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A Synthesis of Safety Culture and Safety Climate Research

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Abstract

Recent years have witnessed a growing concern over the issue of safety culture within aviation and other complex, high-risk industries. The purpose of the present review is to summarize and integrate the numerous reports and studies that have been conducted to define and assess safety culture, as well as the highly related concept of safety climate. Results of the review indicate that few formally documented efforts have been made to assess safety culture within the aviation industry. Furthermore, there exists considerable disagreement among safety professionals, both within and across industries, as to how safety culture should be defined and whether or not safety culture is inherently different from the concept of safety climate. A synthesis of theses different perspectives is conducted and hybrid definitions of both safety culture and climate are offered. A discussion of key organizational indicators of safety culture and the various methods commonly used to assess these factors is provided. Issues that need to be considered when implementing a safety culture assessment program are also presented. The hope is that this review will enable researchers and safety professionals to better understand and assess safety culture and that it will facilitate the sharing of information and strategies for improving safety culture across organizations and industries.

The rapid development of new technology has fundamentally changed the nature of work and has increased the complexity of systems within a variety of industries (Hendrick, 1991). Among these complex systems are those commonly known as “high-risk” systems, such as nuclear power plants, chemical processing facilities, and aviation operations that require a tight coupling between both technical and human subsystems. The failure of either subsystem can often cause a failure of the entire system. Furthermore, catastrophic breakdowns of these high-risk systems pose serious threats, not only for those within the organization, but also for the surrounding public. For some potentially highly dangerous systems, such as nuclear power, this risk can extend far beyond the immediate locality and even “have adverse effects upon whole continents over several generations” (Reason, 1990, pg. 1).

Given the potential for enormous damage that failures of high-risk systems can inflict, the investigation of the causes of system failures is extremely crucial to preventing future occurrences. Toward this end, theories of accident causation have progressed through several stages of development over the past several years in an effort to identify the root causes of system failures (Gordon, Flin, Mearns, & Fleming, 1996; Wilpert, 2000). The first stage is often referred to as the technical period, during which developments in new mechanical systems were rapid and most accidents were caused by mechanical malfunctions, particularly in the design, construction, and reliability of equipment (Wiegmann & Shappell, 2001). The second stage is known as the period of human error, where faults of the human operator, rather than catastrophic mechanical malfunctions, were seen as the source of the system breakdown. The accident at Unit 2 of the Three-Mile Island nuclear plant (TMI-2) raised awareness of human error and cognitive shortcomings of operators and shifted the attention of safety analysis from technical aspects to human errors, where blame and responsibility were assigned to the person directly involved in the unsafe act (Rochlin & Von Meier, 1994; Coquelle, Cura, & Fourest, 1995). The third stage is referred to as the sociotechnical period. This view of human error considers the interaction of human and technical factors when exploring the causes of errors and accidents. Finally, recent years have witnessed the development of a fourth stage, which is often called the “organizational culture” period (Gordon et al., 1996; Wilpert, 2000). This approach recognizes that operators are not performing their duties or interacting with technology in isolation, but rather they are performing as a coordinated team of organizational personnel, which is embedded within a particular culture.

Organizational Culture and Safety

The beginning of the organizational culture period of accident investigation and analysis can be traced back to the nuclear accident at Chernobyl in 1986 (Cox & Flin, 1998; Mearns & Flin, 1999; Rochlin & Von Meier, 1994; Coquelle, Cura, & Fourest, 1995; Pidgeon, 1998; Weick, 1987; Flin, Mearns, Gordon, & Fleming, 1998; Flin, Mearns, O’Connor, & Bryden, 2000). On April 26 1986, two explosions blew off the 1000-ton concrete cap sealing the Chernobyl-4 reactor, releasing molten core fragments into the immediate vicinity and fission products into the atmosphere. It was the worst accident in the history of commercial nuclear power generation. It

has so far cost over 30 lives, contaminated approximately 400 square miles around the Ukrainian plant and significantly increased the risk of cancer deaths over a wide area of Scandinavia and Western Europe (Reason, 1990). A "poor safety culture" was identified as a factor contributing to the Chernobyl disaster by the International Atomic Energy Agency (IAEA, 1986, as cited in Cox & Flin, 1998) and OECD Nuclear Agency (1987, as cited in Mearns & Flin, 1999; Pidgeon, 1998). Since then safety culture has been discussed in other major accident enquiries and analysis of system failures, such as the King's Cross Underground fire in London and the Piper Alpha oil platform explosion in the North Sea (Cox & Flin, 1998; Pidgeon, 1998).

According to Meshkati (1997), the most dramatic turning point for "safety culture" in the United States came with an aviation accident that killed 14 people —the in-flight structural breakup and crash of Continental Express Flight 2574 near Eagle Lakes, Texas, on September 11, 1991. As a member of the National Transportation Safety Board (NTSB) at that time, Dr. John Lauber suggested that the probable cause of this accident included "The failure of Continental Express management to establish a corporate culture which encouraged and enforced adherence to approved maintenance and quality assurance procedures" (NTSB/AAR-92/04, 1992, pg. 54, as cited in Meshkati, 1997). As a result of this and other similar aviation accidents, safety culture came to the forefront as the exclusive topic at the U.S. National Summit on Transportation Safety, hosted by the NTSB in 1997.

Purpose of the Present Paper

The recognition of the importance of safety culture in preventing accidents has led to numerous studies attempting to define and assesses safety culture in a number of complex, high-risk, industries. To date, however, there have been few attempts to examine the various definitions of safety culture that have been proposed in the literature, nor have there been any attempts to examine the various instruments and methods commonly used to assess safety culture within organizations. Furthermore, such terms as "safety climate" are often used in conjunction with safety culture, with little if any differentiation between the concepts (Cox & Flin, 1998, Mearns & Flin, 1999). Consequently, while the concept of safety culture continues to attract more attention, "the existing empirical efforts to study safety culture and its relationship to organizational outcomes have remained unsystematic, fragmented and in particular under-specified in theoretical terms" (Pidgeon, 1998, pg. 203). The purpose of the present paper, therefore, is to address these problems by synthesizing the existing literature on safety culture in order to develop a better understanding of its nature, dimensions, and impact on operational safety.

Conceptualizing Organizational Culture

Conceptualizations and definitions of safety culture have been derived mainly from the more general notion of organizational culture. The concept of organizational culture has been discussed thoroughly in notable works such as *In Search of Excellence* by Peters and Waterman

(1982) and *Corporate Cultures: The Rites and Rituals of Corporate Life* by Deal and Kennedy (1982). Still, due to the interdisciplinary nature of this concept, definitions and methods for studying organizational culture tend to vary according to the academic discipline from which they originated (Helmreich & Merritt, 1998). In general, however, these approaches can be grouped into two broad categories – the socio-anthropological and the organizational psychology perspectives.

Socio-anthropological perspective. When attempting to understand organizational culture, the socio-anthropological perspective highlights the underlying structure of symbols, myths, heroes, social drama, and rituals manifested in the shared values, norms, and meanings of groups within an organization (Deal & Kennedy, 1983; Mearns & Flin, 1999). While an organization's culture is revealed in its general patterns of attitudes and actions, the deeper structure of its culture is often not immediately interpretable by outsiders. Studying organizational culture, therefore, requires the use of ethnographic approaches, including intensive and extensive observations and employee interviews (Schein, 1991).

The socio-anthropological perspective also generally assumes that organizational culture is an emergent property of the organization, generated by its unique history and individual members (Smircich, 1983). In other words, organizational culture is, "more than the sum of its parts," and therefore cannot be completely understood through traditional analytical methods that attempt to breakdown a phenomenon in order to study its individual components, but rather through methods that account for the activity or the nature of what is being studied (Creswell, 1998; Glaser & Strauss, 1967; Suchman, 1987). Furthermore, organizational culture is often considered an "evolved construct," deeply rooted in history, collectively held, and sufficiently complex to resist any attempts at direct manipulation (Mearns & Flin, 1999).

Organizational psychology perspective. Similar to the socio-anthropological perspective, the organizational psychology perspective defines organizational culture as the values and beliefs that organization members come to share through symbolic means such as myths, rituals, stories, legends and specialized language (Smircich, 1983). In contrast, however, organizational psychologists tend to focus on the functional significance of organizational culture and the means by which it might be manipulated to improve productivity (Deal & Kennedy, 1982; Peters & Waterman, 1982; Schein, 1991). As pointed out by Smircich (1983), organizational culture conveys a sense of identity for organization members, facilitates the generation of commitment to something larger than the self, enhances social system stability, and serves as a sense-making device that can guide and shape behavior. In turn, these factors can be used to build organizational commitment, convey a philosophy of management, legitimize activity and motivate personnel. The organizational psychology perspective, therefore, provides a conceptual bridge between organizational behavior and strategic management interests.

Given the goal of organizational psychology is often to modify organizational culture in order to affect performance, this perspective more strongly embraces traditional analytical

methods than does the socio-anthropological perspective. Specifically, this perspective assumes that organizational culture can be broken down into smaller components that are empirically more tractable and more easily manipulated (Schein, 1991). It is not surprising, therefore, that the majority of the attempts to measure and change various aspects of organization culture have arisen out of the organizational psychology perspective. Indeed, researchers in this area have broken down organizational culture into a variety of different components, including service culture, creativity culture, motivation culture, and safety culture.

Defining Safety Culture

As stated previously, current interest in the term “safety culture” can be traced directly back to the Chernobyl accident in 1986. Since then, numerous definitions of safety culture have abounded in the safety literature. Indeed, our recent review of the literature revealed several diverse definitions of the concept (Wiegmann, Zhang, & von Thaden, 2001). These various definitions of safety culture are presented in Table 1. Most definitions originate from articles that have focused on safety culture in industries other than aviation (e.g., nuclear power, mining and manufacturing). Nonetheless, there does appear to be several commonalities among these various definitions regardless of the particular industry being considered. These commonalities include:

1. Safety culture is a concept defined at the group level or higher, which refers to the shared values among all the group or organization members.

2. Safety culture is concerned with formal safety issues in an organization, and closely related to, but not restricted to, the management and supervisory systems.

3. Safety culture emphasizes the contribution from everyone at every level of an organization.

4. The safety culture of an organization has an impact on its members’ behavior at work.

5. Safety culture is usually reflected in the contingency between reward systems and safety performance.

6. Safety culture is reflected in an organization’s willingness to develop and learn from errors, incidents, and accidents.

7. Safety culture is relatively enduring, stable and resistant to change.

Table 1. Definitions of Safety Culture

Source/Industry	Definitions
Carroll (1998) (Nuclear power, US)	Safety culture refers to a high value (priority) placed on worker safety and public (nuclear) safety by everyone in every group and at every level of the plant. It also refers to expectations that people will act to preserve and enhance safety, take personal responsibility for safety, and be rewarded consistent with these values.
Ciavarelli & Figlock (1996) (Naval aviation, US)	Safety culture is defined as the shared values, beliefs, assumptions, and norms which may govern organizational decision making, as well as individual and group attitudes about safety.
Cooper (2000) (Theoretical)	Safety culture is a sub-facet of organizational culture, which is thought to affect member's attitudes and behavior in relation to an organization’s ongoing health and safety performance.
Cox & Cox (1991) (Industrial gases, European)	Safety culture reflects attitudes, beliefs, perceptions, and values that employees share in relation to safety.
Cox & Flin (1998) (Theoretical) Lee (1998) (Nuclear reprocessing, UK) Wilpert (2000) (Theoretical in context of nuclear power)	The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management.
Eiff (1999) (Aviation, US)	A safety culture exists within an organization where each individual employee, regardless of their position, assumes an active role in error prevention and that role is supported by the organization.
Flin, Mearns, Gordon, & Fleming (1998) (Offshore oil and gas, UK)	Safety Culture refers to entrenched attitudes and opinions which a group of people share with respect to safety. It is more stable [than safety climate] and resistant to change.

Helmreich & Merritt (1998) (Aviation, US)	Safety culture (p 133): a group of individuals guided in their behavior by their joint belief in the importance of safety, and their shared understanding that every member willingly upholds the group's safety norms and will support other members to that common end.
McDonald & Ryan (1992) (Theoretical in context of road transportation) Mearns & Flin (1999) (Theoretical) Pidgeon (1991) (Theoretical) Pidgeon & Oleary (1994) (Theoretical in context of aviation)	Safety culture is defined as the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious.
Mearns, Flin, Gordon, & Fleming (1998) (Offshore oil and gas, UK)	Safety culture is defined as the attitudes, values, norms and beliefs which a particular group of people share with respect to risk and safety.
Meshkati (1997) (Transportation industry, US)	Safety culture is defined 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.
Minerals Council of Australia (1999) (Mineral industry, Australia)	Safety culture refers to the formal safety issues in the company, dealing with perceptions of management, supervision, management systems and perceptions of the organization.
Pidgeon (2001) (Theoretical in context of driver behavior)	A safety culture is in turn the set of assumptions, and their associated practices, which permit beliefs about danger and safety to be constructed.

Considering these commonalties among the varies definitions of safety culture, a global definition can be formulated. This definition is:

> Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behavior based on lessons learned from mistakes, and be rewarded in a manner consistent with these values.

It should be noted that the proposed definition of safety culture is stated in neutral terms. As such, the definition implies that organizational culture exists on a continuum and that organizations can have either a good or poor safety culture. However, not all definitions in the literature make this assumption. Some suggest that safety culture is either present or absent within an organization. Nevertheless, it is clear from the initial introduction of the term within various operational environments that safety culture is assumed to be a component of an organization that can be improved rather than simply instilled (e.g., IAEA, 1986, as cited in Cox & Flin, 1998). Obviously, such a distinction is important when it comes to both measuring and changing safety cultures within organizations.

Defining Safety Climate

Although the debate over the definition of safety culture has not reached unanimous agreement, a similar term “safety climate” has been used frequently in the literature and has added to the confusion. Furthermore, our previous review of the literature (Wiegmann et al., 2001) indicated that, from the time the term was first highlighted by Zohar (1980), the literature has not presented a generally accepted definition of safety climate either. In fact, some definitions of safety climate are almost identical to definitions of safety culture. However, as indicated in Table 2, many definitions do have commonalities and do differ from safety culture in important ways. These include:

1. Safety climate is a psychological phenomenon, which is usually defined as the perceptions of the state of safety at a particular time.

2. Safety climate is closely concerned with intangible issues such as situational and environmental factors.

3. Safety climate is a temporal phenomenon, a “snapshot” of safety culture, relatively unstable and subject to change.

Table 2. Definitions of Safety Climate

Source/Industry	Definitions
BASI (1996) (Civil aviation, Australia)	The procedures and rules governing safety within an organization are a reflection of its safety climate, which is centered around employees perceptions of the importance of safety and how it is maintained within the workplace.
Cheyne, Cox, Oliver, & Thomas (1998) (Manufacturing, UK & France)	Safety climate can be viewed as a temporal state measure of culture, which is reflected in the shared perceptions of the organization at a discrete point in time.
Dedobbeleer & Beland (1991) (Construction, US)	Safety climate is viewed as an individual attribute, which is composed of two factors: management's commitment to safety and workers' involvement in safety.
Flin, Mearns, Gordon, & Fleming (1998) (Offshore oil and gas, UK)	Safety Climate refers to the perceived state of safety of a particular place at a particular time. It is therefore relatively unstable and subject to change depending on features of the operating environment.
Flin, Mearns, O'Connor, & Bryden (2000) (Review of various industries, only one aviation related study)	Safety climate is the surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time.
Griffin & Neal (2000) (Manufacturing and Mining, Australia)	Safety climate should be conceptualized as a higher order factor comprised of more specific first order factors. 1st order factors of safety climate should reflect perceptions of safety-related policies, procedures and rewards. The higher order factor of safety climate should reflect the extent to which employees believe that safety is valued within the organization.
Hofmann & Stezer (1996) (Utilities, US)	Safety climate is operationalized as perceptions regarding management's commitment to safety and worker involvement in safety related activities

Mearns, Whitaker, Flin, Gordon, & O'Connor (2000) (Offshore oil, UK)	Safety climate is defined as a "snapshot" of employees' perceptions of the current environment or prevailing conditions, which impact upon safety.
Minerals Council of Australia (1999) (Minerals, Australia)	Safety climate refers to the more intangible issues in the company, such as perceptions of safety systems, job factors and individual factors.
Yule, Flin, & Murdy (2001) (Conventional power, UK)	Safety climate is defined as the product of employee perception and attitudes about the current state of safety initiatives at their place of work.
Zohar (1980) (Manufacturing, including metal, food, chemical and textile, Israel)	Safety climate is a particular type of organizational climate, which reflects employees' perceptions about the relative importance of safe conduct in their occupational behavior. It can vary from highly positive to a neutral level, and its average level reflects the safety climate in a given company.
Zohar (2000) (Manufacturing, Israel)	Group level safety climate refers to shared perceptions among group members with regard to supervisory practices.

Based on these common themes among safety climate definitions, a general definition can also be derived:

> Safety climate is the temporal state measure of safety culture, subject to commonalities among individual perceptions of the organization. It is therefore situationally based, refers to the perceived state of safety at a particular place at a particular time, is relatively unstable, and subject to change depending on the features of the current environment or prevailing conditions.

Safety Culture Versus Climate: A Conceptual Rejoinder

The distinction between safety culture and safety climate appears to be loosely analogous to the distinction that has long been made in the personality literature between psychological states verses traits (Spielberger, 1966). In other words, a person's behavior can be influenced by both circumstantial factors that elicit psychological reactions (i.e., states), such as anxiety or anger, as well as by their enduring personality characteristics (i.e., traits), such as introversion/extroversion. Therefore, repeated observations or interactions with an individual may often be required in order to decipher his or her enduring personality characteristics

(consistent ways of reacting across situations), independent of temporary states elicited by specific contextual factors.

Similarly, safety culture, as defined in the literature, is commonly viewed as an enduring characteristic of an organization that is reflected in its consistent way of dealing with critical safety issues. On the other hand, safety climate is viewed as a temporary state of an organization that is subject to change depending on the features of the specific operational or economic circumstances. Therefore, just like personality researchers, safety researchers have attempted to identify key indicators of organizational safety culture and to develop methods for assessing the extent to which these key organizational features are consistent across time and situations.

Organizational Indicators of Safety Culture

Given the numerous definitions of safety culture that have been proposed in the literature, it is not surprising that there is little consensus as to the exact number of indicators that reflect an organization's safety culture. Indeed, numerous organizational indicators have been proposed, with some estimates ranging from as few as two to as many as 19 (Flin et al., 2000). Again, the numerous inconsistencies and often idiosyncratic labeling of these indicators creates difficulty in reconciling the variety of organizational indicators identified in previous reports. Nonetheless, a closer inspection of these various reports suggests that there are at least five global components or indicators of safety culture. They include organizational commitment, management involvement, employee empowerment, reward systems, and reporting systems.

Organizational commitment. An organization's upper-level management has long been recognized as playing a critical role in promoting organizational safety culture (Dedobbeleer & Beland, 1991; Fleming, Flin, Mearns, & Gordon, 1996; Flin et al., 2000; Gordon, Flin, Mearns, & Fleming, 1996; Meshkati, 1997; Yule, Flin, & Murdy, 2001; Zohar, 1980, 2000). Organizational commitment to safety refers to the extent to which upper-level management identifies safety as a core value or guiding principle of the organization. An organization's commitment to safety is therefore reflected in the ability of its upper-level management to demonstrate an enduring, positive attitude toward safety, even in times of fiscal austerity, and to actively promote safety in a consistent manner across all levels within the organization. When upper-level management is committed to safety, it provides adequate resources and consistently supports the development and implementation of safety activities (Eiff, 1999). An organization's commitment to safety is therefore ultimately reflected by the efforts put forth to ensure that every aspect of its operations, such as equipment, procedures, selection, training, and work schedules, are routinely evaluated and, if necessary, modified to improve safety.

Management involvement. Through participation in the day to day operations, both upper- and middle-level management communicate to their employees an attitude of concern for safety that subsequently influences the degree to which employees comply with operating rules and with safe operating practices (Eiff, 1999). Within the context of safety culture, "management

involvement" refers to the extent to which both upper- and middle-level managers get personally involved in critical safety activities within the organization. Management involvement in safety, therefore, is reflected, by managers' presence and contribution to safety seminars and training, their active oversight of safety critical operations, their ability to "stay in touch" with the risks involved in everyday operations and the extent to which there is good communications about safety issues, both up and down the organizational hierarchy.

Employee empowerment. Errors can originate at any level within an organization. However, frontline employees (e.g., pilots) often represent the last defense against such errors, thereby preventing accidents (Eiff, 1999). Organizations with a "good" safety culture empower their employees and ensure that employees clearly understand their critical role in promoting safety. Specifically, empowerment refers to an individual's perceptions or attitudes as a result of a delegation of authority or responsibility by upper-level management. An empowered attitude can lead to increased motivation to "make a difference," to go beyond the call of duty for organizational safety and take responsibility for ensuring safe operations (Geller, 1994). Within the context of safety culture, employee empowerment means that employees have a substantial voice in safety decisions, have the leverage to initiate and achieve safety improvements, hold themselves and others accountable for their actions, and take pride in the safety record of their organization.

Reward systems. One of the key components of an organization's safety culture is the manner in which both safe and unsafe behavior is evaluated and the consistency in which rewards or penalties are doled out according to these evaluations (Reason, 1990). A fair evaluation and reward system is needed to promote safe behavior and discourage or correct unsafe behavior (Eiff, 1999). An organization's safety culture, therefore, is reflected by the extent to which it possesses an established system for reinforcing safe behaviors (e.g., through monetary incentives or public praise and recognition by management and peers), as well as systems that discourage or punish unnecessary risk taking and unsafe behaviors. However, an organization's safety culture is signified, not only by the existence of such reward systems, but also by the extent to which the reward systems are formally documented, consistently applied, and thoroughly explained and understood by all of its employees.

Reporting systems. "One of the foundations of a true safety culture is that it is a reporting culture" (Eiff, 1999, pg. 17). An effective and systematic reporting system is the keystone to identifying the weakness and vulnerability of safety management before an accident occurs. The willingness and ability of an organization to proactively learn and adapt its operations based on incidents and near misses before an accident occurs is critical to improving safety. Another important facet of a good reporting culture is "the free and uninhibited reporting of safety issues that come to the attention of employees during the course of their daily activities" (Eiff, 1999, pg. 19). Therefore, it is important to ensure that employees will not experience reprisals or negative outcomes as a result of using the reporting system, as well as to have a structured feedback system to inform the employees that their suggestions or concerns have been reviewed and what

kind of action will be taken to solve the problems. In summary, an organization with a good safety culture should have a formal reporting system in place and one that is actually used comfortably by employees. A good reporting system allows and encourages employee to report safety problems, and it also provides timely and valuable feedback to all employees.

Assessing Safety Culture

There are a variety of methods that have been used to assess safety culture and safety climate. Unfortunately, however, there are no standardized or "off the shelf" tools that can be used across domains or even within a single domain (Cox & Flin, 1998). Nonetheless, approaches to assessing safety culture should take into account several critical issues, including the measurement method, level of analysis, and implementation constraints.

Methods of measurement. Tools for assessing safety culture can be classified as either qualitative or quantitative methods. Qualitative methods include employee observations, focus group discussions, historical information reviews, and case studies (Wreathall, 1995). With qualitative measurement strategies, organization members usually serve as informants, who interact directly or indirectly with researchers, using their own terms and concepts to express their point of view, as in focus group discussions (Rousseau, 1990). Therefore, through qualitative measurement, intensive and in-depth information can be obtained using the focal group's own language.

In contrast, quantitative approaches attempt to numerically measure or score safety culture using procedures that are often highly standardized and calibrated, such as highly structured interviews, surveys and questionnaires, and Q-sorts (Wreathall, 1995). In quantitative measurement strategies, organization members usually serve as respondents who react to a standard set of stimuli or questions provided by the researchers (Rousseau, 1990). Quantitative methods are relatively easy to use in cross-sectional comparisons, generally simple to implement in different organizations and by other researchers, and straightforward to interpret according to a common, articulated frame of reference (Wreathall, 1995).

There appears to be agreement among researchers that both qualitative and quantitative methods have unique potential for assessment and theory testing and that there is a benefit to combining methods to gain a comprehensive understanding of safety culture. Nonetheless, quantitative approaches, especially surveys of individuals' responses, are often more practical, in terms of time and cost-effectiveness (Wreathall, 1995). Consequently, surveys and questionnaires have been widely used to assess safety culture within a variety of industries, such as nuclear power, chemical, construction, transportation, and manufacturing. However, few measures of safety culture have been developed for the aviation industry, with the notable exceptions of military aviation (e.g., Ciavarelli & Figlock, 1996).

Level of assessment. One of the major questions that also arises when considering the development of tools for assessing safety-culture is whether the assessment should be at global or local levels. That is, should the organization as a whole be assessed (global) or do assessments need to occur within the organization's various sublevels, such as divisions or departments (local)? For example, within the context of aviation, some researchers (e.g., Reason, 1997; Helmreich & Merritt, 1998) have suggested that cultures vary considerably across operational settings such as the flight deck, maintenance, and ramp environments. The same is likely to be true across various departments within other types of organizations as well. Therefore, separate assessment instruments may be needed to examine the different units within an organization. Consequently, it is important to identify the level(s) of assessment that is to be performed in order to provide a frame of reference and to make use of standardized descriptors (Rousseau, 1990; Wreathall, 1995; Cooper, 2000). Failure to do so may create problems in obtaining consensus across respondents (Rousseau, 1990).

Assessment procedures and implementation. Assessment procedures and implementation issues revolve around two primary questions. The first question concerns who will be involved in the assessment processes. In other words, will the assessment method need to be implemented by an individual, such as a safety representative within an organization or an individual government inspector, or by a team of safety personnel? The answer to this question, however, may be a function of many factors. For example, organizational and union representatives may need to take part in the assessment process, not only to provide the manpower needed to perform the task, but also to make the process acceptable to industry and organizational personnel. However, there may be times when an individual may have to implement the system alone, either because of the format of the assessment method used, or because the organization that is being evaluated is too small to provide the additional representatives needed to perform the task.

Additionally, a second question pertaining to implementation is the issue of *what* will be done with the information that is ultimately gathered. For example, will the assessment instrument be used to determine the need for enforcement action by a regulatory body, and hence, need to be tailored around federal regulations? Or, will the information gathered be used primarily for the purposes of targeting non-regulated organizational factors? If so, the instrument should be designed to help highlight possible areas of voluntary improvement by the organization Of course, there is always the potential that an instrument may be required to serve both functions.

Interaction among factors. Cleary the issues and concerns about assessing safety culture are not independent factors that can be considered in isolation. Indeed, the approach taken to address one issue may directly affect or constrain the approach that can be taken to address another. The relationships between *who* implements the assessment program (e.g., either an individual inspector or team of safety professionals), the level of assessment attempted (e.g., global vs. local) and whether the approach adopted is actually completed by the organizational employees (self evaluation) or an outside observer (direct observation) are issues that need to be

considered together. For example, a government inspector (individual evaluator) would be ill-equipped to attempt an assessment of an entire organization (global approach) using a direct observation approach (e.g., performing safety audits of each department). Rather, he or she might be better served by using of an employee self-assessment approach, such as a safety questionnaire, that allows employees throughout the entire organization to give their personal assessment or evaluation of certain organizational variables. Likewise, a local level assessment using a direct observation approach (e.g., check rides in an airplane) may not be suitable for a team of evaluators. Clearly, there are numerous issues and constraints that need to be considered when developing an assessment program.

Validating measurement tools. Before a measurement instrument becomes widely implemented, its validity should be tested. While there are multiple types of validity, two types of validity are often discussed in the safety culture literature. These are construct and discriminant validity. Construct validity refers to the extent to which an assessment instrument actually measures what it is intended to be measure (e.g., Cook & Campbell, 1979). Therefore, instruments that presumably measure safety culture need to demonstrate that they reliably assess or tap into the multiple dimensions of an organization that reflect its safety culture. Furthermore, in order for such tools to be differentiated from instruments assessing safety climate, safety culture assessment instruments need to demonstrate that the variables being assessed are generally enduring within the organization. Such demonstrations might be accomplished either through repeated applications of the assessment over time, or the phrasing of certain questions during an interview or on a particular survey reflecting an enduring organizational trait (e.g., is safety repeatedly discussed during different training exercises?).

The discriminant validity of a safety culture measurement tool refers to its power to differentiate between organizations or groups that actually poses different levels of safety. One of the most obvious criteria for differentiating between organizations is the number of accidents, incidents and near misses experienced by an organization. However, within high-reliability organizations, such as commercial aviation, accidents and incidents are so infrequent that they produce a highly skewed distributed that cannot be used statistically to differentiate different levels of safety across organizations. Griffin and Neal (2000) in their search for other sources of objective safety data have proposed using safety compliance behavior and employee participation in voluntary safety activities in meetings. Still, given the difficulty in obtaining objective validation criteria, most studies have relied on the use of subjective data, such as employees' perceived risk of the working environment or expert ratings of an organization's safety level. Additional research is needed, however, to determine the extent to which these other general sources of safety data actually relate to operational safety.

Summary and Conclusion

Recent years have witnessed a growing concern over the issue of safety culture within aviation and other complex, high-risk industries. The purpose of the present review was to

summarize and integrate the numerous reports and studies that have been conducted to define and assess safety culture, as well as the highly related concept of safety climate. Results of the review revealed that most documented efforts to define and assess safety culture have arisen outside the aviation industry. Furthermore, there exists considerable disagreement among safety professionals, both within and across industries, as to how safety culture should be defined and whether or not safety culture is inherently different from the concept of safety climate. A synthesis of theses different perspectives was conducted and hybrid definitions were proposed which conceptualize safety climate as a temporal indicator of a more enduring safety culture. A discussion of key indicators of an organization's safety culture and the various methods commonly used to assess these factors was provided. A summary of the issues that must be considered when implementing a safety-culture assessment program was also presented. Hopefully, this review will enable researchers and safety professionals to better understand and assess safety culture and that it will facilitate the sharing of information and strategies for improving safety culture across organizations and industries.

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