Editorial

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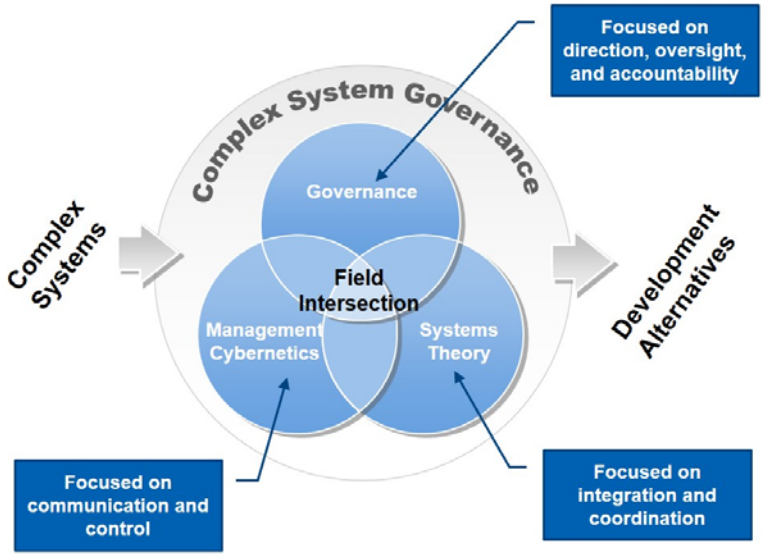
1 Introduction

Complex system governance (CSG) is an emerging field. At a high level, CSG is focused on improving the theory and practice of more effectively 'taming' modern complex systems and their problems. CSG draws upon and exists at the intersection of three primary fields, including systems theory, management cybernetics, and system governance (Figure 1). *Systems theory* provides a strong intellectual foundation focused on effective integration and coordination of disparate elements into a coherent whole. This coherent whole must 'obey' the axioms and corresponding propositions of systems theory that govern behaviour of systems or suffer the consequences related to deviations. *Management cybernetics* brings an emphasis on communication and control essential to provide the continuing existence (viability) of a system as it deals with the inevitable internal flux and environmental turbulence endemic to modern complex systems. Consistent with management cybernetics, CSG must appreciate and respond to the constant change in the context and environment for a governed system or system of systems. Thus, while governance necessarily takes a long view to provide long range stability it must also monitor and acknowledge the potential impact of near term fluctuations on system viability. Finally, *governance* provides an emphasis on direction, oversight, and accountability for the execution and development of a system. While each of the three fields underpinning CSG have made substantial contributions to the state of human affairs, they have not been brought together in meaningful ways that takes advantage of their intersection (Figure 1) to produce a novel alternative to complex system development.

Figure 1 CSG as an intersection of three fields for developing complex systems (see online version for colours)



CSG has been previously defined as the *design*, *execution*, and *evolution of the metasystem functions necessary to provide control*, *communication*, *coordination*, and *integration of a complex system* (Keating et al., 2014). Rather than provide a rehash of the CSG field which has already been articulated in depth in other venues (Keating et al., 2014; Keating and Bradley, 2015; Keating and Katina, 2015), we instead offer several summary points of emphasis and distinction to present the CSG field:

- CSG is *holistic* and considers design, execution, and evolution across the spectrum of technology, human, social, organisational, managerial, policy, information, and political dimensions of modern complex systems. Consistent with this perspective is a concentration on ensuring that the governance of a system is targeted correctly to the purpose, problem, or need that the system is intended to address. In a sense, this is avoiding Mitroff's (1998) Type III error, or solving the wrong problem precisely.
- At a most basic level, CSG is concerned with performance of functions that provide control (installation of the minimal specification necessary to achieve desirable system performance while providing the greatest degree of autonomy to system constituents), *communications* (exchange of information such that consistent decision, action, and interpretation are supported), *coordination* (provision of sufficient standardisation among system constituents such that unnecessary oscillations are avoided), and *integration* (function of the system as a 'unity' to produce capabilities, behaviour, and performance beyond that of individual constituents).

- CSG is built around performance of the set of nine metasystem functions, including: *policy and identity*, *system context*, *strategic system monitoring*, *system development*, *learning and transformation*, *environmental scanning*, *system operations*, *operational performance*, *and information and communications*. The metasystem functions are achieved through implementation mechanisms (artefacts that enable performance of functions) that operate within the parameters of systems theory axioms and propositions. Inconsistency in application of systems theory or violations of its tenets (axioms/propositions) represent CSG pathologies that act to inhibit or degrade system performance.
- The CSG mechanisms to perform metasystem functions are unique to the particular system and context within which the system exists. The completeness and performance of the set of mechanisms (e.g., strategic development procedure) determines the level of system performance.
- Effective execution of CSG permits a system to maintain performance in the midst of internal flux and external (environmental) turbulence. CSG assumes inherent instabilities, complexity, and emergence. This requires a sufficiently robust design to compensate such that performance is maintained and system viability (continued existence) is assured.
- Design for CSG permits the 'active matching' of the infinite variety (measure of complexity) that is generated by both internal (system flux) and external (environment turbulence) to the system. Left without compensating design (e.g., CSG), this variety has the capacity to destabilise the system and inhibit a systems ability to meet performance expectations.
- All complex systems that continue to exist perform the nine metasystem governance functions mentioned above. The degree of performance of a complex system is determined by the efficacy of the governance functions.
- CSG development is not a 'one time' or 'sporadic' event. CSG development is a continuous process that purposefully advances the maturity of CSG and effectiveness of its execution. CSG development operates at the individual, entity, and system levels.
- CSG development is not an 'all or nothing' proposition. There are benefits that can accrue from different levels of CSG engagement, ranging from enhancement of individual practitioner effectiveness through organisational system performance.

This concise overview provides a rudimentary backdrop that captures the essence of the CSG field.

This special issue is a concentrated effort to further explore the emerging CSG field. In this introductory editorial to the special issue, we have focused on three primary objectives:

1 provide an integrative look at the current state of development of the CSG field

2 examine the contributions and interrelationship of articles in this special issue

3 suggest a set of challenges and future directions to accelerate CSG field development.

Following our introductory remarks concerning the nature of the CSG field, our first objective is undertaken to examine the current state of the CSG field. This examination establishes a reference context for the articles that comprise this special issue. In particular, the interconnection and particular contribution of the collected articles to the CSG field is established. The second objective is focused on placement of the contributions of the articles in this special issue within the field. We make particular note of not only the specific contributions of each paper, but also on the interrelationship of their topics to one another as well as placement in the CSG field. For the third objective, we elaborate the challenges facing the CSG field. A path forward is suggested for the further development of the field. The emphasis of this path forward suggests how the field might develop in ways that will preclude a 'faddish' inculcation into the world of the practitioner, which would assure a premature departure of the field. Finally, this introduction to the special issue suggests several considerations concerning the development, limitations, and potential for the emerging CSG field as it continues a rapid progression.

In one sense, the announcement of an emerging field is rather bold, or naïve, depending on the point of view taken. Bold perhaps in the thought that given the plethora of existing methods, tools, and techniques in existence to aid in addressing complex systems and their problems that CSG can stand out. Can CSG contribute as a new, novel, and a substantial departure from what is already available to practitioners? In contrast, perhaps pursuit of CSG might be considered as naïve in seeking to impact the status quo trajectory of the problematic state of our capacity to deal with modern complex systems. Can the integration and synthesis of three fields serve to inform a new set of conceptually grounded methodologies, methods, and developing tools? Can CSG truly emerge to enhance capabilities to deal effectively with modern complex systems and problems? These are vexing questions that should provide reservations to undertaking CSG field development.

Notwithstanding reservations to CSG field development, three considerations suggest that the risk of pushing this advance is a worthy endeavour. First, it is apparent that what we are currently doing to address complex system development is not working. In fact, the problem domain continues to accelerate, deteriorate, and resist our most noble attempts at amelioration. Second, in response to this problem domain, our complex systems appear as out of sync 'monoliths' incapable of effectively responding to the internal flux and external turbulence that are the 'new normal'. Third, rather than continue to push responses that have failed to deliver on promises of performance improvement, the time is ripe for new, innovative, and substantially different thinking and corresponding actionable artefacts. We are not so intellectually arrogant to suggest that there have not been substantially effective approaches to dealing with complex systems and their problems. However, while CSG is not suggested as a panacea to render all other fields and approaches innocuous, it is being positioned as an alternative way of thinking, addressing, and understanding the system generated 'messes' (Ackoff, 1974) and 'wicked problems' (Rittel and Webber, 1973) suggested as endemic to modern complex systems.

In the following section, we set the basis for the current explorations in CSG field development by examining the current state and stage of development for the field.

2 The current state and challenges for emerging CSG field

CSG is certainly a field that can be considered to be in the infancy of development. A quick search to see the recognition of this field shows the paucity of literature for 'CSG' – about a dozen or so articles referenced from a simple literature search. This is particularly interesting considering the wealth of literature that exist in the constituent fields CSG tries to synthesise (systems theory, management cybernetics, and governance). In pondering a response to the question of 'why is there such a scarcity of literature that examines *CSG*?' we are left without a definitive answer. We suggest that, among several plausible explanations, there are five that might provide insight and offer caution as well as encouragement as the CSG field development progresses.

1 *Difficulty finding compatibility of worldviews for constituent fields* – This difficulty follows from the notion that worldview is the system of values and beliefs that allow us to process events, observations, and new experiences such that 'appropriate' meaning can be accorded. 'Growing up' with the predominant worldview that is informed from a primary field colours the way in which we see the world. The corresponding language and interpretative schemas that allow coherence of interpretation lie at the essence of a field. Thus, while there may be overlap between fields (e.g., systems theory and management cybernetics), there is also a set of underlying distinctions that may produce compatibilities as well as incompatibilities based on the differences in the underlying worldviews. The discovery and resolution of these field compatibilities and incompatibilities may enable or constrain the utility found at their intersection. By extension, compatibility of worldviews also extends to individual practitioners engaging CSG. Acceptance of differences and active exploration as to the source and implications for those differences is a continuing challenge for the CSG field.

2 *Traditional domain for constituent field applications* – The practitioners of the 'governance' field have a different application orientation than both 'systems'-based fields informing CSG. In painting with very broad strokes, governance is more directed at higher level (strategic) understanding of dealing with complexities of organisations (e.g., enterprise governance) and the issues of policy (e.g., corporate governance). In contrast (we believe inappropriately), the systems-based applications are more seen as being focused at the detailed, technical, and operational levels of organisations (e.g., systems engineering). Thus, this assumed division, however, we may suggest its inappropriateness, may explain the prior reluctance to engage at the intersection of these fields.

3 *Successes of the constituent fields have not necessitated crosspollination between fields* – Each of the fields being intersected by CSG have been successfully developed and applied to address complex issues. Therefore, there has not been the overwhelming drive for exploring their intersection out of perceived necessity or urgency. Perhaps the anticipated gains have not been seen as substantially beneficial to warrant the investment of resources or intellectual capital necessary to explore the potential for integration. However, we should note the traditional close coupling between systems theory and management cybernetics, both having the strong 'systems' heritage that is central to their essence.

4 *Hesitance to engage yet 'another' new field* – We must appreciate the reluctance to engage yet another 'new field' with the promised potential to significantly alter the landscape of dealing with modern complex systems and their problems. The landscape of practitioners is littered with promises of new approaches that will provide resolution to complex system performance issues. Continual disappointment stemming from failure to achieve promised results is certainly cause for skepticism as a new field comes along with similar promised potential. The list of 'new' fields and approaches that have fallen short of promises and expectations to address complex system problems is substantial and litters the literature. This is not intended to disparage any of the existing attempts. On the contrary, this suggests a caution for the development of the CSG field. The caution to be heeded is to avoid the 'faddish' development and corresponding 'over promising' that is sure to fall short of expectations and lead to a premature demise of the burgeoning field.

5 *Extension into and appreciation of related work in different fields* – CSG field development had to start somewhere, and that was found at the intersection of the systems theory, management cybernetics, and governance fields. However, the further development of the field cannot be arbitrarily closed to injection of knowledge from other fields as the propagation of the CSG field widens in both scope and reach. Likewise, similar concepts and thinking, albeit with different language, should be engaged in the evolving CSG field development. The exclusion of new thinking, approaches, and exemplars would be shortsighted for a field attempting to make a substantial impact.

Having set the stage for resistance to continued development, we now proceed with an exploration of the current state of the CSG field. CSG is emerging to take its place among other systems-based approaches that have been in existence and proven through application in many different circumstances (Jackson, 1991, 2003; Flood and Jackson, 1991). However, there are several distinctions that we should make with respect to CSG being considered for addition to this distinguished set of systems-based approaches. First, CSG purposefully operates at all levels of system development, ranging from individual to an entire system/enterprise. In this sense, CSG is true to the tenets of being 'holistic', operating across the entire spectrum of complex systems (individual practitioner, entity, system, and enterprise). Second, CSG does not bound out or ignore the non-technical, political, and social dimensions of complex system problems. This is not to claim that other systems-based approaches do not take these elements into consideration (tacitly or explicitly) but rather serves to emphasise the explicit consideration CSG makes for these elements. Third, CSG does not assume that a unitary view of system development will be held by those who will engage in that development. There are a myriad of different, and potentially conflicting, motivations, perspectives, and objectives that can exist and be pursued (explicitly or tacitly) related to system development. Instead of ignoring or downplaying the existence of these differentials, CSG embraces the differentials and is clearly focused on exploring the logic and implications the differences hold for system development. Fourth, while some systems-based efforts are directed to a 'singular' application focused on a particular problem, CSG instead is focused on the continuing development of the governing system. In this sense, CSG suggests that there is no end state to CSG development, but rather a continuing engagement in pursuit of evolving governance to achieve more desirable levels of system performance. Fifth, CSG recognises that some activities, although desirable and of great potential significance to

system development, are beyond feasible achievement. CSG cautions that development activities pursued must be compatible with the current state of governance capabilities. This suggests targeting the highest priority development areas identified, but only to the extent that their achievement is feasible given the current state of CSG practitioner competencies as well as compatibility/congruence of supporting infrastructure. Thus, while two systems might identify the same developmental issue, their range of activities that can be undertaken in response will be constrained by the current state of their CSG development. Finally, CSG does not preclude the incorporation of other methods, tools, or techniques into a development effort. On the contrary, CSG encourages and invites incorporation of a variety of existing, developing, and future vehicles to help achieve CSG developmental goals. In this sense, CSG is very much entrenched in the concept of 'bricolage', or improvising by using what is at hand to create new and novel artefacts. Thus, CSG is not presented as an intractable, prescriptive, linear, or stepwise approach that must be followed without deviation – capable of assuring success if only the sequence of activities are precisely followed, without variance, as directed. On the contrary, CSG is more of a guide that must be tailored to the specific system and context for application rather than follow a prescribed formula.

The capture of the current state of CSG field development might be summed up with four critical points:

1 *The newness of CSG stems from integration of established fields* – It would be interesting to posture the CSG field as 'totally new' and finding its basis in itself only. However, the reality of CSG is that it lies at the intersection of established fields and seeks to leverage the interface of these fields in new and exciting ways. As such, 'newness' of CSG draws on the strengths, as well as limitations, inherent in the fields upon which it draws (systems theory, management cybernetics, and governance).

2 *Development of the CSG field has been focused on sustainable foundations* – The preponderance of materials thus far produced for CSG are focused first on establishment of essential foundations (theoretical, conceptual). The developers of CSG have deliberately pursued this course as opposed to engaging development of immediately deployable tools, methods, and techniques (e.g., software). This focus on sustainability through conceptual grounding as the first priority has resulted in a minority of the current work dedicated to application and practice. The strong foundations for CSG are intended to provide a grounding that will better withstand the tests of time. Absent conceptual grounding, the 'half-life' of the CSG field will certainly be questionable and the ability to avoid early obsolescence doubtful as well.

3 *The value in CSG application has not yet allayed perceived practitioner risks* – The current state of value for CSG does not exist at the level of practice. Although the field has been purposefully directed to setting sustainable foundations, these foundations have not yet translated to perceived practice value. This is not a criticism of the work that has been completed in CSG, but rather an opportunity and a recognition that applications are sparse. Therefore, the value to risk ratio for practitioners is not currently such that there is widespread practice, demand, or perceived utility that will accelerate field development as only practice applications can.

4 *CSGs applicability extends to multiple and diverse problem domains and sectors* – CSG is not easily cast in a particular sector (e.g., transportation, energy, security, defence, education, healthcare, commerce) or problem domain. Instead, CSG is 'transdisciplinary', capable of applicability and crossing multiple sectors and problems. Therefore, the responsibility, accountability, and drive for CSG development exist beyond the more traditional realms of scholarship or practice. The consequence is both enabling and constraining for the CSG field. Enabling in that the field is not shackled or held hostage to preconceived notions of development or applicability to narrow domains. Constraining in that the field also brings the limitations inherent to the fields upon which it seeks to draw upon as well as extend to multiple diverse application domains. In response, the CSG field must develop at the intersection of three different fields and associated domains of application. This requires the balancing of congruities as well as incongruities between the fields as well as their traditional primary audiences and application domains.

The current stage and station of the CSG field should be expected. The field is at the convergence of three existing fields, it has only been recently articulated, and the depth of published materials for the field is limited. As Figure 2 demonstrates, the intersection of the systems theory, management cybernetics, and governance fields is new, limited, and localised. This is not a criticism, but rather a recognition that there is much to be done to legitimise, develop, and propagate the emerging CSG field.

The current state of work integrating the three contributing fields (systems theory, management cybernetics, and governance) in CSG are captured in Table 1. Although this table is not presented as all inclusive of literature related to the integration, it is singularly focused on those works that explicitly recognise this integration.

Figure 2 Integrating three fields for CSG (see online version for colours)

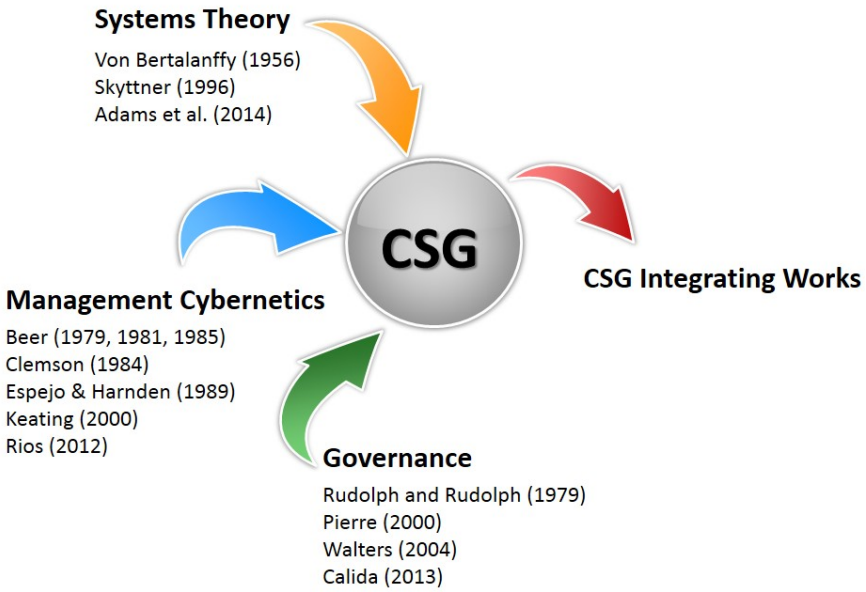


Table 1 Integrating works for CSG

Author(s)	*Year*	*Title of work*	*Integrating theme*
Keating et al.	2009	R&D governance: an emerging systems-based paradigm for public sector R&D	Early grounding work in the development of the CSG field, focused on applicability to R&D
Hester et al.	2010	The emerging role of R&D governance	An early work that detailed the basis for the emerging CSG field
Keating	2011	System identity: balancing tensions in governance	Examination of the systemic tensions inherent in CSG across dimensions of design, change, and control
Keating and Katina	2012	Prevalence of pathologies in systems of systems	First identification of the nature and type of pathologies that can impact performance in CSG
Hester and Keating	2012	An initial perspective on governing a system of systems	An early attempt to articulate the nature of governance in complex systems as distinct from management
Keating et al.	2014	Complex system governance: concept, challenges, and emerging research	Articulation of the emerging concept of CSG, setting the stage for a more coherent approach to field development
Calida and Keating	2014	System governance: emergence of practical perspectives across the disciplines	Analysis of themes of governance from a systems theoretic perspective distinguishing governed, governing, and metagovernance systems
Keating and Katina	2015	Governance implications for meeting challenges in the system of systems engineering field	A first exploration of linking and propagation of CSG to a related field in system of systems engineering
Adams et al.	2014	Systems theory as the foundation for understanding systems	The foundational work for the application of systems theory to CSG
Keating	2015	Complex system governance: theory to practice challenges for system of systems engineering	Suggestion of the difficulties likely to be encountered, and their implications, for application of CSG
Jaradat	2015	Complex system governance requires systems thinking-how to find systems thinkers	Examines the relationship of systems thinking as a necessary but not sufficient condition for effectiveness in CSG
Keating et al.	2015	Challenges for developing complex system governance	Suggests the specific challenges and implications for the development and propagation of CSG

Table 1 Integrating works for CSG (continued)

Author(s)	*Year*	*Title of work*	*Integrating theme*
Keating and Bradley	2015	Complex system governance reference model	Provides the specification for a first generation reference model that details the specific CSG functions and communication channels which must be performed by all systems
Walters et al.	2014	System of systems engineering and enterprise architecture: implications for governance of complex systems	Provides a first articulation of the nature and role of system architecture for achievement of CSG
Carter	2015	A metasystem perspective and implications for governance	Elaborates on the role, function, and implications of the metasystem in relationship to CSG
Katina	2015a	Emerging systems theory-based pathologies for governance of complex systems	Identifies the pathologies that can exist in a complex system and their implications for CSG
Bradley et al.	2015	Competencies for governance of complex systems of systems	A first examination of the CSG related competencies that are essential to effective performance of governance functions
Baugh	2015	Environmental scanning implications in the governance of complex systems	Focus on the environmental scanning function as a necessary element for achievement of CSG
Katina	2015b	Systems theory-based construct for identifying metasystem pathologies for complex system governance	Original research identifying and mapping pathologies related to performance of CSG

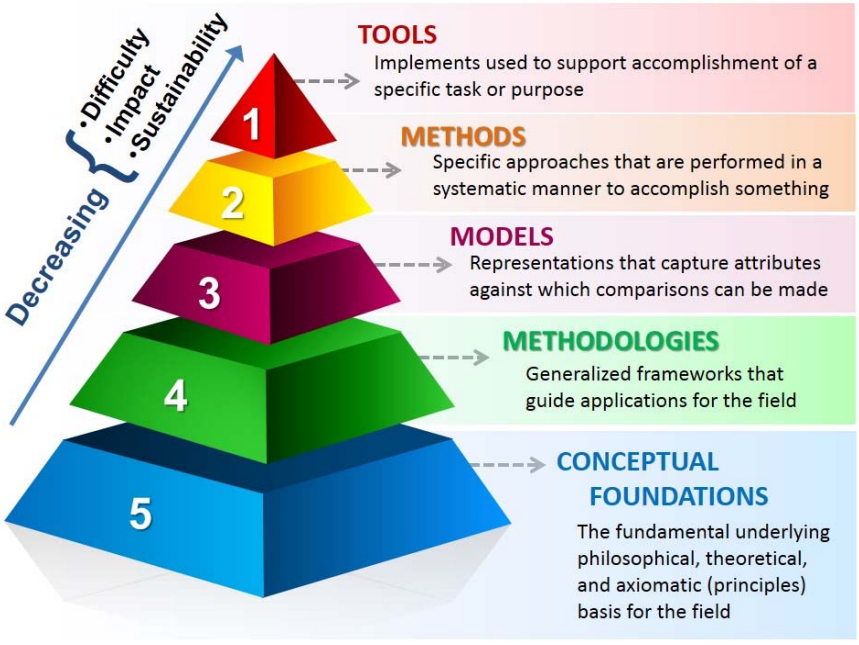
Table 1 attests to the newness of the CSG field. As the field continues to progress, there are three areas that can serve to direct, accelerate, and amplify impact for the field. First, the CSG field development must resist the pressure to sacrifice the early commitment to the strong conceptual foundations that have been laid. These foundations, stemming from systems theory, management cybernetics, and governance provide the underpinnings for the CSG field. However, irrespective of the strength of the initial development of the conceptual foundations, the further evolution of the field must continue to advance the conceptual underpinnings (Figure 3). As Figure 3 suggests, the conceptual underpinnings form the base of the pyramid for CSG development. These underpinnings are found in the body of knowledge drawn from the intersection of systems theory, management cybernetics, and governance. The foundations provide stability in the midst of internal flux and external turbulence for a system. While methodologies, models, methods and tools might change with increasing frequency, conceptual foundations offer sustainability

and consistency. It is noteworthy that as the movement from conceptual foundations to tools for CSG progresses we suggest a corresponding decrease in:

- *Difficulty*– the ease with which implementation can occur. For example, it is easier to implement a new tool than adjust the system worldview.
- *Impact* – the expectations of value accruing from implementation. For example, we should expect that making change in a system at a fundamental level corresponding to conceptual foundations (e.g., worldview shift) will have a greater influence on performance, behaviour, or accrued value than a less substantial undertaking (e.g., new tool introduction).
- *Sustainability* – Just as conceptual foundations are slow to shift, so too should we expect CSG activities at the higher levels (e.g., tools) to produce more rapid but superficial change, have a much shorter longevity, and be more limited in utility. For example, most of the fundamental principles of systems have been around for decades and withstood the tests of time. However, tools (e.g., software programs) to support systems-based activities are subject to frequent change and potential obsolesce in relative short timeframes.

The implications for CSG field development are not subtle. This suggests that the field must not be excessively enamoured with any particular stage of development. Similarly, it would be systemically naïve to think that there is not an interconnection and relationship among and between the different stages presented.

Figure 3 Different stages of CSG field development (see online version for colours)



Another point of consideration for CSG field development is a focused emphasis on enhancing practice. Methodologies, methods, tools, and techniques must remain consistent with conceptual foundations while also being accessible to practitioners. The ultimate utility of CSG will be achieved through its ability to enhance practices that influence performance of complex systems and address problems that practitioners experience with these systems. CSG field development must also generate sufficient (system) science-based technologies (artefacts) to enable practitioners to deploy CSG. This advocates an entirely new class of technologies that we would propose be captured as *governance enabling technologies*. Regardless of the adequacy of the theoretical formulations of CSG, absent the *governance enabling technologies* there is little efficacy that might be found in CSG beyond an academic exercise.

The path forward for CSG implementation must find alternatives to an 'all or nothing' approach for practitioners wishing to benefit from this emerging field. The prospect of a spectrum of CSG application is suggested. This spectrum must appreciate the confluence of systemic proficiency (individual and entity), current state of CSG development, contextual compatibility of the CSG approach, and resource constraints. These considerations will dictate what might be feasibly engaged with respect to a CSG effort. A variety of 'entry points' commensurate with the circumstances and risk tolerance of practitioners taking on a CSG effort must be considered. This is necessary to align expectations for value with what might be feasibly undertaken in a CSG effort.

3 Focus and contributions of the special issue

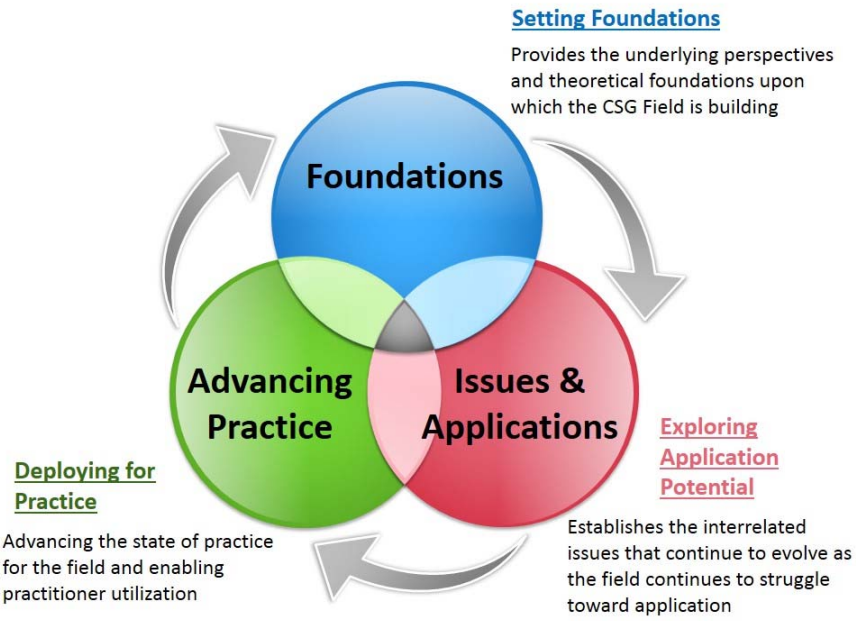
The papers of this special issue on CSG provide a follow on from a previous special issue of the *International Journal of System of System Engineering* (Vol. 6, Nos. 1/2), titled 'Foundational perspectives for the emerging CSG field'. In that issue, the emphasis was directed to exploration of multiple foundational perspectives for the emerging field. In contrast, this special issue is an elaboration of the foundations set by that first special issue. The emphasis of this special issue is directed to exploration of issues and applications for CSG. This present issue presents a natural evolution and progression of the CSG field by laying the groundwork upon which further advances can be undertaken. The groundwork continues as an integrated effort to ultimately influence the practice of CSG and provide support for practitioners who are charged with governance of modern complex systems. Thus, the evolution of the CSG field is predicated on the continuing advancement of foundations, issues, and practice (Figure 4).

By working at the intersection of three fields (Figure 1), CSG field development presents an enormous task. This special issue is an attempt to continue the journey started by the earlier works of CSG, the existing fields, and the increasing knowledge being generated through continued exploration. The papers of the special issue are organised in Table 2. This table presents the author, title, and the particular contribution/relationship to the emerging CSG field. This set of papers represent a significant contribution to the continued development of the CSG field.

In looking at the set of papers for this special issue, we identify the interconnection across three areas in Figure 5. There are several points of intersection for the variety of papers for the issue. First, the underlying paradigm for the papers is based in the systems worldview. This worldview is based in the systems notions of holism, interconnectedness, and the immutable principles that explain the nature, behaviour, and

performance of systems. The systems worldview also appreciates the inherent landscape of modern enterprises that is dominated by conditions of *uncertainty* (incomplete knowledge casting doubt for decision/action consequences), *ambiguity* (lack of clarity in understanding and interpretation), *emergence* (unpredictable events and system behaviours resulting in unintended consequences), *complexity* (systems so intricate that complete understanding or explanation is impossible and performance difficult to predict), and *interdependence* (mutual influence among related systems). These conditions are not going away in the foreseeable future and are more likely to increase in severity. CSG ultimately aims to help practitioners more successfully navigate these conditions to produce higher performing systems. In moving to this goal, the current set of papers contribute substantially to the growing body of CSG knowledge.

Figure 4 Role of the current special issue in advancing the CSG field (see online version for colours)

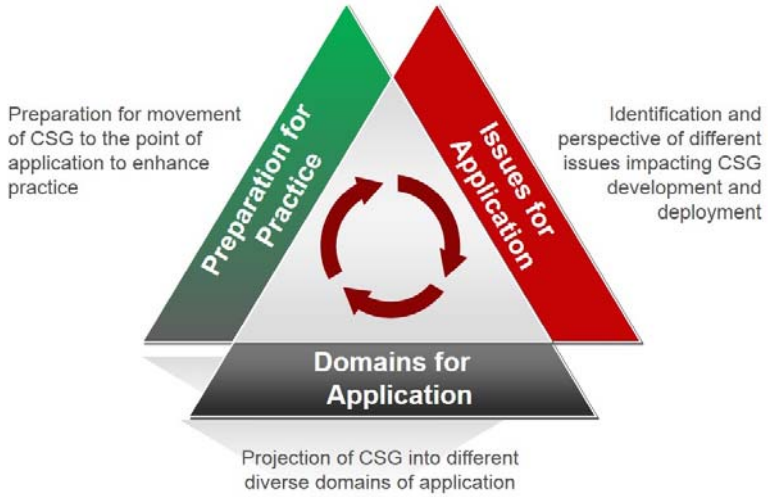


The special issue papers are generally classified into three primary contribution areas for CSG (Figure 5). First, there is a subset of papers that are focused on preparing to move to practice. These papers offer a significant step toward applications for practice. Among these papers are Calida's 'Complex system governance: moving diverse theory to practice' (bridging from the theoretical/conceptual development of governance to transition for practice), Keating and Katina's 'Complex system governance development: a first generation methodology' (preparation for deployment of CSG to improve governance practice), Jaradat and Keating's 'Systems thinking capacity: implications and challenges for complex system governance development' (emphasising the need for assessment of systems thinking as critical to the successful practice of CSG), Carter, Moorthy, and Walters' 'Enterprise architecture view of complex system governance' (setting foundations for application of system architecture to CSG). These papers have contributed to setting foundations for the preparation for practice related to CSG.

Table 2 Papers in the current special issue

Author(s)	*Title*	*Contribution to CSG*
B. Calida	Complex system governance: moving diverse theory to practice	Provides a perspective on CSG and identifies difficulties and the path forward for the continued movement from the theoretical to the practice realm.
C. Keating and P. Katina	Complex system governance development: a first generation methodology	Establishes an approach to engage the process of developing CSG. Emphasises a generalised framework for development.
R. Jaradat and C. Keating	Systems thinking capacity: implications and challenges for complex system governance development	Explores CSG execution and development as dependent on the ability of individuals to engage in systemic thinking/
B. Carter, S. Moorthy, and D. Walters	Enterprise architecture view of complex system governance	Examines the nature and role of architecture in relationship to CSG. Offers a first exploration of the implications that architecture can hold for CSG development and application.
D. Yuchnovicz	Understanding system structural tensions to support complex system governance development methodology	Defines potential issues in the tensions in CSG along dimensions of change, design, and control. Introduces the notion of the achievement of balance in tensions as critical to CSG development.
D. Walters	Leadership issues in governance of complex systems	Provides a first examination of the issues and distinctions of system leadership, exploring how it is both different as well as related to traditional leadership, and quite possibly may require different principles.
C.W. Chesterman, K. Castelle, and J. Shauger	Interpreting barriers to success in software development and deployment using systems theory	From a systems theoretic perspective, examination of governance applicability to software development is explored.
V. Ireland	Governance of collaborative system of systems	Projects the governance field into system of systems, recognising the relationship and applicability of governance to the system of systems domain.
J. Shauger	Introduction to service system governance	Explores insights and implications of governance as it relates to the service sector. Opens CSG applicability to an area in need of new perspectives and approaches.
R. Lum	A futures perspective on constitutional governance	Provides an exploration into application of governance from a political perspective, identifying challenges and necessary innovations in governance to meet those challenges.

Figure 5 Three areas of CSG development for practice and application (see online version for colours)



A second set of papers targets exploration of issues related to CSG application. This group includes Yuchnovicz's 'Understanding system structural tensions to support complex system governance development methodology' (exploring the issues related to balancing design, control, and change in CSG), Walters' 'Leadership issues in governance of complex systems' (identifying the nature of leadership issues applicable to CSG), and Chesterman, Castelle, and Shauger's 'Interpreting barriers to success in software development and deployment using systems theory' (exploring governance issues and their barriers for software development application). These papers offer a perspective on several critical issues related to application for CSG.

The third set of papers in the special issue is aimed at projection of CSG to different application areas. At the source of these explorations lie systems theory concepts and their applicability across a range of domains. This group of papers includes Shauger's 'Introduction to service system governance' (applying concepts of CSG to the service sector), Ireland's 'Governance of collaborative system of systems' (projecting concepts of CSG into the domain of system of systems engineering), and Lum's 'A futures perspective on constitutional governance' (exploring a framework for design of governance systems). The commonality of these three papers is the projection of system governance into three different application domains. The papers attest to the variety of application domains which can benefit from CSG. These benefits can range from simple advances in thinking to actual (re)design of systems based on the foundations of CSG.

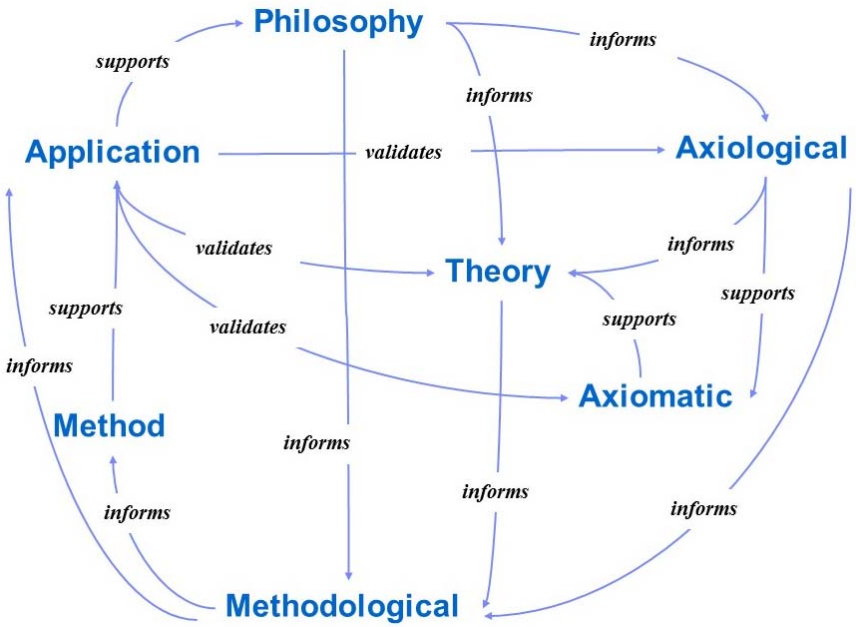
Having set the contributions of the special issue to advancing the CSG field we turn our attention to the future of the field.

4 Future directions for moving the CSG field forward

CSG is certainly in the earliest stages of development. We view this special issue as a significant milestone in the continuing CSG development. This is not to boast with intellectual arrogance, but rather to invite a continuing and broadening dialog. The

ongoing dialog is essential in the early stages of the field development. By engaging dialog, critique, and joint exploration the field can be strengthened from both the research as well as the practitioner perspectives. While there are many developmental paths and directions that can be taken for the future maturation of CSG, we suggest four primary considerations that we feel will accelerate field development and provide greater sustainability.

Figure 6 The CSG field existing across a 'holistic' set of interrelated levels (see online version for colours)



First, continuing focus on the 'holistic' development of the CSG field is essential. In keeping with the most central tenet of 'systems', we suggest that an overly narrow conception of the CSG field will not provide that breadth necessary to address the richness of the problem domain for CSG application. CSG and its application exist across an interrelated set of different conceptual levels that 'holistically' inform the development and utilisation of the field (Figure 6). This need to pursue the 'holistic' nature of CSG field development and application has been cited in the earliest works to guide the field (Keating et al., 2009, 2014; Keating, 2014). An overemphasis on theoretical or practice fronts is likely to slow progression of the field and preclude a balanced discovery – application cycle. Additionally, there must be continuing question of the conceptual basis of the foundational fields (e.g., systems theory, management cybernetics, and governance) for their continuing relevance. Also, expanding the boundaries of consideration for inclusion of concepts/insights from other fields creates the potential for more productive evolution of the field.

This set of seven interrelated developmental levels (Figure 6) are critical not only to the development of the CSG field but also to the applications as well as practitioners of the field. Following the earlier work of Keating (2014), this set of interrelated developmental levels is identified as:

1 *Philosophy* – directed at developing a theoretically consistent articulation of the paradigm(s) for system governance. The emerging system of values and beliefs providing grounding for theoretical development is the primary contribution of this area.

2 *Theory* – focused on explaining phenomena related to CSG and development of explanatory models and testable conceptual frameworks. The range of theoretical developments advances understanding of the field.

3 *Axiological* – establishes the underlying value, value judgement frameworks, and belief propositions that are fundamental to understanding the variety of perspectives for CSG. This also focuses on providing the basis for interpretation of meaning for what is perceived.

4 *Methodological* – undertaken to develop the theoretically informed frameworks that provide high level guidance for design, analysis, deployment, and evolution of governance systems.

5 *Axiomatic* – appreciation of the existing and emerging principles, concepts, and laws that define the field and constitute the 'taken for granted' knowledge upon which the field rests. This also includes integration of knowledge from other informing and related fields/disciplines.

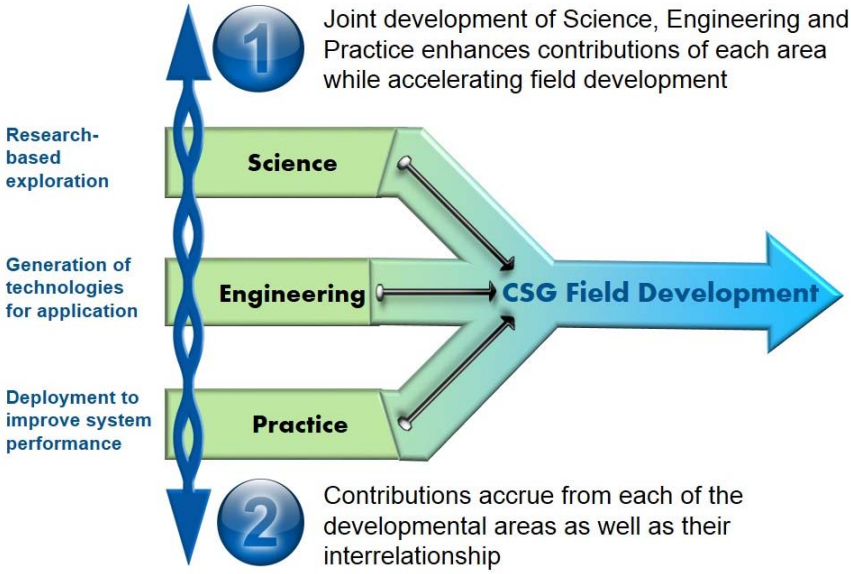
6 *Method* – focused on development of the specific models, processes, technologies, standards, and tools for CSG. This is in effect representative of the development of the toolsets and capabilities for practitioners to perform CSG.

7 *Application* – advancement of the practice of CSG through the deployment of science-based technologies and methods.

Second, ultimately CSG development and deployment must target value driven improvements in practice. Enabling practitioners and practices are the essence of CSG. Therefore, CSG field development must place special emphasis on demonstrable improvement of practices as well as enhancing individual practitioner capabilities. CSG development must accommodate front line practitioners and their need for *governance enabling technologies* (methods, tools, and techniques) with proven capability for addressing their issues through demonstrated *application*. In essence, the CSG field must *engineer* (apply principles of system science) *technologies* (artefacts that enable operation on the governance system design, execution, and evolution) that improve the prospects for practitioners to increase their effectiveness in governing complex systems.

Third, there must be a focus on sustainability of the CSG field as well as enhancement of CSG practices through application. Sustainability of the CSG field is predicated on the holistic development of the different levels identified above (Figures 3 and 6). Pursuit of this balance between research-based knowledge and resultant artefacts for application is essential to more effective field development. Additionally, sustainability of 'local' CSG is dependent on the utility of applications to support practitioners responsible for CSG of particular systems. Thus, CSG field sustainability is dependent on both the evolution of knowledge of the field as well as the translation of that knowledge to support practices and practitioners. In essence, sustainability is a function of both knowledge development as well as practical application. This precarious balance is necessary for CSG field sustainability and can also serve to accelerate field evolution.

Figure 7 Integrated CSG field development (see online version for colours)



In effect, sustainable CSG development is dependent upon development and deployment of research-based technologies. These governance enabling technologies will add value to the practice of governance for complex systems and support the practitioners responsible for implementation of that governance. While the division and balance between research and practice is only clear in abstract thinking, in reality there must necessarily be a 'creative tension' that continually calls to question the continuing directions and utility for development. The continuing progression of CSG (Figure 7) is dependent on simultaneous development and integration of the *science* (research-based extension of the body of knowledge for CSG-based in systems), *engineering* (application of [system] science to produce artefacts [technologies – methods, processes, tools, techniques] to enhance practice, and *practice* (deployment of technologies to improve performance of systems and practitioners through CSG). It is important to note that the development and contributions of each of the three areas (science, engineering, and practice) are neither mutually exclusive nor independent of one another. On the contrary, the 'cross fertilisation' among the three branches of CSG development have potential to spur field advances in ways that the segregated focus cannot. In essence, in true systems fashion the whole of science, engineering, and practice is greater than the sum of the parts.

Fourth, continued development of the CSG field must expand to a wider audience of researchers and practitioners. Advances in CSG will be substantially accelerated and improved by widening the audience for dialog, critique, and recommendations for advancing CSG. Emphasis should be placed on inclusion of perspectives ranging across scholars from associated fields (systems, management cybernetics, and governance) as well as the potential for inclusion of new and novel elements from other fields. Insights might accrue from unlikely sources and the net should be cast as widely as possible. In addition, care must be taken to resist narrowing the field too quickly such that potential advances are not prematurely excluded from consideration. Finally, the practitioner

perspective is essential to the holistic development of the CSG field. As mentioned earlier, not only is practice capable of being informed by research, but likewise research can also be informed from practice feedback. Expansion of CSG to the widest possible venue offers an important opportunity that should not be discounted.

This special issue represents a significant step forward in realisation of balanced sustainability along the dimensions of science, engineering, and practice for the emerging CSG field. Additionally, it seeks to open the channels for fruitful dialog to advance the field.

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