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Further Validation of Safety Culture Measurement Tool for Improving Safety in Commuter Rail Operations

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Further Validation of Safety Culture Measurement Tool for Improving Safety in Commuter Rail Operations

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ABSTRACT

Building upon the development of a measure of safety culture based on a simplified two-factor model of meaning and behavior, a further validation study of the safety culture instrument was undertaken. The Safety Culture Assessment Survey (SCAS) was administered to a large regional railroad organization at two separate times. The instrument has demonstrated psychometric properties of reliability and validity. Combining data from two time periods also demonstrated significant differences in observed safe and unsafe behavior for those who scored high versus low on the SCAS scales. The scale demonstrated criterion validity in that that scores on the SCAS successfully differentiated those who had performed safe versus unsafe behavior as noted by supervisors. Moreover, subscales of the safety SCAS were significantly related to safety performance outcome measures, such as reported injuries, accidents, and near misses. Statistically significant odds ratios of reporting a near miss were obtained when safety culture measures from SCAS subscales were low, which indicated weak safety culture in the areas of senior and front-line management's commitment to safety, a culture that prioritized productivity over safety, and a culture that underutilized safety practices such as job briefings. Similarly, the odds of reporting an accident were nearly five times greater if a respondent perceived the organizational culture as prioritizing productivity over safety. Overall, this study furthered the development and validation of a measure of corporate safety culture for the transportation industry. Recommendations for the measurement that can lead to the development of a strong safety culture were discussed.

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EXECUTIVE SUMMARY

The lessons drawn from a number of recent highly publicized catastrophic accidents have been that, "It is essential to create a corporate atmosphere or culture in which safety is understood to be and is accepted as, the number one priority."

As the construct of corporate culture entered the awareness of the general population, investigators with different occupational and theoretical backgrounds began exploring its impact on organizational performance and other financial outcomes (Kotter & Heskett, 1992; Denison, 1990). James Reason (1998) defined a good safety culture as consisting of five important aspects and related it to industrial and occupational safety. Despite this early clarity many definitions of what constitutes a safety culture and how to assess its presence and characteristics remain.

In an attempt to fill this gap in the literature, the research objective of the current project was the continued development and validation of a measure of corporate safety culture that combined major themes of many previous approaches and measurement tools. Specifically, culture was described as the sum of the *values, meaning systems*, and *behavioral expectations* that exist within a corporation. Each domain was hypothesized to hold an equal role in the assessment of culture (See Figure 1.1). Furthermore, the measurement of the culture and its components was thought to have a significant relationship to organizational outcomes and performance such as accidents, injuries and near miss events.

The creation of a single measurement tool built on a solid theoretical foundation, with recognizable and reliable dimensions and components would be extremely valuable to practitioners and regulators alike. Corporate executives could use the measure to gain a comprehensive understanding of the state of their company's culture. Public safety officials could use the tool to make comparisons and to benchmark organizations against other high performing entities. This would be especially important in the measurement of safety culture, as the repercussions of a poor safety culture can be dire (Hopfl, 1994; Reason, 1990).

Underlying the measurement of safety culture are the assumptions about its nature. A normative conceptualization of culture is one approach and is consistent with measurement theory and psychometric approaches to the development of measurement tools and techniques. The assumption underlying the normative measurement approach is that culture is retained in the perceptions and behaviors of an individual or a group. In such an approach, safety culture can be a factor and a tool or solution that can be applied to an organization by creating perceptions and maintaining behaviors in which safety can be improved or maintained. Haukelid (2008) noted that this approach, which he referred to as an instrumental approach, is common, particularly within the management literature regarding safety culture.

A review of the literature did not uncover a complete or comprehensive measure of corporate safety culture that could be used in the transportation industry. A perfect measure would include an evaluation of each global domain of culture and include reliability and validity data corresponding with safety performance outcome measures. To ensure validity, these overarching domains would be empirically supported. In an effort to fill the gaps in the literature, the current project is designed to develop a measure of corporate safety culture that considers the overarching domains of culture. These domains have been identified as meaning systems, values, and behavioral expectations. In addition, such a measure would also provide useful information on the subcomponents reflected in the three domains. To satisfy the need for an empirically validated measure, the domains were subjected to statistical tests of reliability and validity. The relationship between the measure and safety behavior correlations between subscales and components of the safety culture survey and safety performance outcome indicators were also computed.

To answer these questions all employees of a large commuter rail services organization were invited to participate in the study. Employees at all levels of management and labor were a survey that administered electronically to all 1,800 organization employees.

The Safety Culture Assessment Scale (SCAS) (Sherry & Colarossi, 2016) was used in the present study. The SCAS is based on the theoretical notion that three main domains of perception are involved in the assessment of safety culture, including 1) shared meaning systems, 2) values, and 3) behavioral expectations. The recognition of three global themes led to the hypothesis that corporate culture is a large construct composed of the previously mentioned three themes or factors. The development and initial validation of the model and instrument are described in Sherry & Colarossi (2016). Confirmatory factor analysis (CFA) was used to test the theoretical model, along with an empirical model.

Validation of the safety culture construct was assessed by examining the extent to which scores on the safety culture scale (SCAS) differentiated persons who were noted for using *Safe vs. Unsafe* work practices (see Figure 3.2), and therefore received written or verbal feedback from a supervisor. Results of these analyses (See Table 3.2) provide an indication that persons who have a stronger sense of the perceived safety culture may be less likely to engage in unsafe work practices. Independent sample t-tests comparing the *Safe vs. Unsafe* behavior scores on the SCAS subscales found that the mean of the subscales for the *Safe* group were significantly higher than those of the *Unsafe* group.

Another indication of the validity of the SCAS was the relationship between the scores on the measure and the accidents, near misses, and injury rates reported by members of the organization completing the measure. Scores on the SCAS taken at time 1 and time 2 were correlated with the number of reported injuries, incidents, and near misses. As seen from the data in Table 3.7, significant correlations were observed between the SCAS sub-scale scores and the number of accidents, incidents, and near misses.

Results of the analysis (see Table 3.8) indicate that that employee's perception of senior management commitment to safety resulted in a 3.7 times greater likelihood of not reporting or not being involved in a near miss incident. Similarly, the perception of the immediate supervisor's commitment to safety was 8.5 times more likely to result in not reporting or being involved in a near miss incident. Finally, being involved in job briefings was 3.84 times more likely to result in not reporting or being involved in a near miss incident. These findings support the validity of the SCAS subscales for detecting the presence of important behavioral safety related activity.

Significant correlations were also found between the SCAS subscales of rewards for safety and safety practices and number of injuries reported in Study 1 and for management commitment to safety and personal responsibility (see Table 3.7). The odds of reporting an injury were 6.12 times higher if the perception of the culture was such that persons scored low on feeling free to report accidents. Further, the relative risk of reporting an injury was 4.5 times more likely under those conditions (see Table 3.8). The odds of reporting an accident was 4.9 time greater if a respondent perceived the organizational culture as prioritizing productivity over safety. Put another way, scoring low on the perception that the work environment placed a higher value on safety versus productivity was 4.9 times more likely to result in a greater number of accidents. The relative risk of reporting an accident was 3.35 times higher if productivity was emphasized over safety (see Table 3.8). These results strongly suggest that the risk of accidents decreases significantly when members of an organization perceive senior leaders as having a high level of commitment to safety. In fact, the present results offer a quantitative estimate such that the odds of having and or reporting an accident are five times more likely if there is a perception that senior members do not have a strong commitment to safety.

In conclusion, this study has described the further development and validation of a measure of corporate safety culture for the transportation industry. The instrument demonstrated psychometric properties of reliability and validity. Moreover, subscales of the safety culture assessment survey SCAS) were found to be significantly related to safety performance outcome measures such as reported injuries, accidents and near misses. The odds of reporting a near miss were significant higher when Senior and Front-line management were not perceived as being committed to safety as well as the support of the value that safety is more important than productivity.

1. INTRODUCTION

THE USDOT Strategic Plan (FY2018-2022) identifies safety culture as an essential strategic element of its safety objective. Safety culture was first described in a report by INSAG's (1988), where safety culture was described as:

> "That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."

Later, the U.K. Health and Safety Commission offered its definition of safety culture:

> "The product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management.[9] Organisations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures."[1]

In the United States, a review of the Space Shuttle Challenger disaster identified numerous organizational cultural issues that had influenced numerous "flawed" decisions by NASA contributed to the disaster. The lessons drawn from all of these accidents were that, "It is essential to create a corporate atmosphere or culture in which safety is understood to be and is accepted as, the number one priority."

In our view, the combined set of a corporation's safety-related attitudes, shared meanings, behaviors, practices, and beliefs can be labeled the corporation's safety culture. Safety culture is important as it reduces the prevalence of what Reason (2000) called active failures and latent conditions. When safety becomes a priority over productivity, companies with strong safety cultures are believed to be the most protected and safe organizations. After Chernobyl and several other significant workplace calamities involving chemical plants, commuter boats, oil tankers, freight trains, and commercial aircraft, investigators observed that commonalities existed in the conditions surrounding each accident. Hopfl (1994) explained, "Despite the obvious differences in the industries involved and their technologies….at a contextual level, there [were] many common characteristics" (Reason, 1990, cited in Hopfl, 1994). As researchers identified circumstantial similarities, they began to emphasize social and organizational factors in their evaluations of workplace accidents (Hopfl,1994). This amended focus was shown in the International Atomic Energy Agency's (IAEA) updated safety report on the Chernobyl accident. The IAEA report explained that "the accident … flowed from a deficient safety culture, not only at the Chernobyl plant, but throughout the Soviet design, operating and regulatory organizations for nuclear power that existed at that time" (International Safety Advisory Group, 1991).

The impact of safety culture was also revealed after the 2003 Challenger Space Shuttle disaster. This tragedy was caused by a combination of latent conditions that, though foreseeable, were not corrected prior to the shuttle launch. Until 2003, the National Aeronautics and Space Administration (NASA) had a history of success. The organization had not experienced an in-flight accident in the 17 years prior to the 2003 tragedy. Though engineers were aware of structural problems, the glitches were ignored and considered acceptable risks for the Challenger exploration (NASA, 2003). NASA had a culture focused more on success than safety. Therefore, when the Challenger space shuttle re-entered the earth's atmosphere, a crack in the thermal protection system led to a major catastrophe (NASA, 2003).

[1] HSC (Health and Safety Commission), 1993. Third report: organising for safety. ACSNI Study Group on Human Factors. HMSO, London.

Given the influence of corporate culture on safety, investigators examined the culture at BP (British Petroleum) after the Deep-Water Horizon explosion. As a result of the accident, 11 BP employees were presumed dead, and over 1 billion gallons of oil leaked into the Gulf of Mexico. In addition, in 2005, a BP refinery in Texas exploded, killing 15 employees and injuring 180 people. The company was also associated with the 1989 Exxon Valdez oil spill in Alaska. BP held a controlling interest in the Alaskan oil consortium, which was largely responsible for the cleanup effort and heavily criticized for errors. In reference to BP's accident record, Rep. Joe Barton stated that BP had created a "corporate culture of seeming indifference to safety and environmental issues" (Mauer, 2010).

These events made the public and the safety profession aware of the term, which allowed those same professionals to give a name to a phenomenon they had all observed: Safety Culture, which then led to a series of actions. Although this interest increased the relevance and study of corporate culture, it did not allow for the development of a systematic examination of the construct. Today, the literature remains theoretically disorganized and inconsistent (Pidgeon, 1998; Schien, 2004).

1.1 Defining Corporate Culture

The difficulty inherent in describing corporate culture lies in the need to honor the breadth of the topic while upholding a level of specificity that maintains the construct's significance (Coffey, 2010). Definitions that are too broad run the risk of missing the particular characteristics of culture, while those that are too narrow miss the larger picture. Thus, there are many attempts to provide an accurate explanation of corporate culture.

When reviewing the different conceptualizations of corporate culture and corporate safety culture, it is clear that commonalities exist throughout. Specifically, these terms are repeatedly mentioned: thoughts, beliefs, meaning, values, learning, and behavior. Many focus on behavior and norms, while others center on personal ideals. Each characterization describes an aspect of culture, but there is no single description that combines the critical components of each definition.

In common managerial jargon, the terms culture and climate are often misused and misinterpreted. Executives frequently refer to *culture* in reference to an organization's environment, mood, or feel; yet, these organizational factors are more closely related to *climate* than culture. Organizational culture references an underlying state that impacts productivity, structure, strategy, and climate within an organization. Despite its recent surge in popularity, culture is an elusive construct that is hard to pin down exactly. For example, many managers in high-risk industries hope to enhance the safety of their organizations. They proactively work to modify their facilities, guidelines, mission statements, and reward programs. However, very few consider how cultural assumptions about individual success, responsibility, and masculinity may be thwarting their efforts toward a safer work environment (Schein, 2004). It is clear that defining culture and climate, and understanding the difference between the two concepts, is critical to any evaluation of corporate culture. The following section discusses the etiology and definition of each construct.

1.2 Corporate Culture and Corporate Climate

1.2.1 Climate

The terms corporate climate and corporate culture are often used interchangeably. Denision (1991) argued that the similarities and differences between culture and climate research generally have been neglected in discussions of the culture perspective. The concept of corporate climate has its roots in Lewin's studies of experimentally created social climates (Lewin, 1951; Lewin, Lippit, & White, 1939).

The Iowa experiment in "social climates" represented a seminal moment in the history of social psychology whose influence is still felt almost 70 years later.

The notion of corporate climate was first identified in the 1950s and 1960s as school researchers considered the psychological effects of diverse educational settings (Hoy, 1990). They were particularly interested in uncovering the educational benefits of different teaching environments and worked to define and measure different aspects of educational atmospheres (Halpin & Croft, 1963). This initial interest in environments was appreciated by investigators working in large businesses who believed climate could explain the long-term characteristics of any work environment (Hoy, 1990). In 1964, Forehand and Gilmer defined corporate climate as "a set of characteristics that describe an organization and that (a) distinguish the organization from other organizations, (b) are relatively enduring over time, and (c) influence the behavior of people in the organization." Similarly, Taguiri (1968) drew a connection between personality traits and an organization's climate. The author explained that "a particular configuration of enduring characteristics of the ecology, milieu, social system and culture would constitute a climate, as much as a particular configuration of personal characteristics constitute a personality" (Taguiri, 1968 p. 23, cited in Hoy, 1990).

Morrow (2010) analyzed three facets of safety climate (management safety, coworker safety, and work-safety tension) relating to individual workers' reported safety behavior. All three facets were significantly associated with safety behavior. Dominance analysis was used to assess the relative importance of each facet as related to the outcome, and work-safety tension evidenced the strongest relationship with safety behavior.

1.2.2 Culture vs. Climate

Research on corporate climate increased because it was thought to be a key construct influencing employee behavior (Schein, 1985). As the concept matured through research, investigators began to identify a distinction between the characteristics, behaviors, and feelings that are universally supported by an organization's workforce, and the values and beliefs held by most of an organization's employees (Ekvall, 1983). This recognition of difference led to the identification of corporate culture as opposed to corporate climate. Globally, corporate climate refers to the overt characteristics of an organization's environment, while corporate culture references the underlying values and beliefs of a given organization (Guldenmund, 2000). Climate researchers typically placed greater emphasis on organizational members' perceptions of "observable" practices and procedures that are closer to the "surface" of organizational life (Guion, 1973; James & Jones, 1974) and the categorization of these practices and perceptions into analytic dimensions defined by the researchers (Denision, 1996). On the other hand, the culture perspective is perhaps best exemplified by ethnographic descriptions of occupations and organizations and the set of rituals, practices, and behaviors that members of the organization engage in. It is clear that the constructs of corporate culture and corporate climate are not mutually exclusive. In fact, they are interconnected, influencing one another as a company grows and works through challenges (Schein, 2004).

1.2.3 Culture

With the identification of culture as an important construct, corporate leaders, researchers, managers, and the public began to develop an interest in the possibility of creating an organizational culture that influenced employees to behave in a desired manner. This fascination with culture was fueled by the publication of *Theory Z: How American Business Can Meet the Japanese Challenge* (Ouchi, 1981). This well-received management work suggested that American corporations could increase productivity by adopting Japanese management practices. Specifically, the author referred to an organizational shift that

would carry a more collectivistic culture, characterized by long-term job security, responsibility, group work, and cautious promotion and evaluation practices (Ouchi, 1981).

Similarly, Peters and Waterman's work, *In Search of Excellence: Lessons from American's Best Run Companies* (1982), became a seminal management book that discussed business from a more flexible perspective. As opposed to focusing on productivity alone, the authors suggested that managers ought to reduce bureaucratic controls, focus on customers, facilitate entrepreneurship, value low-paid employees, centralize company values, and maintain a committed management team (Peters & Waterman, 1982).

As the construct of corporate culture entered the awareness of the general population, research on the topic proliferated. Investigators with different occupational and theoretical backgrounds began exploring the impact of culture, finding that positive cultures correlate with positive financial outcomes (Kotter & Heskett, 1992; Denison, 1990). Although researchers agreed on the value of culture, their fundamental theoretical differences led to variant definitions of the construct. As a result, research continued to expand without a solid theoretical foundation. Today, the literature remains theoretically disorganized (Schien, 2004; Pidgeon, 1998). In an effort to describe the unsystematic mass of literature, several investigators have created large, all-inclusive, models of corporate culture.

Schein (2004) worked to condense the literature by describing culture in three interacting levels. The first level, *artifacts*, refers to the observable characteristics of an organization. This includes the language used, the facilities, the dress code, and any other tangible quality that can be quickly observed. The second level, *espoused beliefs and values*, describes shared ideas of people working within the organization. As a company grows and overcomes challenges, its employees learn from the growth and develop long-lasting values and beliefs. The third level, *underlying assumptions*, refers to core assumptions that are universally supported within a corporation. Schein explained that these assumptions are supported so often that employees are unable to consider a different thinking pattern (Schein, 2004).

The models proposed by Keesing, Allaire, and Firsirotu, and Schein are important in understanding the challenge of describing corporate culture. Each author struggled to provide an all-inclusive explanation of culture, while simultaneously providing specific details that maintain the integrity of the construct. The difficulty inherent in describing corporate culture lies in the need to honor the breadth of the topic while upholding a level of specificity that maintains the construct's significance (Coffey, 2010). Definitions that are too broad run the risk of missing the characteristics of culture. Examinations that are too narrow miss the larger picture. Many researchers have attempted to produce an accurate explanation of corporate culture. However, it is clear that limitations can be found in each proposed definition. For a review of recent definitions of corporate culture see Table 1.1.

James Reason (1998) defined a good safety culture as consisting of five important aspects: a) Informed culture: The organization collects information about both accidents and incidents and carries out proactive countermeasures using safety audits and surveys on safety climate. b) Reporting culture: All employees report their errors or near misses and take part in surveys on safety culture and other areas. c) Just culture: There is an atmosphere of trust within an organization that encourages and rewards its employees for providing information on errors and incidents, with the confidence of knowing that they will receive fair and just treatment for any mistake they make. d) Flexible culture: The organization has the ability to change its practices. e) Learning culture: The organization learns from incident reports, safety audits, and so forth, resulting in improved safety.

Table 2.1 Definitions of corporate culture

Author(s)	Definition
(Aceves & King, 1978)	"The totality of the learned and shared patterns of belief and behavior of a human group."
(Steadman, 1982)	"Learned behavior copied from one another."
(Deal and Kennedy, 1982)	"The way we do things around here."
(Murphy, 1986)	"Means that total body of tradition borne by a society and transmitted from generation to generation. It thus refers to the norms, values and standards by which the people act, and it includes the way distinctive in each society of ordering the world and making it intelligible."
(Whitten, & Hunter, 1987)	"The patterned behavior and mental constructs that individuals learn, are taught, and share within the context of the group to which they belong."
(Haviland, 1993)	"A set of shared ideals, values, and standards of behavior; it is the common denominator that makes the actions of individuals intelligible to the group."
(Cunningham & Greso, 1994)	"In its most basic form is an understanding of 'the way we do things around here.' Culture is the powerful yet ill-defined conceptual thinking within the organization that expresses organizational values, ideals, attitudes and beliefs."
(D'Andrade, 1996)	"Consists of 'learned systems of meaning, communicated by means of natural language and other symbol systems, having representational, directive, and affective functions, and capable of creating cultural entities and particular senses of reality.'"
(Harris, 2004)	"The learned patterns of behavior and thought characteristic of a societal group."
(Kessing & Strathern, 1998)	"We will restrict the term *culture* to an ideational system. Cultures in this sense comprise systems of shared ideas, systems of concepts and rules and meanings that underlie and are expressed in the ways that humans live. Culture, so defined, refers to what humans learn, not what they do and make."
(Reason, 1998)	Informed, Reporting, Just, Flexible, and Learning
(Ember & Ember, 2001)	"The set of learned behaviors, beliefs, attitudes, values, and ideals that is characteristic of a particular society or population."
(Jurmain et al., 2000)	"All aspects of human adaptation, including technology, traditions, language, and social roles. Culture is learned and transmitted from one generation to the next by nonbiological means."
USDOT 2017	"The shared values and behaviors that demonstrate a commitment to safety over competing goals and demands."

(adapted from Coffey, 2006)

When reviewing the different conceptualizations of corporate culture, it is clear that a number of similarities exist throughout. Specifically, the terms thoughts, beliefs, meaning, values, learning, and behavior are repeatedly mentioned. However, the definitions undoubtedly hold distinct differences. Many focus on behavior and norms, while others center on personal ideals. Each characterization describes an aspect of culture, but there is no single description that combines the critical components of each definition.

1.2.4 Model of Safety Culture

In an attempt to fill this gap in the literature, the current project was devoted to the continued development and validation of a measure of corporate culture that combined major themes of previous instruments. Specifically, culture was described as the sum of the *values, meaning systems*, and *behavioral expectations* that exist within a corporation. Each domain was hypothesized to hold an equal role in the assessment of corporate culture (See Figure 2.1).

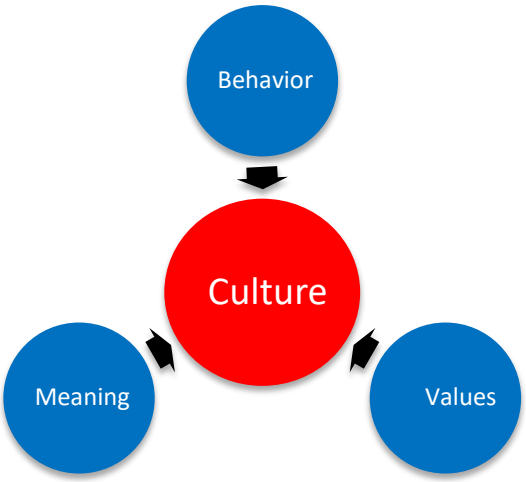

Figure 2.1 Hypothesized model of corporate culture

The unique characteristic of the proposed model was the integration of shared meaning systems. To the authors' knowledge, meaning systems have been considered by numerous researchers (D'Andrade, 1996; Geertz 1973; Kessing & Strathern, 1998), but never considered as a component factor of a full model of corporate safety culture alongside values and behavioral expectations. Typically, meaning (D'Andrade, 1996; Geertz 1973; Kessing & Strathern, 1998) and values (Aceves & King, 1978; Cunningham & Gresso, 1994; Murphy, 1986) are considered together as a single factor. It is possible that researchers have rejected the simultaneous inclusion of both constructs in an effort to avoid redundancy. This was seen as a critical mistake. Though meaning and values are related, they refer to distinct human experiences. The present model hypothesizes meaning systems, values, and behavioral expectations as a more complete model of corporate safety culture, and therefore more comprehensive than earlier conceptualizations of culture. To be complete, the three domains of values, meaning, and behavior would likely be further defined by specific sub-components that would make up the domains.

1.2.5 Assessment of Safety Culture

A report from the Health and Safety Executive office of the Her Majesty's Railway Inspectorate (HMRI) reviewed various pragmatic approaches to the assessment of safety culture. (HME, 2005). The report is based on the work of Cooper (2000), who argued that safety culture be defined as "what people do" and the situational factors that contribute to shaping behavior are defined as "what the organization promotes." Cooper also offered that safety climate referred to "how people feel" about safety and the corresponding values attitudes and perceptions of employees. Using these two different approaches, Cooper argued for a qualitative approach, which was reflected in the HMRI Safety Culture Inspection Toolkit, a qualitative approach to determining safety culture in the UK. The HMRI measures key indicators of corporate safety culture, including the following:

- Leadership
- Two-way communication

- Involvement of the staff in identifying safety practices
- Learning culture that promotes continuous improvement
- Assessment instruments and questionnaires
- Health and safety managed techniques to promote safety

The HMRI toolkit suggests that each of the different indicators request a distinct assessment method. Artifacts, such as reports and posters, are easy to observe and can usually be accessed directly without the involvement of organizational members. However, it is very difficult to understand the real meaning of artifacts and the cultural aspects that lie behind them without conducting a deeper cultural analysis. The corporate values are usually articulated by organizational members and can be readily obtained through written surveys and questionnaires (Guldenmund, 2007; Schein, 1992; Wilpert & Schöbel, 2007). Identifying basic assumptions is more challenging, because basic assumptions are ingrained and often unstated, and even unrealized, until pointed out or stated by persons outside the organization (Schein, 1985). Therefore, basic assumptions cannot be reached by directly asking employees about them; rather, they are usually only revealed through a combination of novel qualitative methodological approaches (Schein, 1985; Wilpert & Schöbel, 2007) and time-consuming objective processes of data integration, deciphering, and interpretation (Schein, 1985). The theory suggests that a qualitative or ethnographic analysis is needed to truly assess the underlying culture. However, in actual practice, the use of a combined approach has become a current and accepted practice.

In a recent publication, the US DOT Safety Council developed and adopted the main definitions of safety culture:

The most critical elements of a strong safety culture are as follows:

1. Leadership is clearly committed to safety.
2. Open and effective communication exists across the organization.
3. Employees feel personally responsible for safety.
4. The organization practices continuous learning.
5. The work environment is safety conscious.
6. Reporting systems are clearly defined and not used to punish employees.
7. Decisions demonstrate that safety is prioritized over competing demands.
8. Employees and the organization work to foster mutual trust.
9. The organization responds to safety concerns fairly and consistently.
10. Safety efforts are supported by training and resources.

One of the most important components of safety culture is leadership. As an industry thought leader, DOT can significantly influence safety culture of the transportation industry. For example, by starting internally, DOT leaders can ensure that employees fully commit themselves to making safety their highest priority and be dedicated to safety in all aspects of their work (Morrow & Coplan, 2017; DOT/FRA/OR, September 2017).

1.3 Measurement of Corporate Safety Culture

Literature consistently demonstrates a relationship between corporate culture and organizational growth and performance (Miron, Erez, & Naheh, 2004; Prather, & Turrell, 2002; Ogbonna & Harris, 2000; Deshpande, Farley, & Webster, 1993). However, the various theoretical positions of different investigators limit the interpretability of these findings. It becomes challenging to comprehend the results of any given assessment of corporate culture, because every measure takes a different perspective. Moreover, common quantitative measures of corporate culture deviate from the construct of culture and unintentionally assesses corporate climate.

The creation of a single measurement tool built on a solid theoretical foundation, and pointedly assesses corporate culture, would be extremely valuable. Corporate executives could then use the measure to gain a comprehensive understanding of the state of their company's culture. This would be especially important in the measurement of safety culture, as the repercussions of a poor safety culture can be dire (Hopfl, 1994; Reason, 1990).

Underlying the measurement of safety culture are the assumptions about its nature. A normative conceptualization of culture is one approach, and is consistent with measurement theory and psychometric approaches to the development of measurement tools and techniques. The assumption underlying the normative measurement approach is that culture is retained in the perceptions and behaviors of an individual or a group. In such an approach, safety culture can be a factor and a tool or solution that can be applied to an organization by creating perceptions and maintaining behaviors in which safety can be improved or maintained. Haukelid (2008) noted that this approach, which he referred to as an instrumental approach, is common, particularly within the management literature regarding safety culture. There are several ways to understand culture – from the linguistic level with a focus on discourse and conflicts, to a ''taken for granted" level where ''tacit knowledge" is the key phrase. In addition, different cultural perspectives like integration, differentiation, and ambiguity are important in cultural analyses; but whether one is dealing with a single unitary culture, many subcultures, or no culture at all is not a theoretical question but an empirical one. Researchers should be more sensitive to different cultural levels/perspectives and methodological triangulation in their cultural analyses (Haukelid, 2008).

By unifying the various conceptual threads into a single, comprehensive measurement approach, we can enable executives of transportation companies to maintain and encourage a culture that will contribute to successful safety performance. Identifying culture problems after the occurrence of large-scale accidents, as shown in BP and earlier NASA cases, companies will have the ability to identify problems in safety culture prior to accidents. The use of a valid and reliable comprehensive measure of safety culture could save employees' lives and increase productivity.

Empirical research validates an interest in safety culture, as investigators have shown repeatedly that a robust culture of safety significantly reduces the overall risk of workplace accidents. For example, in 1997, Judith Erikson completed a nationwide study on the impact of corporate culture on safety performance. Using a survey to evaluate the perceptions of employees, Erikson showed that when an organization's management team works to implement a culture of safety, safety performance and employee health improve (Erickson, 1997).

Erickson's (1997) results were corroborated by Shannon, Mayr, and Haines (1997), who reviewed the conclusions of 10 studies that evaluated the connection between safety and workplace factors. The authors' analysis was comprehensive, as each study included in the review had assessed at least 20 separate occupational settings. Shannon, Mayr, and Haines identified workplace factors that were significantly correlated with injury rates. The significant factors fell under the following four headings: 1) Joint health and safety committees, 2) Management style and culture, 3) Organizational philosophy, and 4) workforce characteristics. The authors synthesized the results by identifying variables that were significantly correlated with injury rates in at least 66% of the reviewed studies. Safety culture and management style, though influential in each of the assessed factors, was explicitly shown to be a significant predictor of reduced injury rates in 100% of the studies evaluating this relationship.

1.3.1 Non-Quantitative Approaches to Safety Culture Assessment

Despite the advantages of quantitative measurement, many corporate culture experts support the use of qualitative assessments (Guldenmund, 2007; Denison, 1996) to gather information related to culture. Guldenmund (2007) explained that the use of surveys is problematic because corporate culture is a construct that is shared by employees. The author noted that:

> In survey research, one is caught between the theoretical demands of statistics (heterogeneous normally distributed variables around a single mean obtained from a large population) and the theoretical requirements of culture ([strong] convictions shared by groups or categories of people, which are small enough to interact and create a culture about safety or any other related topic) (Guldenmund, 2007).

Simply stated, statistical theory requires a large and diverse sample that comes in opposition to corporate culture, which is created in smaller, homogeneous populations.

Guldenmund's reservations about the use of quantitative methods have been echoed by other investigators, who believe quantitative surveys do not accurately assess the culture. These researchers argue that surveys usually address characteristics, behaviors, and feelings associated with an organization. However, they do not consider the participant's underlying values and meaning systems. Essentially, most current culture assessments measure climate, as opposed to culture (Mearns, Whitaker, and Flin, 2001; Denison, 1996).

1.3.2 Current Quantitative Measures

The report also included a number of measures that showed promise for use in the field. The **Aberdeen University Offshore Safety Questionnaire (OSQ99)** (HSE, 1999) was designed to provides companies with information about their current safety climate, and highlights areas of strength and weakness. The OSQ99 includes scales designed to assess a seven-factor model of safety culture, including: 1) policy awareness, 2) involvement, 3) communication, 4) perceived supervisor competence, 5) management commitment, 6) general safety behavior, and 7) job satisfaction. The questionnaire contains 80 items requiring answers on a three- or five-point Likert-type scale. The tool was designed for use in the offshore, gas, as well as power generating industries (RSSB, 2003, pg. 50-56).

The **HSE Health and Safety Climate Survey Tool (CST)** was ranked the best in a review of safety climate/culture tools (RSSB, 2003, pg. 41). The questionnaire was designed to assess employees' involvement in health and safety culture in their organization. Questions on the survey asked employees about aspects of their existing health and safety climate. The CST is a 71-item computer administered questionnaire using a standard 5-point rating scale designed to asses a 10-factor model of safety culture, including: 1) organizational commitment and communication, 2) line management commitment, 3) supervisor's role, 4) personal role, 5) workmates influence, 6) competence, 7) risk-taking behavior, 8) obstacles to safe behavior, 9) permit-to-work systems, and 10) reporting of accidents and near misses. The CST has been used to assess safety climate across a range of industry sectors, including oil and gas companies. It is used to assess managers, supervisors, and the workforce (RSSB, 2003, pg. 41).

The **Occupational Psychology Centre Safety Culture Questionnaire (SafeCQ)** was developed to assess safety culture in rail companies. The questionnaire was based on a 12-factor model of safety culture, and includes the following factors: 1) communications about safety, 2) profile of safety within the organization, 3) access to safety information, 4) management involvement in safety, 5) recognition and openness about safety issues, 6) control over safety, 7) attitudes to safety, 8) safety information, 9) learning from safety issues, 10) perceptions of safety performance, 11) investment in safety, and

12) other factors (e.g., concern over minor incidents and attitudes to short cuts). The questionnaire was developed based on the rail industry; however, according the HSE (2005) report, this tool has not been widely used. It has only been applied within one UK and one US organization (RSSB, 2003, pg. 145).

Quest Evaluations and Databases Ltd Safety Climate Questionnaire (QSCQ). The questionnaire provides methods for measuring attitudes, values, and beliefs of individual workers. It can be used for the assessment of behaviors, working practices and perceptions of safety, and identification of root causes of potential problems. It can also be used to define proposed industry norms for error potential on critical drilling activities, together with norms for safety climate. The tool is useful because it allows companies to identify where improvement efforts need to be focused (HSE, 1999, pgs. 30-34).

The Safety Climate Survey (SCS). This instrument was developed based on a review of accidents and incidents in the oil and gas industry. The factors identified from the 88 factors were grouped into 12 categories to structure the questionnaire. The 12 factors included: 1) safety priorities, 2) communication, 3) training, 4) environment, 5) individual procedures, 6) design of work/people, 7) design of things and equipment, 8) management/structural, 9) investigation/evaluation, 10) emergencies, and 11) maintenance. The questionnaire consists of 319 items that make up the 12 categories using responses on a seven-point Likert-type scale. The survey can be limited to specific sections regarding areas of concern, e.g., management and training. The tool was developed specifically for the offshore drilling environment. (RSSB, 2003).

The Rail Safety and Standards Board (RSSB) Safety Culture Tool (RSSBSCT). The RSSB Safety Culture Tool was designed to assess the safety culture of any rail company. The instrument is a 66-item self-assessment questionnaire using a response format ranging from strongly agree to strongly disagree. The items comprise a nine-factor model of safety culture, which are: 1) positive organizational attributes, 2) management commitment to safety, 3) strategic flexibility, 4) participation and involvement, 5) training, 6) communication, 7) reinforcement and incentives, 8) individual ownership, and 9) individual perceptions. This tool has been highly rated by UK rail professionals (RSSB, 2003).

The Robert Gordon University Computerized Questionnaire (CSCQ). The questionnaire provides offshore rigs/facilities and companies with information about their safety climate and may highlight areas of strength and weakness. The CSCQ was developed as a version of the Aberdeen University Offshore Safety Questionnaire (OSQ, v1.0), also used with offshore operating and contracting companies. The tool is administered through a Microsoft Excel-based software package consisting of the questionnaire and analysis macros. The questionnaire has 49 items adapted from the Aberdeen instrument, and are organized into the following areas (RSSB, 2003, pg. 122): 1) general information, 2) risk-taking behavior, 3) safety attitudes, 4) confidence in safety management, 5) pressure for production, 6) supervision and management, 7) rules and regulations, and 8) safety in operations. Responses are recorded using a five-point rating scale (HSE, 1999, pg. 27).

The Loughborough University Safety Climate Assessment Toolkit (LSCAT). The safety climate assessment toolkit contains several procedures, including a questionnaire designed to assess safety culture and climate in offshore operations. The instrument consists of 47 items comprising the following model of safety culture: 1) organizational content, 2) social environment, 3) individual appreciation, 4) work environment, and 5) organization-specific factors (Cox & Cheyne, 2000; HSE, 1999, pg. 30).

The LSCAT is based on information provided in the HME (2005) report, and designed to be administered as a stand-alone self-report questionnaire. However, some of the assessment questionnaires were intended as components of a larger, more comprehensive qualitative review of the organization. Unfortunately, the HME (2005) did not provide information on the psychometric qualities and

characteristics of the instruments, including such constructs as reliability, validity, utility, and effectiveness at differentiation safe vs. unsafe cultures.

Another general consideration is that most of the tools reported on in the HME (2005) report were designed specifically for and applied within an industry, such as the oil and gas, nuclear, or rail industry. Only the oil and gas industry seems to have a consistent record of using the same instrument and items repeatedly, which would allow for benchmarking and standardization of the instruments. There is also some interchangeable use of the factors of safety culture and safety climate.

1.3.3 Measures of Organizational Culture

An additional review of US-based measures that assess corporate culture in a quantitative fashion was also conducted. Four published instruments (see Table 1.2) that measured corporate culture were identified. Only two of the four instruments included safety culture. Overall, these measures are still quite limited in the depth to which they address culture. The measures identified were limited in their overall conceptual framework and point to the need for an empirically supported measure of corporate safety culture.

The Organizational Culture Inventory (OCI) is a measure designed to assess a corporate culture. A total of 120 items are used to assess a 12-factor model: 1) humanistic-encouraging, 2) affinitive, 3) approval, 4) conventional, 5) dependent, 6) avoidance, 7) oppositional, 8) power, 9) competitive, 10) perfectionistic, 11) achievement, and 12) self-actualizing (Alexander, 1990). The OCI is considered a unique test, because it purports to measure participants' interpretation of their company's culture, as opposed to their own thoughts and behaviors. This difference in focus is believed to decrease personal bias and thus make the measure more valid. In addition to evaluating the style characteristics of the assessed corporation, the OCI also identifies the corporation's culture across the following culture categories: 1) constructive, 2) passive/ defensive, and 3) aggressive/defensive. The conclusions of the measure are cataloged in a culture profile that is easy for a consumer to review and understand (Alexander, 1990). The validity of these outcomes, with respect to organizational safety, are indeed unknown (Alexander, 1990). Unfortunately, the OCI appears to have not published any clear findings associated with the reliability or validity of the measure. This lack of statistical support drastically limits the value of the measure. Similarly, no explanation is provided regarding the selection of the three culture clusters or the 12 style categories. It is unknown if these groupings have theoretical underpinnings.

The Denison Organizational Culture Survey (DOCS) was developed by Denison, a consulting firm based in Ann Arbor, Michigan. The foundation for all of Denison's work is the "Denison Model," a conceptual model consisting of 1) mission, 2) adaptability, 3) involvement, and 4) consistency (Denison, Nieminen, & Kotrba, 2014; Denison, 2010; Denison & Mishra, 1995; Denison & Neale, 1996). The four factors are assessed via 60 items. Denison (2014) reported that the DOCS has 60 items, 12 dimensions, and four traits. Internal consistency characteristics were cited as ranging from .70 to .97. Built on the tradition of the Institute of Social Research at the University of Michigan, the DOCS has been used with more than 1,000 organizations operating in numerous industries. Although the Denison Model completely describes organizational characteristics, only one of the indices (values) addresses corporate culture. With this foundation, the DOCS seems to be more of a climate survey than a culture survey. Interestingly, Denison (1984) summarized the research, which shows a significant relationship between organizational performance on sales and other financial indicators and a participative decision-making culture.

Several other measures of organizational culture were identified by Denison, Nieminen, & Kotrba (2014) with a review of their reliability and validity.

Table 2.2 Reliability and validity evidence for selected corporate culture surveys

Scale Name	Structure	Reliability	Citation
Denison Organizational Culture Survey (Denison & Neale, 1996)	60 items, 12 dimensions, 4 traits	.70 .88 to .97	(Fey & Denison, 2003); (Gillespie, Denison, Haaland, Smerek, & Neale, 2008)
Organizational Beliefs Questionnaire (Sashkin, 1984)	50 items, 10 dimensions	.35 to .78	(Xenikou & Furnham, 1996)
Organizational Culture Survey (van der Post et al., 1997)	97 items, 15 dimensions	.79 to .93	(van der Post et al., 1997)
Value Performance Index (Scho¨nborn, 2010)	105 items, 13 dimensions	.71 to .94	(Scho¨nborn, 2010)

Interestingly, the DOCS has been used extensively as a measure of corporate culture. Evidence for the validity of the measures, in the form of correlations between DOCS subscales and indices of organization performance, has been published recently. Table 1.3 summarizes the correlations between DOCS subscales and other indicators.

Table 2.3 Criterion validity of Denison organizational culture scales

DOCS Dimension	Sales Growth	Market Share	Profit
Involvement	0.24	0.13	0.23
Values	0.2	0.15	0.27
Adaptability	0.29	0.1	0.24
Customer focus	0.21	0.08	0.16

Sackmann (2011) reviewed 55 published empirical studies, 45 of which had been published during the last decade, citing evidence supporting the direct effects of organizational culture on organization-level financial performance and effectiveness. Growing evidence of the link between culture and bottom-line performance also supports the role of surveys in culture research (Sackmann, 2011). However, she noted how the wide variety of instruments used makes it difficult to establish clear patterns across studies creating ‘‘a rather broad and colorful picture of the link between different culture dimensions and performance measures’’ (pg. 196). This criticism contributed to the decision to develop a safety culture survey for the transportation industry.

A recent meta-analysis by Nahrgang et al. (2011) found that safety compliance was more strongly correlated with workplace accidents and injuries ($r = -0.20$), as well as other adverse safety-related events ($r = -0.49$), compared with the relationship between safety participation and these two outcomes (corrected $r = -0.08$ and corrected $r = -0.32$, respectively). Therefore, we chose to focus on safety compliance as our dependent variable of interest, rather than safety participation.

There is considerable research evidence indicating the importance of supervisor safety-specific behaviors in predicting employee safety compliance and safety-related outcomes (Hofmann & Morgeson, 2004). Probst and Brubaker (2001) proposed that *supervisor enforcement* of safety rules and practices would be related to employee safety compliance. An employee's extrinsic safety motivation involves the perceptions of supervisor enforcement of safety policies, including the extent to which supervisors provide praise for safety compliance and punishment for non-compliance. Probst and Brubaker (2001) found that employees who had low extrinsic safety motivation (i.e., supervisors who failed to enforce safety policies) had lower levels of safety compliance and reported more injuries and accidents at work. Fugas et al. (2012) found that supervisors' enforcement of safety norms and employees' perception of behavioral control was strongly related to predict workers' compliance with safety behaviors. Furthermore, a meta-analysis by Clarke (2013) found that transactional safety leadership (i.e., a focus on supervisor enforcement) was more predictive of safety compliance than transformational leadership (which tended to be more related to discretionary safety behaviors) (Petitta, Probst, Barbaranelli, & Ghezzi, 2017).

1.3.4 Safety Culture Assessment Instruments

There have been several attempts to develop safety culture surveys. The following is a brief list with citations and reliability data. The instruments, however, tend to be based on one or two small industry-specific studies, not transportation organizations.

Table 2.4 List of measures of corporate safety culture

Measure	Components of Culture	Weakness	Evidence
Safety Culture Survey (SCS) (SPS, 2010; Geller, 1994)	a) Management support b) Peer Support for Safety c) Personal Responsibility d) Discipline, e) Incident Reporting Analysis f) Safety Rules, Regulations, and Procedures g) Training h) Safety Suggestions and Concerns i) Rewards and Recognition j) Safety Audits & Inspections k) Communication l) Employee Engagement m) Safety Committees n) Miscellaneous	1) Theory (measures climate)	Absent of any reliability or validity data
Safety Culture Values and Practices (QCS) (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz)	a) Human Relation or Support b) Open system or Innovation c) Internal Process or Rules d) Rational Goal or Goal Models	1) Theory (measures values, but no other aspect of culture)	Absent of any reliability or validity data
Safety Culture Indicator Scale Measurement System (SCMIMS) (Thaden & Gibbons, 2008)	a) Organizational Commitment b) Formal Safety Indicators c) Operations Interactions d) Informal Safety Indicators	1) Theory (measures climate)	Alfa coefficients =.81-.95
Safety Culture Enactment Questionnaire (SCEQ) ***(***De Castro, Gracia, Tomás, & Peiró. (2017).	a) strategic b) decisions, c) human resources practices, and daily activities and behaviors.	Based on nuclear power plant operations	**Reliability** – strategic decisions ensuring safety (α= .87), HR practices driving safety (α= .92), and daily activities and behaviors supporting safety (α =93).
Global Aviation Network (GAIN). (Bjørnskau & Longva, 2009)		Primarily used for aviation operations	**N/A**
Safety Culture Scale (Zohar and Luria, 2005)	Fours scales to measure group and individual level perceptions – total of 16 items		reliability (≥0.89)

The Safety Culture Survey (SCS) was designed by Dr. Scott Geller of Safety Performance Solutions (SPS), (SPC, 2010; Geller, 1994) a consulting organization that specializes in helping other companies acquire a "Total Safety Culture." The SCS is specifically designed to evaluate employee's perceptions of a reviewed company's safety culture. It is a 93-item measure, which questions employees about numerous aspects of the 14-factor model of safety culture: 1) management support for safety, 2) peer support for safety, 3) personal responsibility, 4) discipline, 5) incident reporting and analysis, 6) safety rules, regulations, and procedures, 7) training, 8) safety suggestions and concerns, 9) rewards and recognition, 10) safety audits and inspections, 11) communication, 12) employee engagement, 13) safety meetings and committees, and 14) miscellaneous (Safety Performance Solutions, 2010). With 14 separate domains, this test considers a large range of company characteristics. The extensive domain list is designed to assess a company's current safety environment, which best fits the definition of climate. There are no domains that directly address meaning or values.

The Safety Culture Values and Practices Questionnaire (QCS) (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007) is an intricate measure that uses a double-pronged approach to assess corporate safety culture. First, QSC uses a competing values framework to describe a reviewed organization's orientation toward safety. This process ranks the organization across the following values: human relations or support, open system or innovation, internal process or rules, and rational goal or goal models. The test creators explain that each of these orientations exist within all companies, but the different degrees of their presences can provide insight into the safety of the organization (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007). The seven dimensions of safety culture are: 1) training program content, 2) incident and accident reporting systems, 3) orientation of safety rules and procedure, 4) performance appraisal and safety promotion strategies, 5) motivation patterns used, 6) information and communication systems, and 7) leadership styles (Diaz-Cabrera, Hernandez-Fernaud, & Esla-Diaz, 2007). The limitation of this measure is found in the specific categories of culture. The QCS's competing values framework provides insight into the level of value within an organization. However, the specific categories do not present a full picture of culture. The domains are very specific, ignoring the role of meaning and focusing largely on tangible aspects of the corporate climate.

The Safety Culture Indicator Scale Measurement System (SCISMS) (Thaden, & Gibbons, 2008) is a safety culture survey designed for use in high-risk industries. Most recently, the test has been widely used in the aviation industry. The test uses a four-factor model, which includes 1) organizational commitment, 2) formal safety indicators, 3) operations interactions, and 4) informal safety indicators. Combined, each of these factors purports to identify the strengths and weaknesses of an evaluated organization. In an effort to increase the measurability of the modes, each factor is composed of three concrete dimensions. Specifically, organizational commitment is composed of a) safety values, b) safety commitment, and c) going beyond compliance. Formal safety indicators include the following: a) reporting system, b) response and feedback, and c) safety personnel. Operations interactions consist of a) supervisors/foremen, b) operations control/ancillary operations, and c) instructors/training. Finally, informal safety indicators incorporate constructs, such as a) accountability, b) employee authority, and c) professionalism (Thaden & Gibbons, 2008).

In addition to the previously noted factors of safety culture, the SCISMS also carries a correlated factor labeled Safety Behaviors/Outcomes, which is composed of two dimensions: a) perceived personal risk/safety behavior, and b) perceived organizational risk as an outcome measure. The test creators believe safety culture influences both corporate safety behavior and perceptions of risk (Thaden & Gibbons, 2008). This survey has a high degree of internal reliability; however, it only evaluates the concrete categories of safety, and it is not a measure of culture that includes behaviors, values, and meaning. The SCISMS does not measure these aspects of a reviewed corporation.

The **Safety Culture Enactment Questionnaire (SCEQ)** (De Castro, Gracia, Tomás, & Peiró, 2017) is based on a safety culture model consisting of three fundamental components of any organization: strategic decisions, human resource practices, and daily activities and behaviors. The authors validated the SCEQ and the model on which it is based by administering it to employees of two units of a Spanish nuclear power plant company (N = 533). As expected, an exploratory factor analysis (EFA) revealed a three-factor solution corresponding to the three components of the theoretical model. Reliability analyses showed strong internal consistency for the three scales of the SCEQ, and each of the 21 items on the questionnaire contributed to the homogeneity of its theoretically developed scale. Confirmatory factor analysis (CFA) in a second study supported the internal structure of the SCEQ, as well as the internal consistency of the scales. Lastly, the three scales of the SCEQ showed expected correlations with the measured safety outcomes. Results provided evidence of discriminant validity between the SCEQ and safety climate.

Global Aviation Network (GAIN). This questionnaire consists of 25 safety-related questions covering five presumably safety-relevant issues: 1) management's attitude and focus on safety, 2) the attitude and focus on safety among employees, 3) culture of reporting and reactions to reported errors and incidents, 4) safety training and education, and 5) general questions about safety within the organization (cited in Bjørnskau and Longva, 2009).

Safety Culture Scale by Zohar and Luria (2005). Their scale includes 32 items: 16 to measure organization-level safety climate and 16 to measure group-level safety climate. Huang et al. (2017) revised Zohar and Luria's (2005) safety climate (SC) scale, measuring organization- and group-level SC with 16 items each, using Item Response Theory (IRT) analysis with a sample of N=29,179 workers from various industries. The original scales were shortened by (1) selecting items with above-average discriminating ability, resulting in eight-item organization-level and 11-item group-level SC scales; and (2) selecting the most informative items that together retain at least 30% of original scale information, resulting in four-item organization-level and four-item group-level SC scales. All four shortened scales had acceptable reliability (≥0.89) and high correlations (≥0.95) with the original scale scores.

1.3.5 Need for a New Survey

When reviewing the available measures of corporate culture and corporate safety culture, it is clear that the current measures are deficient. Only two of the identified measures also include a major domain of corporate culture that assesses meaning, values, or behavior. These measures, the QCS and the DOCS, are still limited in the depth at which they address culture. This review highlights the need for an empirically supported measure of corporate safety culture. A review of the evaluated measures can be found in Table 2.4.

A second major concern about the existing measures of corporate safety culture that were available for review is due to limited or no evidence to suggest that the measures were created through the use of currently accepted standards of psychometric instrument construction, including factor analysis, reliability and validity analysis, as well as criterion validity techniques. Thus, the available instruments appear to fall short of current accepted psychometric standards and call for the construction of a new instrument.

A review of the literature did not uncover a complete or comprehensive measure of corporate safety culture that could be used in the transportation industry. A perfect measure would include an evaluation of each global domain of culture and include reliability and validity data corresponding with safety performance outcome measures. To ensure validity, these overarching domains would be empirically supported. In an effort to fill the gaps in the literature, the current project is designed to develop a measure of corporate safety culture that considers the overarching domains of culture. These domains have been identified as meaning systems, values, and behavioral expectations. In addition, such a measure

would also provide useful information on the subcomponents reflected in the three domains. To satisfy the need for an empirically validated measure, the domains will be subjected to statistical tests of reliability and validity. The relationship between the measure and safety behavior correlations between subscales and components of the safety culture survey and safety performance outcome indicators were computed.

2. METHOD

2.1 Participants

All the employees of a large commuter rail services organization were invited to participate in the study. All employees at all levels of management and labor were invited to participate. The final version of the survey was administered electronically to all 1,800 organization employees.

2.2 Instruments

The Safety Culture Assessment Scale (SCAS) (Sherry & Colarossi, 2016) was used in the present study. The SCAS is based on the theoretical notion that three main domains of perception are involved in the assessment of safety culture, including 1) shared meaning systems, 2) values, and 3) behavioral expectations. The recognition of three global themes led to the hypothesis that corporate culture is a large construct composed of the previously mentioned three themes or factors. The development and initial validation of the model and instrument are described in Sherry & Colarossi (2016). Confirmatory factor analysis was used to test the theoretical model, along with the empirical model and a modified empirical model. CFA was used to compare the model fit of each of the models.

The validity of the SCAS was evaluated by demonstrating a relationship between each identified component of the measure to a criterion measure of related safety behavior for using good safety practices during the previous 12 months. *Without a validated, preexisting test, the most efficient way to measure behavioral frequency as an outcome variable was to assess a single behavioral frequency item with high face validity.* The use of untested items to assess an outcome raised some methodological questions. Based on their responses, respondents were classified as either "Safe" "Not Safe" or "Unsure." A one-way analysis of variance between groups revealed that, for the full scale and each of the identified domains, the Safe group was shown to have a higher mean score than the Not Safe and Unsure group (see Table 2.1). This finding suggests that high scorers on the CSCS are safer employees than those who score lower.

Table 2.5 Validity of safety culture scales and accident data

Full CSCS				
	Safe	**Not Safe**	**Unsure**	**Sig.**
Mean	65.36	62.62	63.36	Safe> Not Safe & Unsure
N	233	504	100	
SD	7.39	8.36	7.2	
Behavior Domain				Safe> Not Safe & Unsure
Mean	65.36	62.63	63.36	
N	233	504	100	
SD	7.39	8.36	7.2	
Values Domain				
Mean	31.92	31.39	31.23	Safe> Not Safe & Unsure
N	233	504	100	
SD	2.7	3.03	3.34	

2.2.1 Analysis of Subcomponents of the Modified Empirical Model

In the construction of the SCAS reported in Sherry & Colarossi (2016), factor analysis was used to identify additional subscales of the three main factors. These factors were deemed interpretable, were given names, and are presented in Table 2.2. Factor 1, Supervisor Commitment, accounted for the largest percentage of the variance; this factor, along with Factor 2, Safety over Productivity, Factor 3 Peer Commitment, Factor 4, Senior Management Commitment, accounted for 56% of the total variance. The remaining factors, which accounted for only 10% of the remaining variance, include awareness and usefulness of safety staff such as trainers and safety managers, respondent knowledge of safety hazards and procedures, perception of safety being rewarded, knowledge of safety policies, and perception of safe employees. Overall, the total factor model, and the 10 scales that comprise it, accounted for a cumulative 69% of the variance in the items analyzed. Taken together these items and scales then suggest a fairly robust accounting of the components that comprise corporate safety culture in a large state department of transportation.

Table 2.6 Factor components and percent of variance accounted for

Component	Total	% of Variance	Cumulative %
1. Supervisor Commitment	21.176	39.955	39.955
2. Safety over Productivity	4.727	8.919	48.874
3. Peer Commitment	2.181	4.116	52.99
4. Senior Mgmt. Commitment	1.717	3.24	56.23
5. Safe Work Environ	1.515	2.859	59.088
6. Safety Staff	1.369	2.584	61.672
7. Safety Knowledge	1.104	2.083	63.755
8. Safety Rewarded	0.992	1.872	65.627
9. Safety Policies	0.958	1.807	67.434
10. Safe Employees	0.878	1.656	69.09

2.2.2 Importance of Factors

The 10-factor structure derived from the data may be more clearly understood by arranging the relative magnitude of the variance accounted for in a hierarchical format. While a total of 31% of the variance is unaccounted for and unknown, the largest amount of variance is from the supervisor commitment factor (40% - see Figure 2.1). The next largest contributors are Safety over Productivity (9%), Peer Commitment to Safety (4%) and Senior Management Commitment (3%). Thus, the relative magnitude of the variance accounted for by the various components may lead to some prioritization of areas for intervention. These scales were then subjected to additional analysis using Cronbach's alpha to determine their internal consistency. The 10 scales demonstrated adequate reliability ranging from .94 to .58. All of the 10 factors were significantly different, with the Unsafe group scoring lower on all of the factors. Thus, the sub-scales of the Safety Culture measure appear to reflect differences in perceptions of safety culture within the organization.

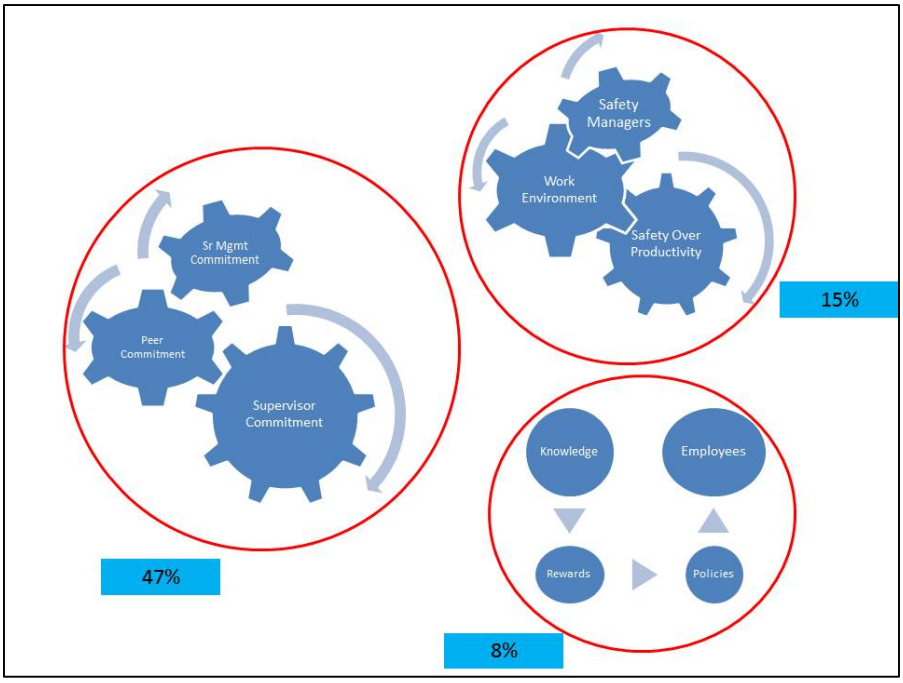

Figure 2.2 The 10 subcomponents of safety culture from the SCAS

These data clearly suggest that the measure of safety culture is capable of differentiating between members of an organization who are likely to receive recognition, versus no recognition for safety practices. Thus, there is some correlation between the perception of safety culture and safety behavior within an organization.

2.3 Procedure

The SCAS was included as a part of an overall safety initiative for a large regional commuter rail organization. The SCAS was administered on two separate occasions about 18 months apart. Appropriate IRB approval was obtained for an anonymous survey to be administered. Surveys were administered electronically to personnel with administrative and managerial duties and those who spent most of their time in one location with a computer. Active front-line staff members met in groups as part of a safety briefing and were asked to complete the surveys in person. The data collection for both Study 1 and Study 2 took place over the course of two weeks in late March and early April.

3. RESULTS

3.1 Study 1

Study participants consisted of a total of N=447 useable responses from several different locations and departments of the railroad company. Of the engineering and maintenance craft employees, 34.2% were from mechanical employees and 49.6% were from transportation-related crafts. In addition, 61.7% of respondents were male, 23.7% were female, and 14.5% of the total sample did not report any gender identification.

3.1.1 Culture Survey Results

Scores of the various subscales are presented in Figure 3.1. The results show a moderate level of endorsement of the subscales where 1 equals Strongly Disagree and 5 equals Strongly Agree. The higher the number the greater the endorsement and presence of the identified subscale factor. The respondents appear to score highest on Personal Responsibility and Safety Knowledge.

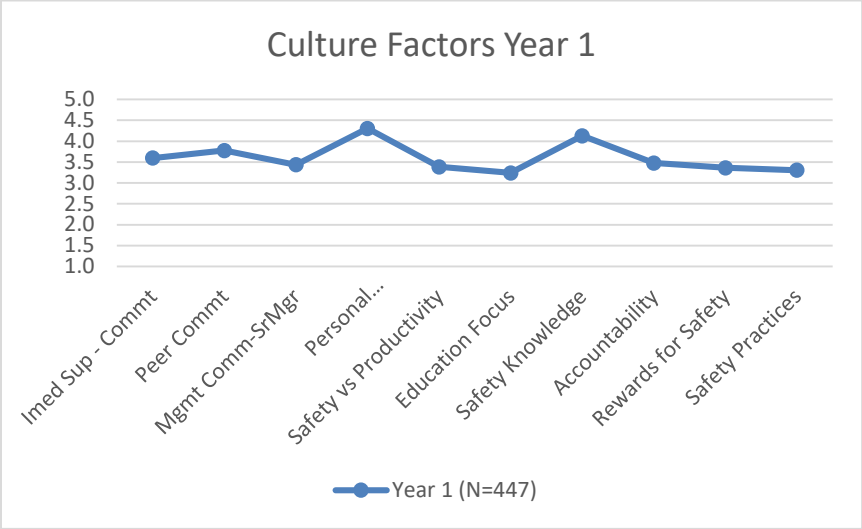

Figure 3.3 Year 1 - SCAS subscale scores

Table 3.7 SCAS subscales scores for Year 1

	Year 1 - Study 1		
	Mean	N	Std. Deviation
Management Commitment-Immed	3.60	447	.95292
Personal Responsibility	4.30	447	.67026
Peer Commitment	3.78	447	.81192
Management Commitment - Sr	3.44	447	1.17279
Safety vs Productivity	3.39	447	1.00282
Education Focus	3.24	447	1.10617
Safety Knowledge	4.13	444	.78868
Accountability	3.48	447	1.04579
Rewards for Safety	3.36	446	.83197
Safety Practices	3.31	435	1.21897

Validation of the safety culture construct was assessed by examining the extent to which scores on the safety culture scale (SCAS) differentiated persons who were noted for using *Safe vs Unsafe* work practices (see Figure 3.2), and therefore received a comment from a supervisor. Results of these analyses (See Table 3.2) provide an indication that persons who have a stronger sense of the perceived safety culture may be less likely to engage in unsafe work practices.

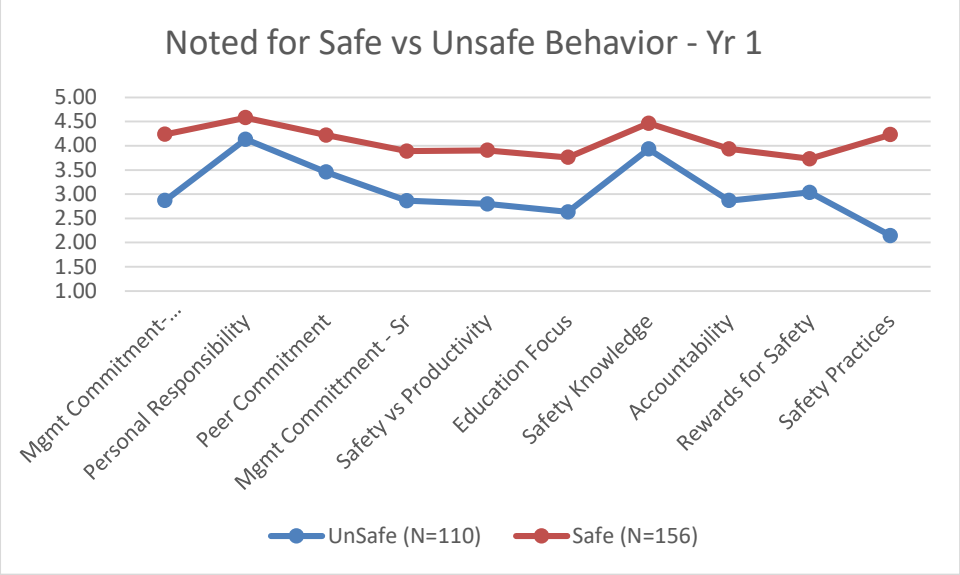

Figure 3.4 Year 1 – safe vs. unsafe behavior comparison

Table 3.8 Year 1 – independent sample t-test on SCAS safe vs. unsafe behavior

	Unsafe (N=110)	Safe (N=156)	t (df=264)	P< (2-tailed)
Mgmt Commitment-Immed Sup	2.87	4.23	(13.50)	0.00
Personal Responsibility	4.13	4.58	(5.77)	0.00
Peer Commitment	3.45	4.22	(8.05)	0.00
Mgmt Commitment – Sr	2.87	3.89	(7.21)	0.00
Safety vs Productivity	2.80	3.90	(9.58)	0.00
Education Focus	2.63	3.76	(8.65)	0.00
Safety Knowledge	3.93	4.46	(5.91)	0.00
Accountability	2.87	3.94	(8.61)	0.00
Rewards for Safety	3.03	3.73	(6.74)	0.00
Safety Practices	2.14	4.23	(17.84)	0.00

Results of independent sample t-tests comparing the *Safe vs. Unsafe* behavior scores on the SCAS subscales found that the mean of the subscales for the Safe group were significantly higher than those of the Unsafe group.

3.2 Study 2

In Study 2, which took place approximately one year following the first assessment, a total of N=478 respondents completed the survey and provided useable data. A total of 23% were engineering and maintenance craft employees, 8.9% were mechanical employees, and 30.7% were from transportation related crafts. In addition, 41.4% of respondents were male, 9.3% were female, and 49.1% of the total sample did not report any gender identification.

3.2.1 Reliability Analysis

Table 3.9 Subscale means and reliabilities for SCAS scale

Scale	Mean	Cronbach's α
F1 - Supervisor Commitment	3.49	.832
F2 – Safe vs Productive	3.161	.675
F3 – Co-Worker Cares	4.010	.780
F4 – Senior Management	3.59	.712
F5 – Safe Environment	3.443	.814
F6 – Safety Staff	3.582	.526
F7 – Safety Knowledge	3.331	.851
F8 – Safety Rewarded	3.644	.628
F9 – Safety Policies	3.287	.528
F10 – Safe Employees	3.204	.618

Cronbach's alpha was computed for each of the subscales for the participants in Study 2. As can be seen in Table 3.3, the alpha coefficients ranged from .52 to .83, representing an acceptable range of internal consistency.

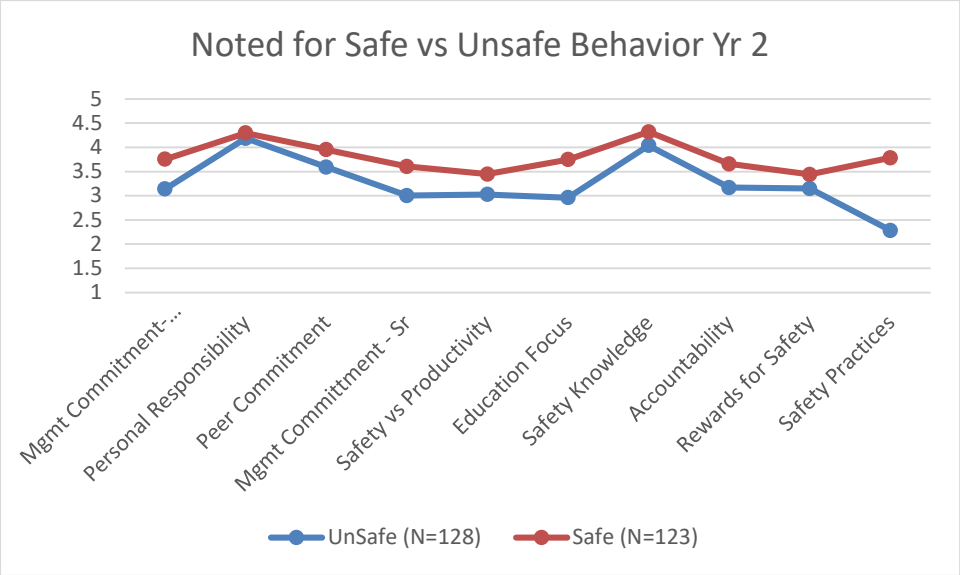

Figure 3.5 Year 2 - safe vs. unsafe behavior comparison

Validation of the safety culture construct was again assessed by examining the extent to which scores on the safety culture scale (SCAS) differentiated persons who were noted for using *Safe vs. Unsafe* work practices (see Figure 3.3), and therefore received a comment from a supervisor. Results of these analyses provide an indication that persons who have a stronger sense of the perceived safety culture may be less likely to engage in unsafe work practices (see Table 3.4).

Table 3.10 Year 2 – independent sample t-tests on safe vs. unsafe behavior

	Unsafe (N=128)	Safe (N=123)	t (df=249)	p< (2-tailed)
Mgmt. Commitment-Immed	2.87	4.23	(4.89)	0.00
Personal Responsibility	4.13	4.58	(1.16)	0.25
Peer Commitment	3.45	4.22	(3.50)	0.00
Mgmt. Commitment – Sr	2.87	3.89	(3.99)	0.00
Safety vs Productivity	2.80	3.90	(3.22)	0.00
Education Focus	2.63	3.76	(5.20)	0.00
Safety Knowledge	3.93	4.46	(2.89)	0.00
Accountability	2.87	3.94	(3.55)	0.00
Rewards for Safety	3.03	3.73	(2.71)	0.01
Safety Practices	2.14	4.23	(10.82)	0.00

Results of independent sample t-tests comparing the Safe vs. Unsafe behavior scores on the SCAS subscales (see Table 3.4) found that the mean of the subscales for the Safe group were significantly higher than those of the Unsafe group. Only the Personal Responsibility subscale did not show any significant difference between Safe vs. Unsafe groups.

3.2.2 Comparison of Data

To further validate the underlying constructs of safety culture, the two samples were compared. As can be seen in Figure 3.4, there was a slight difference in scores on the SCAS subscales between the first and second assessments. These results suggest that the perception of safety culture factors declined somewhat over the year period of time that elapsed between the two assessments.

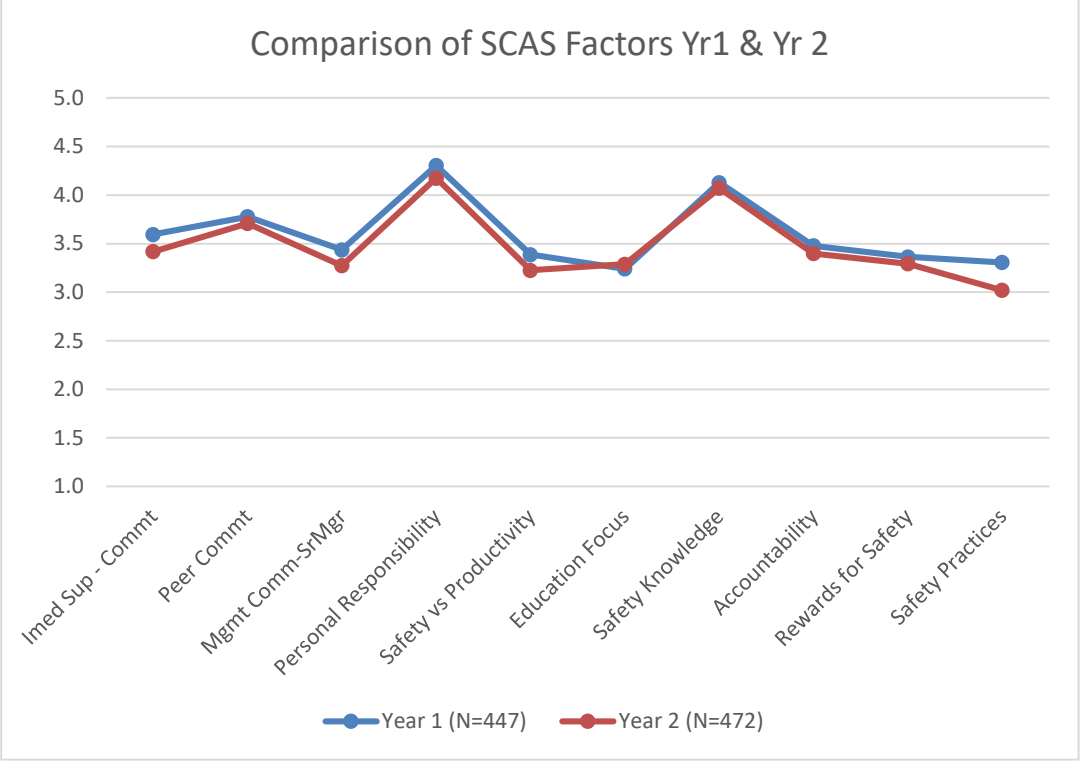

Figure 3.6. Comparison of scores on SCAS factors Year 1 vs. Year 2

Significant reductions in perceived safety culture were observed on supervisor support management commitment personal responsibility safety vs productivity and safety practices.

Table 3.11 Comparison of perceived safety culture between Year 1 and Year 2

	Year 1 (N=447)	Year 2 (N=472)	t	df	Sig. (2-tailed)
Immed Sup - Commit	3.6	3.4	2.7	917	.007
Peer Commit	3.8	3.7	1.3	918	.203
Mgmt. Comm-SrMgr	3.4	3.3	2.1	921	.038
Personal Responsibility	4.3	4.2	2.7	907	.007
Safety vs Productivity	3.4	3.2	2.4	915	.017
Education Focus	3.2	3.3	-0.6	911	.531
Safety Knowledge	4.1	4.1	1.1	915	.272
Accountability	3.5	3.4	1.1	912	.255
Rewards for Safety	3.4	3.3	1.3	910	.185
Safety Practices	3.3	3.0	3.5	868	.000

Additional validation of the overall assessment and construct of safety culture can be seen from a further examination of the extent to which safe versus unsafe behavior was observed and noted by supervisors. Again, comparing the safety culture perceptions of persons noted to have safe versus unsafe work practices, significant differences (See Table 3.5) were obtained between their perceptions of the safety culture (see Figure 3.5).

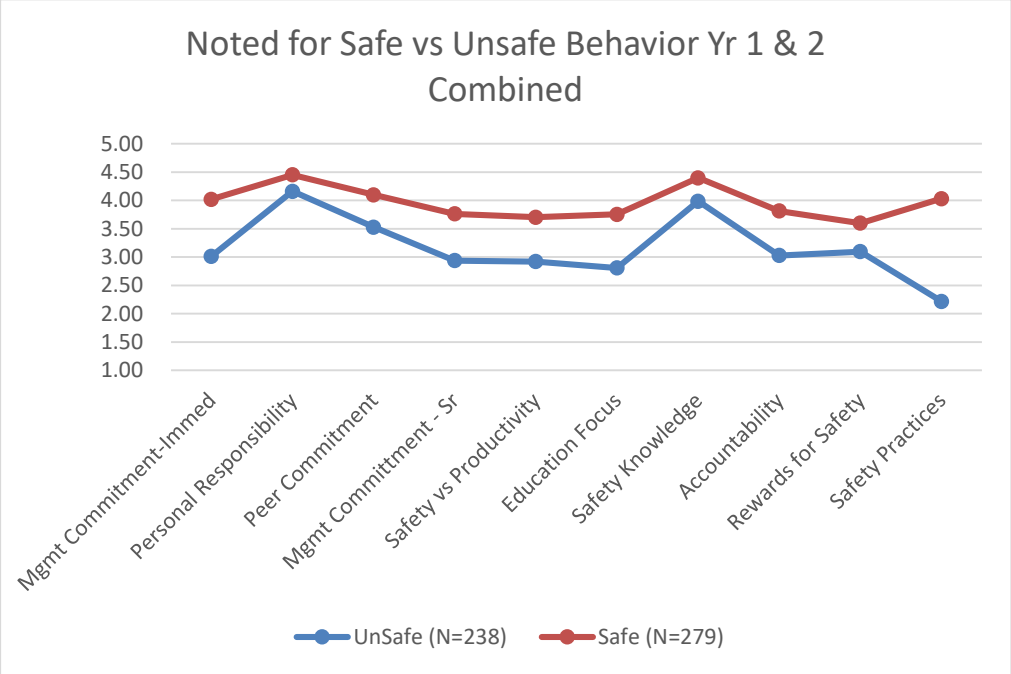

Figure 3.7 Comparison of safe vs. unsafe behavior for combined Year 1 and Year 2

Significant differences on all of the key subscales between the two samples were obtained (see Table 3.6).

Table 3.12 Comparison of safe vs. unsafe for Yrs. 1 & 2 combined

	Unsafe (N=238)	**Safe (N=279)**	**t (df=515)**	**P< (2-tailed)**
Mgmt. Commitment-Immed	3.01	4.02	(12.35)	0.00
Personal Responsibility	4.16	4.45	(4.79)	0.00
Peer Commitment	3.53	4.10	(8.17)	0.00
Mgmt. Commitment - Sr	2.94	3.76	(7.98)	0.00
Safety vs Productivity	2.92	3.70	(8.89)	0.00
Education Focus	2.81	3.75	(9.52)	0.00
Safety Knowledge	3.99	4.40	(6.23)	0.00
Accountability	3.03	3.81	(8.44)	0.00
Rewards for Safety	3.10	3.60	(6.78)	0.00
Safety Practices	2.22	4.03	(19.92)	0.00

3.2.3 Safety Outcomes

In order to determine the criterion validity of the SCAS subscales, it was necessary to analyze the safety performance data for the organization. As part of the assessment study, participants were asked to report the number of injuries, accidents, and near misses they experienced in the previous three years. The study participants reported the number of accidents for the two periods (see Figure 3.6).

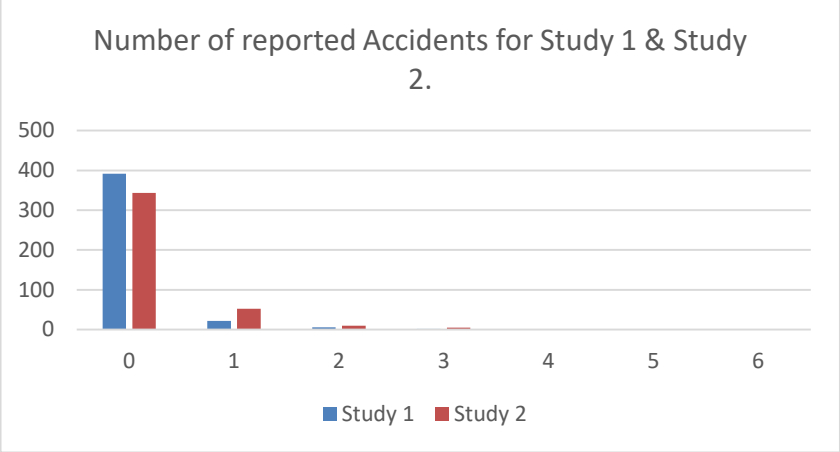

Figure 3.8 Number of reported accidents for Study 1 and Study 2

As can be seen, the majority of respondents reported no accidents during the time period. Similarly, the number of injuries and near misses were also reported as a single number by respondents on the survey (see Figure 3.7).

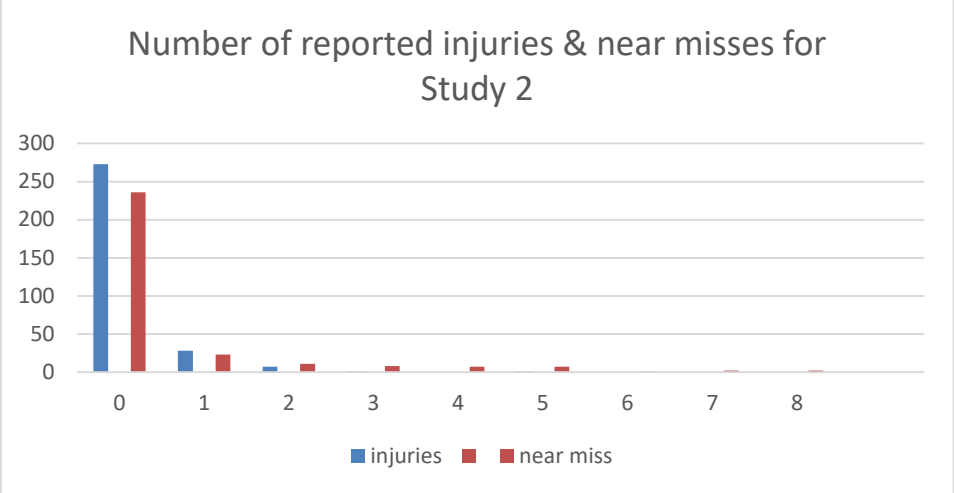

Figure 3.9 Number of reported injuries and near misses for Study 2

It should be noted that railroad employees and railroads are required by law to report their injuries and accidents. They are not required to report their near misses. In addition, an injury on the job can be grounds for disciplinary action. Consequently, there is a risk of underreporting when using only official records of injuries and accidents. Most likely, self-reported counts of accidents and injuries to third parties may be more accurate and slightly higher than actual statistics. However, there is also the

likelihood of error due to memory lapses. In other words, there is no foolproof method for collecting these types of data.

3.2.3.1 Correlations with Safety Outcomes

Another indication of the validity of the SCAS is the relationship between the scores on the measure and the accidents, near misses, and injury rates. Scores on the SCAS taken at time 1 and time 2 were correlated with the number of reported injuries, incidents, and near misses. As seen from the data in Table 3.7, significant correlations were observed between the SCAS sub-scale scores and the number of accidents, incidents, and near misses.

Correlations between SCAS subscales and the safety performance indicators are presented in Table 3.7. These findings suggest are that there is a significant relationship between the scores on the SCAS and actual safety related behaviors. While these data are limited by the self-report nature of the data the statistically significant correlations suggest that these factors are strongly related. Safety managers and others can take guidance from these scores and feel confident that addressing these issues in the work place has an important relationship to actual safety outcomes.

Table 3.13 Bivariate correlations of SCAS sub-scales with safety outcome indices

	2015 (N=300)			**2017 (**N=297)		
	# Injuries	**# accidents**	**# Near Misses**	**# Injuries**	**# accidents**	**# Near Misses**
Mgmt. Commit-Immediate Sup	-0.101	-0.068	-.295**	-.172**	-0.008	-.289**
Mgmt. Commit-Senior	-0.087	-0.065	-.272**	-.154**	-0.001	-.266**
Safety/Productivity	-0.109	-0.081	-.294**	-.129*	-0.025	-.241**
Education Focus	-.130*	-.128*	-.261**	-0.078	0.042	-.231**
Rewards for Safety	-.155**	-.130*	-.140*	-0.039	-0.01	-.183**
Accountability	-0.094	-0.075	-.170**	-0.081	0.021	-.164**
Safety Practices	-.158**	-.121*	-.232**	-0.049	0.016	-0.099
Pers Resp	-0.038	-0.037	-.118*	-.145*	-0.088	-0.081
Safety Knowledge	-0.031	0.021	-0.101	-0.009	0.029	-0.032
Peer Commitment	-0.063	-0.086	-.175**	-0.033	-0.019	-0.09

*p<05
** p<.001

3.2.3.2 Risk of Safety Outcomes

Closer inspection of the components comprising the SCAS demonstrate the validity of safety culture as it affects the three main safety outcomes assessed in our studies. A series of analyses looking at the relative risk of near misses, accidents and injuries reported by employees over the last three years was conducted. Results of these analyses show that components of safety culture are related to the probability of these safety performance indicators. To conduct these analyses responses to the items were dichotomized and entered 2x2 tables to develop odds ratios and relative risk ratios. For example, item 26, found in the Commitment to Safety Subscale of the SCAS – by Immediate Supervisor factor, was dichotomized by recoding responses into a high versus low response format such that “Agree” and “Strongly Agree” were coded “High” and scores of “Strongly Disagree” and “Disagree” were coded as “Low”. Similarly, the safety outcome variables, such as number of accidents, number of injuries and number of near misses

were also recoded and dichotomized into High and Low scores. The resulting analyses are presented in Table 3.8.

Table 3.14 Risk ratios of SCAS components

Safety Outcome Variable	Safety Culture Subscale Component	OR	p<	Rel Risk	P<
Near Misses	Senior Mgmt. Commitment	3.77	0.00	3.28	0.01
	Immediate Mgmt. Commitment	8.51	0.01	6.66	0.01
	Safety vs Productivity	3.15	0.05	2.73	0.06
	Job Briefings	3.84	0.00	3.30	0.00
Number of Accidents	Safety vs Productivity	4.90	0.00	3.35	0.00
Number of Injuries	Freedom to Report	6.12	0.00	4.59	0.00

3.2.3.3 Near Misses

Table 3.8 demonstrates that for the safety outcome indicator of number of reported near misses that scores on the Senior Management Commitment Subscale of the SCAS were highly related. Number of Near Misses was reported as a specific number. Results of the analysis (see Table 3.8) indicate that that employee's perception of senior management commitment to safety resulted in a 3.7 times greater likelihood of not reporting or not being involved in a near miss incident. Similarly, the perception of the immediate supervisor's commitment to safety was 8.5 times more likely to result in not reporting or being involved in a near miss incident. Finally, being involved in job briefings was 3.84 times more likely to result in not reporting or being involved in a near miss incident. These findings support the validity of the SCAS subscales for detecting the presence of important behavioral safety related activity.

3.2.3.4 Number of Accidents Reported

Significant correlations were found between the SCAS subscales of Education focus, Rewards for Safety and Safety practices. (see Table 3.7) The odds of reporting an accident was 4.9 time greater if a respondent perceived the organizational culture as prioritizing productivity over safety. Put another way, scoring low on the perception that the work environment placed a higher value on safety versus productivity was 4.9 times more likely to result in a greater number of accidents. The relative risk of reporting an accident was 3.35 times higher if productivity was emphasized over safety. (see Table 3.8).

3.2.3.5 Number of Injuries

Significant correlations were found between the SCAS subscales of rewards for safety and safety practices and number of injuries reported in Study 1 and for management commitment to safety and personal responsibility in Study 2. (see Table 3.7) The odds of reporting an injury were 6.12 higher if the perception of the culture was such that persons scored low on feeling free to report accidents and the relative risk of reporting an injury was 4.5 times more likely under those conditions. (See Table 3.8)

4. DISCUSSION

The present study continued efforts to develop and validate a measure of corporate safety culture for the transportation industry. A measure of safety culture developed in earlier studies for the transportation industry (Sherry & Colarossi, 2016) was used in the present study of a large rail transportation company. In the current study an effort was made to continue to validate the instrument by demonstrating that there were significant relationships between scores on the scale and external behavioral indicators of the safety in the measured organizational setting.

Previously, the ten-scale instrument was determined to have adequate psychometric reliability and validity. The scales are stable and internally consistent and measure many of the factors that were previously found in other safety culture and safety climate measures. Thus, the instrument shows promise for being useful in other transportation settings.

If corporate safety culture is defined as consisting of the values held by its members and groups, and the resulting behavioral decisions, then culture may be most efficiently addressed through the measurement of perceived behavior. While there is a case to be made for informal, qualitative, and observational methods of determining safety culture, the practical considerations of using a quantitatively survey-based approach are more feasible in a transportation organization. If one assumes that behavior is the result of values, attitudes and beliefs, responses to items tapping those characteristics may be considered a strong indicator of the underlying culture. These considerations, and the strong associations between the perceived values and attitudes of the members of the organization suggest that this may be a very viable method for assessing corporate culture.

Results of the present study replicated the findings of the initial developmental study by showing that there were significant differences between persons who scored high or low on the SCAS and the fact that they had performed safe vs unsafe acts. The present study also demonstrated sufficient scale reliabilities that approximated those of the initial validation study. While the reliabilities of the scales in the current study samples were not quite as strong as those obtained in the initial study, this is not unexpected. There is usually some shrinkage across samples due to the natural differences between settings as well as changes in terminology, practices and the like. Nevertheless, the current instrument, with some additional refinement and scale reconstruction shows promise for being a useful measure of corporate culture.

Most importantly, the instrument demonstrates both *construct validity*, having been derived from factor analytic studies in the initial validation study, plus *criterion validity* in its ability to differentiate between individuals who performed both safe and unsafe behaviors. Statistically significant differences were obtained demonstrating that the scales on the safety culture scale were detecting key differences between individuals who experienced and perceived the elements of the safety culture.

Results of the present study also demonstrated the validity of the instrument in that there was a relationship between scores on the SCAS scales and safety outcome indices such as number of reported injuries, number of reported accidents, and number of reported near misses. These safety outcome indices are typically used to assess the safety record and safety performance of transportation organizations.

A new set of analyses was also conducted that demonstrated the risk associated with certain aspects of safety culture and key behavioral safety outcomes such as reported accidents, near misses and injuries. The SCAS subscales were examined to assess the risk associated with the occurrence of accidents, inquiries and near misses. The results of the risk analyses suggest that the presence of senior management commitment to safety is associated with a lower risk of actual workplace accidents or injuries. By using a 2x2 contingency table and examining persons who perceived high versus low levels of belief in the extent

to which senior management did or did not demonstrate a commitment to safety culture it was possible to differentiate persons who were associated with accidents. Put another way, the presence of low levels of perceived senior management commitment to safety was associated with a much greater risk of actual accidents than for persons who report a high level of perception of senior management commitment.

These results strongly suggest that the risk of accidents decreases significantly when members of an organization perceive senior leaders as having a high level of commitment to safety. In fact, the present results offer a quantitative estimate such that the odds of having and or reporting an accident are 5 times more likely if there is a perception that senior members do not have a strong commitment to safety.

Safety culture measurement was also shown to be strongly associated with the risk of reported injuries. Interestingly results of the analysis of the probability of injuries when perceiving discouragement or less freedom to report injuries likely increased the odds of reporting an injury six times more that those who did feel freedom to report. These findings most likely indicate the presence of a suppressive environment that attempts to underreport actual safety problems. More research is needed on this finding however due to its sensitivity and uniqueness which could indicate a random finding as well.

Near miss reporting has become much more prevalent over the past 10 years. Results of our study show that perceived senior management and immediate or front-line supervisory commitment to safety both contribute to a reduction in reported near misses. Interestingly, the relative risk of near miss reporting was almost doubled when low levels of front-line supervisory commitment were observed as compared to commitment of senior managers. It should be noted that it is unlikely that front line supervisor commitment to safety will be found if there is not a corresponding high levels of top management commitment. So, these results will need to be disseminated wisely. It is not that case the top management can sit back and let front line management take care of safety as it were, rather the commitment from the top is needed to be able to for front line managers to have the confidence that they are pursuing the proper organization goals. Most likely, the effects of top management commitment are mediated through front line supervisor commitment. The current findings are consistent with those of Fugas, et al, (2012) and Probst and Baker (2001) who reviewed the effectiveness of extrinsic motivation and supervisor enforcement on safety behaviors.

4.1 Recommendations for Practice

Senior level management must demonstrate a strong commitment to safety.

The results of this study clearly have implications for practice and the measurement and improvement of safety culture in transportation organizations. The present results point strongly to the importance of senior level and front-line management commitment to safety as a significant factor in the reduction of risk of the likelihood of reporting a near miss.

The belief that safety is more important than productivity must be strenuously promoted by top and front-line management.

A related finding was the fact that an emphasis on safety vs productivity can lead to a lowered risk of reported accidents. Top management and front-line management are the instruments through which the safety culture is formed and maintained. These two groups must be especially targeted for a strong safety culture to emerge.

The promotion of the overall belief that safety really is more important than productivity is likely essential to developing and maintaining a strong safety culture. This value statement, or principle should be reflected in all public statements and corporate communications as it represents a fundamental assumption that will underpin the entire organization. The factor analytic research in the validation study (Sherry & Colarossi, 2016) found that this value was the second most important contributor to a strong Safety Culture. It should be clearly visible and obvious to all members of the corporate environment.

Front line management, supported by top line management, play an extremely significant role in developing and maintaining a strong safety culture. They must be well-trained, supported and incentivized to promote a strong safety culture.

Once the Senior Managers have demonstrated their commitment a focus on the first line supervisor can be undertaken. This can take the form of training for first line supervisors on how to show commitment, knowledge of safety practices, problem solving to address safety concerns, and other important matters. Additional training sessions will need to be provided to ensure that first line supervisors are well situated and prepared to address the culture. But, most importantly, senior leaders must engage in meaningful activity and behaviors that will reinforce the immediate supervisor's role. This is an important component and should not be underestimated in the development of safety culture. Culture evolves from shared experiences and shared belief systems. Typically, examples of how senior leaders act or behave, relative to immediate supervisors and others in the organization. The shared memory of a landmark or bellwether event where the senior leader acts to reinforce the stated beliefs of the safety culture is what serves as the precursor to and the eventual reinforcement of the culture. Members of the culture point to the shared moment in time and use it to guide present and future actions.

An open culture, open to reporting, discussing and changing approaches to dealing with safety and safety hazards must be promoted.

The importance of developing a culture in which there is a freedom to report, to discuss and to examine safety practices as well as hazards is also important. The present findings indicated that a strong freedom to report reduces the odds of reporting an injury. Thus, an open exchange is probably needed as a key component of developing an effective safety culture.

Encouragement and promotion of state-of-the-art best practices is needed to create a strong safety culture.

Some specific safety practices are also needed and have been shown to lower the risk of reported near misses. The use of job briefings, a widely accepted, but not always utilized, practice reduced the odds of reporting a near miss by almost 4 to 1. The continued use and refinement of these techniques is strongly recommended.

To promote and maintain a strong safety culture there is a need for continued emphasis on educating the workforce and developing a detailed and specific knowledge of safety hazards, and best practices for promoting safety. This includes developing and publishing key corporate policies, rules and requires. Understanding the essential components of a comprehensive and strong safety culture is needed.

5. CONCLUSION

In conclusion, this study has described the further development and validation of a measure of corporate safety culture for the transportation industry. The instrument has demonstrated psychometric properties of reliability and validity. Moreover, subscales of the safety culture assessment survey SCAS) are significantly related to safety performance outcome measures such as reported injuries, accidents and near misses. The odds of reporting a near miss were significant higher when Senior and Front-line management were not perceived as being committed to safety as well as the support of the value that safety is more important than productivity.

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APPENDIX. DESCRIPTIONS OF CORPORATE SAFETY CULTURE SCALES

1.1 F1 – Supervisor Commitment

Assesses perceptions that supervisors are committed to safety as evidenced by the perception that they are encouraged to raise safety concerns and that supervisors are engaged in in and investing time in improving safety

1.2 F2 –Safety Over Productivity - Personal Responsibility

Assesses perceptions that employees believe that safety is not sacrificed for productivity and that the work area has been made as safe as possible. Assesses perceptions that safety is a personal responsibility which can be can be prevented by personal actions.

1.3 F3 - Peer Commitment

Assesses perceptions that co-workers are committed to personal safety contribute to making the workplace safe.

1.4 F4 – Senior Management Commitment – SR

Assesses perceptions that the degree to which employees feel that senior mgmt. and the corporation is committed to employee safety.

1.5 F5 – Work Environment

Assesses perceptions that employees believe that the work environment is safe and free of hazards.

1.6 F6 – Safety Managers

Assesses perceptions regarding the extent to which the Safety professionals are seen as helpful and knowledgeable in providing safety training and information to assist with safety.

1.7 F7 – Safety Knowledge

This scale assesses the extent to which employees understand and know how to address risks and hazards in the work environment.

1.8 F8 – Safety Rewards – (Inc)

Assesses perceptions regarding the believe that safe work behaviors are rewarded in the organization through promotions and performance ratings.

1.9 F9 – Safety Policies

Assesses the extent to which employees believe that safety policies have been publicized and that employees are held accountable for their safety actions.

1.10 F10 – Safe Employees

Assesses the extent to which employees feel that safe employees are valued and rewarded by the organization.