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### The comfort of control in uncertain safety spaces: But what *is* a safety control?

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### Extended Abstract

The world of occupational safety management has an interesting relationship with uncertainty. Not only is safety itself a ‘non-event’ (Sutcliffe and Weick 2013) it is also widely accepted to be a socially constructed phenomenon (Antonsen 2009:24). This makes it rather more ethereal and chimeric than most topics studied by researchers of engineering projects and their organization. Indeed, there is no scientifically agreed definition or even a broadly accepted colloquial answer to the seemingly straightforward question: what is safety? It is however unsurprising that the concept of control finds a warm welcome within contemporary practices of occupational safety management. Our common understandings of control provide reassurance, a sense of things ‘under control’, as realized through demonstrable power over a situation – all of which provide explicable comfort for safety professionals that work with uncertainty on a daily basis.

However, empirically grounded understandings of controls and how safety professionals actually conceptualize and make sense of them, theoretically or practically, is currently lacking. This research aims to take first steps towards addressing that gap in knowledge by presenting early findings from a survey of safety professionals that asked just one question: ‘what is your own personal definition of safety controls?’

The concept of control has existed within occupational safety throughout its history (Hollnagel 2004; Dekker 2019). The earliest mention in legislation can be found in the UK’s Factory and Workshop Act 1878 which explicitly notes the need for machine guarding as the first control legally required in the mills and factories of the UK as they sprang up following the first industrial revolution. Theoretically, controls have been approached from two fundamental perspectives: either as a process – as a fundamental part of a Safety Management System (SMS) (Hudson 2001) – or as a means of defense or prevention, a construct with links to accident prevention (Li and Guldenmund 2018). Indeed, much occupational safety research and practice finds its roots and constructs in accident investigation. For example, control can easily be seen in Reason’s (1998) Swiss Cheese model of accident causation, in which the various defenses, barriers and safeguards collectively form controls as manifested in the solid parts of the Swiss Cheese. Accident investigation seeks to find the holes (the causal factors that lead to accidents) and fill

them in through the application of appropriate controls. Early in the history of occupational safety such infills were created through tangible things, able to provide physical defenses (Hollnagel 2014) and barriers to harm (Provan et al 2020). Over time, controls became more associated with processes, as control of human behavior and human error became more prominent within safety management. This eventually also included consideration organizational factors and ‘blunt end’ upstream events that influence safety on jobsites (Dien et al 2012). Process-focused controls seek to put policies and procedures in place to prevent harm through administrative means, often leaning into the concept of safety culture to entrench systems and processes that all workers can readily adhere to.

Arguably the most prominent practical use of controls is found in the ubiquitous *Hierarchy of Control* (OSHA 2023) which has become well-established in the safety management toolkit, directing safety professionals through a series of ranked safeguards to protect workers from hazards. Elimination is prescribed as the most effective action through which the hazard is physically removed, followed by substitution in which it is replaced, engineering controls which isolate the worker from the hazard, administrative controls which change work practices and finally the least effective level of control through the provision of Personal Protective Equipment (PPE). Although very familiar to safety professionals, the Hierarchy of Control emerged from practice and experience, rather than being grounded in scientific evidence or testing. Interestingly, it has also remained relatively unchallenged by researchers, who seem disinterested in further exploring or even validating it in practice. A notable exception is the work of Zhao et al (2015) who analyzed electrical incidents through the Hierarchy of Control and found administrative controls to be the most common in practice, despite their low positioning on the Hierarchy and developments in safety management in recent years.

More recently, research has established the scientifically defined concept of Direct Control (Oguz Erkal and Hallowell 2023) which has sparked a step-change in the use of controls for both research and practice. Grounded in the theory of energy-based safety (Hallowell et al 2017), Direct Controls are measures that meet three core criteria: (1) they directly target the high-energy hazard; (2) they effectively mitigate the high-energy hazard when installed, verified, and used correctly, and (3) they will still work even if there is unintentional human error during the work task. Many construction tasks therefore have direct controls available to them, but around one third of common construction activities involving high-energy hazards do not have an appropriate direct control available at all. Indeed, research is currently ongoing to determine what would make an acceptable adequate control for construction tasks with this precise situation, for example tasks that involve both machines and workers on foot such as excavation or highways work. It may be that solutions for control can be found either through novel innovations in safety management or through the redesign of the work itself to eliminate any potential worker/hazard interfaces from the task.

To support this ongoing research in the field of safety controls, a qualitative survey was distributed to the Construction Safety Research Alliance’s membership network as a sample of convenience. As noted above, the survey asked safety professionals one simple question: ‘what is your own personal definition of safety controls?’ Responses were received from n=103 safety professionals from across North America. Thematic and discursive analysis (Seale 2018) was undertaken of the qualitative data to reveal how controls are currently understood and mobilized within construction occupational safety.

Initial findings revealed that 66% of the safety professionals associated controls directly with the reduction, mitigation or elimination of either risks, hazards, or high energy. The inclusion of high energy

in the responses demonstrates the reach of this relatively new approach to safety management (Oguz Erkal and Hallowell 2023), but given the sample this should perhaps be somewhat expected. The terms 'risk' and 'hazard' were used relatively interchangeably within the data, which is common in safety discussions despite the very different definitions behind each term. This overall construction aligns to the notion of control as a means of defense (Li and Guldenmund 2018) able to reduce, mitigate or even eliminate safety issues from the jobsite. Indeed, 13% of the safety professionals linked controls directly to injury prevention – jumping over precursive states directly to the consequences of safety failure. Within the responses achieving <3%, control of behaviors or control of failure were the most prominent, the former aligning to human factors theories of safety management, the latter to more organizational considerations (Dien et al 2012).

Interestingly 5% of the respondents did not state any ambition or outcome for the use of controls, and instead focused on the mechanisms through which they were delivered. Analysis of this aspect of the data revealed far more variety in responses from the safety professionals, with many different understandings of what controls are and can be. High level analysis revealed that only 6% of respondents adhered to the notion of tangibility and physicality in their version of a control, with 27% aligned to the notion of administrative controls in the form of processes and management systems. 26% defined controls as a combination of both, but the largest proportion of safety professionals (41%) were far less clear in their responses which were in this analysis grouped under a code of 'something'. In this analysis, 'something' included more abstract concepts such as 'methods', 'measures' and 'means'. Under this code, many of the professionals constructed controls not as 'something' to directly tackle the safety problem but rather as the application and management of that 'something'; effectively a control for the control as it were. This adds a nuanced level of complexity to shared understandings and provides a point worthy of note for further research in this space. Interestingly, there were only 5 explicit mentions of the Hierarchy of Control within the survey responses, suggesting this structured application is not as prominent in practice as it once was.

Our findings revealed that 'control' with regards to occupational safety remains a highly diverse construct. There are several different, albeit closely related, conceptualizations of the purpose of controls, with much more variety found with regards to what they are and how they operate. This variation suggests that safety controls are still an uncertain aspect of safety management. Shared definitions and agreed constructs must be developed to ensure optimization of and clear communication around safety controls in both research and practice to support the ready adoption and enhanced use of scientifically validated controls in the field, and ultimately therefore reduce harm.

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