CEROS Project Description

Project: ***Modeling Multi-Hull Stability in Insular Littoral Waters***[1]

Contractor: **Science Applications International Corporation (SAIC), Annapolis MD** with Navatek Ltd, Honolulu HI, the University of Hawai'i, Honolulu HI, and the Maui High Performance Computing Center, Kihei HI

Summary: This project used numerical simulation tools to evaluate the seakeeping, stability, and operational ride characteristics of an advanced high speed catamaran vessel operating in littoral waters. The objective was to develop and demonstrate a software system for naval and other maritime uses that combined a Geographic Information System (GIS) data base of typical worldwide wind, wave, and sea current conditions with a ship motion stability program, providing the means to determine optimal ocean routing conditions for various hull configurations.

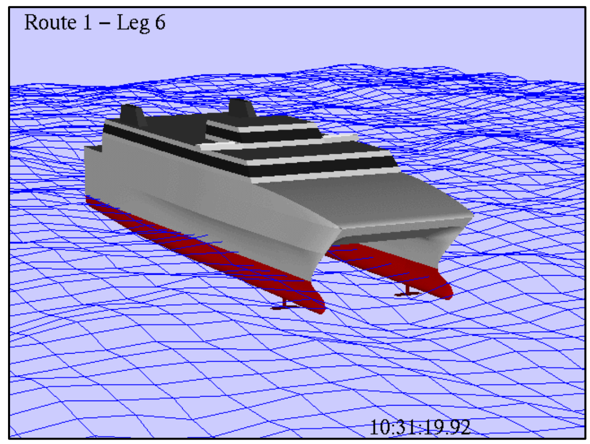

Figure 1. Example of a simulation step of vessel response in a 12-foot significant wave train approaching from the port quarter; the hull shape and geometry are hypothetical.

Description: The goal of this project was to demonstrate a numerical simulation capability for route selection and operational planning for vessels (both naval and commercial); as a test case, a specific evaluation was performed for a high-speed ferry operating between the Hawaiian Islands. The Hawaiian Islands offer a rich and varied set of seaway characteristics because of seasonal wind and wave exposure, sheltering, and wave refraction, reflection and shoaling. Figure 2 shows possible ferry routes between various Hawaiian ports that were used in the simulation analyses.

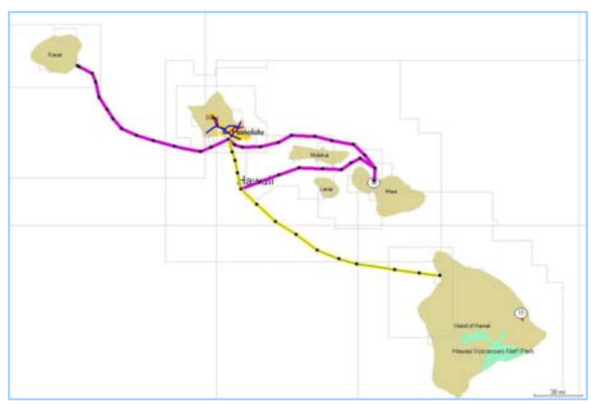

Figure 2. Potential ferry routes between major cities of Hawaii. The waypoints separate computation legs used in the simulation.

The main computation tools used in this study were ENDEAVOR (Environment for Design of Advanced Marine Vehicles and Operations Research) and LAMP (Large Amplitude Motions Program). ENDEAVOR was developed under Office of Naval Research auspices by the

[1] CEROS FY04 contract 50583-S2; this was a supplemental task added on to CEROS FY03 contract 50583, which was entitled *Development and Demonstration of a 3-D Flapping Foil Motion Control System for Advanced Marine Vehicles*.

University of Hawaii and other members of this contract team; it enables designers and planners to rapidly prototype advanced marine vehicles and to simulate the response of the vessels in realistic ocean environments (including surface wave interaction with the bottom). LAMP is a time-domain three-dimensional simulation model, initially funded by DARPA, for platform dynamics, wave loads, and structural responses. It calculates for each time step all forces on a ship, including wave-body interaction, appendages, control systems, main hull-girder loads, and green-water deck overwash.

These two software systems were used in combination to determine ship motions under the influence of seaways defined by location and time of year (Figure 3). Once a discrete set of component wave amplitudes, frequencies, and relative headings had been determined for each leg, LAMP is used to compute time-domain, 6-DOF ship motions over each leg of the route (Figure 4).

A wide variety of motion criteria could be used to characterize the seakeeping performance of a proposed vessel design. For example, critical design issues may involve structural loads, slamming, water on deck, damage to equipment, and loss of human performance or comfort because of motion sickness or motion induced fatigue. In keeping with the study objectives, this effort emphasized motion sickness incidence (MSI) where the tolerance to motion sickness is related to vertical acceleration frequency and amplitude. Figure 5 shows one example of many plots relating vertical accelerations and an established criterion for the onset of motion induced sickness (*i.e.*, 10% of passengers experiencing sickness after a 4-hour exposure to the indicated frequency and amplitude. Similar plots were created for various routes, seasons, wave conditions, and calculation points on the vessel (bow, stern, centerline, and maximum beam)

The project demonstrated the capability of the ENDEAVOR-LAMP software system to provide analytical capabilities for naval and commercial operations in Hawaiian waters; it is readily applicable to other areas in the world ocean.

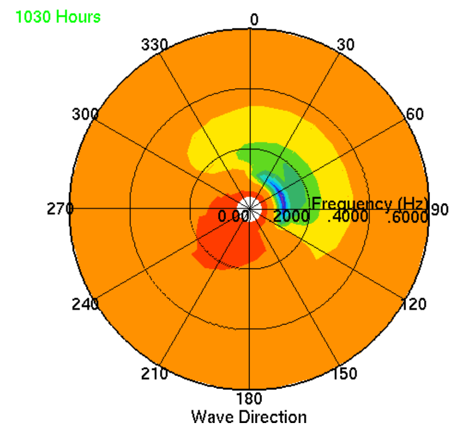

Figure 3. Example of hindcast wave spectra from ENDEAVOR for one leg and time step along an interisland ferry route.

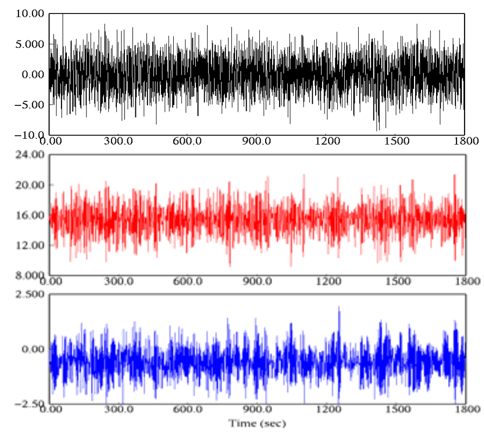

Figure 4. Example of LAMP results for one route leg; incident waves in feet (black), heave motion in feet (red), and pitch motion in degrees (blue).

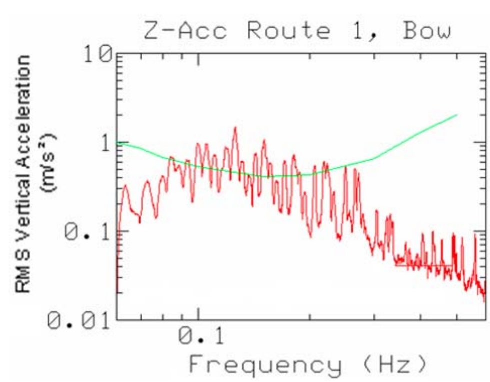

Figure 5. Example of MSI plot for an extreme winter storm scenario; the green line indicates the onset of motion sickness at the indicated vertical acceleration and frequency.

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