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Modeling attitudes and perceptions as predictors for changing safety margins during organizational change

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ABSTRACT

This study describes the relations between different dimensions of leadership commitment, safety climate and attitudes toward change, and how these affect employee perceptions of safety during organizational change in a high risk environment. We collected data from a European national air navigation services provider during a volatile 3-year corporatization process that ended in the sudden collapse of a deliberate change implementation project. Surprisingly, despite visible signs of internal and external stress caused by the volatile and disruptive change process, we did not observe any change in the traditional safety metrics of incident and accident reporting during the study. The study is based on a large survey ($n = 422$) of individual attitudes and perceptions of safety climate, perception of leadership commitment to safety, attitudes to organizational change, and perception of safety. The data support the claim that perception of safety at least, in part, depends on individual perceptions of the leadership's commitment to safety, and the safety climate in place at a given point in time. The model shows how employee perceptions of the leadership's commitment to safety and safety climate are related to both attitudes toward change, and to perceived safety.

1. Introduction

The purpose of this study is to present an alternative approach for measuring safety in a high reliability organization during a period of deliberate organizational change using a combination of leadership survey data and safety climate survey data to test a conceptual structural equation model as a leading indicator of eroding organizational safety—over time. The findings of this article are based upon data gathered during a 3-year longitudinal case study of a national air navigation services provider during a turbulent corporatization initiative that ended in collapse. Yet, despite the intense internal conflict that raged within the company over a 2-year period, we did not observe any change in traditional safety metrics (Lofquist, 2008, 2010).

Various studies have used safety climate survey responses to describe employee attitudes based on the underlying contextual architectures (Zohar, 1980; Cox and Cox, 1991; Cox and Flin, 1998; Cheyne et al., 1999). Safety climate has been described as a surface feature, or manifestation, of an underlying safety culture that provides an understanding of the attitudes and perceptions of a workforce at any given point in time (Schneider and Gunnarson, 1991; Cox and Flin, 1998). Appropriately, Flin et al. (2000) have described safety climate as a snapshot of the state of safety in an organization, and that it represents the underlying safety culture of a group, unit or organization (p. 178). In addition, it has been argued that safety culture, by its nature, is difficult to operationalize within a measurement instrument (Hale and Hovden, 1998). However, safety climate is a more valid measure using psychometric questionnaire studies. This also indicates that safety climate, in contrast to safety culture, is more sensitive to local conditions and will, thereby, provide a more timely measure of eroding conditions. One area of increasing interest in measuring the latent risk in emerging safe systems is the use of proactive measurement techniques that can provide leading indicators that supplement the traditional measures of trial and error learning.

This article considers an alternate approach to safety measurement in High Reliability Organizations (HROs) during periods of deliberate organizational change where the traditional measures of incident and accident reporting have historically failed to capture the latent risk evolving in safe systems prior to disaster. Safety is an important, and often vital, outcome for companies operating in high-risk industries. But the concept of safety has proven difficult to define, and even more difficult to measure or predict using the traditional safety metrics of incident and accident reporting (Lofquist, 2008, 2010). This is particularly true for high-risk organizations that rely heavily on the human element in socio-technical systems, sometimes referred to as High Reliability Organizations

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(Rochlin et al., 1987; Weick, 1987; Roberts, 1990; Weick and Roberts, 1993; Weick and Sutcliffe, 2006).

Measuring safety becomes even more challenging under periods of deliberate organizational change when stable safety processes are stressed in unexpected ways (Turner, 1976). High profile theoretical and empirical studies examining disastrous events, such as: Three Mile Island (Perrow, 1984), the Tenerife Air Disaster (Weick, 1993), the Challenger (Vaughan, 1996) and Columbia (Gehman, 2003) Space Shuttle accidents, have all concluded that organizational change in high-risk industries can adversely affect emerging safe systems. This often leads to unexpected failure. Yet, the adverse effects of change on safety processes often go unnoticed mainly due to the subtle nature of safety as an emergent quality of a complex socio-technical system (Hollnagel, 2006). This erosion of safety processes often manifests itself gradually, over time, and this has been described in terms, such as: incubation periods (Turner, 1976), procedural and organizational drift (Rasmussen, 1994; Elsmore, 2001; Dekker, 2006), cultural deviance (Vaughan, 1996), or even the formation of latent conditions (Reason, 1990) that eventually lead to a disastrous event. However, these same studies also revealed that indications of eroding safety processes were, in fact, both present, noticed and even reported upon within the organizations involved without triggering corrective action from the leadership responsible for safe outcomes prior to failure (Vaughan, 1996; Gehman, 2003).

One explanation for leaders not reacting to these warnings could be that they fell well outside of the traditional indicators upon which they were focusing, specifically, the lagging historical indicators of incident and accident reporting. Yet, as organizations become more reliable, and even achieve ultra-safe levels of performance (Amalberti, 2001), nothing to measure (Weick, 1987), at least not through using traditional metrics, leaves organizational leaders with no proactive indicators upon which to evaluate the true state of an evolving safe system. This is particularly true during periods of deliberate organizational change where strong organizational safety cultures might mask, and even partially compensate for deteriorating safe processes. Many techniques focus on studying organizational culture, and leveraging safety climate as a proactive measure (Zohar, 1980). Safety climate, as a proactive indicator, has been studied for over 35 years, but there is still little agreement as to the best mix of cultural dimensions to be included in a safety climate model (Williamson et al., 1997). However, it has been argued that safety climate questionnaires have not been particularly successful in exposing the core of an organizational culture (Guldenmund, 2007), and have also been criticized for lacking a normative framework (Grote and Kunzler, 2000). By normative, Grote and Künzler explain that "cultural analyses allow a description of norms and assumptions more or less shared by the members of the social system and more or less supportive of achieving the system's expressed goals, but no implications about whether the culture is 'good' or 'bad' can be derived" (p. 135). Others, however, have found that there is evidence that a strong safety climate contributes to better safety performance over time (Powell et al., 1971; Zohar, 1980; Glendon and McKenna, 1995; Diaz and Cabrera, 1997), which supports the view that safety climate data, as a snapshot in time, is a potentially important contribution for evaluating evolving safety states within high-risk industries. This is particularly true during periods of organizational change where lagging indicators often miss the signs of latent risk in safe systems prior to failure. This is especially relevant for High Reliability Organizations undergoing strategic change processes where safety climate indicators will react more quickly than the underlying organizational culture itself.

There is growing interest in understanding the influence of organizational change on safety outcomes due to factors such as: the leadership's commitment to safety, safety culture and safety climate (Ciavarelli and Crowson, 2004). However, there is currently little research focusing upon the direct impact of strategic change on organizational safety. The purpose of this article is to increase our knowledge about the effects of change on safety in "ultra safe" industries by presenting and evaluating "other types of indicators," and to show how safety processes are, in fact, adversely affected in a live case, and which organizational factors are most influential in affecting safety levels.

2. Model and hypotheses

2.1. The role of employee attitudes and perceptions in safety behavior

It is clear from the safety literature that employee attitudes and perceptions have a positive relationship to safety behavior (Schneider, 1975; Zohar, 1980; Schneider and Gunnarson, 1991; Cox and Flin, 1998). However, capturing these changes in attitudes and perceptions during periods of change are often missed in ultra safe systems were failure is often avoided due to large safety margins, and other compensating mechanisms (Lofquist, 2010). The purpose of this study was to design a measurement model that would capture the relationships between different safety concepts within a live change context before an actual failure occurred.

The conceptual safety measurement model used in this study, depicted in Fig. 1, consists of two (exogenous) latent independent variables—perception of the Leadership's Commitment to safety (LC) and perception of Safety Climate (SC), one (endogenous) mediating variable—Attitude towards Change (AC), and one (endogenous) dependent variable—Perception of Safety (PS).

The conceptual safety measurement model in Fig. 1 depicts the four latent constructs of interest in this study, and the five hypothesized causal relationships having direct and indirect causal relationships to the main dependent variable – perception of safety.

2.2. Perception of safety (PS)

There is little agreement in the literature for a universal definition of safety. For this study, we have used a variation of the definition provided by Hollnagel (2008) by focusing on safety as a process that produces outcomes that are safe. But, since these processes are embedded within complex socio-technical systems, as represented by High Reliability Organizations, they cannot be measured directly but only indirectly through other indicators. Though there is no agreement on a definition of safety, there is agreement in the literature that individual perceptions of safety guide cognitive processes, and have a direct influence on behavior (Rasmussen, 1986, 1990; Hollnagel, 1998, Mearns et al., 2003; Flin et al., 2000). We argue that these changes in behavior have a direct effect on safety performance. All of the hypotheses below imply either direct or indirect positive causal influences between the

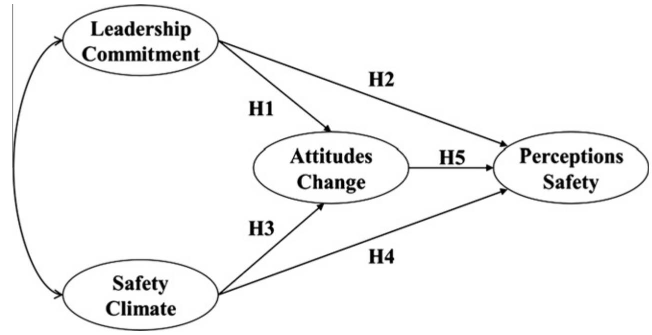

Fig. 1. Safety management model.

latent constructs and the dependent variable Perception of Safety (PS), and it is the strength of these causal influences, together, that affect safety behavior. This is reflected in the safety culture literature where studies have shown that good safety cultures, described as cultures with strong, supportive attitudes and perceptions, perform better than bad safety cultures (Gordon et al., 2007).

2.3. Leadership commitment to safety (LC)

Zohar (1980) was one of the first to examine the implications of safety climate on safety results in organizations based on a study of 20 industrial organizations in Israel. In his determination of safety climate dimensions, Zohar focused primarily on five areas. One of the most consistent findings was the importance of leadership commitment to safety as one predictive measure for safety performance (Zohar, 1980). However, though Zohar focused on leadership commitment directly, it is clear that leadership commitment can also be measured from the perspective of the receiver (employee) and not necessarily the sender (leader).

Although follow-up safety climate studies (e.g. Flin et al., 2000; Gordon et al., 2007) have found other prioritizations of appropriate measurement dimensions, the five original areas of focus are still valid: management commitment to safety, safety training, communication, environmental control and good housekeeping, and a stable workforce (Zohar, 1980). Yet, the literature also reflects that the usefulness of these dimensions is context specific, and, therefore, needs to be matched to the context within which they are employed.

The leadership's commitment is reflected in both what they say and what they do (Schein, 2004). A strong perception of the leadership's commitment to safety positively affects employee confidence that safety is indeed a primary focus. This leads to increased vigilance and mindful actions under normal operating conditions (Weick and Sutcliffe, 2001, 2006), but these are potentially more important during periods of change. Managers' decisions may be hard to understand, and they may be perceived as contradicting explicit goals as e.g. commitment to safety. This creates cognitive dissonance among employees (Festinger, 1957), which triggers sensemaking processes. Inconsistencies between words and actions can lead to distrust, which will have a negative effect on perceptions of management's commitment to safety. Negative perceptions of management's commitment to safety will have potentially negative effects on mindful action and reporting. When organizations undergo changes, these may be hard to understand, and then people engage in discussions to make sense of changes (Weick, 1995). The outcome of these discussions influences how employees perceive managements' commitment to safety, and how they adapt to their perceptions in their everyday operations. Since safety is often expressed as the organization's number one goal, the leaders will always communicate this. However, it may be an institutional goal that is not properly analyzed in terms of other organizational processes like Brunsson's (1989) hypocritical organizations.

Thus, individuals may perceive that the leadership has other more important issues, and that safety is cared for only in a symbolic manner without true conviction and emphasis. In this study, it became clear that individual perceptions of the leadership's commitment to safety, and not necessarily the leader's own commitment to safety through words and actions, had the most influence on perceptions of safety at the individual level. Because of this finding, we decided to isolate individual perceptions of the leadership's commitment into its own concept within the SEM model.

Strong positive perceptions of the leadership's commitment to safety will reassure individuals at the operational level that the leadership is indeed, committed to safety. All changes will be analyzed for potential risk, and compensating measures will be taken, if required, so that safety processes will not be compromised. This will encourage individuals at the operational level to be more mindful of potential risks, and take corrective action at an early stage through reporting. Conversely, negative perceptions of the leadership's commitment to safety will have the opposite effect.

H1. If employees perceive that the leadership has high (low) commitment to safety, they perceive safety as high (low).

2.4. Safety climate (SC)

High-risk organizations, and High Reliability Organizations, in particular, develop strong safety cultures to ensure safe outcomes (Rochlin et al., 1987; Roberts, 1990; Weick and Roberts, 1993; Weick and Sutcliffe, 2001, 2006). But these cultures are complex, and evolve over time, and deficiencies are usually only discovered after catastrophic events (Shrivastava, 1987; Vaughan, 1996; Gehman, 2003; Johnson, 2004). Often, these results are attributed to gradual changes in employee attitudes and perceptions toward safety, and numerous studies have found that employee perceptions of safety directly affect cognitive processes and safety behavior (Diaz and Cabrera, 1997; Flin et al., 2000; Rundmo, 2000; Guldenmund, 2007). Most of these studies focus on changes in safety culture over time, but this can only be done in retrospect. Even though there has been a great deal of interest in the study of safety cultures (Pidgeon, 1997; Cheyne et al., 1999; Mearns et al., 2001), using a cultural approach has been criticized for lacking a normative framework (Grote and Kunzler, 2000), in other words lacking predictive quality.

There is little agreement in the literature as to the most important mix of dimensions for measuring safety climate, but most studies rank the leadership's commitment to safety among those dimensions having the strongest effect (Zohar, 1980, 2003; Diaz and Cabrera, 1997; Flin et al., 2000). Recently, however, there has been a shift in focus from measuring safety cultures to safety climates which have been described as the surface manifestation of the underlying culture, and as such, are observable directly using a combination of psychometric and qualitative approaches (Zohar, 1980; Flin et al., 2000; Ciavarelli, 2003; Gordon et al., 2007). These methods are often conducted in the form of safety audits with the intent of revealing deficiencies in developing safety climates before disaster strikes. This allows leaders to take proactive corrective actions before a safe system erodes to a level where disaster is essentially inevitable. Ek et al. (2007) support the focus of this study by arguing that change processes based on grounded theory from high-profile accidents, can have a negative effect on existing safety cultures, the foundation of safety related work, and ultimately, on safety. However, the effects of change do not have to be negative. If employees perceive changes as an emphasis on improving safety, they will develop a positive attitude towards change. We will argue that improvements in the latent constructs measured relative to safety perceptions will improve safety performance over time.

Safety climate, as a reflection of "the way we do things around here" (Deal and Kennedy, 1982; Schein, 2004) has several interactive elements that affect perceptions. Emphasis on training, reporting systems, internal communications mechanisms, technology, and personal relationships vary by location, and over time. Though many of these elements are externally generated, many evolve differently in local settings. Accordingly, Safety Climate is expected to have a positive causal relationship to Perceptions of Safety.

H2. If employees feel there is a positive (negative) safety climate, they will also perceive safety is high (low).

2.5. Attitude toward change (AC)

Although there is a general lack of academic study on High Reliability Organizations undergoing deliberate organizational change, the importance of the leadership's role in change outcomes is clear in the change literature (Pettigrew, 1985; Aldrich, 1999; Isabella, 1990; Lines, 2005). As deliberate change tends to activate strong emotions, both positive and negative, which are deeply associated with organizational culture, it is important that the leadership considers effects that can produce strong reaction to change (Piderit, 2000). Since safety is a primary focus in high-risk industries, it is natural that the leadership's commitment to safety in a deliberate change process will have a powerful effect on individual perceptions toward change, and this is also reflected in the safety culture/climate literature (Flin et al., 2000; Ek et al., 2007). Grote (2007) argues that even leadership actions designed to minimize uncertainty are limited due to the system's reduced capability to adequately act in the face of requirements stemming from internal and external disturbances of normal operations (p. 639).

H3. If employees perceive leadership's commitment to safety (LC) as high (low), they will have a positive (negative) attitude toward change (AC).

"Every organization has a safety culture (or perhaps a series of sub-cultures), and that culture can be expected to affect safety" (Hopkins, 2006, p. 876). This applies equally to safety climates that are the surface manifestations of culture itself. But we can argue that this is even more evident under conditions of deliberate organizational change in High Reliability Organizations, particularly if individual units or sub-cultures experience different levels of change within the same organization. The question is whether employee perceptions of safety climate react only to changes related directly to safety, or if this reaction also includes other organizational issues. In this regard, change not considered directly linked to safety would be interpreted with skepticism. Accordingly, it is expected that safety climate conditions will have a positive causal relationship to attitudes toward change.

H4. If employees perceive safety climate (SC) as good (bad), they will have a positive (negative) attitude toward change (AC).

This hypothesis is particularly relevant during change processes where potentially conflicting goals that are not adequately communicated to the employees, create mistrust and skepticism toward the change process. This can lead to increased risk-taking based on the premise that the leadership is really not focused on safety but other performance measures, such as cost savings. Schneider (1975) argues that these individual perceptions serve as a frame of reference for guiding appropriate and adaptive behavior. Although this change in behavior may not produce immediate measurable effects on the classic indicators of incident and accident reporting, safety processes will be affected over time. Here it is important to remember that it is the individual perceptions of the leadership's commitment to safety, and not necessarily the leaders' own perceptions of their commitment, that affect cognitive processes, sensemaking and behavior.

Attitudes toward change have a direct positive effect on change implementation, and these attitudes are often formed early in a change process (Lines, 2004). Negative reactions stemming from emotionally enabled bias associated with change, are often manifest by clashes between an organization's culture and its organizational leadership, and can significantly affect strategy implementation (Dasborough et al., 2003), therefore:

H5. If employees have a positive (negative) attitude towards change (AC), they will perceive safety (PS) as high (low).

Attitudes toward change, even in organizations unfamiliar with deliberate organizational change, are expected to have a positive causal affect on change implementation, and correspondingly, is expected to have a positive causal affect on perception of safety. However, negative attitudes toward change will lead to loss of trust, and, in the worst case, resistance, and perception of safety as reduced.

3. Methods

3.1. Research strategy and sample

This study is based on a 3-year longitudinal case study of a European air navigation services provider (ANSP) during a volatile organizational change process that ended in collapse. Yet, at no time were there any indications that safety had become better or worse, at least not in the form of incident and accident reporting. The study focused on four separate air traffic control centers (ATCCs) that experienced a common change process but with different outcomes. Three separate quantitative data sets were collected to test the conceptual structural equation model and the effects on safety during the change process.

The first data set is an internal leadership questionnaire that measures perceptions of leadership commitment and attitudes towards change taken 3 months before the management announced the organizational change process. The second data set is a replication of the first conducted 2 years later, midway through the planned change process, using the same ATCCs but not necessarily the same respondents. At the time of the second survey, one of the original ATCCs had been closed down and merged with a second ATCC. Accordingly, there are only three ATCCs remaining during the second survey.

The third data set is a national safety climate survey collected 4 months after the second leadership survey. We used this dataset to test the conceptual structural equation model (SEM). Quantitative data come from structured questionnaires. The objective of the safety questionnaire was to test the perceptions of safety among the various professional groupings within the civil aviation industry on a national level, and the relationships between organizational climate, organizational change, and the leadership's role in the context of change, and specifically, the leadership's focus on safety issues in a changing environment (TØI, 2005). For this study, we used only data from the group responsible for national air navigation services, specifically air traffic controllers and air traffic controller assistants. Of the total population of 639 air traffic controllers/assistants that received questionnaires, 422 responded for a response rate of 66%.

3.2. Measures

Our safety measurement model includes a combination of constructs taken from the safety climate literature and organizational change literature that affect perceptions of safety. We tested the conceptual model using Lisrel 8.71 (Jöreskog and Sörbom, 1999). A departure from the literature is the addition of the moderating variable Attitude toward Change (AC), which was one of the focus areas in this study. An independent research institute designed and distributed the questionnaire. We measured dependent and independent variables using multi-item measures based on a 5-point Likert scale. The questionnaire contains a composite of questions forming modules from corresponding international civil aviation databases as well as specific interest areas requested by the national civil aviation regulatory agency. The institute took Questions pertaining to safety climate primarily from the Global Aviation Information Networks (GAIN) "Operator's flight Safety Handbook" (GAIN, 2001).

The study questionnaires measure responses across the entire aviation industry using 25 common safety climate items from the Operator's Flight Safety Handbook (Gain, 2001). The institute tailored other portions of the questionnaire specifically for the eight individual professional groupings within the civil aviation industry, including: air traffic controllers and ATC assistants, pilots, cabin crew, ground crew, engineers, technicians, leaders, and regulatory agencies. The air traffic controller and ATC assistant questionnaire consisted of 171 items broken down into four broad areas of interest: leadership, safety climate, organizational change, and safety.

Upon initial examination of the data, we found that many questions were unclear, or not relevant, for the constructs used in this model, so we reduced the number of questions to 72 sorted into the four constructs of interest. The leadership commitment and safety climate measures are based on the five dimensions of safety climate as described by Zohar (1980) but modified slightly to include later research (Flin et al., 2000; Gordon et al., 2007; Flin, 2007), and to reflect the context of change within a High Reliability Organization (HRO). Specifically, there is a stronger focus upon the effects of human factors on safety performance that Weick et al. (1999) argue are the prime causes of accidents in HROs, rather than purely technical failures. This is necessary due to the special pivotal role that air traffic controllers occupy that puts them in a special position in relationship to safety outcomes. This also improves the fit of the constructs to reflect the socio-technical nature of HROs, and more appropriately weights the socio-technical aspects in the interactive phase of the safety management model. Appendix A shows the individual items for each concept that we used to test the model.

3.3. Descriptive statistics—examination of the data

The first step in analyzing multivariate data is to examine the data. Hair et al. (1995) warn that the use of multivariate data, due to its diverse character, can be quite powerful, but can also tempt a researcher to substitute this technique for necessary conceptual development (p. 21). However, once the conceptual development is complete, the burden then shifts to understanding, analyzing and interpreting more complex results. One danger for the validity of the model is to ensure that the data satisfies the statistical requirements and assumptions needed to support the conceptual model. Accordingly, as a first step we conducted a graphical examination of the data to achieve a better understanding of the data. During the second step we conducted a missing data analysis. Finally, we inspected the statistical assumptions of the distributions.

3.4. Graphical examination of the data

We used SPSS and Lisrel 8.71 to conduct an initial evaluation of the data. Histograms and frequency tables gave a better understanding of the distributions and interrelationships of the 72 selected items from the questionnaire. This initial analysis revealed no particular visual non-normality in the data other than some potentially problematic levels of skewness and kurtosis for some items but no items were excluded for this reason during the initial screening. In fact, we expected some skewness and kurtosis due to the intense turbulence experienced in the company during the period we collected the data.

3.5. Missing values analysis

Of the original 72 items chosen for evaluation in the database, 1 item demonstrated a significant number of missing responses (Chng 14), and we excluded this item from the model. Otherwise, we did not observe any clear pattern for missing data in the remaining items, and none of the items used in the final model exceeded 2.5% missing values. Accordingly, to maintain the size of the database, we chose to replace missing values with the mean of the other respondents.

3.6. Statistical test to assess normality

To check for violations of the normality assumptions, we ran a rule of thumb test to check for skewness and kurtosis using Lisrel 8.71. The literature recommends that if the data exceeds certain critical values or limits indicating non-normality, this might bias the results and influence the model fit (Bagozzi and Yi, 1988; Hair et al., 1995). If data proves to fall outside of normal limits, they should either be deleted before proceeding with the analysis or evaluated using alternative methods. A summary of the descriptive statistics provided by Lisrel 8.71 is shown in Table 1.

Though there is differing guidance in parametric inference procedures regarding acceptable cut-off limits for skewness and kurtosis, particularly in large samples, Hair et al. (1995) have proposed a cut-off of ±2.58 indicating that the assumption of normality can be rejected at the 0.01 probability level. The results in Table 1 show that two of the 15 items in the safety measurement model (AC 1 and AC 3) fall outside of this range and appear to be potentially problematic for both skewness and kurtosis. For this reason we have chosen to use a nonparametric inference technique as suggested by Bhattacharyya and Johnson (1977). This approach is especially useful in situations where we ask individuals to express responses that are difficult to measure on a specific and meaningful numerical scale or when we ask individuals to express their views on a 5-point scale where 1 represents strongly disagree and 5 represents strongly agree (p. 506). In these cases, we prefer to use ordinal data because only the order of the numbers is meaningful, and the distance is not necessarily interesting. Jöreskog (2004) explains that a person who has chosen a specific category on a scale, has more of a certain characteristic (such as attitude, for example) than if they had chosen a lower category but we do not know how much more. As such, ordinal variables have no origin or measurement units so that means, variances and covariances have no meaning (p. 10). Accordingly, the data we use in the model are changed from continuous to ordinal throughout the remainder of the analysis. In the final measurement model,

Table 1
Descriptive statistics of the sample.

Var. no.	Factor loading	Mean	Std. dev.	Skewness	Kurtosis
Leadership commitment					
1	LC 1	2.957	1.163	−0.125	−0.826
2	LC 2	2.843	1.173	−0.065	−0.982
3	LC 3	2.805	1.178	0.069	−0.799
4	LC 4	3.083	1.231	−0.067	−0.949
5	LC 5	2.678	1.248	0.121	−1.096
6	LC 6	2.914	1.247	−0.057	−1.001
Safety climate					
7	SC 1	3.594	0.998	−0.541	−0.353
8	SC 2	3.156	1.089	−0.180	−0.769
9	SC 3	2.274	1.005	0.429	−0.580
Attitude towards change					
10	AC 1	1.546	0.814	1.925	4.100
11	AC 2	1.728	0.886	1.248	1.189
12	AC 3	1.595	0.847	1.714	2.993
Perception of safety					
13	PS 1	3.433	1 .021	−0.518	−0.144
14	PS 2	3.090	1.406	−0.126	−1.264
15	PS 3	2.110	0.725	−0.107	−1.008

$N = 422$.

we take a selection of 15 questionnaire items from the questionnaire bank to use as measures for the four latent variables. Perception of the Leadership's Commitment to safety (LC) has six measures reflecting top leadership level qualifications, communication, and actions. Perception of Safety Climate (SC) has three measures reflecting training, communication, and internal reporting (Zohar, 1980). Attitude toward Change (AC) has three items measuring reactions to the change process and the effects of change implementation decisions. Perception of Safety (PS) has three measures addressing overall safety performance, individual ability to perform, and comparative performance over time.

3.7. Goodness of fit

Hair et al. (1995) claim that assessing overall goodness of fit for structural equation models is not as straightforward as other multivariate techniques, and SEM has no single statistic that best describes the strength of the model's predictions (p. 682). The only statistically based measure for goodness of fit in structural equation modeling is the likelihood ratio Chi-square statistic (χ^2). Here a large Chi-square relative to the degrees of freedom is indicating bad fit. However, with large samples this statistic is almost always significant. The reason is that a model almost never fits the data perfectly. With a large sample, the power of the test becomes so strong that even a minor misspecification will be detected. This can be unfair, knowing that models in the social sciences, at best, are only approximations. This has to do with the power of the test.

Therefore, other measures have been developed for Lisrel, and other software dealing with SEM-analysis. The most common alternative measure for assessing model fit is the Root Mean Square Error of Approximation (RMSEA) where values ranging from 0.050 to 0.080 are deemed acceptable. Values under 0.050 are considered good fit, meaning that the data fits well into the model. An RMSEA of 0.030, the result for this model, is a strong indication of good fit. Other appropriate tests include: Non-normal Fit Index (NNFI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), and Adjusted Goodness of Fit Index (AGFI) (See e.g., Bollen, 1989 for more details). All of these are measured on a 0–1.0 scale where values greater then 0.90 represent acceptable levels of fit. According to these tests, the measurement model based on ordinal data received good fit in all categories. The results for the ordinal data model are reflected in Table 2.

3.8. Reliability

The data in the previous section shows that the model exhibits reasonably good fit but it is still possible that the measurement model may be unacceptable due to reliability concerns. Bagozzi and Yi (1988) argue that the model also needs to be justified through internal fit based on three reliability measures as evaluated in the following sections. These measures: individual item reliability, average variance extracted, and composite reliability are presented in Table 3 using standardized data from Lisrel 8.71.

Table 2
Goodness of fit indexes of measurement model.

Goodness of fit		Specification
Model 1 Fit index	Evaluation	Ordinal data
χ^2 = 221.19 (P = 0.00)		
Degrees of Freedom = 84		
RMSEA = 0.030	Good fit	
NNFI = 1.00	Good fit	
CFI = 1.00	Good fit	
IFI = 1.00	Good fit	
AGFI = 1.00	Good fit	
CN = 427.37	Good fit	

The individual items above are all unidimensional, and we computed the reliabilities using Lisrel in the .out file, and they are listed under squared multiple correlations. Reliability refers to consistency of measurement (Bollen, 1989). Evaluating these items is not straightforward, and there is no generally accepted minimum value for individual reliability. However, one rule of thumb proposed by Gulbrandsen (1998) is 0.25 based on fit criteria derived by Bagozzi and Yi (1988). The average variance extracted was calculated using the formula:

$$p\nu = \sum \lambda i^2 / \left(\sum \lambda i^2 + \sum \theta ii \right)$$

For standardized data, values greater than 0.5 are considered adequate (Bagozzi and Yi, 1988). Finally, composite reliability is defined for standardized data with a cut-off of 0.60 (Bagozzi and Yi, 1988).

Only item 7 approaches the individual reliability limit (SC1 at .25) and, therefore, is potentially problematic. This item only explains a small part of the construct which it reflects. The results of this item are further reflected in a slightly lower than adequate average variance extracted value of 0.45 for the safety climate construct, but this is partially due to the fact that the construct is only measured by three items. Item 7 measures adequacy of training and it is not surprising that it scored poorly on reliability since air traffic controllers and ATC assistants receive different levels of initial training, and also different levels of refresher training. However, despite the low reliability of item 7, the composite reliability for this construct is 0.71, and is well within the acceptable limits of 0.60. Accordingly, all items were retained.

3.9. Validity

In addition to reliable measures, different types of validity need to be considered specifically within structural equation modeling. Construct validity addresses whether you are actually measuring what you intend to measure. In addition, Bollen (1989) adds that "construct validity assesses whether a measure relates to other observed variables in a way that is consistent with theoretically derived predictions" (p. 188). But Bollen also argues that defining validity, in itself, is problematic and suggests that there are some weaknesses in traditional validity approaches, and he provides some guidance as to measures to compensate for these weaknesses. However, Bollen proposes that in the end, the question of validity really boils down to the question of whether a causal relationship exists between the latent variable and the observed variable (p. 197).

One way to confirm this causal relationship is to look at two sub-categories of construct validity, specifically, convergent and discriminant validity. Convergent validity addresses whether individual items that should be theoretically related, are related. Discriminant validity, on the other hand, addresses whether individual items that should not be related, are in fact, not related. An approach for assessing convergent and discriminant validity is provided by Andersen and Gerbing (1988). Convergent validity can be assessed by determining whether each item's estimated pattern coefficient on the underlying hypothesized construct is significant. This is represented by the t-values in the λ's of Table 3 above. As all values are significant, convergent validity is assured (Andersen and Gerbing, 1988). Discriminant validity is assessed by determining that the 95% confidence interval around the correlation estimates between two factors should not include 1.0 (absolute value). The necessary information is provided by Lisrel, and is depicted in Table 4.

Table 3
Measurement model: reliability measures and factor loadings.

Factor loadings		t-values	Error terms		t-values	Item reliability	Average variance extracted	Composite reliability
Leadership commitment (LC)								
λ 1,1	0.81	35.29	θ1,1	0.34	3.34	0.66	0.72	0.94
λ 2,1	0.82	40.18	θ2,2	0.32	3.18	0.68		
λ 3,1	0.87	55.72	θ3,3	0.24	2.44	0.76		
λ 4,1	0.89	53.83	θ4,4	0.21	2.14	0.79		
λ 5,1	0.84	46.88	θ5,5	0.29	2.90	0.71		
λ 6,1	0.85	40.92	θ6,6	0.28	2.75	0.72		
Safety climate (SC)								
λ 7,2	0.50	9.89	θ7,7	0.75	6.88	0.25	0.45	0.70
λ 8,2	0.76	26.15	θ8,8	0.42	4.03	0.58		
λ 9,2	0.72	22.89	θ9,9	0.48	4.56	0.52		
Attitude toward change (AC)								
λ 10,3	0.96	0	θ10,10	0.08	−0.77	0.92	0.71	0.88
λ 11,3	0.81	17.78	θ11,11	0.35	3.08	0.65		
λ 12,3	0.75	14.44	θ12,12	0.44	3.74	0.56		
Perception of safety (PS)								
λ 13,4	0.80	0	θ13,13	0.37	3.50	0.63	0.56	0.79
λ 14,4	0.80	24.64	θ14,14	0.36	3.41	0.64		
λ 15,4	0.63	15.01	θ15,15	0.61	5.44	0.39		

$N = 422$.

Table 4
Estimated correlation matrix between the latent constructs.

	AC	PS	LC	SC
AC (attitude toward change)	1			
PS (perception of safety)	0.75	1		
LC (leadership commitment)	0.63	0.93	1	
SC (safety climate)	0.50	0.83	0.81	1

$N = 422$.

As no values violate the 95% confidence interval described earlier, discriminant validity can be claimed for all of the latent variables examined.

Considering the analyses above, we concluded that the model is good. The model is parsimonious yet demonstrates good fit, is valid, and has acceptable reliability.

4. Results

4.1. Changes over time in employees' perceptions of top leadership's performance

We conducted the analyses of the quantitative results from this study in two steps. First, we tested organizational safety by comparing changes in how employees perceived changes in leadership behavior and relations to employees (first and second data sets) during the change process. In the second step, we tested the conceptual structural equation model using the national safety climate survey responses (third data set).

The four ATCCs used in this study experienced the same organizational change process but with different outcomes. At the time of the second survey, ATCC 1 had been closed down and merged with ATCC 2. ATCC 3 had been informed that they would also be closed down and merged with ATCC 4, but this had not been carried out at the time the institute and the ATC service provider conducted the second leadership survey. ATCC 4 had been informed that they would not be closed down, but instead would absorb ATCC 3. Employees responded to the question "I believe that the top leadership in this organization is doing a good job." The response is on a Likert scale from 1 (very bad) to 7 (very good). During the 2 years between the surveys, the top leadership had carried through several organizational changes most of them without much consulting with lower levels. During this process the organization experienced several work conflicts. Table 5 shows that the employees perceive the top leadership as doing a pretty bad job.

Table 6 shows how the employees perceived their work place during the surveys in 2002 and 2004. They responded to the question "I am proud to work in this organization." The table shows that there is a significant decline in agreement to this question.

These tables show that there is a significant drop in how people evaluate the top leadership and their pride in their organization between these two survey points. These changes may have changed the way the employees perceived the leadership's commitment to safety during the tumultuous change processes during the last 2 years.

4.2. Testing the SEM model

The results of the Safety Measurement Model specified by the data presented above are depicted in Fig. 2.

There are several strong positive correlational relationships between the latent independent constructs and the main dependent latent construct Perception of Safety. The total and independent effects for the ordinal data model are presented below. We specify the model by the following two equations for the dependent

Table 5
Leadership group statistics 2002–2004.

	ATCC 1 2002	ATCC 2 2002	ATCC 3 2002	ATCC 4 2002	ATCC 1/2 2004	ATCC 3 2004	ATCC 4 2004
(V73) Top leader performance	3.38	3.48	3.54	2.37	1.48	1.13	1.89
N responses/total number of distributed questionnaires	30/48	33/68	63/120	30/52	46/85	64/103	35/50

Differences between 2002 and 2004 are significant at <5% level.
Table shows mean values. Scale 1–7, very low–very high.

Table 6
Organizational climate group statistics 2002–2004.

	ATCC 1 2002	ATCC 2 2002	ATCC 3 2002	ATCC 4 2002	ATCC 1/2 2004	ATCC 3 2004	ATCC 4 2004
(V72) Pride in organization	4.67	5.38	4.46	4.00	2.57	1.56	2.94

N same as in Table 5.
Differences between 2002 and 2004 are significant at <5% level.
Table shows mean values. Scale is: 1–7, disagree–agree.

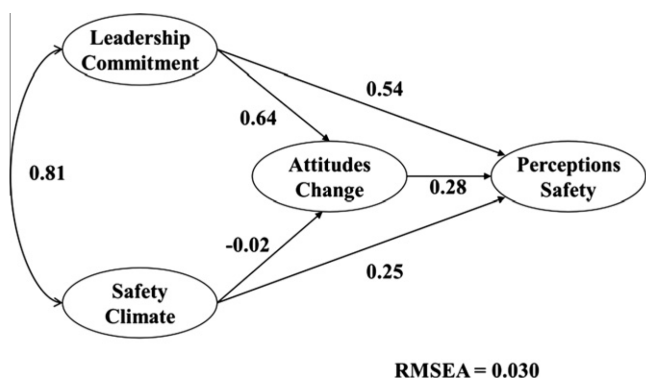

Fig. 2. Safety management model results.

Table 7
Direct and indirect path coefficients.

	Path	Direct effects	Indirect effects
γ_{11}	LC → AC	0.64	
γ_{21}	LC → PS	0.54	
	SC → AC	−0.02	
	SC → PS	0.25	
	AC → PS	0.28	
$\gamma_{11} \times \beta_{21}$	LC → AC → PS		$0.64 * 0.28 = 0.18$
	SC → AC → PS		$-0.02 * 0.28 = -0.01$
φ_{12}	LC ↔ SC	0.81	

N = 422.

variables Perception of Safety (PS) and Attitude toward Change (AC). We use the conventional notation for the LISREL model:

$$PS = \beta_{21}AC + \gamma_{21}LC + \gamma_{22}SC + \zeta_1 \quad (1)$$

and

$$AC = \gamma_{11}LC + \gamma_{12}SC + \zeta_2 \quad (2)$$

By analyzing the path coefficients in Fig. 2 above, we find the direct and indirect effects on perception of safety (PS) in Table 7 below for the structural model:

Accordingly, the total causal effect of changes in individual perceptions of the leadership's commitment to safety (LC) on individual perceptions of safety (PS) through the moderating variable attitudes toward change (AT) are:

$$\gamma_{21} + (\gamma_{11} \times \beta_{21}) = 0.72 \quad (3)$$

The total causal effect of changes in safety climate (SC) on individual perceptions of safety (PC) through the moderating variable attitudes toward change (AT) are:

$$\gamma_{22} + (\gamma_{12} \times \beta_{21}) = 0.24 \quad (4)$$

4.3. Results of hypotheses testing

These results show clearly that individual perceptions of the leadership's commitment to safety have a strong total positive relationship to both attitude toward change and perception of safety for the ordinal data model. In addition, there is a moderate indirect positive relationship to perception of safety via the moderating variable attitude toward change. Safety climate has a moderate positive direct relationship to perception of safety but no relationship to attitude toward change in the ordinal model, and therefore, no significant indirect effect on perception of safety. Based on these results, evaluations of the five hypotheses are listed in Table 8.

The results of the analyses support four of the five hypotheses. H3 received a *t*-value of 0.12 which falls under the minimum acceptable limit of 1.96, and was not supported. The direct relationships of: H2: Leadership Commitment to safety (as employees perceive LC) on Perception of Safety (PS), H1: Leadership Commitment to safety (LC) on Attitudes toward Change (AC), H4: Safety Climate (SC) on Perception of Safety (PS), and H5: Attitudes toward Change (AC) on Perception of Safety (PS) were all significant and supported.

Finally, there is a strong correlation between perceptions of the Leadership's Commitment to safety (LC) and Safety Climate (SC). This is not surprising as the relationship between these concepts is well supported by the safety literature.

5. Discussion and conclusion

We have shown through our presentation of the current safety literature that measuring changes in safety in High Reliability Organizations during periods of potentially disruptive organizational change is a difficult task if leaders only rely upon the traditional measures of incident and accident reporting (Lofquist, 2010). This study tested an alternate method for measuring safety by using a combination of techniques that focused on safety-related attitudes and perceptions at the individual level that can lead to a reduction in safety margins in HROs.

This study addresses the problem of measuring safety in high-risk environments that have reached ultra-safe levels of performance (Amalberti, 2001) where the traditional measures of incidents and accident reporting fail to capture developing latent conditions that may lead to disaster. As discovered early in this study, safety is, at best, a latent concept representing a process (Hollnagel, 2008), and not a product. Safety can only be measured indirectly through other indicators. We could also argue that single indicators are not enough, and relying solely on incident and accident reporting fails to capture an accurate picture of an evolving safe system. Although the literature reflects the frustration of many researchers for finding an alternative to the traditional safety measures of incident and accident reporting, few studies provide alternative measures. One area of particular interest for this study is the growing interest in finding proactive measures of evolving safety processes in socio-technical organizations using a combination of psychometric tools and qualitative approaches to reveal the contribution of safety culture to performance outcomes (Schneider and Gunnarson, 1991; Cox and Flin, 1998; Hale and Hovden, 1998). These efforts, sometimes called safety audits, allow researchers to fine-tune the individual constructs of interest, and may even allow some form of benchmarking safety performance in ultra-safe

Table 8
Summary of hypotheses testing.

Constructs	Hypothesized effects	Findings	*t*-values
H1 If employees perceive that the leadership has high (low) commitment to safety, they perceive safety as high (low)	+	0.64	5.57
H2 If employees feel there is a positive (negative) safety climate, they will also perceive safety is high (low)	+	0.54	5.67
H3 If employees perceive leadership's commitment to safety (LC) as high (low), they will have a positive (negative) attitude toward change (AC)	+	−0.02	0.12
H4 If employees perceive safety climate (SC) as good (bad), they will have a positive (negative) attitude toward change (AC)	+	0.25	2.62
H5 If employees have a positive (negative) attitude towards change (AC), they will perceive safety (PS) as high (low)	+	0.28	5.41

The parameters in the findings column refer to the LISREL model in Fig. 2. $N = 422$.

industries. These findings lead to a shift in focus in safety measurement away from reactive forms of measurement to what we would describe as the interactive phase of a safety management system that relies more heavily on the human element in a socio-technical system, and the idea of mindfulness (Weick and Sutcliffe, 2001, 2006).

Based on a longitudinal case study approach and a couple of surveys with a 2 year interval, we conceptualized a structural equation model and then tested the model for fit using national safety climate survey data. The results of the structural equation model show that there are strong direct and indirect relationships between the latent concepts of interest for safety processes, specifically: perception of Leadership Commitment to safety (LC), Safety Climate (SC), Attitude towards Change (AC), and Perception of Safety (PS). These results indicate that any changes in individual perceptions of the leadership's commitment to safety and safety climate, over time, will have corresponding direct and indirect changes in perception of safety through the moderating variable—attitude towards change. The academic literature in the safety field shows that changes in individual perceptions of safety affect cognitive processes, and ultimately behavior, often in the form of risk-taking. Focusing on employees' perceptions of leadership's commitment to safety is important, because leadership may through their decisions send conflicting signals that employees use to make sense of what they perceive as the priorities of the leadership.

To test our theory of changes in safety during organizational change processes, we compared two internal leadership questionnaires taken at two different points in time and applied these results to the relationships presented in the conceptual structural equation model. The first leadership questionnaire was administered 3 months before the official organizational change process was announced, and the second questionnaire was administered during the middle of the change process corresponding in time with the quantitative data used in the SEM model. The results show a significant reduction in individual perceptions of the top leadership's competence across the board. We also found that the employees lost their pride in their organization. The results of the structural equation model show that employees perceived a decline in safety through changes in individual perceptions of the top leadership's commitment to safety and the safety climate.

The first important contribution from this study, is that the study followed a live case over a 3-year period, and the data was readily available to the leadership of the organization, and could have been analyzed and acted upon in a proactive manner instead of relying solely on the traditional measures of incident and accident reporting to measure safety. Unfortunately, the three data sets were all analyzed in isolation. The leadership did not use the results of the surveys in their decision making despite observing turbulence in the organization during the reorganization attempts.

A second contribution from this study is the differentiation between individual perceptions of the leadership's commitment to safety and the traditional focus on leadership commitment from a leader's perspective as part of a safety climate construct. The distinction lies in how the leadership communicates or signals their commitment. As shown in this study, it is clear that it is the individual perception of this commitment that influences cognitive processes, sensemaking, and ultimately behavior, and not necessarily the leader's actual commitment. When the leadership makes changes that send conflicting signals about their priorities, the employees will engage in discussions to make sense of these signals (Weick, 1995).

A third contribution of this study is the introduction of a safety measurement model based on the results of a safety climate survey that effectively takes a snapshot of safety at a specific point in time. This model shows how important latent constructs combine directly and indirectly to affect the main dependent variable (individual Perception of Safety) in a deliberate change environment. More importantly, this model shows how strongly the perception of the leadership's commitment to safety affects both attitudes toward change and perceptions of safety in an HRO.

We make a fourth contribution in that to our knowledge, no studies have followed a high reliability organization in the context of a disruptive, deliberate organizational change process as experienced in this case. More importantly, no studies have tried to measure changes in safety during deliberate organizational change using alternative methods to the traditional metrics of incident and accident reporting.

A final contribution is identifying and quantifying the importance of individual perceptions of the leadership's commitment to safety in safety outcomes during change. Our results would indicate that a significant reduction in safety margins took place during the time frame studied based on the conceptual causal relationships in the safety measurement model. However, the model also shows that a reversal in the perceptions of the leadership's commitment to safety would have an equally dramatic improving effect on perceptions of safety and, ultimately, behavior.

In a final note, it should be mentioned that in this case study, the organization involved was, in fact, using a combination of tools to measure the internal organizational climate, but the leadership did not relate these results specifically to safety, nor initiate any proactive measures based on the results. However, after the collapse of the change project a new leadership initiated changes to improve the leadership climate survey to better address safety issues, and has taken proactive steps to correct latent conditions uncovered by the surveys prior to failure.

Appendix A. Structural equation model items

Leadership commitment (LC)

V1 – Leaders in my organization are personally involved in activities that promote safety.
V2 – The leaders in this organization are cognizant of the most important safety problems affecting operations.
V3 – The leaders in this organization do all that they can to prevent accidents.
V4 – The leaders consider safety as very important in all work operations and activities.
V5 – The leaders have an adequate technical/operative understanding for making correct safety choices.
V6 – The leadership is genuinely interested in safety.

Safety climate (SC)

V7 – Employees in my organization receive adequate training to perform assigned tasks in a safe manner.
V8 – Everyone is informed about each change that will affect safety.
V9 – All failures and deficiencies are reported and processed in a short period of time.

Attitude toward change (AC)

V12 – The changes in national ANS provider.
V13 – Reorganization from government agency to national ANS provider.
V16 – Disruption and "noise" in the national ANS provider has not had an affect on safety in the long run.

Perception of safety (PS)

V18 – Safety in this organization is generally well handled.
V19 – Safety is the first priority in my organization.
V22 – Safety in the National Civil Aviation Industry as become worse in the past 5 years.

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