

## A Study on Accident Theories and Their Application in Costa Concordia Accident

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### Abstract

**Introduction** - This paper reviews accident theories and categorizes the theories in three groups. The properties of these models are studied and their applicability is discussed. From each group a representative model is chosen to be applied in a maritime accident. The accident of Costa Concordia in 2012 is considered for this study. The study reveals pros and cons of each model. Based on the study future recommendations are made on accident prediction/modeling techniques.

**Accident Theories & Application** - Accident models provide a conceptualization of the characteristics of the accident, which typically show the relation between causes and effects. Many accident models have been proposed over the years. Table 1 shows a very brief classification of accident theories based on the complexity and Figure 1 shows graphical representation of two accident theories. Three models have been selected namely: 1) Domino Theory, 2) Organizational Accident Model and 3) STAMP Model from each group. The following sections discuss these in detail.

**Domino Theory** - Domino theory as suggested by Heinrich in the late 1920s utilizes 5 dominos in a row for an accident: 1) Ancestry and social environment, 2) Fault of person, 3) Unsafe act/mechanical or physical hazard, 4) The Accident and 5) The Injury. By observing the sequence of events of the Costa Concordia accident, only simple events can be matched and modeled by this theory (for example the role of the Captain) but none of the dominos can be constructed that can successfully model the total scenario. Therefore, this model is inapplicable for the accident as a whole.

**Organizational Accident Model** - This model is based of Swiss cheese model and suggests that longstanding organizational deficiencies can create the necessary conditions for a frontline ‘active failure’ to trigger an accident. The presence of these conditions and events in the system represent the inadequacy/absence of defensive barriers (e.g. physical protection, training and procedures) designed to prevent accidents. As far as the accident of the Costa Concordia is concerned, this model fits well and 6 failures could be identified. However, new ideas still remain to be studied to make it computable and predict in a software system.

**STAMP Model** - The Systems-Theoretic Accident Model and Processes (STAMP) is proposed in 2004 by Leveson. According to this theory, safety then can be viewed as a control problem, and safety is managed by a control structure embedded in an adaptive socio-technical system. The goal of the control structure is to enforce constraints on system development and on system operation that result in safe behavior. In this framework, understanding why an accident occurred requires determining why the control structure was ineffective. This theory shows good promise in modeling the Costa Concordia accident but computational techniques require new inventions from multiple disciplines.

**Concluding Remarks** - Simple sequential accident models are incapable of explaining complex systems and thereby inappropriate to be used. The epidemiological models are capable of explaining complex accidents but needs further research on computation techniques. The system theoretic approaches appear to be more detailed and extensive. For maritime accidents, application techniques and theories are needed to developed and investigated.

Table 1: Accident theories and classification.

Class	Name of Accident Theory
Sequential Accident Models	<ul style="list-style-type: none"> <li>• Domino Theory</li> <li>• Failure Modes and Effects Analysis (FMEA) Technique</li> </ul>
Epidemiological Model	<ul style="list-style-type: none"> <li>• Swiss Cheese Model</li> <li>• Organizational Accident Model</li> </ul>
System theoretic Models	<ul style="list-style-type: none"> <li>• FRAM Model</li> <li>• STAMP Model</li> </ul>

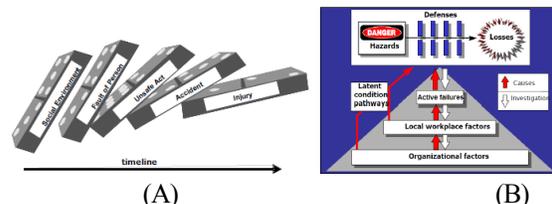


Figure 1: (A) Domino theory of Accident  
(B) Organizational theory of accident.