The Hawaiian Maritime Transportation System: 
Analyzing Resilience and Advising Investment

M.S. Thesis in Operations Research (completion date: March 2011) 
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Background:

The maritime transportation system (MTS) for the State of Hawaii is responsible for delivering food, clothing, automobiles, building supplies, machinery, medical supplies, and agricultural materials from the mainland United States to the local population. In a study prepared for the Hawaii Harbor Users Group, “The Impact of Hawaii’s Harbors on the Local Economy” (May 2007), Dr. Leroy O. Laney of Hawaii’s Pacific University reports that more than 98% of imported consumer goods, which make up 80% of all consumed goods, come in through maritime systems. Hawaii’s MTS is a “hub-and-spoke” system—almost all of the State’s consumed goods come into Honolulu Harbor and are then distributed to Oahu or on to neighbor Hawaiian Islands. Additionally, Hawaii has extremely limited storage capacity, which requires cargo to follow “just-in-time” delivery. The result is that the MTS is vulnerable to both non-deliberate hazards (e.g., accident, failure, natural disaster) and deliberate threats (e.g., sabotage, vandalism, terrorism), and the consequences of a long-term disruption could be severe.

State and Federal government officials are aware of the critical role of the MTS and are interested in achieving a clear picture of the resilience of the MTS to provide commodities to the state of Hawaii.

Scope:

The geographic scope of this thesis project is the state of Hawaii, Oahu and the following Neighbor Islands: Hawaii, Kauai, Lanai, Maui, and Molokai. The project encompasses the delivery of consumer goods to the state of Hawaii, starting with arrival of container ships to the port of Honolulu and including the distribution of cargo to Oahu and the Neighbor Islands via cranes, barges, trucks, and delivery routes, and over a three-month planning horizon. We also consider the potential use of Pearl Harbor in a scenario where Honolulu Harbor is not available.

The objective of this work is to answer two basic groups of questions:

1. How will the Hawaiian MTS perform in the face of major disruptions? What is the worst-case disruption, and how bad could it be in terms of delivery shortages?

2. How would investment of limited defensive resources (for hardening, redundancy, or capacity expansion) make the MTS resilient to such disruptions? What are the best investments?

In Partnership with State and Local Officials:

This project is being conducted in partnership with the US Coast Guard Captain of the Port (COTP) for Honolulu, the Department of Homeland Security Protective Security Advisor (PSA), and the local MTS operating companies: Horizon Lines, Matson, Young Brothers, Hawaii Tug and Barge, and Sause Bros. We are working in coordination with Hawaii State Civil Defense, Hawaii State Harbors, the University of Hawaii DHS Science and Technology Center of Excellence, the Pacific Disaster Center, and Department of Defense Pacific Command.
Method of Analysis:

We use mathematics to represent the day-to-day operations of the MTS under normal conditions as dictated by shipping schedules, barge or ship capacities, supply and demand, and transportation costs. We account for different commodity types (e.g., refrigerated and non-refrigerated containers) and accommodate different classes of customers (used to represent different service priorities, e.g., hospitals). We call this representation the “operator’s model” because it reflects the decisions made by the individual operating companies working together (under ideal circumstances) as a coordinated entity. The objective of this model is to find the distribution of cargo that minimizes shortages.

Using the operator’s model, we can analyze what-if scenarios regarding the loss of individual components (e.g. cranes, barges, etc.) of the MTS. Moreover, by searching systematically over all possible what-if scenarios, we can identify the worst-case disruptions. While it is relatively common to look for single points of failure in systems like the Hawaiian MTS, this thesis considers combinations of secondary components that, when lost together, will have a “first-order” effect on the system. These cases are much harder to identify and require a working knowledge of the domain-specific details of the system, as well as the means to search over the many (often millions) of combinations. In searching for the worst-case disruptions, we are essentially performing an automated “red teaming” analysis at the systems level.

Finally, we consider the task of mitigating potential disruptions to the MTS by strategic investment of limited resources. By exposing the most critical components of the system, we will identify places where investment in protective “hardening” or backup redundancy can have the greatest effect. In addition, we can also evaluate the potential benefit of capacity expansion (e.g., port modernization) and address the question of “how much is enough?” As part of this analysis, we will consider the possible use of Pearl Harbor as a partial backup for the Port of Honolulu in extreme situations.

Project Time Line:

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<th>Month</th>
<th>Event</th>
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<tr>
<td>Oct 2010-Jan 2011</td>
<td>Model refinement and analysis.</td>
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<tr>
<td>Feb 2011</td>
<td>Presentation of final FOUO report to stakeholders.</td>
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<tr>
<td>Mar 2011</td>
<td>Thesis completion and graduation.</td>
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For more information contact:

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