Complex System Governance: Implications and research directions

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Abstract This white paper is developed in response to '*Second Call for White Papers - A Decadal Survey of the Social and Behavioral Sciences for National Security*.' The purpose of the white paper is to call attention current development in Complex System Governance (CSG) as an approach to diagnose and resolve deeper systemic issues affecting society. This is done, first, through articulation of realities of modern society the enterprises must contend. This section includes challenges as well as emerging scientific observations that could be used to address challenges. Second, a call-out of central questions that are ripe for answering is provided. These questions are directly related to the issue of governance of complex systems as they relate to social and behavioral sciences (SBS). Finally, a call-out for benefits of advancing fundamental knowledge in CSG is provided. These benefits are directly associated with developing and building analytic capacity to address deep systemic issues – such as national security challenges.

Attention to SBS Research

In many respects, the operational landscape for current systems and organizations is simply complex. In Tainter's (1988) words, the 21st century is described as a period of "gradual deterioration or depletion of a resource base…often due to humans mismanagement, and the more rapid loss of resources due to an environmental fluctuation or climatic shifts." Certainly, this view is consistent with 'messes' (Ackoff, 1981) and 'wicked problems' (Rittel and Webber, 1973). To this, we add, ambiguity, emergence, and interdependence. Ambiguity is related to increasing lack of clarity and situational understanding. Emergence is the inability to deduce behavior, structure, or performance from constituent elements. Interdependence elaborates on mutual influence among different complex systems in which the state of a system influences and is influenced by the state of interconnected systems. The present landscape involves richly and dynamically interacting systems (and subsystems) with behavior difficult to predict.

Often, we speak of the need to think systemically --- 'systems thinking' approach to phenomena with an emphasis on understanding structure and behavior of the whole rather than parts (Adams et al. 2014; Cabrera and Cabrera, 2015; Hammond, 2002; Jackson, 2003; von Bertalanffy, 1968). There is no shortage of methodological approach to enable holistically and systemically analyzing behaviors of complex systems (e.g., Jackson, 2003; Katina, 2015). Each of these systems theory-based approached have strength and weakness and applied in different contexts. These issues aside, these methodologies are not designed to address issues at the MetaSystem level at the intersection of 'Governance,' 'Systems Theory, and 'Management Cybernetics.' In this case Systems Theory forms the fundamental laws governing complex systems, Management Cybernetics is the science of effective organizations, and System Governance is concerned with direction, oversight, and accountability of systems. Metasystem alludes to 'above and beyond' constituent system (Palmer, 2000). The concept of metasystem aligns with need to consider the whole including interactions, complexity, emergence and ambiguity --- addressing issues above and beyond a single system.

Complex System Governance (CSG) takes a purposeful, 'holistic', and comprehensive approach to more effectively deal with complex systems and their inherent problems and is presented as a guiding design, execution, and evolution of nine essential metasystem functions that are required to sustain and evolve system performance (Keating, 2014; Keating et al. 2014). CSG is grounded in systems theory --- "a unified group of specific propositions [laws, principles, and theorems] brought together to aid in understanding systems, thereby invoking improved explanatory power and interpretation with major implications for systems practitioners" (Adams et al. 2014, p. 114). This view of systems theory is consistent with von Bertalanffy's (1968) concepts of General Systems Theory (GST) where there is need to "concentrate on structure on all levels of magnitude and complexity, and fit detail into its general framework…discern[ing] relationships and situations, not atomistic facts and events" (Laszlo, 1996, p. 9). Management cybernetics is field of science concerned with developing high performing effective organizations. This field emerged from Stafford Beer's research into the concepts of viability and viable system model – concerned with the necessary and sufficient subsystems and their functions for organisational viability in turbulent environments (Beer, 1979).

A reference model providing full description of these functions (MetaSystem Level) and their role can be found in Keating and Bradley (2015). There are several potential benefits of engaging in CSG-related efforts. These benefits should be taken in the context of the articulated operation environment:

- ***Focus is placed on integration***. CSG places emphasis on systemic integration using systems theory. Continuous maintenance of system integrity. This requires a dynamic balance between guiding principles of autonomy of constituent entities and the integration of those entities to form a coherent whole. This balance produces the system identity (uniqueness) that exists beyond the identities of the individual constituents.

- ***Discovery of interactions***. CSG places emphasis on high-level interactions (relationships) between constituent entities within the system, and between the system and external entities, such that unnecessary instabilities are avoided.
- ***Focus on communications***. This is the emphasis on the flow, transduction, and processing of information within and external to the system, that provides for consistency in decisions, actions, interpretations, and knowledge creation made with respect to the system.
- ***Focus on systemic control***. The primary function of control by the metasystem in CSG is to provide the minimal constraint necessary to ensure continued system performance and behavior, while maximizing autonomy of governed entities.

'Other' benefits of this research are buried in the original bylaws of the *International Society for the Systems Sciences (ISSS)* (Hammond, 2002; von Bertalanffy, 1972).

In this case, the methodological approach, CSG can make use of theoretical concepts, principles, and models from other fields and help in the transfer and assimilation of knowledge with minimal duplication and at the metasystem level, leaving less room for creating 'knowledge specialists.'

Central questions for answering

In CSG, systems can be different (i.e., managerially, operationally, etc.) and yet such systems are interconnected --- physically, or otherwise. CSG attempts to integrate such systems by placing emphasis on meta-aspects of the systems including the social and behavioral aspects that are beyond the individual systems. However, there is a lack of research indicating how CSG can be used to measure social/behavioral phenomena or even quantification at the metasystem level. Hence, there is a need to establishing baselines and then developing means for improving systems. Along this thinking, we suggest the following research questions:

- What frameworks can be developed to address quantification of social and behavioral elements in *interdependent* but *different interrelated* systems?
- What simulation paradigms can be undertaken to address issues at the metasystem level?
- What is the form of governance to address metasystemic issues?

Benefits for advancing fundamental knowledge

Along with the recognition that organizations in the 21st must contend with ambiguity, emergence, complexity, interdependence, and uncertainty, there remains a need for methodological approaches that addressing metasystemic issues, and grounded in solid conceptual foundations. CSG use GST and Management Cybernetics --- with an emphasis on the metasystem functions. And yet addressing issues of 'provision of system direction, oversight, and accountability (Calida, 2015).

Beyond this promise, CSG as an approach can offer analytic capabilities to address deep systemic and phenomenological issues such as those involving national security. Table 1 attempts to address different areas of CSG with implications to security – security is used as an example.

Table 1. Benefits of advancing fundamental knowledge in CSG

CSG Area	Description	Implications for national security
Systems Theory Systemic Foundation	Developed utility of different laws, principles, and theorems that describe structure and behaviors of complex systems.	Which systems theoretic laws and principles apply to national security and implications.
Entity Competence for Systemic Thinking	Provides the level of knowledge, skills, and abilities related to systemic thinking for organizations (systems) contemplating engagement in CSG development	Ensuring presence of a capable workforce with requisite knowledge in systems theory to address national challenges.

Reference Model Requirements Assessment	Provides an examination of the function of CSG against the requirements specified for the CSG Reference Model	Development of methods and tools to deal with security-based and non-security-based requirements complex systems.
Framing Methodology	The purpose is to enable making explicit relationships, transformation, and boundaries of systems, subsystems, and entities of focus the development effort.	Developing methods, tools, and techniques to explore relationships among complex systems, especially relations that have implications of national security.
System Leadership Assessment	Identifies the degree to which the existing state of leadership in CSG is consistent with that required for expectations of development	Understanding the nature of leadership required to deal with issues, including security, in the 21st century.
Individual Capacity for Systemic Thinking	Establishes the level of systemic thinking that exist among those (owners, operators, designers, or performers) with responsibilities for design, execution, and development of the metasystem	Developing methods and tools to establish needed thinking capacity (good or bad) and training materials to improve systemic thinking of those that must deal with national security issues.
Environmental Scanning	Elaboration on the need to provides design for sensing of the external environment and identification of environmental patterns, activities, or events with system implications	Developing next-generation sensors to scan for national security and processing of the environmental trends.
CSG methodology	A three-phase development (i.e., initialization, readiness level assessment, and governance development) methodology that rests on governance functions that must be performed by any system to maintain viability (existence).	Development of generalized methodologies – grounded in systems theory as well as system-specific methodologies to address system-specific issues.
Pathologies for CSG	Identified over 80 conditions (pathologies) that act to limit system performance. Pathologies are established against the backdrop of systems theory and the CSG reference model.	A characterization of pathological conditions as they relate to national security --- along with how they can evolve and affect national security.
CSG Simulation	Imitation of the operation of a real-world process or system over time. Such efforts would require representing key characteristics, behaviors and functions of the system.	Design and simulating systems to improve its state; testing of different paradigms; developing of policies and scenarios.

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