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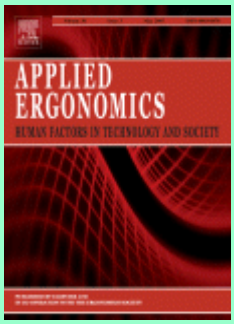

John R. Wilson, Pascale Carayon. *Systems ergonomics: Looking into the future – Editorial for special issue on systems ergonomics/human factors.* Pages 3-4.

In 2010, under the leadership of its president, Andy Imada, the International Ergonomics Association (IEA) convened a committee to address the question of how ergonomics/human factors (E/HF) should best maintain and strengthen both the discipline and the profession (Dul et al., 2012). Discussion in the IEA Future of Ergonomics Committee clearly revolved around 1) what about the core of E/HF makes us unique (or at least distinctive), 2) how we should attract new entrants into the field at all levels, and 3) how we meet the needs of a wider client base and market. A white paper that captured the deliberations of the committee was produced and approved in early 2012 and subsequently published in *Ergonomics* (Dul et al., 2012). A key commonality identified by the working group was of E/HF being clearly a systems discipline. However, perhaps not surprisingly, some group members differed over what that meant. From those discussions grew the idea of a special issue [1] of *Applied Ergonomics* that would contain different contributions that explore, describe, define or question the ideas of systems E/HF. The result, this special issue, includes a mix of viewpoints from different generations, regions, domains and types of E/HF specialization.

The E/HF discipline seems to have reached a time in its development for introspection and a critical review of its contributions and challenges (Hollnagel, 2013). The changing nature of work and society at large also calls for us to examine our discipline and its approaches. Indeed the IEA Future of Ergonomics Committee highlighted the systems approach of E/HF. Likewise, John Wilson (2013) responds that there is an obvious need for a holistic approach to E/HF (Wilson, 2013) while Marras and Hancock (2013) note that this is a sign of "holistic maturity." There may actually be a sense of urgency to the debate on systems approaches and their meaning and implications for E/HF (Wilson, 2013) because very different interpretations of a system exist in the E/HF field (Hollnagel, 2013). Paraphrasing Hal Hendrick, John Wilson (2013) states that "good ergonomics is systems ergonomics".

This special issue on Systems Ergonomics includes 14 articles from authors around the world and brings up critical points in three areas of systems ergonomics. It is our hope that this initiates a healthy debate that results in a clearer understanding of E/HF for research and practice in the coming years.

John R. Wilson. *Fundamentals of systems ergonomics/human factors.* Pages 5-13.

Ergonomics/human factors is, above anything else, a systems discipline and profession, applying a systems philosophy and systems approaches. Many things are labelled as system in today's world, and this paper specifies just what attributes and notions define ergonomics/human factors in systems terms. These are obviously a systems focus, but also concern for context, acknowledgement of interactions and complexity, a holistic approach, recognition of emergence and embedding of the professional effort involved within organization system. These six notions are illustrated with examples from a large body of work on rail human factors.

- **Keywords:** Systems engineering; Systems ergonomics; Systems human factors; Rail systems

Pascale Carayon, Tosha B. Wetterneck, A. Joy Rivera-Rodriguez, Ann Schoofs Hundt, Peter Hoonakker, Richard Holden, Ayse P. Gurses. *Human factors systems approach to healthcare quality and patient safety.* Pages 14-25.

Human factors systems approaches are critical for improving healthcare quality and patient safety. The SEIPS (Systems Engineering Initiative for Patient Safety) model of work system and patient safety is a human factors systems approach that has been successfully applied in healthcare research and practice. Several research and practical applications of the SEIPS model are described. Important implications of the SEIPS model for healthcare system and process redesign are highlighted. Principles for redesigning healthcare systems using the SEIPS model are described. Balancing the work system and encouraging the active and adaptive role of workers are key principles for improving healthcare quality and patient safety.

- **Keywords:** Sociotechnical system; Macroergonomics; Healthcare; Patient safety; SEIPS model; Balanced work system; Patient-centered care; Healthcare team

Kasper Edwards, Per Langaa Jensen. *Design of systems for productivity and well being.* Pages 26-32.

It has always been an ambition within the ergonomic profession to ensure that design or redesign of production systems consider both productivity and employee well being, but there are many approaches to how to achieve this. This paper identifies the basic issues to be addressed in light of some research activities at DTU, especially by persons responsible for facilitating design processes. Four main issues must be addressed: (1) determining the limits and scope of the system to be designed; (2) identifying stakeholders related to the system and their role in the system design; (3) handling the process' different types of knowledge; and (4) emphasizing that performance management systems, key performance indicators (KPIs), and leadership are also part of the system design and must be given attention. With the examples presented, we argue that knowledge does exist to help system design facilitators address these basic issues.

- **Keywords:** Production system design; Complexity management; Stakeholder perspective

Gudela Grote. *Adding a strategic edge to human factors/ergonomics: Principles for the management of uncertainty as cornerstones for system design.* Pages 33-39.

It is frequently lamented that human factors and ergonomics knowledge does not receive the attention and consideration that it deserves. In this paper I argue that in order to

change this situation human factors/ergonomics based system design needs to be positioned as a strategic task within a conceptual framework that incorporates both business and design concerns. The management of uncertainty is presented as a viable candidate for such a framework. A case is described where human factors/ergonomics experts in a railway company have used the management of uncertainty perspective to address strategic concerns at firm level. Furthermore, system design is discussed in view of the relationship between organization and technology more broadly. System designers need to be supported in better understanding this relationship in order to cope with the uncertainties this relationship brings to the design process itself. Finally, the emphasis on uncertainty embedded in the recent surge of introducing risk management across all business sectors is suggested as another opportunity for bringing human factors and ergonomics expertise to the fore.

- **Keywords:** System design; Uncertainty management; Technology–organization interaction

Erik Hollnagel. *Human factors/ergonomics as a systems discipline? "The human use of human beings" revisited.* Pages 40-44.

Discussions of the possible future of Human factors/ergonomics (HFE) usually take the past for granted in the sense that the future of HFE is assumed to be more of the same. This paper argues that the nature of work in the early 2010s is so different from the nature of work when HFE was formulated 60–70 years ago that a critical reassessment of the basis for HFE is needed. If HFE should be a systems discipline, it should be a soft systems rather than a hard systems discipline. It is not enough for HFE to seek to improve performance and well-being through systems design, since any change to the work environment in principle alters the very basis for the change. Instead HFE should try to anticipate how the nature of work will change so that it can both foresee what work *will* be and propose what work *should* be.

- **Keywords:** Human factors/ergonomics (HFE)

Ben-Tzion Karsh, Patrick Waterson, Richard J. Holden. Crossing levels in systems ergonomics: A framework to support 'mesoergonomic' inquiry. Pages 45-54.

In this paper we elaborate and articulate the need for what has been termed 'mesoergonomics'. In particular, we argue that the concept has the potential to bridge the gap between, and integrate, established work within the domains of micro- and macroergonomics. Mesoergonomics is defined as an open systems approach to human factors and ergonomics (HFE) theory and research whereby the relationship between variables in at least two different system levels or echelons is studied, and where the dependent variables are human factors and ergonomic constructs. We present a framework which can be used to structure a set of questions for future work and prompt further empirical and conceptual inquiry. The framework consists of four steps: (1) establishing the purpose of the mesoergonomic investigation; (2) selecting human factors and ergonomics variables; (3) selecting a specific type of mesoergonomic investigation; and (4) establishing relationships between system levels. In addition, we describe two case studies which illustrate the workings of the framework and the value of adopting a mesoergonomic perspective within HFE. The paper concludes with a set of issues which could form part of a future agenda for research within systems ergonomics.

- **Keywords:** Systems ergonomics; Macro/micro integration; Organizational ergonomics

W.S. Marras, P.A. Hancock. *Putting mind and body back together: A human-systems approach to the integration of the physical and cognitive dimensions of task design and operations.* Pages 55-60.

As human factors and ergonomics professionals we should be considering the total context within which the person must operate when performing a task, providing a service, or using a product. We have traditionally thought of the person as having a cognitive system and a physical system and much of our scientific literature has been myopically focused on one or the other of these systems while, in general, totally ignoring the other. However, contemporary efforts have begun to recognize the rich interactions occurring between these systems that can have a profound influence on performance and dictate overall system output. In addition, modern efforts are beginning to appreciate the many interactions between the various elements of the environment that can influence the components of the human systems. The next level of sophistication in the practice of human factors and ergonomics must begin to consider the totality of the human-system behavior and performance and must consider systems design interactions which result from these collective effects. Only then will we be able to truly optimize systems for human use.

- **Keywords:** Human-systems integration; Ergonomics; Human factors; Biomechanics; Cognitive engineering

Leena Norros. *Developing human factors/ergonomics as a design discipline.* Pages 61-71.

This paper deals with internal challenges that the human factors/ergonomics (HFE) research faces when wishing to strengthen its contribution to development of work systems. Three established characteristics of high-quality HFE, i.e., HFE takes a systems approach, HFE is design-driven, and HFE focuses on two closely related outcomes, performance and well-being, are taken as a starting point of a methodological discussion, in which conceptual innovations, e.g. adopting the technology-in-use perspective, are proposed to support development of HFE towards the high-quality aims. The feasibility of the proposed conceptual choices is demonstrated by introducing a naturalistic HFE analysis approach including four HFE functions. The gained experience of the use of this approach in a number of complex work domains allows the conclusion that becoming design-driven appears as that most difficult quality target for HFE to reach. Creating an own design discipline identity in a multi-voiced collaboration is the key internal challenge for human factors/ergonomics.

- **Keywords:** Design thinking; Technology-in-use; Naturalistic approach; Core-task modelling

William B. Rouse. *Human interaction with policy flight simulators.* Pages 72-77.

Policy flight simulators are designed for the purpose of exploring alternative management policies at levels ranging from individual organizations to national strategy. This article focuses on how such simulators are developed and on the nature of how people interact with these simulators. These interactions almost always involve groups of people rather than individuals, often with different stakeholders in conflict about priorities and courses of action. The ways in which these interactions are framed and conducted are discussed, as well as the nature of typical results.

- **Keywords:** Computational modeling; Interactive visualization; Policy flight simulators

Thomas B. Sheridan. *Evaluating models in systems ergonomics with a taxonomy of model attributes.* Pages 78-84.

A model, as the term is used here, is a way of representing knowledge for the purpose of thinking, communicating to others, or implementing decisions as in system analysis, design or operations. It can be said that to the extent that we can model some aspect of nature we understand it. Models can range from fleeting mental images to highly refined mathematical equations of computer algorithms that precisely predict physical events. In constructing and evaluating models of ergonomic systems it is important that we consider the attributes of our models in relation to our objectives and what we can reasonably aspire to. To that end this paper proposes a taxonomy of models in terms of six independent attributes: *applicability to observables, dimensionality, metricity, robustness*, *social penetration and conciseness*. Each of these attributes is defined along with the meaning of different levels of each. The attribute taxonomy may be used to evaluate the quality of a model. Examples of system ergonomics models having different combinations of attributes at different levels are provided. Philosophical caveats regarding models in system ergonomics are discussed, as well as the relation to scientific method.

- **Keywords:** Model; Attributes; System

C.E. Siemieniuch, M.A. Sinclair. *Extending systems ergonomics thinking to accommodate the socio-technical issues of Systems of Systems.* Pages 85-97.

Socio-technical issues for Systems of Systems (SoS) differ in several ways from those for systems, mainly because the individual systems that are components of the SoS are usually owned by different organisations, each responsible for the optimisation and operation of its own system. Consequently, management of the SoS is about negotiation and management of the interfaces. Because of issues of Intellectual Property Rights (IPRs), commercial confidence, and the like, there is seldom sufficient, timely information in circulation about the SoS. Surprises are endemic to SoS, and resilience is a fundamental requirement. This paper outlines the different characteristics of SoS compared to ordinary systems, discusses many of the socio-technical issues involved, and then outlines a generic approach to these issues, treating the SoS as a 'wicked problem'. Endemic to this is the need for governance, which is discussed briefly. This is followed by a description of the evident gaps in knowledge about the functioning of SoS, and a listing of tool classes, the development of which would enable progress to be made more effectively. Finally, the paper discusses how the SoS approach might be the best way to entrain ICT to address global drivers, thus pointing to the importance of the SoS approach.

- **Keywords:** Systems of Systems; Characteristics; Wicked problems; Methods; Governance

R.H.Y. So, S.T. Lam. *Factors affecting the appreciation generated through applying human factors/ergonomics (HFE) principles to systems of work.* Pages 99-109.

This retrospective study examined the levels of appreciation (applause) given by clients to Human Factors/Ergonomic (HFE) specialists after they have modified the systems of work. Thirteen non-academic projects were chosen because the HFE interventions involved changed the way workers work at their workplaces. Companies involved range from multi-national corporations and military organizations with thousands of employees to small trading companies with less than 10 employees. In 5 cases the HFE recommendations were fully adopted and well appreciated. In 4 they were largely

ignored and not appreciated, with partial adoption and some appreciation in the other 4 cases.

Three factors that predict appreciation were identified: (i) alignment between the benefits HFE can provide and the project's key performance indices; (ii) awareness of HFE among the client's senior management; and (iii) a team organization appropriate for applying HFE recommendations. Having an HFE specialist on the client's side can greatly increase levels of appreciation, but lack of such a specialist will not affect levels of appreciation. A clear contractual requirement for HFE intervention does not promote appreciation significantly, but its absence can greatly reduce levels of appreciation. These relationships are discussed using the Kano's model of quality. Means to generate greater appreciation of the benefits of HFE are discussed. Partial finding of this study was presented at the keynote address of the 1st Human Factors and Ergonomics Society of Philippines Conference held in Nov., 2012.

- **Keywords:** System ergonomics; Kano model; Kano map; Attractive factors; Must-be factors

Neville A. Stanton, Kevin Bessell. *How a submarine returns to periscope depth: Analysing complex socio-technical systems using Cognitive Work Analysis.* Pages 110-125.

This paper presents the application of Cognitive Work Analysis to the description of the functions, situations, activities, decisions, strategies, and competencies of a Trafalgar class submarine when performing the function of returning to periscope depth. All five phases of Cognitive Work Analysis are presented, namely: Work Domain Analysis, Control Task Analysis, Strategies Analysis, Social Organisation and Cooperation Analysis, and Worker Competencies Analysis. Complex socio-technical systems are difficult to analyse but Cognitive Work Analysis offers an integrated way of analysing complex systems with the core of functional means-ends analysis underlying all of the other representations. The joined-up analysis offers a coherent framework for understanding how socio-technical systems work. Data were collected through observation and interviews at different sites across the UK. The resultant representations present a statement of how the work domain and current activities are configured in this complex socio-technical system. This is intended to provide a baseline, from which all future conceptions of the domain may be compared. The strength of the analysis is in the multiple representations from which the constraints acting on the work may be analysed. Future research needs to challenge the assumptions behind these constraints in order to develop new ways of working.

- **Keywords:** Cognitive Work Analysis; Socio-technical systems; Submarine; Team work

Klaus J. Zink. *Designing sustainable work systems: The need for a systems approach.* Pages 126-132.

There is a growing discussion concerning sustainability. While this discussion was at first mainly focused on a society level – and sometimes regarding especially environmental problems, one can now see that this topic is of increasing relevance for companies worldwide and even the social dimension of this three pillar approach is gaining more and more importance. This leads to some questions: Is sustainability already a part of human factors thinking or do we have to further develop our discipline? How can we define sustainable work systems? What are the topics we have to consider? Do we need a new systems ergonomics perspective regarding whole value creation chains and a life-cycle perspective concerning products (and work systems)? How can we deal with potential contradictions about social, ecological, and economic goals?

- **Keywords:** System ergonomics; Sustainability; Sustainable work systems; Work system design