COMPARING SAFETY INTELLIGENCE IN AIR TRAFFIC MANAGEMENT AND CONSTRUCTION: A CONCEPTUAL COMPARISON

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Although safety interventions targeted at managers or supervisors are believed to be the most effective leverage for change, the mechanisms involved in developing and propagating a positive safety culture are poorly understood. *"Safety Intelligence"* was first proposed by Kirwan in 2008 as a response to growing disillusionment with safety culture, focusing on recruiting and equipping leaders with the personal attributes, skills, and knowledge required to positively influence safety in their organizations. So far Safety Intelligence has only been studied within air traffic management, but opening up the construct and exploring its relevance to managing complex and hazardous construction projects offers new theoretical directions for occupational safety and health research in the sector. Existing studies of safety-related leadership competences in the US, UK, Australian, and Danish construction industries were reviewed in light of the Safety Intelligence model. These studies have explored specific competences including knowledge; communication; leadership style; emotional intelligence; and emotional expression. By comparing these competences with those of Safety Intelligent leaders within the ultra-safe, highly reliable environment of air traffic management, the differences between the leadership styles required to cope with the differing priorities of the two sectors were highlighted. Safety Intelligent supervisors promote a just culture, empowerment and collaboration with members, proactivity, and communication – aspects of leadership which are difficult to achieve, but have nonetheless been shown to contribute to safe construction. Safety intelligence therefore holds considerable promise for improving safety in construction projects.

Keywords: competence, health and safety, leadership, organizational culture, training.

INTRODUCTION

Leadership is well-established as a defining influence in organizational culture (Zohar, 2010): Authority reinforces the social-learning process that takes place within leader-member exchanges, allowing members to recognize the values and behaviors that form the culture endorsed by the organization. Unfortunately, leaders' lack of commitment to safety has been implicated as a cause in the investigation of several

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major accidents including the Deepwater Horizon oil spill, the Texas City Refinery explosion, and the sinking of the Herald of Free Enterprise (Fruhen *et al*., 2014b).

Cultivating employees' intrinsic motivation for safe behavior is an appealing prospect, and the concept of safety culture has been utilized by many safety programs such as Hearts and Minds (Hudson *et al*., 2000), DuPont's STOP, ProAct Safety's Lean Behavior-Based Safety, and Geller's Total Safety Culture (Guldenmund, 2010). Programs like these have deprived safety culture of its intangible and implicit nature and instead attempt to engineer a culture through behavioral and visible characteristics - tackling the outer *"layers"* of Rituals (such as processes, dress-codes, and slogans), Symbols and Heroes, rather than the beliefs which underpin them (Guldenmund, 2010).

Disillusionment with safety culture is growing (Guldenmund, 2010). Rather than adopt ethnographic approaches traditionally used in anthropology, the majority of research into safety culture takes a functionalist approach, where culture is seen as a causal attitude and a variable subject to manipulation (Sileby, 2009). Given this backdrop, safety culture has been criticized for taking a Tayloristic view of safety. In the early 20th century the human factor was defined as *"Mental, physical and moral shortcomings that predispose a person to accident"* (Dekker, 2015). Accidents were primarily blamed on accident-proneness or a lack of attention and the factory inspectorates of the Industrial Revolution were only interested in accidents *"with technical causes, since others could not reasonably be prevented"* (Hale and Hovden, 1998: 129).

The emergence of Ergonomics in the 1940s shifted the focus away from so called *"shortcomings"* and approached accidents from the point of view that by applying research regarding human capabilities and limitations to the design of tools, tasks, jobs and environments human error could be mitigated. Therefore, attempts to change safety culture through propaganda to capture the Hearts and Minds of the workers implies some form of moral deficiency or a lack of effort and is incompatible with the *"fifth age"* safety paradigm that humans are an asset to systems because their adaptability produces resilience (Borys *et al*., 2009).

Holistic systems and cultural approaches have liberated workers from fear of personal blame and punishment; however, safety culture has struggled to establish itself as a research topic in construction, emerging later than in other industries and declining since 2008 (Zhou *et al*., 2015). Instead research has focused on individual characteristics, indicating that the competency-based model of Safety Intelligence could gain greater acceptance and purchase than *"fuzzy"* cultural methods.

Thus, although the concept of accident-proneness is now regarded as politically incorrect, unethical, and legally questionable, understanding the individual characteristics or conditions which increase the propensity for error is still valuable (de Winter, 2013). Safety Intelligence takes a positive approach and could open up the potential to research the characteristics which predispose a person to safe behaviors.

SAFETY INTELLIGENCE

Safety Intelligence was first proposed by Kirwan (2008) as an alternative to safety culture and a *"way of helping top level management understand safety and react appropriately, rather than just giving 'lip service"*. It recognizes the importance of CEOs and Directors in shaping culture by influencing members' attitudes to safety and defines the combination of personal attributes, skills, and knowledge required for

leaders have a positive influence. Just as leaders with higher Intellectual, Emotional and Managerial Intelligence are believed to be more effective (Müller and Turner, 2010), Fruhen et al., (2014a) propose CEOs with these characteristics are more Safety Intelligent and therefore better equipped to influence to safety culture in their organizations. Safety Intelligence offers a methodology to equip the top executive level of an organization with a means to understand and drive safety as part of their business agenda (EUROCONTROL, 2013).

The proposed Safety Intelligence model has remained undeveloped with the exception of a series of studies of senior managers in Air Traffic Management (ATM) (Fruhen et al., 2014a): Senior air traffic managers were surveyed through questionnaires and interviews about the ideal characteristics and behaviors of a CEO in relation to safety. The study focused on 5 characteristics: Personality, Problem-solving, Motivation, Safety Knowledge and Social Competence, the latter 2 of which were found to be most significant and are shown closer to the *"core"* in Figure 1.

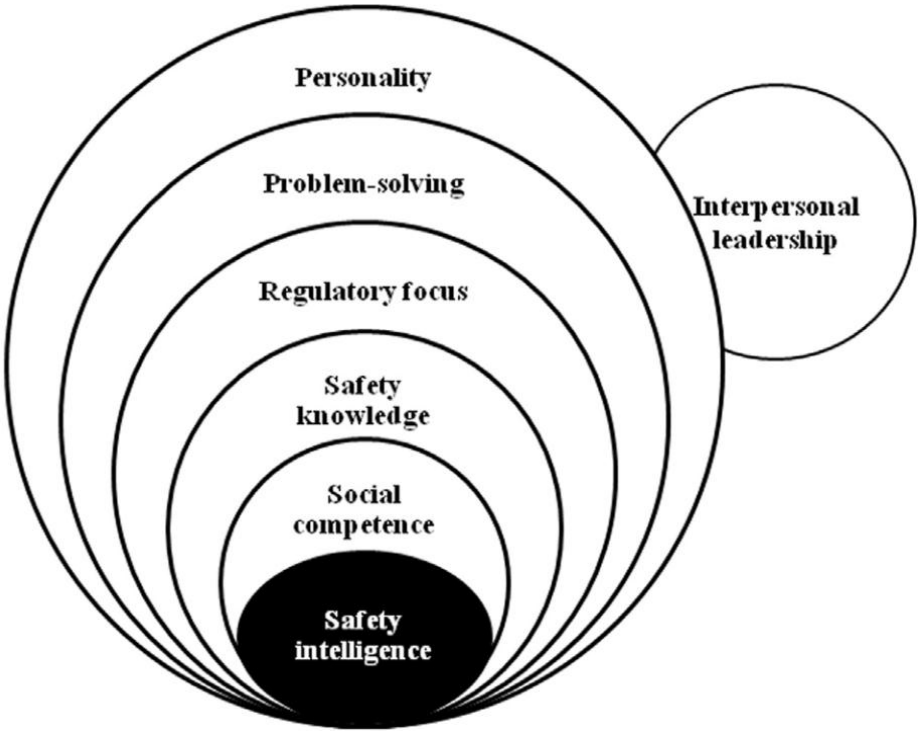

Figure 1: Conceptual Model of Safety Intelligence (Fruhen et al., 2014a)

So far, however, Safety Intelligence has only been studied in ATM – a highly-regulated, safety-critical industry with very different characteristics to construction. The extent to which it might have purchase within project-based environments, and to which it can account for the multiple temporalities and fragmented delivery structure of the industry, remains unexplored.

A competency-based approach to safety management in construction is not a novel concept. Accordingly, the authors' search identified 18 studies from the construction industry which take a similar competency-based approach to influencing safety, although each focusing on a specific safety-related managerial competence - including knowledge; communication; leadership style; emotional intelligence; and emotional expression. However, a study by Zou and Sunindijo (2013) used questionnaires and interviews to identify and rank safety-related competences and build a framework for

construction similar to Safety Intelligence. Using this as a starting point, this paper discusses these studies in light of the Safety Intelligence model in order to open up the opportunities it offers and uncover the differences between these sectors.

Table 1: Comparison of two models of competences for influencing safety

	Skills for Positively Influencing Safety in Construction	"Safety Intelligence" for ATM
Most significant Priority	Self-awareness, visioning, and Sincerity	Social Competence
		Safety Knowledge
	Scoping and Integration and Self-Management	
		Regulatory Focus
	Relationship Management, Social Awareness, and Social Astuteness	Problem Solving
Least significant Priority	Safety Management Tasks	Personality
	(Zou and Sunindijo, 2013)	(Fruhen et al., 2014a)

SAFETY-RELATED COMPETENCES IN CONSTRUCTION

Zou and Sunindijo (2013) describe 4 tiers of skills for construction supervisors: Their most significant priority or 1st tier competences are self-awareness, visioning, and sincerity, followed by scoping and integration and self-management; then relationship management, social awareness, and social astuteness; and finally safety management tasks (Table 1). Parallels can be drawn between this model and that of Safety Intelligence; both list social, problem-solving and technical skills as important, although the definition and prioritization of these skills differ. The differences between safety-management in construction and safety-critical sectors can be explained by exploring these in greater depth.

Safety Knowledge

Behavioral competences without technical skill or knowledge are futile. Many studies have shown knowledge to be integral to authentic and committed leadership (Zou and Sunindijo, 2013; Fruhen *et al*., 2014a). Hardison *et al*. (2014) explored knowledge-based competences for construction supervisors with respect to safety, and found that *"knowledge of pre job planning, organizing work flow, establishing effective communication, and of routine and non-routine work tasks are highly important"* (p. 45). This suggests that Safety Knowledge, from the perspective of construction, is the technical understanding of business processes relating to safety.

In contrast, the Safety Intelligence model puts a far greater emphasis on Safety Knowledge than Zou and Sunindijo, perhaps because its scope is considered to be broader than technical knowledge. EUROCONTROL (2013) advocates Safety Intelligent managers having a clear *"risk picture"* of the threats to their organization and an understanding of how safety works. In accordance with Weick and Sutcliffe's (2007) concept of Organizational Mindfulness, Safety Intelligent managers are encouraged to respond to weak signals of failure, develop a *"just culture"* where reporting is encouraged, and be sensitive to the human factors that are affecting

operations. However, High Reliability Organizing (HRO) has not yet been integrated into construction health and safety (Olde Scholtenhuis and Doree, 2013).

A specific understanding of both safety processes within the organization itself and *"how safety works"* (Eurocontrol, 2013: 8) in general is necessary for Safety Intelligence; thus, construction is hindered by its focus on technical aspects of safety which prevents new paradigms about how safety works, such as HRO, taking hold.

Problem Solving

Problem solving was ranked as the fourth priority (Fruhen *et al*., 2014a) by ATM CEOs – after interpersonal skill, technical knowledge, and motivation – and is vital for understanding problems and generating solutions (Eurocontrol, 2013). In construction, conceptual or problem solving skill is seen as a higher priority: The project-based, dynamic nature of the construction industry, with its temporary workforce and extensive variety, presents challenges for safety management particularly in terms of coordinating subcontractors and keeping up with the pace of change (Biggs *et al*., 2013).

Construction is formed of Temporary Multiple Organizations (TMO) *"where parts of several organizations – each with its own affiliations, its own goals and its own values – are all involved in the achievement of a plan or of an end-result"* (Stringer, 1967: 106). Learning is limited by the uniqueness of outputs and the transient nature, so managing these projects requires conceptual skill to view these complex projects from a *"big picture perspective"* (Zou and Sunindijo, 2013: 94). Visioning, Scoping and Integration were seen as fundamental to understand the dynamic relationships between stakeholders and components; ensure these are integrated as a whole; and influence safety (Zou and Sunindijo, 2013).

In their study entitled *"Preparing project managers to deal with complexity"* Thomas and Mengel (2008) suggest training for this context requires a greater emphasis on continuous change; creative and critical reflection; self-organized networking; and coping with uncertainty. Similarly, Müller and Turner, (2010) showed that construction project managers need greater propensity for Strategic Perspective and Developing.

In both ATM and construction, problem solving as a generic competence is important. However, in construction problem solving is considered more important than social skills as its dynamic, fragmented nature is a major barrier to implementing and influencing safety. The characteristics and pressures of the two sectors are very different, so the problem-solving approaches of the two types of managers are likely to be very different in reality.

Social Competence

Social competence is key in influencing employees' behavior, as leaders' commitment to safety is demonstrated by their interactions with others. Almost every study reviewed agreed that interpersonal skills are essential for successful leadership – both in construction and other sectors, and in safety or general management. The necessary competencies can be divided into Communication, Emotional Intelligence, and Leadership Style.

Communication

"Soft" skills of communication and consultation are often seen as incongruous with the uncompromising, methodical people needed to undertake complex construction

projects (Aulich, 2013). However, the need to strengthen health and safety coordinators' competence in communication and negotiation was highlighted by Antonio *et al*. (2013) and an intervention to train foremen in communication-based competences (such as mentoring and *"toolbox talks"*) increased safety behaviors on residential construction sites (Kaskutas *et al*., 2013). Similarly, Kines *et al*., (2010) found a significant, positive and lasting effect on safety levels though providing feedback and coaching to site foremen in daily verbal safety communication.

Communication needs to be systematic, understood by all stakeholders, and intelligently applied: A communication strategy must be designed with a thorough understanding of the principles of social dynamics in joint undertakings and cognitive learning theory (Aulich, 2013). Sharing tacit knowledge within an integrated project team also builds connections between team members, leading to improved dynamic capabilities and ultimately, greater team flexibility (Zhang *et al*., 2013).

While some research demonstrates that initiatives directed at managers can be more effective (Zohar and Luria, 2003), in construction the role of frontline supervisors has been shown to be more influential than that of senior managers (Lingard *et al*., 2012) and safety competence at all levels of the hierarchy – workers, foremen, and managers – is equally important, because communication between these levels is critical (Hardison *et al*., 2014). As Safety Intelligence focusses only on senior management, this suggests its methods may not be as influential in construction.

Leadership Style

Interviews with 41 construction safety leaders (Biggs *et al*., 2013) identified leadership as a key factor for positive safety culture in the organization, with an emphasis on leaders' visibility and their demonstration of a commitment to safety. This is supported by the findings of a study into the relationship between project managers' leadership style, teamwork, and project success (Yang *et al*., 2011). The results show increased leadership communication and involvement can enhance relationships, fostering teamwork, which is significantly correlated with performance.

Emotional Intelligence (EQ) is associated with many characteristics thought to underpin effective leadership: Improved self-awareness helps to develop effective relationships and understand others' emotions, thus enabling interpersonal skills such as communication, motivating others, resolving conflicts, and building teamwork (Sunindijo, 2013). Specifically, Zhang and Fan (2013) found a strong positive correlation between 6 EQ factors (emotional self-awareness, emotional self-control, empathy, organizational awareness, cultural understanding and communication) and construction project performance.

Although EQ and a transformational leadership style (Ramchunder and Martins, 2014) were found to be significant in leaders from all sectors, the traits of managers in construction do not match those found in other industries. Power, urgency, proximity, competitive threat, opposing position and neutral attitude are shown by the most influential construction stakeholders (Yang *et al*., 2014). Lindebaum and Fielden (2010) show how construction project managers quickly resort to anger in order to resolve issues, and felt this was necessary to raise their visibility, achieve the desired outcomes, and maintain their image and reputation because the trait is seen as *"role-defining"* for managers in the industry.

The need to assert authority reflects the other pressures on construction managers including organizational culture, turnover, job pressures, working relationships, budget and safety communication which dictate safety performance (Kaskutas *et al*.,

2013). Conchie *et al*., (2013) found that managers' engagement in *"safety leadership"* was hindered by workforce characteristics; role overload; production demands; and formal procedures.

Although managers in both sectors need to communicate strong messages, Safety Intelligent managers do this through engaging with others and listening (Fruhen *et al*., 2014a). The way in which social competence is enacted in these two sectors is very different, and Zou and Sunindijo (2013) rate this as a lower of a priority in construction.

Table 2 - Summary of the contrasts between safety intelligent competences in ATM and Construction

Air Traffic Management	
Prioritisation	Interpretation
1. Social Competence	Communication from management is the most important in improving site safety
	A Just culture
	Empower and collaborate with employees
	Engage with employees and listen
2. Safety Knowledge	An understanding of contemporary and emerging safety constructs (such as Organisational Mindfulness) alongside technical processes
3. Problem Solving	Necessary to understand problems and generate solutions
Construction	
Prioritisation	Interpretation
1. Problem Solving	Essential to cope with the fragmented and dynamic nature of the industry
	Emphasis on a strategic perspective
	Communication at all levels is vital to build integrated and flexible teams
2. Social Competence	Power, urgency and anger are traits of good leaders
	Self-awareness and Sincerity
	Emotional intelligence supports effective management
3. Safety Knowledge	A technical understanding of business processes relating to safety

CONCLUSIONS

This literature review has highlighted the differences between these industries which limit the transferability of Safety Intelligence. As a TMO, it is more difficult for managers of complex construction projects to understand these fragmented and transient organizations. Problem-solving must take place between multiple contractors and stakeholders and reaching solutions is prioritized over their tactful delivery through developed interpersonal skills. The dynamic nature of construction and

production pressures also means leaders are required to deal with conflict in an assertive way, rather than collaborate as seen in Safety Intelligent leaders.

Despite the superficial similarities observed between the generic behavioral competences in ATM and construction, the *"job-task"* competences are highly industry specific (Cheng, Dainty and Moore, 2005). To influence safety, the papers reviewed show construction supervisors need to be more assertive and astute in their relationships, cope with constant change, and grasp a more complex operational picture than air traffic managers.

In light of the differences between these two sectors, it is apparent that the ATM Safety Intelligence model would need to be adapted to construction before informing the selection and training of construction supervisors. However, whether the differences in leadership style are due to weaknesses in managers' competency-development, or the challenging environment in which they work, would need to be determined. Although the Safety Intelligence model provides an overview of management competences in an ultra-safe industry, a causal link between these competences and safe operations has not been explored. Validation is needed; in particular, testing a causal link between Safety Intelligence and safety in a more complex environment such as construction.

Risk is often accepted as an inherent part of construction work (Swuste, Frijters and Guldenmund, 2012) but the safe build of the Olympic Park challenged this, demonstrating that it is possible for construction to be a *"highly-reliable"* organization. This unique success was underpinned by a culture of *"respect, trust, clarity, pre-emption, challenge, consistency, collaboration, motivation, empowerment, communication, openness, fairness and assurance"* (Bolt *et al*., 2012) – characteristics which are more consistent with an HRO like ATM than construction.

Safety Intelligent leadership poses a challenge for construction: Although the leadership style necessary to influence safety may be enacted differently in different sectors, the underlying principles of Safety Intelligent leadership – promoting a just culture, empowerment and collaboration with members, proactivity, and communication – have all been shown to contribute to the success of the Olympic Park. Although the uptake of safety culture methods (in their intended form) have been limited, Safety Intelligence provides an alternative with the potential to introduce resilient and proactive safety to construction in a pragmatic way.

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