

**Safety Factors and Leading Indicators in Shipping Organizations:  
Tanker and Container Operations**

by

Haiyuan Wang

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the degree of

DOCTOR OF PHILOSOPHY

Major Subject: Decision Sciences and Engineering Systems

The original of the complete thesis is on file  
In the Rensselaer Polytechnic Institute Library

Examining Committee:

Dr. Martha Grabowski, Thesis Adviser

Dr. Wai Kin (Victor) Chan, Thesis Adviser

Dr. Adrian S. Choo, Member

Dr. Charles J. Malmberg, Member

Rensselaer Polytechnic Institute  
Troy, New York

April 2008  
(For Graduation May 2008)

## **ABSTRACT**

In safety critical systems such as marine transportation, there are two types of performance measures that have different usage for safety management: lagging indicators and leading indicators. Lagging indicators measure historical performance and may have limited predictive capability. Leading indicators, on the other hand, can be signals of adverse events. Therefore, developing a set of safety leading indicators is essential for marine transportation.

In this work, an existing research framework on leading indicators for tanker operations is extended to container operations. By the identification of safety factors and safety leading indicators in container operations, a comparison is made with those in tanker operations. In addition, the results are benchmarked with results from other industries. Using the safety factors and safety leading indicators identified in this study, these indicators can be continuously measured and monitored in shipping organizations. Through this method, problems and potential for incidents and/or accidents can then be identified. As a result, appropriate safety intervention and prevention measures can be adopted. This might save time and money for the organization while reducing risk exposure. The framework provided here can also serve as a reference on how to develop safety leading indicators system for other sectors of marine transportation.

The proposed research focuses on extending existing tanker safety factors to container operations. Research questions that will be answered in this dissertation research are mainly in two parts. The first part is to develop a safety leading indicator identification model for the marine transportation system. The second part is to answer questions beyond leading indicators identification. These mainly include: what do the safety leading indicators identification results suggest? What are the similarities and differences of safety leading indicators between tanker operations and container operations? What are the similarities and differences of the safety leading indicators between marine transportation industry and other industries? What recommendations can be made after these comparisons? The safety factors and leading indicators identified can be used to predict the future safety performance of shipping operations in marine transportation.

In answering these questions, the contributions of this study can be summarized as the following:

- Models on identifying safety factors and leading indicators for tanker operations are further validated;
- Safety factors and leading indicators are quantitatively identified and validated for container operations;
- Sub-culture of safety in container operations are explored;
- Whether significant differences on safety factors and leading indicators exist between tanker and container operations is validated. Although marine transportation practitioners believe tanker operations and container operations have diverse characteristics, safety factors and leading indicators are presumably significantly different. This research intends to validate whether this is true;
- Safety factors and safety leading indicators for shipping organizations in general are proposed based on tanker and container results; and
- The results for shipping organizations are benchmarked with other studies in shipping industry as well as those from other industries.