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Safety culture and accident analysis—A socio-management approach based on organizational safety social capital

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Abstract

One of the biggest challenges for organizations in today's competitive business environment is to create and preserve a self-sustaining safety culture. Typically, the key drivers of safety culture in many organizations are regulation, audits, safety training, various types of employee exhortations to comply with safety norms, etc. However, less evident factors like networking relationships and social trust amongst employees, as also extended networking relationships and social trust of organizations with external stakeholders like government, suppliers, regulators, etc., which constitute the safety social capital in the Organization—seem to also influence the sustenance of organizational safety culture. Can erosion in safety social capital cause deterioration in safety culture and contribute to accidents? If so, how does it contribute? As existing accident analysis models do not provide answers to these questions, CAMSoC (Curtailing Accidents by Managing Social Capital), an accident analysis model, is proposed. As an illustration, five accidents: Bhopal (India), Hyatt Regency (USA), Tenerife (Canary Islands), Westray (Canada) and Exxon Valdez (USA) have been analyzed using CAMSoC. This limited cross-industry analysis provides two key socio-management insights: the biggest source of motivation that causes deviant behavior leading to accidents is 'Faulty Value Systems'. The second biggest source is 'Enforceable Trust'. From a management control perspective, deterioration in safety culture and resultant accidents is more due to the 'action controls' rather than explicit 'cultural controls'. Future research directions to enhance the model's utility through layering are addressed briefly.

Keywords: Safety; Social factors; Social capital; Socio-management; Accident

1. Introduction

> "The safety culture of an organization is the product of the individual and group values, attitudes, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programmes" [1].

> "Man is, at one and the same time, a solitary being and a social being" – Albert Einstein [2].

This paradoxical human nature of retaining individual characteristics but still getting dynamically influenced by the values, thoughts, feelings and actions of those around, makes the management of safety culture and the study of Human Factors in organizational safety challenging. It is almost impractical to remove a person from the influences of the social context in which he (she) exists and study his (her) motivations and behavior in isolation. Any attempts to find universal laws governing human nature seem very difficult to formulate and almost an improbability. "We have hardly been able to formulate any laws of human nature which are of the same rigor and standards as the laws of nature which have been formulated in the hard sciences. . ." [3]. But it is precisely this elusive human nature, which determines the organizational safety culture to a large extent, that organizations striving to achieve the highest workplace safety standards are compelled to manage.

As is evident from the above, any solution to the above organizational challenge of establishing and sustaining a robust safety culture would cut across the fields of both management and sociology. Hence safety culture, as well as accident analysis methodologies that inform prudent safety management, both need to be approached from a socio-management perspective. This paper discusses one of the many possible socio-management approaches to safety culture and accident analysis—through managing the safety social capital inherent in organizational networking relationships. It also discusses and demonstrates the

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applicability of CAMSoC—a socio-management accident analysis model.

1.1. Human Factors analysis models

There are many evolving approaches that help organizations in understanding Human Factors relating to safety culture and accidents. Generally 60–80% of normal accidents are said to be attributed to Human Factors [4]. Over the past few decades, a lot of research efforts and resources have been invested in analyzing Human Factors associated with accidents and incorporating the learning into workplace safety promotion initiatives. Many models have been established that discuss human factor analysis in accidents, e.g. Reason's Swiss Cheese Model, HFACS (Human Factors Analysis and Classification System) developed by Shappell and Wiegmann, Classifications of Socio-Technical Systems involved in safety control by Rasmussen, STAMP (Systems-Theoretic Accident Model and Processes) of Leveson, etc.

These models analyze the root causes of human error (unsafe acts) in accidents: tracing the path from active failures at the accident spot, all the way up to latent defects in the organization in the form of improper management of people, systems, processes and culture (Organizational influences).

But the fact remains that human nature and behavior is not easily predictable. Employees may react differently to similar circumstances in a working environment. The same employee may react differently to the same circumstances when working under pressure. Given this element of dynamism in human nature, discrete organizational steps taken, as a response to the identified past latent defects may not be sufficiently effective. For example, if a particular human error was traced back to lacunae in the selection and placement process, there is no guarantee that a person selected as per the new improved process would not commit this or some other related new error.

Some of the key contributors of human errors/factors are lack of knowledge and/or lack of skill and/or deviant behavior on the part of an employee (or a group of employees) committing the error (deviant behavior is behavior that does not conform to norms or that does not meet the expectations of a group or society) [5]. This leads us to the question: should we analyze human errors at a higher level of granularity or focus on specific deviant human behaviors to make a quantum impact on organizational safety?

1.2. Need for extending the scope of accident analysis into sociological domains

Assuming safety processes and training can address lack of knowledge and lack of skill, what remains immensely challenging to deal with is deviant human behavior that causes accidents. This behavior could be on the part of an individual or a group of networked individuals. Quite evidently, there must have been a social norm that the individuals (groups) did not internalize for the deviant behavior to result. Can this lack of internalization be traced to formal or informal inter-relationships between people or groups of people that did not work the way it was meant to be? For example, the consequences of the Bhopal gas tragedy were magnified due to refusal of Union Carbide to shift the MIC facility to a government designated industrial area for hazardous materials. If there had been a strong relationship between Union Carbide and the Government of Madhya Pradesh, bonded by trust (instead of lobbying) and motivated by a common interest for public safety (instead of profiteering/personal gains), it would have led the plant to be sited in this less populous area. This situation, then, necessitates examining accident causal factors from a sociological perspective.

1.3. Sociology and organizational safety

The application of sociological theories in organizational safety is not new. In the context of organizational safety, sociologists have hitherto been primarily concerned with evaluating possible operator (human) errors and nonconformities. A frequently cited reference in sociological circles is the work done by sociologist Charles Perrow on normal accidents (the term 'normal accidents' refer to those failures that are inevitable given the manner in which human and technological systems are organized) [4]. Attempts have also been made to apply other sociological concepts, e.g. Bandura's Socio-Cognitive Theory to organizational safety [6]. Sociologist Andrew Hopkins, in his book "Lessons from Longford" (2000) has analyzed the Australian Esso accident causes further up the social chain. His approach takes the reader through the full range of contributing factors, such as management system inadequacies, regulatory failures and even the cost cutting pressure driven by the need to meet shareholder dividend demands. The principle behind this analysis is that if the organizational factors are right, the technical causes of accidents will not come into play [7].

The crucial question then is, how to get the organizational factors 'right'? How does one manage organizational features such that safety becomes the second nature of employees in their thoughts, action and behavior and results in a healthy safety culture? If one were to agree that regulation, audits and training are just part of the solution and not the entire solution itself, then what else could be done to narrow the gaps in solutioning?

The formal 'safety' norms/features are documented in regulatory compliance requirements, process and training manuals, codes of conduct and employee role definitions, but the very persuasive informal safety norms/features have to be felt, and experienced—they cannot be easily documented in any manual. They reflect the collective thinking and behavior of the organization and are the organizational safety values in action. In practice, this collective thinking and behavior affect not only how employees relate to one another but also affect how employees relate to people external to the organization, e.g. with regulatory and inspection authorities with respect to safety. The persuasiveness of collective thinking and behavior is well established by the eminent sociologist Durkheim-particularly in his work on social facts [8].

2. A socio-management framework for safety culture

In order to manage such intangible but yet potent organizational networks and relationships, we need a focussed socio-management framework.

The ideal socio-management framework for safety will consist of:

(1) a theoretical foundation with roots in sociology and management,
(2) an actionable framework for managing social capital.

Organizations have traditionally tried to generate and sustain safety values in their employees through training interventions, exhorting the employees to comply with safety norms, etc. However, increasingly organizations are finding that these alone are not the panacea for all problems—they also need to focus on the relationship between individual employees as a key driver to organization wide culture-change initiatives. Tremendous investments are made in collaborative, networking technologies, distributed databases and knowledge management systems with the hope of achieving better safety standards and practices. Such a focus on the interrelationships between employees demands that organizations look more closely at the sociological concept of 'social capital'.

2.1. *Organizational safety social capital—a socio-management theoretical foundation*

Definitions of social capital abound, but this paper is based on the social capital premise of Robert Putnam, whose book 'Bowling Alone' (2000) contributed considerably to the popularity of this concept. "Social capital refers to the collective value of all social networks and the inclinations that arise from these networks to do things for each other [9]. It consists of the features of social organizations such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit" [10].

It follows that if organizational social capital in the context of safety, i.e. 'safety' social capital is managed, developed and encouraged in the organization, we can indeed look forward to favorable organizational features that facilitate coordination and cooperation amongst employees and other stakeholders to achieve the highest standards of workplace safety.

2.1.1. *Safety Social capital and safety culture*

In order to manage organizational safety social capital better, one needs to first have insights on how social capital works. Based on an application of Putnam's views on how social capital works generically [11],it emerges that managing safety social capital well can:

- Help focus on the relationship between employees and other stakeholders in the interests of establishing a safety-first culture. A relationship based on trust and high safety values to a large extent determines the inherent safety in the system.
- Facilitate safety related information flows among employees and other stakeholders including regulators and stockholders—these information flows would be formal as well as informal and will in turn depend on the structure and degree of relationship.
- Determine and positively increase the extent to which employees bond with each other and do things for each other in the interests of safety.
- Enable employees to take collective action if they find safety deficiencies.
- Promote a sense of solidarity amongst everyone in the organization in ranking safety as first—this will facilitate the creation and sustenance of a safety first culture.

A brief review of current literature in Safety Culture suggests that there is no consistent definition of 'Safety Culture'. Many approaches to safety culture are being discussed internationally, including socio cognitive approaches [7]. "Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventative measures" [1]. Considering some of the ways in which safety social capital can work for an organization as discussed above, it follows logically that safety social capital is indeed very indispensable to Organizations in order to have a positive safety culture.

2.2. *An actionable socio-management framework for managing safety social capital*

Social networks (in which social capital resides) are not a natural given and must be constructed through institutional strategies oriented to the institutionalization of group relations [12]. While network relations can be 'created' formally and informally, mere authority upon the networking 'actors' cannot achieve their sustained continuation. The sustenance of this cohesion depends on the motivation of the networking players (actors) to bind together. It follows that if one is looking at any meaningful management of safety social capital, one has to manage the motivational sources that bind the socio-organizational networks and the associated social capital first.

2.2.1. *Motivational sources of safety social capital*

Portes [12] classified sources of social capital into two types: altruistic and instrumental and each is further broken down into two: "value introjection" and "bounded solidarity" for the former; and "simple reciprocity" and "enforceable trust" for the latter [13].

(i) Value Introjection refers to internalized norms and behaviors (e.g. people willingly abiding by safety reporting requirements, preventive maintenance schedules, etc.).
(ii) Bounded Solidarity refers to identification with one's own group, sect or community. It is an emergent product of common fate (e.g. worker unions, from two different chemical companies, by being thrown into a common hazardous situation, learn to identify with each other and support the causes of each other).
(iii) Reciprocity Exchange refers to a generalized system of exchange in which social actors help others not because they expect immediate repayment, but because they anticipate help being extended to them at some future date (e.g.

sharing safety alerts and best practices amongst a community of nuclear power producers across the globe).

(iv) Enforceable Trust refers to trust that exists precisely because obligations are enforceable, not through recourse to law or violence but through the power of the community (e.g. a company may voluntarily withdraw its drugs from the market fearing community reprisals).

Though Portes's model is based on an individualistic connotation of social capital unlike Putnam's collectivist approach, in this paper, Portes's model has been modified to reflect collectivism. A detailed discussion regarding the differences and merits of the two approaches to social capital is beyond the scope of this paper.

2.2.2. The importance of managing negative social capital

Putnam's interpretations of social capital have been largely positive in nature. However social capital has a potential downside to it too and authors like Portes and Landolt have cautioned against regarding social capital as a "cure all" for every situation [14]. Some of the negative aspects attributed to social capital include: networks strong in social capital excluding others from the group, restricting the freedom of certain individuals within the network who may not wish to "conform", etc. Also, mere existence of strong social capital within a network need not necessarily mean benefits accrue to the members—e.g., existence of "Strong" safety social capital that supports a "safety first" culture will not translate into any use for the organization if the underlying technology is unsafe, e.g. the grossly inadequate safety equipment and gear provided by the mine owners was one of the primary causes for the Westray coal mine disaster (1992) in Canada. A high social capital present amongst colleagues based on a strong social network may lead colleagues to stand-in for each other, even in deviant behavior—as it happened in the Exxon Valdez case where tired, overworked colleagues stood in for an alcoholic captain. The potential upsides and downsides underline the need for safety social capital to be "managed" well in the organizational context.

2.2.3. Managing Social capital through behaviorally oriented controls

The depletion/malfunctioning of formal and informal social networks in organizations leads to an erosion of norms and trust. This invariably leads to depletion of the underlying safety social capital and affects safety adversely. Networks are based on relations and relations are dynamic. Consistent safety-first culture throughout the organization requires, apart from motivation for formal and informal groups to bind together in the common interests of safety, a method of installing checks and balances (controls) that prevent the dynamic networks/groups from behaving deviantly. This necessitates a behaviorally oriented control system.

The objective of a behavior-oriented control system is to achieve 'good control' and not 'perfect control'. Perfect control is obviously not a realistic expectation because it is virtually impossible to install controls so well designed that they guarantee good behaviors. What is more realistic is to aim for good control where an informed person can be reasonably confident that no major, unpleasant surprises will occur [15]. In the interests of achieving 'good control', Merchant [15] proposed four main controls: action, personnel, cultural and result controls. An overview of what constitutes these controls and a few examples of each control class is provided below. Readers are requested to refer to the book as cited Ref. [18] for further information and descriptions.

i. Action controls comprise of behavioral constraints, pre-action reviews, action accountability and redundancy: behavioral constraints include constraints like physical constraints, administrative constraints and separation of duties.Poka-yoke type of process constraint, Computer passwords, restricted access to certain hazardous areas are forms of physical /administrative constraints. The necessity to seek approval of shift supervisor when following a non-standard process or a process-deviation is an example of pre-action review. A system of maintaining compulsory on-the-job checklists is a form of action accountability control. A requirement to maintain mirror sites/stand-by service engineers to reduce system downtime is a form of redundancy control.
ii. Personnel controls comprise of selection and placement, training, job design and provision of necessary resources: requirement for interview candidates to undertake personality tests and then map these personality traits to the desired job personality profile is a form of selection and placement control. Requirements for employees to undergo refresher training at pre-determined intervals are an example of training controls. Requiring each role in the organization to have specifically identified KRAs (Key Result Areas) and communicating the same to role-holders in writing is an example of job design controls.
iii. Cultural controls comprise of codes of conduct, group-based rewards and inter-organizational transfers: maintaining and reinforcing a written code of ethics at work is an example of code of conduct control. Apart from team incentives, schemes like ESOPs (Employee Stock Option Plans) are examples of group-based rewards. Requiring every employee to have a change in job-profile at least once in 3 years is an example of intra-organizational transfer mode of controls.
iv. Result controls aim at maximizing the chances of employees producing the results the organization desires: pay-for-performance is a prominent example of results control.

In order to install a system of organizational controls that preserves and enhances safety social capital, it is first important to understand how erosion in safety social capital can lead to deterioration in safety culture and accidents. This requires a socio-management approach to accident causal analysis.

3. The CAMSoC (curtailing accidents by managing social capital) model

All causal factors, including technical factors, identified in an accident causal analysis have the potential to get examined further for the overlying social factors—after all technology is also created and used by humans. This underscores the need for applying sociological concepts in cohesion with management principles in accident analysis-in other words, using a socio-management approach to accident analysis.

Such an analysis needs a critical evaluation of Social Factors contributing to accidents, which in turn necessitates a framework that

- should to be valid in different accident scenarios and in different industries,
- should have a basis in sociological/socio-psychological theories as well as serve as a practical tool for industrial accident analysis.

The framework would typically comprise of the following elements: the social actors involved, the relationships among them and reasons for their deviant behavior that led to the accident. The output of such a framework would be to identify motivation source type problems and specific organizational controls that broke down and led to accidents. This would then help inform the actionable socio-management framework for managing organizational safety social capital as discussed in Section 2.2. In all, such an approach to accident analysis would deliver value to society by helping to systematically extract social lessons learned from accidents, which information, in turn can be utilized by organizations and regulators alike for advancing towards a better safety culture.

3.1. Lending a structure to the CAMSoC model

"Overlying every technical or civil system is a social system that provides purpose, goals, and decision criteria " [16]. The omnipresence of social factors overlying all organizational systems and situations including accidents is well evident. The scope of the term 'social factors' is very wide in sociology. In this paper social factors would mean and include all aspects of the organizational actor group's environment that involve more than one person or that has been, in the past the product of people [17]. It follows that if one were to analyze accident causal social factors in greater depth, then one needs to look at what went wrong with the underlying organizational socio-features like networks, norms and trust in the safety context—in other words how and why was the organizational safety social capital eroded. This entails focusing on deviant behavior (as discussed in Sections 1.1 and 1.2) that resulted in erosion of safety social capital, thereby leading to the accident. The next question is why the actor groups, especially the Key Actor Group indulged in this deviant behavior. The process through which we seek such information is called 'attribution' in social psychology. Many Social psychologists have contributed to theories on attribution, e.g. Graham and Folkes, Heider, Pittman, etc. However, this paper, deals with the question: did others' behavior stem mainly from internal causes (their own traits, motives, intentions); mainly from external causes (some aspect of the social or physical world)' or from a combination of the two? [18]. In developing the CAMSoC model, the internal causes for deviant behavior of the Key Actor Group is analyzed by seeking the fault in the source of motivation and the external causes for deviant behavior is analyzed by seeking to identify the break-down of organizational controls that allowed the deviant behavior to manifest. A discussion of the implications of motivation sources and organizational controls for social capital has already been made in Section 2.2.

The steps followed in the CAMSoC accident analysis (Fig. 1) are:

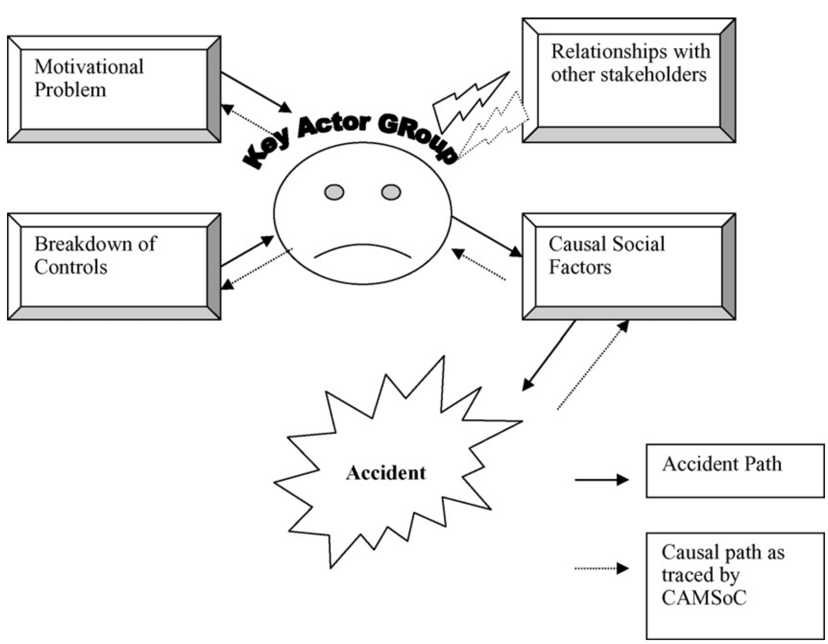

Fig. 1. A pictorial representation of the single layered CAMSoC model.

(i) Identify the accident causal factors—this could be from various sources ranging from primary accident investigation reports and interviews to secondary accident information databases, press reports, etc.
(ii) Once the causal factors (either human or technical factors) of accidents are identified, their social context is examined and Social Factors(SFs) are thus extracted.
(iii) The Key Actor Group (the group which contributed predominantly to the decline in social capital in the context of each SF, by indulging in deviant behavior), is identified.
(iv) The source of motivational problem (using Portes's motivational classifications) for this group's deviant behavior is identified. If there is more than one motivational source attributable, the predominant motivational source is considered.
(v) Failures of controls are mapped from a behaviorally oriented control (Merchant's organizational control model), which in combination with the motivational problem had actually led to the accident. If there is more than one controls class attributable, the predominant control class is considered.

The above is a basic single layered model of CAMSoC. The complexities with the CAMSoC modeling will increase if one were to include more layers in the analysis – e.g. all actor groups – major and minor-for each causal factor in (ii) above, all causal motivational sources in (iii) above and all causal control failures, major and minor in (v) above. In such a multi-layered CAMSoC model, suitable aggregation methods have to be employed and then the social lessons from the accidents have to be extracted in terms of identified flawed motivational sources and organizational controls. In this paper, however, only the basic single-layered model of CAMSoC is elaborated. Further research is required to develop such a multi-layered CAMSoC model.

Social Sciences are not exact sciences. It is quite possible that the classification of the Key Actor Group as in (ii) above as major or minor, the source of motivation problem as in (iii) above and the classification of controls as in (iv) above may differ from one accident investigator/analyst to another. In order to ensure consistent results from the model, further research is required in developing templates that would formalize the process of this classification and reduce subjectivity to a reasonable extent.

In this paper, such classifications in the ensuing accident analysis have been made by the author of her own, based on references as cited and have not been independently verified by any authority. Readers may please be aware that the purpose of these classifications and the consequent accident analysis is to demonstrate the utility and possibilities of deriving social lessons using the CAMSoC model and not to fix/assign accident causing responsibilities on any of the Key Actor Groups in past accidents. Although the author has taken every care for the thoroughness of the detailing, it is possible that there are more social factors existing than those that have been identified in this study. The accident analysis as found in this paper may be treated as an illustration of the model's applicability to accident investigations.

In live safety/accident investigations, the CAMSoC model would be utilized by the accident investigation teams and regulators/judiciary to help identify the Key Actor Group(s) responsible for the accident, provide insights into their motivations, and also identify the failure in specific organizational controls that led to the accident. This in turn would be useful to provide insights and inform socio-management approaches to bettering organizational safety.

4. Socio-management analysis of five major accidents using CAMSoC

In order to lend practical insights into the subject of safety social capital, five major accidents from different sectors, which caused considerable damage to life and property in their vicinity, were analyzed. Care was taken to ensure that these accidents were geographically distributed across the world in order to cover various populations and cultures. A brief outline of the accidents is given below, followed by an illustration of the how the CAMSoC model is applied to causal social factors of these accidents. Results arising out of this analysis are presented, followed by a summary of socio-management learning for organizational safety from the CAMSoC analysis.

4.1. A brief description of the accidents [19,20]

Please note that the description given below is only aimed as a brief introduction to the accident and are by no means exhaustive. Readers are requested to refer to the sources as mentioned in order to obtain more information about the accidents.

4.1.1. The Bhopal Gas Tragedy [21–23]

At mid night of 2 December 1984, the city of Bhopal in India faced the worst ever disaster in chemical accident history. 40 tonnes of Methyl Isocyanate (MIC) escaped from Tank #610 from an Insecticide (Sevin) making Union Carbide factory, killing more than 10,000 people and leaving thousands physically and mentally impaired. It did everlasting damage to the soil and ground water in the plant vicinity. The immediate cause for the disaster was MIC release triggered by water entering Tank #610 and the subsequent pressure build-up that ruptured the tank. The water itself had entered the tank as a consequence of a supervisor ordered water-washing operation. But as is usually the case in many accidents, this accident too was the culmination of a series of factors, whose seeds were sown many years ahead and whose growth was encouraged by consistently inferior and inadequate safety practices. The negligent attitude of Top Management and the telling absence of a basic safety culture were responsible for the disaster as much as the MIC.

4.1.2. The Westray coal mining disaster [24,25]

In the early morning hours of 9 May 1992 the Westray coal mine, promoted by Curragh Inc., in Nova Scotia blew up killing all 26 men working underground. The immediate cause of the accident was a methane explosion most probably ignited due to sparks caused by a continuous miner. Much like Bhopal, Westray was also characterized by an utter lack of safety culture.

4.1.3. The Tenerife Air Tragedy [26,27]

On a foggy early evening of 27 March 1977 two Boeing 747s—Pan Am 1736 and KLM 4805 collided on the runway of Los Rodeos Airport on the Tenerife Island. Five hundred and sixty people lost their lives, over 60 were injured and the airplanes were completely charred. The immediate cause of the accident was the impact of KLM 4805 on the Pan Am 1736 due a take-off operation by the KLM captain, without obtaining the final clearance from ATC. That non-compliance, catalyzed by a general communication gap and an unexpected thick fog finally resulted in the air tragedy.

4.1.4. The Hyatt Regency Walkway collapse [28–31]

On the 17 July 1981, a dance party turned into a nightmare for the 2000-odd guests assembled at the Hyatt Regency Hotel, in Kansas City. Over 114 people were killed and at least 200 injured when the second and fourth level walkways crashed. The immediate cause of the accident was the split of the box beam and the support rod pulling through, causing the second and fourth level walkways to collapse. Unplanned doubling of the structural load onto the box-beam supporting the fourth floor due to an unauthorized change in design and a faulty original design were the prime factors that made the collapse inevitable.

4.1.5. The Exxon Valdez oil-spill disaster [32,33]

On 24 March 1989 the tanker Exxon Valdez piled into the Bligh reef and spilled some 10.8 million gallons of North Slope crude oil into the seas. This act caused immense long-term losses to the fisheries, tourism and the sea ecology apart from fouling up more than 1000 miles of beach in south central Alaska. Though there were no deaths directly as a result of the accident, four lives were lost during the clean up operation. The immediate cause was the inadequate response of the ship to a course change (a ‘steer right’) command given by the Third Mate. The underlying factors of an alcoholic Captain and crew change violations led to one of the world’s worst oil-spill disasters despite a voyage-friendly atmosphere throughout.

4.2. Applying the CAMSoC model for accident analysis

4.2.1. Methodology adopted for accident analysis using CAMSoC model

i. The social context of each of the causal factors was identified and captured as SFs accident wise. In this, the following was used as a general rule for analysis: examine and trace the causal factor up to the point when more than one person is involved and collective thinking/relationships with other actors or the lack of it is detected. This gives the causal social factor. As an illustration (see Table 1), in the case of the Hyatt Regency, inadequate and faulty design was a key cause for the collapse of the walkway. Whereas this could have been traditionally traced to factors like a failure of design supervision, faulty design engineering skills or plain lack of communication between the two actor groups, viz. the Design Engineering Firm and the Fabricator, a sociological perspective suggests that this be seen from a network/relationship point of view where the role of more than one actor comes into play. Consequently, if one were to trace the faulty design to the point of relationships between actor groups in the Hyatt Regency case, the social factor emerges out to be lack of design ownership between Fabricator and Design Engineering Firm.

ii. The next step is to analyze what went wrong with the networks/norms/trust that was supposed to hold the safety social fabric together and which Key Actor Group was responsible for this depletion in safety social capital. This analysis was done on the basis of either contractual obligations or on the basis of generally accepted normative principles. For example in the Hyatt Regency case, both the Design Engineering Firm and the Fabricator were responsible for not aligning the design with the fabrication. However, contractually, the

Table 1
Illustration of CAMSoC model applied to a causal SF of Hyatt Regency

Social factor: lack of design ownership between fabricator and design engineering firm		
Key Actor Group	Design Engineering Firm (DEF)	In this case DEF contributed to a decline in social capital by not maintaining appropriate formal or informal channels of communication with the fabricator (a collapse of extended networking relationships), and making presumptions that the fabricator would have fabricated on the basis of original design (collapse of misplaced trust)
The motivation source type problem	Enforceable Trust	As far as the DEF was concerned, it violated the trust the owners and society had placed in them as ‘professionals’ with a license to deliver reliable engineering design. In a multi-million dollar contract, not checking whether the Fabricator was delivering as per the design speaks volumes of the lack of care and diligence with which the DEF had approached the project construction. To add to this, even had the fabricator delivered as per the original design, the design by itself was in violation of the Kansas City Building code-again a violation of trust placed by society in a professional engineering firm
Behavior oriented control type failure	Pre-action reviews	Pre-action reviews are an important form of control for avoiding such mishaps. This should have been applicable at least at two levels-owners of Hyatt Regency independently validating construction design and DEF checking if the fabricators are proceeding with the right design ‘before’ they began the actual fabrication

Table 2
Bhopal-Key Actor Groups SF wise

Key Actor Group	No. of SFs
Bhopal (see Chart 1)	
Top management	29
Plant management	14
Design engineers	5
Regulators/law makers	2
Total SFs analyzed	50

licensed Design Engineering Firm was expected to validate the designs and take ownership for the designs-hence this makes the DEF the Key Actor Group for this social factor.

iii. Then the source of motivation for this actor group's deviant behavior was examined and categorized (based on Portes's motivational sources of social capital—see discussion in Section 2.2.1 for further information on source of motivation classifications).
iv. Finally the specific failure of controls with identified types of deviant behavior was mapped using the Merchant model of organizational controls (see discussion in Section 2.2.3 for further information on control classifications).

See Table 1 for an illustration of the reasoning underlying the (iii) and (iv) classifications.

4.2.2. Application of CAMSoC model in the Hyatt Regency Walkway collapse—an illustration

An example of how the CAMSoC model was applied to one particular social factor of Hyatt Regency accident is illustrated in (Table 1); limitations of space prevent an elaborate discussion of the other 122 SFs across all the five accidents that were analyzed in the same manner.

Causal factor. Inadequate and Faulty Design was a root cause of the Hyatt walkway collapse. This was later a point of legal dispute with the Design Engineering Firm claiming that the Fabricator had never sought their approval for design modifications.

5. Results of the accident analysis and implications for organizational safety

In all 123 SFs (Tables 2–6) were analyzed across the five accidents using CAMSoC. Key findings from this analysis are summarized below.

5.1. Insights on motivation sources

A summary of the motivation source type problems across the five accidents is given in Table 7.

Table 3
Westray-Key Actor Group SF wise

Key Actor Group	No. of SFs
Westray (see Chart 2)	
Top management	14
Plant management	7
Coal miners	1
Regulators/law makers	8
Total SFs analyzed	30

Table 4
Tenerife-Key Actor Group SF wise

Key Actor Group	No. of SFs
Tenerife (see Chart 3)	
ATC designers	1
ATC controllers	4
Top management	2
KLM captain	3
KLM crew	4
PanAM crew	2
Total SFs analyzed	16

Table 5
Hyatt-Key Actor Group SF wise

Key Actor Group	No. of SFs
Hyatt (see Chart 4)	
Design engineer	5
Fabricator	1
Top management	5
Near-Miss investigators	1
Total SFs analyzed	12

Table 6
Exxon Valdez-Key Actor Group SF wise

Key Actor Group	No. of SFs
Exxon Valdez (see Chart 5)	
Captain	11
Third mate	1
Ship crew	1
Top management	2
Total SFs analyzed	15

In almost all the accidents (except Tenerife) (Charts 1–5), the most frequent disturbance to safety social capital is caused by Faulty Value Systems (FVS) of the Key Actor Group. This is followed by (violations of) Enforceable Trust (ET), lopsided Reciprocity Exchanges (RE) and misplaced Bounded Solidarity (BS).

Table 7
CAMSoC Results-Summary of Motivation Source Type Problems

Motivational Source Type Problem(Single Layered CAMSoC)	Bhopal	Westray	Tenerife	Hyatt	Exxon	Total
Value Introjections (Faulty Value Systems)	20	12	5	5	7	49
Bounded Solidarity	3	4	4	–	6	17
Reciprocity Exchange	9	4	–	4	–	17
Enforceable Trust	18	10	7	3	2	40
Total motivation source type problems	50	30	16	12	15	123

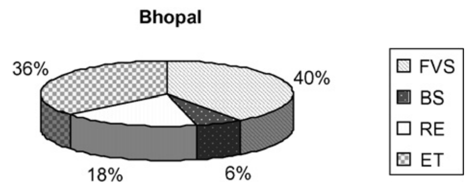

Chart 1.

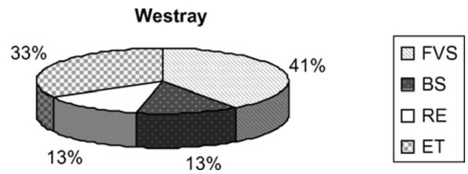

Chart 2.

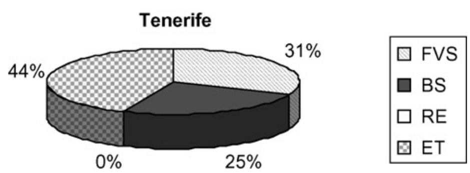

Chart 3.

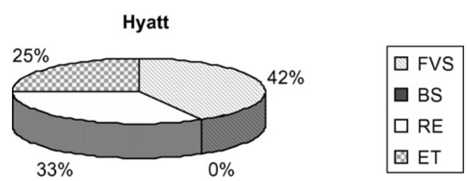

Chart 4.

Motivational problems of Key Actor Groups have significant sociological and management implications for both Organizations and Regulators alike. The frequency-based ranking of the

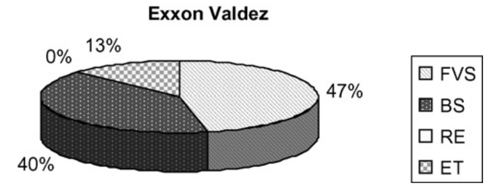

Chart 5.

motivation source type problems, as obtained in the above manner, helps set regulatory and management priorities when dealing with issues relating to safety culture.

A graphical analysis based on the CAMSoC model is presented in Charts 1–5.

5.2. Trends in failure of behavior oriented controls

A summary of failures of controls is given in Table 8.

Within the scope of this accident analysis, the following are the control related observations (Table 8) that have significant sociological and management related implications:

- On an aggregated basis, failures of explicit 'cultural controls' are only on 15 occasions out of a total of 123 SFs. Especially in accidents like Bhopal and Westray where the deterioration of safety culture was very evident, the proportion of explicit cultural control failures were low – 10% and 17%, respectively – as compared to failure of other forms of controls like Action Controls and Result Controls. This emphasizes the role of other forms of organizational controls (though not recognized explicitly as cultural controls) in contributing to the deterioration of the safety culture in the organization.
- In almost all accidents (except Westray (27%)), failure of action controls seems to account for the highest proportion of

Table 8
CAMSoC Results-Summary of Failure of Controls Classes

Failure of controls class(Single Layered CAMSoC Model)	Bhopal	Westray	Tenerife	Hyatt	Exxon	Total
Action controls						
Behavioral constraints	11	3	5		3	22
Pre-action review	10	2	2	2		16
Action accountability	7	3		5	7	22
Total action control failures	28	8	7	7	10	60
Personnel controls						
Selection and placement		2			1	3
Training	3	1	7		1	12
Job design		3	1	2		6
Total personnel control failures	3	6	8	2	2	21
Cultural controls						
Codes of conduct	5	3	1	2	2	13
Group based rewards		2				2
Total cultural control failures	5	5	1	2	2	15
Result or output controls	14	11		1	1	27
Total control failures	50	30	16	12	15	123

control failures. Bhopal (56%), Tenerife (44%), Hyatt (58%), Exxon (67%). This emphasizes the need for well-established formal organizational relationships that define behavioral, pre-action review and action accountability controls, which form a part of the Action Control portfolio (see Section 2.2.3).

- 'Faulty Value Systems' has emerged as the prime motivational source of disruption in safety social capital (49/123 SFs). Correspondingly one would have expected to find a high failure rate of 'cultural controls', which include adherence to codes of conduct, and similar controls that seek to guide/monitor value systems. Actually, as per the results of this analysis, only a minor proportion of the control failures is due to 'cultural controls' (15/123 SFs). Further research is suggested to explore and resolve this paradox.

6. Conclusions

There are many different approaches that can be followed while working towards a better safety culture-this paper discusses a socio-management approach for achieving a better safety culture. Behavioral insights from past accidents provide valuable lessons for safety culture. In this paper, a socio-management accident analysis model called CAMSoC (Curtailing Accidents by Managing Social Capital) is proposed. This method analyses accident causing deviant behavior by tracing the erosion in safety social capital, the networking relationships and the Key Actor Group responsible for this erosion, and finally the combination of motivation sources and failed organizational controls that led to the accident. The CAMSoC model of accident analysis was demonstrated by applying the model on five accidents: Bhopal, Westray, Tenerife, Hyatt and Exxon Valdez. The insights obtained from the analysis in terms of sources of motivation and failure of organizational controls was discussed and summarized. Organizations and Regulators can use these socio-management insights to better manage organizational networks, norms and values in the context of safety, i.e. the organizational safety social capital—and thereby move towards bettering the safety culture.

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