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SYSTEMIC ANALYSIS OF COMPLEX SYSTEM GOVERNANCE FOR ACQUISITION

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Abstract
The purpose of this paper is to explore Complex System Governance (CSG) issues related to systemic analysis of acquisition systems. CSG is an emerging field focused on the design, execution, and evolution of the functions necessary to provide continued system performance (stability) in the midst of incessant turbulence and increasing complexity. Integral to this field is the necessity to engage systems to address behavior or performance that is inconsistent with that which is desired. Systemic analysis for CSG serves to examine a system to discover fundamental system issues (e.g. acquisition). Arguably, system acquisition has an unremarkable record of success, ranging from missing cost, schedule, or performance expectations to outright failure. However, although acquisition has been a continual subject of reform, little emphasis has been placed on a more rigorous systemic exploration of the field. This systemic analysis is aimed at uncovering deeper levels of aberrant behavior/performance as a function of a deficient underlying governance system. To examine systemic analysis of CSG for acquisition, this paper pursues three primary objectives. First, a brief introduction to the acquisition problem domain and CSG are provided. Second, a perspective of systems-based pathologies for CSG is developed. Third, an approach to systemic analysis for CSG is developed (the M-Path Method). This method is introduced as an approach to 'systemic analysis' through the identification of pathologies (deviations from healthy system functioning) in CSG. The paper concludes with directions for future development of systemic analysis for CSG in acquisition.

Keywords
Complex System Governance, Systems Theory, Management Cybernetics, Acquisition

Introduction
Traditional acquisition processes have been under increasing pressure to address missed budgets, delayed deliveries and expensive canceled systems that appear to represent a new normal for complex programs. There have been numerous investigations conducted attempting to determine the underlying factors that resulted in unsuccessful efforts (Berteau, Levy, Ben-Ari, & Moore, 2011; Francis, 2008, 2009; Rascona, Barkakati, & Solis, 2008). Unfortunately, there is not a definitive response that can conslusively offer an explanation or provide a remeady. The acquisition endeavors that have experienced success based on usability, budget and delivery schedule are the rarity and are often the subject of study in the hopes of discovering the critical essence that contributes to success and can be generalized to advance future acquisition programs chances for success (Boudreau, 2007; O'Rourke, 2014). However, to date there is not an accepted articulation of the 'recipe' for ensuring performance in the acquisition of systems. Rather than rehash prior approaches or viewpoints, complex system governance (CSG) is examined as a value adding alternative to examine acquisition systems. The hope is that the CSG perspective might provide new insights to an all too familiar problem domain (Keating et al., 2015). CSG is an emerging field grounded in Management Cybernetics (science of effective system organization) and Systems Theory (principles governing behavior of all systems). CSG has posited nine metasystemic functions required for effective governance, which will be briefly examined in the next section.

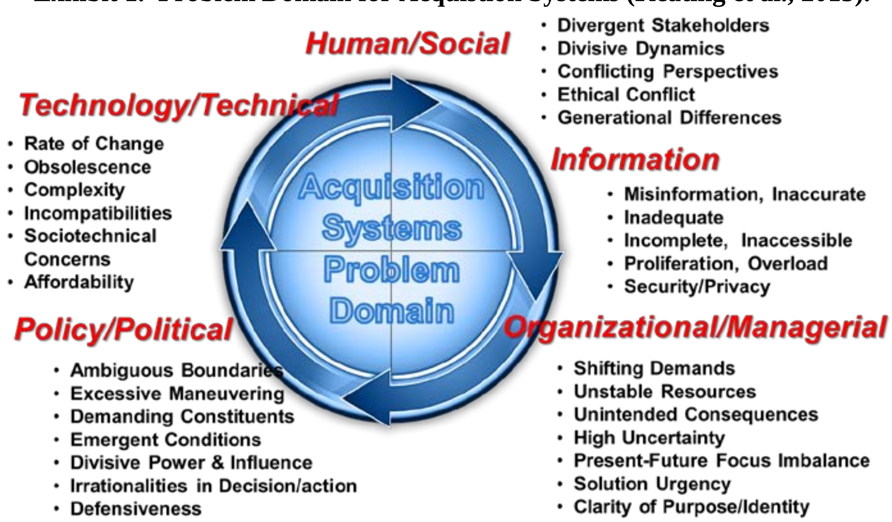
The problems facing practitioners dealing with complex systems appear to be intractable. The domain of the acquisition practitioner is marked by conditions characterized by:

- *Exponential Rise in Complexity* – the availability, magnitude, and accessibility of information, is beyond current capabilities to structure, order, and reasonably couple decisions, actions, and consequences. This, coupled with compression of time and the interconnectedness of 'everything' is challenging our capacity to mount effective responses.
- *Dominance of Emergence* – the appearance of structures, behaviors, performance, or consequences that cannot be know in advance renders traditional forms of planning innocuous at best, unsuited to current realities, and potentially detrimental. Current methods are failing to provide practitioners with the necessary capabilities to engage highly emergent situations.
- *Ambiguity in Understanding* – instabilities in understanding, shifting boundary conditions, and unstable structural patterns create a lack of clarity for decisive action.
- *Uncertainty as a Norm* – the inability to have any measured degree of confidence in how to proceed to produce desired performance is not the exception but rather the stable state of affairs.
- *Holistic Satisficing Solution Spaces* – the problem space is not limited to simple, absolute, or isolated solution forms. The spectrum of technology/technical, organizational/managerial, human/social, and political/policy are in play across special, temporal, and social dimensions.
- *Contextual Dominance* – unique circumstances, factors, patterns, and conditions permeate a situation. They are enabling and constraining to decision, action, and interpretations.

This characterization of the acquisition environment is not intended to create a sense of hopelessness. On the contrary, we are simply attempting to provide a cogent backdrop supporting the need to push our knowledge in ways that will create new pathways forward to advance acquisition systems. These pathways must challenge conventional thinking, and derivative artifacts, with the goal to ultimately enhance capabilities to deal more effectively in these environments.

The problems facing the acquisition community continue to proliferate into all aspects of the world of the acquisition profession. These problems are not the privilege, or curse, of any particular aspect of acquisition, but rather dominate the entirety of the organizational, managerial, social, human, policy, and political dimensions of the field. The complex problems stemming from this domain do not have a precise cause – effect relationship that would make understanding and resolution easy or reducible to the precision demanded by mathematical applications. However, the landscape for acquisition systems might be best characterized as 'complex problem space'. Figure 1 provides a visual representation of this problem space (Keating, Katina, & Bradley, 2015). The different aspects of this 'new normal' complex problem space, within which acquisition systems must exist, has been previously established (Jaradat & Keating, 2014; Keating, 2014; Keating & Katina, 2011; Naphade, Banavar, Harrison, Paraszczak, & Morris, 2011) as being characterized by conditions identified in Exhibit 1. To acquisition professionals this listing is likely recognizable and represents nothing that is not, or has not been faced on a routine basis with varying results.

Exhibit 1. Problem Domain for Acquistion Systems (Keating et al., 2015).



This paper is organized to pursue three primary objectives. First, a brief introductory overview of CSG is provided as an essential grounding for further development. Second, we introduce the concept of pathologies in CSG. The nature of 'systemic analysis' is examined as the identification of pathologies (deviations from healthy system functioning) in CSG. The emphasis of this examination is to suggest that there may exist a generalizable set of pathologies for acquisition systems, irrespective of the specific system being acquired. Third, we suggest the M-Path Method as an approach to discover pathologies in a complex system. The paper concludes with directions for future development of systemic analysis for CSG in light of acquisition systems.

Complex System Governance: A Brief Introduction

CSG is focused on successfully navigating the conditions identified in Exhibit 1 to produce higher performing systems and ease the burden of practitioners. CSG development and application draws upon a strong conceptual base found in Systems Theory (Whitney, et al., 2015) and Management Cybernetics (Beer 1979). In essence, Systems Theory offers the set of propositions that have been continually developed and applied over the past eight decades. The propositions have withstood the test of time and application, defining the structure, behavior, and performance of all systems. Systems Theory propositions are non-negotiable and have real consequences for systems and practitioners that, knowingly or unknowingly, 'violate' them. The strong influences of Systems Theory are found in the emphasis on integration and coordination for CSG.

Management Cybernetics provides a strong conceptual foundation for communication and control essential to CSG. In particular, Management Cybernetics offers CSG design cues for control through the model of a 'metasystem'. The 'metasystem' is a set of functions that stand above/beyond the particular systems/entities that it seeks to "steer" -- in the cybernetic sense of providing control. Management Cybernetics also provides a set of communication channels associated with the 'steering' functions of the metasystem.

From this conceptual grounding in Systems Theory and Management Cybernetics, CSG is formulated as the *"design, execution, and evolution of the [nine] critical metasystem functions necessary to maintain system viability [existence]"* (Keating, et al., 2014) (Exhibit 2).

Exhibit 2. System Functions for CSG.

A brief depiction of the nature and role of the CSG functions (identified as Metasystem functions) is:

- *Metasystem Five (M5) – Policy and Identity* – focused on overall steering of the system, giving policy level direction, representation of the system to external constituents, and maintaining identity for system coherence
- *Metasystem Five Star (M5*) – System Context* – focused on the specific context within which the metasystem is embedded

- *Metasystem Five Prime (M5') – Strategic System Monitoring* – focused on oversight of the system at a strategic level
- *Metasystem Four (M4) – System Development* – focusing on the long range development of the system to ensure future viability
- *Metasystem Four Star (M4*) – Learning and Transformation* -- focused on facilitation of learning based on detection and correction of design errors in the metasystem and guiding planning to support transformation of the metasystem.
- *Metasystem Four Prime (M4') – Environmental Scanning* -- focused on sensing the environment for circumstances, trends, patterns, or events with implications for both present and future system performance
- *Metasystem Three (M3) – System Operations* – focused on the day to day operations of the metasystem to ensure that the system maintains performance levels.
- *Metasystem Three Star (M3*) – Operational Performance* – focused on monitoring system performance to identify and assess aberrant or emergent conditions in the system
- *Metasystem Two (M2) – Information and Communications* – focused on the design for flow of information and consistent interpretation of exchanges (communication channels)

The performance of these functions, required by all existing systems, supports achievement of:

- *Control* - constraints necessary to ensure consistent performance and future system trajectory
- *Communications* - flow and processing of information necessary to support consistent decision, action, and interpretation throughout the system
- *Coordination* - providing for effective interaction to prevent unnecessary instabilities within and in relationship to entities external to the system
- *Integration* - maintaining system unity through common goals, designed accountability, and maintaining balance between system and constituent interests

Ultimately, effectiveness in purposeful design, execution, and evolution of the nine ‘metasystem governance’ functions determines system performance, including acquisition systems.

Complex System Governance: Pathologies

In performance of the CSG functions, all systems are subject to experiencing pathologies, including acquisition systems. Pathologies are circumstances, conditions, factors, or patterns that act to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced (Keating and Katina, 2012). The consequences of pathologies for system performance? -- in the best case they degrade and in the worst case they can derail system performance.

There is much to be gained by exploring the concept of system pathologies that represent common deficiencies in systems. System pathology was selected as a term that most aptly describes common system deficiencies we seek to discover and analyze for the improvement of complex systems. At the most fundamental level, pathology represents a deviation from that which would be considered a healthy or normal state of affairs. The use of the term pathology was purposefully selected for four important reasons. First, generally associated with health, pathology indicates a departure from what is expected as normal, or healthy, operation of a system (e.g., human body). Second, the notion of pathology suggests that there is something underlying which contributes to the departure from normal operating conditions that is manifest as symptomatic of the underlying condition. Third, a pathology is not necessarily something that is obvious, but rather must be established in relationship to how the pathology may manifest itself. This relationship might not be obvious and requires exploration at a deeper systemic level. Forth, a particular pathology must not be addressed in isolation, but rather within the context of the whole system which will be impacted by any effort to address the pathology. With this starting point for pathologies, we move forward to discuss the general nature of pathologies for complex systems.

Following Keating and Katina (2012), Katina (2015a; 2015b; 2016) a set of 53 pathologies corresponding to nine functions for CSG have been developed (Exhibit 3). In effect, these pathologies provide a basis for the purposeful exploration of their existence in a system of interest.

Exhibit 1. Pathologies corresponding CSG functions

Metasystem function	*Corresponding set of pathologies*
Metasystem five (M5): Policy and identity	M5.1. Systems identity is ambiguous
	M5.2. Decision, action and interpretation are incongruent with system identity
	M5.3. Imbalance between short-term operational and long-term strategic focus
	M5.4. Strategic development decisions are made without consideration for system identity
	M5.5. System identity is not routinely assessed, maintained, or questioned
	M5.6. External system projection is not effectively performed
Metasystem Five Star (M5*): System context	M5*.1. Incompatible metasystem context constraining system performance
	M5*.2. Lack of context articulation and representation
	M5*.3. Lack of contextual consideration for metasystem action and decision
Metasystem Five Prime (M5'): Strategic system monitoring	M5'.1. Lack of strategic system monitoring
	M5'.2. Inadequate processing of strategic monitoring results
	M5'.3. Lack of strategic system performance indicators
Metasystem Four (M4): System development	M4.1. Lack of forums to foster system development and transformation
	M4.2. Inadequate (i.e., non-existent, sporadic, limited) interpretation and processing of results of environmental scanning
	M4.3. Ineffective processing and dissemination of environmental scanning results
	M4.4. Long-range strategic development is sacrificed for management of day-to-day operations
	M4.5. Strategic planning/thinking focuses on operational level planning and improvement
Metasystem Four Star (M4*): Learning and transformation	M4*.1. Achieving little to nothing from environmental shifts
	M4*.2. Having an ineffective integrated strategic transformation
	M4*.3. Lack of design for system learning
	M4*.4. Failure to maintain current and future system models
Metasystem Four Prime (M4'): Environmental scanning	M4'.1. Lack of effective scanning mechanisms
	M4'.2. Inappropriate targeting/undirected environmental scanning
	M4'.3. Scanning frequency not appropriate for rate of environmental change
	M4'.4. System lacks enough control over the variety expected to be generated by the environment
	M4'.5. Lack of current model of environment
Metasystem Three (M3): System operations	M3.1. Imbalance between autonomy of productive elements and integration of whole system
	M3.2. Shifts in resources without corresponding shifts in accountability and vice-versa
	M3.3. Mismatch between resource and productivity expectations
	M3.4. Lack of clarity for responsibility, expectations, and accountability for performance
	M3.5. Operational planning frequently pre-empted by emergent crises
	M3.6. Imbalance between short-term operational and long-term strategic focus
	M3.7. Lack of clarity of operational direction for productive entities (Subsystem 1s)
	M3.8. Difficulty integrating system productive entities
	M3.9. Slow to anticipate, identify, and respond to environmental shifts
Metasystem Three Star (M3*): Operational performance	M3*.1. Lack of access to data necessary to enable performance monitoring
	M3*.2. Absent, limited, or ineffective system-level operational performance indicators
	M3*.3. Lack of monitoring mechanisms for system and subsystem level performance
	M3*.4. Lack of analysis for performance variability (i.e., meaning of deviations from expected performance levels)
	M3*.5. Ineffective performance auditing (i.e., non-existent, limited, or restricted) to

	mainly troubleshooting emergent issues
	M3*.6. Examination of system performance largely is unorganized and informal in nature
	M3*.7. Limited system learning based on performance assessments
Metasystem Two (M2): Information and communications	M2.1. Unresolved coordination issues within the system
	M2.2. Excess redundancies in the system resulting inefficient utilization of resources and information
	M2.3. System integration issues stemming from excessive entity isolation or fragmentation
	M2.4. System conflict stemming from unilateral decisions and actions
	M2.5. Frequent occurrence of emergent crises (information transmission, communication, and coordination) within the system
	M2.6. Lack of effective communication systems among system entities
	M2.7. Lack of standardized methods, procedures, or processes for routine system level activities
	M2.8. Overutilization of standardized processes where they should be customized
	M2.9. System coordination is ad hoc as opposed being purposefully design
	M2.10. Difficulty in accomplishing cross-system functions requiring integration
	M2.11. Uncoordinated system changes resulting in excessive oscillation

There are four primary conclusions with respect to pathologies identified for CSG functions. First, these pathologies are not unique to any given system/organization. They may certainly be present or absent and vary in degree should they be present in any system. The set of pathologies are indicative of aberrant conditions in the metasystem functions of viability for complex systems, including acquisition systems. Thus, the 53 pathologies (Exhibit 3) represent the nature of circumstances, conditions, factors, or patterns that can act to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced. Second, these pathologies do not exist in a binary fashion of ‘present’ or ‘not present.’ Rather, it’s best to recognize that they may exhibit themselves in ‘degrees of existence’. This opens the possibility of pathologies having a spectrum of both existence as well as impact. Third, the existence of a pathology has real consequences on performance of a given acquisition system – measured in terms of a range of possible effects. As each acquisition system is unique, so too will be the associated pathologies that manifest as the system operates. The pathologies will not be static over the acquisition life cycle for a given system. Fourth, in accordance with previous research, these pathologies should be a subject of exploration during problem formulation, since bringing change to the system is largely dependent on understanding the current state of the system (Dery, 1984; Katina, 2015a; Quade, 1980). We suggest that in the formative stages of acquisition system exploration, knowledge of pathologies and their assessment can play a vital role. They can serve in both the design of new acquisition programs/systems or evaluation of programs/systems currently underway.

We now shift our focus to elaboration of a developing approach for exploration of pathologies in complex systems. This approach has been identified as the Metasystem Pathologies Method (M-Path Method), with the term ‘metasystem’ serving to articulate the particular functions of CSG previously elaborated. The M-Path Method serves for identification and assessment of the conditions (listed in Exhibit 3) that negatively impact system performance.

Discovery of Complex System Governance Pathologies

The M-Path Method is an approach that guides identification and assessment of specific pathologies that exist in a complex system. A complex system can experience 53 unique possible metasystem pathologies that can exist to varying degrees of *existence*, *impact*, and *feasibility to resolve*. The M-Path Method is conducted in five primary phases (Exhibit 4).

Phase 1 – Identification involves the identification and discovery of the degree to which the 53 pathologies exist for a given situation/system. A determination is made with respect to the perceived existence and impact of pathologies.

This phase produces two essential pieces of information: degree of existence and impact of each of the pathologies. Degree of existence is the level to which the pathology is deemed to be present – ranging from negligible to extreme.

A web-based instrument to capture and synthesize perspectives has been developed. The analyst can use a variety of tools including data mining and survey tools to ascertain information regarding the presence of pathologies in a system of interest as well as their impact on operations of the system. Previous research has used a Web-based instrument (e.g., see Katina, 2015b). The associated pathology analysis involves an ordinal process of 'binning' pathologies based on levels of existence and potential impact.

Phase 2 – Analysis examines the nature and implications of the unique 'landscape' of pathologies for the system being examined. This phase is targeted to examination of the specific implications the pathology holds for the particular system of interest. Pathologies do not have the same relevance, impact, or feasibility for resolution in a complex system.

The first phase only identifies the presence and impact of the 53 metasystem pathologies. The second phase involves an examination of nature and implications of the unique 'landscape' of pathologies for the system interest. Driven by the kind of tools used in data collection of phase I, the analyst collects and synthetizes the data into meaningful information concerning the pathologies. This phase provides an initial portrait of pathologies in the system – unique to the specific system of interest and articulates the degree to which pathologies affect the system. The following caveats apply to this phase:

- This analysis should enumerate metasystem pathologies using measures of existence and impact
- Indicate variability in measures of degree and impact as suggested by participants - in this case as taken from survey data. It is expected that each participant will not provide the same measure for the same pathology. This variability provides insights that might be further examined in Phase III.

Phase 3 – Exploration provides a guided investigation of the meaning and system development implications for identified pathologies. This phase also maps existing initiatives and their contribution to identified pathologies. The result of this phase is a strategy and corresponding actions designed to influence pathologies. Performance of this phase is critical to begin to make the pathology exploration 'actionable'.

The results of phase II are made available to system owners in order to provide a guided investigation into the meaning of the identified pathologies as well as their implications for system development. This phase involves a two-way dialogue between system owners and the analysts involving the general meaning of pathologies and exploration of the meaning in context for the system of interest. This dialogue is instrumental for articulating and/or voicing system of interest development implications in response to the discovered pathologies. It is during this phase that the existing initiatives (development activities underway in the organization) must be mapped against pathologies. This mapping enables discovery of strengths and weaknesses in system development in relationship to the existing pathologies. The results of this phase include a prioritized enumeration of pathologies based on feasibility – organizational ability to successfully address the pathologies as well as a set of strategies and corresponding actions designed to impact the identified pathologies.

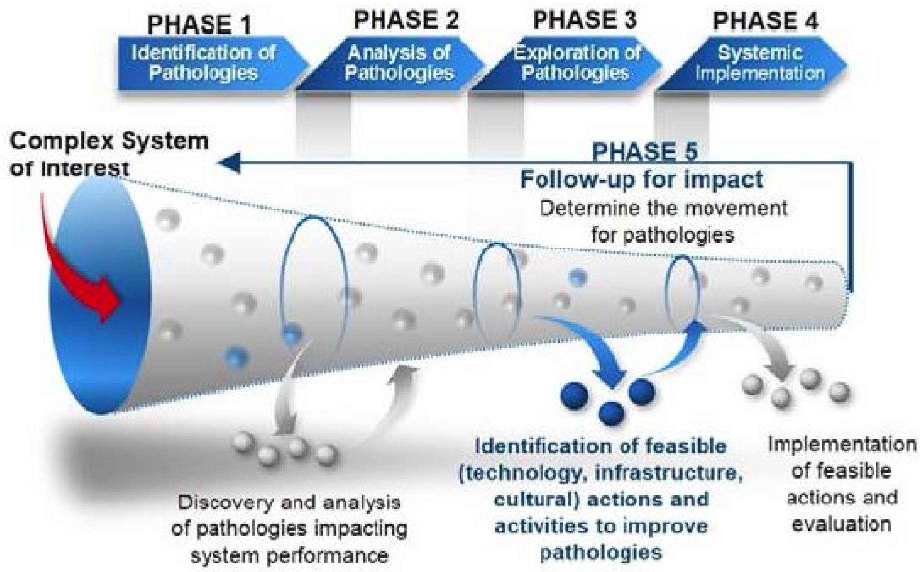
Phase 4 – Systemic Implementation deploys selected responsive actions to address pathologies. As with any system implementation the response to pathologies will involve the potential for emergent conditions. Care must be take to ensure that the implementation actions/strategies are monitored for their impact.

The purpose of this phase is to ensure that selected responsive strategies are effectively deployed. Activities are based on what is decided in the previous phase. For example, this might include 'development of effective environmental scanning mechanisms' in response to metasystem pathology M4*.1 {lack of effective scanning mechanisms} as identified in Exhibit 3. Identifying this as an issue starts in Phase I, making this issue more explicit in Phase II and following through in Phase III to develop new initiatives while understanding and integrating current initiatives – including effectiveness of existing scanning mechanisms for the example. Once there is agreement that there needs to be development of effective scanning mechanisms, a strategy to develop such mechanisms must be put in place in Phase IV. A comparative analogy is being prescribed medication for an illness and failing to take the medication. Surely identified pathologies will not improve and might even get worse if they are not acted upon. In addition, this phase must set a time-line for future incremental system evaluations.

Phase 5 – Follow-up is focused on the examination of the impact for strategy and action execution in response to pathologies. While direct cause-effect is not possible, conclusions concerning the application of pathology responses should be examined for further implications.

This 'final' phase is focused on examination of the effects of the strategies and actions undertaken to address pathologies. An established timeline can serve as a place-maker for a re-evaluation of the system by fulfilling two primary purposes: 1) to measure the effects of the strategies/actions as implemented in Phase IV and 2) identification of new pathologies. Such efforts serve the role of continuous system development. This is essential since the organization in question is operating within a dynamic and most likely turbulent environment. Moreover, the deployment strategies might lose effectiveness over time, new pathologies might emerge, and new technologies might shift the landscape of pathologies. Therefore, navigating through M-Path Method is truly continuous with each phase complementing and interrelated to the previous phases.

Exhibit 4. Five Phases of the M-Path Method

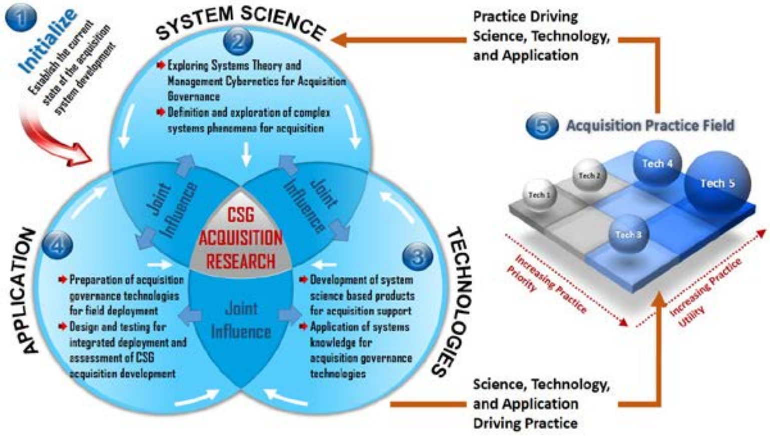


For acquisition systems we identify three primary value adding contributions for CSG development based on development of pathologies through application of the M-Path Method. First, *Identification and representation* of the system pathologies landscape that exist for a system of interest can serve to focus attention on priority issues affecting system performance. Second, the *Exploration* of the nature of system pathologies and their implications for improving system performance can advance depth of understanding of the impediments to system performance. This represents a significant step forward to 'change the conversation' with respect to more focused 'systemic' discussions and discovery of deeper rooted sources of systemic error in systems. Third, d*etermination of feasible prioritized actions and initiatives* to impact pathologies can proceed from a more informed perspective. With scarce resources existing in all systems, the ability to set priorities and focus on addressing higher value adding issues is critical to more effective system development.

Conclusions and Implications

Systemic Analysis of CSG for acquisition is not offered or pursued as a universal remedy for issues that plague acquisition programs and confound practitioners. However, we are confident that rigorous exploration of CSG for acquisition system can significantly advance the state of acquisition performance and enhance professional practice by: (1) introduction of systems theory based acquisition governance technologies to support practitioners, (2) enhancing the capabilities of acquisition professionals by introduction to advanced systems theory and corresponding methods for more rigorous formulation of systemic pathologies plaguing acquisition systems (e.g. M-Path Method), and (3) enhancing acquisition practices by the close coupling of science-based research, engineering of advanced technologies, and deployment in field based applications. In essence, future development of CSG for acquisition can make a major contribution to the acquisition field by focusing on *"acquisition of acquisition technologies"* to advance the state of acquisition practice (Exhibit 5).

Exhibit 5. Development of CSG for Systemic Analysis of Acquistion Systems



Further development of systemic analysis of CSG for acquisition systems is focused on three critical challenges:

1. *Engineering of technologies for acquisition system advancement* – this thrust must focus on the application of system science (found in Systems Theory and Management Cybernetics) to drive new discovery and development of CSG technologies for the acquisition field and practitioners. These CSG technologies (methods, tools, techniques) are informed by both the existing state of the acquisition system as well as the underlying system science basis for the developing technologies.

2. *Design for application and deployment of technologies*– the emphasis of this developmental thrust is to design for deployment of CSG technologies in field settings to enhance acquisition practice. This requires that the technologies be fit to: (a) the particular context within which they will be deployed and operate and (b) the specific acquisition problems for which the technology is appropriate.

3. *Research for Application practice enhancement* – this development thrust is concentrated on the constant interplay between acquisition practice and emerging research. Research priorities must be informed from the acquisition field of practice (Exhibit 5). The pragmatic focus of the acquisition field necessitates the close coupling of *science, engineering technologies, and applications development* with the professional practice demands of acquisition professionals.

The acquisition field is under tremendous pressure to increase effectiveness in delivery of on time, on budget, and on performance systems. While this has always been an objective for acquisition systems, the current nature of the problem domain has substantially increased the challenges facing the field. CSG and systemic analysis of pathologies can serve to advance the capabilities and capacity of the acquisition field and professionals to better address current and future challenges.

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