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The Social Dimension of Human Systems Integration

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Abstract. 20th century engineering was mainly based on mechanical engineering, physics, and mathematics. During the last three decades of the 20th century, electronics and computer science considerably increased their influence on engineering by providing greater and greater automation. Work shifted from physical to cognitive. Human operator's job shifted from doing to thinking. People who were used to manipulate hardware-based machines had to adapt to software-based systems. The shift was from hardware to software. Cognitive engineering was born in the beginning of 1980s. It led to interaction design, user interface design techniques and tools, and usability engineering (UX).

Since the beginning of the 21st century, we are experiencing an opposite approach where the shift is not only from software to hardware, but also from single agent facing a machine to multi-agent sociotechnical systems. This is the reason why social aspects have become so important today. At the same time, digital modeling and simulation techniques and tools never stop to develop and are more effective and realistic. Human factors and ergonomics can be considered seriously during the early stages of the design process, as well as during the whole life cycle of a sociotechnical system. This is currently done using virtual prototypes, digital twins, human-in-the-loop simulations, formative evaluations, agile developments and so on. Participatory design and development have become extremely effective. Human-centered design (HCD) is now a reality (i.e., considering people and organizations at design time effectively).

The association of HCD and systems engineering led to human systems integration (HSI). Performing HSI in industrial settings requires appropriate knowledge representations, which are relevant representations of what a system is about. This leads to a systemic approach of human-machine systems that turns out to be social, or socio-cognitive (i.e., multi-agent). This panel will discuss the social dimension of HSI toward improving the tryptic technology-organizations-people during the whole life cycle of a sociotechnical system.

Panel Position Statements

Guy Andre Boy (Panel Chair): *Revisiting the concept of system.* There is clearly a contemporary need for an appropriate socio-technical framework to support human systems integration (HSI) in research, development (including manufacturing, training, and maintenance) and operations. The very notion of system should be understood as a representation of Technology, Organizations and People (the TOP Model) involved during the whole life cycle of a socio-technical system. In our growing digital society, the concept of tangibility should an important topic of research, more specifically in the context of increasingly autonomous systems. It entails complexity analysis, organization design and management, and maturity management at three reediness levels: technology (TRLs); organizations (ORLs); and humans (HRLs). I will introduce the socioergonomics approach that support the investigation of systemic properties such as flexibility, separability, and emergent social facts.

Shamsnaz V. Bhada: The INCOSE social systems working group addresses the role of social sciences, policy modeling and systems dynamics in systems engineering. In this panel discussion I will layout the goals of the INCOSE social systems working group and the interface points with the system of systems group. Along with that I will also introduce the challenges I face in my research in addressing policy issues in rural broadband, health care and public transportation all of which are social systems but are also multiple independent systems coming together for achieving common goals.

Charlotte Natalie Dunford: *Engineering is a social system*. I described systems engineering to a retired electrical engineering professor once, he listened and then suddenly his eyes lit up and he said, 'you are doing meta-engineering!' I think this is apt. Systems engineering processes and techniques look not at the systems we engineer but the generic activities and techniques engineers use to engineer them. It engineers the engineering. It helps us plan our work and inform the engineering judgements we need to make from initial requirements capture to solution retirement. I think this makes it important for systems engineers to have an appreciation of social systems that is often not part of our formal training. This will help us from better understanding the human factors of the systems we are creating, to improving our study of systems engineering and ultimately help us to create better solutions more effectively.

John Gill: *"What is the System behind the System?"* Sociotechnical Systems Engineering has many facets that extend well beyond what has evolved to become the Systems Engineering process. Over the course of the preceding Industrial Revolutions, we have progressed from tools to complex systems and into the realm of highly integrated technical ecosystems with embedded cognitive and autonomous capabilities. Many such systems already exist that possess characteristics of primitive life forms. And a significant amount of effort and investment is being applied to the development of humanoid systems. While these systems may look and operate as humans can (walk, run, dance, and perform gymnastics), their cognitive abilities are relatively limited. I assert that cognition is a powerful influence over the ongoing evolution of systems and may also have an imperceptible yet overwhelming influence on the trajectory of our ongoing system development. In prior collaborative works, we have presented a framework for Sociotechnical Systems as a balancing complement to what we referred to as the "Traditional" SE process. In a subsequent paper, we introduced an underlying mechanism allowing us to balance the social cost and impact of a given system against the ease and affordability with which the system is developed and may be used. In this panel/paper, we delve further into the motivations that guide us during development. We do so to expose what may be a deeply subliminal influence on what we choose to develop, why and how it (the system) may be used. While Sociotechnical System Engineering may topically be viewed as building systems that we humans interact with (in the form of a complex relationship – each influencing the other), we may be stagnating in our (system) development process owing to a fundamental attribute of human nature – our innate drive to survive.

Grace Kennedy: *Organizations as Systems – a Neglected Perspective in SE?* Traditionally Human Systems Integration efforts revolve around the consideration of the users of the system from as early in the conceptual design phases through the entire lifecycle of the system and how these considerations are integrated into the wider Systems Engineering efforts. Whilst we can design for a given set of characteristics of an intended type of user(s), we should not fall into the trap of only thinking about users as a static set of characteristics (i.e., at the point when the technical system is mature, we cannot assume the individuals who become the users will be automatically able nor willing to use the new technology). Put simply, people have 'baggage'; they have both technical experiences (to build knowledge, skills, ability), but are also shaped by the history of the organizations that they have been part of (e.g., culture, processes, team working, role models, organizational structures, policies, etc.).

As systems engineers we look to create and develop systems that provide new capabilities, and at a socio-technical system level we consider the organizational issues around that system being developed. What if we however broaden the scope and flip our perspective, to considering the organization as the system, parts of which exist in one or more socio-technical systems? This talk will discuss organizational systems change through the lens of the Viable Systems Model (Beer) and asks what we can learn from organizational behavior and design to better inform the way we view socio-technical systems.

Avigdor Zonnenshain: *HSI towards the sociotechnical systems engineering approach in the context of Industry 4.0.* Human Systems Integration concept is evolving through the years from Human Factors & Ergonomics (HFE) to Human Centered Design (HCD), to HSI as an integral part of the systems engineering. The Fourth Industrial Revolution-INDUSTRY 4.0 poses new challenges and opportunities for the HSI discipline and practical processes. The automation and the autonomous of the systems, the digital communication of people through IoT, AI, AR with different types of systems in their environment, create socio-technological systems in an advanced ecosystem. For designing, building, and operating these systems in this ecosystem, we are offering socio-technological systems engineering, which is the next stage of HSI. Overlapping domains of these building blocks reflect the cooperative interfaces of human and AI, in human-system integration. This vision is only in its preliminary steps, further investigation and development is needed, to fulfill the potential of such a relationship.

Biographies

Guy A. Boy, Ph.D., is University Professor, FlexTech Chair Holder at Paris Saclay University (CentraleSupélec) and ESTIA Institute of Technology. He is Fellow of INCOSE and the Air & Space Academy. Former Chief Scientist for Human-Centered Design (HCD) at NASA Kennedy Space Center, and former Dean of the HCD Institute of Florida Institute of Technology. Former President and Chief Scientist of the European Institute of Cognitive Sciences and Engineering (EURISCO), he taught in several engineering schools in France, including ISAE-SUPAERO, ENAC and Ecole Polytechnique. He is currently the Chair of the Human Systems Integration Working Group of INCOSE and the founder of HSI Conference Series organized in cooperation with ACM and IEA. He has more than 40 years of experience in aerospace, mainly with Airbus and NASA. He was Executive Vice Chair of ACM-SIGCHI worldwide from 1995 to 1999, and is Chair of IEA Aerospace Technical Committee.

Shamsnaz Virani Bhada, Ph.D., Assistant Professor of Systems Engineering at Worcester Polytechnic Institute, earned her Ph.D.in Industrial and Systems Engineering from The University of Alabama at Huntsville. Dr. Bhada's research interests include Policy Content Modeling and Human Diversity in Engineering. She serves as Empowering Women as Leaders in Systems Engineering (EWLSE) Lead for New Faculty Support for systems engineering faculty and PhD students. She is dedicated to increasing women and minority population in Engineering.

Charlotte Natalie Dunford graduated with an Engineering Doctorate in Systems from the University of Bristol in 2016 and received a Bachelor of Applied Science in Mechanical Engineering from the University of British Columbia in 2003. Her doctorate was funded by the Engineering and Physical Research Council and Rolls-Royce plc. She works as an Engineering Lead in Systems Engineering and Project Management in Engineering for Rolls-Royce Defence ensuring the business has the capability it needs in these areas. Previously, she worked as a Research Engineer in the Space and Atmospheric Physics Group at Imperial College London. Her research focuses on the social systems aspects relevant to systems engineering. She is a Chartered Engineer and Member of the Institution of Mechanical Engineers and INCOSE.

John Gill, Ph.D., INCOSE ESEP. John has worked in defense technology acquisition for his entire career having served in the United States Air Force as a Chief Scientist at the Kirtland AFB Advanced Weapons Lab and as a project manager for global sensor and communications systems. Subsequently, he was a Systems Engineering Director at BAE Systems, North America. He currently develops autonomous systems and is co-owner of a Veterinary Emergency hospital. John restores and tours in classic cars.

Grace Kennedy is a Research Fellow at the SMART Infrastructure Facility at the University of Wollongong (UOW). She has 15 years' experience as a Systems Engineer; first at BAE Systems, then at the SEIC (Loughborough University), and now in academia at UOW. She is the lead of the SE team within SMART who apply systems modelling to various infrastructure challenges in Australia. She lectures in SE, Innovation & Design and Human Factors topics. Grace is a Chartered Engineer (CPEng) in the Systems Engineering area of practice and a Certified Systems Engineering Professional (CSEP). Grace is co-chair of the INCOSE Human Systems Integration Working Group and a member of Cohort 7 of the INCOSE Technical Leadership Institute. She is currently undertaking a part-time PhD investigating the application of MBSE and Digital Engineering for organizational change through the lens of organizations as systems.

Dr. Avigdor Zonnenshain is currently the Senior Research Fellow at The Gordon Center for Systems Engineering and at the Neaman Institute for National Policies Research at the Technion, Haifa, Israel. He has a Ph.D. in Systems Engineering from the University of Arizona, Tucson, USA. Formerly, He held several major positions in the quality, reliability and systems engineering areas in RAFAEL & in the Prime Minister's Office. He is an active member of the Israel Society for Quality (ISQ). He was also the Chairman of the Standardization Committee for Management & Quality in the Standardization Institute of Israel. He is a Senior Adjunct Lecturer at the Technion–Israel Institute of Technology. He was a member of the Board of Directors of the University of Haifa. He is an active member of INCOSE & INCOSE_IL (past president). He is a Fellow of INCOSE.

References

Boy, GA 2021, 'Socioergonomics: A few clarifications on the Technology, Organizations and People Tryptic'. *Proceedings of INCOSE HSI2021 International Conference*.

Gill, J & Zonnenshain, A, & Lamoureux, D, 2021, Opportunities and Challenges of Sociotechnical Systems Engineering, Proceedings of 2021 INCOSE International Symposium.

Kennedy, G, Zonnenshain, A, Gill, J & Bhada, S, 2021, Exploring the Synergies between Social Systems and Human Systems Integration. Panel at INCOSE HSI2021 Conference.