Sociotechnical Systems:
A Human Systems Integration Approach

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Sociotechnical Systems (STSs) deserve more attention in terms of their definition. Systems Engineering developed formalisms and conceptual tools, such as SysML, to capture the various attributes of a technological system, leaving humans to the courtesy of systems engineers and, in the end, operations people (i.e., people need to adapt to technology). Consequently, technological systems were developed and optimized with technology in mind, not people who will have to handle potential surprises during operations and other contexts, such as maintenance or dismantling. STS complexity is the source of emerging phenomena that cannot be discovered before putting the STS to work. Waiting for the STS to be used at operational time induces constant repairs and adjustments.

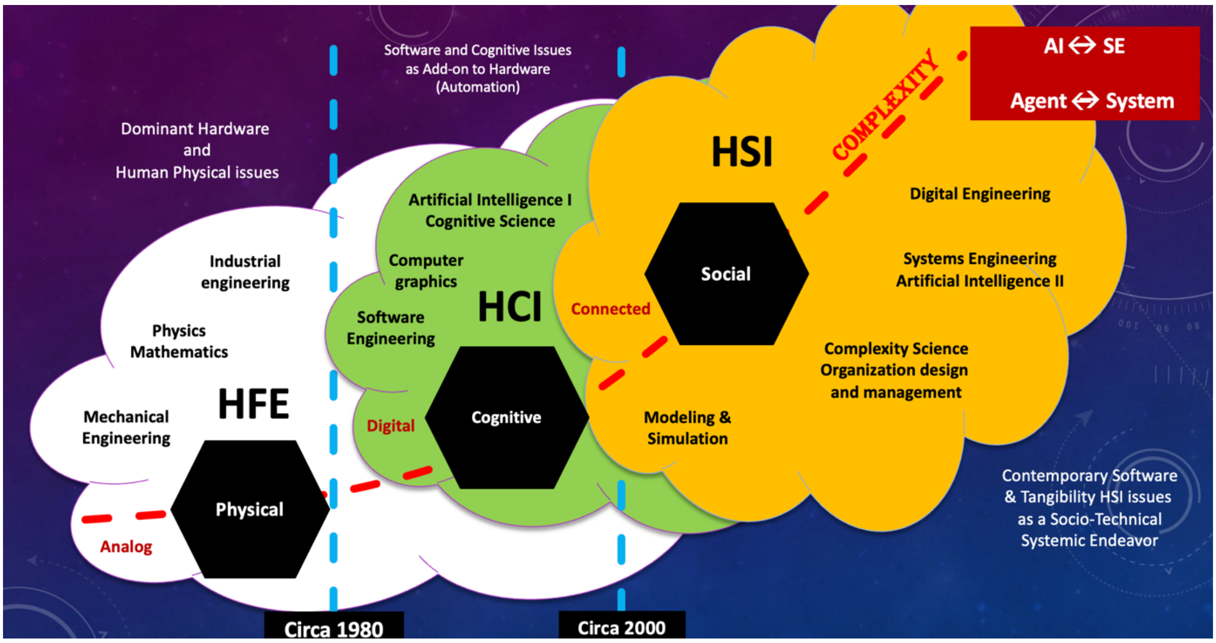

Figure 1. Evolution of STS complexity and disciplines in both engineering and human factors.

Figure 1 shows the evolution of human issues in STSs from physical to cognitive to social. We are facing a bold rethinking of Human Systems Integration (HSI) within STSs, capturing the shift from traditional human-machine interaction to a dynamic, multi-agent systems approach, where agents can be humans or machines, and sometimes a combination of the two. The current new HSI approach to STSs explores integrating technology, organizations, and people in increasingly complex and digitalized environments. The evolution should align with broader societal trends, from the rise of digital engineering and virtual prototyping to the growing necessity for holistic, context-aware design in life-critical domains. A first contribution of the INCOSE HSI Working Group contributed to generating the INCOSE Primer Vol. 1 (Boy & Kennedy, 2024).

Digital engineering is good news, since it enables us to consider people very early during the design process using the tools and perspectives that support shaping resilient, intelligent, and human-compatible systems. Thanks to these principles and capabilities, HSI is evolving. Virtual prototyping is more possible and productive than ever and is necessary for implementing good HSI. Why? Human-in-the-loop simulations (HITLSs) have become possible at design time, which enables us to observe effective human activity, instead of only relying on the prescribed task to be performed. HITLSs must be supported by an appropriate set of metrics and assessment methods. Sociotechnical models support these metrics and assessment methods (Boy, 2023). The development of these models is based on specific lexicons, syntax, and semantics, which are common to people and machines.

Key topics include human-autonomy teaming, performance support, scenario-based design, organizational maturity, and the crucial role of tangibility in digital systems. For professionals focused on AI integration, safety assurance, or enhancing user experience across system lifecycles, the resource offers actionable insights and proven frameworks to meet the challenges of modern system complexity. Our primary goal was to have systems engineers gain a thorough, helicopter view of HSI and STSs in various usable contexts.

During the last three years, 78 research scientists from 13 countries, engineers, and operational operators worked daily to address sociotechnical systems from an HSI perspective. The final product is "Handbook of Sociotechnical Systems: A Human Systems Integration Approach." The handbook explores models, methods, and real-world applications that support the design, development, and management of complex STSs.

The details of this essential topic of sociotechnical systems rely on collaboration between various disciplines, backgrounds, motivations, and many other elements that can make our planet livable and sustainable in the short and long term. The approach underpinning this initiative must be systemic and cognitive, and based on a new fundamental framework, "systemic cognition" (Boy, to appear in 2026). This framework should support HSI by providing a consistent vocabulary (a lexicon) and articulating HSI concepts for systems engineers and engineering design teams.

References

Boy, G. A. (2023). An Epistemological Approach to Human Systems Integration. *Technology in Society* Journal (Open Access), 102298. https://doi.org/10.1016/j.techsoc.2023.102298.

Boy, G.A. et al. (2023). *Human Systems Integration*. In INCOSE Systems Engineering Handbook, 5th Edition. ISBN: 978-1-119-81429-0.

Boy, G.A. & Kennedy, G. (2023). Human Systems Integration Primer. Volume 1. INCOSE, San Diego, CA, USA (https://www.incose.org/publications/products/hsi-primer).

Boy, G.A. (2026). *Handbook of Sociotechnical Systems: A Human Systems Integration Approach*. Taylor & Francis, CRC, Boca Raton, FL, USA.