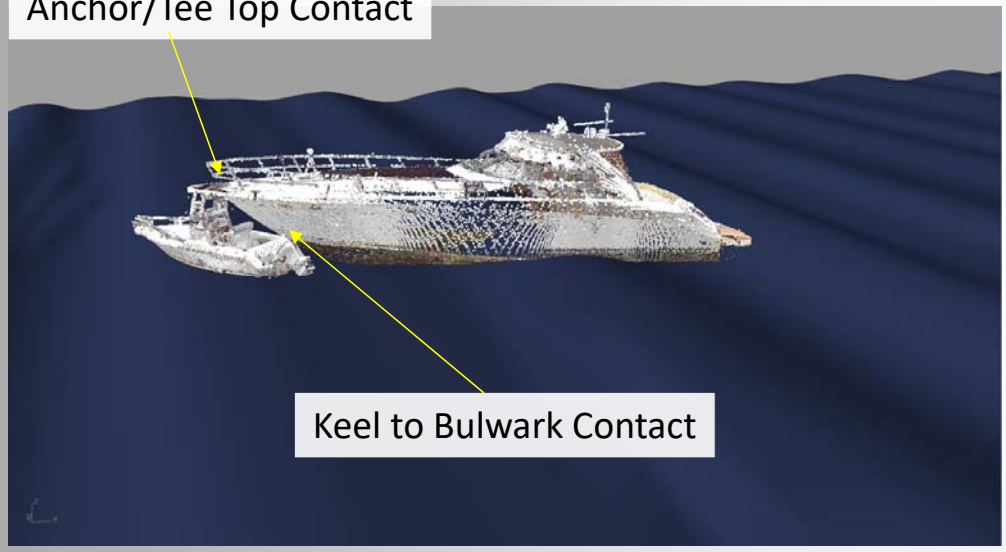
On-water Testing of 54’ Sports Cruiser

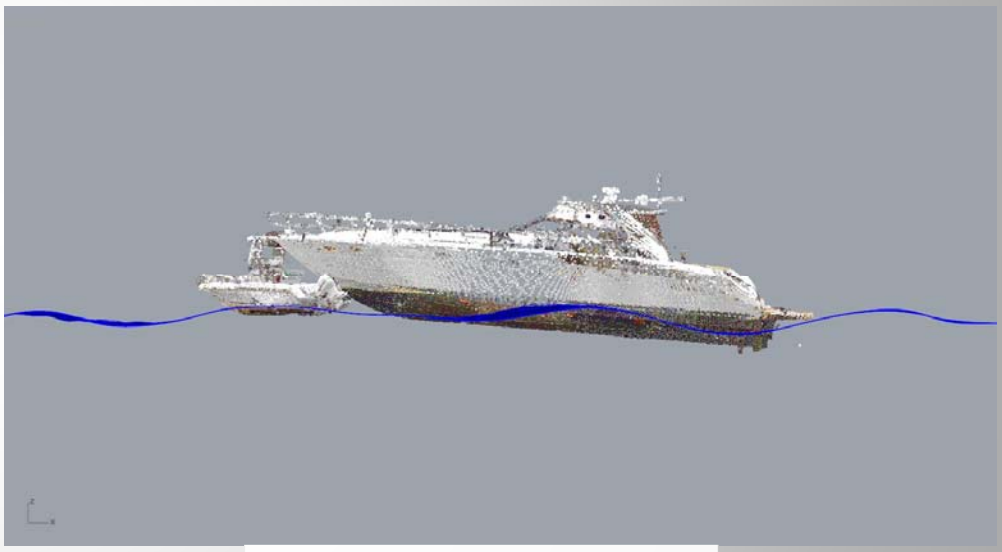
- Captured video at Height of Eye of the operator

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

Visibility Analysis Test Accident Scenarios

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

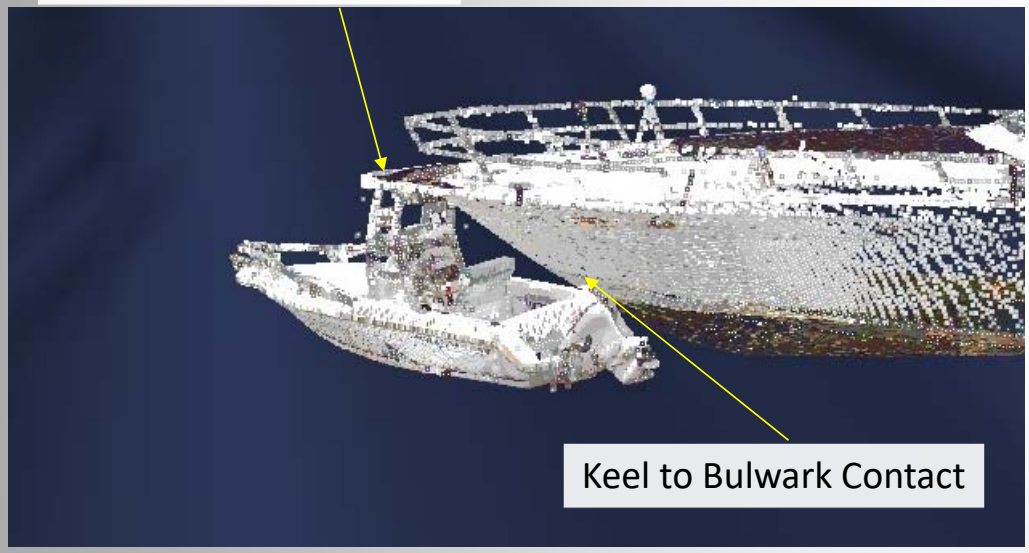


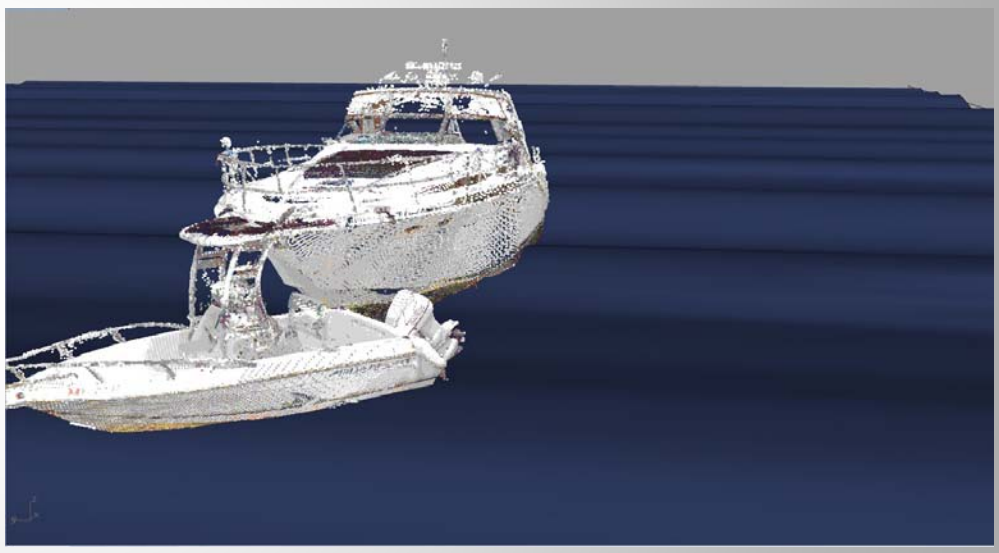


7.5° deck angle in 2 ft. seas

Visibility Analysis

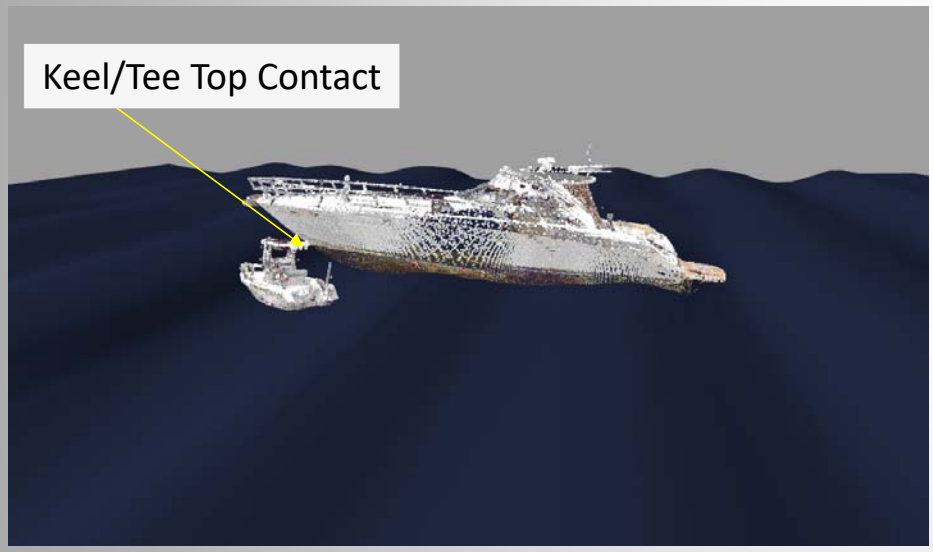
Scenario A: Apx. 2 ft seas, 7.5° Trim, Initial Contact- 54’ vessel keel to 19’ vessel bulwark

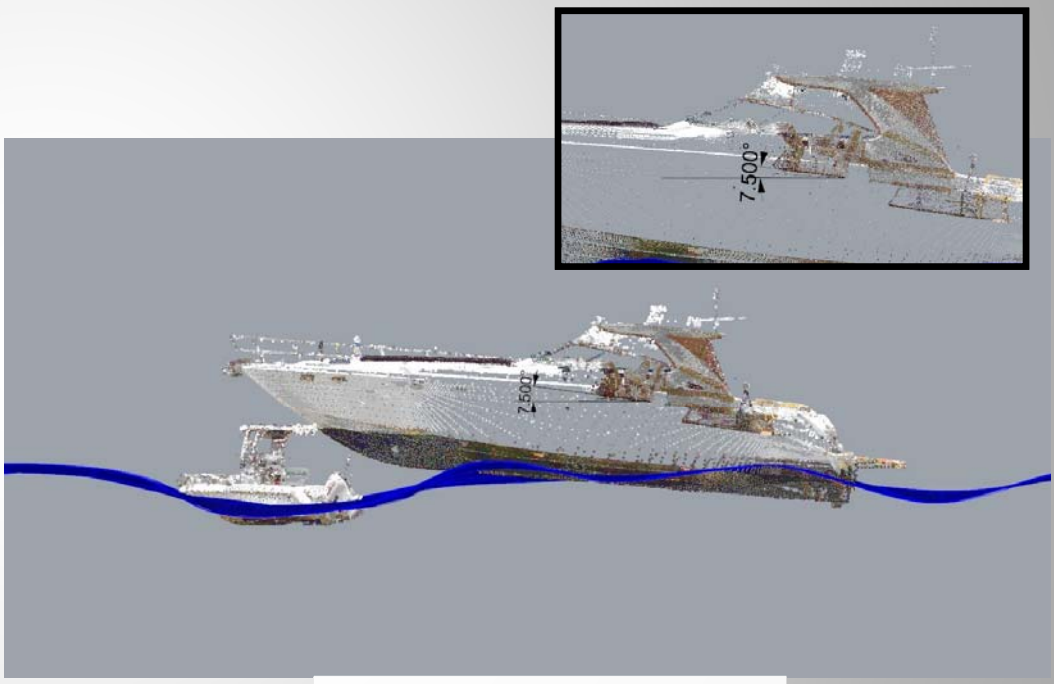




Visibility Analysis

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

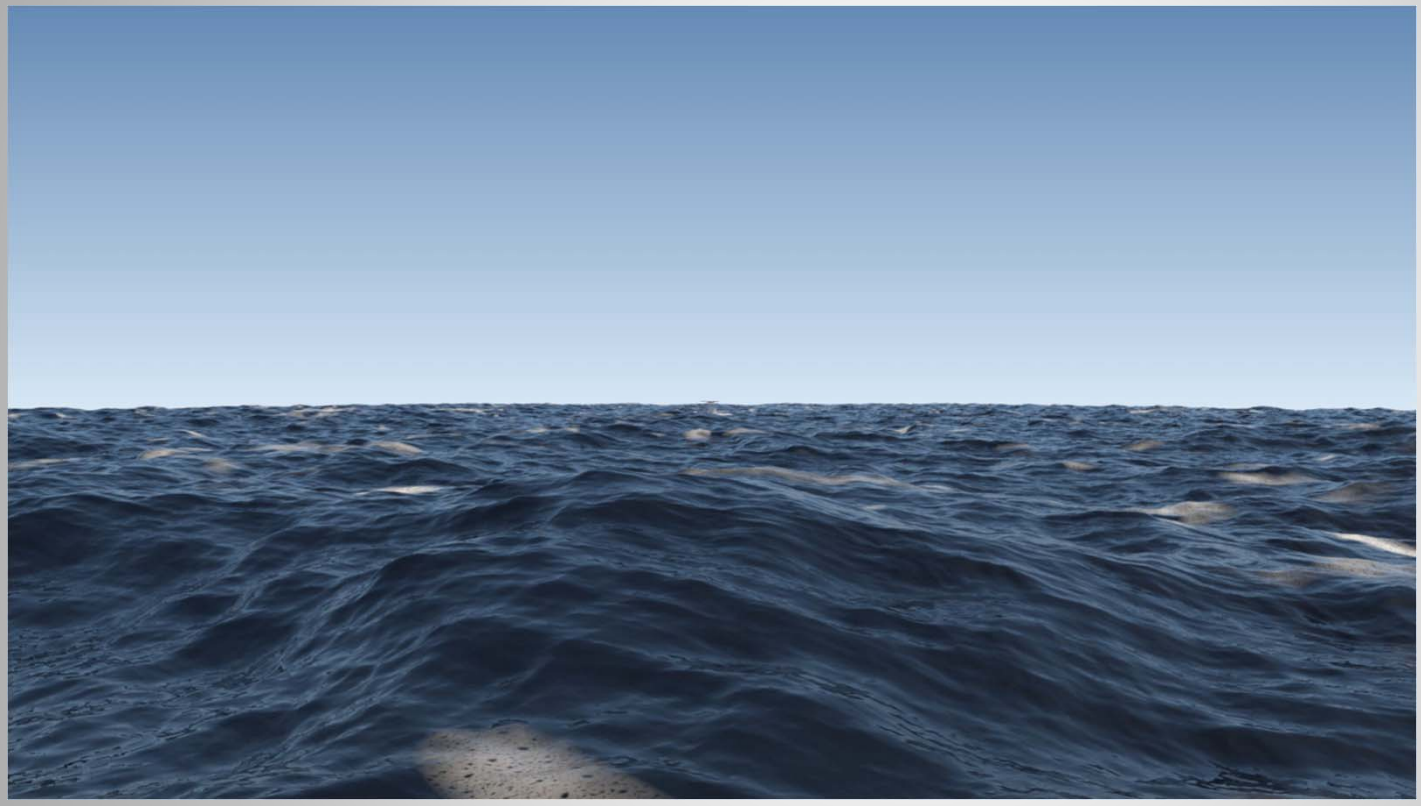




7.5° deck angle in 5 ft. seas

Visibility Analysis

Scaled Animation



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

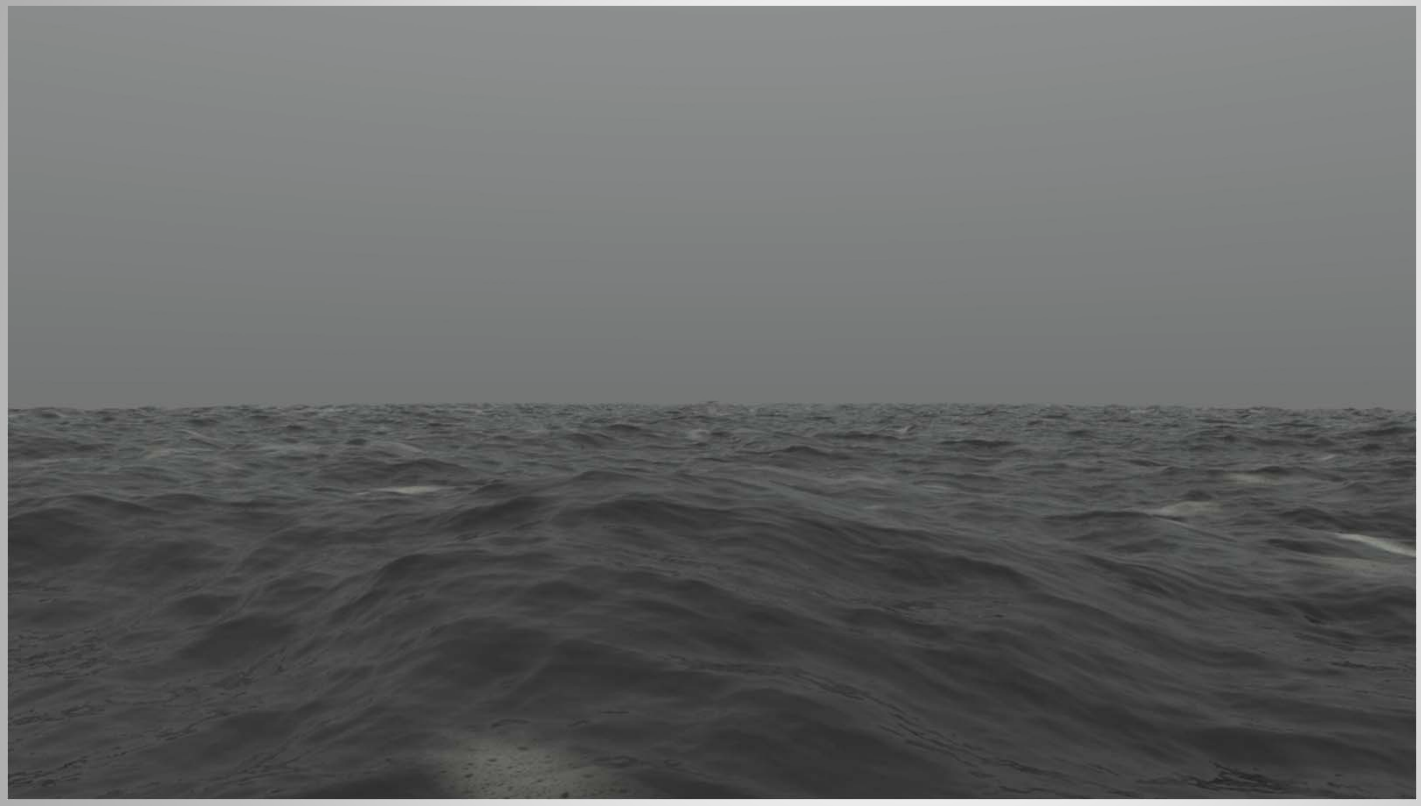
Visibility Analysis

Scaled Animation

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

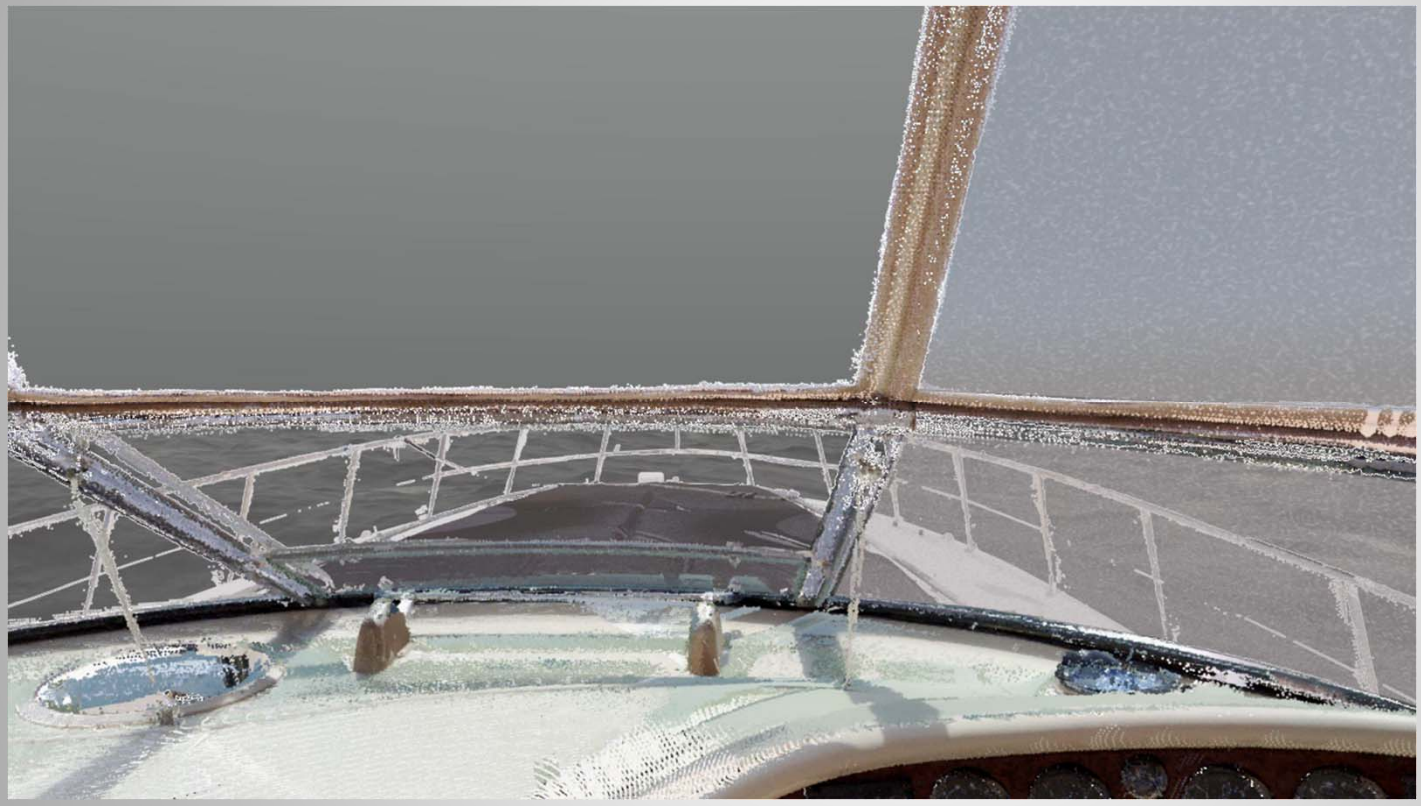
Scaled Animation



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

Scaled Animation



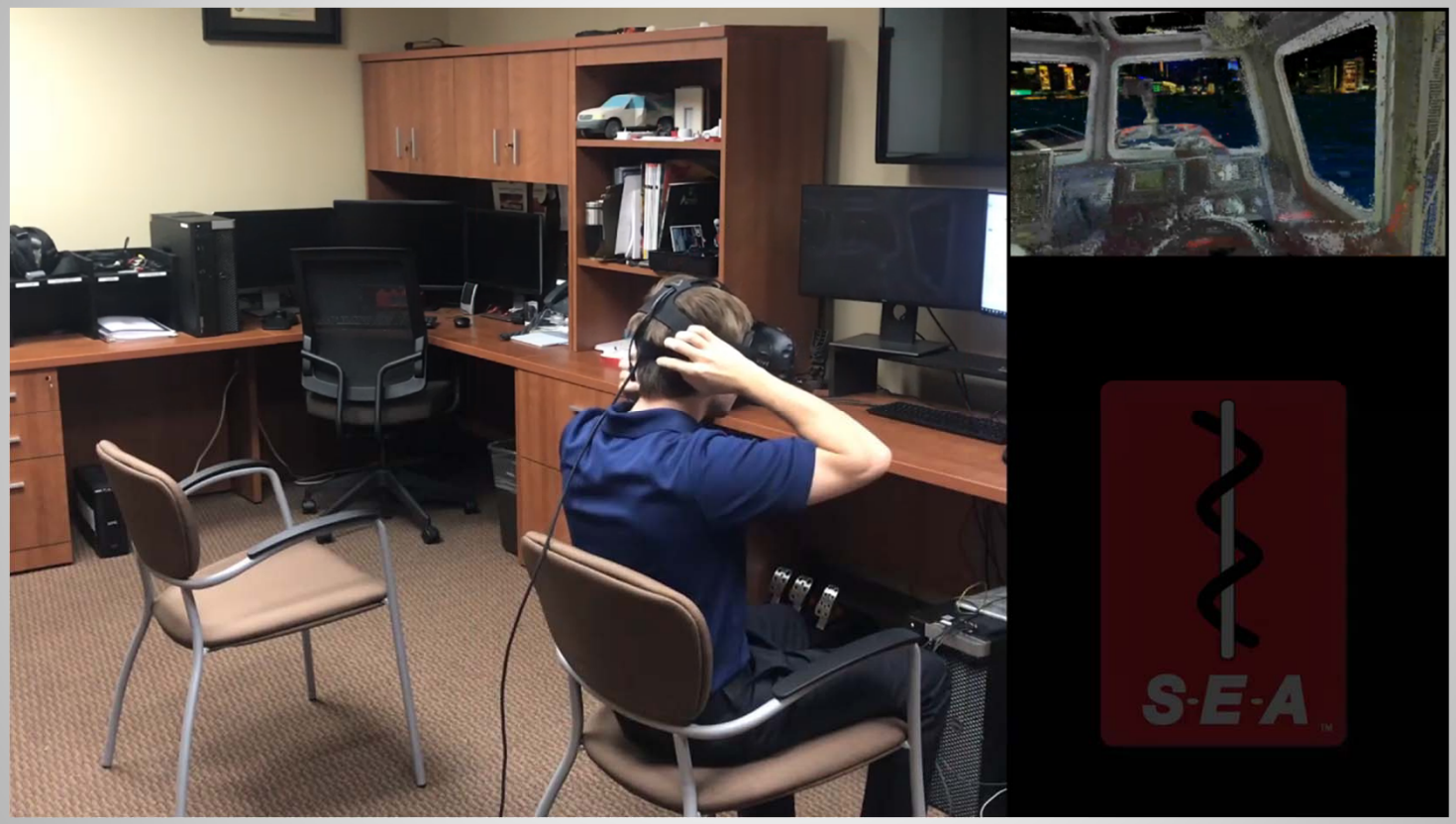
Height of Eye: 4’ 9”
Vessel Speed: 17 knots
Seas : 2-6 ft.
Weather: Cloudy
Trim: 5°-9°
Start Apx. 570 ft. apart

Visibility Analysis

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

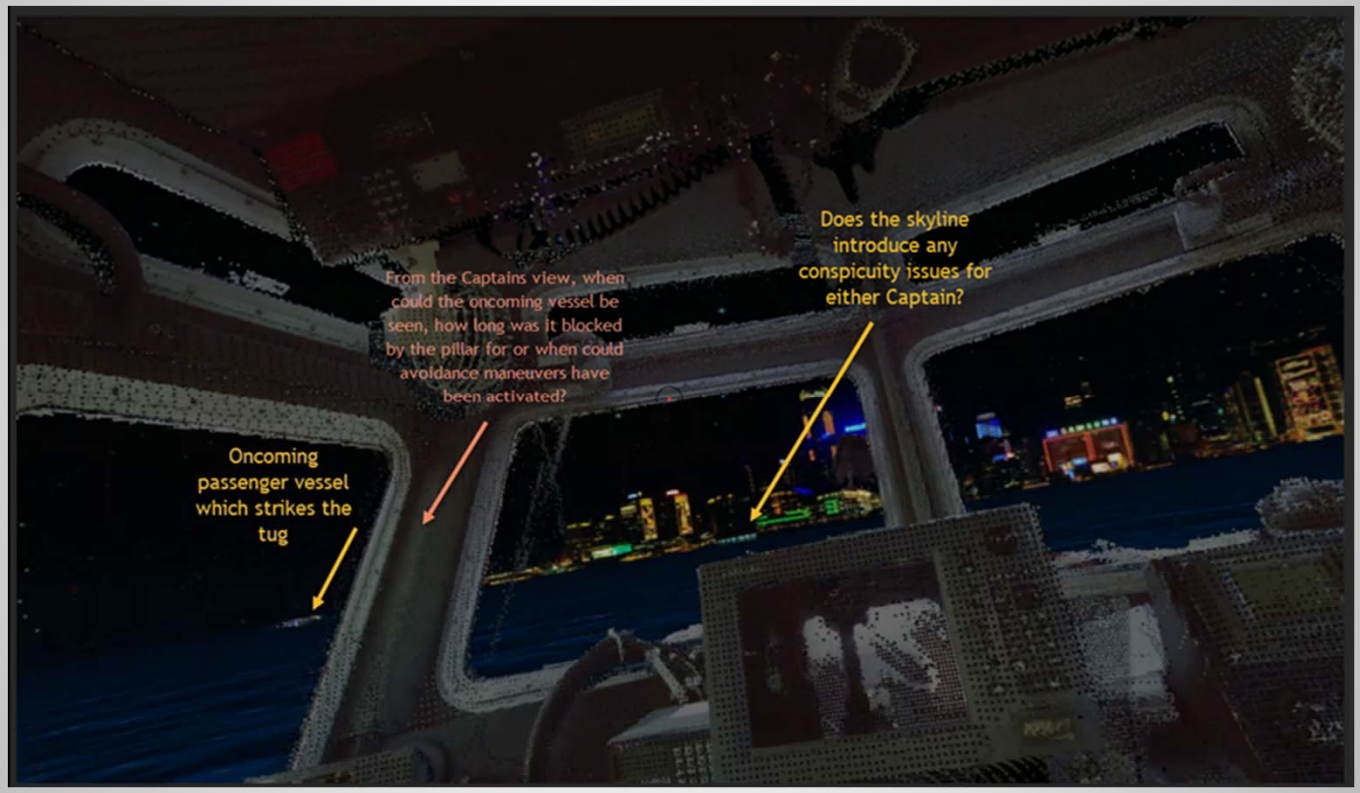
Visibility Analysis

Virtual Reality



Visibility Analysis

Virtual Reality



3-D Modeling – Strengths & Limitations

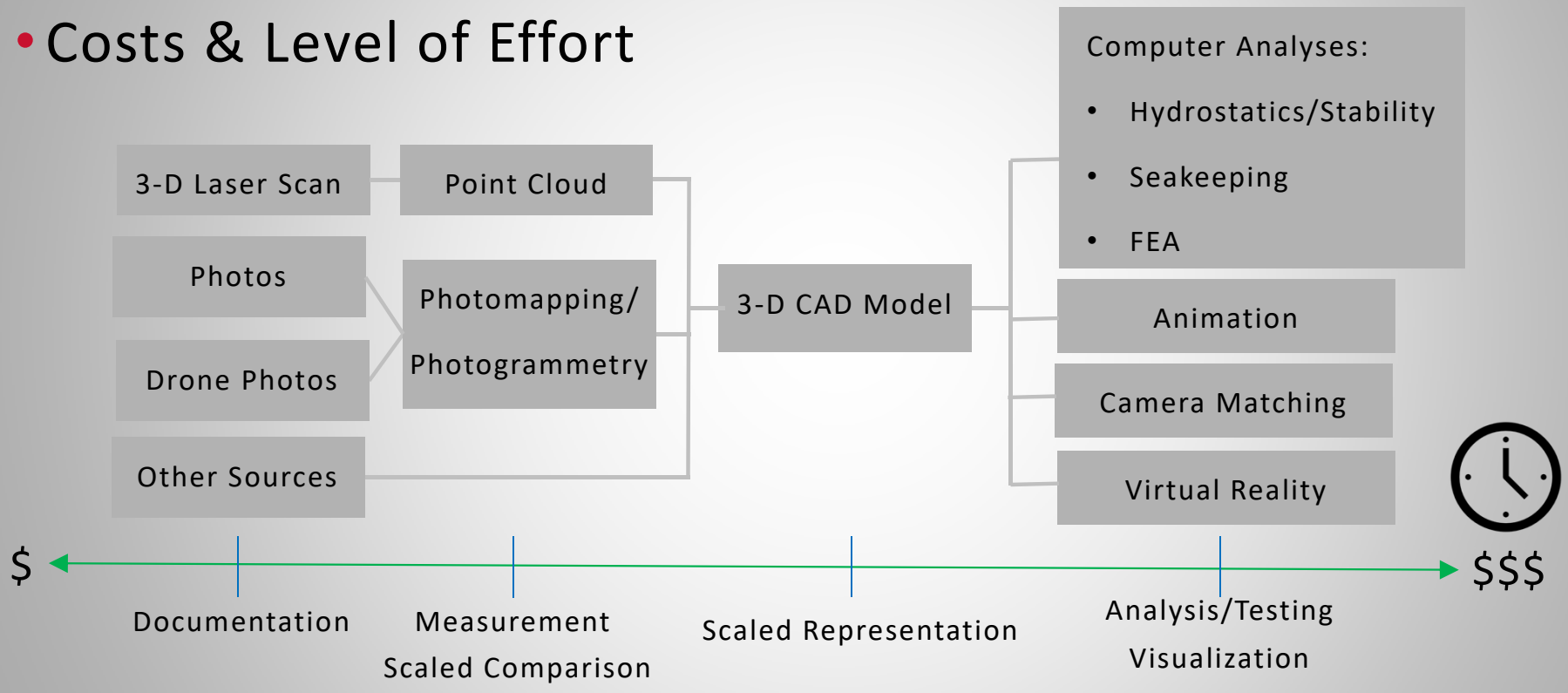
- Data vs. Models
  - —3-D data
    - Unaltered measurements
    - Accuracy
    - Measurement
    - Scaled comparison
  - —3-D models
    - Representations of data
    - Variations (increased uncertainty)
    - Turn back clock
    - Admissibility in court
    - Demonstrative aid

3-D Modeling – Strengths & Limitations

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

3-D Modeling – Strengths & Limitations

- Costs & Level of Effort



Thank you for your attention.

Questions?

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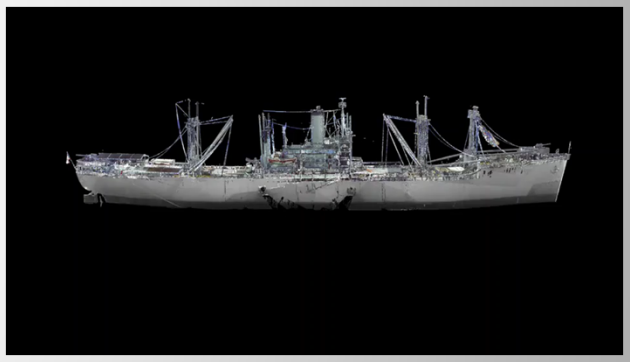

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