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**Y. Ian Noy, Lawrence J. Hettinger, Marvin J. Dainoff, Pascale Carayon, Nancy G. Leveson, Michelle M. Robertson & Theodore K. Courtney. *Editorial: emerging issues in sociotechnical systems thinking and workplace safety. pages 543-547.***

The burden of on-the-job accidents and fatalities and the harm of associated human suffering continue to present an important challenge for safety researchers and practitioners. While significant improvements have been achieved in recent decades, the workplace accident rate remains unacceptably high. This has spurred interest in the development of novel research approaches, with particular interest in the systemic influences of social/organisational and technological factors. In response, the *Hopkinton Conference on Sociotechnical Systems and Safety* was organised to assess the current state of knowledge in the area and to identify research priorities. Over the course of several months prior to the conference, leading international experts drafted collaborative, state-of-the-art reviews covering various aspects of sociotechnical systems and safety. These papers, presented in this special issue, cover topics ranging from the identification of key concepts and definitions to sociotechnical characteristics of safe and unsafe organisations. This paper provides an overview of the conference and introduces key themes and topics. **Practitioner Summary:** Sociotechnical approaches to workplace safety are intended to draw practitioners' attention to the critical influence that systemic social/organisational and technological factors exert on safety-relevant outcomes. This paper introduces major themes addressed in the *Hopkinton Conference* within the context of current workplace safety research and practice challenges.

- **Keywords:** sociotechnical systems, occupational safety, complexity

**Pascale Carayon, Peter Hancock, Nancy Leveson, Ian Noy, Laerte Sznalwar & Geert van Hootegem. *Advancing a sociotechnical systems approach to workplace safety – developing the conceptual framework. Pages 548-564.***

Traditional efforts to deal with the enormous problem of workplace safety have proved insufficient, as they have tended to neglect the broader sociotechnical environment that surrounds workers. Here, we advocate a sociotechnical systems approach that describes the complex multi-level system factors that contribute to workplace safety. From the literature on sociotechnical systems, complex systems and safety, we develop a sociotechnical model of workplace safety with concentric layers of the work system, socio-organisational context and the external environment. The future challenges that are identified through the model are highlighted. **Practitioner Summary:** Understanding the environmental, organisational and work system factors that contribute to workplace safety will help to develop more effective and integrated solutions to deal with persistent workplace safety problems. Solutions to improve workplace safety need to recognise the broad sociotechnical system and the respective interactions between the system elements and levels.

- **Keywords:** sociotechnical system, workplace safety, complexity, system levels, system interactions

**Patrick Waterson, Michelle M. Robertson, Nancy J. Cooke, Laura Militello, Emilie Roth & Neville A. Stanton.** *Defining the methodological challenges and opportunities for an effective science of sociotechnical systems and safety.* Pages 565-599.

An important part of the application of sociotechnical systems theory (STS) is the development of methods, tools and techniques to assess human factors and ergonomics workplace requirements. We focus in this paper on describing and evaluating current STS methods for workplace safety, as well as outlining a set of six case studies covering the application of these methods to a range of safety contexts. We also describe an evaluation of the methods in terms of ratings of their ability to address a set of theoretical and practical questions (e.g. the degree to which methods capture static/dynamic aspects of tasks and interactions between system levels). The outcomes from the evaluation highlight a set of gaps relating to the coverage and applicability of current methods for STS and safety (e.g. coverage of external influences on system functioning; method usability). The final sections of the paper describe a set of future challenges, as well as some practical suggestions for tackling these. **Practitioner Summary:** We provide an up-to-date review of STS methods, a set of case studies illustrating their use and an evaluation of their strengths and weaknesses. The paper concludes with a 'roadmap' for future work.

- **Keywords:** sociotechnical systems, human factors and ergonomics methods, macroergonomics, workplace design and evaluation

**Lawrence J. Hettinger, Alex Kirlik, Yang Miang Goh & Peter Buckle.** *Modelling and simulation of complex sociotechnical systems: envisioning and analysing work environments.* Pages 600-614.

Accurate comprehension and analysis of complex sociotechnical systems is a daunting task. Empirically examining, or simply envisioning the structure and behaviour of such systems challenges traditional analytic and experimental approaches as well as our everyday cognitive capabilities. Computer-based models and simulations afford potentially useful means of accomplishing sociotechnical system design and analysis objectives. From a design perspective, they can provide a basis for a common mental model among stakeholders, thereby facilitating accurate comprehension of factors impacting system performance and potential effects of system modifications. From a research perspective, models and simulations afford the means to study aspects of sociotechnical system design and operation, including the potential impact of modifications to structural and dynamic system properties, in ways not feasible with

traditional experimental approaches. This paper describes issues involved in the design and use of such models and simulations and describes a proposed path forward to their development and implementation. **Practitioner Summary:** The size and complexity of real-world sociotechnical systems can present significant barriers to their design, comprehension and empirical analysis. This article describes the potential advantages of computer-based models and simulations for understanding factors that impact sociotechnical system design and operation, particularly with respect to process and occupational safety.

- **Keywords:** sociotechnical systems, modelling and simulation, occupational safety, complex adaptive systems

**John M. Flach, John S. Carroll, Marvin J. Dainoff & W. Ian Hamilton.** *Striving for safety: communicating and deciding in sociotechnical systems.* Pages 615-634.

How do communications and decisions impact the safety of sociotechnical systems? This paper frames this question in the context of a dynamic system of nested sub-systems. Communications are related to the construct of observability (i.e. how components integrate information to assess the state with respect to local and global constraints). Decisions are related to the construct of controllability (i.e. how component sub-systems act to meet local and global safety goals). The safety dynamics of sociotechnical systems are evaluated as a function of the coupling between observability and controllability across multiple closed-loop components. Two very different domains (nuclear power and the limited service food industry) provide examples to illustrate how this framework might be applied. While the dynamical systems framework does not offer simple prescriptions for achieving safety, it does provide guides for exploring specific systems to consider the potential fit between organisational structures and work demands, and for generalising across different systems regarding how safety can be managed. **Practitioner Summary:** While offering no simple prescriptions about how to achieve safety in sociotechnical systems, this paper develops a theoretical framework based on dynamical systems theory as a practical guide for generalising from basic research to work domains and for generalising across alternative work domains to better understand how patterns of communication and decision-making impact system safety.

- **Keywords:** safety, sociotechnical systems, communications, decision-making, observability, controllability, dynamical systems

**Brian M. Kleiner, Lawrence J. Hettinger, David M. DeJoy, Yuang-Hsiang Huang & Peter E.D. Love.** *Sociotechnical attributes of safe and unsafe work systems.* Pages 635-649.

Theoretical and practical approaches to safety based on sociotechnical systems principles place heavy emphasis on the intersections between social–organisational and technical–work process factors. Within this perspective, work system design emphasises factors such as the joint optimisation of social and technical processes, a focus on reliable human–system performance and safety metrics as design and analysis criteria, the maintenance of a realistic and consistent set of safety objectives and policies, and regular access to the expertise and input of workers. We discuss three current approaches to the analysis and design of complex sociotechnical systems: human–systems integration, macroergonomics and safety climate. Each approach emphasises key sociotechnical systems themes, and each prescribes a more holistic perspective on work systems than do traditional theories and methods. We contrast these perspectives with historical precedents such as system safety and traditional human factors and ergonomics, and describe potential future directions for their application in research and practice. **Practitioner Summary:** The identification of factors that can reliably distinguish between safe and unsafe work systems is an important concern for ergonomists and

other safety professionals. This paper presents a variety of sociotechnical systems perspectives on intersections between social–organisational and technology–work process factors as they impact work system analysis, design and operation.

- **Keywords:** sociotechnical systems, occupational safety, human–systems integration, macroergonomics, safety climate

**Michelle M. Robertson, Lawrence J. Hettinger, Patrick E. Waterson, Y. Ian Noy, Marvin J. Dainoff, Nancy G. Leveson, Pascale Carayon & Theodore K. Courtney. *Sociotechnical approaches to workplace safety: Research needs and opportunities*. Pages 650-658.**

The sociotechnical systems perspective offers intriguing and potentially valuable insights into problems associated with workplace safety. While formal sociotechnical systems thinking originated in the 1950s, its application to the analysis and design of sustainable, safe working environments has not been fully developed. To that end, a Hopkinton Conference was organised to review and summarise the state of knowledge in the area and to identify research priorities. A group of 26 international experts produced collaborative articles for this special issue of *Ergonomics*, and each focused on examining a key conceptual, methodological and/or theoretical issue associated with sociotechnical systems and safety. In this concluding paper, we describe the major conference themes and recommendations. These are organised into six topic areas: (1) Concepts, definitions and frameworks, (2) defining research methodologies, (3) modelling and simulation, (4) communications and decision-making, (5) sociotechnical attributes of safe and unsafe systems and (6) potential future research directions for sociotechnical systems research.

**Practitioner Summary:** Sociotechnical complexity, a characteristic of many contemporary work environments, presents potential safety risks that traditional approaches to workplace safety may not adequately address. In this paper, we summarise the investigations of a group of international researchers into questions associated with the application of sociotechnical systems thinking to improve worker safety.

- **Keywords:** sociotechnical systems, occupational safety, complexity, systems theory