2015 Conference on Systems Engineering Research

A network-based approach to organizational culture and learning in system safety

Mark S. Avnet[a],*

[a]Texas A&M University, 4075 Emerging Technologies Building, 3131 TAMU, College Station, TX 77843-3131, USA

Abstract

While it is now generally agreed that system safety cannot be adequately addressed using technical analysis alone, an approach to modeling the organizational issues associated with safety is still needed. This paper offers an analytical approach to assessing the complex relationships among organizational culture and safety practices and outcomes. The paper argues that, in principle, organizational culture can be represented as a network of shared mental models (SMMs). While it would be impractical to construct a network that fully captures an organization's culture, the approach can be used to model particular dimensions of culture. Thus, a network of SMMs is a meaningful representation of safety culture to the extent that the data effectively capture shared knowledge about system safety. Similarly, organizational learning can be quantified as the evolution of that network's structure over time. The goal of the research is to develop a quantitative methodology for analyzing the relationship of organizational culture and learning to safety performance. The research is built on a collaborative effort between academia and industry focused on improving process safety in the oil and gas industry, but it can be applied to safety-related problems across organizations. The results are expected to have implications for training, professional development, safety protocols, and methods for measuring and managing safety practices in the development and operation of complex engineered systems.

1. Introduction

System safety has emerged as a critical issue in recent years as large-scale engineered systems have become larger and more complex. While much of this is driven by technical complexity (larger numbers of components with

* Corresponding author. Tel.: +1-646-286-4739; fax:+1-979-458-4299.
  E-mail address: avnet@tamu.edu

doi:10.1016/j.procs.2015.03.061

Nomenclature

SMM	Shared mental model
LNG	Liquefied natural gas
PSM	Process Safety Management
OSHA	Occupational Safety and Health Administration
$S_{x,y}$	Mental model sharedness between persons x and y
MKOPSC	Mary Kay O'Connor Process Safety Center

more and more interactions among them), some of the most difficult safety-related problems have more to do with organizational systems and structures than with specific technical issues. As Reason argues, these "latent failures" are defined by their presence "within the system well before the onset of a recognizable accident sequence."[1] Leveson points out that the proximate technical cause of an accident is often only a symptom of a broader and more systemic problem.[2] Even if the hazard seems to be of a purely technical nature without an apparent organizational cause at the time of the incident, the existence of the technical problem often can be attributed to "inadequate control over the [engineering design and] development process" rather than over operations.[2] So, in such a case, the organizational dimension is still relevant but must be considered further upstream during engineering design.

The goal of this paper is to introduce an emerging research program focused on a systems-oriented approach to organizational culture and its relationship to safety practices and outcomes. In this section, a brief review of the literature on organizational culture and system safety is presented, and the case for a systems view of safety culture is made. Then, a network-based approach for modeling organizational culture and learning is introduced. Following that, some of the details of the methodology are presented. Finally, the application of this research to process safety in the oil and gas industry is discussed.

This section reviews the interdisciplinary literature that forms the basis for the proposed systems approach to safety culture. The first subsection discusses how the term "culture" has been defined and used in the literature and presents an argument for applying the concept of culture to system safety. The second subsection then discusses the motivation for analyzing safety culture from a systems perspective.

1.1. Organizational culture and safety performance

Schein defines culture as "a pattern of shared basic assumptions learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems."[3] Still, culture is both "broad and deep" and includes many different dimensions of an organization and its people. For this reason, any study of organizational culture should focus on specific elements of culture with the goal of addressing a particular observed phenomenon.[3] While Schein's definition is the one being used here, the scope of the present research is limited to safety culture, i.e., the particular elements of culture that are related to system safety. In terms of Schein's definition, the "problems" solved and the resulting "way to perceive, think, and feel" are those that have direct or indirect implications for safety practices and outcomes.

Most researchers and practitioners agree that culture, however it is defined, plays an important role in virtually every aspect of an organization's performance. Based on research and professional experience in process safety, Mannan et al. developed a list of 10 attributes for creating a "Best-in-Class safety culture." Although the authors point out that an organization does not need to possess all of these attributes to achieve excellence in safety performance, organizations that do have exemplary safety records tend to demonstrate some subset of these attributes.[4] In a study of 500 organizations conducted over a 10-year period, Keller and Price examined the relationship between sustained operational performance and an aspect of culture that they call "organizational health," a metric based on survey data assessing 37 specific management practices.[5] Fig. 1 shows the authors' analysis of the relationship between performance and health among several refineries of a particular oil company. These results demonstrate a positive correlation between an organization's focus on health-related (i.e., cultural)