2017-03

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Monterey, California. Naval Postgraduate School

SYM-AM-17-065

# Proceedings
## of the
# Fourteenth Annual Acquisition Research Symposium

## Wednesday Sessions
## Volume I

**Acquisition Research:**
**Creating Synergy for Informed Change**

**April 26–27, 2017**

**Published March 31, 2017**



Prepared for the Naval Postgraduate School, Monterey, CA 93943.

# A Systems Theoretic-Based Framework to Discover Pathologies in Acquisition System Governance

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## Abstract

The acquisition field continues to face increasing pressures to perform under conditions of escalating complexity, uncertainty, and ambiguity. These conditions suggest that traditional approaches, practices, and acquisition technologies might be incongruent with support demands for acquisition practitioners. *This research is focused on exploiting and extending recent developments in Complex System Governance (CSG) to advance the acquisition field*. CSG is focused on the design, execution, and evolution of fundamental system functions necessary for control, communications, coordination, and integration of complex systems (e.g., acquisition). CSG is based in Systems Theory (fundamental laws governing complex systems), Management Cybernetics (the science of effective system organization), and

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Governance (provision of direction, oversight, and accountability for systems). Recent advances in CSG (Keating, Katina, & Bradley, 2015) make this an opportune time for exploitation of this field to advance acquisition research and practice in novel ways. Following an introduction and literature review, this paper reports on efforts to (1) establish a systems theory based framework for Acquisition System Governance, (2) mapping of systems pathologies (systemic errors that degrade system performance) to a CSG Reference Model with implications for acquisition practice, and (3) suggests implications for moving CSG forward to improve acquisition practice. The paper closes with directions for bringing CSG to practice through research based application development.

## Introduction

The Defense Acquisition System continues to struggle in the midst of increasing levels of complexity, uncertainty, and ambiguity. There are enormous pressures on the acquisition field and practitioners faced with the new realities of increasingly complex systems, resources become further constrained, and expectations for maintenance of cost, schedule, and performance projections escalating. These pressures for change (a.k.a. reform) in the Defense Acquisition System to evolve in response to shifting circumstances is not new or unprecedented. In fact, the history of defense acquisition has been one marked by numerous attempts at reform. For instance, Fox (2011) has traced 50 years of acquisition reform through several periods from the 1960s. Among these reform periods he identified were the following: (1) 1960s and 1970s McNamara innovations and the birth of DoD Directive 5000.1 specifying the Acquisition process; (2) 1980s Carlucci initiatives, PPBS, and weapons acquisition reform; and (3) 1990s, where the DoD 5000 series incorporated less than 50% of reform initiatives. The difficulties and results of Defense Acquisition System reform were captured by Fox's (2012) assertion that

> despite the defense community's intent to reform the acquisition process, the difficulty of the problem and the associated politics, combined with organizational dynamics that are resistant to change, have led to only minor improvements. The problems of schedule slippages, cost growth, and shortfalls in technical performance on defense acquisition programs have remained much the same throughout this period. (p. vii)

Numerous authors have echoed these sentiments. In fact, Schwartz (2013) cites that over 150 major studies examining acquisition reform have been conducted since World War II—with the state of continuing cost overruns, schedule slippages, and missed technical performance remaining. However, Swartz (2013) also cites multiple improvements in the processes used by the DoD to procure goods and services, such as (1) the creation of the Federal Acquisition Regulation; (2) the formation of the Defense Acquisition University: and (3) the institution of such changes to acquisition as multi-year procurement, independent cost estimation, joint requirements board, and movement to commercial technologies. However, despite improvements and initiation of (e.g., should-cost analyses) a recent GAO (2007) assessment of defense acquisition for selected weapon programs concluded that programs continued to experience cost increases and schedule delays. Continuing difficulties in acquisition of defense systems does not to minimize either the dedicated professionals in the acquisition workforce, the well-intentioned aspirations of acquisition institution leaders, or system modifications instituted. Instead, it invites new and novel thinking in response.

Given this seeming consensus on the state of affairs for acquisition, and corresponding attempts for reform, the question is begged, *why does this state of acquisition continue to have difficulty in meeting cost, schedule, and technical performance expectations?* There have been many attempts to explain the factors that delineate the nature and sources of failure in acquisition (Berteau, Levy, Ben-Ari, & Moore, 2011; Francis, 2008, 2009; Rascona, Barkakati, & Solis, 2008). In fact, a look at recent Government Accountability Office assessments of major acquisition programs continues to accentuate difficulties in the acquisition field (Cilli, Parnell, Cloutier, & Zigh, 2015). However, there are continuing efforts at Acquisition System reform (Bucci, Slattery, & Maine, 2015) that recognize the need to streamline the system and craft a more agile and flexible Acquisition System. While these are noble ideals, agreement on how to engage such an endeavor is far from a consensus. The outward appearance of the Acquisition System is that of a monolithic system not well-suited for the complexity, speed, uncertainty, and ambiguity that exist in warfighting needs and environments.

Although the underlying reasons for Fox's (2012) criticisms of the performance of the Defense Acquisition System might be debatable, adequately addressing the continuing difficulties in defense acquisition appears to remain an elusive goal. Providing a sampling of external examinations of past and current reports on defense acquisition program difficulties supports the conclusion that Defense Acquisition continues to struggle, suggesting that "In general, these reports call for early, robust, and rigorous assessments of a broader range of alternatives across a thorough set of stakeholder value criteria to include life-cycle costs, schedule, and performance" (Cilli et al., 2015, p. 587). From a systems perspective of the state of acquisition, we suggest five thought provoking considerations (Figure 1). These considerations provide a systemic frame of reference for the modern landscape of defense acquisition. While these characteristics are endemic to modern systems in general, the particular emphases of the Defense Acquisition System invites a different level of dialog, exploration, and systemic understanding.

1. *Sprawling Complexity Exceeding Absorptive Capacity of the System.* While the technologies and operation and maintenance demands for future weapons systems have continued to rise exponentially, so too has the complexity of systems designed to acquire them. For the Defense Acquisition System this suggests that the calls for reform, increased agility, and other such suggestions by numerous authors, is perhaps best summed up in Kendall's (2014) congressional testimony stating,

   > Our system over time accumulated excessive levels of complex regulatory requirements that are imposed on our program managers and other acquisition professionals. … One thing I hope we can all agree on is the need to simplify and rationalize the bureaucratic burdens we place on our acquisition professionals. (p. 6)

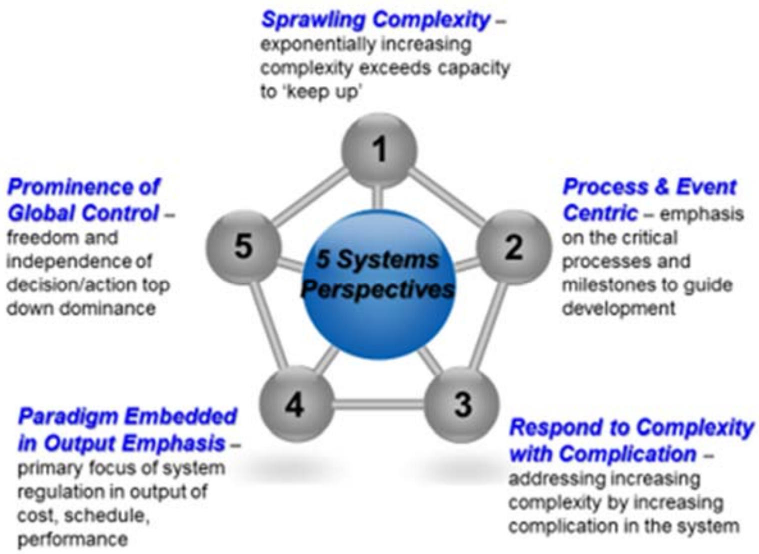


**Figure 1. Five Systems Perspectives for the Defense Acquisition Field**

2. *Process and Event Centric Focus.* Although the Defense Acquisition System is proclaimed to be a system, in reality it is hard pressed to meet the standard tenets that are central to classification as a system (e.g., boundary, transformation, etc.). Instead, the Acquisition System is a collection of elements for which the precise representation is not presented, operated, or evolved holistically as a system. For instance, Friar's (2015) depiction of the sprawling regulatory environment surrounding the FAR and its implementation notes the precarious relationship of related FAR elements, such as service specific FAR supplements, corresponding guidebooks, implementation instructions, and the DoD 5000 series. Even the DoD 5000 refers to the Defense Acquisition Management System as both a "framework" as well as an "event-based process." The demands placed on the systems that are the product from the Defense Acquisition System are somehow held to a different standard when it comes to *systemic grounding* (design, execution, development) expectations. Processes and events fall short in classification as a system. The ramifications of this distinction are profound and far reaching for understanding of critical issues and future development.
3. *Response to Increasing Complexity Relegated to Increasing Complication*. The original intent of the FAR was quite straightforward in attempting to provide a streamlined approach to the acquisition of material to support the effective functioning of the government enterprise. However, in the time since the inception of the FAR it has continued to elaborate in structure, volume, and complication of process and implementation controls. For instance, the Federal Acquisition Regulation expanded from 1,953 pages at introduction in 1984 to 2,193 pages by 2014, with the DFAR supplement adding another 1,554 pages and each of the services initiating a host of their own specialized implementation guides, instructions, directives, and memorandums (Friar, 2015).
4. *Driving Paradigm Embedded in an Output Emphasis*. Outputs from the Defense Acquisition System are those tangible, verifiable, and objective elements that serve as products that provide value consumed external to the

system. This provides the basis for a worldview (the system of values and beliefs through which all that is sensed is processed) which translates into the design, execution, and development of the Defense Acquisition System. It is hard to read a criticism of the current state of affairs for acquisition that is not targeted to cost, schedule, and technical performance. However, we suggest that these indicators are systemically limited in their measuring the value of the Defense Acquisition System. While these indicators (cost, schedule, performance) are necessary indicators of system performance, they alone do not provide sufficiency as a set of judgments of Acquisition System performance. For example, Cilli et al. (2015) point out the sunk costs of five programs between 2006 and 2011 in excess of $32 billion. The question for examination of paradigm consistency would need to consider whether or not the failure in these programs, and the acquisition system which permitted those failures, might be found beyond the cost, schedule, and technical performance triad.

5. *Prominence of Global Control.* From a systems perspective, control is about providing constraint of a system only to the degree to which is necessary to assure continued performance (Keating et al., 2016). Excess constraint in a system (control) wastes resources and limits local autonomy independence for decision, action, and interpretation. The common manifestation of excessive global control is what has been described aptly in much of the acquisition literature as overregulation, bureaucracy, and excessive constraint without evidence of commensurate value added to the system. The near constant state of acquisition reform (Fox, 2012; Schwartz, 2014) supports the increasing elaboration of the system in ways that do not necessarily enhance performance. This does not demean the improvements achieved in reform processes, but instead suggests that a different (systemic) viewpoint might shift the premises, and thus understanding of the complexities inherent in the system.

This systems perspective for the Defense Acquisition System is intended to suggest that a different frame of reference might be helpful. Our intention is to invite a dialog to further exploration and understanding of the current system, while offering insights into issues in design, execution, and development of the system from an alternative frame of reference. For our purposes, the alternative frame of reference is focusing on understanding system difficulties through discovery of underlying pathologies (aberrations from ‘healthy’ functioning of a system). To achieve our purpose, the remainder of the paper is organized around four primary objectives. First, in Literature Review for Defense Acquisition System Governance, we provide a literature review targeted to an examination of defense acquisition in relationship to the emerging Complex System Governance field. Second, in the section titled A Systems Theory Based Paradigm and Model for Complex System Governance for Defense Acquisition, we elaborate a Systems Theory based paradigm for Complex System Governance and draw the relevance for the Defense Acquisition System. Third, the System Pathologies in Complex System Governance for Acquisition section describes a set of pathologies in the governance of complex systems and projects that set to the acquisition field. Fourth, the final section concludes the paper with implications for further research and application development of CSG for the acquisition field, focusing on the Defense Acquisition System.

## Literature Review for Defense Acquisition System Governance

The literature for the Defense Acquisition System is substantial. A simple search of Google Scholar (April 2, 2017) identified over 3,400 citations for “defense acquisition system.” The detailed parsing of this literature is beyond the scope of this paper. However, we can engage a level of literature review to suit our purpose of this paper—*exploiting and extending recent developments in Complex System Governance (CSG) to advance the acquisition field.* To tailor the literature we have focused on three primary objectives (Figure 2) for the literature review, including (1) capture the literature of the Defense Acquisition System with respect to inclusion of the Systems Theory, Management Cybernetics, and System Governance fields; (2) examine the premier defense acquisition related journals for distribution of literature across a taxonomy of research and development areas; and (3) suggest preliminary literature review implications for CSG development in relationship to the Defense Acquisition System.

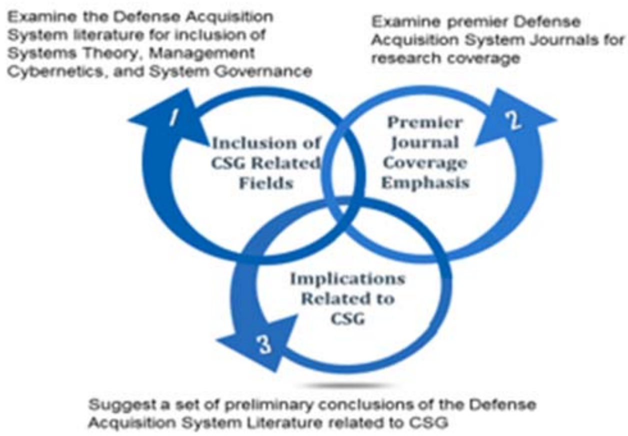


**Figure 2. Organization of the Literature Review**

### *CSG Related Field Coverage in the Defense Acquisition System Literature*

The three primary informing fields for CSG are found in Systems Theory (Adams et al., 2014; Whitney et al., 2016; von Bertlanffy, 1968), Management Cybernetics (Beer, 1972, 1979, 1985), and System Governance (Calida & Keating, 2014). Several predominant scholarly databases were reviewed for each of the CSG informing fields with respect to “defense acquisition system.” The results of the review of the CSG informing fields identified a scarcity in coverage in relationship to Defense System Acquisition. The results of this examination are summarized in Table 1.

Table 1. Coverage of CSG Related Field in the Defense Acquisition System Literature

| CSG Informing Field | Related Works for Defense Acquisition System | Synthesizing Themes |
|---|---|---|
| **Management Cybernetics** | Vore (1990) | Examined application of management cybernetics to work measurement for weapon systems acquisition. |
| **System Governance** | Berteau, and Ben-Ari (2014) | Focused on acquisition challenges of systems of systems and offers best practice themes, including level of organizational focus, decision-making authority, and enforcement. |
| **Systems Theory** | Magee and de Weck (2004) | Classification scheme for complex systems using Systems Theory |
| | Sheard and Mostashari (2010) | Examined the relationship of complexity to complex systems and systems engineering (including acquisition) |
| | Schwenn et al. (2015) | Systems Theory basis to better explain, model, and simulate the complexity in acquisition of systems |
| | Willette (2014) | Application of (complex) Systems Theory to understanding incongruities within aspects of defense acquisition |
| | Robey (2009) | Application of Systems Theory to better understand DoD Acquisition System |
| | Alexander (2007) | Applied Systems Theory to identify improvement areas in defense acquisition |
| | Walker (2014) | Basis of Systems Theory for requirements in support of defense acquisition |

From this preliminary review of literature for the Defense Acquisition System body of knowledge, we make three initial conclusions. First, the coverage of the three informing fields for CSG have not received significant levels of development. While we might conjecture as to the proximate cause of this scarcity, the fact remains that the coverage is minimal. Second, it appears that there is an opportunity to project relatively unexplored fields into the Defense Acquisition System dialog. The extension of CSG to the Defense Acquisition System might provide fruitful insights into developmental issues that continue to plague the field. Third, we must be cautious not to overextend these preliminary results. This is representative of an initial exploration of the vast literature for defense acquisition. Care must be taken not to amplify this "glimpse" as more than an invitation for further examination at this point. For example, there were other references to "governance" in acquisition literature (e.g., Rebovich, 2007; Gansler, Lucyshyn, & Rigilano, 2012). However, these articulations were tangential to the primary focus on the systemic nature of governance in relationship to the Defense Acquisition System.

### *Emphasis of Premier Journals for Defense Acquisition System Literature*

The literature for the Defense Acquisition System is immense. For the second phase of the literature review we examined three premier sources of literature supporting development of the acquisition field. The purpose of this exploration was to examine the distribution of articles across a spectrum of the acquisition body of knowledge, ranging from conceptual/theoretical to practical tools. This provided a gestalt view of the distribution of field development. The sources for this review included (1) the *Defense AT&L Magazine*, a publication of the Defense Acquisition University serving professionals in the acquisition community; (2) the *Defense Acquisition Research Journal,* a publication of the Defense Acquisition University targeted to development of a spectrum of topics targeted to the professional acquisition community of researchers and practitioners; and (3) the *Systems Engineering Journal*, a peer reviewed journal published by Wiley publishers under the auspices of the International Council on Systems Engineering (INCOSE). INCOSE is an organization dedicated to the advancement of systems engineering, of which acquisition is a central focus for the organization. Our approach was to fit the documents from a 10-year window (2006–2016) into a taxonomy (based on the description of the classification identified in Table 2).

**Table 2. Distribution of Literature Published (Focused During the 10-Year Period of 2006–2016, Total 151 Articles)**

| Area | Description for Classification | Defense AT&L Journal | Defense AR Journal | Systems Engineering Journal | TOTAL (number) | TOTAL (percent) |
|---|---|---|---|---|---|---|
| *Tools* | Implements used to support accomplishment of a specific task or purpose | 25 | 35 | 0 | 60 | 40 |
| *Methods* | Systematic approaches that are performed to achieve an objective | 15 | 25 | 3 | 43 | 29 |
| *Models* | Representations that capture attributes against which comparisons can be made | 7 | 15 | 4 | 26 | 17 |
| *Methodologies* | Generalized frameworks that guide applications for the field | 3 | 10 | 1 | 14 | 9 |
| *Conceptual Foundations* | The fundamental underlying philosophical, theoretical, and axiomatic (principles) basis for the field | 2 | 4 | 2 | 8 | 5 |

We used these results to establish an initial view of the distribution across a spectrum of focal areas contributing to the body of knowledge for acquisition. This classification provided a gestalt indicator of the emphasis for the field.

### *Implications of Literature Related to CSG for the Defense Acquisition System*

We are hesitant to draw absolute conclusions based on our preliminary review of literature. However, this analysis does suggest several indications that warrant further exploration in a more rigorous examination of the literature in the acquisition field. Among these we include the following:

1. The existence of Defense Acquisition System literature directly drawn from the underlying CSG informing fields (Systems Theory, Management Cybernetics, System Governance) is scarce. What is there is limited in depth related to the CSG fields. This is not unexpected and suggests that inclusion of these fields, and CSG which is drawn from them, might enhance the Defense Acquisition System literature.
2. There appears to be a heavy inclination toward the practice side of literature (tools, methods, models) as fully 127 articles (84%) fit into these categories. Without explanation as to why this skewed distribution exists, it does lend itself to a closer examination of the literature and proclivities of the community.
3. At the level of Methodologies and Conceptual Foundations there were 22 articles (approximately 15%). This result provides an interesting pivot point to provide a closer examination as to the degree that this relatively limited balance in acquisition field development might offer new insights.
4. These preliminary results ask many more questions than they answer. However, they do suggest some different paths of inquiry into further research based development of the Defense Acquisition field. For instance, can tools, methods, and models be more insightfully grounded in an underlying conceptual/theoretical base? Are there implications for acquisition tool/method development stemming from expanding conceptual foundations? And, do failures of tools/methods for acquisition programs suggest that underlying conceptual/theoretical foundations might be contributing to failures?

The initial results of this literature have served the purpose for this paper. The review provides sufficient motivation to pursue two further aims in establishing CSG research in relationship to Defense Acquisition System development. First, a deeper examination and more extensive/rigorous classification of literature is warranted based on initial results. Second, the scarcity of CSG and informing fields application to the acquisition field suggests an opportunity to expand the breadth and depth of the body of knowledge for the Defense Acquisition System. At this point of examination, it does not appear that CSG or its tenets have been a subject of investigation or application in Defense Acquisition System research/applications.

## A Systems Theory Based Paradigm and Model for Complex System Governance for Defense Acquisition

In this section we provide the basis for CSG with respect to defense acquisition. To provide this link, three primary themes will be developed. First, we provide the underlying source for CSG as stemming from the intersection of three fields, including *Systems Theory* (propositions that define behavior and explain performance of all complex systems), *Management Cybernetics* (the science of effective structural organization of systems), and *System Governance* (provision of direction, oversight, and accountability) for a system. Second, we introduce the paradigm for CSG. Our emphasis is to provide the high-level depiction of CSG such that the ensuing detailed development of CSG will have an intellectual grounding. Third, we introduce the CSG reference model. This model is explained in relationship to the underlying CSG paradigm and implications for extension to the Defense Acquisition System and field are suggested. We close this section with CSG implications for defense acquisition and a summary of the paradigm as it relates to defense acquisition.

In broad terms, DoD Directive 5000.01 (2007, p. 4) defines the *Defense Acquisition System* as "the management process by which the Department of Defense provides effective, affordable, and timely systems to the users." with the primary objective (DoD 5001.01, p. 3) being "to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price." At an abstract level, the ambitions of the acquisition system are certainly noble. However, as identified in the previous section, the Defense Acquisition System continues to be a source of challenge. While the precise cause-effect relationships generating difficulties in acquisition deployment are uncertain, the drive for reform, adjustment, and performance improvement in the system continue. Given the complexity in modern warfare systems, and the processes necessary to bring those systems to fruition, it is not likely that a single breakthrough will vanquish issues in the acquisition field. Instead, it is likely that there are numerous contributors to issues, and the resolution of acquisition field issues will require a continuing series of evolutionary changes. In pursuit of Defense Acquisition System improvement, we suggest that new thinking and approaches might provide an acceleration of advancement. CSG is proposed as a contribution to bring the Defense Acquisition System to a different level of understanding. This different level of understanding might provide for a corresponding different level of decision, action, and interpretation to guide evolution of the field in different directions.

As the basis for this different understanding of the Defense Acquisition System, CSG offers three important distinctions. First, CSG is built on an underlying foundation steeped in a strong conceptual grounding. The conceptual basis for CSG development and application is found in Systems Theory (Whitney et al., 2015), Management Cybernetics (Beer, 1979), and System Governance (Calida & Keating, 2014; see Figure 3).

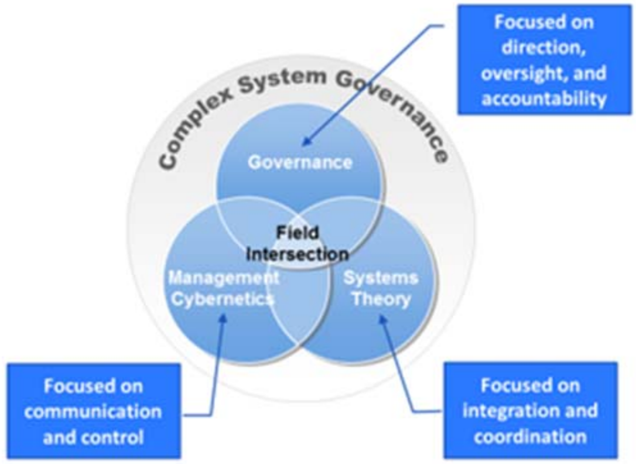


**Figure 3. CSG Draws Upon Governance, Systems Theory, and Management Cybernetics**

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. 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. System Governance is concerned with the provision of direction, oversight, and accountability for a system such that future performance and trajectory are ensured.

Governance and systems perspectives were chosen for very specific reasons versus the management and process terms used with respect to defense acquisition. First, the focus on governance permits a distinction to be made from the management perspective. Second invoking systems allows distinction from more limited process perspectives for acquisition. Table 3 is offered as an attempt to clarify distinctions across several attributes. This listing is not intended to provide absolutes, but rather to point out that (1) the Governance/System orientation operates at a different level than more traditional Management/Process focused thinking; (2) in actuality, the table provides bookends along a spectrum—the realities of any system might vary along that spectrum for each attribute; and (3) the shift in perspective for Governance/System introduces the opportunity to foster different thinking, decision, action, and interpretation possibilities.

Table 3. Attributes of a Governance/System Perspective Versus a Management/Process Perspective

| Attribute | Governance/System | Process/Management |
|---|---|---|
| *Execution* | Adaptability/Improvisation | Repeatability/Consistency |
| *Objective* | Long Range Effectiveness | Short Range Efficiency |
| *Time Horizon* | Longer/Strategic | Shorter/Operational |
| *Definition* | Malleable/Emergent/Evolving | Rigid/Absolute/Stable |
| *Change* | Global/Evolutionary/Chaotic | Local/Short term/Ordered |
| *Primary Emphasis* | Viability, Adaptation, | Cost, Schedule, Technical Performance |
| *Dominant Paradigm* | Holism/Antipositivism/Emergence | Reductionism/positivism/determinism |
| *Relationship Understanding* | Complexity/irreducible/synthesis | Cause-effect/reducible/decomposition |
| *Interpretation* | Subjective-negotiable | Objective-absolute |
| *Boundaries* | Ambiguous/Shifting | Defined/Stable |
| *Environment* | Amorphous | Coherent |
| *Behavior Preference* | Uncertain/Non-linear | Deterministic/Linear |
| *Risk Tolerance* | High (Acceptance) | Low (Avoidance) |
| *Representation Preference* | Interpretative (relationships/diagram/approximate) | Symbolic (mathematical/model/precision) |
| *Solution Goals* | Satisficing/feasible/desirable | Optimal/absolute/expected |
| *Rationality* | Anticipated irrationality (pluralism) | Expected rationality (unitary) |
| *Development* | Unique-Not Replicable-Methodology | Standardized-Replicable-Method |
| *Design Focus* | Sociotechnical/External/Strategic | Technical/Internal/Operational |
| *Engagement* | Power/Politics/Flexibility | Hierarchy/Apolitical/Repeatability |

We now shift attention to the underlying paradigm that defines the essence of the shift to CSG.

### *The CSG Paradigm Shift*

CSG is built upon an underlying paradigm intended to suggest a departure from more traditional reductionist thinking concerning the design, execution, and evolution of systems. In this sense, the paradigm construct is used intentionally to signal a shift in thinking. The CSG Paradigm is composed of three primary elements, including (1) the *Systems Philosophical, Theoretical, Conceptual* foundations which act to provide a stable theoretical/conceptual grounding for everything that follows; (2) *Metasystem Functions* which include nine essential functions, drawn from Management Cybernetics, that define what must be performed by any complex system to remain viable (continue to exist); and (3) *Implementing Mechanisms* that are specific to a particular system and define how it performs metasystem functions. Together, these three elements form the triad of CSG (Figure 4) and are invoked to produce governance. In turn this governance is responsible for the behavior/performance of a complex system and the degree to which a system continues to exist (i.e., remain viable). Continued viability will be determined by (1) the degree to which the design for CSG is capable of meeting the demands of the system environment; (2) the effectiveness of CSG execution consistent with the design; and (3) the ability of the system to evolve in response to the nature and pace of perturbations emanating from internal system flux and external environmental turbulence.

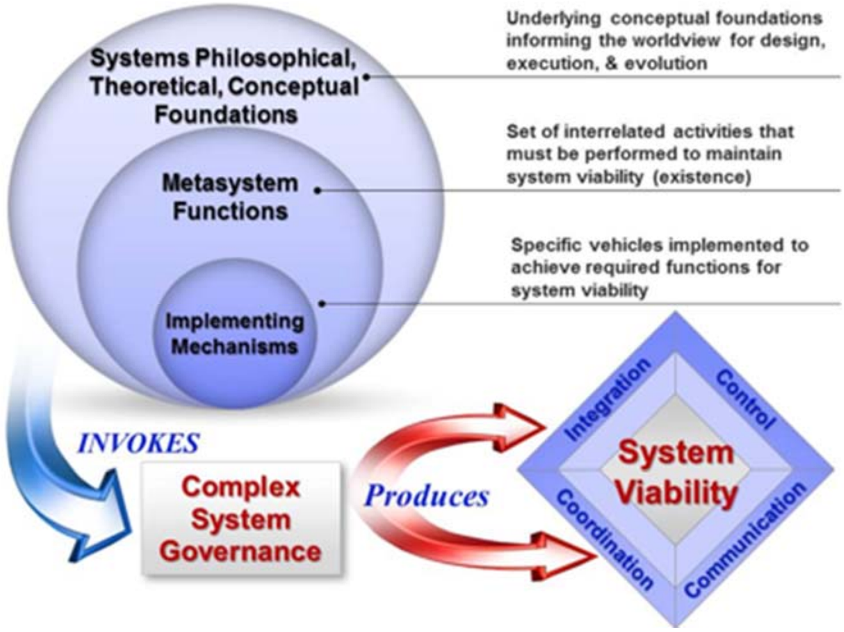


**Figure 4. The CSG Paradigm**

The high level CSG paradigm can be stated succinctly through the definition as "design, execution, and evolution of the metasystem functions necessary to provide control, communication, coordination, and integration of a complex system" (Keating et al., 2015, p. 274). A further elaboration of the terms in the definition provides insight into the nature of CSG:

- **Design:** purposeful and deliberate arrangement of the governance system to achieve desirable system performance and behavior.
- **Execution:** performance of the system design within the unique system context, subject to emergent conditions stemming from interactions within the system and between the system and its environment.
- **Evolution:** the change of the governance system in response to internal and external perturbations as well as revisions to system trajectory.
- **Metasystem:** the set of nine interrelated functions that provide for governance of a complex system.
- **Control:** invoking the minimal constraints necessary to ensure desirable levels of performance and maintenance of system trajectory, in the midst of internally or externally generated perturbations of the system.
- **Communication:** 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.
- **Coordination:** providing for interactions (relationships) between constituent entities within the system, and between the system and external entities, such that unnecessary instabilities are avoided.
- **Integration:** continuous maintenance of system integrity. This requires a dynamic balance between autonomy of constituent entities and the interdependence of those entities to form a coherent whole. This

interdependence produces the system identity (uniqueness) that exists beyond the identities of the individual constituents.

- **Complex system:** a set of bounded interdependent entities forming a whole in pursuit of a common purpose to produce value beyond that which individual entities are capable.

It is important to note that all systems must perform the metasystem functions at a minimal level to maintain viability. However, viability is not a guarantee of performance excellence. On the contrary, viability simply assures is that the system continues to exist. There are degrees of viability, the minimal of which is existence. *Implementing Mechanisms* are the specific vehicles (e.g., processes, procedures, activities, practices, plans, artifacts, values/beliefs, customs, mores) that implement metasystem governance functions for a system. These mechanisms are not a general set of mechanisms, but rather exist as unique to a specific system to define how a specific system performs the functions. CSG mechanisms may be explicit/tacit, formal/informal, routine/non-routine, effective/ineffective, or rational/irrational. However, all mechanisms can be articulated in relationship to the metasystem governance functions which they support.

The essence of this paradigm can be used to guide thinking about CSG for acquisition. We now shift attention to the CSG Reference Model. This model is consistent with the CSG paradigm shift and provides a detailed description for application.

### *The Complex System Governance Reference Model*

Central to CSG is a reference model that depicts the central elements of CSG and their interrelationships (Figure 5). A brief depiction of the nature and role of the CSG functions (identified as Metasystem functions) has been previously developed in several publications (Keating et al., 2015; Keating et al., 2016; Bradley et al., 2016).

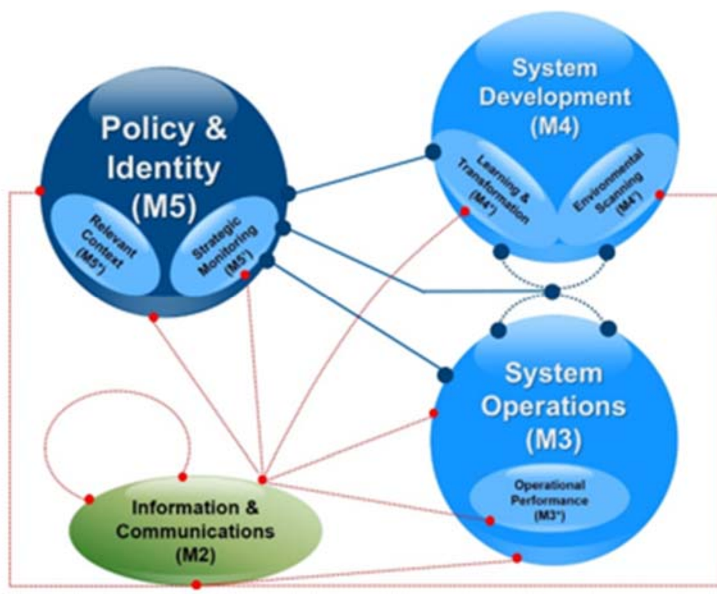


**Figure 5. The CSG Reference Model**

We summarize the nine critical functions performed by a complex system to maintain viability (continued existence):

- *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. For example, M5 would be concerned with the generation and propagation of consistency of purpose for a particular acquisition program.
- *Metasystem Five Star (M5*)—System Context*—focused on the specific context within which the metasystem is embedded. Context is taken as the circumstances, factors, conditions, trends, or patterns that constrain and enable the execution of a system. For example, the particular political dynamics in play for an acquisition program would be an element of consideration for context.
- *Metasystem Five Prime (M5')—Strategic System Monitoring*—focused on oversight of the system at a strategic level. This monitoring is essential to ensure that the trajectory of the system is consistent with the desirable future state. For example, stability of future program resources essential to maintain system development would be a possible area for strategic monitoring.
- *Metasystem Four (M4)—System Development*—focusing on the long-range development of the system to ensure future viability. This function ensures that the current and future models of the system are examined to ensure consistency with trajectory and expectations for system development. For example, this function would identify inconsistencies between existing capabilities in the program (system) and those required for realization of the future capabilities required to ensure integrity of the program (system).
- *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. For example, execution of design reviews targeting errors in material procurement.
- *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. For example, the early identification of new regulatory requirements.
- *Metasystem Three (M3)—System Operations*—focused on the day to day operations of the metasystem to ensure that the system maintains performance levels. For instance, responding to schedule shifts to compensate for supplier shifts in material availability.
- *Metasystem Three Star (M3*)—Operational* Performance—focused on monitoring system performance to identify and assess aberrant or emergent conditions in the system. For example, conducting audits of resource utilization.
- *Metasystem Two (M2)—Information and Communications*—focused on the design for flow of information and consistent interpretation of exchanges (communication channels). For instance, providing forums for dissemination of information for access throughout the system.

Ultimately, effectiveness in purposeful design, execution, and evolution of the nine metasystem governance functions, via implementing mechanisms, determines system performance, including acquisition systems. We now examine the essence of CSG for defense acquisition.

### *Essence of CSG for Defense Acquisition*

Although the underlying theory, concepts, and execution of CSG are challenging, the essence of CSG related to defense acquisition is not difficult to gasp. The essence of CSG for acquisition might be captured in the following paragraph and elaborated in the four points that follow:

> Subject to fundamental system laws, all systems engaged in acquisition (programs, projects, entities, agencies, etc.) perform essential governance functions. System performance is determined by effectiveness in achievement of nine governance functions consistent with system laws. Violation of system laws degrades system performance. System performance can be enhanced through purposeful development of governance functions and their implementing mechanisms.

1. ***All systems are subject to the laws of systems***. Just as there are laws governing the nature of matter and energy (e.g., physics law of gravity), so too are our systems subject to laws found in Systems Theory and Management Cybernetics. These system laws are always there, non-negotiable, non-biased, and explain system performance. The implication for *acquisition practice is understanding system performance in relationship to underlying systems laws*.
2. ***All systems perform essential governance functions that determine system performance.*** Nine system governance functions are performed by all systems, regardless of sector, size, or purpose. These functions define what must be achieved for governance of a system. Every system invokes a set of unique implementing mechanisms (means of achieving governance functions) that determine how governance functions are accomplished. Mechanisms can be formal-informal, tacit-explicit, routine-sporadic, or limited-comprehensive in nature. CSG produces system performance which is a function of previously discussed communication, control, integration, and coordination. *Acquisition practitioners must ask*, "*Do we understand how our system performs essential governance functions to produce performance?"*
3. ***Violations of systems laws in performance of governance functions carry consequences***. Irrespective of noble intentions, ignorance, or willful disregard, violation of system laws carries real consequences for system performance. In the best case, violations degrade performance. In the worst case, violations can escalate to cause catastrophic consequences or even eventual system collapse. *Acquisition practitioners must ask*, *"Do we understand problematic system performance in terms of violations of fundamental systems laws?"*
4. ***System performance can be enhanced through purposeful development of governance functions.*** When system performance outputs fail to meet expectations (e.g., cost, schedule, technical performance), deficiencies in governance functions can offer novel insights into the deeper systemic sources of failure. Performance issues can be traced to governance function issues as well as violations of underlying system laws. Thus, system development can proceed in a more informed and purposeful mode. *Acquisition practitioners must ask, "How might problematic performance be explained as stemming from deeper system governance issues and violations of system laws, suggesting different development directions?"*

We now shift our attention to exploration of pathologies that are representative of violations of systems laws in performance of CSG functions.

## System Pathologies in the Complex System Governance for Acquisition

At a basic level, a system pathology has been described as a "circumstance, condition, factor, or pattern that acts to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectation is reduced" (Keating & Katina, 2012, p. 253). The basis for pathologies in systems, including the acquisition system, stems from Systems Theory (the set of principles, laws, and concepts that explain behavior and performance of systems) and Management Cybernetics (focused on the structure that serves to produce system organization). Stemming from the work of Katina (2015, 2016) and Keating and Katina (2012) a set of 53 system pathologies has emerged. While each of these pathologies is mapped to the underlying systems law(s) in violation, that mapping is beyond the scope of this paper. However, in this section we present the current state of set of pathologies and project their implications for the Defense Acquisition System. We close the section with the implications that further development of pathologies can hold for improving the acquisition system.

**Table 4. Metasystem Pathologies With Acquisition System Applicability**

| *Metasystem function* | *Corresponding Set of Pathologies* | *Acquisition System Applicability* |
|---|---|---|
| Metasystem Five (M5): Policy and Identity | M5.1. Identity of system is ambiguous and does not effectively generate consistency system decision, action, and interpretation. | Identity clarity is essential to increase the likelihood of consistency in establishment of priorities and tradeoffs. For example, given cuts in scarce resources, the tradeoffs among cost, schedule, and technical performance should be informed by a consistent and stable reference frame (identity). |
| | M5.2. System vision, purpose, mission, or values remain unarticulated, or articulated but not embedded in the execution of the system. | Consistency in program tradeoffs occurring throughout the acquisition system are dependent on the congruence of thinking, decisions, and interpretations held by the entity. |
| | M5.3. Balance between short-term operational focus and long-term strategic focus is unexplored. | Every program has a tension between long- and short-term objectives. The explicit definition and resolution of this tension over the acquisition process is essential to avoid unnecessary crises and conflicts. |
| | M5.4. Strategic focus lacks sufficient clarity to direct consistent system development. | Purposeful direction for strategic development of an acquisition program/entity should be by design, explicit, measurable, and dynamic—not a haphazard endeavor in response to crises. |
| | M5.5. System identity is not routinely assessed, maintained, or questioned for continuing ability to guide consistency in system decision and action. | Every acquisition entity has an identity that marks its uniqueness. Purposeful articulation and development left to chance misses the opportunity to exploit this advantage in dealing with complexity. |
| | M5.6. External system projection is not effectively performed. | Providing clarity in communication and messaging to external entities can help preclude expectation mismatches. |
| Metasystem Five Star (M5*): System Context | M5*.1. Incompatible metasystem context constraining system performance. | Potential incompatibilities between a program design and execution with the context within which it is embedded invites system degradation. |
| | M5*.2. Lack of articulation and representation of metasystem context. | Lacking an explicit mapping of contextual influences misses opportunities to influence impacts or preclude disruptions stemming from context. |
| | M5*.3. Lack of consideration of context in metasystem decisions and actions. | Performance impacts of contextual factors should be part of program planning and execution. |
| Metasystem Five Prime (M5'): Strategic System Monitoring | M5'.1. Lack of strategic system monitoring. | Strategic system performance indicators should be monitored to identify emergent variability. |
| | M5'.2. Inadequate processing of strategic monitoring results. | Program/system development should be in direct response to identified strategic variabilities. |

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|---|---|---|
| | M5'.3. Lack of strategic system performance indicators. | Strategic system performance indicators, beyond cost, schedule, and technical performance should exist to guide strategic execution. |
| Metasystem Four (M4): System Development | M4.1. Lack of forums to foster system development and transformation. | Beyond day-to-day execution, strategic development activities should be engaged for long range, strategic system evolution. |
| | M4.2. Inadequate interpretation and processing of results of environmental scanning—non-existent, sporadic, limited. | Results of active scanning for potential system perturbations should be routinely processed and responses formulated. |
| | M4.3. Ineffective processing and dissemination of environmental scanning results. | Scanning results should be disseminated to the point where responsive decision/action can be implemented. |
| | M4.4. Long-range strategic development is sacrificed for management of day-to-day operations—limited time devoted to strategic analysis. | Appropriate balance in emphasis between present and future is essential to ensure that both short-term and long-term viability are maintained. This balance may dynamically shift over time for the program and/or changing circumstances. |
| | M4.5. Strategic planning/thinking focuses on operational level planning and improvement. | Programs that are consumed with day to day existence sacrifice long-term viability and precluding avoidable future crises. |
| Metasystem Four Star (M4*): Learning and Transformation | M4*.1. Limited learning achieved related to environmental shifts. | Without a continuous and explicit learning system in place, opportunities for system development can be missed. |
| | M4*.2. Integrated strategic transformation not conducted, limited, or ineffective. | Long-range viability of a program/system should be by active comprehensive design, not left to chance. |
| | M4*.3. Lack of design for system learning—informal, non-existent, or ineffective. | Vehicles to invoke continuous detection and correction of design, execution, and development issues should be in place. |
| | M4*.4. Absence of system representative models—present and future. | Programs/systems should have a dynamic mapping showing how value is produced, for both the current and future anticipated system. |
| Metasystem Four Prime (M4'): Environmental Scanning | M4'.1. Lack of effective scanning mechanisms. | Environmental scanning mechanisms should be comprehensive, focused, and integrated. |
| | M4'.2. Inappropriate targeting/undirected environmental scanning. | Program/system environmental scanning should be by purposeful design. |
| | M4'.3. Scanning frequency not appropriate for rate of environmental shifts. | Timing of environmental scanning should be appropriate and shift over the life cycle of a program. |
| | M4'.4. System lacks enough control over variety generated by the environment. | Filtering of environment noise and amplification of the program to the environment (e.g. external stakeholders) should be instituted by design. |
| | M4'.5. Lack of current model of system environment. | Programs/systems should have a dynamic explicit mapping of the environment. |
| Metasystem Three (M3): System Operations | M3.1. Imbalance between autonomy of productive elements and integration of whole system. | Constituent systems/entities should be given the maximum autonomy possible without degrading program/system performance. |
| | M3.2. Shifts in resources without corresponding shifts in accountability/shifts in accountability without corresponding shifts in resources. | For every shift in resources provided for a program/system, there should be a corresponding negotiated adjustment in expectations. |
| | M3.3. Mismatch between resource and productivity expectations. | Alignment between expectations for program value production and resources allocated for that production should be congruent. |
| | M3.4. Lack of clarity for responsibility, expectations, and accountability for performance. | Roles for system design, execution, and development should provide clarity of assignment and eliminate unnecessary redundancy. |
| | M3.5. Operational planning frequently pre-empted by emergent crises. | Crises must be understood in relation to underlying issues in system design, execution, or development. |
| | M3.6. Inappropriate balance between short-term operational versus long-term strategic focus. | Continual sacrifice of system long-term development can degrade near-term performance or sacrifice long-term viability. |
| | M3.7. Lack of clarity of operational direction for productive entities (i.e. subsystems). | Program/system entities producing core value should be given clear, concise, and timely direction for expectations as to what must be accomplished. |

| | | |
|---|---|---|
| | M3.8. Difficulty in managing integration of system productive entities (i.e. subsystems). | Constituent entities of a program/system must be provided clear direction on limits for autonomy and expectations for integration into the program. |
| | M3.9. Slow to anticipate, identify, and respond to environmental shifts. | Robust processes must mount timely, resilient, and effective responses across a spectrum of environmental perturbations. |
| Metasystem Three Star (M3*): Operational Performance | M3*.1. Limited accessibility to data necessary to monitor performance. | Actionable data on performance of operation design and execution must be available. |
| | M3*.2. System-level operational performance indicators are absent, limited, or ineffective. | Program/system performance indicators, in addition to cost, schedule, and technical performance should exist to provide a holistic performance picture. |
| | M3*.3. Absence of monitoring for system and subsystem level performance. | Monitoring performance must be accomplished for variances in operational trajectory and expectations. |
| | M3*.4. Lack of analysis for performance variability or emergent deviations from expected performance levels or the meaning of deviations. | Programs/systems should have analysis methods in place to systemically examine sources of performance variation to derive interpretations and support informed responses. |
| | M3*.5. Performance auditing is non-existent, limited in nature, or restricted mainly to troubleshooting emergent issues. | Non-pejorative internal auditing of performance should be conducted routinely within the program/system to determine consistency in design and execution of the program/system. |
| | M3*.6. Periodic examination of system performance largely unorganized and informal in nature. | Examination of system performance across operational design and execution should be efficient with minimal disruption. |
| | M3*.7. Limited system learning based on performance assessments. | Results of performance assessment should be interpreted and actionable across system design, execution, and development aspects of the system. |
| Metasystem Two (M2): Information and Communications | M2.1. Unresolved coordination issues within the system. | Program/system entities should not continue to experience identified coordination issues. |
| | M2.2. Excess redundancies in system resulting in inconsistency and inefficient utilization of resources—including information. | Existence of potentially unnecessary redundancies within the program/system should be continually questioned and identified for elimination when necessary. |
| | M2.3. System integration issues stemming from excessive entity isolation or fragmentation. | Isolation/fragmentation of entities attributable to inadequacies in system design, execution, or development should be targeted for elimination. |
| | M2.4. System conflict stemming from unilateral decisions and actions. | Conflicts stemming from decision/action execution should be mapped to identify system design/execution/development inconsistencies. |
| | M2.5. Excessive level of emergent crises associated with information transmission, communication, and coordination within the system. | Crises should be examined for design and execution issues in communications and implications for system development. |
| | M2.6. Weak or ineffective communications systems among system entities (i.e. subsystems). | Communications within the program/system should be explicitly designed and execution monitored to identify performance or development issues. |
| | M2.7. Lack of standardized methods (i.e. procedures, tools, and techniques) for routine system level activities. | Expectations for design, execution, and development of standardized methods within the system should be clear. |
| | M2.8. Overutilization of standardized methods (i.e. procedures, tools, and techniques) where they should be customized. | Programs/systems should understand their unique needs and question application of standardized approach compatibility and necessity. |
| | M2.9. Overly ad-hoc system coordination versus purposeful design. | Program/system design should preclude repetitive coordination conflicts. |
| | M2.10. Difficulty in accomplishing cross-system functions requiring integration or standardization. | Interfaces between program/system entities should enhance rather than detract from cross-functional activities. |
| | M2.11. Introduction of uncoordinated system changes resulting in excessive oscillation. | Changes in programs/systems should be integrated by design with minimal disruption to ongoing operations or system development. |

There are four primary conclusions with respect to pathologies identified for CSG functions and their implications for the Defense Acquisition System. First, these pathologies are not unique to any given acquisition entity (program, project, agency). 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 necessary to maintain viability for complex systems, including acquisition systems. Thus, the 53 pathologies (Table 4) can act to limit system performance, or lessen system viability, such that the likelihood of a system achieving performance expectations is reduced. This is particularly critical in acquisition systems that must function in conditions of increasing complexity. Second, these pathologies do not exist in a binary fashion of "present" or "not present." Rather, they may be experienced in "degrees of existence" along a continuum ranging from minimal to significant. This opens the possibility of pathologies having not only a degree related to their existence, but also the potential system degradation that may be experienced stemming from that level of existence. Third, the existence of a pathology has real consequences for performance of a given acquisition system—measured in terms of a range of possible effects. These effects may not be easily derived from the observable (e.g., crisis) surface manifestations resulting from the underlying pathology. As each acquisition system is unique, so too will be the associated pathologies that become apparent as the system operates. The pathologies will not be static over the life cycle for a given program/system. Thus, the impact of a pathology may lessen or exacerbate over time as the acquisition system is executed. Fourth, based on prior research, these pathologies should be a subject of exploration during problem/program formulation, since bringing change to the system is largely dependent on understanding the current state of the system (Dery, 1984; Katina, 2015; Quade, 1980). We suggest that in the formative stages of acquisition system exploration, knowledge of pathologies and their assessment can play a vital role in targeted system design and subsequent development. They can serve in both the design of new acquisition programs/systems or evaluation of programs/systems currently underway.

## Conclusions and Implications

CSG is a systems based field in the embryonic stages of development. The contribution of CSG to the Defense Acquisition System is targeted to enable practitioners to better deal with issues stemming from the problems associated with increasing complexity in the systems and environment they face. In essence, CSG purposefully addresses system drift. System drift denotes systems/programs that, irrespective of the best intentions, have either never been purposefully designed or whose execution continually fails to meet desired performance expectations. In short, these drifting systems/programs fail to deliver anticipated value, much less produce high performance. We do not need to look far to see examples of drifting systems/programs related to defense acquisition. Consider the following examples (Table 5) and the suggestion of how the CSG perspective might view the program failures (Bradley, Katina, & Keating, 2016). While CSG provides a set of lenses from which to view program deficiencies, CSG pathologies provides a deeper examination of the deep systems sources of program failure or degradation in relationship to system functions necessary for CSG. We cannot provide assurance that CSG and discovery of pathologies in these efforts would have precluded failure. However, CSG pathologies provide a different perspective and set of insights. This might direct acquisition professionals to early identification of sources of system errors with sufficiently early identification to provide correction prior to program/system collapse.

Table 5. Analysis of Troubled Programs Through the Lens of CSG

| DOD program/ Report Source | Problem/failure appear to be governance related? | Does the language in the report indicate a similar meaning for governance as the Complex System Governance? | Is there any concrete indication that CSG would have helped this program? |
|---|---|---|---|
| ***Zumwalt Class Destroyers (DDG1000) GAO-08-904*** | Yes | No, model/framework of governance (Milestone C suggested) won't help with alignment of perspectives or understanding decisions and actions (communication channel dialog) among others | Yes—this initiative seems to lack clear vision/strategy. Report suggests that channels of communication are weak (p. 45 for example) |
| ***Ford Class Aircraft Carrier (CVN78) GAO-16-847*** | Yes | Yes, the report seems to identify many governance issues that can be mapped to metasystem functions within the CSG Reference Model | Yes—contextual assessment to evaluate acquisition culture. The ship is already built though, so now the asset needs to be protected and maintained. |
| ***Total Asset Visibility (Air Force) GAO-08-866*** | Yes | Yes, especially the "transformation plans" demonstrating initiative to evolve meta-systemic functioning | Yes—systems thinking likely not present in development; poor coordination of unsuccessful program |
| ***Major Automated Information Systems (MAIS) GAO-12-629*** | Yes | Yes, GAO seems to have an idea of the metasystem governance expected of a complex system, as well as realistic expectations regarding scope | Yes—some metasystem functions are clearly missing or inadequate, ex. poor coordination and communication (GAO, 2012, pp. 57–58) |
| ***National Security Cutter (Coast Guard/Navy) GAO-16-148*** | Yes | Yes, report seems to capture design/execution elements necessary for control/communication/coordination/integration (but possibly not sufficient?) | Yes—CSG embraces varying perspectives—the CG and Navy did not seem prepared to align perspectives and have poor communications |

Further research and development directions for CSG in relationship to research in acquisition is envisioned in the application of the research and development model provided in Figure 6. This model suggests a close coupling of four primary elements to holistically engage CSG development and deployment to improve practices in the acquisition field. In a nutshell, we summarize this as *The system-science based engineering of technologies to support application development that advances practices related to design, execution, and development of complex systems*. These four elements include the following:

1. *System Science Based*. System science is a broad area that includes multiple different fields that explore the phenomena associated with explaining the behavior and performance of systems. For our purposes, we suggest that system science provides the conceptual underpinnings for all derivative developments (e.g., technologies, methods, tools) based on application of the science. For CSG, the systems science basis is found primarily in Systems Theory and Management Cybernetics.
2. *Engineering of Technologies*. Based upon the underlying systems science, engineering involves the development of implementing technologies. These technologies are developed as CSG supporting artifacts (e.g., tools, techniques, software), grounded in systems science and addressing a targeted aspect of design, execution, or development of complex systems.
3. *Application Development*. Application is focused on development of the particular methods and methodologies that bridge the divide between the engineering of technologies and preparation for deployment in practice. The application emphasis is the appropriate preparation of technologies respective of their qualification for deployment for particular purposes,

integration with other technologies and methods/methodologies, and providing for effective deployment within operational/practice contexts.

4. *Practice*. Ultimately the beneficiary of the systems science, engineering, and application triad is the practice field where deployment is targeted. This is where the different technologies, as deployed through application design, are targeted to enhance practices related to better design, execution, and development of complex systems and their problems.

A central and critical aspect of this framework is the close coupling of science, engineering, application, and practice. Each of the elements in this framework are interrelated. This suggests that their execution is not mutually exclusive or independent of one another. On the contrary, the breakthroughs in CSG for acquisition are seen as four interconnected elements operating to inform, and be informed by, the other elements. We postulate that this interdependent coupling will moderate the trajectory of each of the constituent elements in ways not accessible with their independent development.

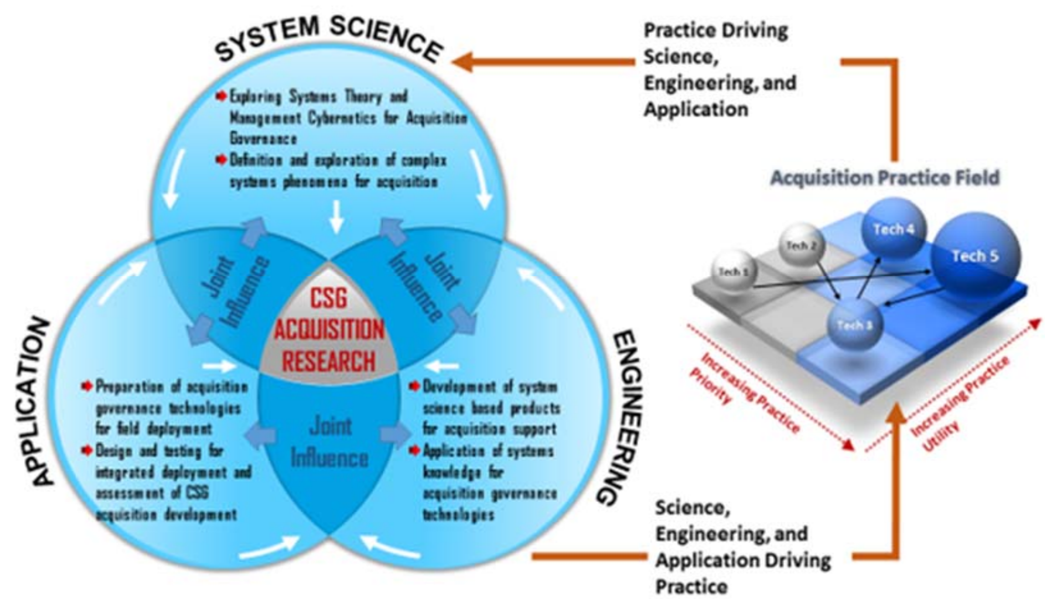


**Figure 6. The CSG Research and Development Framework**

Further development of CSG pathologies for acquisition systems is focused on four critical challenges:

1. *Maintenance of grounding in Systems Science*. There is a propensity in the professions (e.g., acquisition) to be pragmatic and practitioner focused. While this is expected from a practitioner's perspective, development of the CSG field will be enhanced by the appreciation and grounding of advancements in the underlying theoretical and conceptual basis. Further development of pathologies must remain grounded in the Systems Science base if the ultimate utility of this area is to be achieved.
2. *Engineering of technologies to support practical applications of CSG.* Technologies are the byproduct of engineering to address problems or fulfill needs in ways that advance practical purposes. Engineering of CSG technologies (tools, techniques, artefacts) is critical to help link the theoretical/conceptual science-based formulations of CSG in preparation for

deployment. CSG technologies should advance practical aspects of deployment for practitioners and also be appreciative to their fit within the larger landscape of the emerging CSG field for application to acquisition.

3. *Design for application and deployment of technologies*. CSG technologies are not intended for direct deployment to acquisition practice settings. Instead, emphasis must be placed on effectively bridging between technologies and their deployment. This bridge exists as the design for application. The design for application must take into account the wider perspective of the problem/need, the context, qualifying assumptions, and so forth. The building of applications of CSG from this perspective is essential to enhance the appropriate qualification of technologies to unique acquisition practice circumstances. 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.
4. *Case demonstration of deployable applications*. Advancing CSG for acquisition cannot be achieved separate from the world of practice. The determination of application utility for practice can only be established from deployment in practice. The pragmatic focus of the acquisition field necessitates the development of practice enabling tools, techniques, and technologies. CSG must emphasize producing these tools to aid practitioners in the acquisition field.

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. Further development of 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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