Complex Systems Working Group

The purpose of the Complex Systems Working Group is to enhance the ability of the systems engineering community to deal with complexity. The Complex Systems Working Group works at the intersection of complex systems sciences and systems engineering, focusing on systems beyond those for which traditional systems engineering approaches and methods were developed.

The Complex Systems Working Group focuses on the challenges and opportunities presented by systems with large numbers of components, with even greater numbers of interactions distributed in scope across multiple scales and/or across large areas. Systems of interest are characterized by rich interdependence among diverse components, non-linearity, open systems boundaries, networks of causality and influence (vice linear causal chains), emergence, varied and changing system goals, self-organization, and multi-level adaptation. These traits limit the utility of traditional systems engineering paradigms, which are generally centralized, goal oriented, requirements driven, and reductionist in approach. These traits, however, are increasingly the norm and not the exception. The Complex Systems Working Group collaborates with the Systems Sciences Working Group to define the scientific basis of these characteristics.

Further, complexity is a characteristic of more than just a technical system being developed. The socio-technical ecosystem in which a system under development will be employed exhibits these attributes, as does the environment that gave rise to the challenge or opportunity to which the system was developed in response. Further, the design and development of technical systems is a complex endeavor itself. It is critical for systems engineers to understand the nature of the systems with which they are working, and of which they are a part, to be effective.

The goals of the Complex Systems Working Group are to communicate the complexity characteristics to systems engineering practitioners, provide knowledge and expertise on complex systems in support of other INCOSE working groups working in their systems engineering areas, facilitate the identification of tools and techniques to apply in the engineering of complex systems, and provide a map of the current, diverse literature on complex systems to those interested in gaining an understanding of complexity.

The Complex Systems Working Group has developed a “Complex Systems Primer” which briefly categorizes various approaches to handling complexity in systems engineering endeavors. This Primer is not an exhaustive treatment of the subject but provides systems engineering practitioners with a view of the landscape in dealing with complex systems. The Primer includes a list of 15 characteristics of complexity derived from cognitive, structural, balance, control, and integration. The Primer also includes tables on candidate approaches to address complexity in problem context or environment; and selected modeling methods for complex systems.

The Complex Systems Working group is currently seeking to expand collaborations with other INCOSE working groups. These collaborations provide assistance in relating complex systems

insights to relevant activities in other working groups, and better integrate and align the Complex Systems Working Group's approaches for dealing with complexity with the range of systems engineering communities represented in INCOSE. In addition to our work with the Systems Sciences Working Group, active collaborations are currently in discussion with the Agile SE Working Group and the Natural Systems Working Group.

The Complex Systems Working Group co-chairs are Dr. Jimmie McEver and Dr. Michael Watson. Dr. McEver is a Senior Scientist at the Johns Hopkins University Applied Physics Laboratory. Since 1997, he has worked with the U.S. Department of Defense on a range of complexity-related challenges, including network-enabled approaches for military command and control, and the acquisition and systems engineering of capabilities for cyberspace operations. He was a member of the NATO Study Panel SAS-065, which developed the *NATO Network Enabled Capability C2 Maturity Model*, and of The Technical Cooperation Program's Action Group on Complex Adaptive Systems for Defense. He holds a Ph.D. in Physics from the Georgia Institute of Technology, and a Master of Public Policy from the John F. Kennedy School of Government at Harvard University. Dr. Watson is a practicing systems engineer at the NASA Marshall Space Flight Center. He is leading a Systems Engineering Research Consortium studying product-focused systems engineering approaches and seeking the mathematical basis of systems engineering. He has been at NASA MSFC since 1989 working as a systems engineer on various projects including the International Space Station, Spacelab, optics, integrated system health management, Ares I, and the Space Launch System. He holds a Ph.D. in Electrical and Computer Engineering from the University of Alabama in Huntsville.

To learn more or inquire about participation in this working group, contact Jimmie at jimmie.mcever@jhuapl.edu. All working group charters and points of contact are on the INCOSE website at www.incose.org/about/organization/ti.aspx