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Surfacing Your Safety Culture

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Abstract
In recent years, the results of public inquiries into large scale disasters has highlighted the important role of the corporate atmosphere or 'culture' whereby safety is understood to be, and is accepted as, the number one priority (Cullen, 1990). This has led to many companies and industries giving high priority to improving their safety 'culture' without really knowing what it is, or whether or not they have achieved an improvement. Historically, this situation was caused by the lack of a universally accepted definition of safety culture or measurement methodology. Cooper (2000) offers a practical triadic model to overcome both of these issues to facilitate the measurement and quantification of safety culture. Cooper's model asserts that safety culture can be measured by examining the interactions between safety management systems, people's perceptions about safety and people's actual safety related behaviour, by using Safety Management System Audits, Safety Climate Surveys and Behavioural Safety Systems. The model predicts that an improvement intervention aimed at any one of these three components will exert a reciprocal effect on the other two (e.g. The quality of the company's safety management system will exert an effect on people's safety behaviour and their attitudes and beliefs about safety). For example, Townsend (2001) recently completed a study in heavy construction based on 700 million man-hours. He showed that, within the context of a structured safety management system (Organisation), the top 25% of safety performers habitually (behaviour) intervened to correct unsafe acts/conditions and praise safe working, and considered safety management a moral duty (attitude and beliefs) to be taken seriously. In another study based on 110 million man-hours of petrochemical construction, it was identified that improving safety performance by 50% was associated with productivity improvements averaging 12% (Stewart & Townsend, 2000). This demonstrates that effective safety management can increase productivity as well as profitability (Levitt & Samelson, 1987). However, this is dependent on companies optimising the balance between the effort and resources they allocate to developing safety systems, promoting safe behaviour and encouraging positive safety values and beliefs. This paper presents real world data using Cooper's reciprocal safety culture model to demonstrate how companies can identify exactly where best to focus their efforts and resources in pursuit of their safety goals.

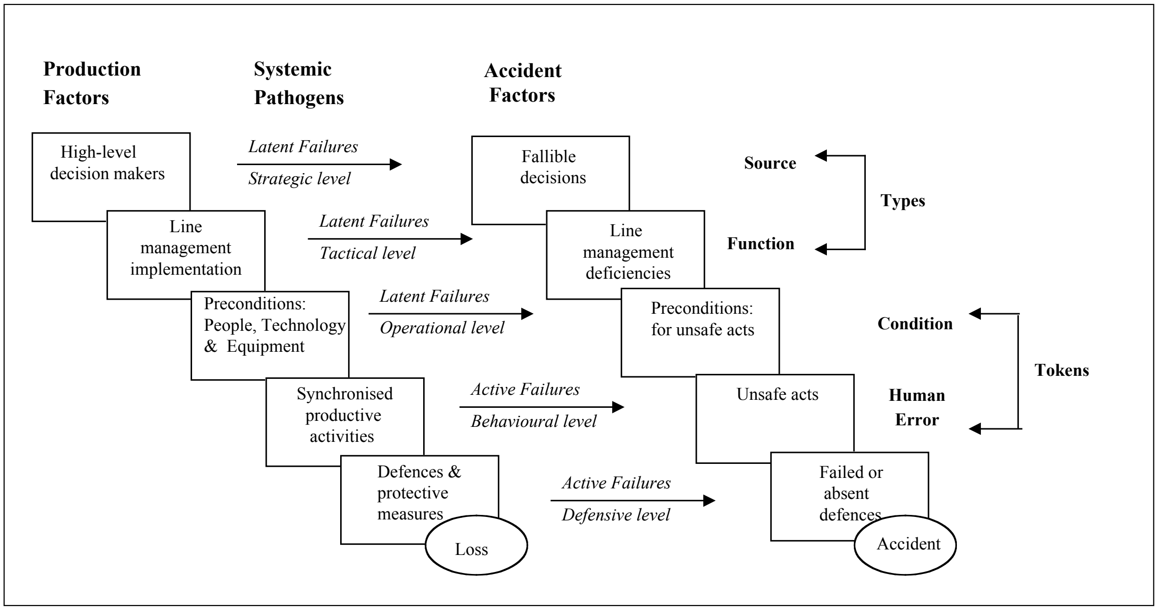
Introduction

The term 'Safety Culture' first made its appearance in the 1987 OECD Nuclear Agency report (INSAG, 1988) on the 1986 Chernobyl disaster. Gaining international currency over the last decade, it is loosely used to describe the corporate atmosphere or culture in which safety is understood to be, and is accepted as, the number one priority (Cullen, 1990). Unless safety is *the* dominating characteristic of corporate culture, which arguably it should be in high-risk industries, safety culture is a sub-component of corporate culture, which alludes to individual, job, and organizational features that affect and influence health & safety. As such the dominant corporate culture *and* the prevailing context such as downsizing and organizational restructuring (e.g. Pierce, 1998) will exert a considerable influence on its development and vice-versa as both inter-relate and reinforce each other (e.g. Williams, 1991). This latter point illustrates that safety culture does not operate in a vacuum: It affects, and in turn is affected by, other operational processes or organizational systems.

This becomes more apparent when theoretical models of accident causation are examined (See Cooper 1998 for a detailed overview). The most influential of these is Heinrich's Domino model (See Heinrich *et al.* 1980; Weaver,1971; Adams, 1976 ; Reason,1990). While Heinrich concluded that the key domino was that pertaining to unsafe acts, Weaver (1971) focused on symptoms of operational error (management omissions) that interact with unsafe acts and/or conditions. Adams (1976) emphasised that operational errors were caused by the Management structure; Management's objectives; the Synchronisation of the work flow system; and How operations were planned and executed. In turn these operational errors caused 'tactical errors' (unsafe acts or conditions). Reason & Wreathall, (Cited in

Reason 1993) aligned the domino model to a parallel five element production model and identified how and where latent and active safety failures (termed "*pathogens* ') might be introduced into organizational systems (See figure 1). Both latent and active failures are introduced by organisational or managerial factors (e.g. top-level decision-making), but individuals (e.g. psychological or behavioral precursors) trigger the active failures. Like Adams before him, therefore, Reason shifts the main focus of accident prevention away from unsafe acts and more onto the organization's management systems.

Figure 1: Adaptation of Reason & Wreathall's pathogen model



Defining safety culture

Although numerous definitions of safety culture abound in the academic literature, the one most widely used to guide British industry was developed by the Advisory Committee for Safety on Nuclear Installations on behalf of the British Health and Safety Commission (1993) which states that safety culture is:

'*... the product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organizations health & safety management.*

Organizations with a positive safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventative measures'.

One aspect overlooked by all concerned was the lack of clarity about the safety culture '*product'*. This caused confusion amongst both practitioners and academics as to what a safety culture is. Due to the lack of any concrete definition of this '*product'*, many practitioners focused their efforts on improving peoples shared values, beliefs and attitudes in the hope that this was improving their company's safety culture. This approach was reinforced by academics who developed safety climate surveys as a surrogate measure of safety culture (e.g. Flin et al, 1996; Lee, 1998). Although they are useful tools designed to encourage participation in safety by gauging people's opinions about things like the extent of risk taking, compliance with procedures etc., as well as safety attitudes, such surveys only offer a partial view of a company's safety culture (See Guldenmund 2000). A perusal of safety research (e.g. ASCNII, 1993; Adams, 1976; Cohen, 1977), Psychological research (e.g. Bandura, 1986; Locke & Latham, 1990) and cultural change research (e.g. Atkinson, 1990) all reveal the presence of a dynamic reciprocal relationship between psychological, behavioral and situational factors. On this basis it was argued that organisational culture is

'*The product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (Situational)'* (Cooper & Phillips, 1995; Cooper 1998).

This definition provides benefits from its explicit acknowledgement of the interrelationships between people's actual behavior on the job, the company's management systems, and people's values and beliefs *and* their goal-directed nature (i.e. they have a purpose). In other words our 'worldview' of organisational culture is widened to include more than just people's opinion's, shared values, beliefs, and attitudes.

Importantly, it is the *product* of these goal directed relationships that comprises the 'culture' or corporate atmosphere. If the goal–directed interactions are aimed at safety then we can say that we are striving to create a safety culture, or a quality culture if directed at quality, and so on (for the purposes of these definitions safety is taken to include health). This makes it even more important to define the 'product' in a way that can easily be understood, measured and quantified. Consistent with culture research (Deal & Kennedy, 1982; Rousseau, 1988; Schein, 1990) and goal-setting theory (Locke & Latham, 1990), Cooper (2000) tentatively conceptualised the product as:

> '*That observable degree of effort by which all organizational members direct their attention and actions toward improving safety on a daily basis'*.

In essence, this definition asserts that the product of the multiple safety-directed interactions between people, job and organisation will be a collective behavioural commitment to improving safety that can be seen at every level of the organisation, all of the time. If the organisational membership can not be seen directing their attention and actions towards improving safety (e.g. trip alarms being ignored or over-ridden in control rooms without further investigation) it could be argued that there is not a culture of safety at that level of the organisation. Thus, the degree to which the safety culture is positive or negative will depend entirely upon the collective amount of energy *visibly* expended in the pursuit of excellence by organisational members. The major advantage offered by the above definition is its emphasis on an *observable* commitment, which is necessary if we are make the concept of safety culture tangible.

Accepting that the safety culture product is something that is observable also provides a common outcome measure with which to assess all types of safety improvement interventions. Some might argue that incident rates provide a better outcome measure of the prevailing safety culture. Whilst it is imperative that an improved safety culture does reduce accidents in the workplace and hence the number of injuries sustained, it must also be borne in mind that incident rates are not sufficient in themselves to indicate the quality of a safety culture. Once a zero incident rate is achieved we still need to be able to monitor the organisations '*potential'* for introducing accident causation factors (i.e. latent and active failures) into the workplace i.e. its safety culture. The importance of this to high consequence, low probability environments such as the major hazard industries cannot be under-estimated. A salutary example is provided by the Phillips Chemical Company's Houston Chemical Complex in Pasadena, Texas. In 1989, the site had achieved some 5 million man hours without a lost time incident, when an explosion occurred that killed 23 people, injured more than 130 and caused property damage in the region of a billion dollars. Had an alternative outcome measure been available, it might have been possible to identify many of the problems that led to the disaster, prior to them being realised. At the very least such a measure would have provided a crosscheck on the organisations underlying assumptions that all was well.

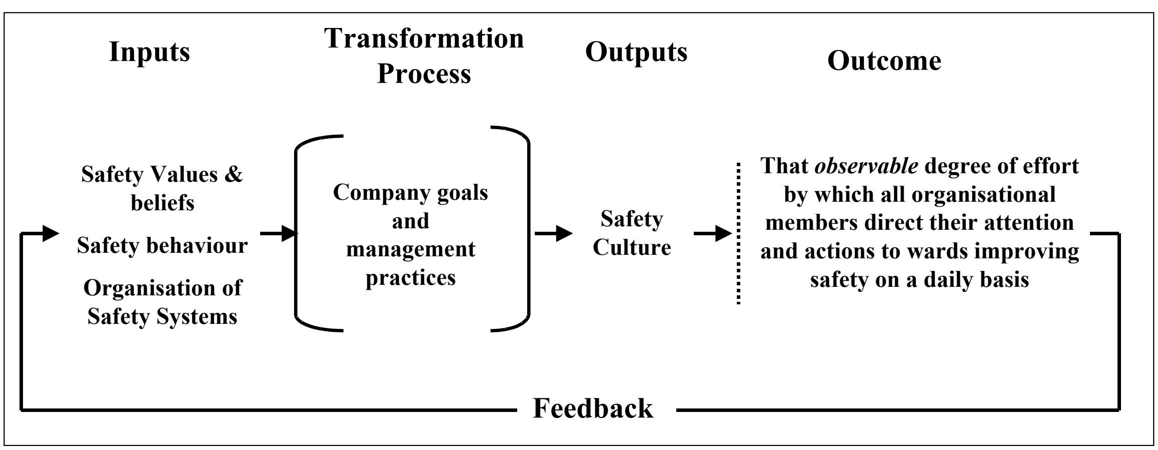
Because it is people who create and determine safety culture, I would argue that it makes sense to use an outcome measure that focuses on people, hence monitoring *'that observable degree of effort…'*. It is recognised that different industries or organisations would focus upon different 'units' of effort that would depend upon the different types of activity they are engaged in. For example, high hazard industries tend to focus their efforts at the prevention of risks related to loss of containment or risks to the public, whereas manufacturing tends to target the majority of its control efforts towards the 'at-risk' behaviours of the workforce. Byrom (2002) defined a classification of common risk behaviour types that could comprise a common measure of 'that observable degree of effort…' (see table 1) across all types of industry. The organisation could 'observe' the effort by which all organisational members try to reduce the 'risk producing' behaviours and increase the mitigating, procedural, supportive and commitment behaviours. Scores for each of these behavioural types could be combined to assess ' that observable degree of effort…..".

Table 1: Classification of Risk Behaviour Types

Behaviour Type	Examples
Risk Producing	Lifting incorrectly; Driving too fast
Mitigating or Alleviating	Wearing PPE
Procedural (Risk Control Systems)	Following a confined space entry procedure
Supportive (SMS Systems)	Reporting Accidents
Commitment	Safety Leadership

The use of such an outcome measure also offers other advantages. For example, it allows us to discover the strength of correlation between the measured safety culture and incident rates. This is currently unknown but absolutely critical if industry is to continue to invest its energies into safety culture. It also allows company's to assess the impact of their improvement interventions to discover the financial value of one standard deviation in safety performance to construct utility models that facilitate cost-benefit analyses.

Figure 2: Business Process Model of Safety Culture

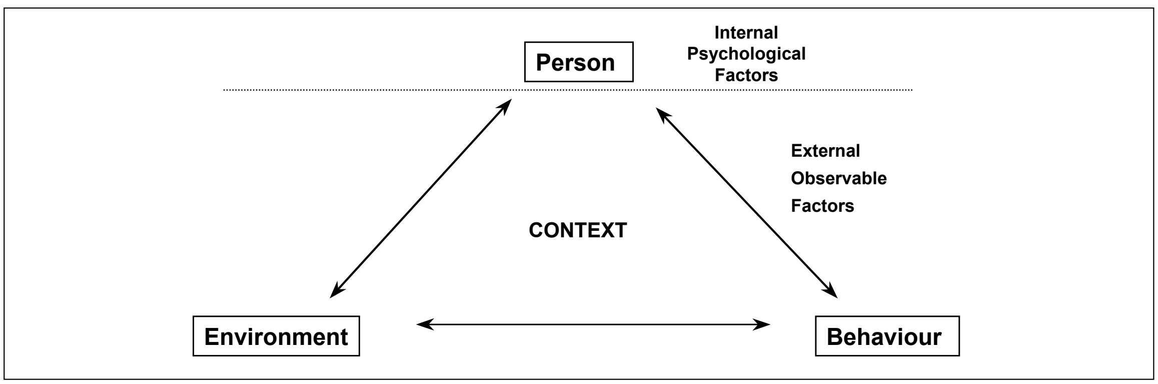


The Business Process model of Safety Culture (see figure 2) illustrates that the broad attributes that comprise Cooper's safety culture construct (i.e. Inputs) are processed by a combination of the company's goals and management practices and transformed into the safety culture (i.e. Output) to create the safety culture product (i.e. Outcome). This process model makes it very clear that it is how a company manages the safety 'Inputs" that determines the degree to which people commit themselves to safety. This means that companies must ask themselves very searching questions about the best ways to manage safety so that people will direct their attention and actions towards the improvement of safety on a daily basis. Brown (1997) indicates that a genuine participative 'safety partnership' between management and the workforce is required.

Measuring Safety Culture

Cooper's (1998) definition of safety culture mirrors Bandura's (1986) model of Reciprocal Determinism derived from Social Cognitive Theory (SCT) shown in figure 3. This focuses on cognitively based antecedents (e.g. goals), behaviors, and consequences (e.g. self-evaluative rewards), while also stressing the use of *observable* variables for assessment purposes. Importantly, Bandura's model asserts that people exist in a state of reciprocal determinism with their environment, whereby they and their environments influence one another in a perpetual dynamic interplay (Davis & Powell, 1992). Reciprocity is not thought to occur simultaneously, nor are the different influence sources of equal strength. Rather it takes time for a causal factor to exert an effect and activate reciprocal influences (Bandura, 1977).

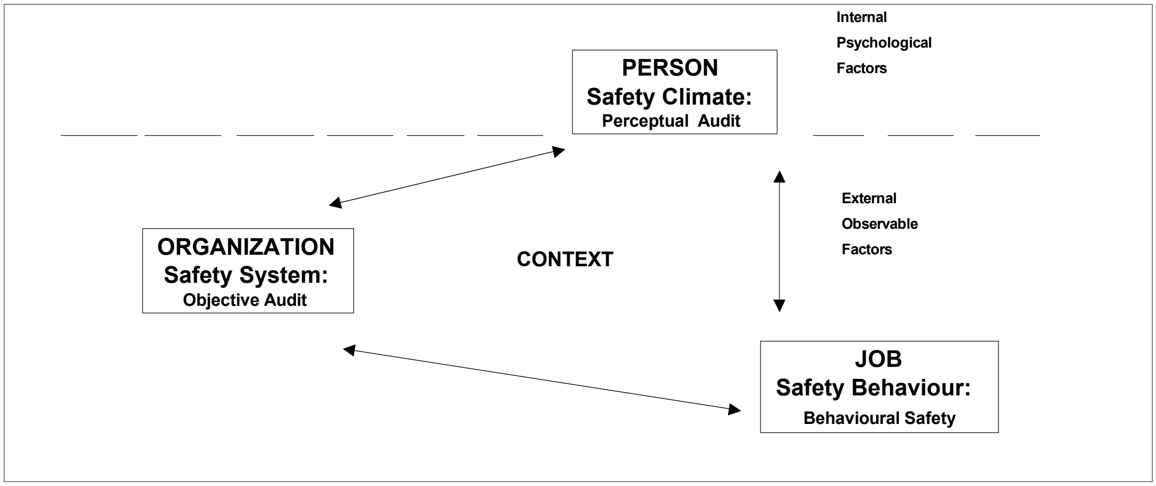
Figure 3: Bandura's Model of Reciprocal Determinism



Bandura's Model was adapted by Cooper (1993a) to reflect the concept of safety culture to facilitate the measurement and quantification of safety culture (see figure 4). This adaptation asserts that safety culture can be measured by examining the reciprocal interactions between safety management systems, people's perceptions about safety and people's actual safety related behaviour. Since each of these safety culture components can be directly measured in their own right, or in combination, by using Safety Management System Audits, Safety Climate Surveys and Behavioural Safety Systems, it becomes possible to quantify safety culture in a meaningful way at many different organizational levels.

The model predicts that improvement interventions aimed at any one of these components will exert a reciprocal effect on the other two while also recognising that this influence may or may not occur simultaneously. In other words, a change in the company's safety management system *will* exert an effect on people's safety behaviour and their attitudes and beliefs about safety *but* it may take time. Time is an important factor. Industry tends to work to short time frames (e.g Q1, Q2, Q3, Q4) and many good safety initiatives are abandoned simply because of the longer time frame it takes for them to impact on accident rates. Using '*that observable degree of effort…*" as the outcome measure of safety performance could help to establish these timeframes. It would also give management something tangible with which to assess the impact of such interventions during the short time frames they normally operate in. Ultimately, industry would then be in a better position to predict how long a particular type of intervention (e.g. safety training) would take to achieve its stated purpose.

Figure 4: Cooper's (1993a) Reciprocal Safety Culture Model



Similarly, the particular intervention type could be assessed for its impact on each of the three safety culture components. Over a period of time, sufficient information would be generated allowing industry to focus its efforts and resources to better effect.

Quantifying Safety Culture

To quantify safety culture two relatively simple things have to occur. The first requires the measurement of 'matched' factors within each element of the model. This is best illustrated by using the measurement of management's commitment as an example. Questions would be asked about it via a safety climate survey (e.g. are they perceived to be committed by the workforce) and also via a safety management system audit (e.g. what is the safety budget, relative to the total budget). The degree to which managers visibly demonstrated their commitment would also be monitored during a behavioral safety initiative (e.g. the frequency with which management actually 'walked the talk').

The second is to use a common metric across each of the three elements. Percentages are perhaps the easiest to use as they are commonly found in safety management system audits and behavioral safety systems. Safety climate surveys scores using 5 point Likert-type scales can easily be converted into percentages by multiplying the mean average score (=3.10) by 100 (=310) and dividing the result by 500 (= 0.62). The product of this calculation is then multiplied by 100 (= 62%). Percentage scores also facilitate the use of a 5 point banding scale which ranges from Alarming (0-20%) to Excellent (80-100%).

In principle, the percentage score for each element can also be converted into the 5-point scale by dividing the percentage score (=62%) by 100 and multiplying the result (=0.62) by 500 (=310). The product of this calculation is then divided by 100 (=3.10). Which ever metric is used, the scores relative to each other indicate which of the three safety culture elements is weaker. This area should then become the focus of attention and remedial action.

Analysing safety culture

The following uses the results of a case study designed to measure safety climate to provide an illustration of how safety culture can be quantified and analysed by making use of the safety culture model.

Method

Sample

The author was approached to conduct a safety climate survey with a view to assessing whether or not the site was ready to implement a Behavioural Safety system run by the workforce and facilitated by management. From a total approximate site population of 600, the sample comprised 125 employees representing a 20% return rate. 103 of the sample were male (82.4%), 20 female (16%) and 2 unidentified (1.6%), from 3 main site areas (i.e. Goods In, Packaging and Goods Out).

Measures

A questionnaire based on the work of Cooper & Phillips (1994) comprising 96 items was developed specifically for the site and distributed internally to every member of the facility during August 1998. Employees were provided with an envelope in which they could seal the completed questionnaire and return it to the Health and Safety office. The safety climate measure included a covering letter from the author, explaining the aims of the survey and an assurance of confidentiality. A letter from the Site's management reinforced the confidentiality aspect. Instructions were provided for the completion of the questionnaire and its return. Requests were also made for demographic information such as Department; Age, Gender, Managerial/Supervisory duties and Accident involvement.

Each of the 96 questions was rated on a Likert-type scale, that ranged from Highly disagree to Highly agree. Polarity on some of the items was reversed to avoid response set (i.e. where the same pattern of responses is given regardless of what the question is asking). At the end of each questionnaire, the respondents were invited to make any comments they wanted about safety issues. The 96 question items were distributed among 17 dimensions, each containing an average of 5 questions:

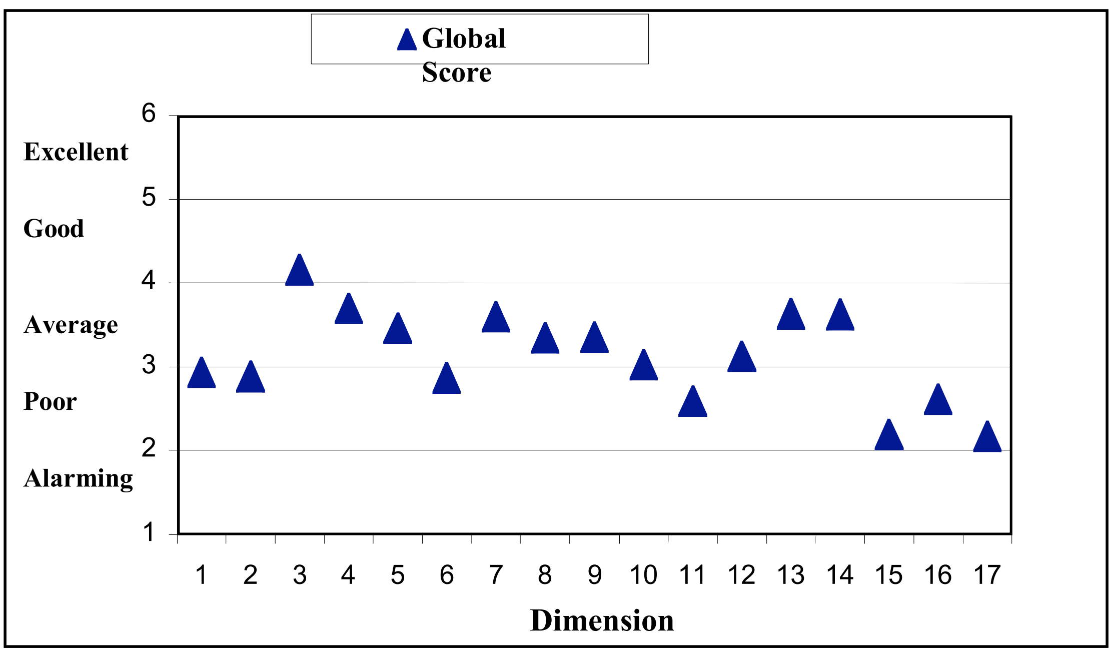
- D1 Managerial Commitment to Safety;
- D2 Management actions in regards to safety;
- D3 Personal Commitment to and Involvement with Improving Safety;
- D4 Perceived Levels of Risk in the Workplace;
- D5 The Effects of the Required Workpace on Safety (i.e. the conflict between productivity and safety);
- D6 Beliefs about Accident Causation;
- D7 The Effects of Job-induced Stress;
- D8 The Effectiveness of Safety Communications within the organisation;
- D9 Emergency Preparedness;
- D10 The Importance of Safety Training;
- D11 The Status of Safety Personnel;
- D12 Responses to Breaches of Standard Operating Procedures (SOP's);
- D13 The Effectiveness of Standard Operating Procedures (SOP's);
- D14 Housekeeping;
- D15 Job Design Changes related to Manual Handling;
- D16 Personnel's Commitment to the Organisation;
- D17 The Effects of Reduced Manning Levels on Safety.

Analyses

Original Analyses
Cronbach's Alpha reached 0.94 indicating that the survey instrument had very high internal reliability. The average overall safety climate score for the site was calculated by summing the average scores for each dimension, and dividing by the total number of dimensions (n = 17). This calculation provided an overall Safety Climate Score of **3.13,** which was deemed to be an average safety climate score, indicating that scope for improvement was present. The result for each individual dimension is shown in figure 5. Out of the 17 dimensions, Seven scored in the average range (scale points 3-4), Nine scored in the poor range (scale points 2-3), and One scored in the good range (scale points 4-5).

The data were subsequently divided by 3 different subsidiary groupings (Work area, Managerial duties and Age group). One-way ANOVA's (Analysis of Variance) was the analytical method. This allowed the significance of any differences in perceptions to be ascertained on each dimension, indicating whether or not any of the obtained differences were due to chance. The few statistically significant differences that emerged were primarily related to the difference between physical and clerical type duties, with some found for age. Each work area's profile was very similar with no statistically significant differences emerging.

Figure 5: Original Safety Climate Analyses



Safety Culture Analysis
For this analysis the author was attempting to embed the safety culture model within the framework of Health & Safety management advocated by the British Health & Safety Executive (HSE, 1997) to assist companies compliance with the 1999 Management of Health and Safety at Work Regulations (MHSWR). The HSE model incorporates a 5 stage management process of Policy, Organising, Planning & Implementation, Measuring and Reviewing Performance.

Policy setting, organising structures to deliver policy, and planning and implementation are clearly linked to the strategic, tactical and operational levels respectively of Reason & Wreathall's pathogen model, in so far as decision-making is the primary route by which pathogens or *Latent failures* are introduced into organisations (Reason, 1993). Similarly, the behavioural and defensive levels are clearly linked to measuring and reviewing performance to control *Active failures*. Thus, it appears possible to integrate the safety culture model with Reason & Wreathall's pathogen model and established management processes.

The original 96 question items contained in the Safety Climate Survey were re-categorised into a new taxonomy that accorded with Cooper's Safety Culture Model presented in figure 4 *and* the organisation levels presented in Reason & Wreathall's 'Pathogen' Model (see figure 1). Thus instead of analysing the data by safety climate dimensions as is normally the case, the data were to be analysed according to whether or not the question item asked about Person, Behavioural or Organisational factors at the Strategic, Tactical, Operational, Behavioural or Defensive levels. The original dimension D16 (Personal commitment to the organisation) was excluded entirely from the process, as it was not focused on safety. The number of survey items that belonged in each of these categories is presented in Table 1.

Table 1: Taxonomy of Safety Culture variables with Organisational Level

Organisation Level	Person	Job	Organisation	Totals
Strategic	6	2	3	**11**
Tactical	10	6	5	**21**
Operational	5	2	7	**14**
Behavioral	11	11	5	**27**
Defensive	10	6	2	**18**
Totals	**42**	**27**	**22**	**91**

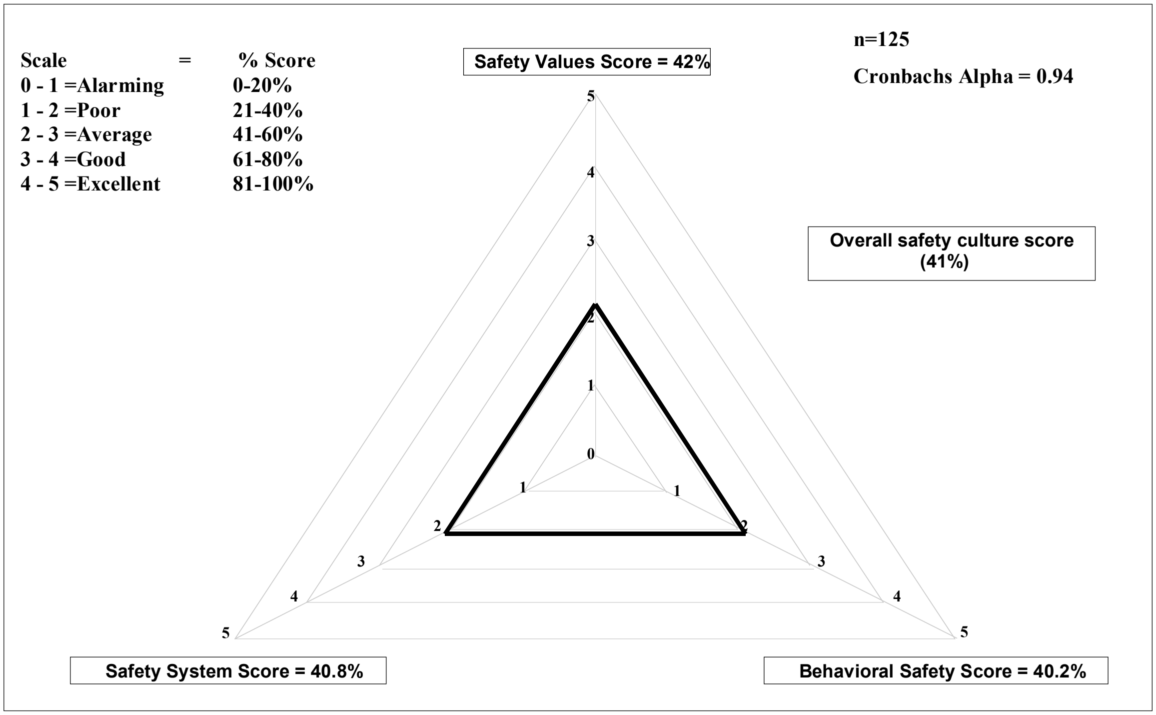
When examined in this way the original questionnaire items contained in the survey were found to be very unbalanced in their focus. For example, 42 of the items were asking about people's attitudes or perceptions about safety, whereas only 27 items asked about what people actually do, and a further 22 items asked people their views about the safety systems. In other words, there is not an even spread across the three safety culture variables. Similarly, the number of items assigned to each organisational level is also unbalanced. Accounting for this balance is something that developers of safety culture measures will need to take into account in their own work.

Each of the sets of questions contained within each of the new categories (e.g. Strategic – Person; Tactical-Behaviour; Operational-System, etc.) were analysed via ANOVA's using the demographics as levels of the factors.

Results

A global mean average score was computed for each of the three safety culture variables. In this example, a mean average score of 3.10 (SD=0.93) was obtained for all the items comprising the psychological safety culture component (i.e. values and beliefs); a mean average score of 3.04 (SD=0.97) for the situational aspect reflected by safety systems, and a mean average score of 3.01 (SD=0.98) for the behavioural component. As shown in figure 6 the resulting safety culture profile provides a completely different view of safety than that shown in figure 5, as we can now see where each one of the safety culture components resides in relation to each other. In principle, we can also tell at a glance how far the site has to go to achieve its optimal safety culture. Each of the scores for the safety culture components were then converted into a percentage score. In this example, all three components are largely on the same plane at the 40% safe level, with an overall safety culture score of 41% (deemed to be average, bordering on poor) indicating great scope for improvement within each of the individual safety culture components. As such the safety culture profile appears to be a useful tool to enable industry to focus its efforts and resources for the best effect.

Figure 6: Safety Culture Profile



One problem encountered was due to the two different scales. The Likert-type scale used ranged from 1-6 and excluded Zero, whereas the 5-point percentage banding scale includes Zero. To align the original 6 point Likert-type scale into the 5 point percentage banding, the mean average score minus One was used to calculate the equivalent percentage score (i.e. 3.10 minus 1=2.10 multiplied by 100 = 210 divided by 500=0.42 multiplied by 100= 42%).

Further work computed the safety culture scores for each of the organisational levels presented in Reason & Wreathall's s Pathogen model (See table 2). These reveal that many of the company's safety efforts were exerting their greatest effects at the behavioral and defensive levels of the organization, indicating that by and large the potential *active failures* were being controlled. In other words, the scores for these two levels indicate that relatively good safety systems were in place and working at the 'coal-face', with people largely adhering to the rules and procedures and holding reasonably positive attitudes about safety, albeit that there was still a lot of room for improvement.

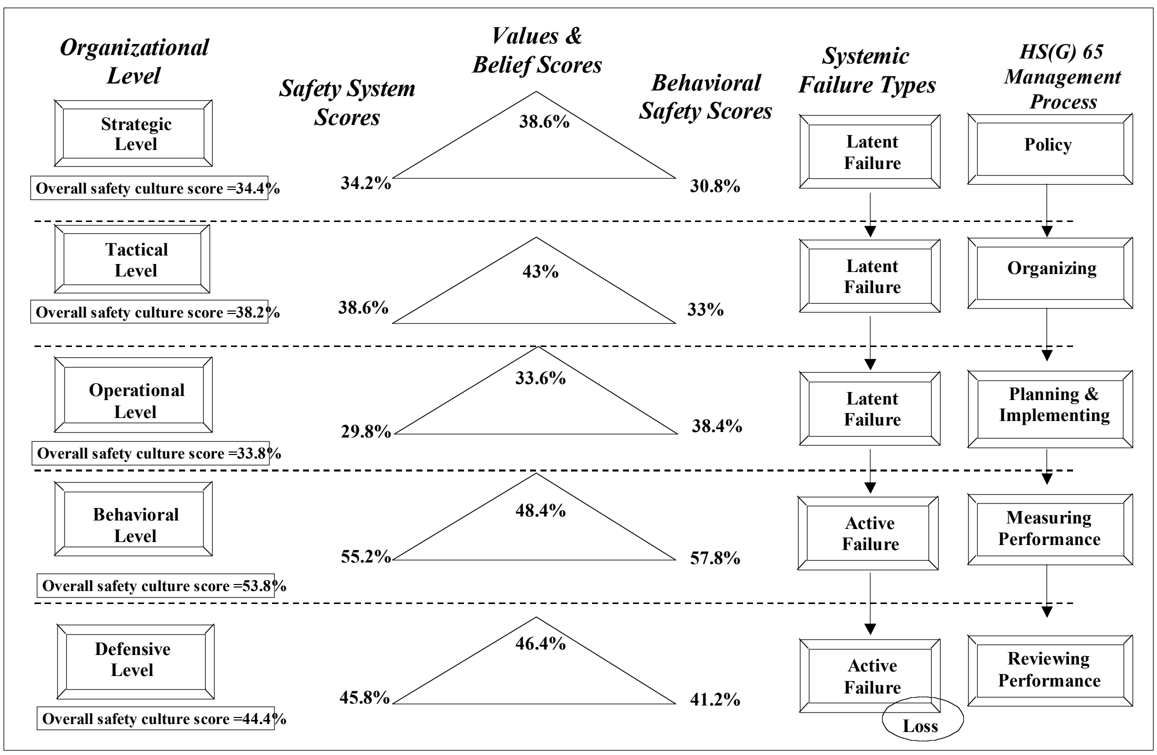
However, the scores also indicate that the company's safety effort had been less influential at the Strategic (Leadership), Tactical (Managerial) and Operational (Support) levels. With one exception, all of the scores pertaining to these levels fell into the poor range. The low scores and the decision-making nature of people populating these levels, indicates the strong possibility that many *latent failures* were developing and laying dormant waiting for an *active failure* to trigger an incident. Were an incident to occur, it is almost certain that the company concerned would focus more of its resources and effort at the behavioural level to eliminate a recurrence of the active failure. In other words, it would focus its remedial actions at the level offering the least 'payback', while ignoring the levels that would yield the greatest.

Table 2: Mean Scores for Safety Culture Variables X Organisational Level

Organisation Level	Organisation		Person		Job		Totals	
	X	SD	X	SD	X	SD	X	SD
Strategic	2.71	1.41	2.93	1.60	2.54	1.65	2.72	1.32
Tactical	2.93	1.24	3.15	0.97	2.65	1.05	2.91	0.94
Operational	2.49	1.03	2.68	1.18	2.92	1.46	2.70	0.95
Behavioral	3.76	1.11	3.42	0.89	3.89	1.03	3.69	0.76
Defensive	3.29	1.70	3.32	1.14	3.06	1.34	3.22	1.20
Totals	3.04	0.97	3.10	0.93	3.01	0.98	3.05	0.90

The mean safety culture scores in table 2 were subsequently converted into percentages to provide safety culture profiles at different pathogenic levels (see figure 7) to make the safety culture more visible. This revealed instantly that remedial actions should be focused on the safety systems at the operational level and on safety related behaviours at the strategic level, as these are the two areas with the lowest percentage safe scores. Focus could then be placed on the next lowest scoring aspect and so on, until such time as acceptable scores were being consistently obtained and maintained at every organisational level.

Figure 7: Safety Culture Profile by Organisational Level



The outcome measure described above could also be used to determine the amount of effort being directed at each of the safety culture components at each of the organisational levels. In other words we could correlate or compare the degree of effort scores with the scores obtained from audits, surveys and behavioural safety at each organisational level, to reveal where that effort is and is not being successful in bringing about the desired outcomes.

Discussion

From definition to model to analysis this paper has attempted to build a coherent argument that safety culture is not an invisible concept that exists in the minds of academics or the legislature, but is something that is already visible or can be made visible. The problem has been that we have not really known what it is, and therefore have not really known what to examine. The ideas and safety culture components discussed here are based on a wide range of empirical research from a multitude of business disciplines. Each of the safety culture components possesses business tools that have been validated and tempered in the harsh realities of industry and commerce. In combination, they provide us with a very powerful means with which to surface industrial safety culture via measurement, quantification and analysis.

The case study reported here illustrates how the safety culture model can be used to bring a company's safety culture to the surface and make it visible for all to see. Although based on a single measurement method, it has demonstrated that it is possible and realistic to measure and quantify safety culture using readily available measurement methods. It has also demonstrated that analysing the data in accordance with Reason & Wreathall's Pathogen model can reveal insights beyond those normally found by traditional analytic methods. As such the safety culture model has been demonstrated to be a useful business tool to help companies find the right balance between developing safety systems, promoting safe behaviour and encouraging positive safety values and beliefs when allocating effort and resources.

One of the purposes of undertaking this safety culture analysis was to try and embed the safety culture model within the HSE's (1997) process model of safety management in a meaningful way. As illustrated in figure 7 this was made possible by the correspondence between the stages of the HSE's management process with the various organisational levels in Reason & Wreathall's pathogen model. In effect, therefore it becomes possible to integrate organisation structure, management process, accident causation and the measured safety culture into one unified whole.

The advantage is that when developing a safety culture we will have to consider that *latent failures* are introduced [1] at the strategic level by ineffective health & safety management policy development, [2] at the tactical level by an inadequate management structure that cannot deliver the health & safety policy; and [3] at the operational level by inadequate risk control systems. Similarly, we will have to consider that *active failures* are introduced [1] at the behavioural level from poorly synchronised workflow systems and inadequate or non-existent performance monitoring; and [2] at the defensive level by a failure to install the appropriate failsafe review mechanisms or act on the findings of such mechanisms.

In turn we then have to consider the situational, behavioural and psychological components that comprise good policy development, organising structures, risk control systems, synchronised workflow systems, performance monitoring systems and defensive mechanisms at each of the five organisational levels. Thus, whether we are attempting to intervene to improve the situation or develop measurement instruments we are guided where to focus our efforts to the best effect. As such the integration of proven safety management processes, with configurations of organisational structures, accident causation models and the measurement of safety culture is a step forward in the right direction for both the development of the appropriate safety structures in industry and in safety culture research.

In sum, I believe that the merging of the safety culture model with Reason's & Wreathall's Pathogen model and the HSE's management model has given us all the potential to make a quantum leap in the improvement of industrial safety performance at the turn of the 21st Century.

Footnote

A worldwide programme of research on safety culture using the reciprocal framework presented here is being established at Indiana University, Bloomington, USA. Reader's organizations are invited to contribute via sponsorship and / or participation. For further details contact the author on 001 (812) 856 4778 or via email: domcoope@indiana.edu.

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