MOOR THAN AN ANCHOR: EXPEDITIONARY MOORING SYSTEMS

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ABSTRACT

The U.S. Navy is addressing a capability gap in their expeditionary warfare forces performing missions abroad. Existing practices for mooring large warfare vessels require barges, cranes, underwater construction teams, and specialized training. This increases cost and precious time, which is not conducive to expeditionary missions. To resolve this complication, a temporary mooring system was designed to fit into three shipping containers (8 x 8 x 6.5 ft.) that can be carried on a C-130 cargo aircraft to destinations around the world for rapid deployment. The containers are devised to act as a kit containing all the necessary mooring system components, equipment, and procedure documents.

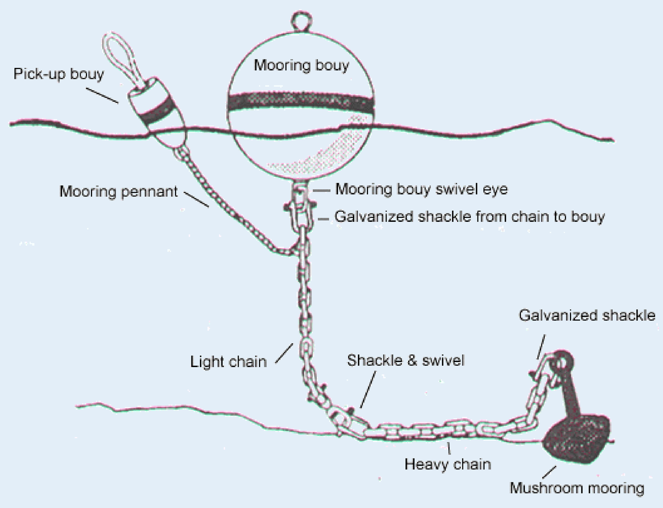

Figure 1: *Diagram of basic mooring components.*

Figure 2: *Angela & Alejandro in front of large mooring buoys.*

The kit will be comprehensive, including an assortment of line lengths for varying depths, an assortment of anchor types for varying bottom compositions (mud, sand, coral, rock, etc.), all the necessary connectors, buoys, and a penetrometer for remotely detecting the bottom composition. The assembled mooring system was modeled with an amphibious assault ship (LHA/LHD) plus simulated wind, current, and wave loads using AQWA and Orcaflex software. The resultant dynamics and stability of the system were analyzed for future design iterations.

PROJECT GOAL

Figure 3: *The basic mooring components including 1) Buoy, 2) Line, 3) Shackle, 4) Soft Sediment Anchor, 5) Hard Sediment Anchor.*

Design a kit for an easy-to-use, rapid-to-install mooring system, that fits into three "tri-cons."

These containers can be loaded onto a C-130 cargo aircraft for rapid shipment to destinations around the world.

The kit needs to contain all the mooring components, equipment and tools for installation at varying sites.

Figure 4: *Tri-con with dimensions 8 x 8 x 6.5 feet and weight limitations of 6 tons (12,000 lbs).*

Figure 5: *A tri-con being loaded onto a C-130.*

METHODS

Due to the temporary nature of expeditionary moorings, we made substitutions for smaller, lighter-weight components. We modeled the assembled system using AQWA & Orcaflex software with simulated waves, wind, and currents.

Soft-Bottom Anchor Solution

Figure 6: *Manta Ray Anchor installation diagram.*

Hard-Bottom Anchor Solution

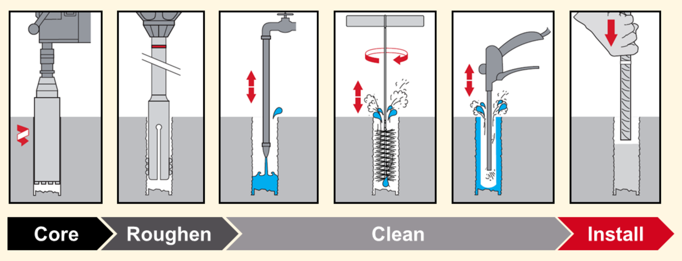

Figure 7: *Drill & Epoxy Anchor installation diagram.*

Synthetic-Line Chain Solution

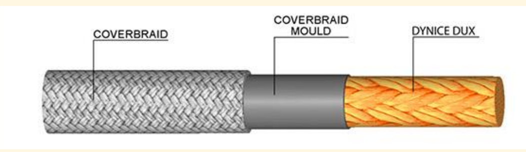

Figure 8: *DynIce synthetic line diagram.*

Inflatable Buoy Solution

Figure 9: *Deflated inflatable buoy.*

Orcaflex 4-Point Mooring Model

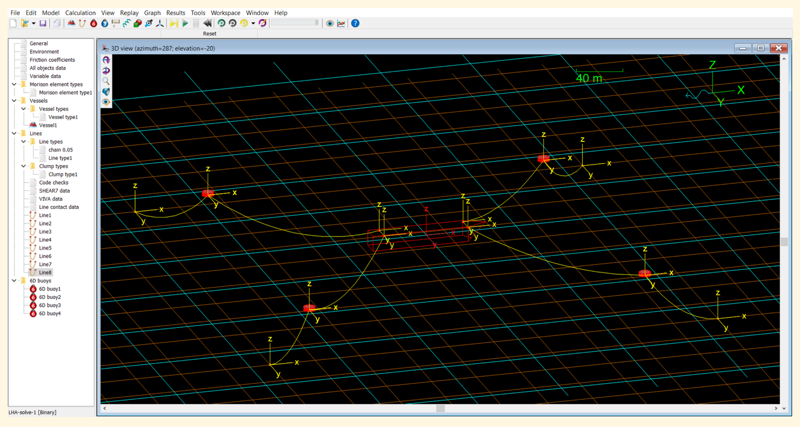

Figure 10: *Orcaflex Isometric view of the ship in a 4-point moor.*

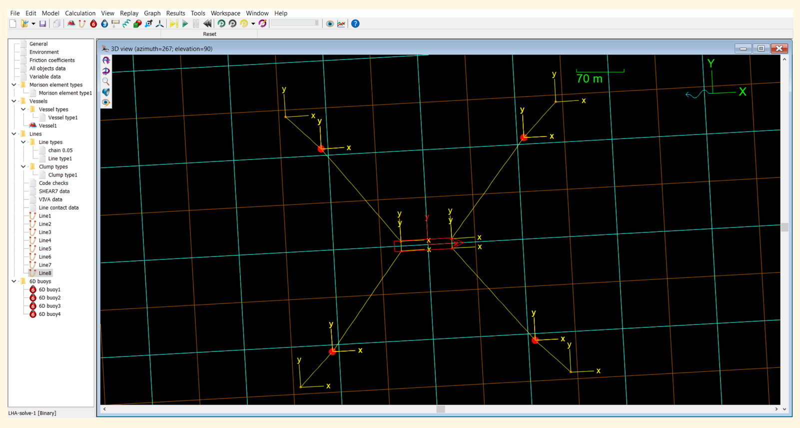

Figure 11: *Orcaflex plan view of the ship in a 4-point moor.*

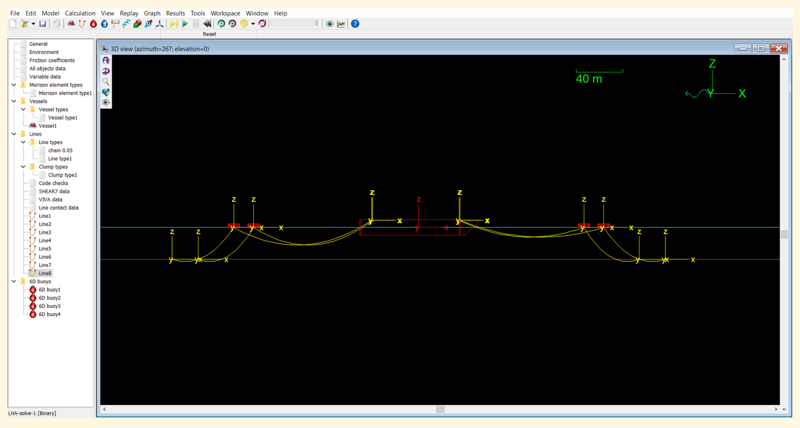

Figure 12: *Orcaflex elevation view of the ship in a 4-point moor.*

RESULTS

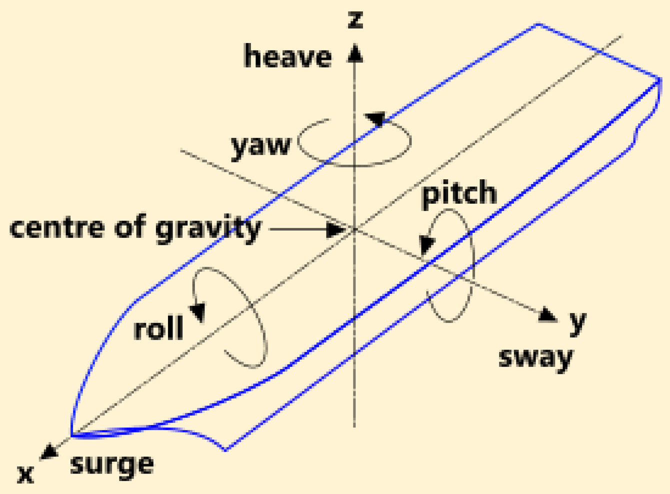

Figure 13: *The six degrees of freedom for a vessel. Orientation determined by surge, sway, and heave. Rotation determined by roll, pitch, and yaw.*

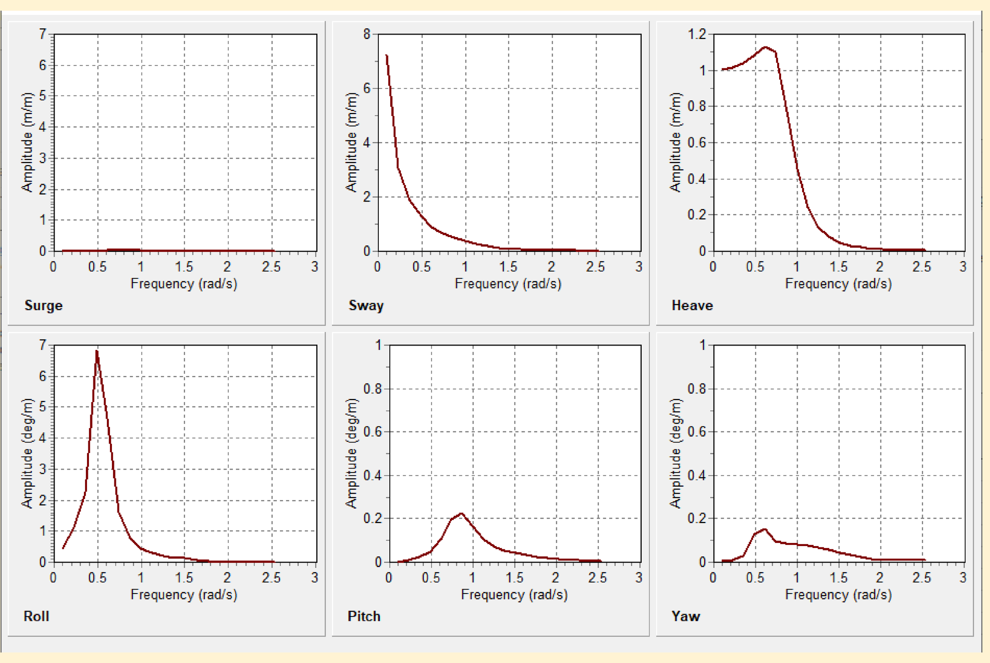

Figure 14: *Orcaflex plots of the six degrees of freedom vs. wave frequency for 90 degree incoming waves (broadside).*

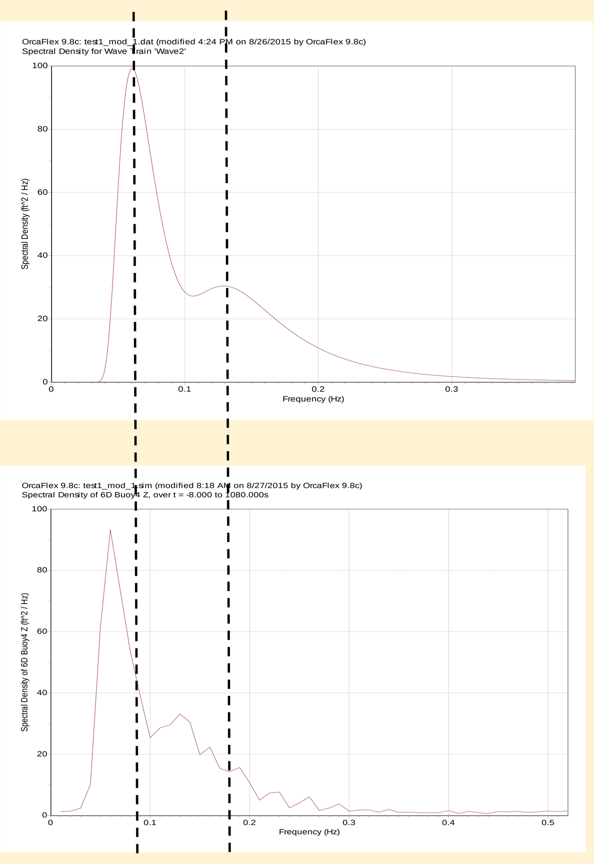

Figure 15: *Orcaflex plots of (top) Wave Swell Spectrum and (bottom) Buoy Heave Motion Spectrum.*

Dashed lines indicate peak wind forcing frequencies, showing the misalignment with the buoy heave natural frequencies, ensuring the system will not resonate with the waves.

CONCLUSION

In order to fit an expeditionary mooring system into three tri-cons, each mooring component must conserve space and weight. New technology has made this possible for a temporary system. Future work will include completion of the Orcaflex simulations for tension and dynamics analysis of the system. This analysis will support future iterations of expeditionary mooring designs.

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