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A Systems Theory-Based Framework for Environmental Scanning in Complex System Governance

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A SYSTEMS THEORY-BASED FRAMEWORK FOR ENVIRONMENTAL SCANNING IN COMPLEX SYSTEM GOVERNANCE

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ABSTRACT

A SYSTEMS THEORY-BASED FRAMEWORK FOR ENVIRONMENTAL SCANNING IN COMPLEX SYSTEM GOVERNANCE

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The purpose of this research was to develop a Systems Theory-based framework for Environmental Scanning (ES) in Complex System Governance (CSG) using an inductive research design. Complexity and uncertainty are normal for external environments in which today's systems (organizations) exist. These environmental characteristics provide impetus for researchers to focus on organizational planning for disruptive external forces that could threaten system stability and future system existence. The ES function supports the requisite governance metasystemic functions to be enabled, executed, and evolved sufficiently well to promote continuous system viability. In this research the functioning of ES was examined from a diverse literature-based perspective. The literature acknowledges the importance of the ES function, but its consistent development and its impact on system viability in a turbulent environment is not well developed from a Systems Theory-based perspective. This gap in knowledge was addressed in this research.

This research examined metasystemic functions performed by ES across a broad literature base encompassing Systems Theory, CSG, Managerial Cybernetics, and ES from several fields of study. This research focused on the lack of explicit use of Systems Theory in ES functionality in metasystemic governance. This research presents a theoretical construct for the expansion of the functionality of ES in CSG that supports enhanced system viability.

A rigorous research approach employing a constructivist Grounded Theory Method (GTM) was used to analyze the qualified research literature with a focus on Systems Theory to both consolidate and expand the known functionality of ES in CSG. This research provided a theoretical seventeen-function Systems Theory-based framework for ES in CSG. The overarching theory from this framework is that ES functions support complex system viability through regulation of internal and external variety that is induced by external changes. The literature-based identification of the ES functions demonstrates that ES operates in newly identified mechanisms, beyond the original identification provided by Keating & Katina (2016). A case study was undertaken to demonstrate face validation of the applicability of the emerging Systems Theory-based functions of ES in CSG in an applied setting where possible utility was developed.

Topics for future research in ES functionality were identified.

This work is dedicated to my late wife Donna Baugh. There is the blessing of a supportive family, and I was favored to have an encouraging and patient wife who pushed me along to achieve my educational goal. Donna understood my reason and passion, she was always my companion, and she taught me how to balance time between work on new aircraft carriers, academic studies, and family. She insightfully helped me learn to take remote classes, dress for the occasion, and to spend time with her and not communicate with words she did not understand. To Ms. Charlee Eaves, my musician daughter, who expanded my systems foundations with the helpful diversions of two grandchildren, academic discussions, and always beneficial feedback. To Newport News Shipbuilding for supporting me financially and with relevant and motivational experiences. To my Shipmates who gave freely to support all our freedoms, may the complex work you have accomplished support our nation's continued viability.

"Mental toughness is spartanism with qualities of sacrifice, self-denial, dedication. It is fearlessness, and it is love." Vince Lombardi

ACKNOWLEDGEMENTS

My journey began with the gift of U.S. Navy GI Bill funding to be used or lost, that led to covering tuition expenses at Old Dominion University (ODU). I am grateful for the wise counsel of Dr. Joseph Bradley who connected me to ODU and Dr. Charles Keating in the EMSE department, where a flame of excitement was ignited. The efforts of any journey are eased with the help of friends, family, classmates, and professionals. My incredibly supportive wife led the way with her continuous encouragement and feedback. Dr. Charles Keating was a phenomenal influencer, teacher, mentor, and consummate advisor that without his steadfast engagement over the years of this research, this point would not have been reached. To him I always say "*Beat Army*" but readily recognize that his superior academic strategy and engineering experience always wins my salute of respect. There are many people who have contributed to the successful completion of this dissertation. To the other members of my committee, Dr. T. Steven Cotter, Dr. Resit Unal, and Dr. Behnido Calida who collectively with their teachings and writings, and individually with their personal time, shaped my thoughts and understandings, thank you, I am grateful. To Dr. Polinpapilinho Katina, Dr. James Pyne, Dr. Joseph Bradley, Dr. Bry Carter, Dr. C.W. Chesterman, Dr. Dave Walters, Dave Fenton, Sharon Purvis, Abbey Basile, and Hannah Wingfield, who gave freely of their time, advice, experiences, expertise, and support, thank you so very much. The Complex Systems Governance Learning Community (Kevin, Walt, Bry, Katie, Satya, Meggan, Jennifer, Drew, Joe, Dave, Dan, Hart, Behnido, Ra'ed, C.W., Chuck and James) and so many shipmates and U.S. Navy Civil Servants who provided insights to the functioning of Complex System Governance, thank you. For everyone, I look forward to continuous viability with you all as the future unfolds its changes.

This research was conducted to contribute to the ongoing research efforts committed to understanding and developing solutions to contemporary problematic issues in complex systems. Many disciplines in the Engineering Management and Systems Engineering communities are moving towards a Systems Theory-based approach to dealing with issues affecting systems. There is a pressing need to understand that our systems are interdependent and complex; that they require innovative ideas and approaches to ensure their stability in a changing environment. Our systems are affected by a multitude of issues that can hinder expected performance and challenge system viability. This challenge requires that we think systemically about these systems and develop new concepts, tools, and approaches to dealing with system complexity.

There were two primary motivations for conducting this research. First, the researcher has experienced many complex systems in his career, from operating an eight-reactor complex on USS Enterprise to leading a 12,000-person shipyard in nuclear ship modernization and repair. In all these circumstances, this researcher has felt inundated with the complexity of the circumstances leading to a sense of suboptimum performance. Why does this continually happen? How can it be improved? Complex issues appear to be accelerating in all areas of our businesses, without an end in sight, and are challenging the viability of all the systems we recognize today. As I have come to learn, cause and effect in these complex instances are not easy to articulate, and if they are not readily connected, we will have difficulty resolving the issues involved with a propensity for type three errors. This researcher wants to learn how to perform better in complexity and how to share this learning with others who can apply it in practice. Secondly, I wanted to utilize my GI Bill benefits to pursue educational opportunities that would support research about complex systems. In exploring educational opportunities, Dr. Joe Bradley (Captain, USN retired) entered the picture with an idea. “Come to ODU and meet my advisor, you won't be disappointed" he said. I trusted him, so I did. The rest is my story in the pursuit of this research effort. I met his advisor and was immediately drawn into the discussions on complexity and innovative ideas on how to deal with complex environments from a Systems Theory-based perspective. I registered for classes, took my first Systems Theory class, and joined the most influential activity of all my research efforts, the ODU Complex System Governance (CSG) Learning Community.

This community of scholars, staff, and students was at the forefront of defining and pursuing governance in complex systems from a Systems Theory basis. The open scholarly discussions, the stream of scholarly guest lecturers, the community effort in drafting journal articles and book chapters, all aimed at advancing managing in complexity, were both exciting and intriguing. I felt like I had met Stafford Beer himself; I was hooked.

While working full-time, progress was slow, but my interest in contributing was large. I learned about reductionism and linear thinking. Systems Theory was taught as a needed alternative to reductionism. A specific philosophical paradigm for Systems Theory, the need to holistically deal with entities and to account for their interrelations rather than isolated parts, was a major influence that sparked my research interests. As CSG developed in the Learning Community and CSG metasystemic functions were identified, I was attracted in a scholarly means to the relationship of an open system with its environment. This relationship was described by Stafford Beer in his Viable System Model and had become part of the CSG metasystemic functions. As other researchers were selecting various aspects of the CSG metasystemic functions to research, I chose Environmental Scanning to be the one I would pursue.

Several years down the academic road, I am excited to have made some contribution to the ongoing development of CSG. I hope many researchers get involved in CSG and further develop its applications to improve system viability in an ever increasingly complex environment.

I am incredibly grateful to the many ODU professors and staff who have been proponents of Systems Theory, scholarly research, and simply encouragers to a novice scholarly researcher. They all made the journey worthwhile.

The next steps are to share what I have learned with those who can continue the CSG development and who can put into practice the learning from this and all the other related research efforts. I also want to put into practice what I have learned and perform better in growing complexity.

NOMENCLATURE

Terms germane to this research and their initial definitions for the purposes of this research are included in the nomenclature list below. A reference is cited for each definition.

Term	Definition	Reference
Complexity	Displaying many constituents interacting nonlinearly which are interdependent, spanning multiple scales, and being subject to emergent behavior and feedback. Non-linearity is a defining concept for this research.	Baranger, 2001 Keating et al, 2022
Complex systems	"Systems characterized as having a large number of subsystems that are involved in many loosely structured interactions; the outcome of which is not predetermined"	Jackson, 2003, p. 19
Complex Systems Governance (CSG)	The "design, execution, and evolution of the metasystem functions necessary to provide control, communication, coordination and integration of a complex system." The "evolution of the metasystem functions necessary to provide control, communication, coordination, and integration of a complex system."	Keating & Bradley, 2015, p. 2 Keating et al., 2014, p. 273
Framework	"The system of concepts, assumptions, expectations, beliefs, and theories that supports and informs your research…."	Maxwell, 2012, p. 39
Governance	"Governance produces the communication, control, coordination, and integration essential to ensure continued system viability"	Keating et al., 2015, p. 2947
System	"A system is a functioning whole that cannot be divided into independent parts"	Ackoff & Gharajedaghi, 1996, p. 13
Viability	"Viability is the ability of a system to maintain existence"	Keating et al., 2016, p. 296
Metasystem	"A set of functions that must be performed by any viable (continuing to exist) system"	Keating et al., 2014, p. 272
Variety	A synonym of complexity, conceived around the notion of surprise in contrast to redundancy	Gershenson, 2015
Systems Theory	"A unified group of specific propositions which are brought together by way of an axiom set to form the construct of a system"	Adams, et al., 2014, p. 121
Regulation	Related to the flow of variety, blocks the flow of variety from disturbances to essential variables	Ashby, 1961

Term	Definition	Reference
Environmental Scanning	ES "designs, deploys, and monitors sensing of the environment for trends, patterns, or events with implications for both present and future system viability"	Keating & Katina, 2016, p. 49

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

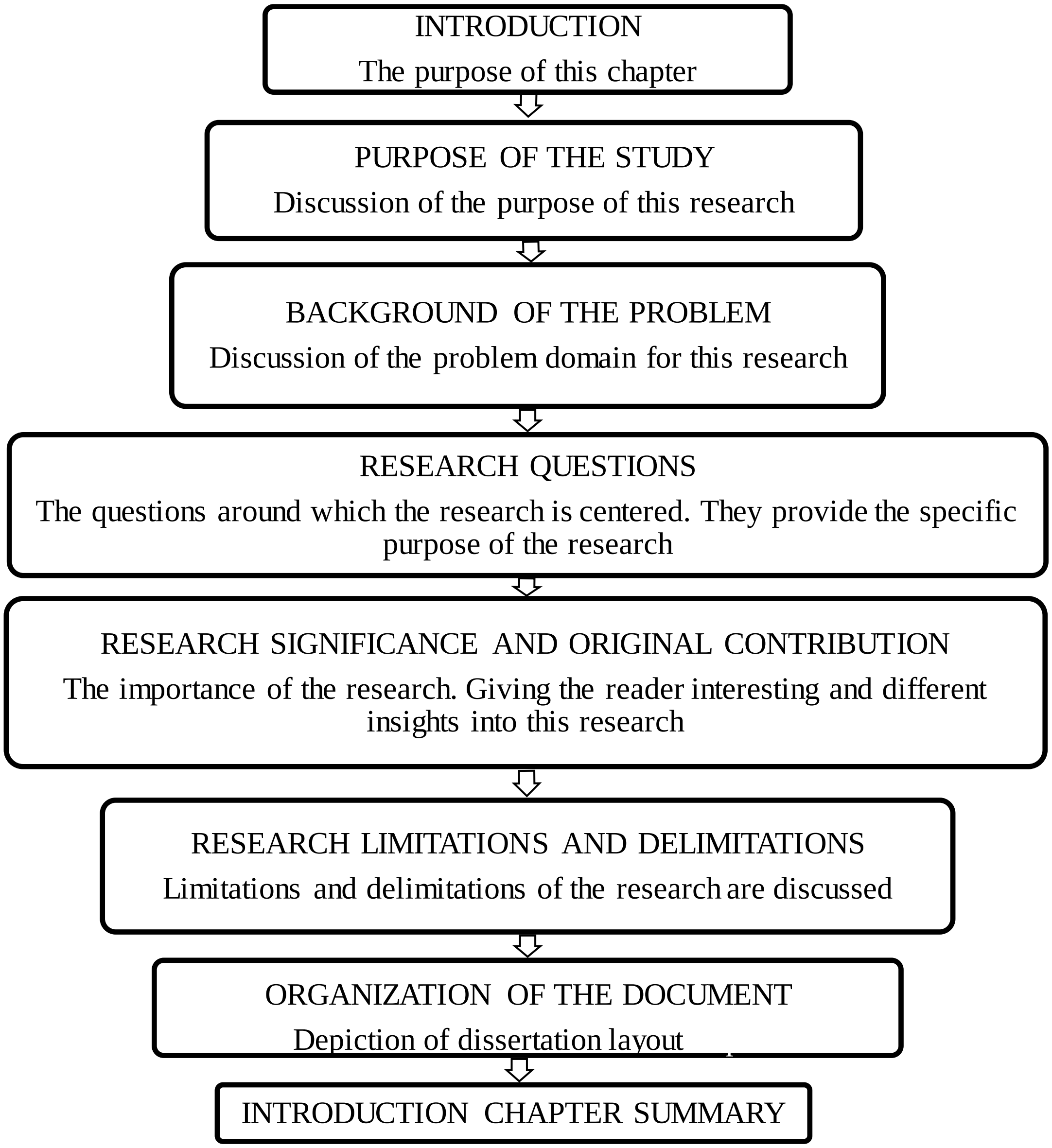
The purpose of this chapter is to establish the foundation for this research that addresses an identified need (literature gap) for a Systems Theory-based framework for the Environmental Scanning (ES) functions in Complex Systems Governance (CSG).

Additional purposes for this research are: (1) a contribution to knowledge, worthy of publication or dissemination, in whole or in part, which would advance the evolving field of Complex Systems Governance, (2) the application of the Grounded Theory research method in an engineering field of study will help expand the understanding of this method in a non-traditional field, and (3) the review of the ES literature will provide new insights into categorizing and organizing ES related literature.

Some ES functions have been initially identified (Keating & Katina, 2016), but have not been fully developed, categorized, described, and explored from a Systems Theory-based perspective. This research will employ a constructivist Grounded Theory research method to both confirm existing ES functions and develop new functions not yet identified. The research method will be grounded in a Systems Theory-based perspective.

Figure 1

Outline of Chapter 1



1.2 PURPOSE OF THE STUDY

The purpose of this study is to develop a Systems Theory-based theoretical framework for Environmental Scanning in Complex Systems Governance using an inductive research design. This research fulfills an identified gap in the literature. The identified gap is to construct a Systems Theory-based framework for ES as an essential function in CSG. This research also applies the theoretically constructed ES framework in an applied setting for a face-validation of practical utility. This research is a contribution to knowledge, worthy of publication or dissemination in whole or in part, which could contribute to additional development in the evolving field of CSG. CSG, as described by Keating et al. (2014) in their paper "Complex System Governance: Concept, Challenges, and Emerging Research," is built on Systems Theory and Managerial Cybernetics. CSG incorporates as a cornerstone the metasystem, which is described in Stafford Beer's presentation of the Viable System Model (VSM) (Beer, 1979; 1984). Managerial Cybernetics itself is developed from a Systems Theory construct (Schwaninger, 2004; Keating et al., 2014). One of the nine metasystem functions identified in CSG is the metasystem four prime (M4´) function (Keating & Katina, 2016). M4´ is identified as the ES function which "designs, deploys, and monitors sensing of the environment for trends, patterns, or events with implications for both present and future system viability" (Keating & Katina, 2016, p. 49). The ES function has been shown to support an organization's planning for external forces that could threaten the organization's stability and future existence (its viability) (Albright, 2004), thus contributing to positive system governance (Keating, 2014a). There has been no identifiable extensive research performed on M4´ (ES) from a Systems Theory-based perspective in CSG. The ES function has been explored, applied, discussed, and observed as part of several fields of study but has not been solidly grounded in a Systems Theory-based perspective. Therefore, it is reasonable to suggest that researching the ES function from a Systems Theory-based grounding is novel. Such research could further the contribution of CSG to system viability and could add to the advanced development of CSG as a significant field of study (Keating, 2014a).

1.3 BACKGROUND OF THE PROBLEM

The study and research in the field of communication and control have been formalized in the discipline of cybernetics. Norbert Wiener captured the evolution of the field of cybernetics from its early predecessors of statistical methods and quantum mechanics (Weiner, 1948) in the late 1940s. The original works in cybernetics focused on information transmission and controlling a specific, controllable situation. This "mechanical" focus fell short of dealing with increasing trends of change being experienced by modern systems or organizations (Umpleby, 2017). W. Ross Ashby took the mathematical aspect of cybernetics and simplified this technical approach to traditional language through the field of biology and living organisms (Ashby, 1956). He expanded the scope of cybernetics into network communications with his "Law of Requisite Variety" that states: "R's capacity as a regulator cannot exceed R's capacity as a channel for variety," where R refers to the function of a regulator (Ashby, 1958, p. 4). Ashby's work was predicated on the communications of interest being well defined so that their variety could be measured straightforwardly. Beer (1970) stated that:

> Variety is the cybernetic measure of complexity. It is explicitly the possible number of states of a system. The Law (Ashby's) says that the variety of a given situation can be managed adequately only by control mechanisms having at least as great a capacity to generate variety themselves. (p. 246)

Beer took the communication and control work of Ashby and related it to the design and diagnosis of organizations (Beer, 1979, 1981, 1985). Beer's works were the genesis of the field of Managerial Cybernetics. His crowning work was the definition of the viable systems model

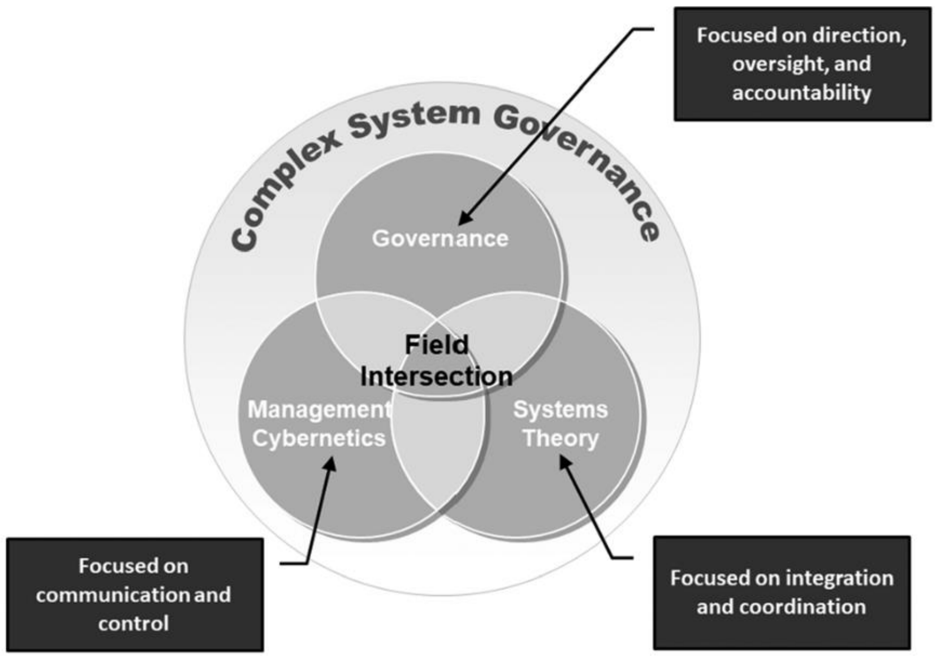
(VSM). The VSM made it possible to see complex organizations (those involving people) as a recursive set of closed webs of communications systems (Beer, 1979). Beer developed his work first by studying living organisms, then organizations composed of living beings. This aspect of complex systems was helpful in the diagnosis of and the strategic design for viable complex systems. One of these recursive systems identified in the VSM was system four (S4), whose purpose was to interface with the complex system's environment to help predict a future state of the system (Beer, 1984). A system's environment is defined as that which surrounds, affects, and is affected by a system, whether group or individual (Beer, 1984). It is an abstraction for the primary purpose of system analysis. This function was labeled as Environmental Scanning (ES). ES has been described by others as the "internal communication of external information about issues that may potentially influence an organization's decision-making process" (Albright, 2004, p. 40). The ES function has been shown to help focus an organization's planning on external forces that could threaten the organization's stability and future existence (its viability) (Keating & Katina, 2016). Studies have shown that there is a relationship between ES processes and organizational performance as measured by profitability and growth (Subramanian et al., 1993).

General Systems Theory grew out of dissatisfaction with a reductionist view of organizations created during the machine age (Agazzi, 1978). Reductionism, from the machine perspective, held that all relationships between parts, and between parts and the whole, were explained by cause and effect. This yielded a mechanistic understanding of organizations (Ackoff, 1973). Von Bertalanffy (1972) applied his knowledge from the study of living organisms to organizations, leading to General Systems Theory or systemic thinking. Systemic thinking is about understanding how the parts relate to each other and create larger wholes, leading to self-organization, understanding language, emotion, interactive processes, and learning how to handle situational complexity (Espejo, 1994). Thus from a Systems Theory perspective, for an organization to be capable of adapting to environmental changes and to have a viable future, it can be considered similar to a living organism instead of a passive machinery system (de Geus, 1997). In recent years, Systems Theory has developed from multiple viewpoints so that there is no longer a widely agreed upon definition of Systems Theory (Adams et al., 2014). Adams et al. (2014, p. 1) "proposed systems theory as a unified group of specific propositions which are brought together by way of an axiom set to form a system construct." Systems Theory is intended to provide explanations for real-world systems. These explanations can lead to increased understanding and provide improved levels of explanatory power and predictive capability for real-world systems, like large organizations, where there is a need to improve (Adams, 2011). Therefore, Systems Theory is explanatory to the ES process.

The emerging field of study, CSG, has been developed from Managerial Cybernetics and Systems Theory principles. Keating et al. (2015) explored the emerging paradigm and implications for CSG from the intersection of three fields of knowledge: Governance, Managerial Cybernetics, and Systems Theory (Keating & Katina, 2019). They examined these areas for contributions to the emerging CSG field. They concluded that CSG, drawn on the intersection of the Governance, Managerial Cybernetics, and Systems Theory fields of study, "represents a developing field with the significant potential to address some of the most daunting problems currently facing society" (Keating et al., 2014, p. 282). See Figure 2 from (Keating & Katina, 2019).

Figure 2

CSG at the Intersection of Governance, Management Cybernetics, and Systems Theory (used with author permission, C.B. Keating correspondence 11/22/22)

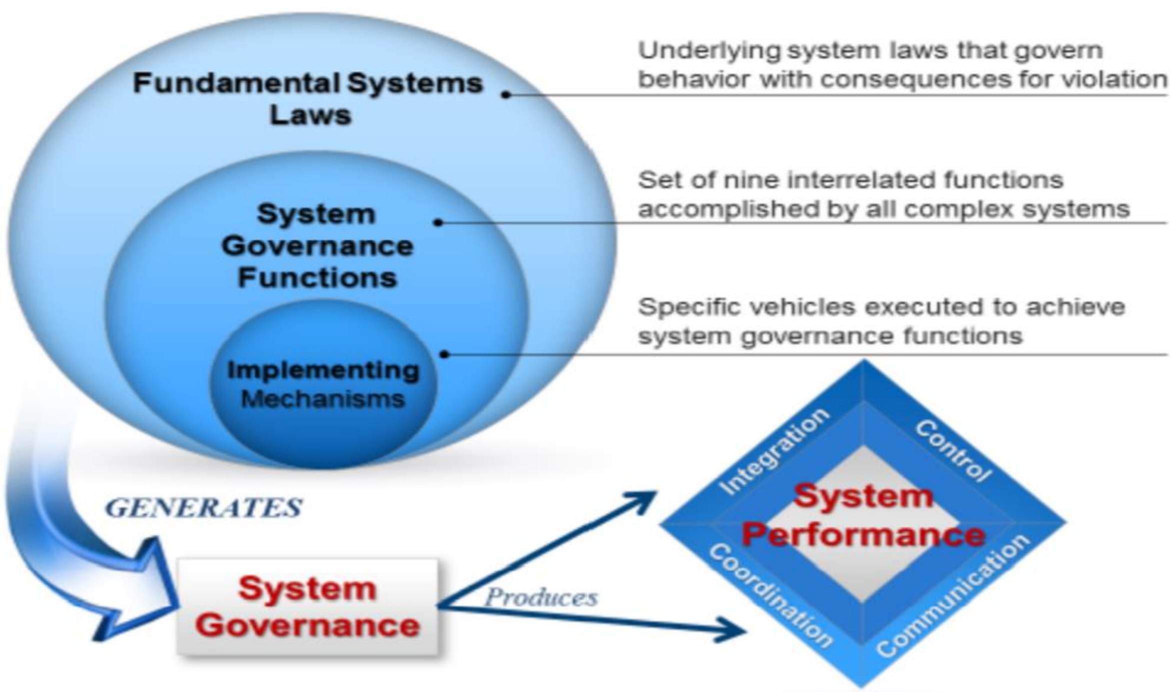


Keating & Bradley (2015) present the first exploration into the development of a reference model suitable for the emerging field of CSG. Though the model is preliminary, it is thoroughly grounded in Systems Theory and Managerial Cybernetics and supports meeting the application challenges that modern complex systems pose (Keating & Katina, 2016). One of the functions of the reference model, ES, is stated as a responsibility focused on "sensing the environment for circumstances, trends, patterns, or events with implications for both present and future system performance or viability" (Keating & Katina, 2019, p. 694). Keating & Bradley (2015) suggest that the CSG reference model is an ideal candidate for which rigorous CSG development frameworks can be established. It then seems plausible that by researching a

Systems Theory-based framework for the ES function in Complex System Governance that considers complexity and managerial cybernetic principles, a system's viability or longevity might be better governed over current practices that are grounded in more mechanistic and ad hoc approaches. Figure 3 taken from Keating et al. (2014) shows the relationship of CSG functions, that are grounded in systems theory, to system performance (viability). The relationship diagram shows that system laws govern behavior, that system behavior is governed by interrelated functions, and that system performance is generated by system governance. This research on ES functions has the potential to contribute to future developments in understanding some of the CSG functionality.

Figure 3

CSG Functions Relationship to System Performance (used with author permission, C.B. Keating correspondence 11/22/22)



CSG, which is grounded in Systems Theory and Managerial Cybernetics, works on a system through an "evolution of the metasystem functions necessary to provide control, communication, coordination, and integration of a complex system" (Keating et al., 2014, p. 273). The CSG reference model, also known as the metasystem governance reference model, identifies one of the nine metasystem functions as M4´. Summarized in Table 1 are the functions, primary responsibilities and product descriptions for metasystem function M4′ from (Keating & Bradley, 2015).

Table 1

Metasystem Functions for ES (M4´) in the CSG Reference Model

Metasystem function	**Primary role**	**Responsibilities**	**Product descriptions**
Metasystem four prime (M4′)- Environmental Scanning	• Primary function is providing the design and execution of scanning for the system environment. • Focus is on identification of circumstances, patterns, trends, threats, events, and opportunities for the system	• Designs for environmental scanning for the entire system (includes trends, changes, patterns, critical stakeholders, collaborative entities, research, etc.) • Executes the environmental scanning designs • Maintains a model of the metasystem environment • Captures emergent environmental conditions, events • Consolidates results from environmental scanning and provides a synthesis • Informs the development of the strategic plan • Disseminates essential environmental information and shifts throughout the system	• Design for environmental scanning including objectives, organization, execution, and performance monitoring • Publication of environmental scanning activities enabling coordination of targets, execution, data capture and analysis • Dissemination of scanning results, and implications of patterns, trends, threats, events, and opportunities for the system

The work on CSG development described above is a holistic approach, working from the metasystemic perspective, described in CSG where “the metasystem construct only defines ‘what’ must be performed to maintain system viability (existence). It does not specify ‘how’ a particular system is configured, or what devices (mechanisms) the system implements to achieve the metasystem functions” (Keating, 2015, p. 228).

The development of the ES function “how” by inductive means that incorporates all the functionalities of M4´, grounded in CSG and Managerial Cybernetics, in a complex environment, can be contributory and applicable to the future development of CSG principles. Given that CSG works on a system through an evolution of the metasystemic functions (Keating & Katina, 2019), it is logical that the ES function “how” must have evolutionary elements to it. This follows as environmental change is not static (Espejo & Gill, 1997). Thus, the impact of the environment on the system of interest is not static. This evolutionary, dynamic effect was challenging to consider in developing the ES framework, as the input data field to this study from the historic ES extant literature base is essentially static to enter into the applied Grounded Theory research method. To ensure that the research findings considered new developments in the ES literature that occured during the period of the research; a search of journal articles and books using Google Scholar® and Google Books® was conducted on all related literature written after the research literature input cut-off date was established. The search results were then screened for applicability and added to the research database where contributory to the research objectives. This covered the searchable literature base through 2021 for additional material supporting current ES writings. The research library is the set of journal articles and book sections that were used as the data source for the constructivist Grounded Theory Method

(GTM). These articles came from three search engine sources: (1) the researcher's personal library collected over years of classwork, (2) an Engineering Village database search, and (3) a Google Scholar and Google Book search. This search is explained in more detail in section 5.2.1.

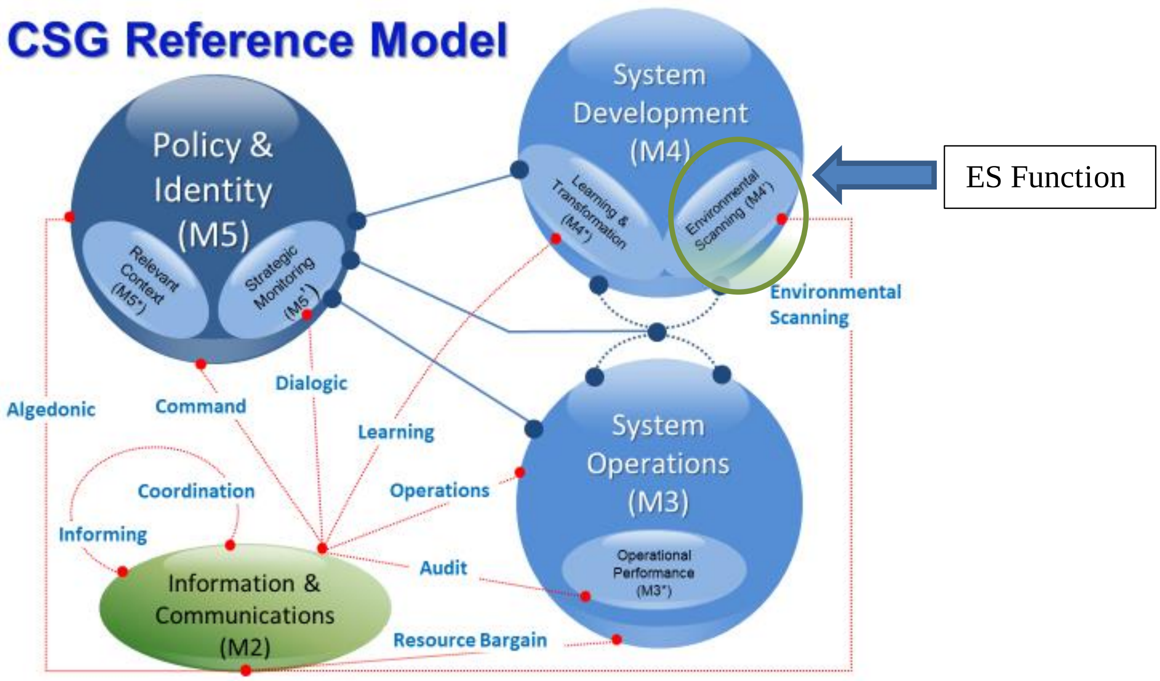
1.4 RESEARCH QUESTIONS

The purpose of this study was to develop and deploy a Systems Theory-based conceptual framework for Environmental Scanning in Complex Systems Governance using an inductive research design. It will be articulated below and in Chapter 3 that the inductive approach was developed from a constructivist GTM following the works of Charmaz (Charmaz, 1996, 2000a, 200b, 2006, 2014, 2015a, 2015b, 2016; Charmaz & Belgrave, 2019; Charmaz & Bryant, 2011; Charmaz & Thornberg, 2021; Bryant & Charmaz, 2007).

The development of CSG works on addressing "three primary shortcomings in addressing modern complex system problems" (Keating, 2015, p. 226) which are: a holistic appreciation of the problem space, distinctions between "hard" and "soft" system paradigms, and the ever more complex conditions characterizing the landscapes faced by practitioners of modern complex systems. CSG, built on Systems Theory and Managerial Cybernetics, looks towards the development of the nine metasystem functions identified in the CSG reference model (Keating & Bradley, 2015). See Figure 4 taken from Keating & Bradley (2015) for a depiction of the CSG reference model and identification of the ES function M4 prime (M4´). Figure 4 represents M4´ (ES) as part of the larger metasystem development functions, M4, and M4 star (M4*) the learning and transformation function. These three specific functions (M4´, M4, and M4*) are very integrated, and function essentially simultaneously.

Figure 4

CSG Reference Model Interrelated Nine Functions and Ten Communication Channels Highlighting the ES Function M4´ (used with author permission, C.B. Keating correspondence 11/22/22)



This research concentrated on the ES function identified in the CSG reference model as M4´ and considered M4* (learning and transformation) and M4 (system development) functions that are inseparably integrated with M4´ (ES).

This research answered the following questions:

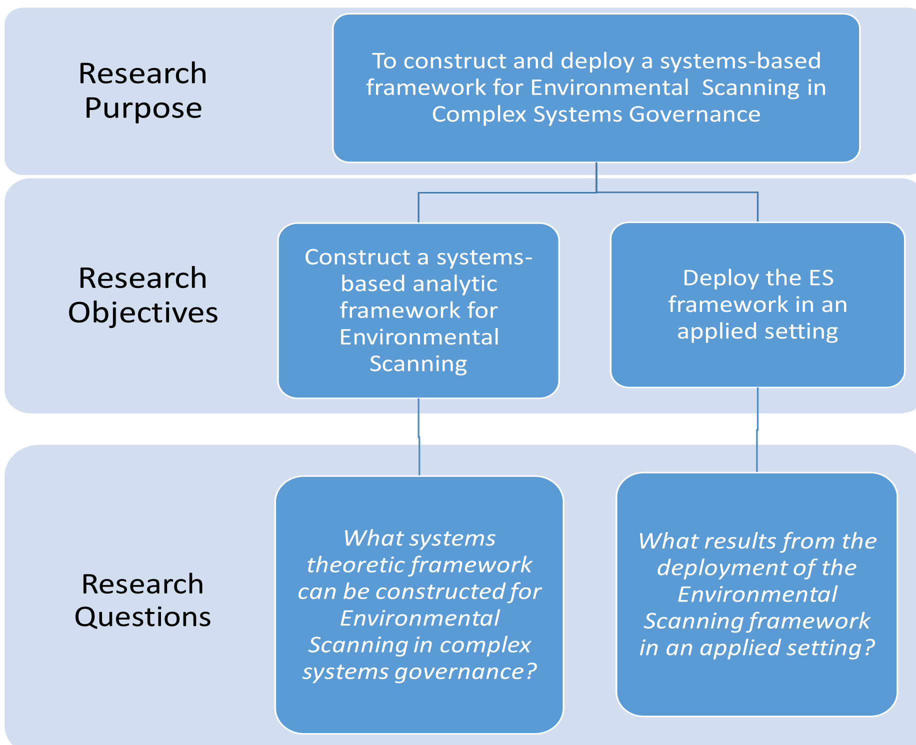
A. *What Systems Theory-based framework can be constructed for Environmental Scanning in Complex Systems Governance?*

B. *What results from the deployment of the Environmental Scanning framework in an applied setting?*

Figure 5 depicts the relationship between the research purpose, research objectives and the research questions.

Figure 5

Research Purpose, Objectives, and Questions



1.5 RESEARCH SIGNIFICANCE AND ORIGINAL CONTRIBUTION

This research builds a framework for the Environmental Scanning function in Complex System Governance based on Systems Theory using an inductive research design. This development of the ES function is expected to be a significant original contribution to several areas of knowledge.

This research fulfills an identified need (literature gap) to provide a Systems Theory-based approach to ES as an essential process in CSG that has implications for the viability of a system (organization). It is also a contribution to knowledge, worthy of publication or dissemination in whole or in part, which could contribute to future development in the evolving field of CSG. This research contributes to the construction of governance principles for the improved viability of systems. CSG is an evolving field where scholarly contributions are necessary for describing, assessing, critiquing and contributing to this field's development. The value of this research resides in identifying a theoretical framework for ES using CSG and Managerial Cybernetic principles that are uniquely contributional. The ES framework, when applied in practical situations, could have the potential to enhance system (business) and organizational viability, possibly leading to organizational longevity, increased profitability and better performance in general. Such improvements could be essential in a rapidly changing environment. System viability improvement is particularly relevant in the face of the rate of environmental change and the shortness of organizational (system) longevity being experienced today (de Geus, 1997).

Finally, as the use of Grounded Theory has not extensively been applied as a research method associated with Systems Engineering and Engineering Management, its use in this study will continue to expand the application of GTMs from their original concept and traditional fields of application. In the social sciences, many researchers use questionnaires, interviews and/or detailed observations as the source of rich data. This research primarily used selected peer-reviewed journal articles as the basis for the authoritative data source. This use of an author's knowledge presented in their scholarly writings is similar to the Sociological Science practice of interviewing, the original basis for Grounded Theory application.

The significance of this research can be succinctly viewed as a scholarly contribution in terms of (1) theoretical, (2) methodological and (3) practical implications. These specific elements of significance are summarized in Table 2.

Table 2

Elements of Research Significance and Element Description

Elements of significance	**Element description**	**Reference**
Literature gap	Demonstrated a gap in subject discipline	Bourner et al., 2001
Theoretical	Contribution to theory, must be original in the literature set	Bourner et al., 2001
Stimulate further studies	Originality of research should be clear enough to induce the asking of further questions	Corbin & Strauss, 1990
Explain a range of phenomena	Avoiding a trivial outcome	Corbin & Strauss, 1990
Methodological	Continue to expand the application of applied methods from their original concept	Corbin & Strauss, 1990
Practical Implications	When applied in practical situations, could have the potential to enhance system governance function.	Baugh, 2015

1.6 RESEARCH LIMITATIONS AND DELIMITATIONS

This section presents the limitations and delimitations that are associated with this research. The limitations and delimitations were developed using the cannons of science, applied to an inductive research methodology, as the baseline for determination. Researchers follow the canons of science as accepted universal norms in the development of credible literature. Bozkurt and Sousa-Poza (2005) identified the universal canons as significance, applicability, consistency, reproducibility, precision, verification/validation, and neutrality. They then further defined credibility, transferability, dependability, and confirmability as the most important characteristics that are suitable to an inquiry-based research philosophy. Table 3 from Bozkurt & Sousa-Poza (2005) lists the attributes associated with the canon characteristics most closely identifiable to qualitative research.

Table 3

Canons of Qualitative Research and Associated Attributes

Canons for a qualitative research paradigm	**Attributes of canon characteristics**
Credibility	• Identification and description of variables • Research participants • Accurate Triangulation • Transparency in analysis • Inductive reasoning
Transferability	• Applicability to other contexts • Purposive sampling
Dependability	• Transparency
Confirmability	• Rigorous documentation

Bozkurt and Sousa-Poza (2005) posit that dependability, which is a determinant of consistency, is probably one of the biggest concerns in qualitative research.

Credibility and dependability in this inductive research, as related to the internal validity of constructivist research, was challenging for this research project, as they are for qualitative research in general. Mitigations to this criticism are presented in in Chapter 3.2.4, 3.5, and 3.8, and focus on the researcher's familiarity with the research topic, applying a rich data base to the research, transparency in the research method, and discipline in applying the GTM that was validated by scholarly peers.

1.6.1 LIMITATIONS

Limitations are influences that generally are beyond the control of the researcher (Theofanidis & Fountouki, 2018). The use of inductive methods of theory building, specifically Grounded Theory, have the issue of dependability and credibility (Bozkurt & Sousa-Poza, 2005). Engineering education researchers appear to strongly prefer quantitative methods (Borrego et al., 2009). Thus, the use of the Grounded Theory method is not extensive to Systems Engineering and Engineering Management. The application of the Grounded Theory method in this research ensured that the design and execution of the research was conducted with an elevated level of transparency. Secondly, the development of the applicable ES framework was transparent and was grounded in the data that was used to develop it. The use of Grounded Theory historically is perceived to impose challenges to the generalizability or transferability of the research (Corbin & Strauss, 1990). Thirdly, the challenges to generalizability can be associated with the positivistic view of limited sample size and a research design that is pre-planned, structured, and bounded by specific rules and questions. The use of Grounded Theory necessitates rigorous documentation of the procedure and the research plan to achieve confirmability (Strauss & Corbin, 1998). Researchers new to this method can apply coding quality guidelines as a checklist to assess the quality of their constructivist grounded theory research (Charmaz & Thornberg, 2021).

The GTM applied in this research utilized peer reviewed journal articles and scholarly book sections in contrast to the more classical use of focused subject interviews. The researcher's ability to interact with the interviewee was not possible. This prevented applied theoretical sampling of data as would conventionally be done. Instead, additional journal articles and scholarly book research were performed to expand on a category of interest. The lack of live interaction reduced the researcher's ability to develop an emerging theme with real-time, focused, additional data. This was mitigated by continually searching for new ES-related literature to be coded, and by pursuing additional literature searches to add detail to new categories as they emerged from the coded data.

Coding in the GTM is traditionally performed line-by-line to capture all the flavor of an interviewee's input. Utilizing journal articles and book sections as opposed to interviews necessitated a different approach than line by line coding, as a significant amount of material in the journal articles and book sections was not relevant to the research topic, e.g., references. A key word search method was substituted for line-by-line coding to reduce the volume of unrelated material to be coded. The outcome of the key word search was further evaluated by the researcher's analysis of surrounding text for relevant context to ensure maximum variational data sampling to be coded. This is a non-traditional Grounded Theory process (applying extant literature in place of live interviews and line-by-line coding) that is unique to the methods used in this research. This could cause concern for the validity of the research methods by Grounded Theory purists who might see this as a limitation to the research. This concern was mitigated by coding an extensive literature database, including emergent journal articles, developing several thousand open codes, and by aggressively applying the constant comparison method to all levels of data to identify both convergent and divergent data categorizations. This criticism is discussed in detail in Chapter 3.

Due to the limited face validation method applied in this research, no claim of transferability of the case study findings can be made to other cases. The purpose of the case study is to simply provide a practical perspective on the research findings for future exploration.

1.6.2 DELIMITATIONS

Delimitations are defined as the boundaries of the research, describing what is included or excluded (Daymon & Holloway, 2011). This research develops a framework for Environmental Scanning in CSG grounded in Systems Theory that will contribute to the advancement and maturity of the CSG knowledge base. It also develops further applications of inductive research methods to system engineering problems. The research was bounded by the constructs resident in Managerial Cybernetics, ES, and Complex System Governance, all of which are based in Systems Theory principles. Other fields of study, such as Economics, which apply ES functions are considered, but did not make up the focus of the data used for theory development. No fields of study were purposefully eliminated from the search for reference material. The full content of the search engines' databases was available to identify relevant research literature. As such, this research did not encompass an end-to-end analysis of-Complex System Governance as might be expected in the application of a systems-based methodology. However, ES functions are an essential part of CSG as indicated in Chapter 2 and provide for a rigorous Systems Theory-based problem formulation.

A major part of this research was the development of a construct that links System Theory to ES within the context of CSG. This construct is a conceptual model for the purposes of problem formulation and does not represent a model of any real-world problem formulation.

This research stops at the development of a theoretical framework. The research does not engage in theory testing or the development of methods, tools, or procedures for application of the theoretical framework in operational settings.

Research Question 2 is intended to only address the face validation setting simply for potential applicability for future exploration with no intent to be a test of the ES framework theory.

This research conforms to a rigorous constructivist Grounded Theory approach primarily from the works of Charmaz (Charmaz, 2014). It is expected that a framework for ES functions in CSG will emerge from this work. Given that a wide spectrum of literature was used to create the research database, it should be anticipated that the emerging ES framework can be applied to social systems.

The reference article search in the literature stream was not bounded by the identified eight fields of study. The eight fields of study identification were an after the fact grouping of related articles based upon the authors' general background.

Qualified, obtainable, and relevant ES literature was considered for coding up to the end of the research period in mid-2021. No new relevant literature discoverable beyond that point in time was included in this research. This could exclude new concepts recently developed.

The purpose of the Likert scale application in this research effort is to support the collection of data from the scholarly peer reviewers about their assessment of the applied GTM process as it was presented in this research effort, there is no intent to apply the Likert scale as a research instrument.

The scholarly peer review process presented in Chapters 3 and 4 is intended to be a limited face validation of the proposed GTM transparency. It is not intended to demonstrate construct validity. The purpose of the graphical data analysis of the reviewers' scores is to develop a simple approach to data triangulation of the reviewer's comments.

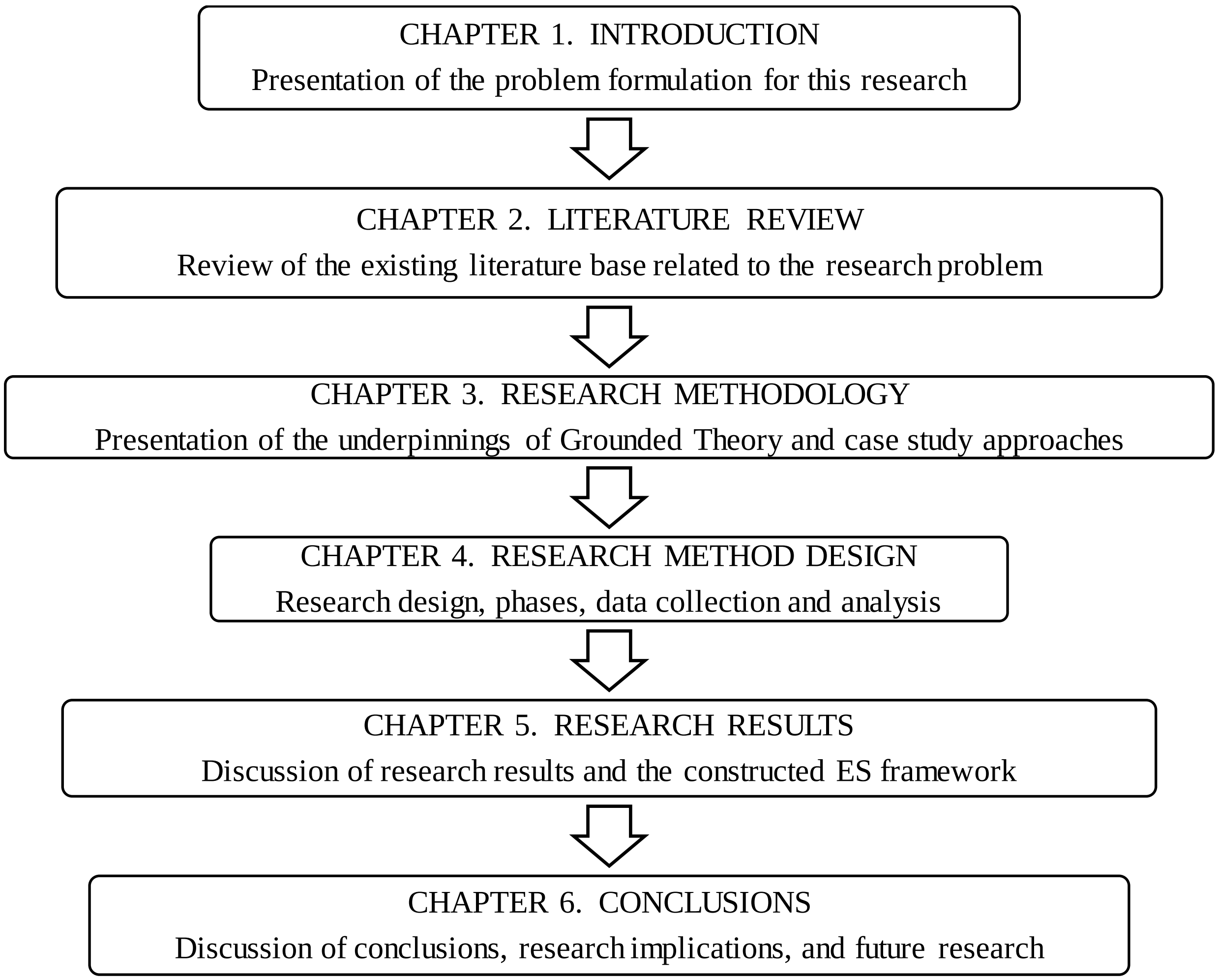
The limited face validation case study is not intended to make any knowledge claims about external validity and transferability of the case study outcomes. The intent of the case study outcomes is the potential applicability for future exploration.

1.7 ORGANIZATION OF THE DOCUMENT

This section provides an overview of the remainder of this document. Chapter 2 is a critique of the literature fields that form the basis for the problem statement. It is the basis for the construction of an ES framework that is grounded in Systems Theory. Chapter 3 presents the research methodology. It describes the research perspective, including theoretical underpinnings, which are necessary to develop the research construct. Case study and constructivist GTMs are discussed. Chapter 4 describes in detail the research method design as it is a unique and non-traditional application of the GTM. Chapter 5 provides a detailed discussion of the results of the research including the relationship between Systems Theory and the problem formulation, the emerging theoretical framework for ES functions in CSG, and the results of applying the theoretical framework in an applied setting. Chapter 6 provides the conclusions and interpretations of the research and the contribution of the research to practice, methods, the body of knowledge, and provides future research directions. Figure 6 depicts the sequence of chapters in the remainder of the dissertation.

Figure 6

Sequence of Dissertation Chapters



1.8 CHAPTER SUMMARY

This chapter provides an introduction to the research effort. It describes the purpose of the study as well as gives a background of the problem under consideration. It gives a description of Managerial Cybernetics, System Theory and CSG development and their intrarelationships to ES functions in CSG. It states the research problem formulation. Two research questions were identified. The significance of the research and its original contribution to the field of study were presented. Research limitations and delimitations were discussed, and the organization of the dissertation was presented. Though the CSG field of study is still maturing, the proposed research in developing an ES framework grounded in Systems Theory has possible significance beyond just a contribution to the evolution of CSG.

Chapter 2 provides a limited review of the body of knowledge on ES. This limited review establishes a gap in the ES function construct that this research addresses.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 1 detailed the purpose of this research and this research's problem formulation as a Systems Theory-based approach to developing ES functions in CSG. This chapter reviews the literature relevant to the problem formulation. It is organized to provide a review of the body of knowledge on Systems Theory, Managerial Cybernetics, CSG, and ES. This review will then be followed by a critique of the literature that leads to defining a credible gap that can be addressed by this research

In order to be significant, one of the essential aspects for academic research is its need to be placed within the context of gaps within the broader context of knowledge that may be reflected in credible literature (Boell & Cecez-Kecmanovic, 2014; Ridley, 2012; Shaw, 2010; Van de Ven, 2007). Ridley (2012) suggests that the multiple purposes of a literature review include: a historical background; an overview of current context in which the research is situated; a discussion of concepts underpinning the research; an introduction to relevant terminology and definitions; and addressing a gap in work in the field of interest that underlies the significance of the research. These purposes will provide the framework for the literature review for this research in Chapter 2.

The purpose of the GTM is to develop a theoretical analysis of the data that is grounded in the data set and that is relevant to the research (Charmaz, 1996). Since the GTM is based upon data, a relevant point of question is what amount of literature should be reviewed prior to the conduct of research. Grounded theorists diverge on the timing of the literature review. "Classic grounded theorists eschew relying on extant theory and enjoin researchers to delay the literature review until they develop their own analyses" (Charmaz & Bryant, 2011, p. 409). The research methodology presented in Chapter 3 is based on constructivist GTMs. Charmaz & Bryant (2011) address the place of the literature review in constructivist Grounded Theory in the excerpt below:

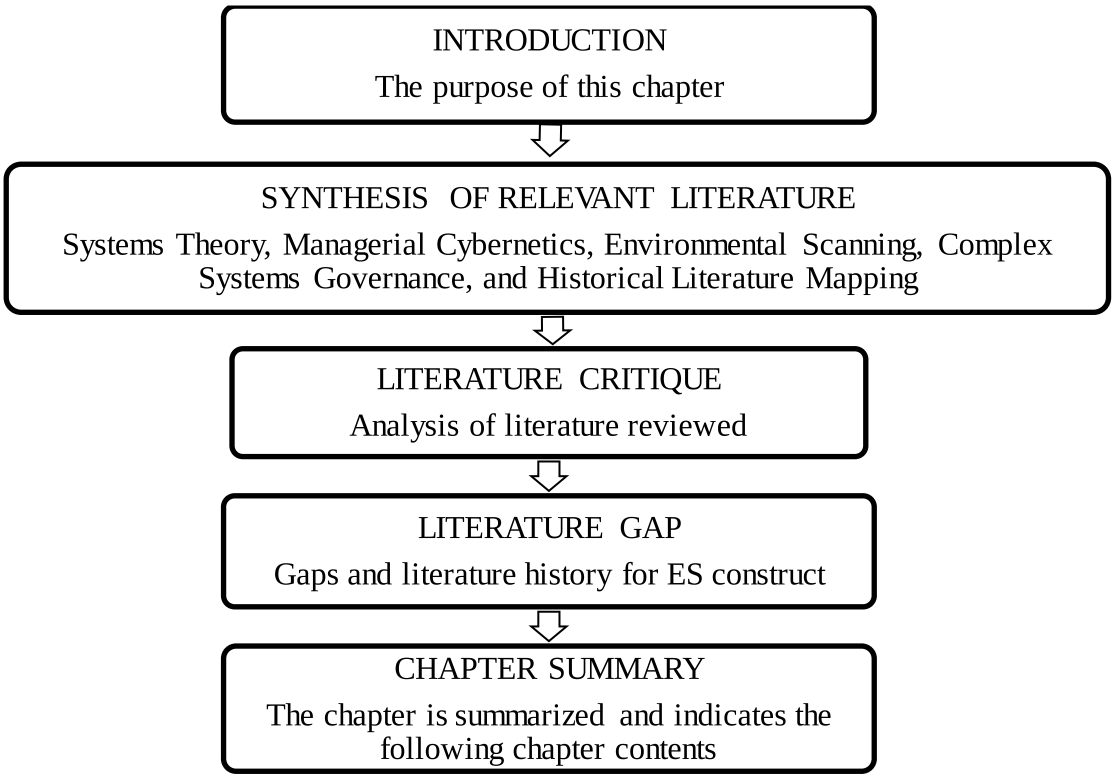
> Constructivist grounded theorists argue that researchers:
>
> 1. already possess a fund of knowledge and experience before they begin;
> 2. may draw on broad ideas from their experience or discipline as starting points for data collection but not as ending points analyses;
> 3. should remain open to the empirical world; and
> 4. must subject all ideas about it to rigorous scrutiny, including their own emerging theoretical notions.
>
> Constructivists position their research in relevant literatures and explain how it advances knowledge. (p. 409)

Given the constructivist view on the literature review in Grounded Theory, this researcher chooses to review the literature to determine where there are existing gaps with respect to ES and to inform the research to develop a familiarity with key topics and concepts.

Figure 7 introduces the layout of Chapter 2. Chapter 2 synthesizes the review of multiple literature fields and analyzes this data to identify a gap in the extant literature that can be filled by new research.

Figure 7

Layout of Chapter 2



2.2 SYNTHESIS OF RELEVANT LITERATURE

Charmaz (2014, p. 306) states that: "The place of the literature review in Grounded Theory research has long been both disputed and misunderstood." Glaser & Strauss (2017) advocated for delaying the literature review to avoid importing preconceived ideas into the research problem. Thornberg (2012) calls for an informed Grounded Theory, in which both the product and process have been thoroughly grounded in the researched data. Charmaz (2014) suggests that the Grounded Theory literature review should challenge the researcher to clarify ideas, make interesting comparisons, begin a theoretical discussion, and show where the research fits in with the relevant literature. In this research, following the model of Charmaz (2014), the literature review was conducted before the GTM was applied, serving to challenge the researcher to clarify ideas prior to Grounded Theory application.

Associated with the choice of a Grounded Theory research method is the question of what data source ought to be reviewed as part of the research. Documents, such as journal articles or books, can provide a significant form of data in Grounded Theory research (Charmaz, 2006). Documents apply to Grounded Theory research because most qualitative research efforts entail analyzing texts. Since documents, like journal articles, have not been shaped by the researcher, they can be seen as objective sources of primary information, presenting what their authors assume as objective facts. Literature that has been authored by credible researchers, peer-reviewed, and is contextually related to the research questions can then be considered primary knowledge (Charmaz, 2006). Charmaz (2006) states that “A major way of using texts is as objects for analytic scrutiny themselves…” (p. 39). Therefore, a careful selection of documents to comprise the research library is fundamental to the credibility of any theories that emerge. The careful document selection also helps when coding and categorizing with the Grounded Theory Method since the emerging analysis can be placed in proper context (Charmaz, 2006).

This researcher chose to review the appropriate literature to determine if there exists a gap in the literature field concerning ES functions in CSG that are grounded in Systems Theory. Literature was found on ES topical material from Systems Theory, Managerial Cybernetics, and mostly from the broadly defined topic of ES. CSG is an emerging field of study and is framed by a small number of recent articles involving ES. This chapter is not a synthesis of all literature. Instead, it is a write-up organized to provide an understanding of the interrelationships of ES in Managerial Cybernetics and CSG (both of which are grounded in Systems Theory), and the extant historical literature on ES. For the purposes of this research, extant historical literature is defined as the literature not related to this researcher's writings and literature that is identified by the applied search engines with no predetermined limitations. This is discussed in more detail in section 5.2.1. The following subsections will provide an overview of Systems Theory, Managerial Cybernetics, CSG, and extant ES literature that will summarize their development, explain their constructs around ES, and demonstrate the opportunity for the development of ES functions that are Systems Theory-based. The purpose of the write-up is to provide the link to the stated research questions.

2.2.1 SYSTEMS THEORY

Systems Theory is the foundation for understanding systems (Adams et al., 2014). "Modern organization theory and general system theory are similar in that they look at organizations as an integrated whole" (Scott, 1961, p. 21). Whitney et al. (2015) suggest that the theoretical basis of Systems Theory is valuable for increasing our understanding of real-world systems. They also state that Systems Theory provides for the improved interpretation for analysis of complex systems. Since Systems Theory is also multidisciplinary in its application (Nielsen et al., 2015), it provides an ideal groundwork for the consideration of complex system governance (Whitney et al., 2015).

Systems theory was considered established as a science by Ludwig von Bertalanffy, Anatol Rapoport, Kenneth E. Boulding, William Ross Ashby, Margaret Mead, Gregory Bateson and several others in the 1950s (Mitchell, 1972). Mitchell (1972) posited that Systems Theory was transdisciplinary in its role and that it "brought together theoretical principles and concepts from ontology, philosophy of science, physics, biology and engineering" (p. 1), and he stated that applications of Systems Theory can be found in numerous fields of study.

Mitchell (1972) goes further to state that the concept of a system has been developed due in a large measure to contributions made by Karl Ludwig von Bertalanffy (1901-1972). One of Bertalanffy's approaches was to look at the empirical universe and to pick out certain general phenomena which are found in many different disciplines, then seek to construct relevant general theoretical models. Bertalanffy's ideas were eventually developed into a General Systems Theory (GST).

Boulding (1956) states that GST "has come into use to describe a level of theoretical model-building which lies somewhere between the highly generalized constructions of pure mathematics and the specific theories of the specialized disciplines" (p. 197). He recognized an increasing need "for a body of systematic theoretical constructs which will discuss the general relationships of the empirical world" (p. 197). Boulding (1956) states that one of the objectives of Systems Theory is to develop a spectrum of theories that performs the functions of a gestalt (an organized whole that is perceived as more than the sum of its parts) in theoretical constructs. Boulding (1956) summarizes GST as "the skeleton of science in the sense that it aims to provide a framework or structure of systems on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge" (p. 208).

Rapoport & Horvath (2009) explore the constraining framework of thought stemming from analytic thinking related primarily to the study of physics. They start their exploration from the perspective that in an attempt to understand complexity, it is simpler to examine the parts as they are more amendable to understanding. They suggest there is an implied hope that it is possible to build up understanding by superimposing the functioning of the various parts. They then challenge this perspective by recognizing that the methods and outlook stemming from biology, approach those of the physical sciences and that the organized complexity of systems may be exemplified by living organisms. They then state that “Cybernetics has shown that a teleological way of thinking is not incompatible with … physical determinism” (Rapoport & Horvath, 2017, p. 74). They conclude that cybernetics show promise in the theoretical underpinnings of organization theory.

Skyttner (1996) states that GST transcends conventional reductionist boundaries and is rooted in the concept of a hierarchy of hierarchies. He defines a system as something that an observer recognizes, the constructivist view of the world, that systems do not exist independent of the observer. Skyttner (1996) cites Boulding (1956) that modern Systems Theory is postulated from five points: order, orderliness, second degree orderliness, quantification is valuable in establishing order, and the search for order embodies the quest for these postulates. Skyttner goes on further to state his view on the agreement on the ten properties that comprise GST. Table 4 summarizes Skyttner’s (1996) ten properties of GST and their definitions.

Table 4

Skyttner's Properties of GST

GST property	GST property definition
Interrelationship and interdependence of objects and their attributes	Necessary for a system
Holism	Holistic properties impossible to detect but should be possible to define in a system
Goal seeking	Systemic interaction must result is some final state being reached
Transformation Process	Systems must transform inputs into outputs

GST property	GST property definition
Inputs and outputs	Open system admits additional inputs from the environment
Entropy	The amount of disorder present
Regulation	System objects must be regulated so that goals can be reached
Hierarchy	The nesting of systems within other systems
Differentiation	Specialized system units perform specialized functions
Equifinality and Multifinality	Open systems have multiple, valid paths to same objective or from same initial state can obtain mutually exclusive objectives

Skyttner (1996) concludes that the roots of Systems Theory rest on old thoughts, and that System Theory's most significant quality is that of a built-in implicit order.

Adams et al. (2014) stated that "systems theory is the foundation for understanding multidisciplinary systems" (p. 120). They proposed an axiom set as a construct of a system. Table 5 summarized from Adams et al. (2014) lists these axioms and their definitions.

Table 5

Systems Theory Axioms and Their Definitions

Axiom	Axiom definition
Centrality	Central to all systems are two pairs of propositions: emergence and hierarchy and communication and control
Contextual	System meaning comes from the circumstances that surround the system
Design	Purposeful imbalance of resources and relationships
Goal	Specific behavior achieved through pathways and means
Information	Systems create, possess, transfer, and modify information

Axiom	Axiom definition
Operational	Must address a system in situ while it is exibiting purposeful behavior
Viability	Key system parameters must be controlled to ensure existence

Adams et al. (2014) stated that the application of Systems Theory to the management of complex systems can provide valuable insight.

Schwaninger (2001) considers Systems Theory and Cybernetics to be a solid basis for transdisciplinarity in management education and research. Velentzas & Broni (2011) provide that Systems Theory is coherent for the study of open systems and their environments: "In the 1950s and 1960s, open systems theory, together with sociological systems theory, was enormously influential in providing a coherent framework for the study of organizations and their environments" (p. 738).

Considerable literature has been developed since the 1960s that examines the relationship between Organizational Theory and Systems Theory (Kahalas, 1977). Kahalas (1977) posits that in open systems where an organization is influenced by its environment, that the organization is not predictable and that its survival is not guaranteed. He further posits that organizational barriers are erected in response to the environmental changes since the environmental input is not entirely controllable. He concludes that Systems Theory may provide "an essential perspective for studying organizations by focusing on the complex interrelationships among organizational variables and by providing a set of concepts useful in describing and analyzing the relationships" (Kahalas, 1977, p. 79).

Jaradat (2015) states that: "Systems thinking is considered to be the basic foundation necessary for individuals to effectively engage in thinking, making decisions, and constructing coherent interpretations concerning critical system governance issues and how they might be effectively approached" (p. 60). He posits systems thinking as foundational to system governance. Adams et al. (2014) relate systems thinking to Systems Theory, thus underpinning system thinking with Systems Theory.

Krippner & Laszlo (1998) describe a system as "a complex of interacting components together with the relationship among them that permit identification of a boundary-maintaining entity" (p. 1). They posit that "since social and psychological phenomenon tend to resist quantitative modeling … alternative approaches must be relied upon" (Krippner & Laszlo, 1998, p. 1), and they suggest that Systems Theory is one such approach. They recognize the Systems Theory contributions of Bertalanffy (1968), Rapoport (1968), and Boulding (1956) among others and suggest that the advantage of Systems Theory is "its potential to provide a trans-disciplinary framework for a simultaneously critical and normative exploration of the relationship between our perceptions and conceptions and the worlds they purport to represent" (Krippner & Laszlo, 1998, p. 4). They suggest that Systems Theory can provide a platform for the integrated study of complexity and that it pertains to both epistemological and ontological situations. Their systems design construct seeks to assess a complex system as a "system of interconnected, interdependent, and interacting problems that involve complex combinations of fields, and the multifaceted situations to which they give rise require a holistic approach for their solution" (Krippner & Laszlo, 1998, p. 4). They posit that Systems Theory provides an approach to assessing complexity and that Systems Theory can be considered as a field of inquiry.

Keating & Katina (2019) present the contributions of Systems Theory to CSG. A summary of their development of Systems Theory contributions to CSG is presented in Table 6.

Table 6

Systems Theory Contributions to CSG

Systems Theory contribution to CSG	**Description of contribution**
Response to inabilities of reductionist views	Account for behavior of complex systems
Holism	Knowledge is subjective and observer dependent
Different level of thinking	Based on understanding systems' behaviors from non-traditional reductionist views
A common platform for understanding the behavior of all systems	A basis for a common frame of reference for universally applicable principles
A strong theoretical grounding	A set of axioms and propositions that describe the behavior of complex systems
Provides the integration and coordination necessary to ensure system viability	Provides seven system axioms that organize Systems Theory principles

Keating and Katina (2019) state that the recent depictions of Systems Theory can generally be attributed to the authors Rapoport, Weiner, Bertalanffy, Ashby (Klir, 1972), and Krippner & Laszlo (1998).

Table 7 is a synthesis of the key points on Systems Theory from the works of the authors reviewed in Table 7.

Table 7

Synthesis of Systems Theory Literature Reviewed

Author	**Key points**
Adams, et al., 2014	• Foundation or understanding systems • Look at organizations as integrated wholes
Whitney, et al., 2015	• Understanding real-world systems • Provides for analysis of complex systems
Mitchell, 1972	• Transdisciplinary

Author	Key points
	• GST development attributed to Bertalanffy
Boulding, 1956	• Theoretical model building • Gestalt of theoretical constructs • Structure of a system
Rapoport & Horvath, 1959	• Living organisms may exemplify complex systems • Cybernetics shows promise in underpinning organizational theory
Skyttner, 1996	• GST transcends reductionist boundaries • Five points of systems theory from Boulding • Identifies 10 properties of GST • Most significant quality is built-in implicit order
Adams, 2012	• Foundation for understanding complex systems • Proposed a seven-axiom set to describe • Can provide valuable insight to complex systems
Schwaninger, 2001	• Considers ST related to cybernetics for transdiciplinarity
Velentas & Broni, 2011	• Coherent for study of open systems and their environments
Kahalas, 1977	• An essential perspective for studying complex organizations
Jaradat, 2015	• Relates systems thinking to system governance
Krippner & Laszlo, 1998	• ST is an approach to analyzing complex systems • Transdisciplinary • Holistic approach to analysis
Keating & Katina, 2019	• ST contributes significantly to CSG

From the synthesized key points of view on Systems Theory in Table 7, it can be seen that Systems Theory is the foundational field from which Cybernetics and CSG have been developed, that it is foundational to analyzing complex systems, that it is multidisciplinary in its application, and that it is relevant for the study of open systems and their environments.

This research will focus on how ES functions in CSG. Both CSG and Managerial Cybernetics (on which CSG is based) can be seen to be grounded in Systems Theory. There exists then, a close relationship between ES functions in CSG and Systems Theory. It is appropriate, then, that Systems Theory is used as the basis for developing a framework for ES in CSG, which is the purpose of this research.

2.2.2 MANAGERIAL CYBERNETICS

Cybernetics is defined by Beer (1981) as the science of control. Cybernetics is "concerned with general patterns, laws and principles of behavior that characterize complex, dynamic, probabilistic, integral and open systems" (Clemson, 1984, p. 19). Cybernetics highlights the existence of holistic behavior patterns in a system of interest. Beer (1979) describes a system as consisting of a group of elements related in time to each other, according to some coherent pattern. According to Beer (1979), the laws of cybernetics are founded around three supporting laws which are the self-organizing systems law, the feedback law, and the law of requisite variety. The self-organizing system law is "Complex systems organize themselves; the characteristic structural and behavior patterns in a complex system are primarily a result of the interactions among the system parts (Clemson, 1984, p. 26). The feedback law is "The output of a complex system is dominated by the feedback, and, within limits, the input is irrelevant" (Clemson, 1984, p. 24). The law of requisite variety is "Given a system and some regulator of that system, the amount of regulation attainable is absolutely limited by the variety of the regulator" (Clemson, 1984, p. 36). The law of requisite variety highlights the importance of continuous interactions between the system, its environment, and the regulator. Ashby's Law describes the conditions under which a complex system can be externally or internally controlled (Espejo & Harnden, 1989). Control stems from the ability/inability to manage system variety. Understanding these conditions under which complex systems can be controlled is an underpinning for the understanding of how Beer's (1979) VSM works. Cybernetics, as a science of control, examines the system holistically, not just its individual parts (Beer, 1981). The cybernetic basic laws and the law of requisite variety described above form the foundations used for the VSM.

Beer's (1979, 1981, 1984, 1985, 1994) work in managerial cybernetics resulted in a model for viable systems that can be used to assess and evaluate complex system performance for the understanding and the redesigning of the complex systems (Espejo & Gill, 1997). Beer's (1979, 1981, 1984, 1985, 1994) work on the VSM has stood with minimal debate for many years (Espejo & Gill, 1997).

In *Brain of the Firm*, Beer (1981) intended to unearth the laws underpinning the viability of systems. His purpose was to understand how systems could be capable of independent existence (viability) in a changing environment. The VSM is the realization of Beer's (1981) aim. It emerged first in *Brain of the Firm* from a comparison of brain functions and management structures (Beer, 1981). In *The Heart of Enterprise*, the VSM was built from the bottom up from cybernetic foundational principles (Beer, 1979). In the VSM, Beer (1979) summarizes the cybernetic laws he sees as underpinning system viability and he demonstrates their interrelationship. A system is considered viable "if it is capable of responding to environmental changes even if those changes could not have been foreseen at the time the system was designed" (Jackson, 1988, p. 559). A system must achieve requisite variety with the complex environment it faces to remain viable (Ashby, 1958). It must be able to respond appropriately (achieve requisite variety) to the various threats and opportunities presented by its environments, both internal and external. The balance of varieties (requisite), both internal and external, is determined by the purpose the system is designed to pursue. Beer (1979) identifies a set of strategies that can be employed by managers (Managerial Cybernetics) to balance system variety. These strategies involve what Beer (1979) identifies as variety engineering. The VSM can then be seen as a model to work out of the implications of Ashby's (1958) law of requisite variety, where Ashby's Law describes the conditions under which a complex system can be controlled.

The basic VSM is constructed as an arrangement of five functional elements, which Beer (1994) identifies as systems 1-5 (S1-S5). These five systems are then connected by a complexity of information and control loops. A key aspect of the VSM is multiple recursions (layers) of the same basic model that can then be used to represent any system or subsystem of interest. A brief description of the VSM's systems 1-5 from (Jackson, 1988) is summarized in Table 8 and presented in model form in Figure 8 summarized from Beer (1979).

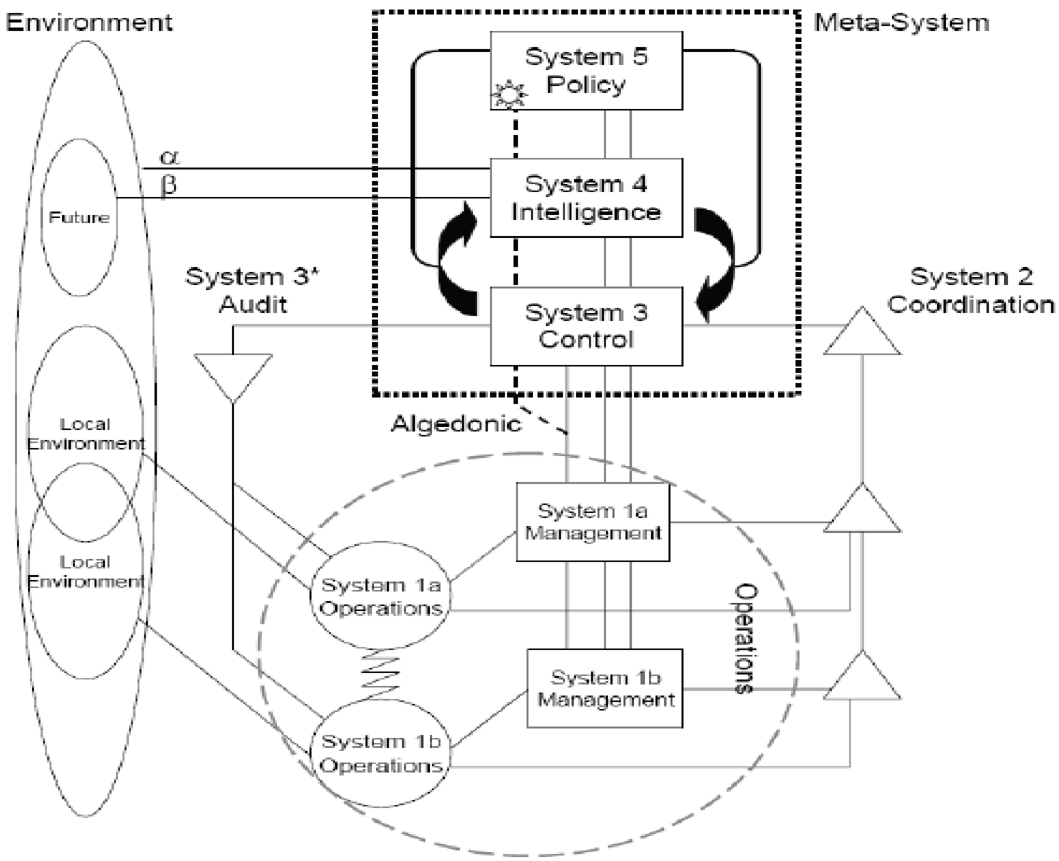
Table 8

Summary Description of the VSM

VSM Function	Function description	Function purpose
S1	System autonomous operational unit	Produce what the system offers, absorb variety, each a recursive unit of the larger system
S2	Coordination	Necessary to ensure the elements making up S1 act in harmony with each other
S3	Control	A control function responsible for the internal stability of the system
S4	Intelligence	Captures for the system all relevant information about its internal and external environment
S5	System Identity	Responsible for system policy, represents the essential qualities of the entire system to any wider system of which it is a recursive part

Figure 8

Summary Model of the VSM



Beer (1981) identified S4 most closely with system intelligence. This function has been defined as making sense of external changes and proposing innovative directions for the organization of interest based on its current condition (Sung et al., 2008). System four provides strategies that are future-oriented, helping the organization (system) under study adapt to environmental changes (Ahmad & Yusoff, 2006). S4 functions this way so that the organization "can invent its future (as opposed to being controlled by the environment)" (Espejo & Gill, 1997,

p. 4). ES is integral to this function (Clemens, 2009). However, there is little research available as to the "how" and "why" ES operates in the system governance function to make sense of rapidly changing and unknown environments to support this intelligence function. The VSM provides a framework for assessing organizational systemic strengths and weaknesses, but is currently underutilized for business analysis (Brocklesby & Cummings, 1996). This situation presents an opportunity to construct ES concepts for system viability in CSG that are grounded in Systems Theory.

2.2.3 ENVIRONMENTAL SCANNING

Scanning the Business Environment (Aguilar, 1967) is generally considered the seminal literature on Environmental Scanning (Choo, 1993). Before this book, scanning was recognized as simply a search for all identifiable scanning activities. Aguilar (1967) was the first to describe the what, where, and how relevant information about events outside a company can guide the company's future course of action. ES has been recognized as an important role in today's businesses to help organizations reduce their chances of being blind-sided into poor or reactive performance (Albright, 2004). Though many organizations recognize the importance of ES, "past studies indicate that very few organizations have adopted a systematic and structured approach to this task" (Subramanian et al., 1993, p. 272). Fahey & King (1977) go further to explain that their findings support the conclusion that organizations recognizing the need for ES do not yet have sophisticated systems and have not integrated their outputs into the strategic planning process. ES seeks social, technological, environmental (biosphere), economic and political information, across international, national and local domains, relating to the future viability of an organization and its success in meeting its strategic objectives (Morrison, 1985). Subramanian et al. (1993) found support for a relationship between scanning systems and performance in FORTUNE 500 companies, but they also concluded a better perspective is needed in scanning practices and the relationship that exists between ES and organizational performance. Stanwick et al. (1991) researched marketing literature and concluded that "organizations need to adapt to their environment to survive" (p. 106). They suggest that marketing literature has failed to analyze how information about the environment is perceived and analyzed by organizational decision makers. They present a framework for identifying how ES is influenced by the degree of change in the environment and by the capabilities of the organization to adapt to its environment. This framework was developed mainly from the organizational strategy literature. There is recognition that ES capability is related to organizational viability, but there is little consideration given to Systems Theory in the framework basis. Albright (2004) defines ES, explains why it is vital to an organization's strategic planning process and describes some of the processes involved in ES. The basis for her article stems from information sciences perspectives. She describes five basic steps of an organizational ES process. These five steps in the ES process are summarized in Table 9.

Table 9

Five Steps in a General Environmental Scanning Process

Step number	**Step function**	**Step description**
1	Identify the environmental scanning needs of the organization	Identify purpose, participants, time frames, process, and resources for scanning
2	Gather the information	Translate system needs into specific items of information, select sources
3	Analyze the information	Analyze data for issues and trends influencing the system

Step number	Step function	Step description
4	Communicate the results	Report analyzed and translated information to decision makers
5	Make informed decisions	Take action to position the system to be responsive to the identified opportunities or threats

These steps were derived from observations in the information management field of study. Albright (2004) recognizes the value of ES to an organization's planning process by helping to increase its flexibility and responsiveness in decision making. There is no consideration given to Systems Theory principles. Yasai-Ardekani & Nystrom (1996) recognize that ES is essential to organizational success by supporting adaptive capabilities. They attribute the need for ES to organizations operating as open systems. The focus of their research is on the contingency theory of organizational design to develop the ES processes in an organization. The basis of their research is found in the organizational sciences field of study. Their research indicates a need for requisite variety in scanning processes, but they attribute this need to organizational size and structure and relate its outcome to organizational success. They do not recognize this concept as a principle in Systems Theory. Less than 400 peer-reviewed articles could be found on ES from a topical search on Elsevier's Engineering Village® (see charts in Appendix A). The general topic of ES is not well-developed, is not focused in any one field of study, and has not been extensively developed. These conditions make it susceptible to further development. Table is a synthesis of each different field of study, related references, and that field's description of ES. Table 10 demonstrates both the common and divergent views of ES from each field of study's perspective.

Table 10

Synthesis of Literature for Environmental Scanning Functions

Field of study	**ES elements**	**References**
Business Management	Collection of information about events; interpret information for strategic planning	Beal, 2000; D'aveni, 1989; Kelly, 1997; Mayer, et al., 2013; Ojo & Abdusalam, 2011; Wambua & Omondi, 2016
Cybernetics	Adapting to environmental change; predicting the future; adaption for viability	Ashby, 1956; Beer, 1994; Beer, 1981; Heylighen, 1992; Heylighen & Joslyn, 2001; Nechansky, 2013; Pickering, 2002
CSG	Design, deploy, monitor for sensing of environment for both present and future system viability	Baugh, 2015; Calida 2013; Carter, 2016; Keating, et al. 2014; Walters et al., 2014; Keating & Bradley, 2015
Information Science	Assess strength and weakness in support of future plans; influence decision making processes	Abels, 2002; Choo, 1999; Maier, et al., 1997
Management	Perceive environment and respond; spotters; keep abreast of happenings; gather data about events	Ackoff, 1967; Elenkov, 1997; Leonard, 2000; Milliken, 1987; Samsami, et al., 2015; Saviano & Di Nauta, 2011
Marketing	Learning about events to cope with environment; adapt to changing conditions at leadership level; stay competitive	Frazier, 1983; Saxby, et al., 2002; Stanwick et al., 1991; Sptiz & Ludlow, 2015
Planning	Criteria based screening of information; futurism; foresight; discern information from signals; create understanding for decision making; systemic collection of external information to reduce randomness; detecting trends for strategic planning	Bryson, 1988; Clemens, 2009; Fahey & King, 1977; Fahey, et al., 1981; Kahalas, 1977, Silverblatt & Korgaonkar, 1987
Political Science	Detect trends and developments that could shape the future	Bouhnik & Giat, 2015; Clemens, 2009; D'aveni, 1989; Daft, et al., 1988; Tversky & Kahneman, 1986; Zheng & Carter, 2015
Systems Theory	Sensing of environment for implications of both present and future system viability	Ackoff, 1974; Espejo, 1994; Ireland, 2014; Keating & Katina, 2011; Richardson, 2004; Thomas, 1980; Thompson, 2005; Von Bertalanffy, 1972; Waelchlif, 1992; Whitney, et al., 2015

Field of study	ES elements	References
Futurism	Anticipate an organization’s knowledge of the future; define status quo; define preferred state; commit logical and predictable actions	Beer, 1979; Conway, 2009; Dunagan, 2012; Fahey et al., 1981; Slaughter, 2002, 2006; Voros, 2003

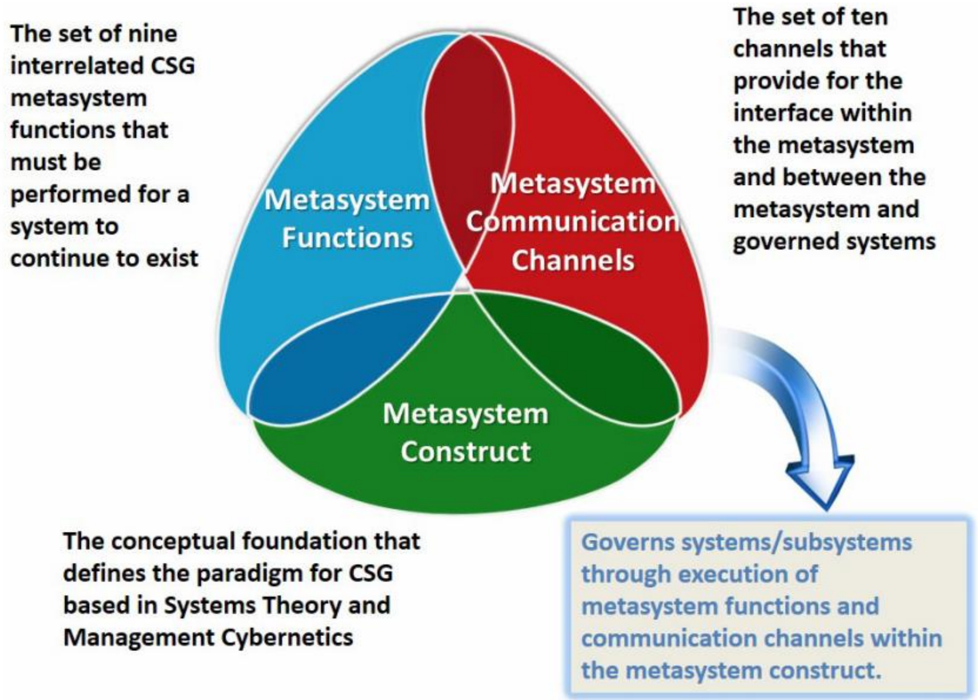
In summary, a review of the existing ES literature indicates that writings on this topic are relatively few, are diverse from their respective field of study viewpoints, are not grounded in any one perspective and have multiple definitions and applications of how ES functions. The application of the ES function is CSG is developmental. There are only several articles written that involve the ES function in governance of complex systems. The review of ES related literature indicates that constructing a Systems Theory-based study of ES as it functions in CSG would be contributory to the CSG emerging field.

2.2.4 COMPLEX SYSTEM GOVERNANCE

Keating (2014a) posited that development of the System of Systems Engineering (SoSE) field could be enhanced through the inclusion of complex system governance and the underlying Systems Theory upon which that field is developing. CSG is not a new concept. However, the grounding of the governance functions in Systems Theory and Managerial Cybernetics represents an emerging paradigm (Keating, 2014a). The metasystem from Managerial Cybernetics is the integrating and coordinating set of functions that provides for the function of the complex system of systems as a unitary system (governance) (Keating, 2014a). The metasystem governor and this emerging paradigm are primary considerations of SoSE in the integration and coordination of multiple complex systems (Keating, 2014a). Keating & Katina (2016) describe the four fundamental elements of CSG as shown in Figure 9.

Figure 9

The Four Fundamental Elements of CSG (used with author permission, C.B. Keating correspondence 11/22/22)



These four elements are the set of metasystem functions, the metasystem construct grounded in Systems Theory and Managerial Cybernetics, the metasystemic communication channels, and the governed systems/subsystems. At the intersection of these four elements, CSG is focused on the design, execution, and evolution of essential system functions (Keating &

Katina, 2016). At the most basic level, the metasystem keeps the system of interest from collapsing from external pressures. It keeps the system from separating in the face of increasing environmental complexity. Proficiency in execution of these essential functions, which include ES, ultimately determines the level of system performance (Keating & Katina, 2016).

Keating et al. (2014) describe CSG as an emerging field that is still developmental. They posit that CSG development is necessary to address contemporary complex system problems, bridge the divide between hard and soft technical aspects of complex systems, and to identify the conditions that characterize landscapes faced in modern complex systems. From works in Managerial Cybernetics and Systems Theory, they identify two critical elements that are foundational in CSG: holism and requisite variety. From these two critical elements, they posit nine functions as meta-systemic elements of CSG. They describe the metasystem as a set of nine interrelated, higher-level functions, which provide for the governance of complex systems. One of the nine functions is identified as ES. It is "focused on sensing the environment for circumstances, trends, patterns, or events with implications for both present and future system performance" (Keating & Bradley, 2015, p. 7). This description of ES in CSG metafunctions is grounded in Systems Theory principles since CSG is grounded in Systems Theory and Managerial Cybernetics. Keating & Bradley (2015) identify several critical challenges for CSG deployment. One of the challenges is organizational competence for systems-based applications, which is the relevant organization's ability to develop the requisite knowledge, skills, and abilities for engaging in systems-based behavior. ES, in this construct, is an essential application for organizational competence (viability) from a Systems Theory perspective. They conclude that developments in CSG might help in addressing the absence of a foundational theoretical grounding (Keating & Katina, 2016). This theoretical grounding could then assist in identifying areas that can feasibly improve system performance. Development of ES functions as part of CSG, grounded in Systems Theory, could then lead to improved system performance.

Adams et al. (2014) proposed a unified group of specific propositions from Systems Theory to form the construct of a system. Among those that are relevant to the governance of complex systems are communication, control, emergence, hierarchy, darkness, holism, viability, self-organization, recursion, and requisite variety. From this work, significant Systems Theory background is present to develop a more detailed approach to understanding the construct of ES in CSG.

From the literature reviewed, Table 11 is a summary of what is known and what remains to be developed about ES.

Table 11

Summary Table of Literature Key Themes and Gaps

Literature synthesis summary-known	**References**	**Gaps in the reviewed literature-unknown**
1. Importance of the ES function to organizational decision making	(Stanwick et al., 1991)	1. What is an ES framework from a Systems-Theoretical perspective
2. Rapidly increasing rate of environmental change	(Thomas, 1980)	2. No framework for improving ES in CSG in support of organizational viability
3. The relationship of an open system to its surrounding environment	(Kahalas, 1977)	3. No framework for how ES contributes to the CSG function
4. The role of ES in the governance metasystem	(Keating & Bradley, 2015)	4. How the ES function acts to meet requisite variety within an organization
5. ES functions in a marketing and business development framework	(Babatunde & Adebisi, 2012)	5. No framework for ES functionality to improve system governance

Literature synthesis summary- known	**References**	**Gaps in the reviewed literature- unknown**
6. ES as a function in managerial cybernetics	(Beer, 1981)	6. No framework for ES to be optimized in support of command and control in CSG
7. ES functionality is related to system viability	(Nechansky, 2013)	7. How can the ES function in CSG be optimized to improve system viability
8. ES is a vital part of future planning in large corporations	(Thomas, 1980)	8. No framework for improving the effectiveness of the ES function in CSG in support of corporate planning
9. ES is often perceived as an analytical, rational, practical practice in organizations, which is not broad enough to deal with all the relevant signals in a changing environment	(Voros, 2001)	9. This paper suggests a framework for improving ES that is grounded in the psychology of intelligence; there is no basis for grounding in Systems Theory considered
10. A method is needed which enables administrators to integrate understanding about various interrelated sectors of the external environment, a capacity to translate this understanding into an institution's planning activity, and a sufficient priority given to the activity to ensure its translation into decisions and implementation	(Morrison, 1988)	10. This report states that ES has stimulated a new approach to planning while the methodology is still developing. The case study is about a continuous environmental scanning project that attempts to identify signals of change in all sectors of the external environment. The study recognizes difficulties with ES in communication, time-response, and decision making, but offers no approach to improving these issues, and does not recognize a CSG function
11. Costa defines the concepts of and importance of systematic ES processes, and their role in the effectiveness or organizational strategic planning	(Costa, 1995)	11. Costa states that to be successful, ES activities must be linked to the strategic planning process. He grounds these processes in practical, systematic steps based upon strategic planning and executive decision-making. There is no study of Systems Theory involved or recognition of ES in CSG functions
Synthesis Summary		Literature is fragmented, some redundancy of language is used, lack of rigorous research and unusual designations, most research efforts on practical side, absence of tools, no consistent philosophical basis, no

Literature synthesis summary-known	References	Gaps in the reviewed literature-unknown
		recognition of a framework for ES in CSG

From the literature reviewed, there is no philosophical, consistent, researched, and documented approach to the functioning of ES in CSG. There is minimal literature developed on the ES function, particularly in the last six years, and there is no expansive study of ES that is grounded in Systems Theory. Managerial Cybernetics and CSG both address ES as a critical function, but fall short of fully developed, practically applicable ES functions in CSG. This gap in the literature provides a unique opportunity to develop a detailed and practically applicable Systems Theory-based framework for ES functions in CSG that could advance the CSG field of study.

2.2.5 HISTORICAL LITERATURE MAPPING

The Old Dominion University's National Centers for System of Systems Engineering (NCSoSE) is a pioneering organization in the development and application of Systems Theory to CSG. The last several years of their efforts have identified and cataloged foundational works that are common building blocks for the development of CSG. These building blocks have then been integrated into CSG research from several different perspectives but remain foundational. Figure 10 portrays these foundational research building blocks in the literature and shows how those literary works are interrelated thematically. The historical literature components for the ES function are displayed in their specific "swim lane" as labeled (shaded boxes). The black curved lines show notionally how the literature building blocks in the other related fields of study: Managerial Cybernetics, CSG, and Systems Theory, are interrelated to the ES literature. The call-out boxes summarize key concepts in the literature development swim lanes. The smaller, numbered blocks in each swim lane link to the legend below Figure 10 which summarizes the key literature articles at that point on the timeline. These literature building blocks and their interrelationships provide the conceptual basis for developing a framework for ES that is grounded in Systems Theory.

Constructing the literature framework is fundamental to providing the foundations for the ensuing research.

Figure 10

Historical Literature Components for the Environmental Scanning Function

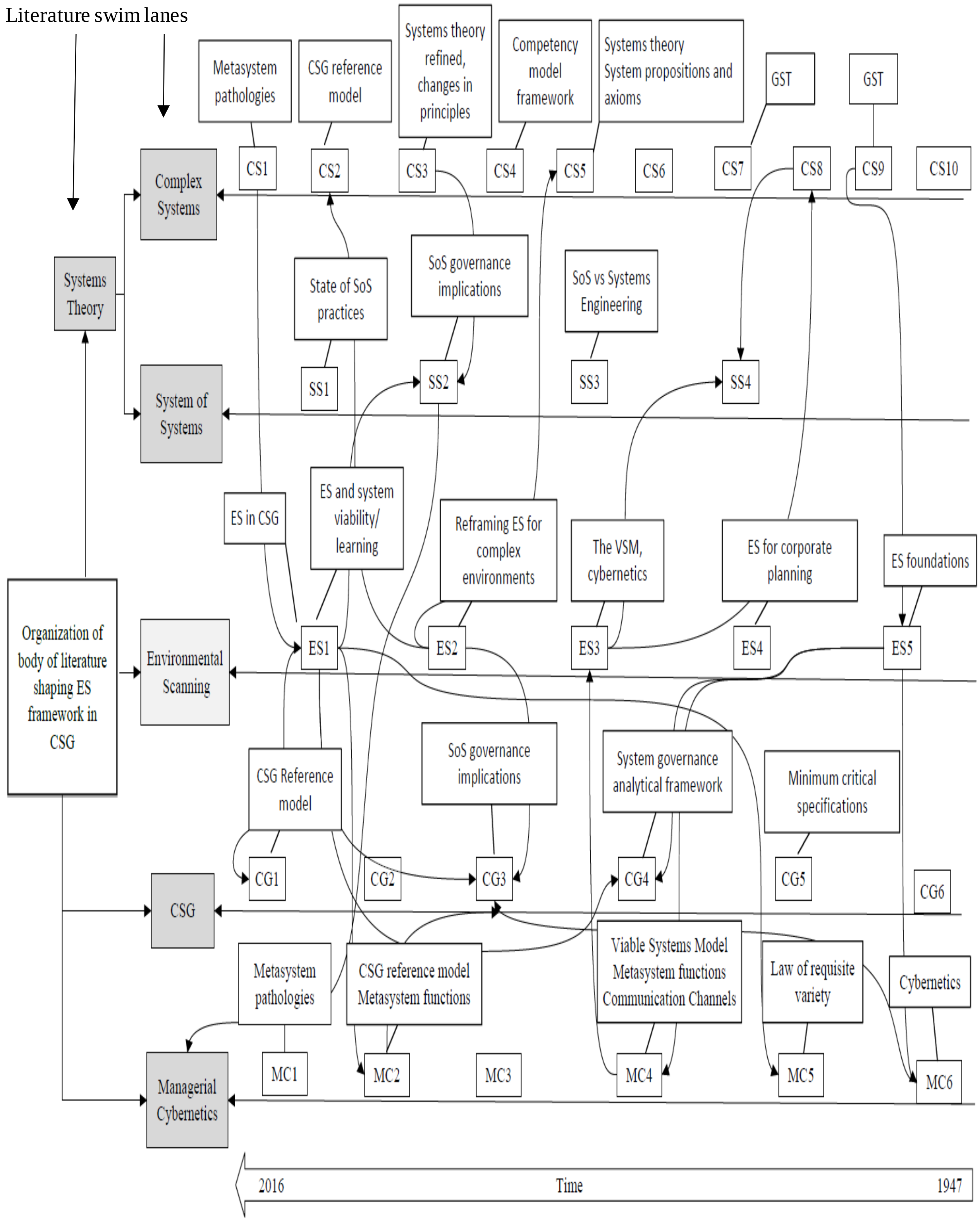


Figure 10 Legend	
Timeline elements	**References**
Complex systems	
CS1	(Katina, 2015)
CS2	(Keating & Bradley, 2015) (Keating et. al, 2014)
CS3	(Whitney et al., 2015)
CS4	(Bradley, 2014)
CS5	(Adams et al., 2014) (Keating, 2014b)
CS6	(Newman, 2006)
CS7	(Skyttner, 1996)
CS8	(Ackoff, 1971, 1974, 1981) (Beer, 1979) (Checkland, 1981, 1985, 1993) (Cherns, 1976, 1987) (Cilliers, 1998) (Jackson, 1988) (Jackson & Keys, 1984) (Flood & Jackson, 1991) (Keating et al., 2003; Keating, Rogers, et al., 2003) (Krippner & Laszlo, 1998) (Richardson, 2004) (Kickert & van Gigch, 1979)
CS9	(Von Bertalanffy, 1950, 1968, 1972)
CS10	(Ashby, 1947, 1956)
System of systems	
SS1	(Nickerson et al., 2012) (Walters et al., 2014)
SS2	(Keating, 2014a)
SS3	(Keating et al., 2008; Keating et al., 2003)
SS4	(Beer, 1979) (Checkland, 1981, 1999) (Flood & Carson, 1993) (Weinberg, 1975)
Environmental Scanning	
ES1	(Choo, 2001, 2003) (Albright, 2004) (Andriani & McKelvey, 2007) (Babatunde & Adebisi, 2012) (Ashby, 1958)
ES2	(Subramanian et al., 1993) (Yasai-Ardekani & Nystrom, 1996) (Choo, 1999) (Slaughter, 1999)
ES3	(Beer, 1984)
ES4	(Fahey et al., 1981) (Hambrick, 1981) (Hambrick, 1982) (Jain, 1984) (Daft et al., 1988)
ES5	(Aguilar, 1967)
Complex System Governance	
CG1	(Keating & Bradley, 2015) (Keating et al., 2014)
CG2	(Carter, 2016)
CG3	(Keating, 2014a)
CG4	(Calida, 2016) (Djavanshir, 2000)
CG5	(Cherns, 1976, 1987) (Vasconcelos & Ramirez, 2011)
CG6	(Von Foerster & Zopf, 1962)
Managerial Cybernetics	
MC1	(Katina, 2016)
MC2	(Keating & Bradley, 2015) (Keating et al., 2014)
MC3	(Espejo & Harnden, 1989) (Flood & Jackson, 1991) (Keating, 2000) (Keating et al., 2001)
MC4	(Beer, 1979, 1981, 1984, 1985)
MC5	(Ashby, 1956, 1958)
MC6	(Weiner, 1948)

2.3 LITERATURE CRITIQUE

The initial reading of literature was prompted by Systems Engineering class work and by participation in the ODU Engineering Management and Systems Engineering CSG Learning Community discussions and presentations. These early efforts were concentrated on articles associated with the topics: viable systems model, requisite variety, ES, Beer's works in Managerial Cybernetics, CSG development, and Systems Theory. These early efforts provided a fundamental understanding of the topics and linkage to potential research questions. Table 12 is a tabular representation of the streams of the topics from the literature that lead to identified gaps and to the formulation of the research problem.

Table 12

Summary Table of Literature Key Themes and Gaps

Literature key themes summary	References	Gaps in the reviewed literature
Importance of the ES function to organizational decision making	(Stanwick et al., 1991)	What is an ES framework from a Systems-Theoretical perspective
Rapidly increasing rate of environmental change	(Thomas, 1980)	No framework for improving ES in CSG in support of organizational viability
The relationship of an open system to its surrounding environment	(Kahalas, 1977)	No framework for how ES contributes to the CSG function
The role of ES in the governance metasystem	(Keating & Bradley, 2015)	How the ES function acts to meet requisite variety within an organization not discussed
ES functions in a marketing and business development framework	(Babatunde & Adebisi, 2012)	A framework for ES functionality to improve system governance is not addressed
ES as a function in managerial cybernetics	(Beer, 1981)	A framework for ES to be optimized in support of command and control in CSG is not addressed
ES functionality is related to system viability	(Nechansky, 2013)	How can the ES function in CSG be optimized to improve system viability

Literature key themes summary	References	Gaps in the reviewed literature
ES is a vital part of future planning in large corporations	(Thomas, 1980)	A framework for improving the effectiveness of the ES function in CSG in support of corporate planning is not addressed
ES is often perceived as an analytical, rational, practical practice in organizations, which is not broad enough to deal with all the relevant signals in a changing environment	(Voros, 2001)	This paper suggests a framework for improving ES that is grounded in the psychology of intelligence, there is no basis for grounding in Systems Theory considered
A method is needed which enables administrators to integrate understanding about various interrelated sectors of the external environment, a capacity to translate this understanding into an institution's planning activity, and a sufficient priority given to the activity to ensure its translation into decisions and implementation	(Morrison, 1988)	This report states that ES has stimulated a new approach to planning while the methodology is still developing. The case study is about a continuous environmental scanning project that attempts to identify signals of change in all sectors of the external environment. The study recognizes difficulties with ES in communication, time-response, and decision making, but offers no approach to improving these issues, and does not recognize a CSG function
Costa defines the concepts of and importance of systematic ES processes, and their role in the effectiveness or organizational strategic planning	(Costa, 1995)	Costa states that to be successful, ES activities must be linked to the strategic planning process. He grounds these processes in practical, systematic steps based upon strategic planning and executive decision-making. There is no study of Systems Theory involved or recognition of ES in CSG functions
Synthesis Summary		The ES literature is fragmented, some redundancy of language is used, there is a lack of rigorous research and unusual designations, most research efforts exist on the practical side, there is an absence of tools, no consistent philosophical basis, no recognition of a framework for ES in CSG

Though ES has been addressed in multiple fields of study, none of these areas has focused on the rigorous exploration of ES from a Systems Theory-based perspective.

The outcome of the literature review is that the extant literature describes how ES functions in business strategy, how it is performed in business scenarios as it has developed over time, and how the results of its performance can impact business longevity (viability). Wong & Hung (2012) performed extensive research on ES literature to establish research propositions to fill gaps in the ES literature. They concluded that ES research has expanded over time and evolved in three distinctive phases. See Table 13 based on work from Wong & Hung (2012). None of these areas focused on exploring the ES functions from a Systems Theory-based perspective.

Table 13

Environmental Scanning Literature History

Phase	**Time frame**	**Characteristics**
Infant	~1967-1980	• understanding ES, how it worked in large US industries • descriptive in nature • focus on sources of and computer applications in ES
Exploration	~1982-1992	• how firms conduct ES • impact of ES on strategic management issues • ES intensity and cultural issues
Expansion	Most recent 1995-2008	• geographical areas • services firms included • small and medium enterprises studied

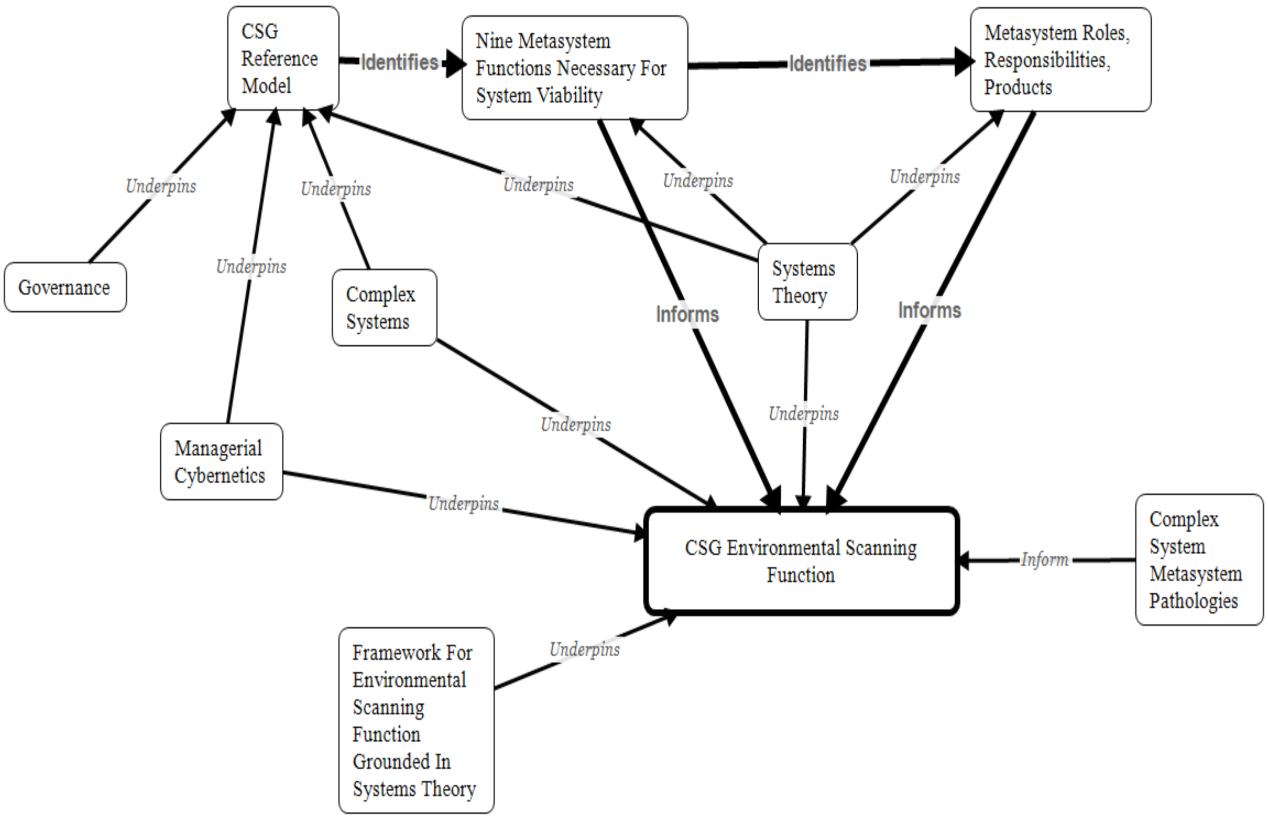
Note: Wong & Hung (2012) did not research ES literature beyond 2008. The charts in Appendix A demonstrate that there are numerous writings on ES in the 2009-2020 period. This research effort indicates that these writings continue to expand upon the widespread interest in the consequences of Environmental Scanning.

In Figure 11, the supporting literature fields are interfaced for the function of ES in CSG. The Systems Theory-based underpinnings of Managerial Cybernetics, CSG, and ES are demonstrated. A framework for ES functions that is grounded in Systems Theory is shown to underpin the role of ES in CSG. For the purpose of this research, "underpins" means the intent to explain the how and why things happen, and "informs" means the application of theory to explain findings.

Wong & Hung's (2012) conclusions and recommendations for areas of future research include: the antecedents of ES practices are understudied, the literature focuses on tools and systems, not theory, and the results of the ES function on performance is not developed. They state gaps remain in what affects ES practices, including top management's perspectives, firms born globally, and foreign market entry modes. There is no assessment or proposition that suggests ES be studied from a Systems Theory-based perspective nor any significant recognition or development of the functioning of ES in CSG.

Figure 11

Environmental Scanning Supporting Fields of Study



Appendix A shows the results of an ES search performed in the Engineering Village search engine. This search provides a perspective on the status of ES literature development. This is not a complete search for all ES literature but is representative of the presence of ES literature in the engineering sciences. The ES articles are majorly present in the literature from strategic planning, scanning, decision making, information systems, management, and business systems. ES article authorship in this search is limited to about ten authors and is found primarily in journals and conference reports. CSG article authorship is similar. The predominance of ES article development has occurred from 2009 to 2016. CSG development is from 2014 to present. These searches demonstrate that the peak of ES literature development is mostly in the past, spread among several literature fields, and has not been rigorously explored from any one perspective or any one author.

2.4 LITERATURE GAP FOR THE ES CONSTRUCT

Although ES researchers from multiple disciplines discuss some ES issues germane to system governance, the initial review of related scholarly literature has yielded virtually no material that explicitly addresses ES functions in CSG that are grounded directly in Systems Theory, thereby exposing a gap in the literature. The literature search to date has not answered the question of what functions are associated with ES from a Systems Theory-based perspective in CSG. While there are descriptions of the ES function in Managerial Cybernetics (Beer, 1979) and CSG (Keating & Katina, 2016) they do not comprehensively explain how the ES function performs in CSG and from a Systems Theory-based perspective.

Based upon the lack of a comprehensive Systems Theory-based perspective for ES being established in the extant literature, this researcher is led to conclude that the major literature streams to be included in the literature review appropriately should focus on Managerial Cybernetics, Systems Theory, ES and related scanning topical information, and the developing area of CSG. Systems Theory is foundational to both Managerial Cybernetics and CSG, thus is a foundational contributor to the ES function in CSG. This supports the formulation of research question one by grounding the literature review primarily in Systems Theory-based scholarly literature. Other related literature fields were included to provide a broad generalizability to the research effort.

The proposed research for ES functions in Complex System Governance will help fill this gap in the literature field by developing a framework to aid in the identification and understanding of the functions of ES which are underpinned by Systems Theory, Managerial Cybernetics, and Complex Systems Governance.

2.5 CHAPTER SUMMARY

This chapter provided the results of a limited literature review of ES, Systems Theory, Managerial Cybernetics, and CSG supporting this research. This literature review was accomplished in keeping with the constructivist GTM, where the literature review is essential to ground the researcher in the data field available for this specific research method before and during the application of the GTM. These streams of literature were expounded upon as they relate to this research's methodology. The foundational role of these literature streams to this research was established. Beer's (1979) VSM was established as a foundational part of CSG development which includes the functions of ES. The literature streams were synopsized to identify that they did not present a clear and identifiable approach to how ES would function in CSG from a Systems Theory-based perspective. This lack of literature on ES constructs in CSG that are grounded in a Systems Theory-based perspective indicates the proposed research questions are unique and contributory to the body of literature. This chapter addressed the historical background, the contexts, the terminology, and the research concepts related to ES in CSG. These then pointed to a gap in the literature field for ES functions that are grounded in Systems Theory that this research proposes to fill. The purpose of this research is to construct a Systems Theory-based framework for ES in CSG. The following Chapter will discuss the use of the constructivist GTM to develop an ES framework in CSG that is grounded in Systems Theory.

The extant literature used as the research library for the GTM is taken from the literature reviewed in this chapter.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to present the research paradigm applied to conduct this study. Figure 12 is the outline of the material in Chapter 3. The applied research paradigm is an inductive methodology to address both research questions.

MacNaughton et al. (2001) defined the research paradigm to include three elements: (a) a belief about the nature of knowledge, (b) a methodology, and (c) a criterion for validity. This chapter presents the rationale for the selection of the research paradigm associated with conducting this research and addresses the three research paradigm elements identified by MacNaughton et al. (2001). In addition, this chapter presents the rationale and application of the GTM and the Case Study Method to address the two research questions.

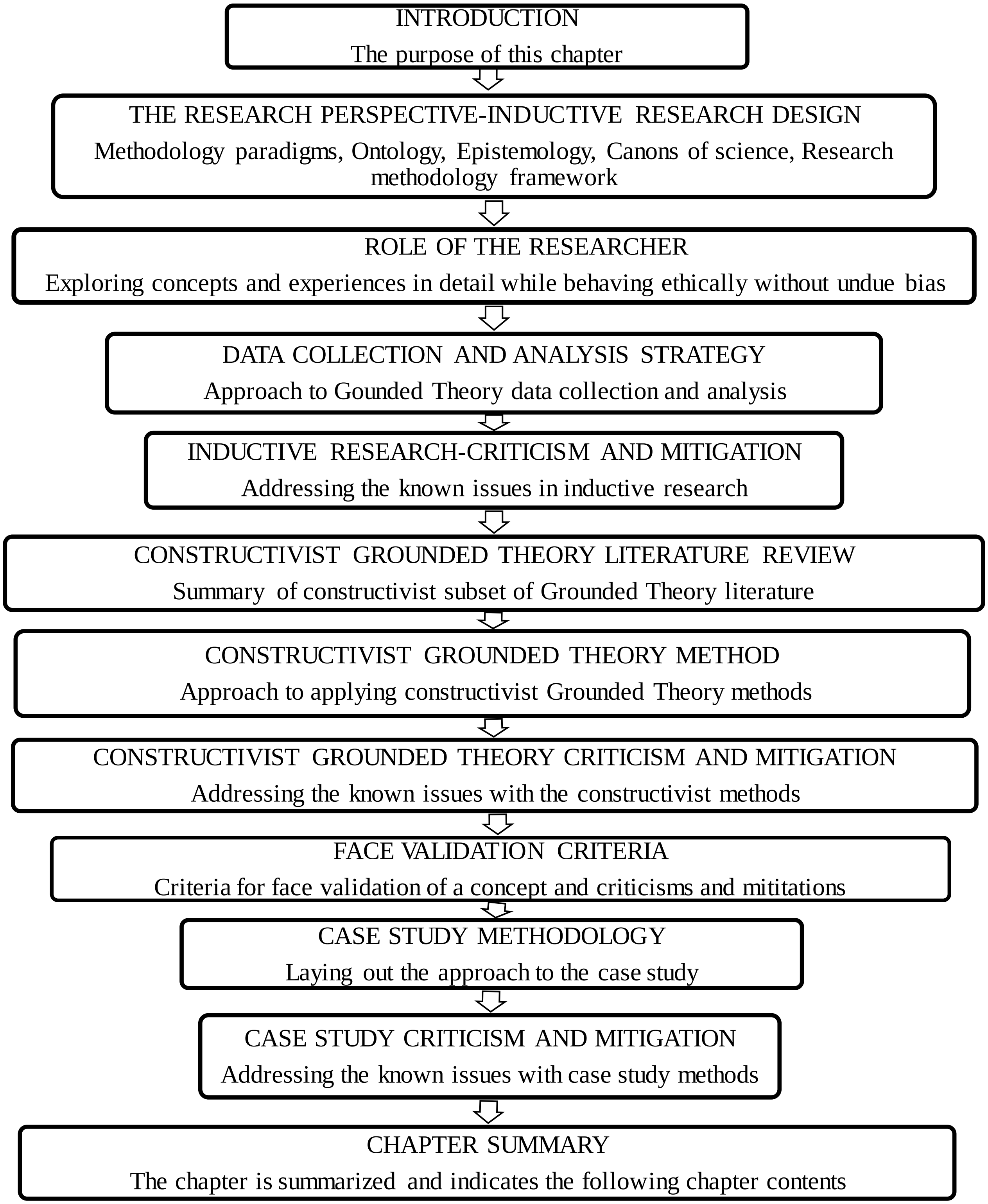
An inductive research design was chosen to construct a Systems Theory-based framework specific to ES as it functions in CSG. A constructivist GTM was applied to construct the ES framework following Charmaz (2014). A face validation case study was undertaken to assess the ES framework's utility for application in an applied setting.

3.2 THE RESEARCH PERSPECTIVE-INDUCTIVE RESEARCH DESIGN

The purpose of this research was to construct and deploy in an applied setting a Systems Theory-based framework for ES in CSG.

Figure 12

Outline of Chapter 3



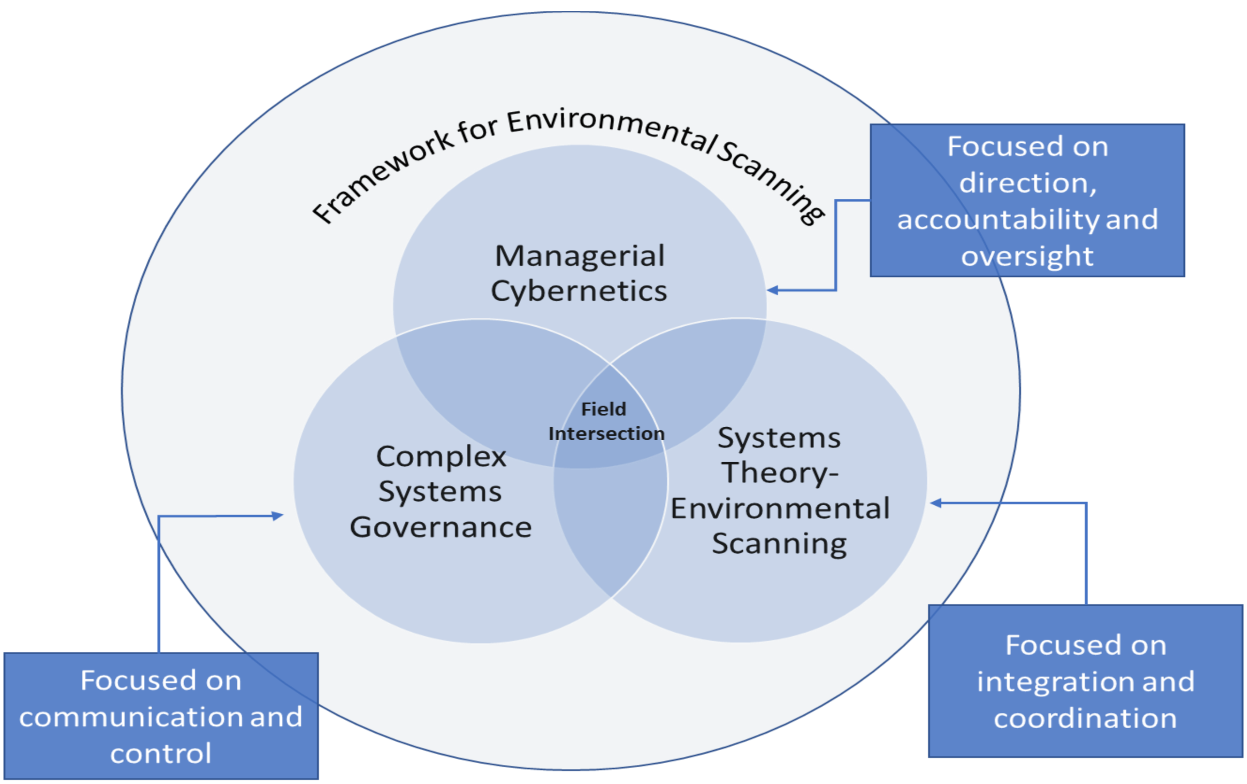
This research was accomplished by applying an inductive research design, constructing new concepts from data coding, and thematic coding development.

Two research gaps motivated this research: (1) the lack of an integrated conceptualization of a system governance construct for ES and (2) an absence of studies that consider Systems Theory as the basis for ES functions. This research was approached on a qualitative basis, employing an inductive research methodology. The inductive methodology is based on Grounded Theory and Case Study practices.

Figure 13 (summarized from Keating & Katina (2019)) illustrates the synthesis of the existing literature fields into a Systems Theory-based framework for ES functions in CSG.

Figure 13

Research Data Set Relationships



Due to the newness of the CSG field of study, there is limited literature available for study (Bradley et al., 2016; Katina & Bradley, 2016; Katina, Keating, Gheorghe et al., 2017; Katina, Keating, Magpili, 2017; Keating et al., 2017; Keating, 2015; Keating & Katina, 2016; Keating et al., 2015, Keating et al., 2014). ES related literature from Managerial Cybernetics, ES, Futures, Information Sytems, Marketing, Management, and Planning were added to the CSG literature base to form the research library for this study. Literature from these fields of study was where writings on the ES function were most prevalent.

This researcher applied the GTM to construct a framework for the function of ES in CSG via inductive theory building. This application of the GTM is presented in detail in Chapter 4. The face validation study (case application) examined the ES framework in an applied setting, revealing possible systemic inconsistencies that could be closed in a future transformational effort. The high-level phases of this research's approach to this inductive research methodology were taken from Creswell (2013) and are (a) exploration, (b) Grounded Theory development, (c) case application, and (d) summary and write-up. Typical of the GTM, the literature review and the researcher's perspective on ES are present in all the phases of this research (Charmaz, 2006).

3.2.1 METHODOLOGY-RESEARCH PARADIGMS

A research paradigm underlies the design, execution, and interpretation of the research (Guba & Lincoln, 1994). It is a particular worldview that informs the conduct of the research. Therefore, at the center of rigorous research is the need to establish a paradigm for addressing knowledge claims. This section elaborates on the research paradigm that underlies this study.

"Researchers generally reflect on their philosophy of science through examination of their ontological, epistemological, and methodological assumptions in relation to research paradigms and apply research methods consistent with their assumptions" (Bozkurt & Sousa-

Poza, 2005, p. 143). Bozkurt and Sousa-Poza (2005) also suggest that research design and research methodology should follow the underlying philosophy of the research and the researcher's ontological and epistemological viewpoint. Therefore, a limited presentation of each of these constructs as related to this research is appropriate and is presented in this chapter.

Research methodology is defined by Leedy & Ormrod (2013) as "the general approach the researcher takes in carrying out the research project; to some extent, this approach dictates the particular tools the researcher selects" (p. 7). The dictionary definition of methodology is a set or system of methods, principles, and rules for regulating a given discipline (Dictionary.com, 2019). Tolk et al. (2011) suggest that a systems-based methodology can provide a framework that can be elaborated to effectively guide action. They describe a systems-based methodology as one built upon a holistic and systemic understanding of the technical problem and as one where the contextual framework is present to arrive at a satisfactory solution. They suggest that methodologies will also require supporting methods, techniques, and tools. Combining the viewpoints above from Leedy &Ormond (2013), and Tolk et al. (2011) and stating these viewpoints simply, a methodology can be considered a strategy or framework within which methods, procedures, and processes can be developed and organized to guide action. In this study, the methodology is to guide actions addressing the answers to the research questions.

3.2.2 ONTOLOGY

Ontology can be defined as the form and nature of reality and what can be known about it (Guba & Lincoln, 1994). The two predominant ontological positions are: (1) positivism, which suggests that reality is held to be external and objective, that there is a single objective reality, independent of what is perceived and (2) constructivism which suggests reality is a mental creation or perception where no single reality will emerge from multiple research inquiries

(Guba & Lincoln, 1994). Ontology relates to whether we believe there is one verifiable reality or whether there exist multiple socially constructed realities (Patton, 2002). The ontological question for the researcher to address is whether reality exists apart from the researcher's perception. To answer this question, the researcher must determine where on the ontological continuum their worldview exists as related to their research (Creswell, 2009). Guba & Lincoln (1994) summarize the implications of the major interpretations of paradigms (worldviews) around a set of defined issues. Table 14 is derived from their summary.

Table 14

Summary of Paradigm Implications Around a Set of Issues

Issue	Positivism	Constructivism
Aim of the inquiry	Explanation, prediction, and control	Understanding, reconstruction
Nature of knowledge	Verified hypotheses established as facts	Individual reconstructions coalescing around consensus
Knowledge accumulation	Accretion, cause-effect linkages	Informed reconstructions, vicarious experiences
Quality criteria	Conventional benchmarks of rigor	Trustworthiness and authenticity
Hegemony	In control	Seeking recognition and input

The primary research objective stated in Chapter 1 is based on the action to “construct” a framework for ES. This objective of constructing most closely aligns with the constructivist ontological viewpoint of creation or perception and the Table 14 constructivism paradigm.

3.2.3 EPISTEMOLOGY

Epistemology is the relationship between the researcher and what is to be known. It concerns the nature of knowledge and its source (Siangchokyoo & Sousa-Poza, 2012). Epistemology determines the approaches that can be taken to gain understanding, the way something can be known. Empiricism and rationalism represent the major opposing positions in epistemology. Empiricism holds that the justification of a belief (knowledge) is established through observations and the sense of experience; rationalism holds that knowledge is derived through reasoning and the use of rational thoughts (Siangchokyoo & Sousa-Poza, 2012).

The research questions stated in Chapter 1 are based upon answering "what is." This implies that the response to the research questions is established through observations or experiences, indicating an empirical epistemological viewpoint.

The combination of opposing positions in epistemology and ontology reveals the differences in the underlying philosophical paradigms of research (Siangchokyoo & Sousa-Poza, 2012). From Table 15, the general research approach assessment adapted from Creswell (2003), the qualitative research approach was determined to be appropriate for this research. This determination was made by defining this research's concepts and comparing them to the qualitative or quantitative concepts, then annotating which concept was most relevant to this research.

Table 15

General Research Approach Assessment

Research characteristic	Quantitative concept	Qualitative concept	This research concept	Outcome
Role of theory in this research	Deductive	Inductive	To be developed, starting with the researcher's context, derived from data	Qual
Epistemological orientation	Positivist	Constructivist	Must develop/discern relationships between the four fields of study from the literature library	Qual
Ontological orientation	Positivism	Constructionism	The contextual framework does not exist; it must be induced from the data	Qual
Characteristics of the research approach	Objective Impersonal Reductionist Generalization	Subjective Personal Holistic Uniqueness	Exploratory, researcher involved, involves four fields of study unique to the new CSG field	Qual
Types of data	Quantifiers Numbers	Describers Words	Literature-based, applying coding techniques to words	Qual

In each characteristic of research that is addressed in Table 15, the qualitative paradigm has been determined to be the best description of each research characteristic assessed. The circles in the table indicate the researcher's assessment of the paradigm (qualitative/quantitative) that most closely fits this research's concept, which is captured in summary in the evaluation comments in the concept column. The key research concepts from the table are: (a) derived from data, (b) induced from data, (c) researcher involved, and (d) literature based. These concepts strongly suggest a qualitative approach is most appropriate for this research. Table 16, summarized from Bozkurt & Sousa-Poza (2005), also points to a constructivist, qualitative research paradigm for this research, with the key ontological and epistemological underpinnings of this research methodology aligning under the constructivist column. This alignment under the qualitative research paradigm, in turn, points to the applicable canons of science that are applied to evaluate this research. The constructivist research philosophy in Table 16 also points to Grounded Theory as an appropriate research methodology.

Table 16

Comparison of Research Paradigms from Bozkurt & Sousa-Poza (2005)

Research Philosophy	**Positivist**	**Constructivist**
Knowledge Claims		
-Ontology	Realist, Absolute	Multiple, Dependent
-Epistemology	Detached, Objective	Related, Subjective
Research Paradigm	Quantitative	Qualitative
Methodology	Experiment Quasi-Experiment Surveys	Grounded Theory Interviews Observations
Canons of Science	Internal Validity Generalizability Reliability Objectivity	Credibility Transferability Dependability Confirmability

3.2.4 CANONS OF SCIENCE

To conduct scholarly research, a researcher needs to identify certain principles, identified as canons, to be applied to the research (Sharpe, 1940). The canons provide a degree of vigor and rigor to the research design (Bozkurt & Sousa-Poza, 2005), and they are the criteria by which the research is judged. Bozkurt & Sousa-Poza (2005) suggest that the canons of research design should be followed according to ontological and epistemological arguments. Bozkurt & Sousa-Poza (2005) identified the constructivist universal canons for quality as truth or credibility, neutrality or confirmability, consistency or dependability, and applicability or transferability. These are the same attributes that Guba & Lincoln (1994) suggest as alternative criteria for scientific rigor in qualitative research. Table 17 summarized from Guba & Lincoln (1994) and agreeing with Bozkurt & Souza-Poza (2005), defines the canons for qualitative research that are applied in the development of an ES framework in this qualitative research. Assessment of the canon applicability is summarized in Chapter 6.

Table 17

Canons for Qualitative Research

Canons for a Quality Qualitative (Inductive) Research Paradigm	**Attributes of Canon Characteristics**
Credibility	• Accurate identification and description of variables and research participant units • Triangulation • Transparency in analysis • Inductive reasoning
Transferability	• Applicability to other contexts • Purposive sampling
Dependability	• Transparency-rigorous documentation of the process and research design, consistency
Confirmability	• Objectivity

3.2.5 RESEARCH METHODOLOGY FRAMEWORK

Creswell (2003) describes research methodology as the strategy or plan of action that links methods to outcomes and that governs the choice and use of methods. Checkland (1999) describes methodology as a guide more specific than philosophy but more general than a method. Table 18, summarized from Creswell (2013), demonstrates the overarching approach for this research is qualitative in nature. Each research methodology characteristic that is assessed, is evaluated with a qualitative outcome.

Table 18

Research Methodology Assessment

Characteristic	**Quantitative**	**Qualitative**	**This research concept**	**Outcome**
The role of theory in this research	Deductive	Inductive	To be developed, starting with the researcher's context	Qual
Epistemological orientation	Positivist	Interpretive	Must develop/discern relationships between the four fields of study	Qual
Ontological orientation	Realism	Constructionism	The contextual framework does not exist; it must be developed	Qual
Characteristics of the research approach	Objective Impersonal Reductionist Generalization	Subjective Personal Holistic Uniqueness	Exploratory Researcher involved Involves four fields Unique to the new CSG field	Qual
Types of data	Quantifiers Numbers	Describers Words	Literature-based using coding techniques	Qual

Table 19, summarized from Creswell (2013), demonstrates that from the several qualitative methods available, a Grounded Theory approach is an appropriate qualitative method for addressing research question one. The GTM is the qualitative approach that most closely addresses the challenges presented in Table 19.

Table 19

Qualitative Methods Assessment

Qualitative Approach	**Challenges to approach**	**Satisficing assessment of this research approach**
Content Analysis/Narrative	• Need to collect extensive information • Need to have a clear concept of the participants' life • Difficult to explain the multi-textured aspect of the participants' life • Study qualities to be examined must be pre-defined	No clearly definable participant is involved. The data being assessed comes from a library of relevant literature written by several authors. No information exists about the specific research question. No qualities are pre-determined.
Case Study	• Identification of the case or study boundary • Deciding to study case or cases • Collecting enough in-depth information to make the case relevant	No clearly definable case is present. In-depth information does not exist about the research question.
Ethnography	• Need to understand the relevant cultural anthropology • The data collection time is extensive • The possibility the researcher is compromised by the fieldwork • Sensitivity to impact on participants	The research question, as stated, is not related to cultural variables.
Phenomenology	• Requires some understanding of the broader philosophical assumptions that may be challenging to novice researchers • Participants must all have experienced the phenomenon • The researcher's personal understanding of the phenomenon must be accounted for • Active collaboration is necessary • Must consider own "story" in shaping data analysis	The research question does not involve a phenomenon.
Grounded Theory	• Must set aside theoretical ideas • Must employ a basic systemic process	A systemic approach was applied to answer the research question. Theoretical ideas were developed; none are pre-existing.

Qualitative Approach	Challenges to approach	Satisficing assessment of this research approach
	• Difficulty in determining category saturation • Difficulty determining when theory is well-developed	The relevant library is defined, and saturation was achieved. A well-developed framework has been justified in this research.

Table 19 lists challenges to each of the five methods of qualitative research assessed in this paper, and it provides a satisficing assessment of each approach's applicability to the research question in this research. This was done by determining if the challenge could be mitigated as related to the research question. The Table 20 assessment of Grounded Theory data collection demonstrates that the data collection methods in this application of the GTM are satisficing to this researcher's research question. In each identified data collection activity, the methodology applied in this research aligns well with the data collection activities described for the GTM.

Table 20

Assessment of Grounded Theory Data Collection

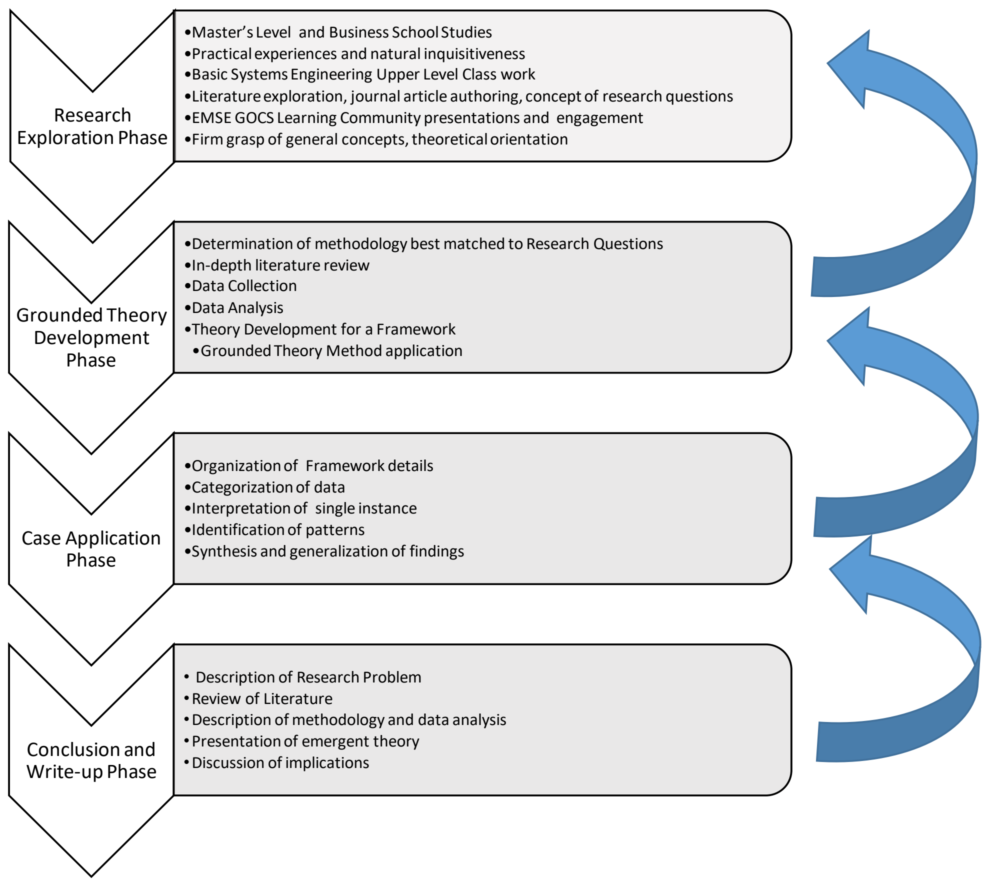
Data Collection Activity	Grounded Theory Method	This Research
What is traditionally studied?	Multiple individuals who participated in a process about a central phenomenon	The books and articles are written by many authors that posit on CSG, ES, and Managerial cybernetics
What are typical access and rapport issues?	Locating a homogenous sample	Appropriate, comprehensive literature research as input to this study
How does one select a site to study?	Finding a theory-based sample	A justified literature sample is an input to this study

Data Collection Activity	Grounded Theory Method	This Research
What type of information is typically collected?	Interviews to achieve detail in the theory	Coding of selected literature set
How is information recorded?	Memoing	Memoing through coding protocol, computer-assisted
What are common data collection issues?	Logistics, openness	Appropriate literature set as input to the study
How is information typically stored?	Computer files	NVivo® data files

Charmaz (2014) states that Grounded Theory methods begin with inductive data collection, invoke iterative strategies of back and forth between data and analysis, use comparative methods, and keep the researcher interacting and involved with the data and emerging analysis. From an ontological perspective, this is a constructivist approach, treating this research as a construction but under specific conditions bounded by the methodology. From the epistemological viewpoint, this is an inductive reasoning process that takes the direction of going from data to the idea. Knowledge (ideas) is gained through the researcher's ability to derive meanings out of the data collected (Siangchokyoo & Sousa-Poza, 2012). Creswell (2013) suggested a generally phased approach for inductive research design and case application that was generally applied to this research. See Figure 14 for the general phased approach.

Figure 14

The Phased Research Design for Framework Development and Case Application Summarized From Creswell (2013)



Each phase in this approach is accomplished in sequence, but once it has been performed, it influences the following phases, and the following phases then influence the performance of previous phases in an iterative approach. A brief description of each of the research phases follows.

Exploratory Phase: This phase consists of the background academic work, academic studies, and practical experiences that developed into an interest in Systems Theory, Managerial Cybernetics, and CSG. These background experiences were then focused by ODU Engineering Management Ph.D. curriculum classes and participation in ODU NCSoSE and associated learning community involvement. Significant literature exploration and review occurred during these later experiences. The result of this phase was a firm grasp of Systems Theory principles and a focus area of significant interest in the ES function in CSG. This interest was grounded in many years of practical experience with technical systems and organizations that experienced struggles in a changing environment. This focus was fundamental in shaping the research questions and fundamental to shaping the general approach to the research methodology.

Grounded Theory Development Phase: This phase resulted in the determination of a research method best matched to the research questions and results in the application of the determined method. A constructivist GTM was assessed as an appropriate approach to addressing the research question discussed previously in Chapter 1. Glaser & Strauss (1967) offer that a "comparative method … can greatly enhance the discovery and analysis of relevant qualitative data drawn from documentary sources" (p. 161). They establish that various qualitative documentary resources can help the researcher understand the area of study, can be informative to the specific research topic, can support highly empirical studies, and can be valuable for generating theory. Glaser and Strauss's (1967) approach to Grounded Theory development begins with a qualified data source, which through a rigorous coding process, develops conceptual categories and their conceptual properties, which then leads to generalized relations among the categories and their properties, and which then becomes elements of theory. The constant comparative method is used to check out initial evidence in the coding process for its correctness or not by generating comparative evidence both internally to the initial data source and externally by exploring data sources not previously considered. Glaser & Strauss (1967) state that the purpose of comparative analysis is the generation of theory, and that comparative data is the best test of the relevance of the developed categories. Therefore, it is important that the literature for accomplishing a GTM of analysis be purposefully determined and qualified to support the credibility of the research.

The data for a Grounded Theory can come from various sources (Corbin & Strauss, 1990). Corbin & Strauss (1990) state that data collection involves anything that can shed light on questions under study and that any data source can be coded in the same way as interviews. In qualitative data analysis, "a code is a researcher-generated construct that symbolizes and thus attributes interpreted meaning to each individual datum for later purposes of pattern detection, categorization, theory building, and other analytic processes" (Saldaña, 2013, p. 4).

The sources of literature (data) initially used in this research are associated with key works in CSG, Managerial Cybernetics, and ES writings. Charmaz (2006) states that some researchers obtain data from extant sources that consist of various documents that the researcher had no hand in shaping and that they treat texts as data to address their research questions. She posits that these texts tell something of intent. Charmaz (2006) further states that texts need to be situated in their contexts to prevent methodological issues, that texts can be used as objects of analytical scrutiny themselves, and that most grounded theorists start with the content of the texts. Ralph et al. (2014) state that the use of documents in the GTM is relatively common, but a consistent commentary on using documents is difficult. They posit that the need to be aware of the context of the extant data is a vital step prior to commencing research/data analysis, and they propose contextual positioning as a tool that can be used to prepare extant data for analysis.

They state that data collection "should be a systemic and reflexive process aimed at collecting the data source and its concomitant information to optimally position that data for analysis" (Ralph et al., 2014, p. 3). They state that it is important to be theoretically sensitive to the possibilities of the data source in its own context. To contextually position the extant literature data source, they suggest establishing the who, what, when, where, why, and how of context. In this research, the extant literature context was established by demonstrating that the literature that is coded is embedded within the framework of the historical literature components for the ES function that has been developed from Managerial Cybernetics, CSG, and ES writings. The historical literature framework was presented in Chapter 2.

Charmaz (2014) suggests that the researcher may not know what they need to find out until they grapple with their data and that the logic of Grounded Theory involves openness to learn more about the empirical world. Charmaz (2014) states that:

> The number of interviews depends upon the analytical level to which the researcher aspires as well as a set of purposes that include: norms of your discipline, aiming for credibility across disciplines, meeting a doctoral requirement, and presenting and publishing papers from the study. (p. 106)

Charmaz (2014) offers a set of guidelines to help decide how many interviews (articles) are needed. These guidelines suggest increasing the number of interviews (articles) when pursuing a controversial topic, when anticipating surprising findings, when constructing complex conceptual analysis, when interviews are the only source of data, or when seeking professional credibility. Applying these guidelines to this research effort would suggest a robust set of articles would be more appropriate to code than a few key ones. This research library was developed to meet specific selection criteria (presented in Chapter 4), was predominantly grounded in Systems Theory-based literature, and was the literature subset from the literature review that was most closely related to this research's objective of a framework for ES that is Systems Theory-based. It is only the initial set, as the constant comparative method of Grounded Theory brought other relevant literature into the analysis process after the GTM process had started.

Hennink et al. (2017) found that frequently occurring codes were typically identified in early interviews and reached meaning saturation by nine interviews or sooner. Meaning saturation, per Hennink et al. (2017), is the general concept related to the predominant codes. Codes identified in later interviews that were low-prevalence codes required more data to reach meaning saturation, or they did not reach meaning saturation (Hennink et al., 2017). Thus, a code may be identified in one interview and repeated in another, but additional interviews are needed to capture all aspects of the coded issue to fully understand it. Hennink et al. (2017) state that their "findings underscore the need to collect more data beyond the point of identifying codes and to ask not whether you have 'heard it all' but whether you 'understand it all'—only then could data saturation be claimed" (p. 605). In this research, extant data was collected by contextual positioning in the literature stream. Contextual positioning enhances the interactivity of the data collection process, and it presents data ready to contribute to the development of a theory grounded in data (Ralph et al., 2014). Charmaz (2006) uses the term "extant text" to indicate data sources that the researcher had no hand in shaping (p. 35). "Extant data may take the form of existing text relevant to the study" (Ralph et al., 2014, p. 3). Therefore, to ensure that sufficient data is collected to support meaning saturation, a wide literature search was accomplished to identify literature contextually relevant to addressing the research question.

This was done to build a research database that adequately supports addressing the research question and to provide a data-rich base from which to work the GTM.

Achieving saturation in coding/categorizing is the break-point for including any additional literature in the research library (Hennink et al., 2017). Researchers are challenged with the trustworthiness of their research findings pertaining to when data collection should cease (Aldiabat & Le Navenec, 2018). There is a specific need to demonstrate the trustworthiness of the findings by describing steps taken to meet theoretical saturation (Aldiabat & Le Navenec, 2018). Morse (2004) defines theoretical saturation as: "the phase of qualitative data analysis in which the researcher has continued sampling and analyzing data until no new data appear and all concepts of the theory are well-developed…and their linkages to other concepts are clearly described" (p. 1123). He states that data collection could then cease. "This concept was also put forth by Strauss & Corbin (1997) as a specific element of the constant comparison [analysis method]" (Malterud et al., 2016, p. 1753). Aldiabat & Le Navneet (2018) concluded that there are six factors that facilitate reaching data saturation. They are: (1) the nature of the research question, (2) the researcher's experience, (3) triangulation of data collection methods, (4) philosophical underpinning of the research method, (5) a guiding theoretical framework, and (6) using sensitizing concepts. They also point out three factors that hinder reaching data saturation as: (1) an abbreviated time frame, (2) a limited budget, and (3) limited resources for training and monitoring. Explaining what saturation means and how it occurs in the course of the data analysis is essential to ensure methodological rigor and adherence to trustworthiness principles (Bowen, 2008). Data saturation is explained in Chapter 4, section 4.3.2.

Charmaz (2014) states that "coding is the pivotal link between collecting data and developing an emergent theory to explain these data" (p. 113). Charmaz (2014) defines coding as "categorizing segments of data with a short name that simultaneously summarizes and accounts for each piece of data. Codes show how to select, separate, and sort data and begin an analytic accounting of them" (p. 111). Coding work involves four phases: preliminary coding, initial coding, focused coding, and axial coding (Charmaz, 2014). Preliminary coding is performed by applying knowledge of the relevant literature to define initial keywords to begin initial code identification. Initial coding is the process of breaking down the research library into coded data. Focused coding examines individual codes for commonality or contrast and organizes the codes into categories. Axial and Selective Coding takes categories and codes and abstracts them into thematic streams of information (Charmaz, 2014). The themes are then compared to develop a framework.

Peer Review was used to provide a face-validation of the application of the GTM to this research. This is a step in the GTM that supports the credibility, dependability, and confirmability of the research data and research process. Qualitative research presents a recognized challenge to traditional views of validity; thus supporting methods are needed to substantiate the validity of the research (Golafshani, 2003). Using multiple, independent team members is a type of triangulation to assess the validity of the data provided. The outcome of the peer review was applied to ensure clear research documentation to provide a transparent and understandable review of the research method and the data generated.

It is problematic to provide a definitive description of the "classical" grounded theory method. There are multiple approaches to grounded theory (Clarke, 2003; Glaser & Strauss, 1967; Strauss & Corbin, 1994; Charmaz, 2006; Maz, 2013) which reflect how the methodology has been diversifying over time. Harris (2014) states there are three basic tenets of grounded theory: (1) theory generation, (2) an emergent theory grounded in empirical research, and (3) concurrent collection and analysis of data (using theoretical sampling and constant comparative analysis). Charmaz (2017) describes grounded theory as "a systemic method consisting of several flexible strategies for constructing theory through analyzing qualitative data…that begins with inductive data, relies on comparative analysis, involves simultaneous data collection and analysis, and includes strategies for refining the emerging analytic categories" (p. 299).

Charmaz (2006) states that she:

> views grounded theory methods as a set of principles and practices, not as prescriptions or packages…[that] describe the steps of the research process and provide a path through it. Researchers can adopt and adapt them to conduct diverse studies…we can use basic grounded theory guidelines with twenty-first century methodological assumptions and approaches. (p. 9)

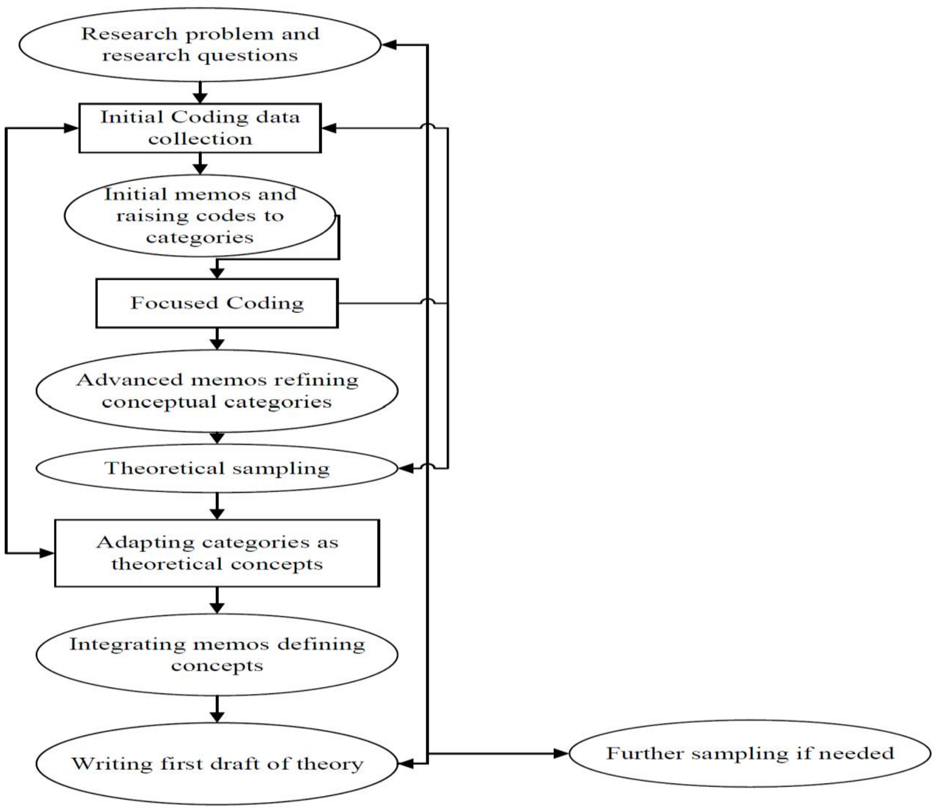
Corbin (2016) states that:

> There is another point that I believe is important to make here because there have been some misunderstandings about how Strauss and I use techniques and procedures. Techniques and procedures are tools to be used by the researcher as he or she sees fit to solve methodological problems. They are not a set of directives to be rigidly adhered to. (p. 40)

Charmaz (2006) states that her approach (constructivist GTM) "assumes that any theoretical rendering offers as interpretive portrayal of the studied world, not an exact picture of it" (p. 10). Charmaz (2006) states that emphasis may vary among researchers but there is a shared commonality which defines the grounded theory process. Charmaz (2006) states that "Grounded theory methods enhance possibilities for you to transform knowledge. … your journey through grounded theory may transform you" (p. 185). Given that the research design in this study is based on constructivist Grounded Theory, Charmaz's (2006) explanation of the constructivist GTM is used as the basis for assessment of this research's method design. Figure 15 is adapted from Charmaz (2006) and is the reference point for this discussion, as it demonstrates the basic elements of constructivist Grounded Theory. Charmaz (2006) presents her construct of the GTM in summary detail as: gathering rich data, coding (Initial, Focused/Axial, Theoretical), memoing, theoretical sampling, saturation, integrating, writing the theoretical framework.

Figure 15

Charmaz Constructivist Grounded Theory Process



Nobel & Mitchell (2017) summarize, at a high level, the GTM's four steps as shown in Figure 16 in support of a straightforward process explanation.

Figure 16

Four Steps of a Simplified GTM

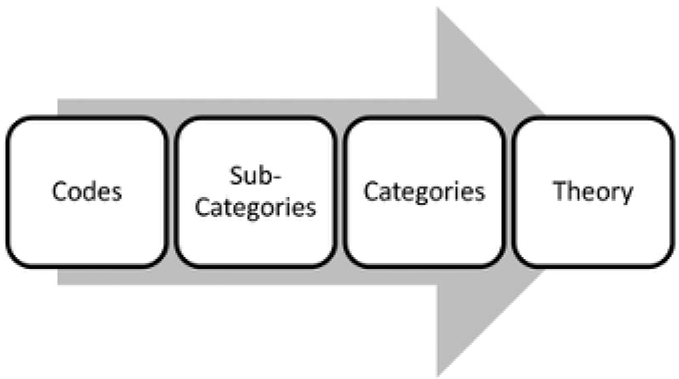


Table 21 summarizes Chun Tie et al. (2019) different genres of Grounded Theory and the associated coding nomenclature. This study's research method design is based primarily upon the constructivist approach of Charmaz (2006) and that of Saldaña (2013). This research method design used the terms Initial Coding, Axial Coding, and Selective Coding. Table 21 demonstrates the overlap in terminology for the coding processes as related to the genre of Grounded Theory applied. The vertical columns refer to similar processes in the Progressive Coding method. Progressive Coding, in terms of this research, is defined as "the reverberative nature of coding – comparing data to data, data to code, code to code, code to category, category to category, category back to data, etc." (Saldaña, 2013, p. 58).

Table 21

Comparison of Coding Terminology in Traditional, Evolved and Constructivist Grounded Theory

Grounded Theory genre	**Coding terminology**		
	Initial	**Intermediate**	**Advanced**
Traditional	Open coding	Selective coding	Theoretical coding
Evolved	Open coding	Axial coding	Selective coding
Constructivist	Initial coding	Focused coding	Theoretical coding
This research method design	Initial coding	Focused/Axial coding	Selective coding

Chapter 4 presents the eight tiers of codes constructed in this research study. As noted in Figure 16, above, Nobel & Mitchell (2017) show sub-categories in their steps of the GTM. In this research study, what is identified as sub-codes and collective codes are analogous to sub-categories, i.e., they abstract to the next higher level, thus are consistent with the GTM Progressive Coding process. They are only used due to the volume of data generated in this study's GTM. It is reasonable to understand that a "classical" Grounded Theory study in the Social Sciences, involving interactive subjects, that the amount of data generated could be controlled to readily align with the prime coding methods.

In summary, this research's coding method design was modified to fit the nature of this research method but is consistent within the flexibility of constructivist Grounded Theory approaches and methods as discussed above.

What is the product of the GTM? What defines a Grounded Theory? Charmaz (2006) posits that a "grounded theory is a theory of resolving a main concern that can be theoretically coded in many ways" (p. 180). Charmaz (2006) further posits that: a grounded theory can have varied constructions and competing definitions; grounded theories should be situated in their social, historical, local, and interactional contexts; generality of the theory emerges from the analytic process; and it should be a conceptual analysis of patterned relationships. More specifically, Charmaz (2006) summarizes a constructivist grounded theory as one that sees both data and analysis as created from shared experiences with sources of data; that the resulting theory is an interpretation; it depends on the researcher's view; and it is embedded in larger positions.

Chun Tie et al. (2019) state that:

> The meticulous application of essential GT methods refines the analysis resulting in the generation of an integrated, comprehensive GT that explains a process relating to a particular phenomenon. The results of a GT study are communicated as a set of concepts, related to each other in an interrelated whole, and expressed in the production of a substantive theory. A substantive theory is a theoretical interpretation or explanation of a studied phenomenon. Thus, the hallmark of grounded theory is the generation of theory 'abstracted from, or grounded in, data generated and collected by the researcher.' However, to ensure quality in research requires the application of rigour throughout the research process. (p. 7)

In this research, the product of the progressive coding method is a set of concepts, the 17 interrelated themes. The umbrella theme is abstracted from the source data and is a theoretical explanation of the constructed 17 themes. The 17 themes and the umbrella theme are the product of the GTM.

Chun Tie et al. (2019) posit that the quality of the product of the GTM can be related to three focus areas identified as: (1) the researcher's skills, (2) methodological alignment with the research question(s), and (3) the procedural precision in the use of methods. The Preface and Chapters 3 and 4 present the researcher's skills as related to this research study. Chapter 3 identifies the methodological alignment with the research questions. The procedural precision of the constructivist GTM was presented in the above paragraphs and was assessed by scholarly peers.

In summary, this research design aligns with the general requirements for quality in a GTM research study and this research's method design was compared to "classical" Grounded Theory methods and found to be consistent with accepted GTM practices with an expected quality product.

Limited Face Validation (FV) Phase: "'Face valid' measures are measures which have not yet achieved as great a degree of certitude of validation as measures validated empirically" (Turner, 1979, p. 85). "Face validity is only considered to be a superficial measure of validity, because it is not really about what the measurement procedure actually measures, but what it appears to measure" (Jayasooriya & Gunawardana, 2015, p. 95). Researchers are interested in face validity due to a belief that a measure should appear to measure what it measures (Lund Research LTD, 2019). FV for this research effort is consistent with Turner's (1979) and Jayasooriya & Gunawardana's (2015) definition as "not a great degree of certitude" and a "superficial measure of validity." The FV is not a test of the ES framework theory.

The ES framework that was constructed in the theory development phase of the GTM was applied in a limited practical setting to reveal information about its relevance in practice. This is the approach addressing research question two. Face validity helps to give participants greater confidence in the measurement procedure and the results; it can also give greater confidence to administrators and sponsors of a study, not just participants (Lund Research LTD, 2019).

A case study method was employed in this limited practical setting. Yin (2003) discusses the application of case study methods to cover contextual conditions where they are relevant to the phenomenon under study. Baxter & Jack (2008) suggest that a conceptual framework can serve as an anchor for a case study and is useful at the stage of data interpretation. Triangulation of data sources and data types as a primary strategy would support that the phenomena studied be viewed and explored from multiple perspectives (Baxter & Jack, 2008). "Case study research design principles lend themselves to including numerous strategies that promote data credibility or 'truth value'" (Baxter & Jack, 2008, p. 556). The collection and comparison of limited case study data enhance research data quality based on the principles of idea convergence and the confirmation of research findings (Baxter & Jack, 2008). The purpose of the case study in this research effort is fivefold: (1) to address research question two, (2) to address research contextual conditions, (3) to support data interpretation, (4) to provide a practical perspective on the research, and (5) to add to the credibility of the constructed ES framework.

Conclusion and Write-up Phase: In this phase, the research problem was described, the literature review was summarized, the research methodology and research design were described, the data was presented, data analysis was described, an emergent ES framework was submitted, and a discussion on implications for the research and for future research was documented.

3.3 ROLE OF THE RESEARCHER

The role of the researcher in Grounded Theory has been a topic of debate since the initial development of the GTM (Thomas & James, 2006). Glaser & Strauss (2017) initially aligned on the premise that the researcher should enter the research in “abstract wonderment,” having abstained from literature research before undertaking the study (Thomas & James, 2006, p. 19). Later on, they departed ways from this line of reasoning, with Strauss teaming up with Corbin to advocate researcher engagement with the literature for informed research efforts (Priya, 2016). Corbin & Strauss (2015) state that “Qualitative researchers want the opportunity to connect with their research participants and to see the world from their viewpoints” (p. 5). This view was further modified by Charmaz (2006), who argued that neither data nor theories are discovered but are constructed through the researchers' past and present experiences. This research is firmly established in Charmaz’s (2006) constructivist GTM.

This researcher was involved in all phases of the research methodology. His knowledge of the ES function guided the development of the research methodology and helped customize the GTM to fit within the research methodology. This is clearly a constructivist approach, as Charmaz (2006) provides.

The constructivist GTM applied in this research makes use of the researcher’s background understanding of the ES function in CSG to support this research effort (advocated by Priya, 2016), but it is the disciplined application of the GTM presented in Chapter 4 that results in constructing the ES framework from the foundational data.

3.4 DATA COLLECTION AND ANALYSIS STRATEGY FOR GROUNDED THEORY

Data collection in the application of the GTM to a research question is fundamental to the development of resultant, credible theories (Ralph et al., 2014). Ralph et al. (2014) state that “GT promotes the dictum ‘all is data’” (p. 1). The GTM is characterized by the systematic application of essential methods that guide the researcher through processes of theory building in the context of their adopted philosophical viewpoint (Birks & Mills, 2015). One of those "essential methods" is the collection of data to be used in the research study.

There are several sources of data that can be used in the GTM process (Charmaz, 2014). The classical source of Grounded Theory data is interviews, but other data sources are acceptable for use in theory development (Charmaz, 1996). Although many forms of data are available, qualitative researchers have shown a preference for utilizing elicited data such as from interviews (Ralph et al., 2014). Restricting the scope of research data to just interviews as the preferential source is problematic as it can deemphasize the value of other sources of information (Silverman, 1998). In the case of this research, without explicit access to a field of experts in ES functions in CSG, an alternative data collection source strategy other than interviews was developed. This strategy was based upon extant literature as a credible source of data for theory development in the GTM. Yarwood-Ross & Jack (2015) discuss the use of extant literature in the GTM from three perspectives. These three Grounded Theory perspectives are: classic, Straussian, and Charmaz (constructivist). This researcher's methodology was structured around constructivist grounded theory and used extant literature as a credible data source. Table 1 in Yarwood-Ross & Jack (2015, p. 20) summarizes the constructivist approach for the use of extant literature. Table 22 summarized from Table 1 in Yarwood-Ross & Jack (2015) summarizes that approach.

Table 22

Constructivist Approach to Use of Extant Literature in Grounded Theory

Approach to use of literature
Charmaz (constructivist)
Acknowledges delaying the literature review to allow researchers to articulate their ideas but tends to focus on the expectation of a literature review in the research.
Extant literature can help the researcher clarify ideas and make comparisons. Sensitizing concepts can be used as points of departure.
Extant literature should be used without letting it stifle creativity or strangle the theory.
The literature helps to demonstrate a grasp of relevant works and identify significant findings and connections between the research and earlier studies.

The data collection strategy employed in this research is the constructivist approach and is detailed in Chapter 4. A detailed literature review was conducted before implementing the GTM to frame the extent and bounds of the literature field that was the source of credible data. This literature review supported the research methodology by helping develop sensitizing concepts, making comparisons, and clarifying the research approach.

The data analysis strategy in the GTM begins with selected data that the researcher analyzes from the very beginning of data collection. The data analysis strategy is an iterative method. The iterations come from a constant comparison of coded data, data categories, and emerging themes that, in turn, identify further data collection. The data analysis strategy causes a back and forth between data collection and data analysis. This data analysis strategy leads to refining emerging theoretical categories and themes through successive levels of increasingly focused data collection and analytic development. The constructivist GTM is an interactive method where systemic checking of codes, categories, and themes is an analytic progression that keeps the researcher interacting with data, emerging analyses, and the extant literature on framing the thematic, topical development (Charmaz, 2015a). Throughout the entire process, the GTM is a comparative method**.** The researcher engages in continuously comparing data with data, data with coded data, codes with codes, codes with theoretical categories, theoretical categories with themes, and themes with an overarching theory. This data analysis strategy leads to the inductive construction of themes and to an overarching theoretical framework.

Egan (2002) stated that “it is left to the discretion of the researcher to determine the adequacy of the theory-building process” (p. 286). Strauss & Corbin (1998) suggested that the “empirical grounding of the research” be evaluated to assess the development of relevant categories and concepts that are the building blocks of the theory (p. 268). Their criteria for empirical grounding are taken from (Egan, 2002, p. 289) and shown as adapted in Table 23. Consideration of these criteria for the assessment of the empirical grounding of this research is included.

Table 23

Criteria for Empirical Grounding

Criteria for the empirical grounding of a Grounded Theory study	**Evaluation of this research’s empirical grounding**
Quality of the concepts generated	Each concept (theme) was evaluated as unique and can be directly traced back to source data through thematic development
Systematic relationships between the concepts	The constant comparison method applied established the relationships between the concepts
Clarity and density of conceptual linkages	Both clarity and density are captured in the coding process applied
Inclusion of variation into the theory	Constant comparison and theoretical sensitizing allow for variation in theme development

Criteria for the empirical grounding of a Grounded Theory study	**Evaluation of this research's empirical grounding**
A clear description of the conditions under which variation can be found	The variation in theme development is captured in thematic memos
Account of the research process	The research process is detailed in flow charts and narrative terms and validated by GTM peer review
Significance of theoretical findings.	Significance is presented in sections of this report as contributory to the field of literature, worthy of publication, and face-validated in a practical setting

With a solid grounding in empirical evidence, the ES framework development resulting from this research methodology should be credible.

3.5 INDUCTIVE RESEARCH-CRITICISM AND MITIGATION

Grounded Theory "has been packed with multiple meanings, but also fraught by numerous misunderstandings, and complicated by competing versions" (Charmaz, 2014, p. 320). Grounded Theory is also a widely used qualitative research methodology that seeks to inductively identify issues of importance, create meaning about the identified issues through analysis, and seeks the modeling of theory (Mills et al., 2006a). The original form of Grounded Theory was devised by Barney Glaser and Anselm Strauss and published in their seminal text, *The Discovery of Grounded Theory* (Glaser & Strauss, 1967). Glaser and Strauss had three aims with the publication of their book: "to offer a rationale for theory that was grounded (generated and developed during research projects), to suggest the logic for and the specifics of grounded theories, and to legitimize careful qualitative research" (Mills et al., 2006a, p. 8).

Qualitative research has been critiqued as lacking in scholarly rigor (Bendassolli, 2013). Bendassolli (2013) summarizes the problems with inductive research as: the role of empirical evidence in the theory-building process as contrasted to the role of logic, the application of analytical discipline that leads to credible interpretations of the data, and that a researcher's philosophical stance, background, experiences, biases, and emotions may influence the research and the eventual knowledge that is produced. To address his critique, Bendassolli (2013) asserts that:

> qualitative researchers contend that their work as being inductive does not consist of proposing and testing hypotheses. Their primary interest is to achieve understanding (*Verstehen*) of a particular situation, or individuals, or groups of individuals, or (sub) cultures, etc. (p.1)

The fundamental issue here is validity and justification for inductive findings where "induction negotiates the relationship between empirical reality and its theorization, in addition to the production and validation of knowledge" (Bendassolli, 2013, p.1).

Charmaz (2014) evaluates the GTM from the perspective that the completed work makes sense because the researcher has been immersed in the process, but the audience of the research may see blurred lines between process and product or could see the Grounded Theory process as part of the product. Glaser (1978) suggests that fit, work, relevance, and modifiability are useful for evaluating how constructed theory renders the data. There are undoubtedly other criteria like discipline, evidence, or aesthetics (Corbin & Strauss, 1990) that could also be applied as determined by the discipline involved. This researcher chose to take the quality criteria for qualitative Grounded Theory studies from Charmaz (2014) as she is arguably at the forefront of contemporary, constructivist GTMs and research. Constructivist Grounded Theory is the method applied in this research project. This researcher applied the attributes of Table 24 derived from her work (Charmaz, 2014) to this research as credible criteria attesting to research validity.

Careful and transparent application of criteria is the prime mitigation to the challenges to Grounded theory of producing valid research results. These attributes were applied primarily in Chapter 4 and 5 discussions and presentations.

Table 24

Criteria for Grounded Theory Studies from Charmaz (2014)

Criteria	Validity attribute
Credibility/trustworthiness	• The researcher has intimate familiarity with the topic • Data is sufficient to merit the research claims • Systematic comparisons between observations and between categories • Categories cover a wide range of observations • Strong logical links between the data and the argument • Research provides enough evidence to allow readers to form an independent opinion and agree with claims • Saturation is explained and justified
Originality	• Are the categories fresh and offer new insights? • The analysis provides a new conceptual rendering of the data • Theoretical significance exists from the work • The Grounded Theory challenges, extends, or refines current ideas, concepts, and practices
Resonance	• The categories portray the fullness of the studied experience • The analysis reveals both liminal and unstable taken for granted meanings • The constructed grounded theory makes sense to subject matter experts • The analysis offers deeper insight into the subject matter experts' experiences
Usefulness	• The analysis offers interpretations that can be used in the practical world • The analytic categories suggest any generic processes • The research sparks further research in other substantive areas • The work contributes to the body of knowledge • The work is an improvement identifiable in the current world

Careful consideration of the Table 24 attributes in the design of the research method is mitigating to the stated criticisms of the Grounded Theory method. Chapter 4 details the Table 24 research validity attributes in the specifics of this research's GTM design.

3.6 CONSTRUCTIVIST GROUNDED THEORY LITERATURE REVIEW

The constructivist GTM is relatively new in the development of GTMs (Mills et al., 2006b). There is evidence that Grounded Theory research is used increasingly in other fields of study from its roots in nursing (Egan, 2002). According to Denzin (1994), "the grounded theory perspective is the most widely used qualitative interpretive framework in the social sciences today" (p. 508). This relatively recent and wide application of the GTM in different fields of study has led to variability in defining the GTM process. "Although considerable debate has ensued among those practicing and writing about grounded theory research (including disagreement between the founders of the approach), many of the assumptions underlying grounded theory remain resilient" (Egan, 2002, p. 279). Charmaz, a former student of Glaser and Strauss, pioneered a significant departure from both Straussian and Classic GT (Kenny & Fourie, 2015). Her adaptation of the GTM is characterized by a constructivist philosophy that departed from the more concrete, rule-bound, prescriptive approach to coding in the earlier Straussian methods. Charmaz advocated adaptable and flexible coding guidelines which supported an "imaginative engagement with data" (Charmaz, 2008, p. 168).

A 2000 Charmaz critique took Grounded Theory in new directions (Charmaz, 2000a). Charmaz (2000a) viewed both Glaser's (1978) and Strauss and Corbin's (1998) versions of Grounded Theory as tied to positivist epistemologies. Charmaz (2000a) argued that researchers could adopt the methodological guidelines of classical Grounded Theory without importing positivist assumptions. The classical guidelines could be used from a number of epistemological starting points and initial theoretical standpoints (Charmaz & Bryant, 2011). Charmaz (2006) published her book, *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*, in which she explained how to conduct a Grounded Theory study founded on a separate set of epistemological principles which are constructivist. Grounded theory development has been a methodological spiral that is anchored with Glaser and Strauss's original text (Glaser & Holton, 1967) and continues today through Charmaz and others (Charmaz, 2006; Clarke, 2003; Lincoln & Guba, 2011; Mills et al., 2007; Traynor, 2006). There are a variety of epistemological positions that researchers can adopt at various points in this spiral (Mills et al., 2007). Since 2000, Charmaz has researched and published six books and at least ten peer-reviewed journal articles and co-authored several more. Her articles and books are the foundational references applied to develop the constructivist GTM applied in this research. An Engineering Village topical search on constructivist Grounded Theory since 2000 returned 212 hits. None of these were authored by Charmaz. Three of the authors can be attributed to five articles each, the remainder are mostly one-time writings. Prior to 2000, only 17 articles were identified as related to constructivist Grounded Theory. This demonstrates that the constructivist application of the GTM as developed by Charmaz is relatively new in the literature field and is dominated by her publishing. Appendix B is the listing of all the constructivist Grounded Theory articles used in developing the GTM applied in this research. This does not mean that other works in Grounded Theory were not consulted. Corbin & Strauss (1990) state that other criteria like discipline, evidence, or aesthetics could be applied to the GTM employed as determined by the discipline involved. Accordingly, Grounded Theory resources other than constructivist were consulted in building this research's specific methodology. The non-constructivist sources are listed in Appendix C.

3.7 CONSTRUCTIVIST GROUNDED THEORY METHOD

The constructivist GTM developed in this research project is unique. It is unique in that the researcher is heavily involved with data sourcing and data analysis, both of which are key attributes of the constructivist GTM (Mills et al., 2007). The researcher's involvement is what makes the applied method unique. Different researchers will engage differently with data collection and data analysis due to their own unique experiences and worldviews. Constructivism epistemologically emphasizes the subjective relationship between the researcher and the object of the research, and the unique co-construction of codes, categories, themes, and theories. Researchers are part of the research effort rather than isolated objective observers, and the researcher's values must be acknowledged by themselves and by their evaluators as an inseparable part of the research outcome (Lincoln & Guba, 2001; Mills et al., 2007). Charmaz (2000a) has contended that a constructivist approach to Grounded Theory is both possible and desirable because "Data do not provide a window on reality. Rather, the discovered reality arises from the interactive process and its temporal, cultural, and structural contexts" (p. 524).

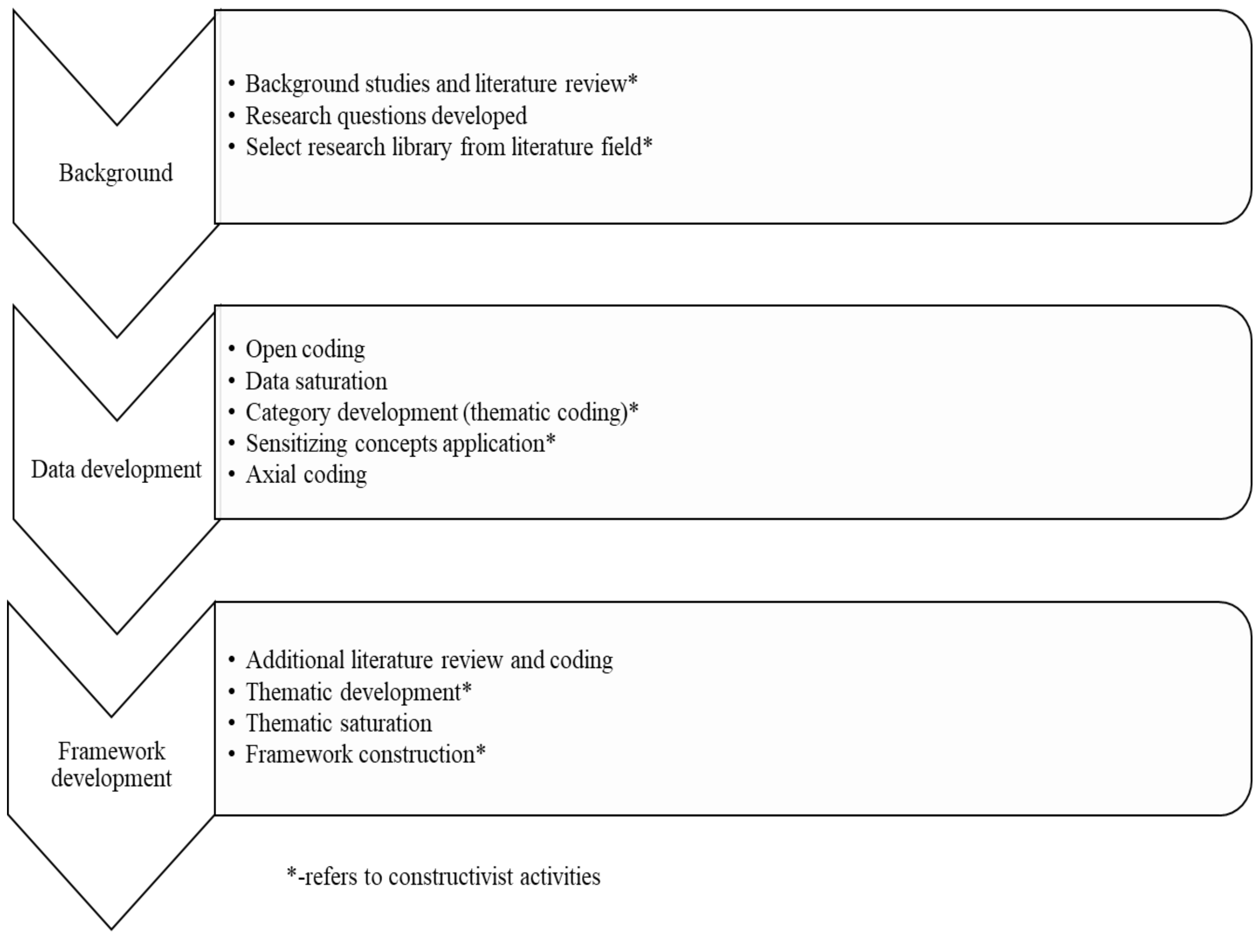
Charmaz's (1996) form of constructivist Grounded Theory applies the strategies of traditional Grounded Theory within a constructivist paradigm that rejects notions of emergence and objectivity and is centered on the underlying assumption that the interaction between the researcher and the researched "produces the data, and therefore the meanings that the researcher observes and defines" (p. 35). The method applied in this research consists of classic GTMs that are modified in support of the constructivist paradigm.

Figure 17 is a simplified constructivist GTM activities map that was developed for this research. It shows both the conventional Grounded Theory activities and the constructivist activities. The conventional Grounded Theory activities are explained in detail in section 3.2.5. This section focuses on constructivist activities.

Constructivist activities begin in the background phase, where the literature review takes place. The literature that was reviewed was developed as part of classwork in systems engineering courses and developed in the ODU CSG Learning Community. This researcher's interests in ES focused on the literature that was studied on ES topically and expanded the literature field studied beyond that of academic class work on the ES topic, primarily from class projects and scholarly contributions to the CSG Learning Community. The researcher's interest in ES functions in CSG lead to determining a literature gap and the shaping of research questions. A selective filter, explained in Chapter 4, was developed to apply to all the ES literature that had been collected to determine which articles were relevant to creating the research library that subsequently was going to be coded. This level of researcher engagement with the literature field before beginning coding is an earmark of constructivism.

Figure 17

Constructivist Grounded Theory Map



3.8 CONSTRUCTIVIST GROUNDED THEORY CRITICISM AND MITIGATIONS

Criticism and related mitigations of inductive research and Grounded Theory, in general, were presented in section 3.5. This section specifically addresses criticisms and mitigations of constructivist Grounded Theory. The principal critique of constructivist Grounded Theory comes from one of Grounded Theory's founding fathers. Glaser (2002) states that

"Constructivist Grounded Theory (GT) is a misnomer. GT can use any data; it remains to be figured out what it is" (p. 1). His criticism is based on his view of Grounded Theory that "GT is a perspective based methodology and people's perspectives vary" (Glaser, 2002, p. 2). He claims that Charmaz's (2000b) defining of constructivism as a future method within the Grounded Theory construct is only a major worry in qualitative data research that should not affect Grounded Theory, as it is "just a different take on the personal predilections of interviewer and interviewee" (Glaser, 2002, p. 1). Glaser alleges that data is just data no matter what its source is, and he alleges that constructivism appears to be an effort to justify the data as accurate to avoid the issue of the impact of researcher bias. His view is that if the researcher is exerting bias, then it is part of the research; it is a variable to consider in the constant comparative process.

Charmaz & Bryant (2011) state that "constructivist grounded theory arises from a relativist epistemology, challenges positivist assumptions in earlier versions of grounded theory, and aligns the method with interpretive inquiry" (p. 408). Their basic argument is that constructivist Grounded Theory is based upon the researcher's view of the research problem, setting, and participants. They state that constructivist generated data is data viewed "as co-constructed with research participants, whether these data consist of interviews or documents or anything else" (Charmaz & Bryant, 2011, p. 409).

Glaser's (2002) criticism of Charmaz's (2000b) constructivism is based on his very broad view of data as "all is data" (p.1), while Charmaz (2000b) sees the data as co-constructed with the researcher and research participants. In the opinion of this researcher, this criticism does not merit a resolution. The Glaser view of data (all is data) encompasses what Charmaz articulated about data (co-constructed). This then does not create a process issue to be mitigated. It becomes a terminology or labeling issue that does not bear weight on the research method employed in this research nor on the quality of the research findings. This researcher's own experience in employing a constructivist Grounded Theory method is more specifically aligned to Charmaz's view of the data being co-constructed than it just being "all is data."

The generation of open codes from authoritative data sources (selected reference articles) requires the researcher to label (code) a selected text. That labeling then guides how future selected texts are labeled, distinguished, contrasted, combined, and constructed into categories, and categories into themes, and themes into a framework.

Quality in research findings from qualitative research is an ongoing issue of debate: "Criteria about the quality in qualitative research remain unsettled" (Charmaz & Thornberg, 2021, p. 308). Charmaz and Thornberg (2021) go further in their quality assessment to state that Grounded Theory needs its own version of quality and, more specifically, that individual methods of Grounded Theory should have their own criteria for quality due to their unique methods. From their perspective, they lay out four criteria for quality in constructivist Grounded Theory studies: credibility, originality, resonance, and usefulness (Charmaz & Thornberg, 2021). Table 25 summarizes their four criteria for constructivist Grounded Theory quality and shows the applicability of these criteria to this research. By developing this research's constructivist methods with these four quality criteria in focus, the risk to a quality research product (a framework) has been mitigated as far as practicable against the criticism of quality in constructivist Grounded Theory research. The Table 25 constructivist quality attributes are explained in the specifics of the research method design in Chapter 4.

Table 25

Criteria for Quality Constructivist Grounded Theory Studies

Criteria for quality in constructivist Grounded Theory studies	**Criteria definition**	**Applicability to this research**
Credibility	Sufficient relevant data for making systematic comparisons	An extensive research library developed with data from seven different fields of study
Originality	Providing fresh conceptualization of a recognized problem	Sensitizing concepts from CSG metasystemic functions were used to both validate the existing ES process but also to support functions that are new to the existing, current view of ES functions
Resonance	Constructing concepts that provide insights to others	New theoretical functions for ES in CSG were recognized in the data analysis that can lead to new understandings of the CSG metasystemic functions
Usefulness	Using input from data sources creates new lines of research	Data-driven constant comparison process created new themes and innovative ideas outside of the scope of the research that can be explored

3.9 FACE VALIDATION CRITERIA

In its early years of development, the term FV was confused by many and not clearly articulated as to its meaning and application and was a source of confusion (Nevo, 1985; Turner, 1979). Nevo (1985) went further to specify that “In fact, a theoretical framework and a measurement procedure with recommendations for its [FV] application have never been suggested” (p. 288). Nevo (1985) proposes a definition of FV that consists of four elements: (1)

the rater, (2) the object of the rating, (3) the technique of rating, and (4) its relevance to its intended use. Taking from Nevo's (1985) algorithm and applying it to this research results in a research-specific definition of FV. This definition is *a measurement of FV is made when the rater, who is a researcher, rates a test item by employing a relative technique that is suitable for its intended use.* Turner (1979) defines FV as "'face valid' measures are measures which have not yet achieved as great a degree of certitude of validation as measures validated empirically" (p. 85). The Oxford online dictionary defines FV as "the degree to which a procedure, especially a psychological test or assessment, appears effective in terms of its stated aims" (Oxford University Press, 2021). Rubio et al. (2003) define FV as "face validity indicates that the measure appears to be valid, 'on its face'" (p. 94). From these multiple definitions of FV, there is not a clear, acceptable standard to measure against. From this perspective, this researcher chose to apply the FV definition derived from Nevo (1985) that was stated above. It provides a framework for a clear as possible construct for FV: who, what, how, and why. Table 26 summarizes the derived Nevo (1985) framework and its applicability to this research. The framework measurement criteria are the FV quality criteria applied to the findings of this researcher's case study addressing research question number two.

Table 26

FV Measurement Criteria and Application

Nevo (1985) FV Measurement	**Application to this research**
Rater position	This researcher
Object of rating	The research results: application of the ES framework in an applied setting
Employed technique	Applying ES framework in an applied setting (FEMA communications in Hurricane Katrina)
Intended use	Evaluation of the applicability of the new ES framework in an applied setting for future research concerns, testing of applicability of the framework in an applied setting, emergent concepts identification.

3.9.1 FACE VALIDATION CRITICISM AND MITIGATIONS

FV has been claimed to be an inferior form of validity, in contrast to validity which is established by empirical evidence (Turner, 1979). Turner (1979) uses the concept of “correspondence rules” to justify that there is no need to make assertions about validity independently of a theory (p.89). He treats the principles governing the relationship between a concept and its measure as conventions, which he labels “correspondence rules." The term "rule," as applied to his definition, is meant to mean that the conventions are neither true nor false, resulting in no evidence being needed to justify them. He states that “they become a non-truth functional component of the theory, and are open to revision along with the claims of the theory” (Turner, 1979, p. 89). Rubio et al. (2003) state that although content validity is subjective, using a FV method can add objectivity and that while validating a finding is a never-ending process, evaluating the FV of the measure is a start.

This researcher took Turner's (1979) viewpoint that the criticism of FV as inferior is relevant only to the stated goals of the validation. Therefore, to mitigate the FV quality concerns, the goals for this research's FV must be clearly stated. These goals are stated in Chapter 4, section 4.7.

3.10 CASE STUDY METHODOLOGY

The case study methodology addresses the approach to answering research question number two, which concerns the results from the deployment of the ES framework in an applied setting. Research question two was addressed with a face validation case study of the ES framework. The case study is based upon the functioning of FEMA (Federal Emergency Management Agency) during the Hurricane Katrina natural disaster crisis. This event was selected for the case study because of the abundance of information publicly available concerning how FEMA prepared, responded to, and then optimized its functioning for the future, i.e., acting as a system).

Fidel (1984) identifies a case study as "investigations of phenomena as they occur without significant intervention of the investigators" (p. 275). Yin (1981) states that case studies "may be used for either descriptive or explanatory purposes … to describe a situation, or to test explanations for why specific events have occurred" (p. 98). In addressing research question two, the case study methodology applied was for the purpose of investigating a phenomenon for explanations of why the event has occurred. This research applies the theoretically constructed ES framework in an applied setting (FEMA actions before, during, and after Hurricane Katrina) for a face-validation of practical application.

Yin (1981, 2018) posits that a single-case design can be used to test theory and can provide valid test results. The Yin approach is applicable to this research. Responding to research question two is a face validation that tests the applicability of the ES framework in one applied setting, thus limiting its validation value.

Yin is arguably the leading author of case study methods (Yin, 2018). He has authored more than 100 publications and 11 books in multiple languages (Yin, 2018). He proposes a six-function methodology for conducting case studies in general, which he describes as a linear but iterative process. An adaption of his methodology is shown in Figure 18.

Figure 18

Six Function Case Study Methodology Adapted from Yin (2018)

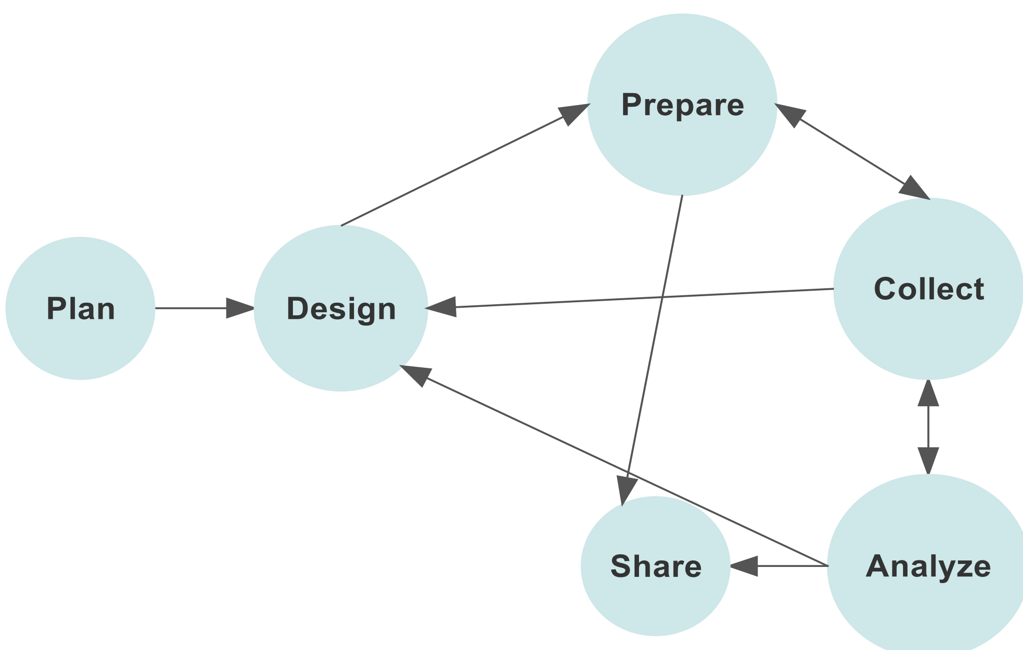


Table 27 summarizes the functions in each of the six activities shown in Figure 18 as they are applied in this research.

Table 27

Yin (2018) Case Study Methodology Summary

Function	Function summary
Plan	• Identify the relevant situation for the case study
Design	• Define the case to be studied • Develop theory and related propositions to guide the study • Identify the study design • Test design against quality criteria
Prepare	• Develop case study protocol • Select final case
Collect	• Assemble data into a case study database • Maintain chain of evidence • Triangulate evidence from multiple sources
Analyze	• Display data • Look for patterns, insights, concepts • Develop analytic strategy
Share	• Define audience • Compose written materials • Display enough evidence for reader to reach own conclusions

3.10.1 CASE STUDY CRITICISM AND MITIGATIONS

Qualitative research has been critiqued as lacking in scholarly rigor (Bendassolli, 2013). Yin (2018) states that "many researchers disdain case studies" based on their view a case study is a less desirable method for an experiment and the need for greater rigor (p. 18). Therefore, it is most appropriate to address quality in a case study.

Lee, et al. (2010) present criteria for quality of the case study as transferability, credibility, confirmability, and dependability. These criteria are defined, and their application to the FV case study in this research is discussed in Chapter 4, section 4.7.

Case study concerns from Yin (2018) include rigor, confusion with non-research case studies, generalizability from a single case study, unmanageable levels of effort, and lack of comparative advantage. Fidel (1984) states that "the nature of the data collected and the type of analysis performed introduce problems" (p. 285). He categorizes the problems as getting in, the searcher's bias, the study effect, and the observer's bias. Yin's (2018) and Fidel's (1984) combined concerns and the appropriate mitigations to these concerns are discussed in Chapter 4, section 4.7.

3.11 CHAPTER SUMMARY

This chapter presented the paradigm for the conduct of research to address the stated research questions. An inductive research design and the application of constructivist Grounded Theory were chosen to develop a framework specific to ES functions in CSG that are grounded in Systems Theory. This research design was justified from an ontological, epistemological, and researcher's role perspective. Additionally, as Grounded Theory in the disciplines of Engineering Management and Systems Engineering has been limited and as there are associated concerns with the application of Grounded Theory, the mitigation criteria to stated concerns were discussed.

The inductive research methodology applied to this research was explained in detail as a key tenant in the Grounded Theory research finding's credibility. The level of detail provided is to support transparency in the application of the Grounded Theory method to provide assurances of credible results.

The canons of science were defined as applicable to qualitative research. The research methodology was developed and presented to apply the identified qualitative canons to this research.

A limited face validation case study was discussed as an approach to provide a degree of applicability to the research findings and to provide feedback to the ES framework for future development. The case study methodology was presented in a level of detail that supports a face validation study. The general criticisms of both face validation and case studies were identified, and mitigations were enumerated in support of the quality of this research's findings and conclusions and are explained in Chapter 4.

A generalized approach and strategy for data collection and analysis was presented in support of clarity in this unique research methodology. Constructivist GTMs are relatively new, are influenced by the researcher, can conflict with classic Grounded Theory methods, and rely heavily on method documentation. Unlike classical Grounded Theory practices that center around interviews, this researcher selected journal articles and book sections as the source data, essentially capturing the thoughts of the respective authors through their written products. This choice of data sources then drove the development of the specific Grounded Theory methods that were applied to this research and that are presented in this methodology section.

As the constructivist method of Grounded Theory is still developing, additional insight into this method was provided by a constructivist methods' literature review, by providing additional details about the constructivist method applied to this research, and by affording additional attention to criticisms aimed at constructivist methods and providing attention to their mitigations applicable to this research.

A methodology for applying FV quality criteria to the case study FV was presented. FV criticisms were identified and are responded to in Chapter 4.

A case study methodology was presented to address the response to research question two. Case study criticisms were identified, and appropriate mitigations were identified as appropriate to this research and discussed in Chapter 4.

Chapter 4 is a detailed explanation of the constructivist Grounded Theory research design as well as the Case Study application for FV applied in this research. This chapter provides added transparency to the researcher's research methods to strengthen the credibility of the research findings. Chapter 4 details the researcher's uniqueness in the constructivist Grounded Theory process and the establishment of FV through a Case Study application.

CHAPTER 4

RESEARCH METHOD DESIGN

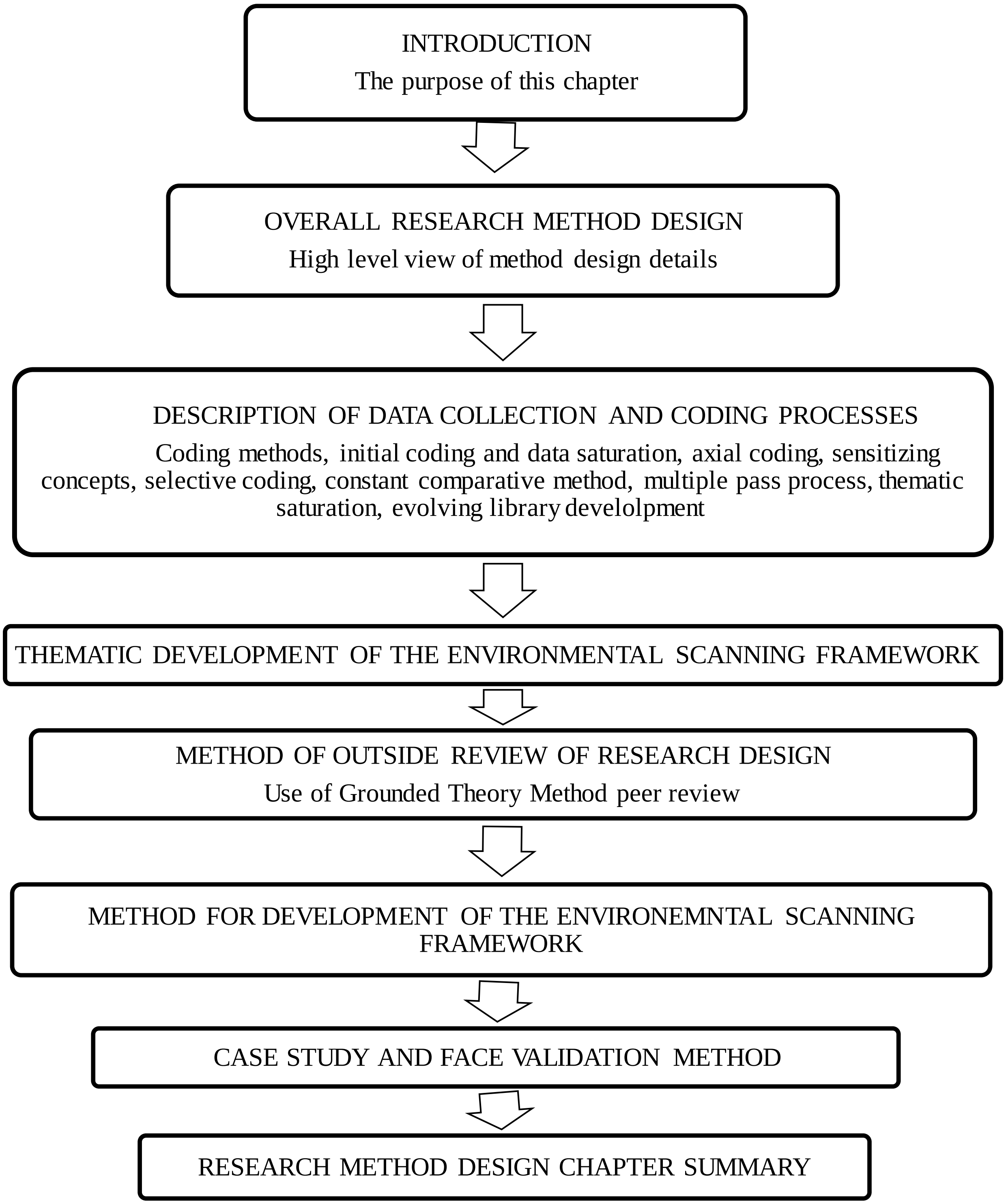
4.1 INTRODUCTION

This chapter presents the research method design, the details on how the research was accomplished with application of the constructivist GTM, the details of the method for the face validation of the resultant ES framework using a case study, and the specific mitigative actions taken to address criticisms of the GTM identified in Chapter 3. The purpose of this research is to construct a Systems Theory-based framework for Environmental Scanning in Complex System Governance using an inductive research design and to face-validate the resultant framework in an applied setting using a case study. Chapter 2 previously described the literature review with respect to ES functions in CSG from a Systems Theory-based perspective. The literature review established a gap in the extant literature that points to the opportunity to construct a rigorous Systems Theory-based approach to the functions of ES in CSG. This literature gap opportunity is the response to research question one. Chapter 3 described and justified the overarching inductive research methodology employed to respond to both research questions.

Chapter 4 is the linkage between the research questions and the response to those questions that is presented in Chapter 5. Chapter 4 builds upon the material in Chapters 1-3 and provides the research design details that enables research findings for a framework to be developed for the Systems Theory-based functions of ES in CSG. It also presents the method employed to articulate how the developed ES framework will be face-validated in an applied setting. Figure 19 is the outline of Chapter 4.

Figure 19

Outline of Chapter 4

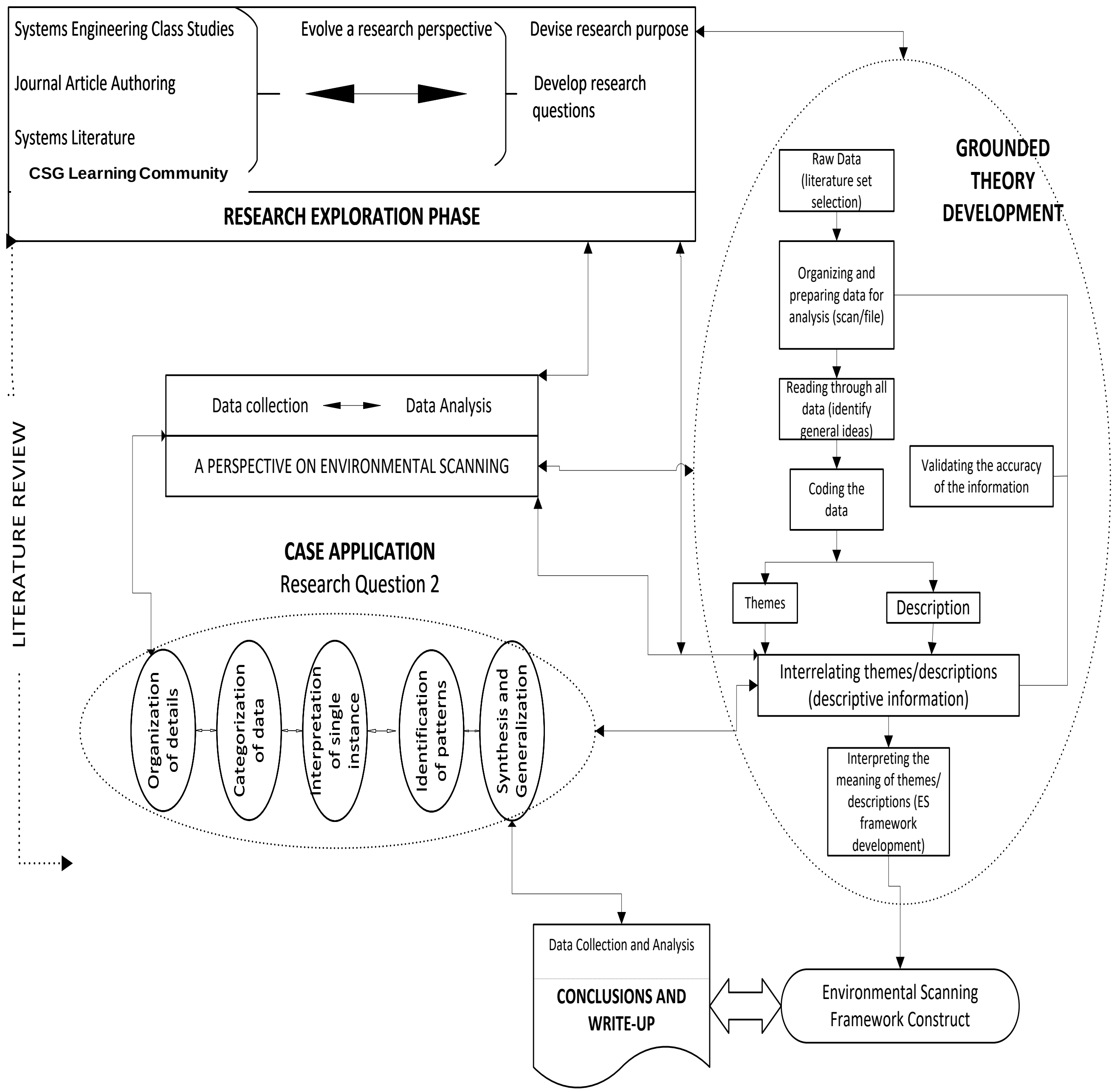


4.2 OVERALL RESEARCH METHOD DESIGN

The overarching research method design is presented in Figure 20. It consists of four overarching phases from research exploration through conclusions and write-up phases.

Figure 20

Overall Research Method Design



OVERALL RESEARCH PHASES

The research exploration phase consists of all the background work accomplished that leads up to the definition of a research question(s). This phase covers ODU Engineering Management and Systems Engineering Ph.D. academic class work, readings, class-based research projects, community learning, personal interests, and the researcher's relevant experiences. These items are presented in more detail in the Acknowledgments.

The Grounded Theory development phase and the case study phase will be explained in detail in this chapter.

Applying the research method to the research literature (data) results in research findings. The conclusion and write-up phase presents the findings and interprets their contribution to addressing the research questions. The conclusions present the research findings' contributions to theory, practice, the ES body of knowledge, and the Grounded Theory research method application. These are presented in Chapter 6. Future research directions stemming from these research findings are also presented in the write-up in Chapter 6.

4.3 DESCRIPTION OF DATA COLLECTION AND CODING PROCESS

Applying as a guide Charmaz's (2014) Grounded Theory experience in working with texts and recognizing the requirement for use of scholarly literature in scholarly research (Rosenblatt, 2010), the criteria (SUNY, 2022) for choosing the extant literature to be used as the appropriate Grounded Theory data source were developed and are listed in Table 28 *Criteria for Choosing Extant Research Literature*. These criteria, when applied, define the basis for scholarly literature to be used for the construction of the ES framework for this research.

Table 28

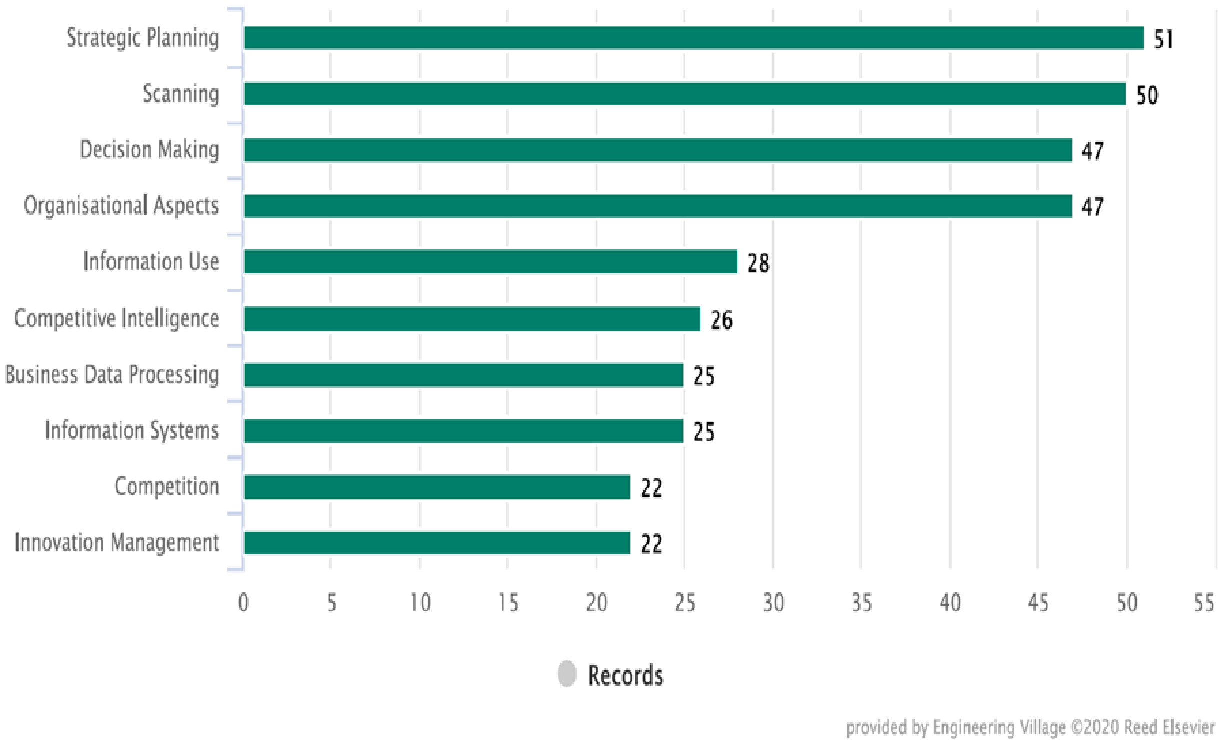
Criteria for Choosing Extant Research Literature

Criteria for choosing selected scholarly literature	
Included	
	Peer-reviewed journal articles from journal article databases of scholarly recognition
	Published in an edited textbook
	Cited in Peer-reviewed journal articles or textbooks
	Published Conference Proceedings from authors renowned for their research in the field of interest
	Topically related dissertations
	The item was a reprint of an article or chapter that appeared in a scholarly or peer-reviewed publication
	Websites where an author could be determined, and a bibliography or references were provided to support assertions made in the item
And	Contextually relevant to the research objective
Excluded	Non-peer reviewed literature (wiki, magazines, newspapers)
	Unpublished or preliminary literature, literature not related to the functioning of ES
	Contextually not relevant to this research's objective

The numerous sources of data present from the literature review and other sources needed to be reduced to data that is contextually related to CSG, Managerial Cybernetics and ES as necessitated by the GTM and the Systems Theory-based approach of this research. Elsevier's Engineering Village with its comprehensive database that includes the leading engineering information discovery platform is a search and discovery platform that provides the high-quality content, data, and intelligence engineering resources available at ODU. It was searched to frame the ES literature from its engineering related databases. Only 393 records containing ES in the title or text were found in the Compendex & Inspec databases from 1884-2021. In contrast, a Google Scholar search returned 30,200 records that contained ES. This difference is related to the fields of study included in the respective data bases, with Google Scholar containing multiple fields of study (Mayr & Walter, 2007) versus Engineering Village that is engineering focused in two major databases. Using the Engineering Village searches as the most relevant databases to explore ES topics contained in the field of Systems Engineering in contrast to other non-engineering fields, a preliminary but dynamic framework for ES relevant literature that is grounded in Systems Theory was developed. Table 29 summarizes the search information taken from Appendix A Engineering Village Search Results for ES related literature. It presents the number of articles found and what field of study the articles were found in. This search outcome formulates the literature starting point for ES literature that is found in the engineering sciences related literature.

Table 29

Engineering Village Database Search for ES Related Literature



The authors listed in Table 30 come from searching the Engineering Village database for reference articles topically found under Managerial Cybernetics, CSG, and ES as the Systems Theory-based literature. It is the writings of the Table 30 authors, in part, that were coded to develop the research data that is Systems Theory-based.

Table 30

Summary of Engineering Village Search Key Authors

Systems Theory-based Field of Study	**Key Authors**	**Article count**
CSG	Keating	23
	Katina	18
	Bradley	11
Management Cybernetics	Keating	10
	Katina	6
ES	Choo	7
	Mayer	7
	Maier	4

The search performed in Engineering Village was a starting point. A broader search for reference articles was performed to assure that the constructed ES framework would have a wide generalizability. Additional reference articles from the researcher's ES literature library, taken from other than Engineering Village sources, and from a Google Scholar search for ES reference articles that were relevant to this research's objectives, were coded to ensure a robust and multi-faceted database. A total of 150 reference articles comprised the research library from these multiple sources and were identified with the eight fields of study listed in Table 31 to provide a broad base for credible data analysis.

Table 31 identifies the initial literature coded and the initial keywords used in coding the chosen literature. This literature set was chosen because it met the selection criteria in Table 28 Criteria for Choosing Extant Research Literature), was predominantly grounded in Systems Theory, was sourced from multiple fields of study, and was the literature subset from the literature review that is most closely related to this research's objective of constructing a framework for ES functions in CSG that are Systems Theory-based. It is only the initial set, as the constant comparative method of Grounded Theory brought other relevant literature into the analysis process. The initial literature set selection process was dynamic in that it left room for additional articles to be brought into the Progressive Coding process when additional specific information was identified in support of code clarity of meaning or code depth (number) of references. Those articles are included in the Table 31 list of reference articles coded. The complete list of literature coded from all sources in the applied GTM in this research is presented in Chapter 5.

From this researcher's existing ES literature library and the outcomes of the Engineering Village and Google Scholar ES searches, this researcher identified an initial, qualified, 124 reference articles that were coded as the basis for developing a meaningful and relevant database for GTM framework development. These are listed in Appendix D.

Table 31

Initial Literature Coded

Field of Study	**Initial Reference Literature for Coding**
CSG, Governance literature	See Appendix D
ES literature, Managerial Cybernetics, Systems Theory	See Appendix D
Related to ES Literature	See Appendix D
Futurism	See Appendix D
Planning	See Appendix D

Field of Study	**Initial Reference Literature for Coding**
Marketing	See Appendix D
Information Science	See Appendix D
Management	See Appendix D

The qualified literature bank from Table 31 was coded to develop objective data for analysis and ES framework development.

Because not all the writing in the selected reference articles is about the functioning of ES in CSG (e.g., pictures, bibliographies, histories), line by line coding (Charmaz, 1996) would not be a productive coding process as it would generate large numbers of codes that are not related to the research objective. A large number of unrelated codes would complicate the construction of categories and themes and could potentially detract from valid theme development. Additionally, a large amount of research time would be invested in developing these unrelated codes to just eventually place them in a parking lot for unrelated codes to be ignored. A method was developed to identify the research-related information in each reference article that could then be coded in a line-by-line method. Key words were identified that are related to the research objective. These key words were then used to identify the text material in each reference article that was related to the research purpose. This was accomplished by performing a text search for the key words. The key word identified text material was then line-by-line coded. The key words used to identify research related texts for this research are listed in Table 32. These key words were developed from the keywords taken from journal articles in each of the literature streams that were searched for ES data. These key words were selected because they indicated a function for ES. The reasoning for including them in the data search function is given in Table 32.

Table 32

List of Key Words Used to Identify Research-related Text Material for Coding

Field of study	**Key words**	**Reasoning**
CSG	Governance, Complex System Governance	Both terms relate to the ES function in CSG
	M4´	Is the designator for ES in CSG
	Design	Is part of the ES function
ES/Managerial Cybernetics/Systems Theory	M4	Is part of ES function
	Environmental Scanning, Scanning (the environment)	Is the key function of interest
	Learning	Is part of ES function in CSG
	Detect Trends	Is part of ES function in CSG
	System Four, S4	Name for ES in Cybernetics
Futurism	Futures, Foresight, Futurism	Involves ES-like functions
	Sensing	Involves ES-like functions
Planning	Planning	Involves mining of data from the environment (ES-like)
	Predicting	Outcome of ES function
Management	Planning	Involves mining of data from the environment (ES-like)
	Gather Information	An ES function
	Gather Data	An ES function
	Decision making	A function closely related to ES
Marketing	Environmental analysis	A function of ES in CSG
Information Science	Data mining	A function of ES in CSG

These key words pointed to sections of text that described ES or ES-like functions. The key words were chosen by this researcher from the context of the field of study that is related to the ES function. From these sections of text, new, open codes were identified and recorded following a line-by-line coding process. This process was applied to all new literature brought into the GTM during the constant comparative process.

At the initial completion of the data collection process, a database of qualified literature articles existed to support the research's intended purpose. This database of the research literature resided in NVivo as searchable PDF files. NVivo tools were then used to keyword search the literature for the relevant texts to be line-by-line coded and to record the resultant codes and memos for further analysis.

4.3.1 CODING METHODS

Saldaña is generally considered a world-renowned expert in data coding (Sage, 2022). His seminal work (Saldaña, 2013) "remains the only book that looks specifically at coding qualitative data, as a core but often neglected skill that researchers and students alike need to effectively make sense of their data and to identify patterns, before they can analyse the material" (Sage, 2022, p. 1). Strauss (1987) suggests that a researcher who is to be proficient at doing qualitative research must learn to code well because the excellence of the research is closely related to the excellence of the coding. He states that coding is a way to analyze data. Therefore, it was important to assess the methods available to perform the function of coding. Consulting Saldaña (2013) was a credible way to determine a coding method that was best suited for this research's coding methods.

Saldaña (2013) provides 32 coding methods that can be applied to analyzing and interpreting information that informs the research's objectives. See Table 33 for a summary of these methods from Saldaña (2013).

Table 33

A Summary of Saldaña's (2013) 32 Coding Methods

No.	Coding method	Attributes
1	Attribute Coding	Provide essential information about data for future reference
2	Axial Coding	Develop a category by grouping/sorting/reducing the number of codes generated from the first cycle of coding
3	Causation Coding	Analyze the causality by identifying causes, outcome, and links between them
4	Descriptive Coding	Describe the topic of data with descriptive nouns (i.e., topic coding)
5	Domain and Taxonomic Coding	Analyze the cultural knowledge participants use and organize them into categories and reorganize them through further analysis into a taxonomic tree diagram
6	Dramaturgical Coding	Apply dramaturgical terms to qualitative data to analyze interpersonal and intrapersonal participant experiences
7	Eclectic Coding	Combine two or more similar First Cycle of coding methods purposefully
8	Elaborative Coding	Develop codes to refine theoretical constructs emerged from previous research or investigations
9	Emotion Coding	Apply codes accompanying emotion(s) to explore the interpersonal and/or intrapersonal participants' experiences
10	Evaluation Coding	Apply non-quantitative codes (e.g., +/-) to qualitative data for the evaluative purpose
11	Focused Coding	Develop categories with significant or frequent codes that emerged from In Vivo, Process, and/or Initial Coding
12	Holistic Coding	Analyze the data corpus as a whole and identify the basic themes or issues in the data
13	Hypothesis Coding	Apply pre-established codes to qualitative data to examine a researcher-generated hypothesis
14	In Vivo Coding	Apply the words verbatim that participants use to examine the possible dimensions or ranges of categories
15	Initial Coding	Apply provisional and tentative codes in the First Cycle of coding
16	Longitudinal Coding	Organize collected qualitative data across time; Categorize data into matrices for further analysis and interpretation

No.	Coding method	Attributes
17	Magnitude Coding	Apply supplemental or sub-codes to quantitize or qualitize the phenomenon's intensity, frequency, direction, presence, or evaluative content
18	Motif Coding	Apply original index codes utilized to classify the elements of folk talks, myths, and legends; This method can be utilized for story-based data such as journals or diaries
19	Narrative Coding	Develop codes representing participant narratives from a literary perspective (e.g., storied, structured forms)
20	Outline of Cultural Materials Coding (OCM)	It was created as a specialized index for anthropologists and archeologists; Provide coding for the categories of social life
21	Pattern Coding	Develop meta-codes that identify similarly coded data by grouping them and generate major themes; Appropriate for Second Cycle coding
22	Process Coding	Apply codes by using -ing words to indicate actions
23	Protocol Coding	Apply codes or categories in a previously developed system to qualitative data (e.g., ALCOH = alcoholism or drinking)
24	Provisional Coding	Utilize the preset codes emerged from preliminary investigations or literature review and anticipated to be modified, revised, or deleted during the data analysis
25	Simultaneous Coding	Apply two or more different codes to a single qualitative datum in the different dimensions
26	Structural Coding	Categorize the data corpus into segments by similarities, differences, relationships by using conceptual phrases
27	Sub-coding	Develop sub-categories in the hierarchies and taxonomies added to the primary codes
28	Theoretical Coding	Develop the central category that covers all other codes and categories by integrating and synthesizing them
29	Values Coding	Apply codes consisting of three elements, value, attitude, and belief to examine a participant's perspectives or worldviews
30	Verbal Exchange Coding	Interpret data through the researcher's experience and reflection to explore cultural practices; Extensive written reflection is preferred to traditional margined coding methods
31	Versus Coding	Identify phenomena in a dichotomy term and exhibit itself as X vs. Y
32	Theme	Theming the data identify codes in the form of sentences capturing the essence and essentials of participant meanings

The various coding attributes identified in Table 33 coding methods reveal how research coding objectives can be set up. Saldaña (2013) states that "some methodologists advise that your choice of coding method(s) should be determined beforehand to harmonize with your study's paradigm and should enable an analysis that directly answers your research questions" (p. 62). He goes further to state "If your goal is to develop new theory about a phenomenon or process, then classic or re-envisioned grounded theory and its accompanying coding methods are your recommended but not required options" (Saldaña, 2013, p. 62). Saldaña (2013) suggests that In Vivo Coding and Process Coding are the foundational methods for Grounded Theory development and that these techniques are also employed in other Grounded Theory coding methods such as Initial, Focused, Axial, and Theoretical Coding. Process Coding uses gerunds ("-ing" words, the noun form of a verb) exclusively to connotate action in the data (Charmaz & Belgrave, 2002). Action codes help compare data from various sources about similar processes and to show what is happening (Charmaz & Belgrave, 2002). Charmaz & Belgrave (2022) try to make action in the data visible by looking at the data as action. Charmaz (2015a) states that "using gerunds for coding helps researchers to see actions and to begin to theorize processes" (p. 405).

Saldaña (2013) states that Process Coding is particularly appropriate for "those that search for 'ongoing action/interaction/emotion taken in response to situations, or problems, often with the purpose of reaching a goal or handling a problem'" (p. 96). He points out "for grounded theory, Process Coding happens simultaneously with Initial Coding, Focused Coding, and Axial Coding, and a search for consequences of action/interaction is also part of the process (Saldaña, 2013, p. 96). Saldaña (2013) however, states that "Process Coding is not necessarily a specific method that should be used as the sole coding approach to data" (p. 96).

The purpose of this research project was to construct a framework for how ES functions in CSG. Functioning is an action. Google's English dictionary defines the verb form of function as “work or operate in a proper or particular way” (“Function", 2022). The research objective is centered on “functions.” It is about action, how ES acts or operates in a particular way in its role in CSG.

From the preceding discussion, Process Coding is the coding method most closely aligned with Grounded Theory objectives, and is about finding action in the data, and occurs across several phases of the data coding process. It was the basic coding method applied in this research. The library of reference articles selected to be coded were searched to find text data that was relevant to the ES function. The reference article searches resulted in lines of text to be coded using gerund (“-ing”) action words (e.g., deciding, planning, searching) which is Process Coding. The process of searching each reference article for ES related texts, abstracting the resultant search text into a code, and recording the finding in a code database is the Initial Coding process. This process was accomplished using the NVivo software toolset. The initial codes abstracted from the reference data are sometimes called open codes (Williams & Moser, 2019) and are referred to as that in this report to distinguish them from the Initial Coding process and other tiers of codes.

“Most methodologists concur that coding schemes are customized to the specific contexts of a study; your data are unique, as are you and your creative abilities to code them” (Saldaña, 2013, p. 38). In this research’s data set, some of the same code-names (open codes) were generated repeatedly throughout the Initial Coding process. Saldaña (2013) posits this as a natural event because the researcher’s primary goal is finding repetitive patterns of action (coding process) documented in the data. Even though some of the codes had the same name, these same-named codes did not all have the same context (e.g., the open code-gerund “searching” has at least two contexts: (1) searching internally and (2) searching externally). To separate these same-named codes, the Initial and Axial Coding processes were modified to include Saldaña's Simultaneous Coding method (Saldaña, 2013).

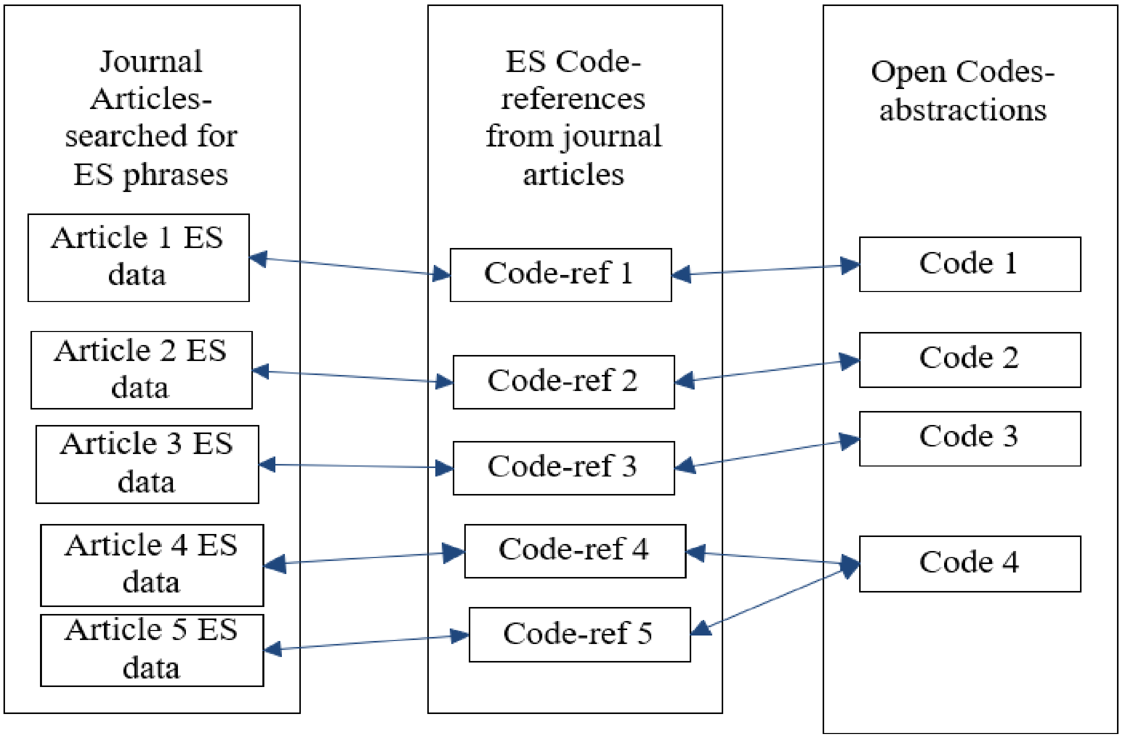
Simultaneous Coding applies two or more code-methods within a single coding event (Saldaña, 2013). Initial Coding began by assigning singular gerunds to the selected text to be coded. This method abstracted the selected text into action-oriented gerunds (Process Coding) (e.g., searching, documenting, finding). As much as possible during Initial Coding, this researcher also used another coding method called In Vivo Coding. In Vivo Coding uses the author's own words to code the selected text when the code-gerund appears in the selected text to be coded. After several hundred open codes were generated, the "same code-name" phenomenon was recognized. This caused the Initial Coding process to be paused while this issue of "same code-name but different code-context" was resolved. The resolution applied was to acknowledge that a confounding property of code and category construction in qualitative inquiry is "that data cannot always be precisely and discretely bounded; data are within "fuzzy" boundaries at best" (Tesch, 1990, p. 139). As first pass Initial Coding was undertaken, the researcher was initially unfamiliar with code-names. At some point in the Initial Coding process, repetitive patterns in the coded text began to be recognized, thus the Initial Coding process was paused to understand how to react to this same coding process occurrence.

With Simultaneous Coding the process of coding and recoding strives for the codes and categories to become more refined, more conceptual, and more abstract (Saldaña, 2013). The process of Descriptive Coding (described in Table 33) was added to the Initial Coding methods of Process Coding and In Vivo Coding, with the intent to provide specific context to the "same gerund-name" codes. Descriptive Coding summarizes in a short phrase the basic topic of the text selected to be coded (Saldaña, 2013). The topic is what the code or category is written about, its purpose. The topic's content is the substance of the code or category. This method enhancement resulted in open codes and categories constructed of two parts: (1) the action part (gerund-codes and in vivo codes) and (2) the result of the action part (descriptive codes). Thus, an open code would look like, for example, "scanning to reduce variety" and "scanning to learn." By adding the Descriptive Coding process method, codes and categories could be identified as uniquely related to their purpose: ES function and result of the function. This method enhancement resolved the same-named gerund issue. This coding method revision was retroactively applied to all data that had previously been coded and was carried forward through the rest of the coding process. The coding method decisions in this research were based on the methodological needs of this research study.

Figure 21 depicts the Initial Coding process. Note that journal articles 4 and 5 in Figure 21 had similar ES data (code-references) and were added to the same code 4, thus together created only one new code from multiple data sources (code-references). The constant comparative method, when applied to the data field, continuously caused codes to be re-analyzed for meaning, combination, or separation. This comparative analysis was performed continuously throughout the progressive coding process.

Figure 21

Initial Coding Process Example



The resultant code catalogue (listing of all codes) is presented in Chapter 5.

4.3.2 INITIAL CODING AND DATA SATURATION

Saldaña (2013) identifies what he calls first cycle coding methods as the coding processes that happen during the Initial Coding of data. Charmaz (2015b) describes Initial Coding as engaging in comparative analysis of the selected literature. Charmaz then identifies Focused Coding studies that compare initial (open) codes and combines or subsumes them into larger or new batches of represented data identified as categories (Charmaz, 2015a; 2015b). "The researcher can use the most frequent and/or significant codes in Focused Coding to test whether and to what extent these codes account for large amounts of data" (Charmaz, 2015a, p. 405).

Saldaña (2013) identifies second cycle coding methods, such as Axial Coding, which are to find "bigger-picture" ideas through concepts that link across several categories. Axial Coding, then abstracts codes and categories into themes. The themes are analyzed, compared, and contrasted to construct a framework for ES functions. A theme functions as a way to categorize a set of data categories into "an implicit topic that organizes a group of repeating ideas" (Saldaña, 2013, p. 176). Saldaña (2013) states that this foundational Axial Coding work leads to the development of higher-level theoretical constructs when similar themes are clustered together, such as in a framework.

Coding is validated through a memo writing process (memoing) that documents each coding decision. Glaser & Strauss (2017) state that "the second rule of the constant comparative method is: stop coding and record a memo of your ideas" (p. 107). Charmaz (2014) states that memo writing is a crucial method in Grounded Theory requiring the researcher to analyze their data and codes early in the research process. At each step in this research's coding process, code memos were developed to document the code/category/theme decision. Examples from the memoing process are given in Chapter 5.

As data-driven themes were developed from the coding and category identification process, a framework was considered that was dictated by the data collection and analysis process. The coding and analysis processes were iterative through the constant comparative method until no new codes (data saturation) and no new or changes to the context of categories and themes emerged (theoretical saturation).

Saunders et al. (2018) state that there is uncertainty as to how saturation should be conceptualized, and that there are inconsistencies in its use. To address these inconsistencies, Saunders et al. (2018) identify four approaches to saturation "which differ in terms of the extent to which an inductive or a deductive logic is adopted, and the relative emphasis on data collection, data analysis, and theorizing" (Saunders et al., 2018, p. 1893). They conclude:

> that saturation should be operationalized in a way that is consistent with the research question(s), and the theoretical position and analytic framework adopted, but also that there should be some limit to its scope, so as not to risk saturation losing its coherence and potency if its conceptualization and uses are stretched too widely." (Saunders et al., 2018, p. 1893)

Table 34 adapted from Saunders et al. (2018) presents their four approaches to saturation, the description of the saturation model, and the principal focus of each saturation method.

Table 34

Four Approaches to Saturation from Saunders et al. (2018)

Saturation model	**Description**	**Principal focus**
Theoretical saturation	Relates to the development of theoretical categories; related to Grounded Theory Methodology	Sampling
Inductive thematic saturation	Relates to the emergence of new codes or themes	Analysis
A priori thematic saturation	Relates to the degree to which identified codes or themes are exemplified in the data	Sampling
Code Saturation	Relates to the degree to which new codes repeat what was expressed in previous code data	Data collection

Charmaz (2006) states that the primary goal for the researcher in Grounded Theory studies is to achieve data saturation which she describes as when no new properties of a particular category can be discovered. Charmaz (2006) states that when researchers use a

Grounded Theory approach, data saturation can be used to demonstrate evidence regarding the trustworthiness of the research findings. Data saturation then, is fundamental to the credibility of the research product.

Hennink et al. (2017) identified two types of data saturation: code saturation and meaning saturation. They suggested that code saturation in Grounded Theory "could be reached when researchers … 'heard it all,' whereas meaning saturation could be reached … when researchers 'understand it all (Hennink et al., 2017, p. 248). Morse (2015) posited that qualitative researchers need to reach both types of saturation, by using both subjective and objective data, which then affords the researcher the best guarantee of research rigor.

In this research, data saturation was considered to consist of two types, code and meaning or theoretical. Both necessitated demonstration in support of research rigor. The data saturation models identified in Table 34 (code and theoretical) were applied to demonstrate both types of saturation identified by Hennink et al. (2017), code and theoretical. These models were chosen as the ones most applicable to the constructivist Grounded Theory method applied in this research. This choice was based upon the data collection method employed of searching reference articles for sentences to be coded. Each reference article coded generated new codes until the data being coded began to significantly generate repetitive or unrelated codes. After coding more than 100 reference articles, new code generation was significantly reduced and the new codes that did emerge were generally not related to the purpose of this research. This condition of saturation was validated by purposefully holding back several ES related articles that were then purposefully coded later in the coding process to demonstrate that few new codes were still being generated when compared to data which was already coded. Additionally, a weekly search was kept open during the research process in Engineering Village looking for ES related articles. This search turned up no new articles. Aldiabat & Le Navneet (2018) cited six factors to consider for data saturation. These factors are the nature of the research question, the researcher's experience, triangulation of data collection methods, the philosophical underpinning of the research method, a guiding theoretical framework, and using sensitizing concepts. Each of these six factors was integrated into the GTM applied to this research as presented in this chapter.

Similarly, the abstracted codes and code categories were analyzed and re-arranged until there was only one collection of codes into a category, and one collection of categories into a theme, and one set of themes that made sense with the intent of the research. This is when theoretical saturation was recognized. The data-driven demonstration of these two types of saturation is presented in Chapter 5.

At the end of the Initial Coding of the research library, over 3000 code-references and several hundred open codes had been generated. These code-references and open codes (data abstractions) represented the relevant content of the research library in a form that allowed for further analysis and assessment to support addressing the research question. Since the result of the Initial Coding process generated over 3000 code-references, further open code analysis was required to ensure that each open code was unique, to combine open codes that had similar or same meaning, and to begin to see codes that "grouped" together with similar higher-level meaning (abstraction). The open code generating process was tedious, and the volume of data generated made it difficult to ensure that every code generated and recorded was unique. The NVivo tools used in the initial coding process were sensitive to spelling, capitalization, punctuation, and word choice. This made searching the open code database for a repetitive code very precise and necessitated several "passes" through the open code database to ensure that the code data was properly compared, combined, and documented (memoed) accurately. Using a smaller volume of reference articles to code would have simplified the coding process by reducing the number of sub-codes but at the same time would effectively reduce the generalizability of the resultant ES framework. During this open code analysis process, it was the actual data behind the code that was used to make code labeling decisions. This was in keeping with the essence of the GTM to keep the process grounded in the relevant data. The code applied to the code-reference data was an abstraction of that data, which left room for researcher variation in code identity that had to eventually be resolved to be consistent with the research objectives. The resolution was obtained by creating unique codes from the applied Simultaneous Coding method and memoing, and by applying the constant comparative process throughout the entire Progressive Coding process.

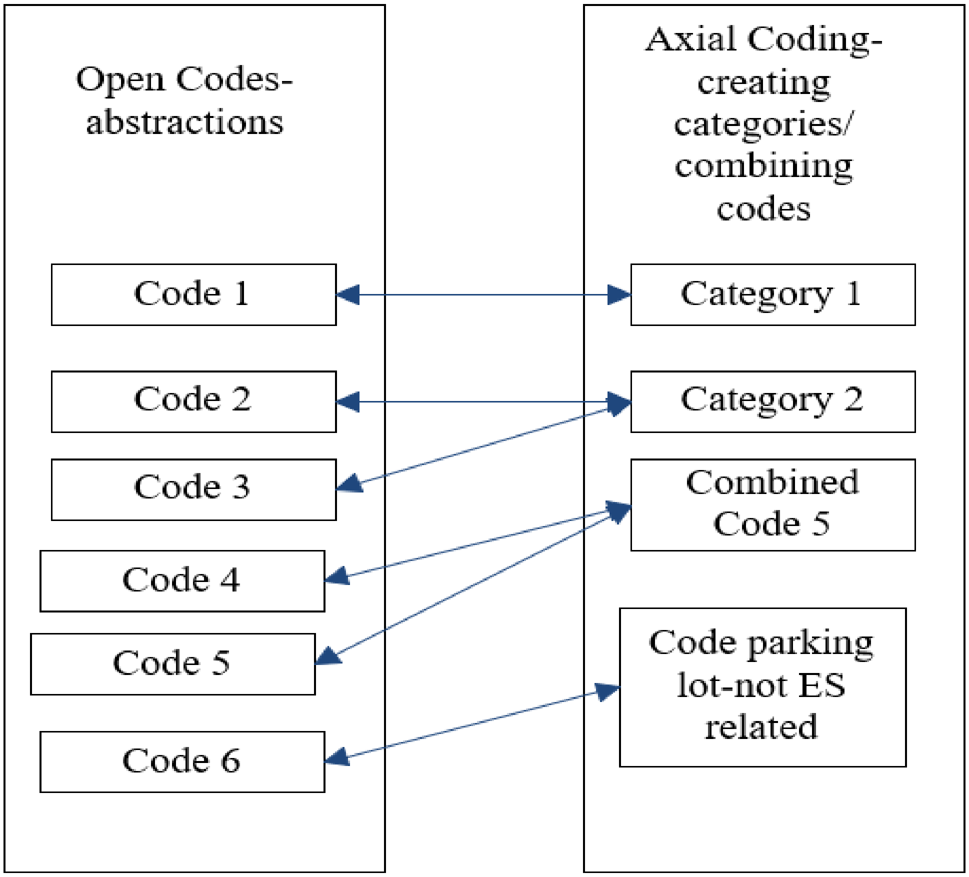
4.3.3 AXIAL CODING

Saldaña (2013) identified Axial Coding as a second cycle coding method whose purpose is to find "bigger-picture" ideas through concepts that link across several categories. He stated that one of the goals of Axial Coding is to support achieving saturation, the point at which no added information seems to emerge during coding. Strauss (1987) stated that Axial Coding is a process of exploring the relationships among categories. Cho and Lee (2014) stated that "in axial coding, researchers relate categories with their subcategories, test the relationships against data, and test the hypothesis" (p. 8) quoting Corbin & Strauss (1990). Charmaz (2006) stated that Initial Coding is like Open Coding, during which the researcher develops categories of information, and that Focused Coding is a process designed to narrow initial codes down to frequent and important codes. As similarities and differences in the codes were identified, a coding method reflecting theoretical constructs was developed by clustering similar meaning codes together to make categories. Theoretical data saturation was reached when no new categories were generated from the open codes (Kendall, 1999). The categories were then examined for their relationships to each other. The integration and interrelationships of the categories into themes formed the basis of the theoretical framework. This is the Axial Coding process. Once the framework was developed, it was compared to previous work as well as other literature and other perspectives to validate or point out differences or gaps in the current understanding of its definition. This comparison resulted in a data-evidenced recognition of existing themes in the ES literature stream, but also new themes that evolved from the constructivist GTM that was applied.

Taking from these discussions on coding processes, this researcher defined Axial Coding from Corbin and Strauss (1990) to be essentially the same process as Charmaz's (2006) Focused Coding. After the literature research library was initially coded (in this research identified as a "first pass" through the data field), there was a first pass open code database of over 3000 code-references and several hundred codes. There was also a set of codes constructed that had sub-codes mapped to them (called a collective code), where the code meaning was similar enough to group together but needed further analysis to determine if the sub-codes should be combined with the parent code or left alone as amplifying data, but not sufficient to stand alone. To further analyze this open code database into coherent constructs, the process of Axial Coding or Focused Coding was conducted. The process consisted of comparing first pass codes and code definitions into both like and unique code categories, and memoing the reasoning behind the structuring changes. This second pass through the data field (Focused/Axial Coding) resulted in the construction of a set of categories. Each category consisted of several like-meaning codes. The data field after the second pass (Axial Coding) consisted of: (1) several abstracted categories comprised of several open codes and/or collective codes, (2) a set of open codes that did not fit into any category at this point in the analysis, and (3) a set of open codes that had several data elements supporting the individual codes which resulted from combining two or more codes into one code name (a near-category), where the data-meaning behind the codes was essentially similar. This mixture of codes and code categories had over a thousand elements and necessitated further analysis, comparison, and abstraction for theoretical meaning and applicability to emerge. See Figure 22 that illustrates the Axial Coding process. Note that codes 2 and 3, with similar meanings, were combined into a new abstracted category 2. Code 1 was elevated to the level of a category due to its meaning and will have other codes aligned to it with additional analysis of the data field. Codes 4 and 5, when reviewed in the constant comparative method, were combined into the meaning of code 5 only. Code 6 was evaluated as off-theme to ES functions in CSG and placed in a code parking lot for further analysis. Through the constant comparative method, these code and category analyses were performed continuously throughout the coding progressive process.

Figure 22

Axial Coding Process



4.3.4 SENSITIZING CONCEPTS

Coming off the second pass through the data field, a method enhancement was needed to assist in further analysis of the data field that would lead to higher-level abstractions of the thousands of data field elements in support of the construction a theoretical framework. Bowen (2006) stated that researchers who use a Grounded Theory inductive analysis approach often use sensitizing concepts to guide their analysis. Given (2008) states:

> Sensitizing concepts are constructs that are derived from the research participants' perspective, using their language or expressions, and that sensitize the researcher to possible lines of inquiry. Sensitizing concepts are distinctive, natural terms used within a researched population that the researcher can also use to develop more generic, social constructs that are useful in studying other social settings. (p. 813)

Blumer (1954) stated that sensitizing concepts give the user a general sense of reference and guidance in approaching empirical instances, suggesting helpful directions along which to look. Blumer (1954) did not intend sensitizing concepts to be definitive in offering a clear-cut identification of a particular class of data, but for the sensitizing concepts to be useful in studying empirical instances. He further posited that such an inductive approach allows one to derive generic statements from what constitutes unique data from unique settings. Bowen (2019) states that “sensitizing concepts draw attention to important features of social interaction and provide guidelines for research in specific settings” (p. 3) Charmaz (2000b) referred to sensitizing concepts as “those background ideas that inform the overall research problem” and stated further:

> Sensitizing concepts offer ways of seeing, organizing, and understanding experience; they are embedded in our disciplinary emphases and perspectival proclivities. Although sensitizing concepts may deepen perception, they provide starting points for building analysis, not ending points for evading it. We may use sensitizing concepts only as points of departure from which to study the data. (p. 259)

“Sensitizing concepts may suggest possible lines of inquiry or alert researchers to some important aspects of a particular research situation as they undertake fieldwork or begin coding (labeling and categorizing) data” (Bowen, 2019, p. 2).

Given that sensitizing concepts are seen as a valid, research supporting method, they were added to the coding method in this research in support of research-focused analysis of the large research data field. The intent of applying sensitizing concepts was taken from Charmaz (2000b) to “provide starting points for building analysis” (p. 259). Given's definition (2008) that “sensitizing concepts are constructs that are derived from the research participants' perspective, using their language or expressions, and that sensitize the researcher to possible lines of inquiry” (p. 813) was applied to develop a set of sensitizing concepts in support of additional data field analysis.

Since the purpose of this research is to develop a framework for ES in CSG, ES functions identified in CSG literature were identified as the basis for appropriate sensitizing concepts. In the constructivist GTM, there is a heavy focus on inductive theme development (Charmaz, 2015b). Hundreds of open codes and code categories can be aligned in many different thematic channels (Cho & Lee, 2014). Applying sensitizing concepts focuses those channels towards a manageable and research-meaningful outcome supporting the basic tenants of the research question. Twenty-four sensitizing concepts were developed from the CSG literature from the three metasystemic functions of ES in CSG that had been identified by Keating & Bradley (2015). The application of these 24 sensitizing concepts from the CSG reference model was both a normal GTM process and in this research a necessary starting point for building analysis from several hundred open codes and categories. Application of the 24 identified sensitizing concepts that were grounded in Systems Theory (CSG) did not bound the number of possible themes and did not determine the ultimate number of themes or the number of elements in a theme but guided the abductive inference (Bendassolli, 2013) process in Axial and Selective coding. Per Bendassolli (2013) abductive inference is that “which, roughly speaking, stimulates the researcher to overcome the initial surprise provoked by an unexpected fact, leading to the creation of new rules (theories) for its explanation" (p. 13). Code and category alignment either fit the sensitizing concepts or went in new directions (categories or themes) on their own data-backed merit. Even with data saturation (code level-no new relevant codes available) having been obtained, thematic development was possible by always comparing the data for new constructs, competing constructs, or aligning with what had already been constructed. Chapter 5 presents the sensitizing concept development from the CSG reference model literature.

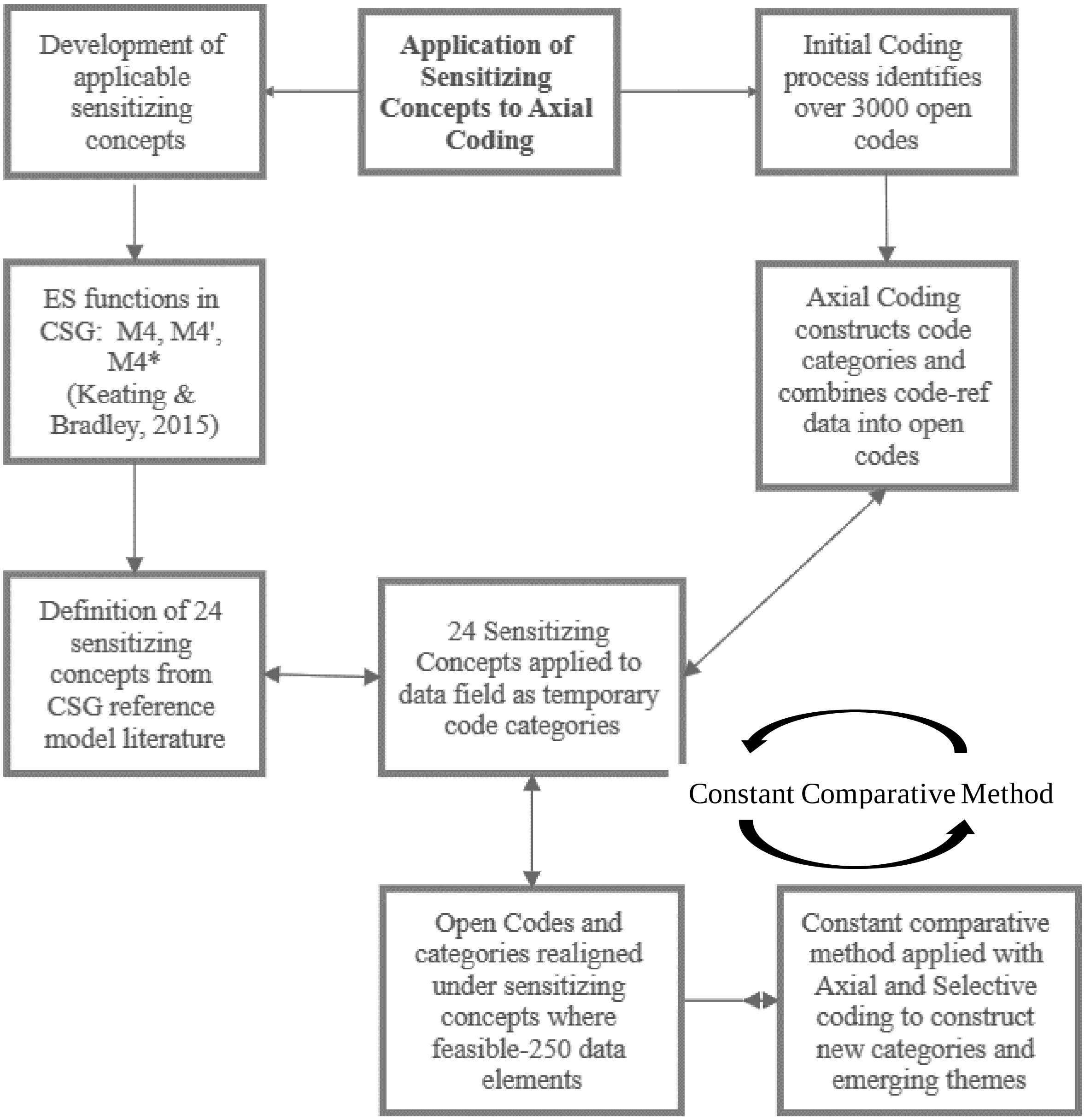
Applying sensitizing concepts was an excellent implementation of the GTM constant comparative method. Each code and code category were compared to other codes and code categories, were compared to the sensitizing concepts, were compared to themes developed or under development, and were compared with the original literature text (code-references) that were Initial Coded. These comparisons were done by taking additional passes through the data field until no more realignment of codes, categories, and/or themes was evident. Charmaz (1996) stated that:

> From the standpoint of grounded theory, each idea should earn its way into your analysis (Glaser, 1978). If you apply concepts from your discipline, you must be self-critical to ensure that these concepts work. Do these concepts help you to understand and to explicate what is happening in this line of data? If they do not, use other terms that do (p. 38)

Modifying the GTM to apply sensitizing concepts with the constant comparative method was supportive of data analysis resulting in research-related themes that eventually lead to a framework for ES that was constructed from the original source data. The sensitizing concepts helped organize the codes into related groupings but did not hinder the construction of new groupings that did not fit within the sensitizing concepts. At the end of applying sensitizing concepts, there were less than 250 data elements (open codes, categories, emerging themes). Figure 23 demonstrates the application of the sensitizing concepts to the Axial and Selective Coding processes.

Figure 23

Application of Sensitizing Concepts to Axial Coding

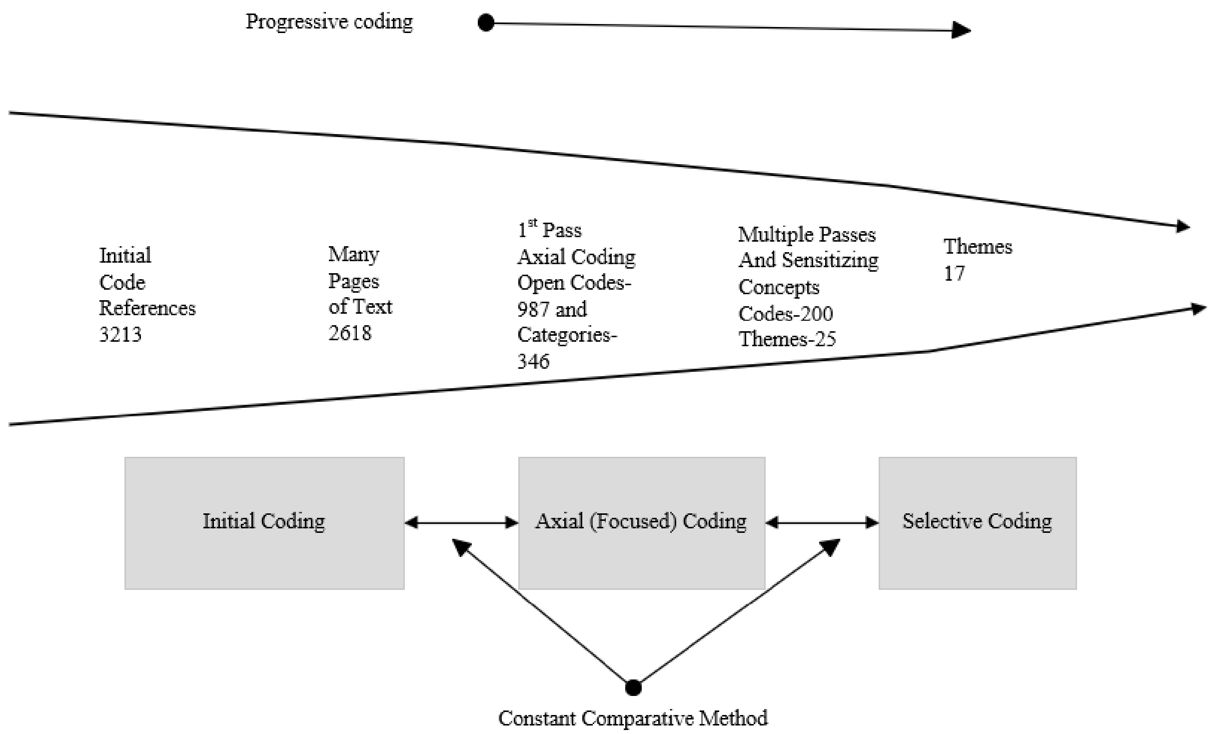


4.3.5 SELECTIVE CODING AND CONSTRUCTING THE INITIAL FRAMEWORK

"The construction of meaning from collected data is the result of the progressive data coding process. In order for researchers to generate theory, researchers need to evidence employing an analytic approach and rationale methodological decisions" (Williams & Moser, 2019, p. 46). The progressive data coding process applied in this research consisted of Initial, Axial (Focused), and Selective Coding of the research data resulting in the creation of a theoretical framework, leading the researcher to construct deeper theoretical meaning. This method of progressive data coding provides researchers with a distinctive access process to study the source material authors' perspectives on ES (Williams & Moser, 2019). Figure 24 illustrates the Progressive Coding sequence and the related reduction of data elements though the process. The Initial, Axial (Focused), and Selective Progressive Coding strategy enabled a cyclical and evolving data loop in which this researcher interacted, constantly compared data, and constantly applied data reduction and consolidation techniques through the constant comparative method.

Figure 24

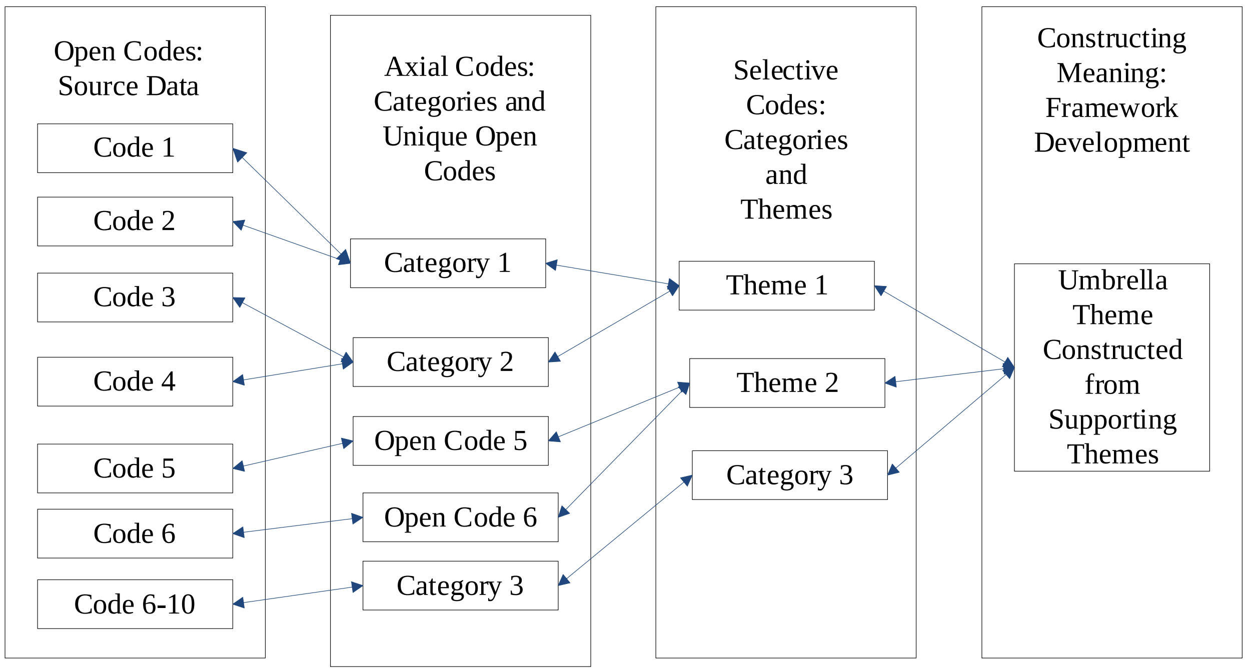
Example of Progressive Coding and Data Element Number Reduction



Selective coding is the third level of coding. It enabled this researcher to select and integrate categories of organized data, obtained from Axial Coding, into cohesive and meaningful thematic abstractions. Selective coding was a unique phase of the data analysis process of the research design method in that it influenced not only what theoretical constructs emerge (categories and themes), but also how theoretical meaning was constructed through the presentation of the data. "Selective coding continues the axial coding at a higher level of abstraction [through] actions that lead to an elaboration or formulation of the story or the case (Flick, 2009, p. 310)" quoted by (Williams & Moser, 2019, p. 52). Central to constructing the theoretical ES framework from the data themes, categories, and codes, was the process of enabling further refinement of the data, constructing the main thematic categories, and then in a systematic manner combining the themes to an umbrella, overarching theme. The Selective Coding approach to data framing enabled this researcher to work continually toward thematic specificity and theoretical framework construction. During Selective Coding, degrees of likeness or like-meaning emerged from the thematic refining process, allowing this researcher to identify categories and themes that elicited responses suggesting certain categories and themes should receive unique and differentiated responses. As the work of Selective Coding was done, this researcher moved toward constructing a theoretical framework and ultimately constructing meaning from the research methodology. The outcome of the Selective Coding process enabled the crafting of an ES framework that accurately and powerfully presented the sum of the Progressive Coding process. Figure 25 illustrates the Selective Coding process and the constructing of the framework (meaning) from source data.

Figure 25

Selective Coding and Framework Development



Each stage of the coding process progressively integrated the emergent themes identified during data collection and each continually refined the codes, categories and themes that culminated in the framework construction and the creation of meaning.

4.3.6 THE CONSTANT COMPARATIVE METHOD

The data collection strategy employed in this research supports the constructivist GTM approach. A detailed literature review was conducted before implementing the GTM to frame the extent and bounds of the literature field that is relevant to this research's objectives. This literature review helped develop sensitizing concepts, make comparisons, and clarify the research approach. As the research progressed into coding, additional literature was brought into the process to clarify developing themes and as sources of current information that was recently published. Additional literature also played a role in determining data saturation and verifying emerging themes as existing or new to the ES framework development. Throughout the entire framework development process, data was constantly being obtained and compared. Birks & Mills (2015) state that:

> Part of the process of concurrent data collection and analysis is the constant comparison of incident to incident, incident to codes, codes to codes, codes to categories, and categories to categories. This is termed constant comparative analysis [the constant comparative method] and is a process that continues until a grounded theory is fully integrated. (p. 11)

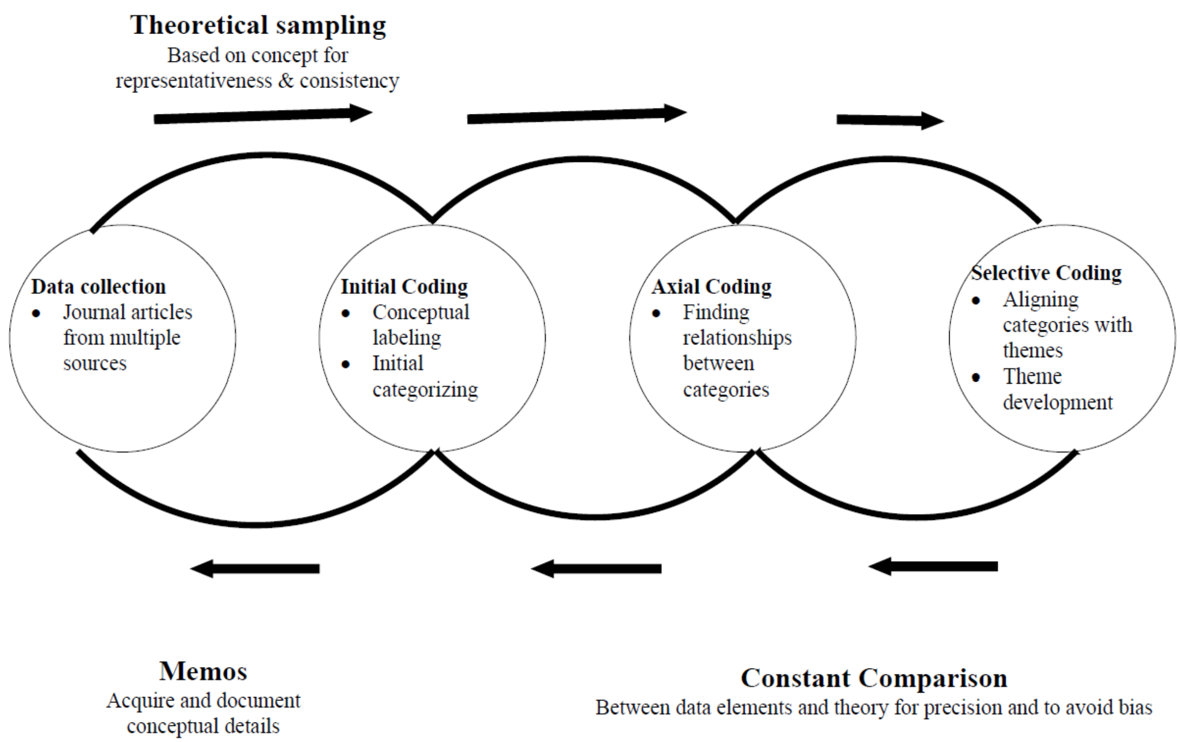
As the GTM is inductive, it is the process of building theory up from the data itself (Charmaz, 2006). The induction of theory is accomplished through successive comparative analyses of research data (Birks & Mills, 2015). Charmaz (2006) defined the constant comparative method as "a method of analysis that generates successively more abstract concepts . . . through inductive processes of comparing data with data, data with category, category with category and category with concept" (p. 187). Kolb (2012) citing Bogdan & Taylor (1998) states that "The constant comparative method is used by the researcher to develop concepts from the data by coding and analyzing at the same time" (p. 83). Kolb (2012) posits that the constant comparative methodology has four stages: (1) comparing raw data with codes, codes to codes and codes to categories, (2) integrating categories and their properties with themes, (3) delimiting the themes and (4) writing the framework. Kolb's (2012) phased implementation of the constant comparative method was the model applied to this research. Throughout these (Kolb, 2012) four stages of the constant comparative method, this researcher continually sorted through the data that was produced. The data was analyzed, coded, and applied to reinforce the emerging themes. Kolb (2021) states that “The benefit of using this method is that the research begins with raw data; through constant comparisons a substantive theory will emerge” (p. 83).

Charmaz (2006) adds that the logic of abduction is apparent in recent literature about GTMs. Reichertz (2007) identifies abduction as a means of inference. “It is a logical inference (and thereby reasonable and scientific), however it extends into the realm of profound insight and therefore generates new knowledge” (p. 216). Reichertz (2007) qualifies abduction as a form of inference that extends to deep insight and the creation of new knowledge, and that abduction inference is intended to help researchers make new discoveries in a logically and methodologically ordered way. Abductive reasoning occurs during the constant comparative analysis of categories to categories, categories to themes, and themes to themes that leads to theoretical integration into a theoretical framework. “Abduction is therefore a cerebral process, an intellectual act, a mental leap, that brings together things which one had never associated with one another: A cognitive logic of discovery” (Reichertz, 2007, p. 213).

Figure 26, summarized from Cho & Lee (2014), illustrates the constant comparative method by the directional arrows. The arrows show for each of the progressive coding steps, the resultant data is always compared with existing data in the step it was generated in, and with the data in the step it is being elevated to. This comparative data analysis was an abductive inference process that resulted in new categories and new themes being constructed. This was a detailed, researcher involved process that was both very tedious and very time-consuming. The end of the constant comparative process was the construction of the themes that made up the ES framework that was grounded in Systems Theory principles.

Figure 26

Constant Comparative Method Adapted From (Cho & Lee, 2014)



The constant comparisons of data elements, codes, categories, and themes were significantly aided by the NVivo functionality. NVivo's search engine, export function to Excel®, printing function, and database were used together to support comparing similar words, similar meanings, and correcting spelling. It was also applied to demonstrate contrasting meanings for constructing new codes, categories, or themes.

At the end of the progressive coding process, by following the constant comparative method demonstrated in Figure 26, a set of theoretical themes were constructed from the source data that became the framework for ES functions that were grounded in Systems Theory.

4.3.7 THE MULTIPLE PASS PROCESS

The multiple pass process in this research's GTM refers to a top to bottom analysis of all the data elements in the research database. Data elements (code-references, codes, categories, themes) are compared both in their own element and in elements above and below their own element for alignment, for new element construction by abductive inference, for contrast, and for ongoing inclusion or exclusion from the database. Each pass through the research database was supported by the tools inherent with NVivo. NVivo allowed for experimenting with names and definitions, abstractions and temporary codes, categories, or themes without losing track of the original configuration. By this means of experimenting, this researcher was able to "try" new constructs (new codes, categories, or themes) and compare them to the original constructs before making a change to the database structure. Eight passes through the entire research database were made before it became clear that additional passes would no longer add content or change content from the existing database structure of codes, categories, and themes. These passes through the data field were integral to the constant comparative method applied in this research.

4.3.8 THEMATIC SATURATION

Theoretical or thematic saturation requires that the data collected must be adequate for the purposes of addressing the research question (Bowen, 2008). Eisenhardt (1989) noted that data collection should end once improvements become marginal. "Theoretical saturation is simply the point at which incremental learning is minimal because the researchers are observing phenomena seen before" (Eisenhardt, 1989, p. 545).

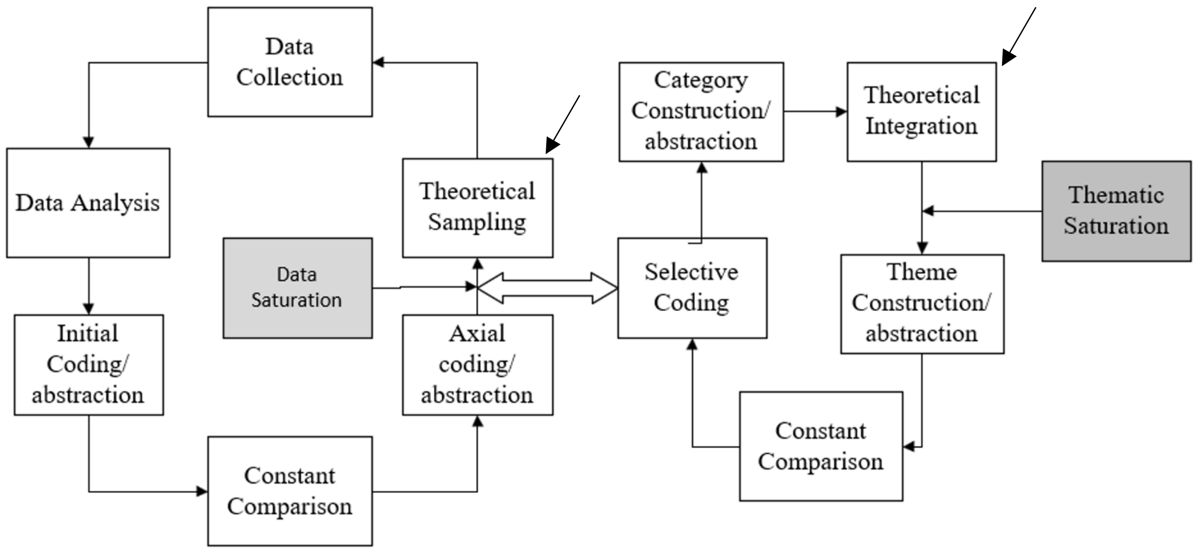
Following data saturation, the code database was stabilized. Coding additional journal articles at this point resulted in no new meaningful codes. With the codes stabilized, categories were abstracted from the codes until no new categories could be formed from collections of codes. With the categories stabilized, the starting point for thematic development was achieved. Categories were compared (aligned or contrasted) with each other through abductive inference to construct themes. This was an iterative process as part of the constant comparative method. Green & Thorogood (2018) state that:

> the cyclical process of collecting data, analysing it, developing a provisional coding scheme, using this to suggest further sampling, more analysis, checking out emerging theory, and so on, until a point of 'saturation' is reached, when no new constructs are emerging. At this point, you have a rich, dense theoretical account – but one that is completely grounded in empirical data. (p. 181)

When categories can no longer be recombined into themes that are relevant to the research question, no new constructs are emerging. After eight passes through the research database there were no additional or alternative arrangements of categories into themes that supported the objective of the research. Thematic saturation as defined above was obtained with 17, rich, theoretical themes, grounded in empirical data. Figure 27 presents the process from data analysis to thematic saturation and theme construction. This process was adapted from Roman et al. (2017) to fit this research's GTM. This was an iterative process, taking eight passes through the data to reach the point where no new theoretical constructs were emerging. Each data pass took over a week to complete, working at it for a full workday.

Figure 27

Process From Data Analysis to Thematic Saturation and Theme Construction



4.3.9 THE EVOLVING RESEARCH LIBRARY CODING PROCESS

Figure 27 shows two process blocks (arrows pointing in) that each involve the possibility of additional, new data being entered into the GTM processes. These are the theoretical sampling and the theoretical integration blocks. The data referred to here is data that is new to the research method from that in the original research database.

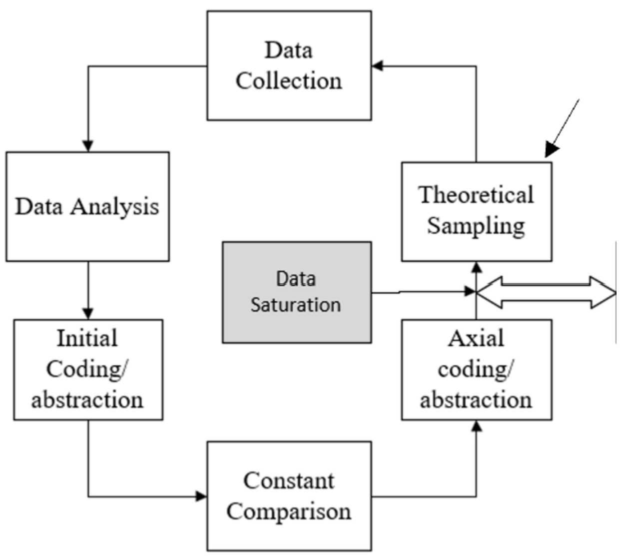
Theoretical sampling is about including new journal articles and their associated code-references, and other data sources, in the research library based on an understanding of the research field, emerging categories from ongoing data analysis by Axial Coding, and a deliberate attempt to substantiate such categorization. New data is introduced to expand and clarify emerging concepts, to add reference-depth to existing codes, and to follow-up on research directions indicated by the abstraction of codes and or categories. The intention is to keep sampling and analyzing the research data until little, new, and relevant data is being generated (saturation) (Green & Thorogood, 2018). During the Initial Coding process, some open codes collected more code-references than others. A valid open code could have one code-reference from the literature, or it could have dozens of code-references from multiple journal articles. Those open codes with multiple code-references are considered well-established codes in terms of their contribution to building categories and themes. They have substantial backing in the source literature. Open codes with one or just several references were less understood in terms of their contribution to building categories but could be of equal or even greater importance than open codes with many code-references. To resolve the role that the less referenced codes play in building categories, additional data was brought in to amplify their meaning and document their relative strength in the literature field.

Additional data was also brought in for Initial Coding that was more current than the data originally identified for coding. This was the result of the research process stretching out over several years. So, to ensure that the research library had recent, available journal articles and book sections identified that were relevant to the functioning of ES in system governance, a new search in Google Scholar and Google books was performed to identify relevant literature newer than that in the research data base up to 2021. The several journal articles identified (no books were identified as relevant) were added to the research library and coded like all the others.

This same process was also applicable to categories of codes that were abstracted from the open codes. Some categories had many codes aligned to them. Other categories had just several codes. To enhance the meaning of the categories with the smaller number of aligned codes, additional, new research data was collected. This process of bringing in new material to compare with existing data demonstrated the constant comparison method. It was also a fundamental part of validating the point of data saturation. Figure 28 demonstrates the theoretical sampling process and its role in establishing data saturation by the constant comparison method.

Figure 28

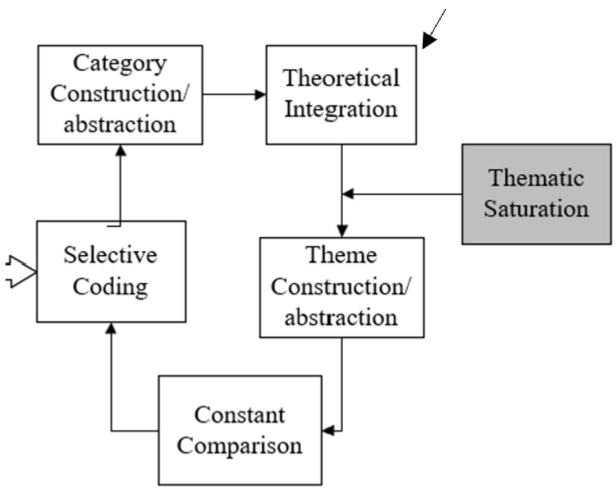
The Theoretical Sampling Process



Theoretical integration is part of the process of abstracting categories into themes. As initial themes are constructed from their supporting categories, additional literature research is performed to identify what has been written or not written about the emerging themes. If literature is identified that supports the emerging themes, it is compared to the category and code-refence data behind the emerging themes. If it repeats what is known, no further action is taken on it. If it points in a different direction, it is coded and added to the code database for analysis. If no new literature is identified with the emerging theme, the theme is considered essentially saturated and unique. Figure 29 demonstrates how theoretical integration is part of the theme construction process and demonstrates how it supports thematic saturation.

Figure 29

Theoretical Integration in the Theme Construction Process



4.4 THEMATIC DEVELOPMENT OF THE ENVIRONMENTAL SCANNING FRAMEWORK

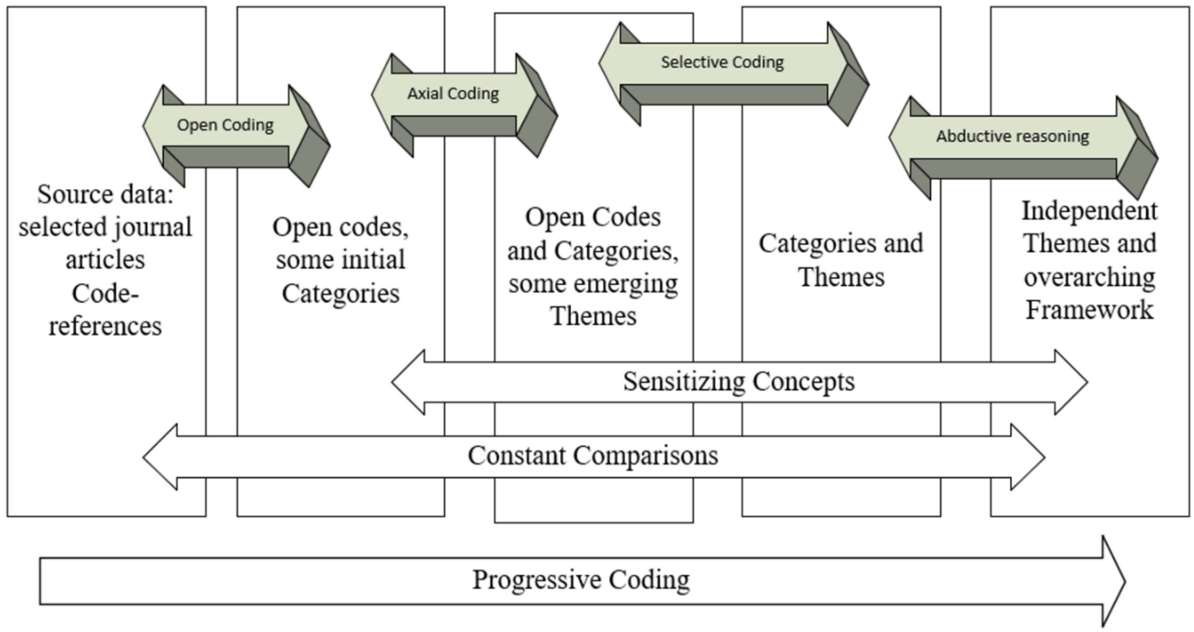
During the Initial, Axial, and Selective Coding phases, category and theme development were guided by the researcher's thematic view of the functions of ES in CSG. This kind of researcher involvement is typical in constructivist GTM (Charmaz, 2015a; 2015b). Data elements (code-references) of similar meaning were combined into singular open codes and open codes of similar meaning were combined into new categories. Categories of like meaning were then aligned into themes. Themes were compared (aligned or contrasted) with each other to construct a unique framework that consisted of 17 themes. Each step in this process from data, to code, to category, to theme, involved a higher level of abstraction. With several hundred open codes developed from a database of over 3000 code-references (a code-reference is one string of text that was identified for coding from the source data), sensitizing concepts taken from CSG metasystemic functions were applied to the codes database to support category and Axial Coding development along the sensitizing axes. This had the effect of providing insightful direction on how the data that was abstracted in the Initial Coding process was to be aligned into categories, themes, and eventually a framework. Charmaz & Belgrave (2019) state that "Constructivist grounded theory captures the dynamic interplay between the form and content of data. Form and content of data inform and shape each other in constructivist grounded theory. Researchers give data form through definition and categorization" (p. 749). Giving data form through definition and categorization is the process of abstracting meaning:

> The process of data analysis in qualitative research involves working with data, organising it, breaking it down, synthesizing it, searching for patterns, discovering what is important and what is to be learned, and deciding what you will tell others. … data reduction refers to the process of selecting, simplifying, abstracting and transforming the new case data. (Japhet & Usman, 2013, p. 29)

Thematic development came out of the Axial and Selective Coding processes that were guided by the sensitizing concepts. See Figure 30 for a visual presentation of the thematic development process.

Figure 30

Thematic Development Process

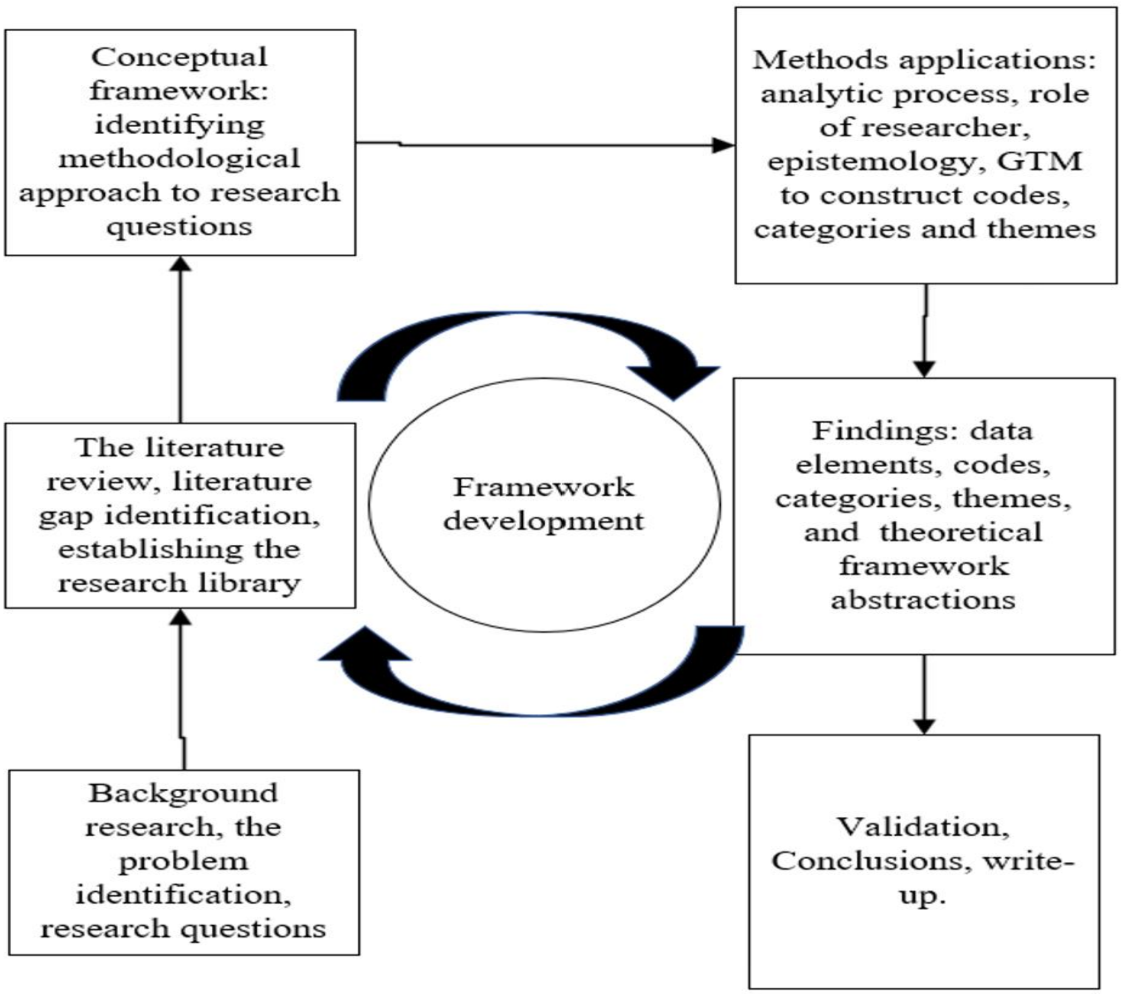


The thematic development process resulted in a set of seventeen themes that were descriptive of the functioning of ES in CSG, and that were traceable to the originating text-references (genealogy). The 17 themes were then abstracted into the framework for the functioning of ES in CSG. The framework is grounded in the source data, but its development was guided by the researcher's background knowledge on the known functions of ES in CSG. This data genealogy is demonstrated in Chapter 5.

The constructed codes fit the data with this researcher's engaging in Initial Coding in which data with data, data with codes, and codes with codes were compared (aligned or contrasted). This resulted in staying close, but remaining open, to exploring what was happening in the data. The initial open codes were carefully compared with each other and with source data, further elaborated and grouped together based on similarities and differences, leading to focused and comprehensive codes and categories. As a result of this iterative process, Initial Coding and constant data comparison, the constructed open codes fit closely with the source data, but their abstraction was guided by this researcher's perspective on the purpose of this research effort. At the end of the research process, however, the resultant framework is still just research data to be presented for assessment. Elliott & Higgins (2012) "define theoretical framework as any empirical or quasi-empirical theory of social and/or psychological processes, at a variety of levels (e.g., grand, mid-range, and explanatory), that can be applied to the understanding of phenomena" (p. 6). The abstracted theoretical ES framework in this research is constructed from empirical data, at a grand level, which can be applied to understanding the functions of ES in CSG. Figure 31 shows the over-arching method that was applied to develop the ES theoretical framework that is consistent with this research methodology.

Figure 31

Theoretical Framework Development Method



4.5 METHOD OF OUTSIDE REVIEW OF RESEARCH DESIGN

Utilizing qualified peers from the CSG Learning Community provided a team that has the background and understanding of the primary Systems Theory-based literature involved in this research as well as expertise in applying the GTM. Each expert that was requested to apply to be considered a GTM scholarly expert responded to a qualification questionnaire that sought information about their academic backgrounds, their studies, their writings, and their scholarly experiences applying the GTM to published works. Each of the five that applied was validated as a qualified scholarly peer in GTM application. The peer expert qualification details are provided in Appendix E. The peer experts were provided with the GTM flowchart developed for this research project's methods, the summary documents of the GTM process employed in this research, the memoing database, the code database, and the constructed ES framework. The expert reviewers were provided with thirteen questions to guide their review of this research's GTM application. These questions are listed in Appendix F. The questions were designed to elicit specific feedback on the scope and appropriateness of the GTM applied to this research. They were provided an assessment guide for each of the questions that was based on requirements from the constructivist GTM literature, primarily from Charmaz & Thornberg (2021), and were requested to develop their own independent assessments. The peer experts' assessment applied a four-point Likert scale to each of the assessment questions. The application of the Likert scale in this research is for the purpose of facilitating data collection and is not intended to be used as a research instrument. A Likert scale is commonly used to measure attitudes, knowledge, perceptions, values, and behavioral changes. A Likert-type scale involves a series of statements that respondents may choose from in order to rate their responses to evaluative questions (Vogt, 1999). The method applied to interpret and evaluate the peer feedback consisted of the following steps:

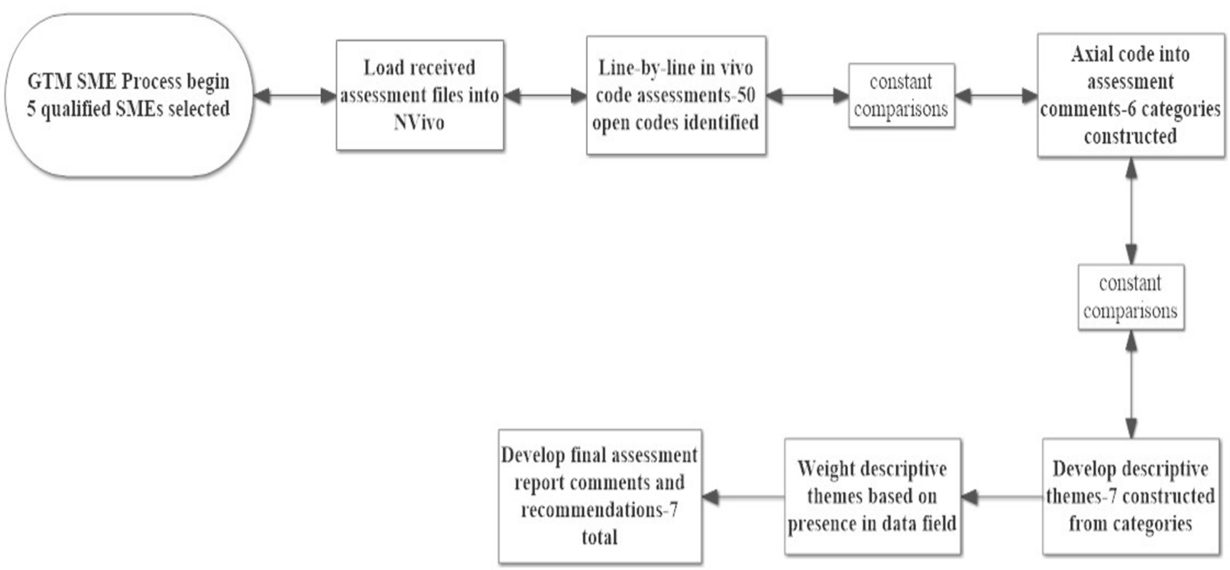
1. consolidate peer evaluation comments into a common Word document with no attribution
2. load the Word document into NVivo

3. determine most appropriate coding method-Saldaña (Saldaña, 2013). Determined to be the line-by-line in vivo coding method
4. in vivo code the consolidated Word document. First pass open code development
5. 2nd pass was theming the in vivo codes, axial coding, and categorizing the data
6. 3rd pass development of final product in descriptive phrases built from the second pass axial codes, that support or criticize the constructivist GTM applied in this research

These steps are summarized in the Figure 32 process chart.

Figure 32

GTM Peer Review Evaluation Process



The results of the peer review assessment are presented in Chapter 5.

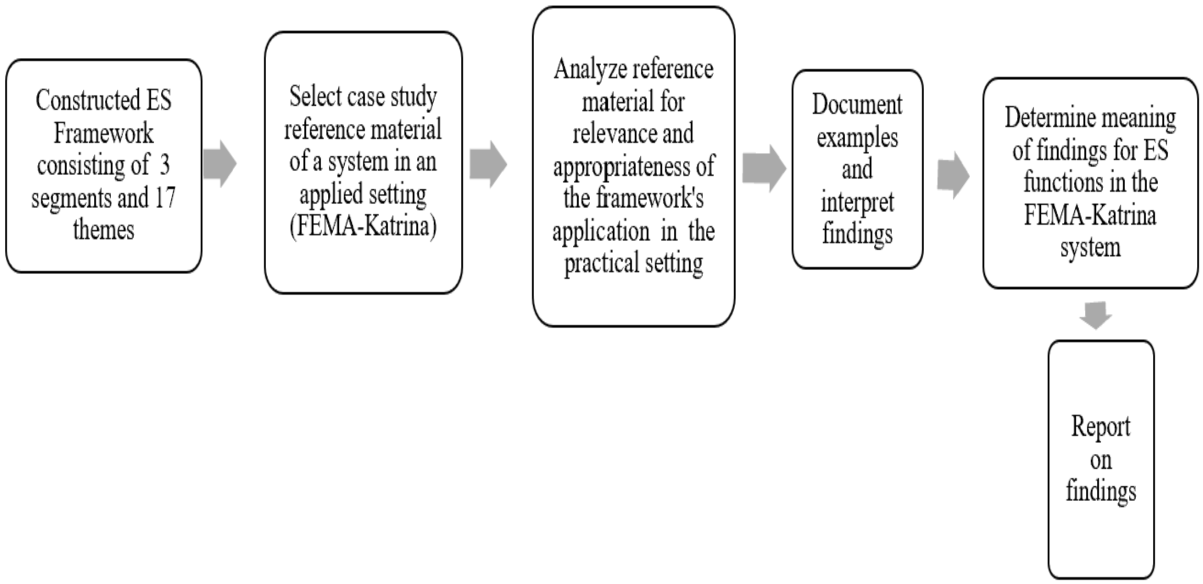
4.6 METHOD FOR DEPLOYMENT OF THE ENVIRONMENTAL SCANNING FRAMEWORK

The resultant ES theoretical framework was applied to a practical setting for face validation purposes. The practical setting chosen to assess the ES framework was the actions of the FEMA during Hurricane Katrina. FEMA was considered the system under study, but FEMA's actions as a system were bounded by its actions only during the Hurricane Katrina time frame. This boundary around FEMA's actions as a system was determined from the readily abundant amount of public literature available on FEMA's actions during Hurricane Katrina. The selection of FEMA during Katrina was not guided by any view of positive or negative considerations of its actions, but only on the fact of abundant literature available for the research face validation assessment.

The ES theoretical framework deployment was accomplished by choosing a practical system as a target (FEMA-Katrina system), collecting research supporting literature, assessing that literature as to its applicability to ES functions, assessing the functioning of the 17 ES framework themes to the selected practical system, and collecting and reporting on the assessment information. Given that that deployment in the practical setting was a face validation, one pass through the data collection and analysis was performed. Bhandari (2022) states that "This type of validity [face] is concerned with whether a measure seems relevant and appropriate for what it's assessing on the surface. …It's a relatively intuitive, quick, and easy way to start checking whether a new measure seems useful at first glance" (p. 1). The objective of the ES framework's deployment is to assess the relevance and appropriateness of the ES framework's utility for application in an applied setting. Figure 33 outlines the ES framework deployment method.

Figure 33

ES Framework Deployment Method



4.7 CASE STUDY AND FACE VALIDATION METHOD

Taking from Yin's (2018) designing case studies methodology, Table 35 was derived to develop the general methodological approach for this research study to address research question two. It consists of six steps. The plan and design steps are serial. The other four steps are interrelated. Each of the six steps is defined by one or more subordinate steps. Each major step is assessed in terms of its applicability to this research study in Table 35.

Table 35

Case Study Methodology

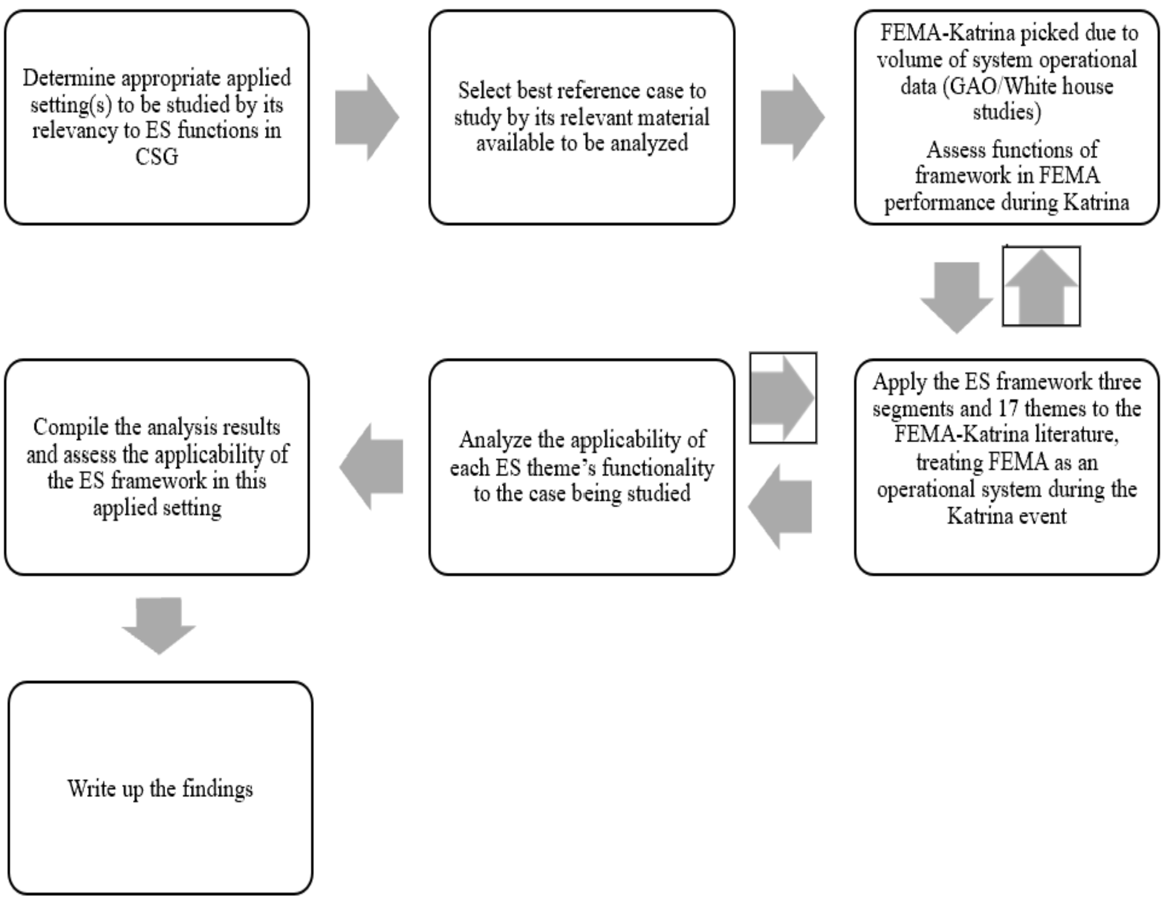
Steps in case study methodology	**Definition of Steps in methodology**	**Application to this research**
Plan	• Identify relevant situations for doing case study • Address traditional case study concerns	Assessing the application of the ES framework in an applied setting is a solid basis for case study methods compared to other qualitative research approaches as it meets the definition of a case study. Case study concerns are addressed in section 3.11 case study criticisms and mitigations.
Design	• Define case to be studied • Develop theory to guide the study • Identify study design • Test design against quality criteria	FEMA action during Katrina event was defined as the case to study due to the abundance of public information about internal communications that is available. The theory is the application of the ES framework developed in response to research question one. The study design is a single case study that supports the face validation criteria. The quality criteria are addressed in section 3.11.
Prepare	• Develop case study method	Scanned case study design and methods book by Yin (2018). Researched potential cases to be studied on the internet seeking availability of material. Selected material that could best support the application of ES framework. Developed method for face validation using case study.
Collect	• Assemble data • Maintain chain of evidence • Triangulate evidence from multiple sources	Created library of relevant reference material to the case. Multiple references from several authors are used in support of data triangulation.
Analyze	• Display data • Watch for concepts and insights • Develop analytic strategy	Application of the ES framework is done by tabulating information from the reference material into explanations of how the ES framework themes function. Explanation building is the prime analysis strategy.
Share	• Define audience • Compose materials • Display evidence to reach conclusions • Recompose until meet quality standards	The dissertation findings will be presented to a scholarly audience. The materials are a written report. The evidence is appropriate summarizations from the reference material. Recomposing occurs to meet the identified quality criteria.

The application assessment in Table 35 demonstrates that the applied case study methodology from Yin (2018) is supportive of addressing research question two.

The detailed FV method applied in this research is derived from the works of Yin (2018) and Nevo (1985). Figure 34 presents the FV method applied for the case study in this research.

Figure 34

Face Validation Case Study Method



Face validations have been criticized over their apparent lack of rigorous quality in scholarly research (Turner, 1979). Turner (1979) suggests that having a clearly defined set of goals for the FV brings credibility to the implementation of the FV process. The defined goals of the FV in this research are to: (1) apply the ES framework constructed in this research in an applied setting, and (2) to analyze the applicability of the ES framework to the governance system of the system of interest. The results of the FV will be assessment observations on the applicability of the framework in an applied setting. Exemplars will be stated and observations on the functioning of the ES framework themes in the exemplars will be documented. The intent of the documentation is to point to possible new themes in ES functions, and to explain the meaning of the ES framework functions in this applied case.

Yin (2018) posited that many researchers view a case study as a less desirable method for an experiment due to the need for greater rigor. Therefore, it is most appropriate to address quality in a case study method. Lee et al. (2010) presented criteria for quality in a case study. Table 36 adapted from Lee et al. (2010) applies their case study quality criteria to the case study method applied in this research. Each of the quality criteria can be applied to the case study method in this research as presented in Table 36. The application of the case study quality criterion to this research mitigates the expressed concerns over case study methods.

Table 36

Case Study Quality Criteria

Case study quality criteria	**Criteria definition**	**Application of criteria to this case study**
Transferability	Findings can assist the evaluator in deciding whether the intervention can be applied to work with similar cases	The ES framework was constructed from multiple fields of study. It would be expected that its application would be relevant in multiple fields of study.
Creditability	Achieve rich and meaningful descriptions of the case, assure internal coherence of findings in the data analysis, and use three multiple data sources	The findings are detailed with summary information from the reference material. Several sources of reference material are applied.
Confirmability	Establishing a logical and reasonable conceptual link among the constructs studied in the case and the measures used, which function as indicators of such constructs	The measures applied are the applicability of the ES themes in the framework to the FEMA-Katrina system under study.
Dependability	Study could be repeated to yield the same findings	The transparency of the detailed FV case study method and results and the identification of the publicly available reference material support that repeating the study could exhibit similar findings. However, applying the same case study method could yield similar or different findings. The ES theoretical framework is subject to researcher's interpretation, thus could be applied with multiple perspectives creating different findings, all of which would be valid in at a FV level of detail.

Case study concerns were identified by (Yin, 2018) and Fidel (1984) and are listed in Table 37. Each concern is described and the mitigations for those concerns in this research are expressed.

Table 37

Case Study Concerns and Mitigations from Yin (2018) and Fidel (1984)

Concerns	**Description**	**Mitigations**
Rigor	Sloppiness, lack of systemic procedures, no equivocal evidence to influence findings	These are research quality issues. Mitigation to case study quality in this case study is presented in Chapter 4 with case study method details.
Confusion with non-research case studies	Case studies that serve teaching, appear in popular literature, or are case records	The purpose of the case study in this research is specifically to address research question two. The criteria for quality in this case study is specific to its intended purpose in this research.
Generalizability from single case study	Single experiment, not generalizable to populations, not extrapolating probabilities	This case study research supports the finding of a theory in an applied setting, it is generalizable to a theoretical proposition, not a population or a statistical generalization.
Unmanageable levels of effort	Take too long, result in massive documentation, confused with ethnography	Application of this case study is a face validation of the constructed theory. The case is built from a defined set of literature. The FV criteria is clearly defined and is not comprehensive.
Lack of comparative advantage	Not a randomized controlled trial, not establishing effectiveness	Goal is to offer insight on ES framework in applied setting, not to validate effectiveness of the ES framework.
Getting in	Permission to study	Data is taken from publicly available resources not requiring permission.

Concerns	Description	Mitigations
Searcher's bias	Impact of researcher's bias on study	Transparent case study methods, detailed documentation of results are justified by the data.
The study effect	Impact of observer on researcher changing researcher's study approach	No direct observer is present. Method of performing case study is defined.
Observer's bias	Observer's predisposition to the study and firsthand experiences	Transparency and clarity are present in the case study method. Findings are supported with data from the case studied.

Careful consideration of the Table 37 attributes in the design of the case study method mitigates the stated criticisms.

4.8 CHAPTER SUMMARY

Chapter 4 provided the details of the GTM applied in this research. The overall research method consisting of four major phases was presented. Each phase was explained in detail.

Data collection from selected reference articles was presented. A filter for taking into the research library appropriate reference articles was discussed. Additional reference articles were added in as the research progressed because of the constant comparative method and data saturation techniques.

The coding method was explicitly detailed as it is unique to the application of the GTM to this research. Saldaña's (2013) coding methods were outlined, and an explanation was given for choosing in vivo coding and gerund coding as the most appropriate coding methods for this research.

The Initial Coding process to develop open codes from in vivo and gerund coding was explained. The Axial Coding process that constructed categories from open codes was outlined.

Data saturation was explained as taking two forms: data and theoretical saturation. The reasoning for recognizing both points of saturation was given. The process to reach data saturation was explained in detail for this research such that additional reference material was not adding anything new to the purpose of the research.

Due to the substantial number of open codes generated from the Initial Coding process, sensitizing concepts were introduced to guide data construction into logical codes and categories, confirming both existing ES processes and identifying new ES process functions not previously documented. The Selective Coding process was then identified that led to constructing themes and then abstracting themes into an ES framework. Thematic saturation was presented at the theme level to demonstrate that the options for building the framework were bounded by the existing reference material and that additional data was not purposeful in constructing the framework.

The constant comparative method was demonstrated at each level of the Progressive Coding process by coding flow diagrams. It was demonstrated how the constant comparative process resulted in introducing new literature into the GTM. The bottom-to-top multiple pass analysis process was explained and diagramed to show how the constant comparative method was applied in data analysis and how it supported determining data and thematic saturation points.

The theoretical sampling and the theoretical integration processes were shown to result in the introduction of additional reference material to the GTM process. This additional material was supportive of adding additional detail to existing categories and themes and supported the determination of data and thematic saturation.

The method for developing the ES framework was explained and diagrammed in detail. It was then explained how the ES framework was deployed in an applied setting which was selected as the actions of FEMA during Katrina.

The GTM applied in this research was reviewed by five GTM peer experts. The process for their review of this research's GTM and for assessing their GTM process review comments was outlined. Seven process themes were identified in the peer review analysis results and are presented in Chapter 5. The process for their review and for assessing their review comments was outlined. Seven themes were identified in the peer review analysis results and are presented in Chapter 5.

The case study and face validation methods were explained and diagramed. The reference material for the applied setting was determined to be the systemic performance of FEMA during the Hurricane Katrina event. Criticisms of the face validation and case study processes were discussed and the mitigations to these criticisms for this research were presented. Quality issues with case studies were identified and the mitigations to the quality issues for this research were presented.

Chapter 5 is the presentation of the research results stemming from the research methods applied in Chapter 4.

CHAPTER 5

RESEARCH RESULTS

5.1 INTRODUCTION

Chapter 1 identified that the purpose of this research was to construct a Systems Theory-based framework for ES in CSG and to apply the ES framework in a practical setting. This research was done to address two primary issues. First is the gap in the literature that stems from inconsistent definition and application of ES functions, and second is a grounding of ES functions in Systems Theory. This research specifically focused on addressing the following research questions:

A. *What Systems Theory-based framework can be constructed for Environmental Scanning in Complex Systems Governance?*

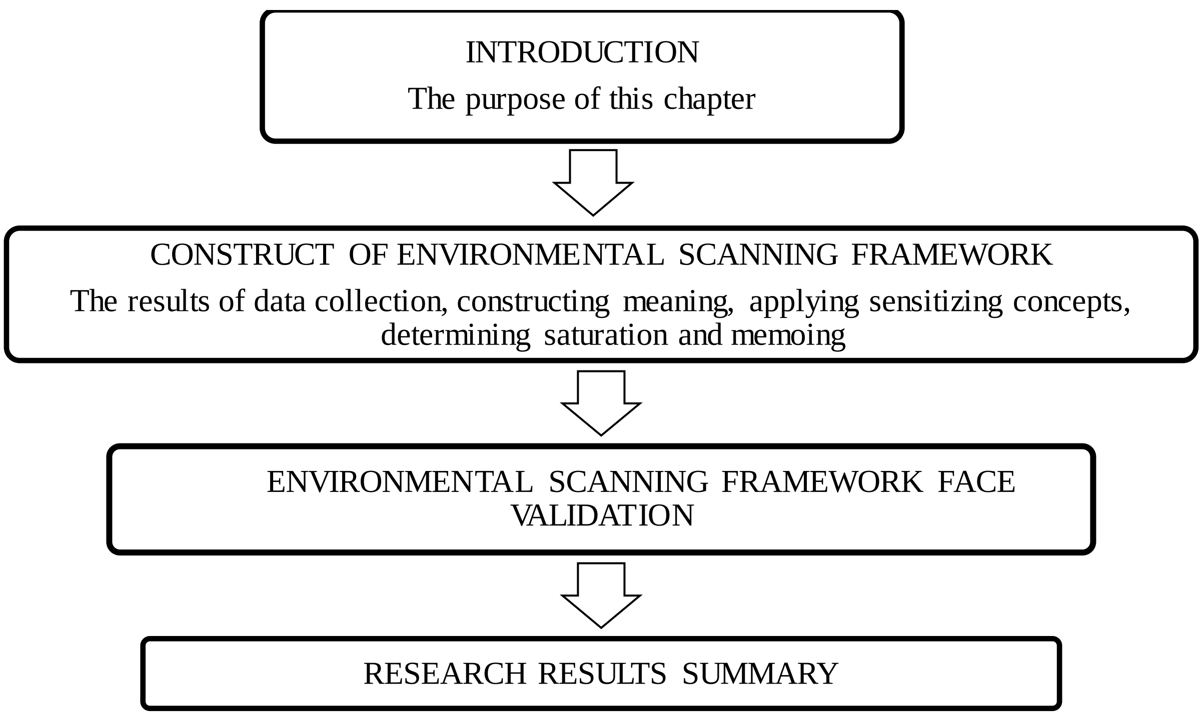
B. *What results from the deployment of the Environmental Scanning framework in an applied setting?*

To accomplish the objective of this research, and respond to the research questions, a multi-phased research design approach was identified and implemented. Chapter 2 provided the basis for the research questions stemming from the literature review. It also provided the setting for constructing an ES framework grounded in System Theory. In Chapter 3, an inductive research design perspective was established as the foundation for the pursuit of constructing a Systems Theory-based framework for ES in CSG and face-validating the ES framework in an applied setting. Chapter 4 presented the detailed research design methods for executing this research effort. The research design included the application of the constructivist GTM, following Charmaz (2006), to inductively develop the ES framework that addresses research question one. The research design included a single case study method to face validate the practical applicability of the constucted Systems Theory-based ES framework in an applied setting to address research question two.

This chapter presents the results of each of the major method steps in the research method design. This is followed by the ES framework development and then the results of the single case study face validation. Finally, a summary integrating the high points in each major research design method step is discussed. Figure 35 is the outline of Chapter 5.

Figure 35

Outline of Chapter 5



5.2 CONSTRUCTION OF THE ENVIRONMENTAL SCANNING FRAMEWORK

The construction of a framework for the functions of ES in CSG is the response to research question one. The construction of this ES framework occurs by applying the steps of the research method. The preliminary steps of background and problem formulation are presented in the Preface and Chapters 1 and 2. The first step in the research method is the collection of the data necessary to feed into the constructivist GTM process.

5.2.1 DATA COLLECTION

The research library is the set of journal articles and book sections that were used as the data source for the constructivist GTM. These articles came from three sources: (1) the researcher's personal library collected over years of classwork, (2) an Engineering Village database search, and (3) a Google Scholar search. To begin the search for literature that would populate the research library, a set of literature databases was identified as credible (related to research purpose) and scholarly (peer reviewed) sources. Upon visiting the ODU library and meeting with the librarian responsible for the Engineering Management and Systems Engineering Department library resources, a recommendation was provided to use Monarch OneSearch, Engineering Department Library Guide, and Google Scholar. This recommendation was given from the perspective of the relevant databases to Systems Engineering and closely related topics. Engineering Village from the ODU Engineering Library Guide with its Compendex® database was highly recommended. Table 38 was prepared to compare the different source databases to assess the breadth of topic material, depth of source material, and relevancy to a research effort in Systems Engineering and ES. The grey shading indicates databases that appear in more than one search engine, and it indicates that most of the ODU Engineering Library Guide databases are embedded within the applied search engines.

Table 38

Search Engine Comparison Guide

Search engine	Monarch OneSearch	Google Scholar	ODU Engineering Library Guide recommended databases	Engineering Village
Databases included	ProQuest Elsevier JSTOR Web of Science SAGE complete IEEE Xplore Engineering Database ABI/INFORM Global	Web of Science SCOPUS Cite Seer Elsevier Journals Science Direct SABRE Publishing OpenScience Applied Science and Technology Others (not listed by Google)	Engineering Village IEEE Xplore Web of Science Applied Science and Technology ProQuest SciTech Science Direct	Ei Compendex NTIS GEOBASE GeoRef AGI EnCompass PaperChem Chimica Knovel CBNB Patents
Depth of material	280 million articles based upon ProQuest alone, 175 subject areas, 6,000 journals	80-90% of all English published articles 389 million articles	Covered by Monarch OneSearch and Engineering Village	19 million indexed documents 190 disciplines
ES Search results	341 returns on ES search	30,200 returns	Covered in other searches	393 returns

Gusenbauer (2019) provided a comparative picture of 12 of the most used academic search engines and bibliographic databases. His results showed that Google Scholar, WorldWideScience, and ProQuest are the largest systems providing scholarly information, with each containing about 300 million records. He stated that the smaller databases are Scopus, Web of Science (Core Collection), and Q-Sensei Scholar each containing around 60 million records. Based on his data, Gusenbauer (2019) posits that Google Scholar, with 389 million records, provides by far the greatest volume of scholarly information and that ProQuest's 280 million records place it among the most comprehensive databases.

Given that Monarch OneSearch (which includes Engineering Village) and Google Scholar together encompass the greatest volume and most comprehensive scholarly databases, they were the search engines of choice for this research effort.

Books and book sections were identified in the search results, but books were not initially considered to be included in the research library due to the implausibility of coding an entire book. However, sections of books, primarily from Beer on Managerial Cybernetics, were included. During the Progressive Coding process an update to the research library literature was accomplished using both Google Scholar and Google Books®. An assessment was made at that time if the search of related book sections could add data into the ES code database. In case that they could add data, they were included.

Each of these sources identified a large number of reference articles that were then passed through the filter discussed in Chapter 4. The output of the filter was an initial set of reference articles that were scholarly and related to the purpose of this research. Then during the implementation of the constructivist GTM, several more journal articles and book chapters were identified because of the GTM's constant comparative process and because of an update to the original searches to capture current ES literature. The constant comparative process is comparing data with other data, data with codes, codes with codes, codes with categories, and categories with themes (Charmaz, 2015a). The sum of the initial set, the constant comparative method identified, and the updated search created the final research library of 150 reference articles. This research library was grouped into eight fields of study to ensure both a wide range of literature sources were available for coding (a generalizability enhancing function), to ensure the literature was grounded in Systems Theory, and to provide a basic categorization of the literature in support of organizing the research library. The reference articles were then loaded into NVivo by field of study groupings in preparation for coding. This research library, at the journal article and book section level, was first searched for the keywords discussed in Chapter 4 for the purpose of identifying reference texts. These reference texts were then coded to create codes that were abstracted from their context. This coding produced the code database comprised of individual codes mapped to their specific code-references that came from the source reference articles. The complete list of reference articles that were coded and their source fields of study are presented in Appendix G. These selected references were loaded into NVivo in PDF searchable format. Figure 36 is a screenshot of the NVivo data input file folders used in this research. It shows the eight source fields of study that are the file folder labels and then two others (ES Crosscheck and New Evolving articles) that were also used in the study but not related to the study's outcome.

Figure 36

NVivo File Folder Listing

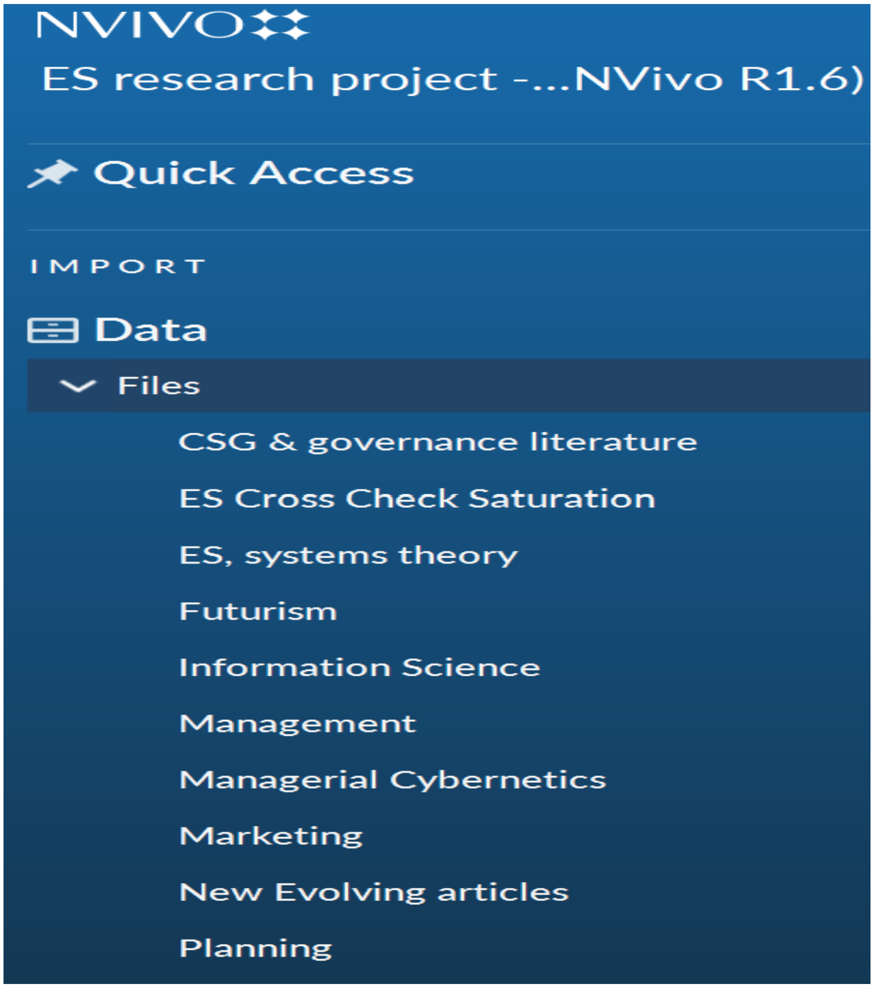


Figure 37 shows the journal articles that have been mapped into the CSG and governance literature file folder as an example. There are 16 named journal articles in this folder. Each name shows the author(s) and publication year for reference purposes, the number of codes that were developed from each article, the number of code-references identified in each article from the keyword search that was performed, the most recent modification date, and the green color code indicates that the coding was completed. This is similar to each of the seven other reference file folders in NVivo.

Figure 37

Journal Articles Mapped Into the CSG and Governance Literature File Folder

CSG governance literature

Search Project

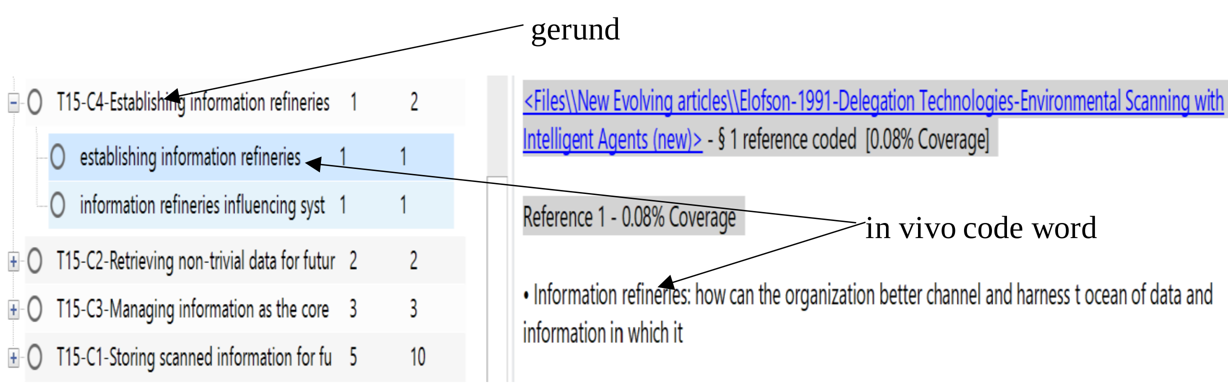
Name	Codes	References	Modified on	Modified by	Classification
Bradley et al. - 2016 - Governance for Acquisition Bradley et al 2016	39	114	4/20/2021 16:28	DEB	Journal Article
Calida Dissertation for Committee - 2013	18	48	3/6/2021 12:12	DEB	Journal Article
Complex system governance Moving diverse theory to practice Calida 2016	7	18	3/19/2021 14:29	DEB	Journal Article
Davies - 2007 - Models of governance-a viable systems perspective	77	207	3/29/2021 20:44	DEB	Journal Article
Governance_for_sustainability espinosa 2015	32	77	4/1/2021 18:46	DEB	Journal Article
Jessop - 2003 - Governance and meta-governance on reflexivity, requisite variety and requisite irony	66	163	4/2/2021 16:59	DEB	Journal Article
Katina et al 2017	27	60	3/26/2021 13:31	DEB	Journal Article
Keating & Bradley - 2015 - CSG Reference Model OCR M4 functions	45	90	6/16/2022 11:32	DEB	
Keating 2015 complex system governance-theory to practice challenges for system of systems engineering-	38	76	4/1/2021 19:18	DEB	Journal Article
Keating and Katina 2019 Complex System Governance	49	107	4/2/2021 12:40	DEB	Journal Article
Keating et al-2017- SYSTEMIC INTERVENTION FOR COMPLEX SYSTEM GOVERNANCE	44	96	4/2/2021 20:55	DEB	Journal Article
Keating, Katina - 2016 - Complex System Governance Development A First Generation Methodology	35	93	4/1/2021 20:12	DEB	Journal Article
Keating, Katina& Bradley 2015- Challenges for developing Complex System Governance	10	11	4/2/2021 13:45	DEB	Journal Article
Keating, Katina, Bradley - 2014 - Complex system governance concept, challenges, and emerging research	41	102	3/12/2021 11:59	DEB	Journal Article
Keating-2014-Governance Implications for Meeting Challenges in the System of Systems Engineering Field	24	38	4/1/2021 19:46	DEB	Journal Article
Keating-Bradley (2015)	27	100	3/6/2021 11:53	DEB	Journal Article

Note: This figure is an annotated actual screenshot from NVivo at the time it was being used. The figure is for demonstration purposes. The data in the figure is available in Appendix G.

The process of developing codes, taken from Saldaña (2013), was implemented by four coding methods. Process Coding, which generates a gerund form to the text to be coded, In Vivo Coding, which uses the actual words in the text being coded as the code, Descriptive Coding, which simply creates a phrase that describes the text being coded, and Simultaneous Coding which combines two or more of the other coding methods together. The Figure 38 screenshot from NVivo is an example of Simultaneous Coding that combines Process Coding, NVivo Coding, and Descriptive Coding. The code phrase is "establishing information refineries." "Establishing" is the Process Coding gerund form, "information refineries" is from the direct copy In Vivo Coding method, and the entire phrase is the Descriptive code of the reference text.

Figure 38

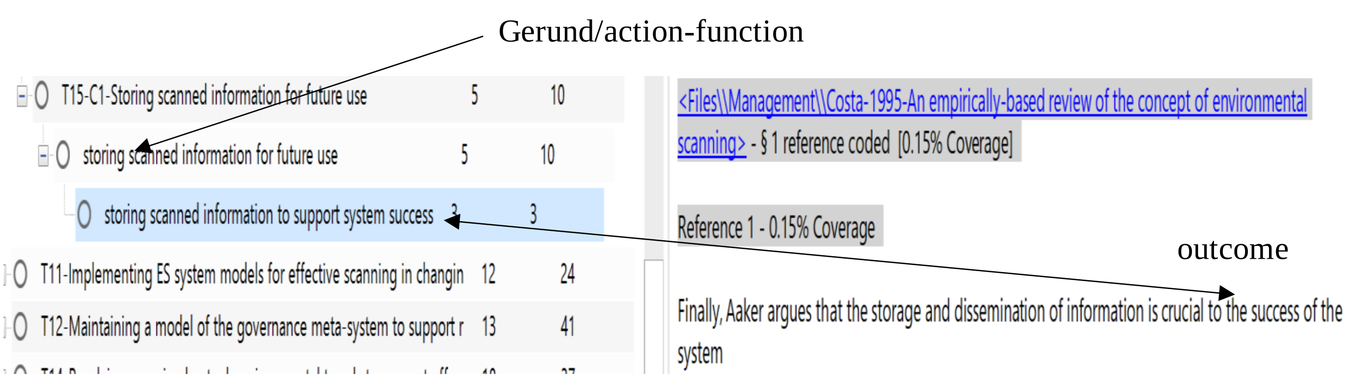
Example of Coding Methods Applied In This Research



As much as practicable, this researcher abstracted codes into the form of a gerund (a function) with a description (the result of the function) to ensure each code was uniquely identifiable and to enhance the abductive inference process of abstraction into higher, more consolidated tiers of data. Figure 39 is an NVivo screenshot of a simultaneous code consisting of a gerund (function) and a description (the result of the function). The simultaneous code is "storing scanned information to support system success." The gerund function is "storing" and the descriptive result is "to support system success." Applying the Simultaneous Coding method was fundamental in developing the umbrella code in the ES framework. A list of dozens of abstracted code functions could have been the product of the research and could have simplified the GTM application. Adding the result of the function to the code provided a purpose to the function, which made the ES framework more applicable in a practical setting. The Simultaneous Coding method was not applied to each of the hundreds of codes developed. It was used when the code-reference actually stated the result of the function as in the Figure 39 example and when the Axial coding process collected enough similar codes into a code grouping that an outcome result of the collective code could be readily determined by inference.

Figure 39

Example of a Simultaneous Code



The NVivo query that was applied to each journal article to identify keywords was: *environmental or scanning or "system four" or futures or design or M4 or M4´ or S4 or governance or planning or change or predicting or spotters or "gather information" or "gather data" or learning or futurism or foresight or "systemic collection" or "detect trends" or sensing or environment or “environmental scanning” or “decision making*

The query was applied to each journal article and book section in the reference library. The outcome of the query was a report listing the number of findings for the keywords in the query. See Figure 40 for an example of a query report. In the case of Du Toit (2016) there were 358 findings in the article.

Figure 40

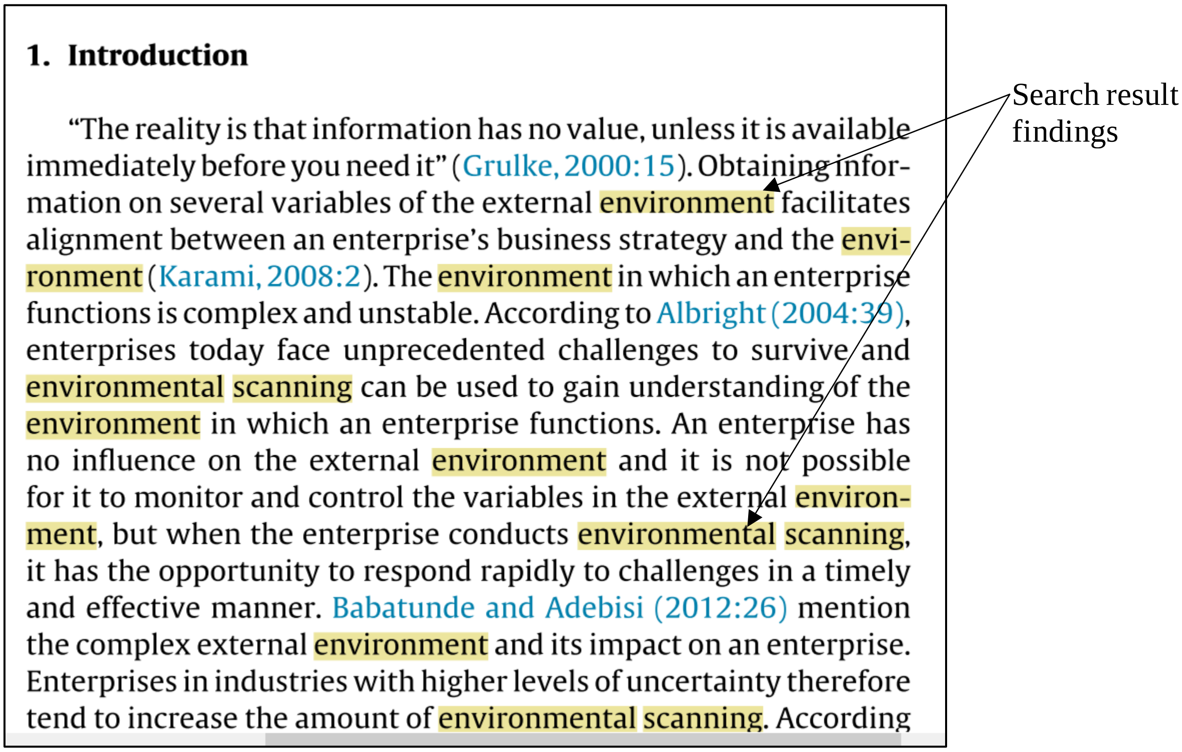
NVivo Query Result Report

Name	In Folder	References	Coverage
Toit-2016-using es to collect strategic information	Files\\ES Cross Check Saturation	358	4.01%

Once the query was completed, opening the subject reference article showed each of the query findings highlighted. Each occasion of highlighted query-result text was then assessed for coding by reading the surrounding sentences for context. See Figure 41 for an example of queried, highlighted text from the subject journal article Du Toit (2016).

Figure 41

Query Result Showing Highlighted Search Text



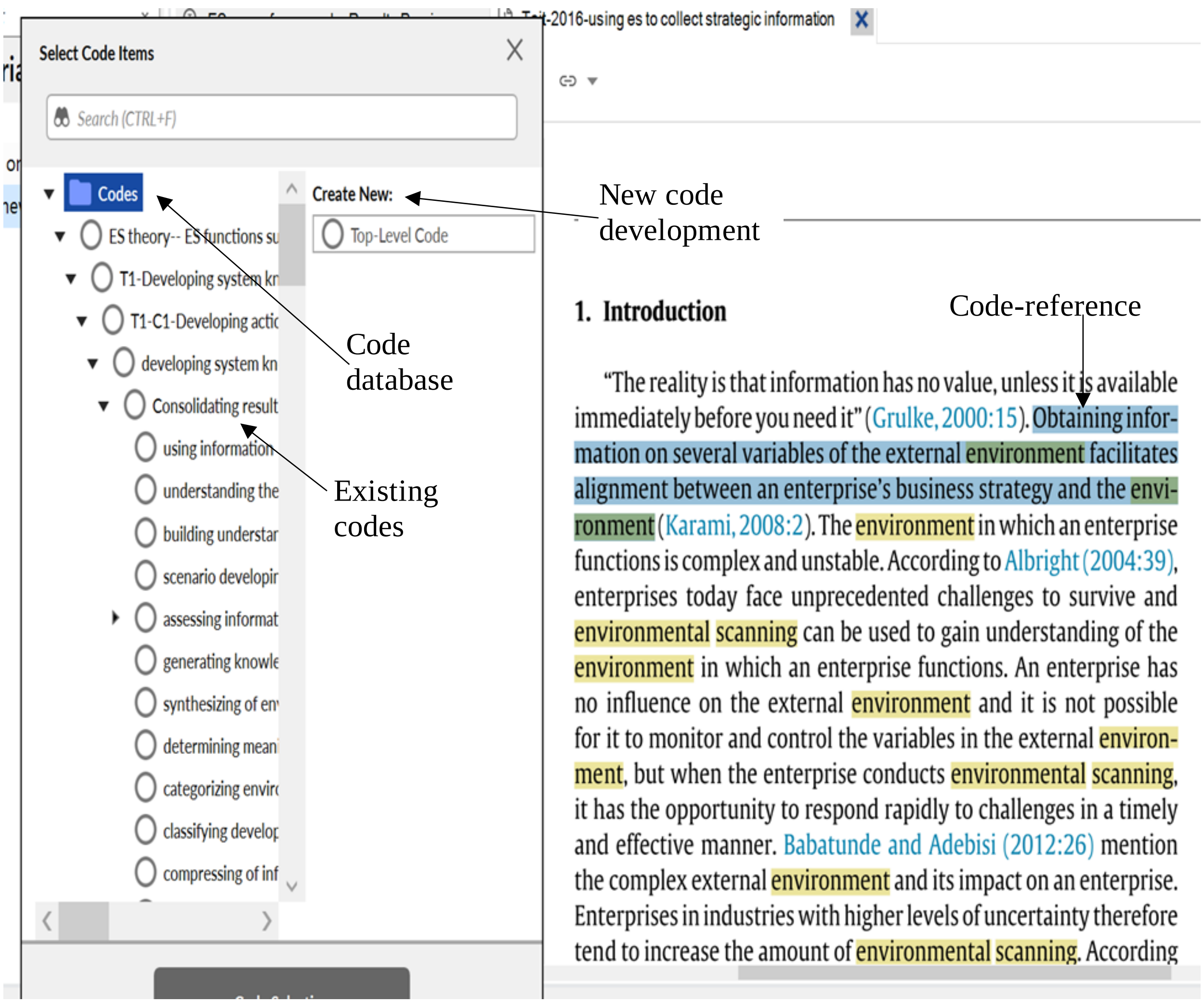
1. **Introduction**

"The reality is that information has no value, unless it is available immediately before you need it" (Grulke, 2000:15). Obtaining information on several variables of the external environment facilitates alignment between an enterprise's business strategy and the environment (Karami, 2008:2). The environment in which an enterprise functions is complex and unstable. According to Albright (2004:39), enterprises today face unprecedented challenges to survive and environmental scanning can be used to gain understanding of the environment in which an enterprise functions. An enterprise has no influence on the external environment and it is not possible for it to monitor and control the variables in the external environment, but when the enterprise conducts environmental scanning, it has the opportunity to respond rapidly to challenges in a timely and effective manner. Babatunde and Adebisi (2012:26) mention the complex external environment and its impact on an enterprise. Enterprises in industries with higher levels of uncertainty therefore tend to increase the amount of environmental scanning. According

Once the query-identified text was assessed for coding, the actual text to become the code-reference was highlighted in the document, the NVivo code menu was selected, and an existing (a duplication) or new code (an abstraction), as appropriate, was assigned to the text. In Figure 42 from an NVivo screenshot, the blue highlight shows the text that was selected to be the code-reference; on the left the code menu was turned on to select an existing code from the code database or to enter a new code name into the code database.

Figure 42

NVivo Screenshot Showing a Code-reference Selection



This code construction process was repeated for each query result on each of the reference articles in the research library. At the end of this Initial Coding process, 4704 code-references were generated. See Figure 43 for the NVivo screenshot of generated code-references. The Name column is the highest-level code in NVivo, called a level 1 code. It is a summary code for all the codes cataloged under it. The files column refers to the number of journal articles the code-references were taken from. The References column lists the number of code-references catalogued under the Name code. The “ES theory” code at the bottom of the list represents the code database relevant to the purpose of this research.

Figure 43

NVivo Listing of Code-references

Codes

Name	Files	References
SME composite document descriptive themes	1	79
scanning sources	36	123
scanning behaviors	86	930
Parking Lot	2	10
Issues identified with the ES process	68	227
ES theory-- ES functions support complex system	150	3414

Top level code name

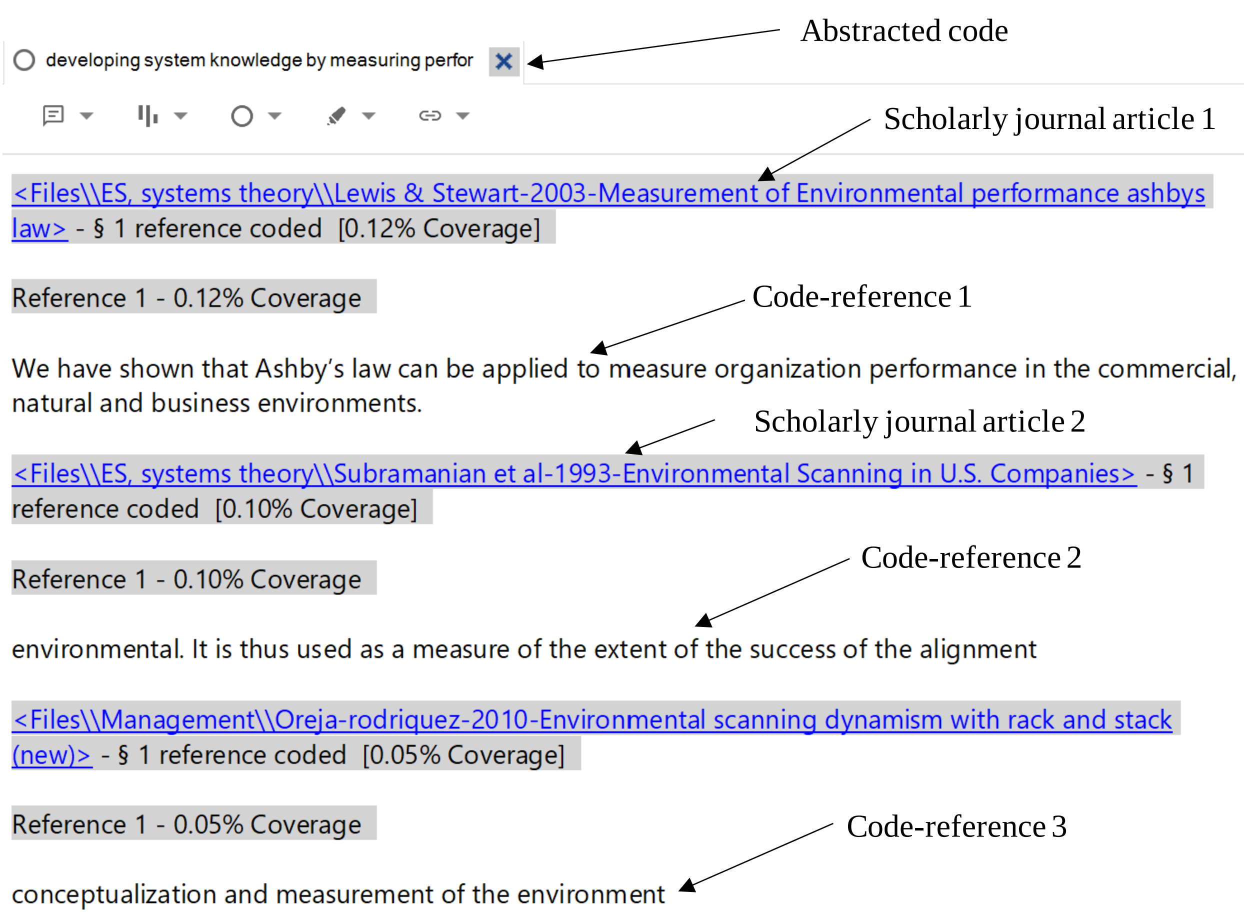
Code-references numbers

When the Initial Coding of all the reference articles in the research library was completed, the NVivo database then contained all the initial codes and associated code-references that were either the input to the constructivist GTM or were determined to be out of bounds to the scope of the study. The codes determined initially to be out of bounds were continually assessed in the constant comparative method to be brought back into the GTM. As Progressive Coding was implemented, some of these codes were abstracted into the research process while others remained not relevant. In the end, 280 open codes were intentionally left out of the research.

The source literature at this point had been broken down into individual data references and identified by a code phrase that represented the ES function demonstrated in the text reference an its outcome when applied. The data references that were selected from each reference article were combined into a single database in NVivo. These data references summarized the ES functions in each of the reference articles coded but were now available to be constructed into related categories through Axial Coding and would no longer be specifically tied to the reference article they originated from. See Figure 44 for an example of a code with its associated code-references that came from several different journal articles. The code is "developing system knowledge by measuring performance." It has three code references, each from a different journal article. In NVivo, each code is linked to its code references which in turn are identifiable to the journal articles they originated from. This unique identity provides the "DNA" of all the codes in the code database. This code DNA is retained throughout the rest of the Progressive Coding process such that at the theme level, all the code and category data that support the themes are traceable back to their origination in the specific text from the research reference articles. This traceability provides a transparent and visible means of keeping the abstracted codes, categories, and themes grounded in the original data, which is the basic concept of the GTM.

Figure 44

Example Code and Associated Code-references (code DNA)



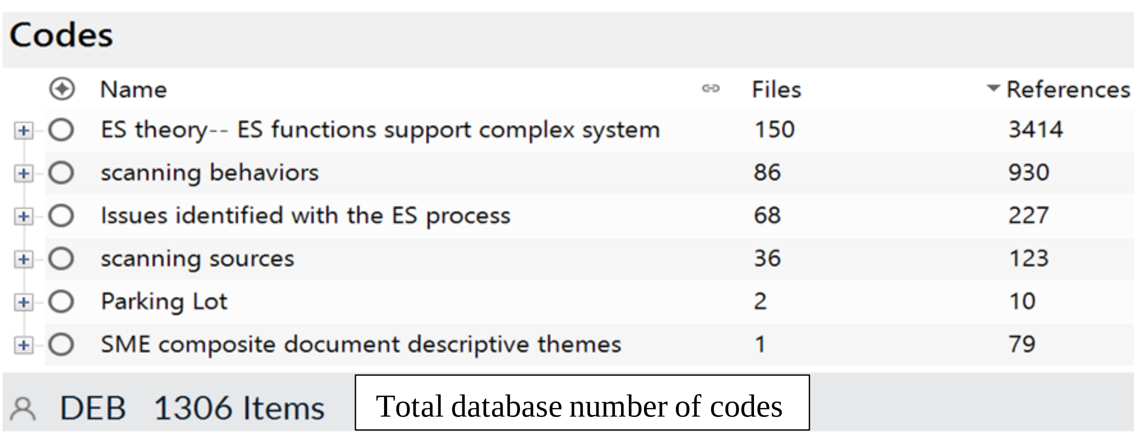
The next major step in the research method was to construct meaning from the code database.

5.2.2 CONSTRUCTING MEANING

The construction of meaning from the set of code-references is an abductive inference process. The GTM "helps scientists to fulfill two tasks: the intellectual task of coding (open, axial, selective), and the intellectual task of developing and redeveloping concepts and theories while repeatedly moving to and from between the collection of data, coding, and memoing" (Reichertz, 2009, p.11). Charmaz (2015a) states that "As more researchers aim toward theory construction, engaging in abductive reasoning becomes a crucial element in constructing fresh theoretical analyses of the studied empirical problems. The most helpful way to use abduction is to expand the range of theoretical possibilities and subsequently confirm which hypothesis offers the best theoretical account for the data" (p. 406). Constructing meaning from the code database begins with the Axial Coding of the code database. After completion of Initial Coding, the code database consisted of 1306 codes, which were comprised of 4783 code-references, taken from 343 reference articles (files) (many of the reference articles are repeated). Figure 45 is a screenshot from NVivo that shows the summary data for all the codes, references, and files in the research database. Each of the "Names" shown below is a tier 1 code that represents the hundreds of codes underneath it.

Figure 45

NVivo Code Database Summary



Codes

Name	Files	References
ES theory-- ES functions support complex system	150	3414
scanning behaviors	86	930
Issues identified with the ES process	68	227
scanning sources	36	123
Parking Lot	2	10
SME composite document descriptive themes	1	79

DEB 1306 Items — Total database number of codes

The codes in the NVivo code database are tiered. Table 39 shows the code tier structure used in NVivo for tis research effort.

Table 39

Code Tier Structure

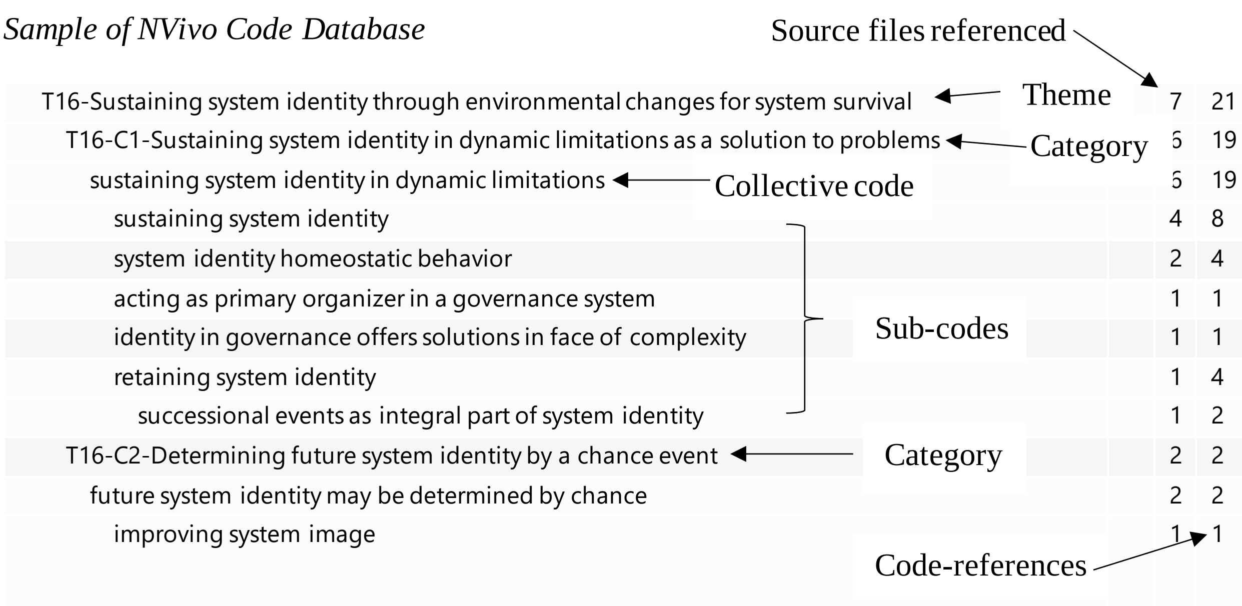
Tier Level	**Tier Name**
1	Umbrella Theme
2	Theme
3	Category
4	Collective-code
5	Sub-code (1)
6	Sub-code (2)
7	Sub-code (3)
8	Open code

At the lowest levels, the tiers are groupings of codes with related meanings, combining open codes into sub-codes that are then incorporated into collective code levels. This was done to make the code database more manageable when applying the constant comparative method. Instead of comparing a thousand codes several times over, several hundred collective codes of related meanings were compared and analyzed.

Theme 16 will be used as a representative example of the code database since it has the fewest number of codes supporting it. Figure 46 from an XLS (MS Excel® spreadsheet) abstract from the NVivo code database is displayed. T16 represents a theme (the second-highest code tier) that is abstracted from its categories. T16-C1 and C2 are category labels (a third-tier code) that are abstracted from their collective codes. Each line in the category label is a collective code (a word phrase with a gerund, the action part of the code, and an outcome of the action) that is a fourth-tier code. Code abstraction occurs at all code levels to construct the code tiers from open codes up to themes. The memoing process is applied to capture the abstraction analysis. Memoing is explained in detail in section 5.2.5. Not shown here are all the sub-codes and code-references supporting each collective code (the code DNA). Code-reference examples supporting codes were shown in Figure 46. A more complete code database is presented in Appendix H.

Figure 46

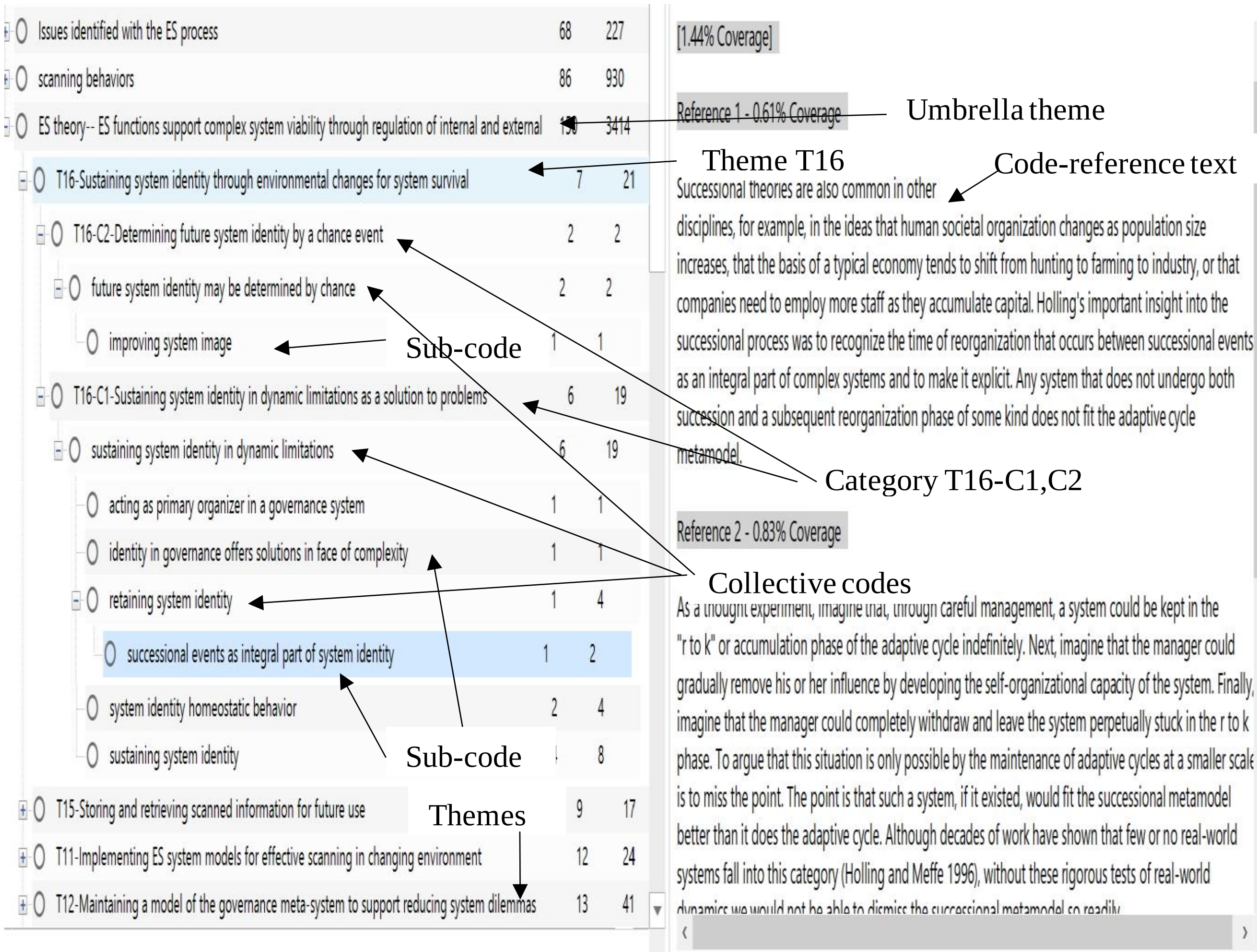
Sample of NVivo Code Database



Once the open codes were established in the code database, Axial Coding began with the objective of building code categories. Due to the large volume of open codes, similar open codes were constructed together into collective codes (a kind of code sub-category). Code categories were then abstracted (abductive inference) from the tiers of sub-categories (collective codes) that were constructed under them in the Axial Coding process. Figure 47 is an example of the code tier structure in NVivo. The ES theory line is tier 1. T16 is a theme at the tier 2 level. T16 is abstracted from two categories C1 and C2 at the tier 3 level. C1 is an abstraction of two collective codes at the tier 4 level. One of the two collective codes, *retaining system identity*, has one open code (tier 5 level), *successional events as integral part of system identity*. This open code is abstracted from the two references shown in the column on the right side of the figure. This tiering of data from code-reference up to theme is called code DNA. Each code is uniquely identifiable from this perspective. A simplified version of the ES framework code DNA is shown in Appendix H. The outcome of the Axial Coding process is the construction of categories from the original open codes. This construction is then captured in the code DNA. Appendix I shows the entire code DNA structure numerically from code-references up through the umbrella theme. The number of code-references and source data files are shown for each code level. They are aggregated at each higher code level but displayed at the category level and higher.

Figure 47

Example of Code Tier Structure (Code DNA)



Note: This figure is an annotated actual screenshot from NVivo at the time it was being used. The figure is for demonstration purposes. The data in the figure is available in Appendix H.

Once the Axial Coding process had been implemented with categories identified, the Selective Coding process began. Selective Coding enabled this researcher to select and integrate categories of organized data, obtained from Axial Coding, into cohesive and meaningful thematic abstractions. Selective Coding was a unique phase of the data analysis process of the research design method, in that it influenced not only what theoretical constructs emerged (categories and themes), but also how theoretical meaning was constructed through the presentation of the data. The outcome of the Selective Coding process enabled the crafting of an ES framework that accurately and powerfully presented the sum of the Progressive Coding process. Though the outcome of the research method is presented in sequential steps, the method was accomplished in overlapping steps. As Initial Coding was proceeding, some Axial Coding was being done, and similarly, as Axial Coding was being done, some Selective Coding was occurring. As the Progressive Coding process moved to the right on the coding timeline, the processes of data abstraction and constant comparison converged on a set of 17 themes. The 17 themes are presented in Table 40. The themes are listed in NVivo sort order by number of sources files referenced, from most to least. Each theme is the abstraction of the categories that are mapped to it. The category-to-theme mapping is presented in Appendix I. These 17 themes are the framework for ES functions in CSG.

Table 40

Outcome of the Selective Coding Process (source file count sort order)

Framework Themes
T1-Developing system knowledge from environmental information (data) to support system future viability
T2-Acting on information from the external environment to create system value
T3-Actively obtaining (proactive scanning) system external environmental information to support system planning
T4-Identifying system transformation objectives in support of future system viability
T8-Evolving the governance system functions in support of future system viability
T5-Designing environmental scanning system processes for internal and external functions to support system present and future viability

Framework Themes
T6-Regulating internal-external variety generated from external turbulence to support system viability
T7-Disseminating essential environmental information (internal-external) throughout the system to support decision making
T13-Looking at (viewing) the external environment to identify information of interest (passive scanning)
T9-ES system responding rationally to environmental turbulence to support system viability
T10-System-environment influencing to prevent future problems
T17-Understanding the systemic role of scanning functions to enhance effective system governance
T14-Resolving perceived-actual environmental trends to support effective decision making
T12-Maintaining a model of the governance meta-system to support reducing system dilemmas
T11-Implementing ES system models for effective scanning in changing environment
T15-Storing and retrieving scanned information for future use
T16-Sustaining system identity through environmental changes for system survival

Each theme consists of a gerund-word function and the outcome of that function in terms of how ES functions in CSG. For example, T16-Sustaining system identity through environmental changes for system survival contains the gerund “sustaining” for the ES function, and the results of “sustaining” are “system survival.” This abstraction was constructed from the two categories, T16-C1/C2. The other 16 themes and the umbrella theme are similarly constructed. This Simultaneous Coding code-form (function-result) was applied to the entire code database as it distinguishes the codes, categories, and themes from each other and adds purpose to the ES function in the codes, categories, and themes.

The constructed ES framework is the response to research question 1. The ES framework consists of 17 themes for how ES functions in CSG. Table 41 summarizes the ES functions from the framework and the resultant outcomes from those functions acting within CSG.

Table 41

Summary of ES Framework Functions and Resultant Outcomes

Theme	ES function	Resultant outcome
T1	Developing	Support system future viability
T2	Acting on	Create system value
T3	Actively obtaining	Support system planning
T4	Identifying	Support of future system viability
T5	Designing	Support system present and future viability
T6	Regulating	Support system viability
T7	Disseminating	Support decision making
T8	Evolving	Support of future system viability
T9	Responding	Support system viability
T10	Influencing	Prevent future problems
T11	Implementing	For effective scanning
T12	Maintaining	Reducing system dilemmas
T13	Looking at	Identifying information of interest
T14	Resolving	Support effective decision making
T15	Storing and retrieving	Future use
T16	Sustaining	System survival
T17	Understanding	Enhance effective system governance

Analyzing the ES functions and resultant outcomes in Table 41 abstracts into the umbrella theme-*ES functions support complex system viability through regulation of internal and external variety induced by external changes*. The ES umbrella theme consists of the abstracted 17 ES theme functions and three Systems Theory-based constructs: (1) system viability, (2) regulation of system variety, and (3) external changes. The ES themes that support each of these constructs were constructed from the ES codes and categories identified in each of the 17 themes' DNA. To abstract the constructs, the ES themes were placed in a table by ES theme function and outcome, then abstracted to the construct level with the predominant functions and outcomes inferring the constructs. See Table 42 for the mapping of theme functions and outcomes to the umbrella theme constructs.

Table 42

Mapping Theme ES Functions and Outcomes to ES Umbrella Theme

Theme	**External environment**	**System viability**	**Regulating variety**	**Other**
T1		Supporting future viability		System knowledge
T2	External environment	System value	Acting on	
T3	External environmental information		Actively obtaining	Planning
T4		Future system viability		Identifying system transformation
T5	Environmental scanning	Present and future system viability	Designing	
T6	External turbulence	Support system viability	Regulating internal-external variety	
T7		Support decision making	Disseminating information	
T8		Future system viability		Governance functions
T9	Environmental turbulence	System viability		Responding rationally
T10		Preventing future problems	Influencing	
T11	Scanning in changing environment			ES system models
T12		Reducing system dilemmas		Governance meta-system model
T13	Viewing external environment		Identifying information	
T14	Environmental trends	Support decision making	Resolving trends	
T15		Future use	Storing and retrieving	
T16	Environmental changes	System survival		System identity
T17	Scanning functions	Enhance system governance		

Several minor themes were identified in the “other” column but were not considered major influences on the umbrella theme constructs. Three constructs were identified in the umbrella theme and have definitions in Systems Theory literature (Beer, 1979), their definition for purposes of this research are grounded in the functions and outcomes from which they were abstracted. See Table 43 for their definitions. Table 44 summarizes the mapping of the 17 themes to the umbrella theme constructs, indicating the presence of the themes in those constructs

Table 43

Umbrella Theme Constructs Definition

Umbrella theme construct	**Research-based definition**
External environment	The external environment is what surrounds the system of interest. It is where the system of interest is influenced by external turbulence and changes. It is where the system looks and scans for information that the system considers impactful.
Regulation of system variety	The system of interest’s external environment is a source of changes (variety in conditions) to the system that then causes the system to respond. Regulating that external variety is performed by the system to eliminate disruptive residual internal variety (variety not regulated). Regulation is done by acting on external information, obtaining and identifying relevant external information, viewing the external environment, designing the ES system to dispose of external variety, disseminating relevant external information internally, influencing the external environment to act predictably, resolving trends in external changes, and storing, retrieving relevant external and internal information. Requisite variety is reached when the residual variety from external changes is minimized.
System viability	System viability is related to system survival in a changing external environment. It involves preparing for the future so that when the future comes the system is not overwhelmed with environmental variety and is able to govern present day environmental variety. Viability is a measure of system value.

Umbrella theme construct	Research-based definition
	System viability is a product of system level decision making that has a focus on preventing future problems and reducing system dilemmas. System governance functions act to sustain system viability in a changing environment.

Table 44

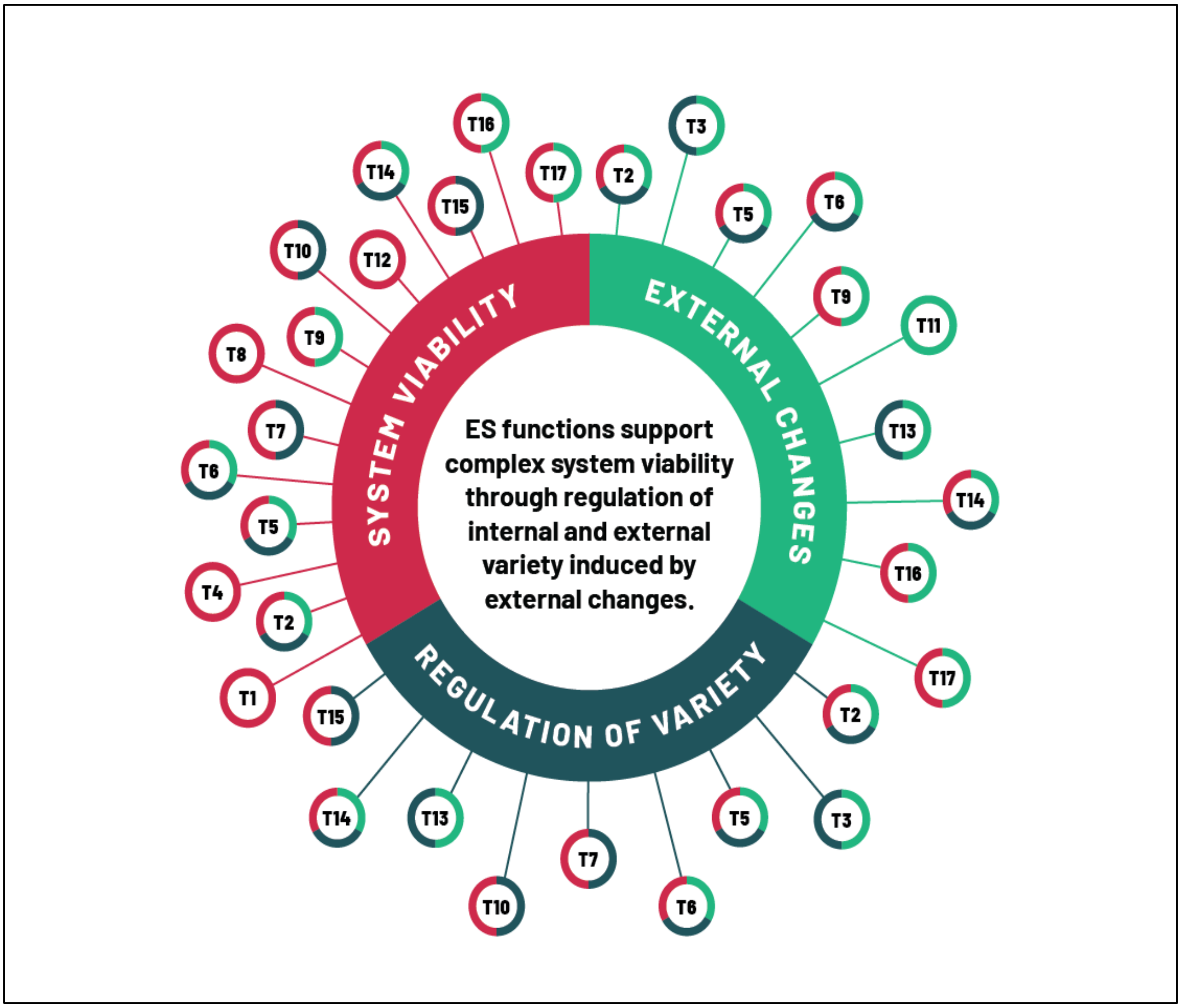
ES Themes Supporting Framework Constructs

Theme	Framework constructs		
	External changes	Regulation of system variety	System viability
T1			X
T2	X	X	X
T3	X	X	
T4			X
T5	X	X	X
T6	X	X	X
T7		X	X
T8			X
T9	X		X
T10		X	X
T11	X		
T12			X
T13	X	X	
T14	X	X	X
T15		X	X
T16	X		X
T17	X		X

Figure 48 summarizes the relationships between the umbrella theme constructs and the ES framework themes. The umbrella theme is stated in the center. The three umbrella theme constructs are color-coded in the circle. The ES themes from the ES framework are attached to the umbrella theme construct that they support. The theme numbers represent the Table 40 theme descriptions from the outcome of the Selective Coding process. The theme circumferential colors are the colors that represent the constructs to which they are related. These relationships are those that are described in Table 44. Supporting Figure 48 are 4783 code-references from 150 reference articles, 1306 codes, 78 categories, 17 themes, and an umbrella theme. Figure 48 represents the constructivist GTM pictorial summary response to research question 1.

Figure 48

Relationship of the ES Themes to the Umbrella Theme Constructs



CODE	DEFINITION	REGULATION OF VARIETY	SYSTEM VIABILITY	EXTERNAL CHANGES
T1	Developing system knowledge from environmental information (data) to support system future viability		SV	
T2	Acting on information from the external environment to create system value	RV	SV	EC
T3	Actively obtaining (proactive scanning) system external environmental information to support system planning	RV		EC
T4	Identifying system transformation objectives in support of future system viability		SV	
T5	Designing environmental scanning system processes for internal and external functions to support system present and future viability	RV	SV	EC
T6	Regulating internal-external variety generated from external turbulence to support system viability	RV	SV	EC
T7	Disseminating essential environmental information (internal-external) throughout the system to support decision making	RV	SV	
T8	Evolving the governance system functions in support of future system viability		SV	
T9	ES system responding rationally to environmental turbulence to support system viability		SV	EC
T10	System-environment Influencing to prevent future problems	RV	SV	
T11	Implementing ES system models for effective scanning in changing environment			EC
T12	Maintaining a model of the governance meta-system to support reducing system dilemmas		SV	
T13	Looking at (viewing) the external environment to identify information of interest (passive scanning)	RV		EC
T14	Resolving perceived-actual environmental trends to support effective decision making	RV	SV	EC
T15	Storing and retrieving scanned information for future use	RV	SV	
T16	Sustaining system identity through environmental changes for system survival		SV	EC
T17	Understanding the systemic role of scanning functions to enhance effective system governance		SV	EC

5.2.3 SENSITIZING CONCEPTS

Sensitizing concepts are applied to inductive research to help suggest possible lines of inquiry or to help researchers identify some important aspects of a particular research situation as coding begins (Bowen, 2019). These concepts help the researcher to understand and to explicate what is happening in this line of data (Charmaz, 1996). Researchers use sensitizing concepts in examining substantive codes with a view to developing thematic categories from the data (Blaikie, 2000). The sensitizing concepts applied in this research to help guide the coding process through the rich data field were taken from the CSG reference model (Keating & Bradley, 2015). The CSG reference model was selected for providing a source of sensitizing concepts because: (1) it is grounded in systems theory, (2) it addresses basic functions of ES in CSG, and (3) it is an evolving field of study in CSG. The CSG reference model sensitizing concepts from Keating & Bradley (2015) are represented in Table 45.

Table 45

Sensitizing Concepts Taken from CSG Reference Model

CSG metasystem function	Primary role	Responsibilities (concepts)
Metasystem Four (M4) – System Development Metasystem	The primary function is to provide for the analysis and interpretation of the implications and potential impacts of trends, patterns, and precipitating events in the environment.	• Analyzes and interprets environmental scanning results for shifts, their implications, and potential impacts on system evolution • Guides development of the system strategic plan • Informs the development of the strategic plan • Guides future product, service, and content development • Guides investment priorities • Identifies future relationships critical to system development • Identifies future development opportunities and targets that can be pursued in support of mission and vision of the System
Metasystem Four Star (M4*) –	The primary function is to provide for identification and	• Processes inputs for system wide implications

CSG metasystem function	Primary role	Responsibilities (concepts)
Learning and Transformation	analysis of metasystem design errors (second order learning) and suggest design modifications and transformation planning for the system.	• Identifies mechanisms for Double Loop Learning • Designs objectives, measures, and accountability for second order learning in the system • Leads in future transformation analysis • Provides future focused input to strategy development • Informs the development of the strategic plan
Metasystem Four Prime (M4′) – Environmental Scanning	The primary function is to provide the design and execution of scanning for the system environment. Focus is on patterns, trends, threats, events, and opportunities for the system.	• Designs for environmental scanning for the entire system (includes trends, changes, patterns, critical stakeholders, collaborative entities, research, etc.) • Executes the environmental scanning designs • Maintains a model of the metasystem environment • Captures emergent environmental conditions, events • Consolidates results from environmental scanning and provides synthesis • Informs the development of the strategic plan • Disseminates essential environmental information and shifts throughout the system

Each of the three metasystemic ES functions was taken as a collective code. Under these three collective codes each of the responsibilities (concepts) was identified as an ES function. The existing code database was then analyzed by this sensitizing framework. The Table 46 NVivo screen shot shows the results of aligning the code database into sensitizing concepts where possible. The three metasystemic CSG functions were collecting codes for the sub-codes in the code database. The number of original references and code-references are shown in the two adjacent columns. 2934 of the 3414 code-references were abstracted into the sensitizing concept structure. The remainder were aligned under codes outside of the sensitizing concepts. This resulted in 221 codes/sub-codes aligned within the sensitizing concepts. This provided a data field that was manageable going forward in the data abstraction process of coding and the constant comparison method.

Table 46

Outcome of Sensitizing Concepts Application

CSG reference model sensitizing concepts	129	2934
Developing the system for future viability	114	716
ES function sensitizing concepts	126	1735
Learning and Transformation sensitizing concepts	107	482

The next step in the Progressive Coding process was to continue code abstraction with the Axial Coding and Selective Coding processes to construct new categories and themes from the bottom up on the codes now collected under the sensitizing concepts. The initial sensitizing concepts were either abstracted into sub-codes, categories, or themes, but eventually no longer guided the data abstraction process. They were subsumed in the code abstraction process as the data meaning and abstraction guided the ongoing coding process, not the sensitizing concepts.

5.2.4 SATURATION

In this research study, data saturation was considered to consist of two types: code and meaning or theoretical. The point of code saturation was determined when further coding of reference articles resulted in no or few new open codes and was generating duplicate codes.

Figure 49 shows the number of new reference articles that were bi-weekly coded. Figure 50 shows the number of new open codes that were generated from Appendix G reference articles. Note that by week 17, the number of new codes being generated was down to 10 from four journal articles being coded. Figure 51 shows the number of duplicate open codes being generated bi-weekly.

Figure 49

Bi-weekly Reference Articles Coded

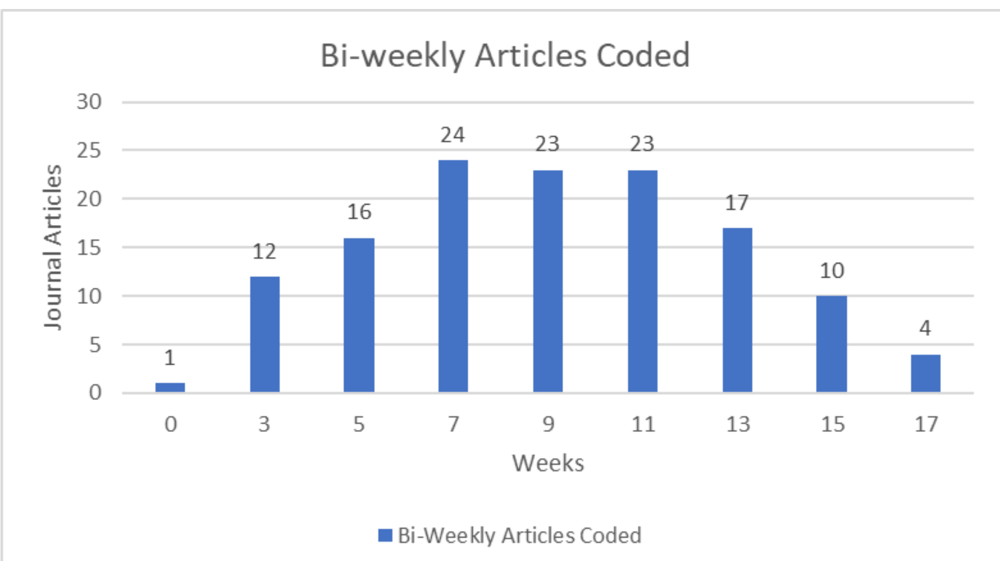


Figure 50

Bi-weekly Generated New Open Codes

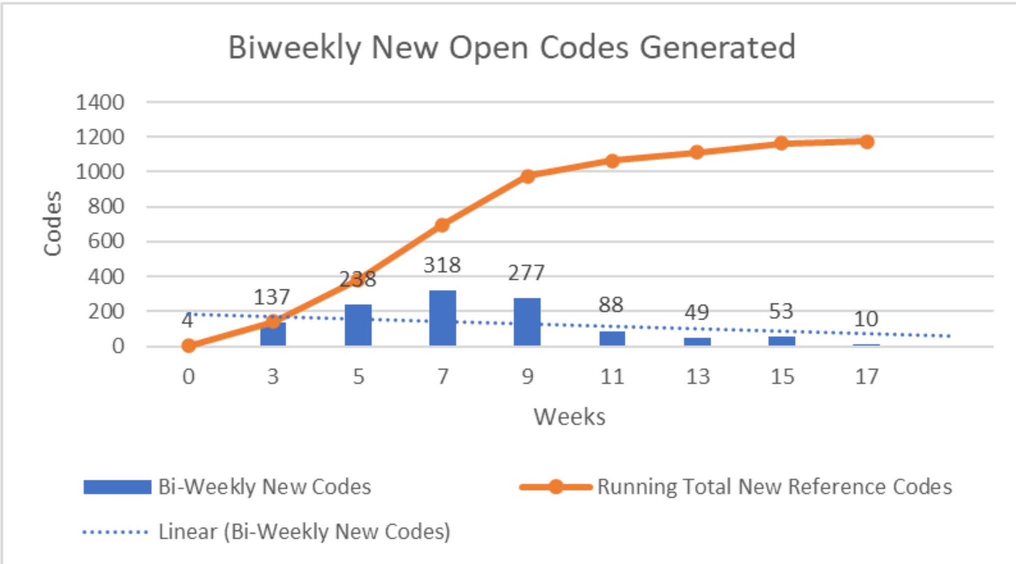
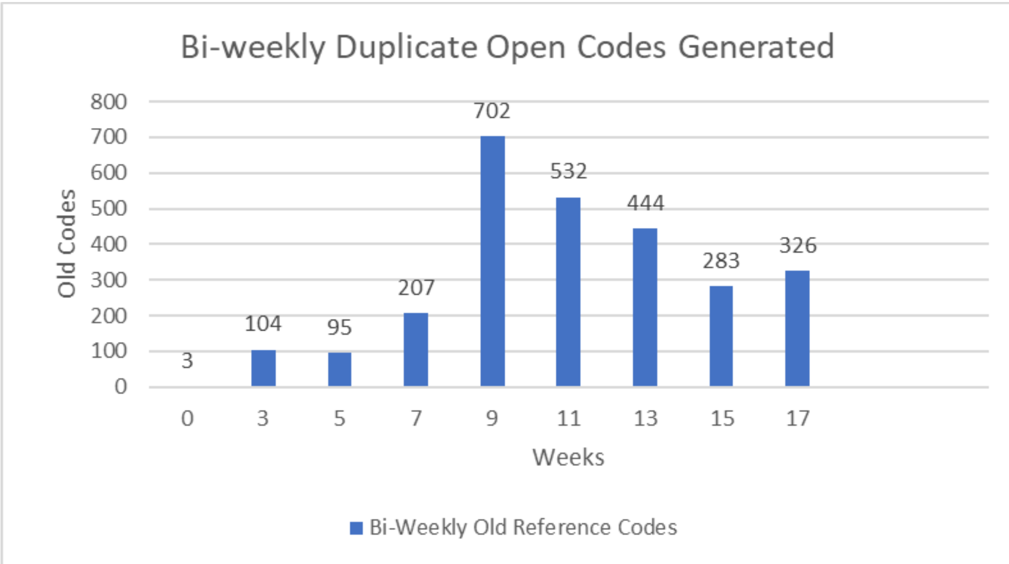


Figure 51

Bi-weekly Duplicate Open Codes Being Generated



The number of new codes being generated in week 17 was very few per reference article and the number of duplicate codes being generated was increasing. The 10 new codes in week 17 were readily abstracted into the existing code structure as they did not point sufficiently to new directions to create a new category or theme on their own. The last set of journal articles coded in week 15 was the set taken from Google Scholar to update the research library from its original content to include journal articles published between 2006 and 2021, that were relevant to ES functions. Charmaz (2006) described data saturation as when no new properties of a particular category can be discovered. At this point in the research, there were no recent journal articles to code, and there were no new codes emerging from those articles that were notably unique in their content. No new properties were being discovered. At this point code saturation was reached.

Theoretical saturation occurs when no new context or changes to the existing context of categories and themes emerges (Charmaz, 2006). At the end of the Selective Coding process there were 78 categories constructed from 1306 codes. See Appendix I for the constructed code structure (DNA). The categories were constructed from a minimum of 1 to a maximum of 144 codes. With the code database saturated, no new codes were being added to construct new directions to the category/theme development. Categories with a large number of codes behind them (38-144) were firmly grounded in their functional descriptions and the number of reference articles from which they were constructed. Those categories with fewer codes behind them (1-33) tended to be constructed from the more recent literature and suggested newer functionality for ES in CSG as they were not easily combined into the other categories with more numerous codes. At the end of the selective coding process, the 17 constructed themes were uniquely supported by their categories, and the categories so well developed that changes to their theoretical directions at this point were not supported. As discussed in Chapter 4, four journal articles: Du Toit (2016); Tang (2016); Costa (1995); and Morrison (1985) from the original search results, were set aside to "test" the saturation concepts in this GTM. Coding these four articles generated 972 code-references and a total of 43 possible new codes. All codes were readily assimilated into existing categories except for one code. That code was used to construct a new category T9-C5. Four journal articles focused on the ES function were readily absorbed into existing categories (redundant information not leading to new themes), but for one new category that enhanced the richness of an existing theme. It did not create a new path of theoretical thought; it reinforced an existing path of thought (theme). Theoretical saturation was demonstrated by not being able to construct changes to the existing themes with new literature or by rearranging existing categories into new theoretical directions.

5.2.5 MEMOING

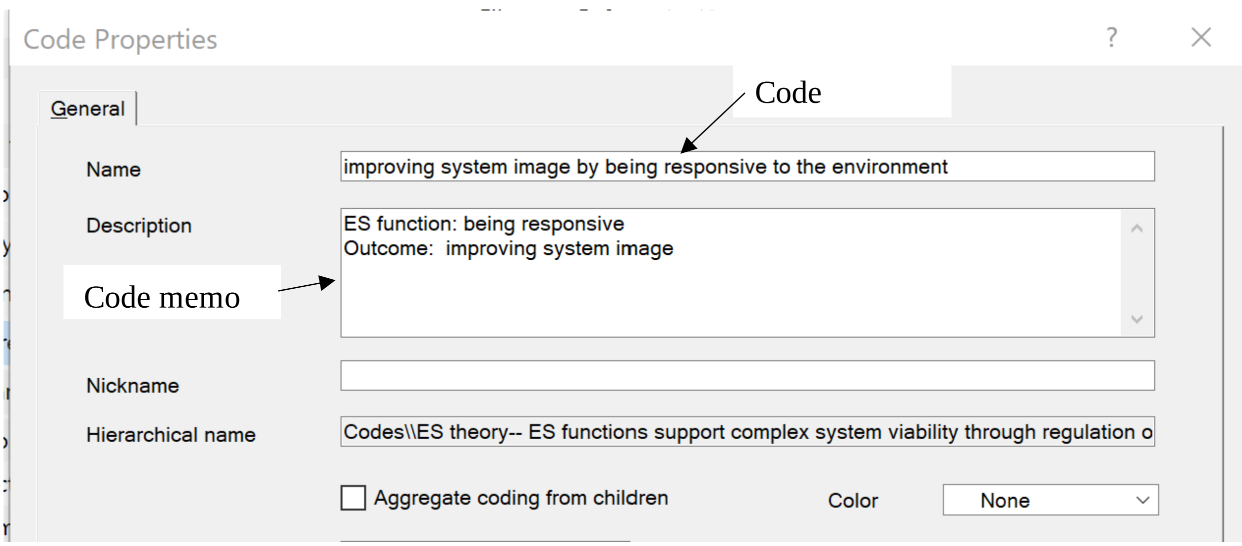
Coding is validated through a memo writing process. Charmaz (2006) posits that memo writing is a crucial method in Grounded Theory requiring the researcher to analyze their data and codes early in the research process. Memo writing is done at each stage of the Progressive Coding process. The first memos are part of the Initial Coding process. As an open code is abstracted from its source text, NVivo requires a properties dialogue to be filled in. See Figure 52 for a sample of an NVivo code memo. The code properties dialogue box captures the code name, the researcher-defined description, and the hierarchical name for the code that demonstrates its lineage from source to the umbrella theme (tier 1). In NVivo, the code is also linked to the code-reference from which the code was abstracted. For the code in Figure 52, the hierarchical name from NVivo is: *Codes\\ES theory-- ES functions support complex system viability through regulation of internal and external variety induced by external changes\T16-*

Sustaining system identity through environmental changes for system survival\T16-C2-Determining future system identity by a chance event\future system identity may be determined by chance\improving system image by being responsive to the environment.

This code example is a 5th-tier code. The code is attached to the umbrella theme, theme 16, category T16-C2, and the collective code "*future system identity may be determined by chance event*." A code memo like this exists for each code in the NVivo code database.

Figure 52

Example NVivo Code Memo

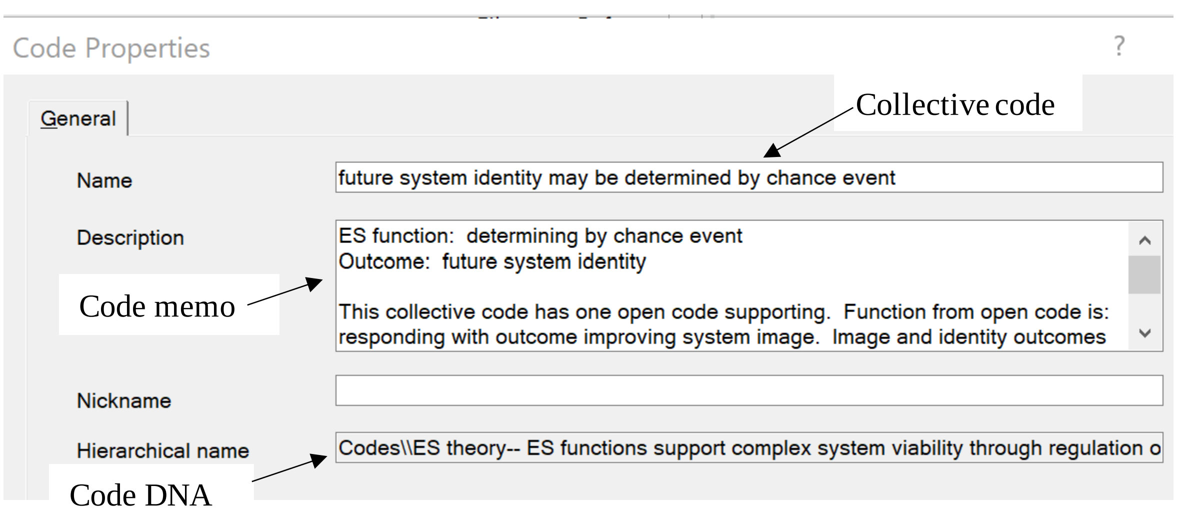


As the coding becomes tiered, the code memos contain more information supporting the abstraction process. Figure 53 shows the properties dialogue (code memo) for a collective code (4th tier). The full memo description is: *ES function: determining by a chance event Outcome: future system identity*. This collective code has one open code supporting it. The ES function from the open code is: *responding with outcome improving system image*. In the collective code analysis, image and identity outcomes are similar. Determining and responding have similar action related functions. Chance is the more challenging event to system viability, so it is selected to amplify this code's function.

At each tier of coding, the code descriptions contain more details that support the code abstractions at that tier level.

Figure 53

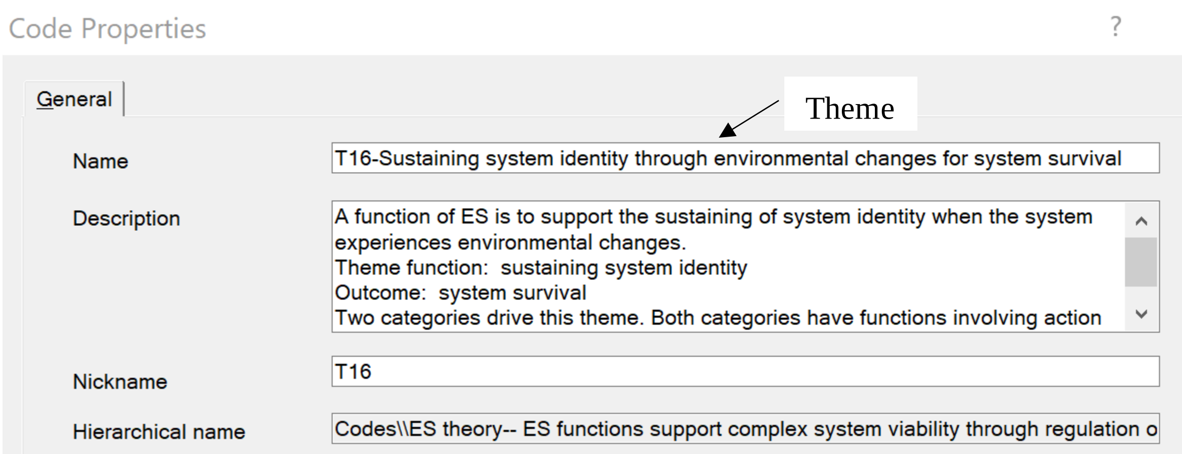
An Example of a Code Memo for a Collective Code



The memoing that supports the Selective Coding abstracting of themes from categories is structured similarly but contains details related to category functions and outcomes. See Figure 54 for an example of memoing a theme.

Figure 54

Example of Memoing for a Theme

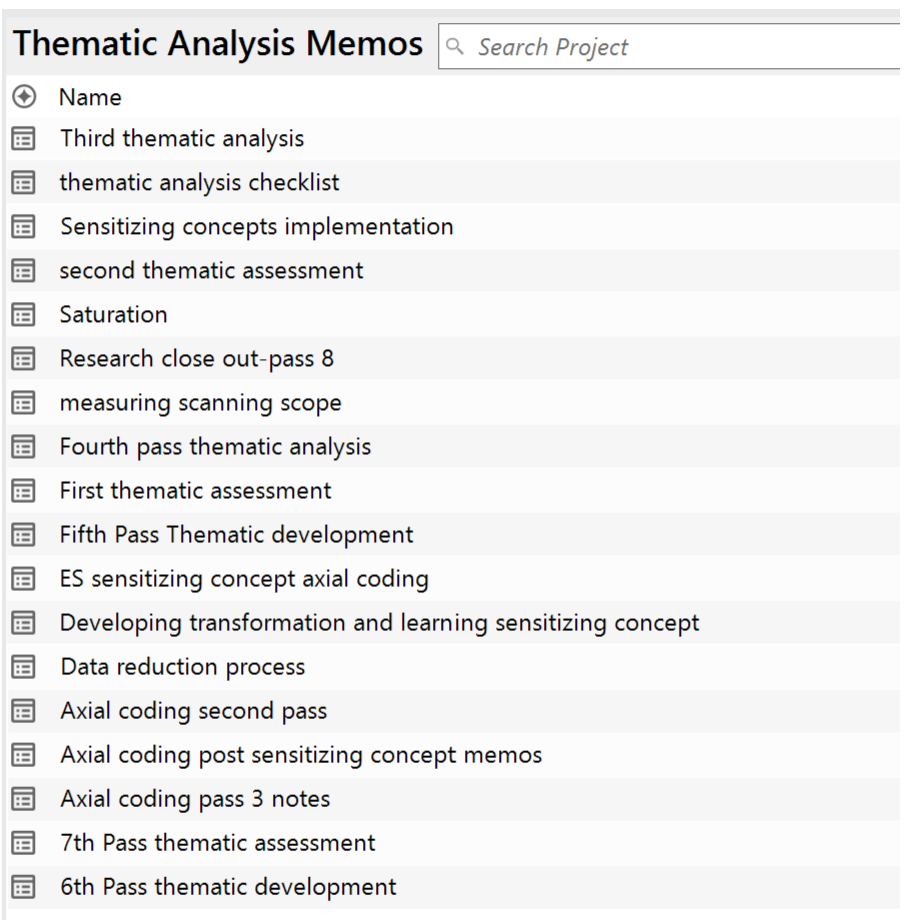


The full memo description for T16 is: *A function of ES is to support the sustaining of system identity when the system experiences environmental changes. Theme function: sustaining system identity. Outcome: system survival Two categories drive this theme. Both categories have functions involving action to sustain a system's identity with the outcomes being system survival.*

These were examples of memoing at code and theme level. Their primary purpose was to track the abstraction of data between tiers of codes into categories and themes. Memoing was also done at the thematic level during Selective Coding to capture thoughts and ideas on where the data seemed to be going and the response to those insights. These memos were developed and kept in the NVivo Notes-Memo functions. Figure 55 shows a summary level example of the thematic memos that were kept in NVivo. Each of the 18 lines is a detailed memo on those lines topical heading.

Figure 55

Example of Memos Kept at the Thematic Development Level



See Appendix J for an example of an "as written" thematic analysis memo from the Figure 55 list-*Fifth Pass Thematic Development*.

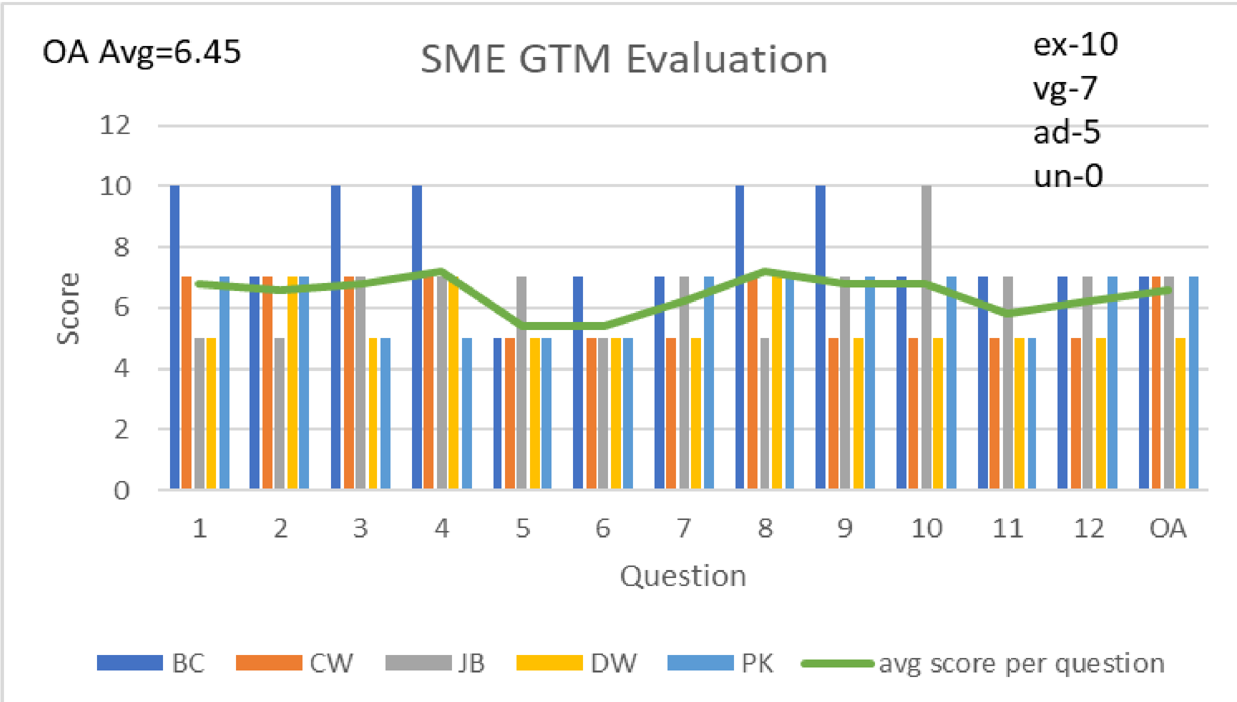
Memoing was effective at capturing points of analysis, method processes, evolving concepts, and coding and thematic development history.

5.2.6 PEER EXPERT OUTSIDE REVIEW OF GTM

The peer experts were asked to evaluate the reliability of the proposed GTM compared to the scholarly literature-based GTM descriptions and their own scholarly expertise. The purpose of this review was to provide a third-party assessment that the research findings could be replicated due to the transparency and accountability for changes in the research method design. The overall peer review reliability determination was evaluated at 6.45 on a 4-point Likert scale. This score is about half-way between adequate and very good. See Figure 56 for the summary of the evaluation assessment. There were 13 evaluation questions asked that were scored on the four-point Likert scale with question 13 being an overall assessment (OA). The application of the Likert scale in this research is for the purpose of facilitating data collection and is not intended to be used as a research instrument.

Figure 56

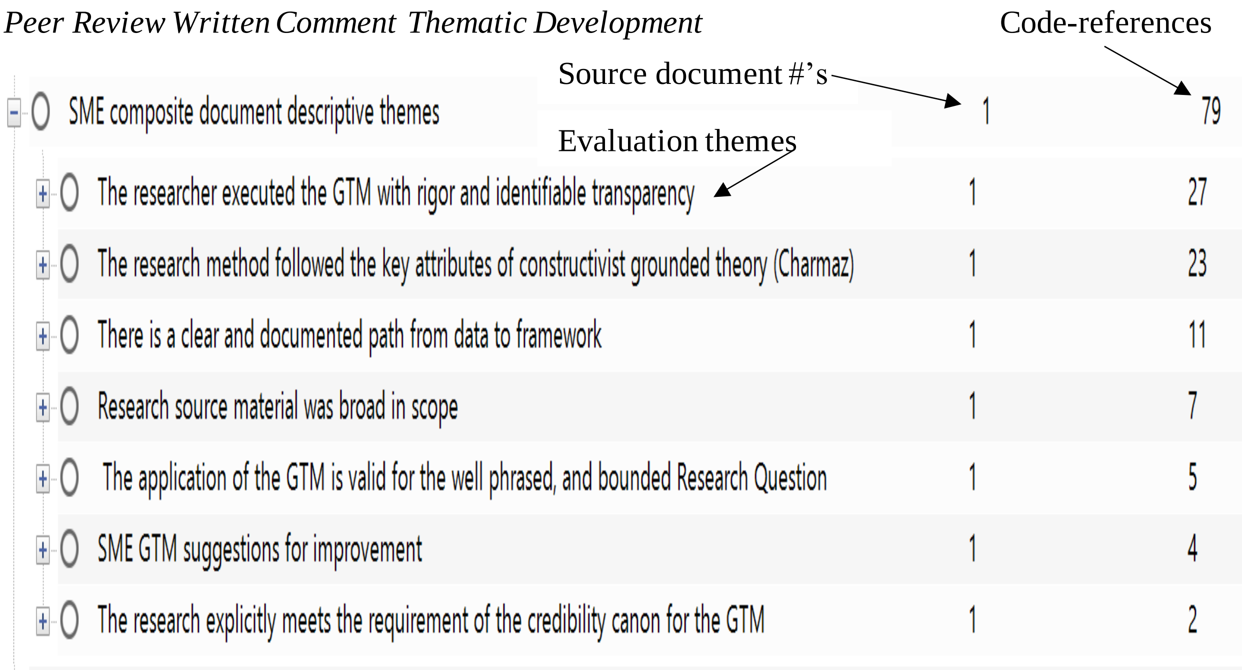
GTM Peer Review Summary



The written responses from the peer experts were line-by-line, In Vivo coded, to develop evaluation themes from the peer review results. NVivo software was used to support the evaluation. Figure 57 shows the evaluation thematic development from the peer review written descriptions.

Figure 57

Peer Review Written Comment Thematic Development



	Source document #'s	Code-references
SME composite document descriptive themes	1	79
The researcher executed the GTM with rigor and identifiable transparency	1	27
The research method followed the key attributes of constructivist grounded theory (Charmaz)	1	23
There is a clear and documented path from data to framework	1	11
Research source material was broad in scope	1	7
The application of the GTM is valid for the well phrased, and bounded Research Question	1	5
SME GTM suggestions for improvement	1	4
The research explicitly meets the requirement of the credibility canon for the GTM	1	2

The peer review written comments were combined into one source document. The number of code-references is the number of times that specific codes aligned under the stated evaluation themes. These were in vivo codes, a direct copy of evaluation written comments. The results demonstrated that the predominance (95%) of the written comments (75 of 79) as coded were associated with positive attributes of the proposed research method. There were four evaluation comments of suggestions for improvement with one being a duplicate. See Table 47 for the improvement comments and responses to the comments.

Table 47

Peer Review Improvement Comments

Peer review comment	**Researcher's response to the evaluation improvement comment**
Exercise continual awareness that GTM is vulnerable to appearing cursory or a way to produce a theory from an exercise.	• The peer review was implemented to assess the strength of the proposed GTM and the evaluation was positive for the strength of the proposed method. • Much detail was written in Chapter 4 about the constructivist GTM that was not available to the peer experts at time of evaluation. The research method design details showed how the data drove the findings (data DNA) and the rigor of the GTM applied.
The research should also include the strategy to address a typical criticism of GTM which is the question of 'theory' being a product of the application of the method.	• A specific section was written in Chapter 3 that assessed the outcome of this research project compared to the expectations from an applied classical GTM. The assessment showed that the results of a GTM study can be communicated as a set of concepts, related to each other in an interrelated whole, and expressed in the production of a substantive theory. This research produced a set of interrelated concepts (themes) in the production of an umbrella theme about an ES framework that is an interpretation; it depends on the researcher's view; and it is embedded in larger positions and has the strength of a theory. It can be evaluated in applied settings. GTM quality attributes were identified and implemented in the GTM application.
The Research Purpose does not indicate that the researcher will use GTM.	• Chapter 1 explains the purpose of this research is to develop a Systems Theory-based theoretical framework for Environmental Scanning in Complex Systems Governance using an inductive research design. The GTM is an inductive research design method.

Each of the peer review suggestions for improvement was incorporated into the research effort.

5.3 ENVIRONMENTAL SCANNING FRAMEWORK FACE VALIDATION

The face validation method using a case study produced the response to research question two: "*What results from the deployment of the Environmental Scanning framework in an applied setting*?" The applied setting used to evaluate the applicability of the ES framework was FEMA as a system, specifically FEMA systemic operations assessed after the fact of Hurricane Katrina. Hurricane Katrina was selected due to the abundance of credible literature that would go in-depth into how FEMA functioned as a system during the Katrina event. Three comprehensive government sources were used as the case study to document FEMA's behaviors as a system during Katrina. These three sources were: (1) Etats-Unis. Senate. Committee on homeland security and governmental affairs. (2006). Hurricane Katrina: A nation still unprepared. US Government Printing Office., 2006; (2) United States. Congress. House. Select Bipartisan Committee to Investigate the Preparation for, Response to Hurricane Katrina, Congress House Select Bipartisan Committee to Investigate the Preparation for, Response to Hurricane Katrina Staff, House (US), 2006; and (3) United States. Executive Office of the President, Etats-Unis. Assistant to the President for homeland security, counterterrorism, Superintendent of Documents, President of the United States Staff, United States. Assistant to the President for Homeland Sec, 2006. The Federal response to Hurricane Katrina: lessons learned.

The three constructs from the ES framework (regulation of variety, external changes, and system viability) were used as sensitizing concepts to identify FEMA actions to be documented from the three data sources. NVivo was used as the tool to collect the data. The sensitizing concepts were treated as a code. The data sources were then read, and appropriate FEMA system actions related to the three sensitizing concepts were documented as code-references in the NVivo database, primarily from in vivo coding. This action resulted in 318 code-references being identified in NVivo from reading and coding the three reports. Each of these code-references was a narrative description of an aspect of FEMA's actions from a systems perspective. An inductive reasoning process (abstraction) was applied to identify the code-references from the source literature. Twelve code-references (narratives) were selected from the NVivo code-reference database to be analyzed, four to be assessed under each of the ES framework constructs. The applicability of each of the ES framework themes that are associated with the three constructs were then assessed in terms of how they were functional in each of the code-reference (narrative) FEMA system actions. Table 48 summarizes the number of assessments each theme was subject to from the selected code-reference literature. The variation in the number of theme assessments is due to the variation in the presence of the themes in the three ES framework constructs.

Table 48

Theme Assessment Count

Theme	**Number of assessments**
T1	4
T2	8
T3	8
T4	4
T5	12
T6	12
T7	8
T8	4
T9	8
T10	8
T11	4
T12	4
T13	8

Theme	**Number of assessments**
T14	12
T15	8
T16	8
T17	8

Three forms of theme assessments were performed with a yes-no scoring method. The first assessment was the hypothetical relevance of the theme's function. Hypothetical for the purpose of this research is defined as: "what is guessed, involving or being based on a suggested idea for the purpose of reasoning" ("hypothetical", 2022). The selected FEMA-system narratives were evaluated as to the hypothetical relevance of the theme's function. Hypothetical relevance was determined positive (yes) if the theme's function could have functioned in the selected narrative from a systems governance perspective. The purpose of this assessment was to develop a hypothetical relevance face-value factor for each of the 17 themes, i.e., given the selected narrative, was it conceivable that the theme's function could have been part of the FEMA-system governance process. The purpose of the second theme assessment was to determine the theme's function practical value in the selected narrative. Given that the theme's function was relevant, did that theme's function act in the chosen FEMA narrative's governance system? This assessment was a "yes" if the theme function acted to support a positive outcome in the selected narrative; it was a "no" if the theme's function was not present in FEMA's governance system in the specified narrative or if it acted so weakly that the outcome appeared to not be influenced by the theme's function. The purpose of the third assessment was to assess the hypothetical practical value of the themes' function in the selected narrative. If the theme's functions were relevant, hypothetically could FEMA's system performance outcome have been improved if the theme's functions had acted in the FEMA-system's governance system. A "yes" meant the individual theme's function could have had a positive effect if it had acted with a strong influence on the system. A "no" meant that the theme's function would have no useful impact on the outcome. Appendix K provides the detailed assessment sheets and researcher's comments for the face validation of the ES framework's themes. Table 49 summarizes the theme function relevance results from the data in the Appendix K assessments. The summary data in Table 49 demonstrates that the 17 themes in the ES framework were relevant 50% to 100% of the time in the selected FEMA scenarios, with an average of 82% relevance in the 12 selected FEMA scenarios.

Table 49

Theme Hypothetical Relevancy Assessment Summary

Total theme assessments performed		**Theme hypothetical relevance count "yes"**	**Percent (%) hypothetically relevant in the FEMA scenarios**
T1	4	4	100
T2	12	11	92
T3	8	7	88
T4	4	3	75
T5	12	7	58
T6	12	11	92
T7	8	8	100
T8	4	3	75
T9	8	6	75
T10	8	4	50
T11	4	3	75
T12	4	3	75

Total theme assessments performed		**Theme hypothetical relevance count "yes"**	**Percent (%) hypothetically relevant in the FEMA scenarios**
T13	8	8	100
T14	12	12	100
T15	8	7	88
T16	8	6	75
T17	8	6	75

The theme function practical values from Appendix K data are summarized in Table 50. The values range from 13% to 50%, with the theme average at 27%. The theme function practical values low percentage stems from the fact that the reference data used in the FEMA case study were generally negative findings, with poor system performance being the primary outcome. In several narratives, the theme function was demonstrated, but so weakly revealed that the determined outcome of its practical value in those narratives was a "no," the theme function was not demonstrated. In each of the three ES framework constructs, one of the four selected narratives was a scenario where the outcome was positive. For the four positive outcome FEMA narratives, 29 of the 33 themes assessed were evaluated as "yes" (88%), the theme function was demonstrated.

Table 50

Theme Function Practical Value Assessment

Total theme assessment count		**Theme practical value count "yes"**	**% Theme valued practical "yes"**
T1	4	1	25
T2	12	4	33
T3	8	2	25
T4	4	1	25
T5	12	2	17
T6	12	3	25
T7	8	3	38
T8	4	1	25
T9	8	1	13
T10	8	2	25
T11	4	1	25
T12	4	1	25
T13	8	4	50
T14	12	3	25
T15	8	4	50
T16	8	2	25
T17	8	1	13

Table 51 summarizes the theme function hypothetical practical value results from the data in the Appendix K assessments. The summary data in Table 51 demonstrates that the 17 themes in the ES framework were hypothetically practical 50% to 100% of the time in the selected FEMA scenarios with an average of 85% hypothetically practical value in the 12 selected FEMA scenarios.

Table 51

Theme Hypothetical Practical Value Assessment

Total theme assessment count		Theme hypothetical practical value count "yes"	Percent (%) hypothetically practical value "yes"
T1	4	4	100
T2	12	11	92
T3	8	7	88
T4	4	3	75
T5	12	8	67
T6	12	11	92
T7	8	8	100
T8	4	3	75
T9	8	6	75
T10	8	4	50
T11	4	3	75
T12	4	3	75
T13	8	8	100
T14	12	12	100
T15	8	8	100
T16	8	6	75
T17	8	8	100

The ES framework face validation was accomplished from three perspectives: (1) hypothetical relevancy, (2) demonstrated practical value, and (3) hypothetical practical value. Each of the ES framework's 17 theme's function was assessed at least four times in a practical application FEMA-system scenario. The theme function hypothetical relevance was evaluated to be 82% on average. The practical value was 27% on average, and the hypothetical practical value was 85% on average. The assessment data indicates that all of the 17 ES framework themes were relevant to the selected FEMA-system scenarios. The 27% average practical value assessment is related to the narratives selected for evaluation that were all negative findings, that certain functions were not performed, impacting the results negatively. The four positive FEMA-system narratives selected for evaluation showed an 88% practical value. This is indicative of the practical value of an ES theme function in a positive outcome scenario.

There was an observed variance in the value between themes' functions in these FEMA-system scenarios. Table 52 summarizes the "yes" value for each theme from the selected FEMA-system scenarios that were evaluated. The T13 function of "looking at" was assessed as the highest value in these scenarios. The T10 function of "influencing the environment" was assessed as the lowest value in the selected scenarios. Given that the scenario materials used for theme assessment face validation were after-the-fact assessments of FEMA, "looking at" was a key function in the after-the-fact evaluations, and "influencing" most likely would have needed to be done before the event. This additionally indicates that the ES themes could have practical value in assessing and influencing real system events.

From the data above, the face validity test of the ES framework appears to measure what the test was intended to measure (framework practical value) and would suggest a strong face validity for the constructed 17 ES themes as they function in CSG in an applied setting.

Table 52

ES Framework Theme Overall Function Values

Theme	Theme Overall % Yes (value)	Theme function
T1	75	Developing

Theme	Theme Overall % Yes (value)	Theme function
T2	72	Acting on
T3	67	Actively obtaining
T4	58	Identifying
T5	47	Designing
T6	69	Regulating
T7	79	Disseminating
T8	58	Evolving
T9	54	Responding
T10	42	Influencing
T11	58	Implementing
T12	58	Maintaining
T13	83	Looking at
T14	75	Resolving
T15	79	Storing and retrieving
T16	58	Sustaining
T17	63	Understanding

5.4 RESEARCH RESULTS CHAPTER SUMMARY

Chapter 4 provided the details of the GTM applied in this research. Chapter 5 is the results of executing the research method.

The construction of the ES framework was explained in detail. The research source data was developed from 150 reference articles on ES functions from eight different fields of study that bring generalizability to the research results.

The coding method was explained. It consisted of a combination of In Vivo Coding, Process Coding, and Descriptive Coding to develop a simultaneous code. The simultaneous code consisted of two parts, an active function (gerund) and a function outcome description. Through the eight tiers of coding, the coding methods applied began with simple phrases or descriptions but then evolved at the higher code tiers into the simultaneous codes. The source database consisted of 4783 code-references that were then abstracted into 1306 codes.

The constructivist GTM was a Progressive Coding method that began with Open Coding and progressed through Axial and Selective Coding methods. The resultant abstraction was an ES framework consisting of 17 themes and an umbrella theme. The DNA (data tracing) of the umbrella theme is presented in Appendix I which shows how the umbrella theme is grounded in the source data. The umbrella theme is the output of the constructivist GTM-- *ES functions support complex system viability through regulation of internal and external variety induced by external changes.* The ES framework grounded in System Theory is the umbrella theme and its 17 sub-themes. Together they are the answer to research question one.

Sensitizing concepts were developed and applied to the GTM as a response to the large amount of data generated by Open Coding the 150 reference articles. The sensitizing concepts supported a focused abstraction of codes into higher tiers of codes but were absorbed into the abstraction process and did not determine the outcome of Selective Coding into themes.

Saturation was explained as being necessary from two perspectives: code saturation and theoretical saturation. Code saturation was obtained and justified by tracking the incidence of new open codes from the research literature and running a face validation looking for new codes from recent literature. Theoretical saturation was reached when there were no more possible ways to construct the 78 categories into themes.

The memoing method was discussed, and examples of the research memoing were provided in the text and in Appendix J.

The case study face validation of the ES framework was based upon the literature available about the performance of FEMA as a system during Hurricane Katrina. The 17 theme functions were shown at a face validation level to have both practical and hypothetical relevance in the FEMA-system narratives that were assessed.

Chapter 6 presents the conclusions and implications that resulted from this research effort. Interpretations of the implications of this study for theory, methodology, and practice are presented and explored. Future research opportunities are identified.

CHAPTER 6

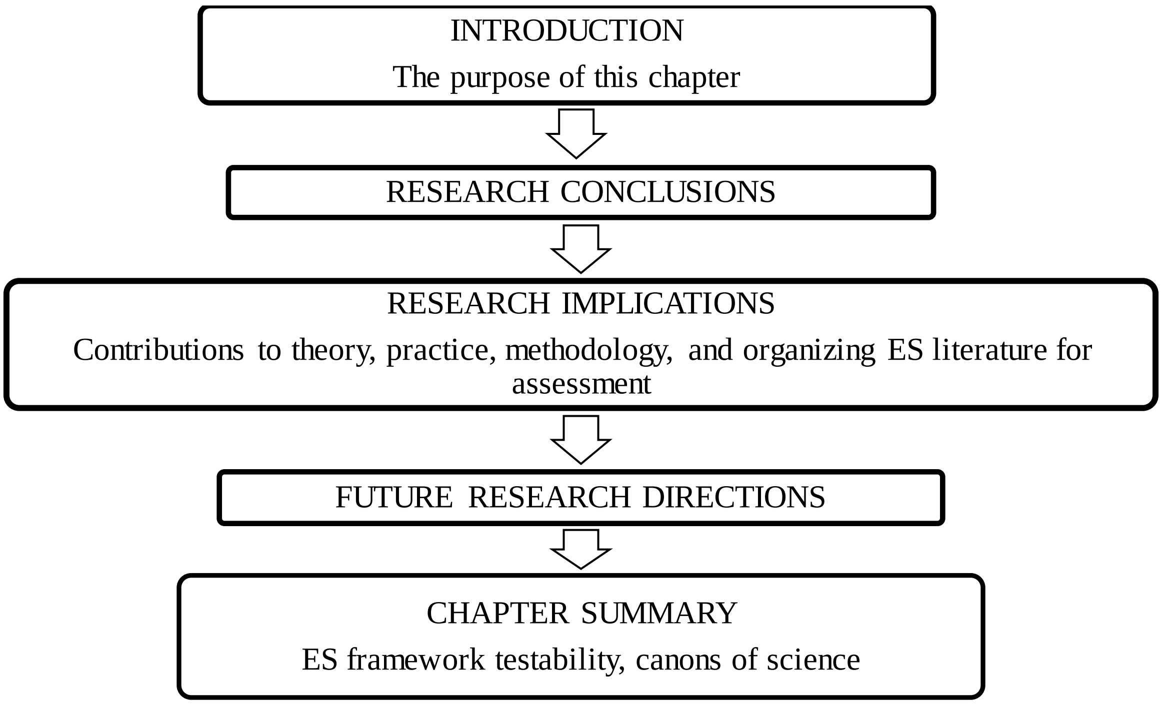
CONCLUSIONS

6.1 INTRODUCTION

Chapter 5 presented the results of the inductive research accomplished using a constructivist GTM to develop a framework for ES functions in CSG that is based in Systems Theory. Chapter 5 also presented the results of a face validation of the ES framework in an applied setting. In this chapter, the contributions of the research to the body of knowledge for ES functions in CSG are discussed. This is followed by a discussion of the implications for theory, methods, and practice resulting from this research. The challenges of applying the constructivist Grounded Theory research method and the use of a case study research approach are examined for implications of research practice in the Engineering Management and Systems Engineering field of study. Future research directions are discussed, and the chapter is summarized including ES framework testability and the canons of science. The chapter outline is illustrated in Figure 58.

Figure 58

Outline of Chapter 6



6.2 RESEARCH CONCLUSIONS

This research project began with the exploration of the influence of Systems Theory on ES functions in CSG. Accordingly, the purpose of this research was established to develop a Systems Theory-based framework for the functions of ES in CSG using an inductive research approach. Given that Systems Theory is a general approach to understanding system behavior (Adams et al., 2014), the ES framework research was grounded in Systems Theory. The newly evolving CSG research effort merged aspects of complex systems and governance to develop a systems-based framework "to guide systemic inquiry, analysis, and (re)design" for complex systems (Keating & Katina, 2015, p. 5). CSG was developed to "provide practitioners with increased effectiveness in understanding, decision, action, and meaningful interpretations for the complex system problem domain" (Keating & Katina, 2015, p. 5). To focus this research effort on the intersection of Systems Theory and system governance functions, the research question *What Systems Theory-based framework can be constructed for Environmental Scanning in Complex System Governance?* was identified.

The scholarly reference articles discussed in the Chapter 2 literature review exposed a limited body of work addressing ES from multiple perspectives. In summary, the review of the existing ES literature indicated that writings on the topic of ES from a Systems Theory-based perspective are relatively few, are diverse from their respective field of study, are not grounded in any one perspective, and have multiple definitions and applications of how ES functions. Additionally, the application of the ES function in CSG is developmental (Keating et al., 2019). There are only several articles written that involve the ES function in governance of complex systems. The review of ES related literature indicated that constructing a Systems Theory-based study of ES as it functions in CSG would be contributional to the CSG emerging field of study. The literature review also identified a variety of theories on how ES functions. These theories included: three distinct models-irregular model, periodic model, and emerging theory model (Fahey & King, 1977); four phases-primitive, ad hoc, reactive, and proactive (Jain, 1984); frameworks that integrate perspectives from both organization theory and information needs and uses (Choo, 1999); and system development, learning and transformation, and environmental scanning (Keating & Bradley, 2015). As discussed in Chapter 2, despite this body of work, the literature review yielded little material that explicitly addressed ES functions grounded in Systems Theory in CSG, thereby exposing a gap in the literature. This research was undertaken to address that gap.

Chapter 4 provided the detailed method undertaken to develop the ES framework that was presented in Chapter 5 results. A scholarly research library was built from the literature review and other credible sources of ES literature. A research method involving a delimited set of ES descriptive terms as primary search terms was conducted to gain insight regarding the influence of Systems Theory-based ES functions in the research library. Applying a constructivist GTM, the data identified from the initial search were initially coded followed by Axial Coding where analysis and abstraction of the initial open codes occurred to gain further insight into possible ES themes. Selective Coding followed to construct themes. The Selective Coding revealed the impact/influence ES functions have on the CSG metasystemic functions and became the basis for the resultant ES framework. The constructed ES framework is the response to the research question - *What Systems Theory-based framework can be constructed for Environmental Scanning in Complex Systems Governance?* Therefore, the purpose of the research was accomplished.

The ES framework illustrates the Systems Theory-based ES functions that act in the CSG metasystemic functions, which leads to regulating system variety that is induced from external changes, which in turn leads to system viability. The ES framework provides a theoretical structure for insight into the influence of Systems Theory regarding ES functions as they act in the CSG metasystemic functions or act to enable conditions necessary for the execution of ES in the CSG metasystemic functions. Appendix L documents insights into the functions of the ES framework's themes constructed as part of this research. The framework's 17 themes are constructed from a constructivist GTM exploration of scholarly ES literature that was broadly focused on ES functions in several different fields of study, but was steered by Systems Theory, Managerial Cybernetics, and CSG, each of which is Systems Theory-based.

Implications for the ES functions in the framework's 17 themes are that the functions act together to regulate externally induced variety for the purpose of sustaining system viability. These implications suggest that decisions and actions undertaken when executing ES functions in CSG should be considerate of Systems Theory. In a summary statement of the Systems Theory-based ES functions framework, system viability is sustained by ES functions in CSG that support regulation of variety induced by external disturbances. It should be noted that the resultant ES framework is a first-generation outcome that is expected to evolve as further research is accomplished. This does not diminish the present ES framework, but rather acknowledges that CSG, and correspondingly ES functions in CSG, will continue to evolve with new knowledge, research, and applications.

Additional purposes for this research were: (1) a contribution to knowledge, worthy of publication or dissemination, in whole or in part, which would advance the evolving field of CSG, (2) the application of the constructivist Grounded Theory research method in an engineering field of study to help expand the understanding of this method in a non-traditional field, (3) the contributions of ES framework functions to practice**,** and (4) the review of the ES literature to provide new insights into categorizing and organizing ES related literature.

6.3 RESEARCH IMPLICATIONS

Research implications suggest how the research findings could be important for method, practice, theory, or subsequent research. Research implications are the conclusions that can be drawn from the results of the research and that can explain how the research findings may be important for method, practice, theory or subsequent research. Research implications express how the research can affect future prospects in the subject area of the research. The research implications are supported by correlations of results from the research keeping in view the shortcomings of the study (Shridhar, 2017).

6.3.1 CONTRIBUTIONS TO THEORY (BODY OF KNOWLEDGE)

This research effort has contributed to the body of knowledge in the fields of Managerial Cybernetics and CSG. It also has expanded the view of the functions of ES in other fields of study. In Managerial Cybernetics, the ES function is considered to reside in the Viable Systems Model's (VSM) System Four, whose function is to observe the anticipated future environment and the system of interest's own states of adaptiveness and to act to bring them into harmony. System four's functions are generally considered to create knowledge in order to make internal system modifications to be ready for coming changes. System four would feed that knowledge into a system's research and development, strategic planning, borrowing policies, and marketing functions (Leonard, 2009). An effective System Four is stated to engage in a continuous dialogue between its model of the anticipated future and its model of itself.

In the CSG nine metasystemic functions, ES is identified as M4 prime whose primary function is providing the design and execution for scanning of the system's environment (Keating & Bradley, 2015). M4 prime's focus is on patterns, trends, threats, events, and opportunities for the system. In CSG however, ES is paired with two other metasystemic functions, M4-system development and M4 star-learning and transformation. These three metasystemic functions are both interdependent and uniquely functioning in the CSG reference model with the other six metasystem functions. The three together offer a more detailed and specified expression of the functions of ES in the VSM.

The ES framework constructed in this research considered both the VSM and CSG reference model functions of ES. This was accomplished by using both CSG and Managerial

Cybernetics literature in the research library. Additionally, the CSG ES functions were used as sensitizing concepts to support data abstraction. This research effort however, resulted in expanded ES functions that provide new insights into how ES functions within CSG and tied the ES functions to regulating system variety with the intent of sustaining system viability. Both the newly identified ES functions in CSG and the tying of the functions together for the purpose of regulating variety to achieve system viability are new constructs in the CSG reference model for the ES functions. See Table 53 for a comparison of ES functions in VSM, CSG reference model and the ES framework from this research. Common functions are aligned horizontally in the table.

Table 53

Comparison of ES Functions

VSM system four functions	**CSG reference model M4, M4´, and M4* functions**	**Research based ES framework in CSG**
Observe the anticipated future environment	Focus on patterns, trends, threats, events, and opportunities for the system	T13 Looking at
Know a system's state of adaptiveness	System Development	T1 Developing
Bring harmony with internal and external environments	Design and execution for scanning the system's environment	T5 Designing T6 Regulating internal-external variety
Create knowledge for system functions to use	System learning and transformation	T4 Identifying T2 Acting on
Engage in continuous dialogue		T7 Disseminating
		T3 Actively obtaining
		T17 Understanding systemic role of ES functions
		T10 Influencing system environment

VSM system four functions	CSG reference model M4, M4´, and M4* functions	Research based ES framework in CSG
		T8 Evolving governance functions
		T9 Responding rationally to turbulence
		T11 Implementing ES system models
		T12 Maintaining governance system model
		T14 Resolving perceived environmental trends
		T15 Storing and retrieving data
		T16 Sustaining system identity

The data in Table 53 demonstrates that the ES framework developed in this research effort presents several more functions for ES acting in CSG than the existing VSM and CSG reference model functions. At the same time, the data in Table 53 confirms the ES functions as stated in the existing VSM and CSG reference model. This affirmation was done by a rigorous application of the constructivist GTM that constructed the ES functions from 150 scholarly references, an affirmation that has not been done until this research effort. This research additionally identified 10 ES themes that were additional to the existing functions of ES in the VSM and in CSG.

The research results demonstrate that system viability is associated with a strong and multi-purposeful ES function in CSG. Eight of the 17 outcomes of the ES framework themes' functions are related to system viability. These eight themes have a high presence in the source literature with 127 articles being referenced that create over a third of the total code-references. The strong source literature backing of these functions and function outcomes strongly suggests that a robust (multi-functional) ES function in CSG is important for system viability. The ES functions from these eight themes (developing, acting on, identifying, designing, regulating, evolving, responding, and sustaining) are proactive actions. This would also suggest that more emphasis by the system on these ES functions would have a positive impact on system viability.

The FEMA-Katrina face validation case study outcome is consistent with the construct of a robust ES function contributing to system viability. The eight themes were evaluated with an average hypothetical relevance to the FEMA-Katrina scenarios of 80%. This indicates that these functions tend to be highly relevant in practical situations. These same eight themes have an average 82% hypothetical practical value score, indicating that their functions have a high practical value in applied settings. These eight ES functions, having such high hypothetical relevance and practical values, strongly suggest that where they can act in a system's ES functions, the system's viability could be strongly and positively influenced.

The research results indicate that the ES framework's functions play a substantial role in the operation of the CSG metasystemic functions. In the CSG reference model, the ES function M4´'s focus is generally on patterns, trends, threats, events, and opportunities for the system that come from examining the system's environment. The CSG reference model closely tied the M4´'s functions together with system development and system learning and transformation. These three CSG metasystemic functions act together to scan and capture information from the environment, to assess that information for strategic implications and system level impacts, and to model the future and strategic evolution of the system. They are part of the interrelated metasystemic functions that provide for the continuing viability of a system. Keating & Bradley (2015) stated "all of the CSG Reference model functions are necessary to ensure the continuing viability of the System in Focus. Deficient performance of one metasystem function will propagate through the entire metasystem" (p. 8). Accordingly, a robust performance of the CSG

ES functions could enhance system performance. This research identified a set of themes that both support and expand upon ES functionality in CSG. The expansion of ES functions in CSG adds robustness to how CSG functions overall in support of system viability. These 10 expanded functions are summarized in Table 54.

Table 54

Additional ES Framework Functions to the CSG Reference Model

Theme	Theme Function
T3	Actively obtaining
T8	Evolving governance functions
T9	Responding rationally to turbulence
T10	Influencing system environment
T11	Implementing ES system models
T12	Maintaining governance system model
T14	Resolving perceived environmental trends
T15	Storing and retrieving data
T16	Sustaining system identity
T17	Understanding systemic role of ES functions

Out of these 10 themes, the functionality of T17 fundamentally supports the actions of the other 16 themes. In the FEMA-Katrina case study, T17 had a hypothetical practical value of 100% and hypothetical relevancy value of 75%. In each of the FEMA-Katrina event positive outcome cases, T17 was evaluated as a positive contribution function, and in the negative event evaluations T17 was evaluated as only 17% applicable to the events' ES functions. This data indicated the strong contribution the functions of T17 make to the value of the ES process in CSG. T17 is identified as "Understanding the systemic role of scanning functions to enhance effective system governance." T17's categories suggest that developing a Systems Theory-based framework for proactively and holistically analyzing and engaging the environment (ES) is contributory to system viability.

With 17 ES themes in the ES framework, and 78 categories supporting those 17 themes, where each category has its own function, there exists a good likelihood of significant interconnectivity amongst the themes. The ES framework face validation showed that not all themes have the same value in any given event, that they act situationally, but taken together they have an impact on system viability. Table 55 was developed to assess the interconnectivity of the functions in the ES framework. The functions at the theme category level were assessed in terms of influence-which ones of the other themes were influenced by the action of the theme under study. Similarly, each theme being studied was assessed as to what functions from the other themes informed it. Table 55 demonstrates that there is significant interconnectivity amongst the ES framework themes.

Table 55

ES Framework Themes Interconnectivity

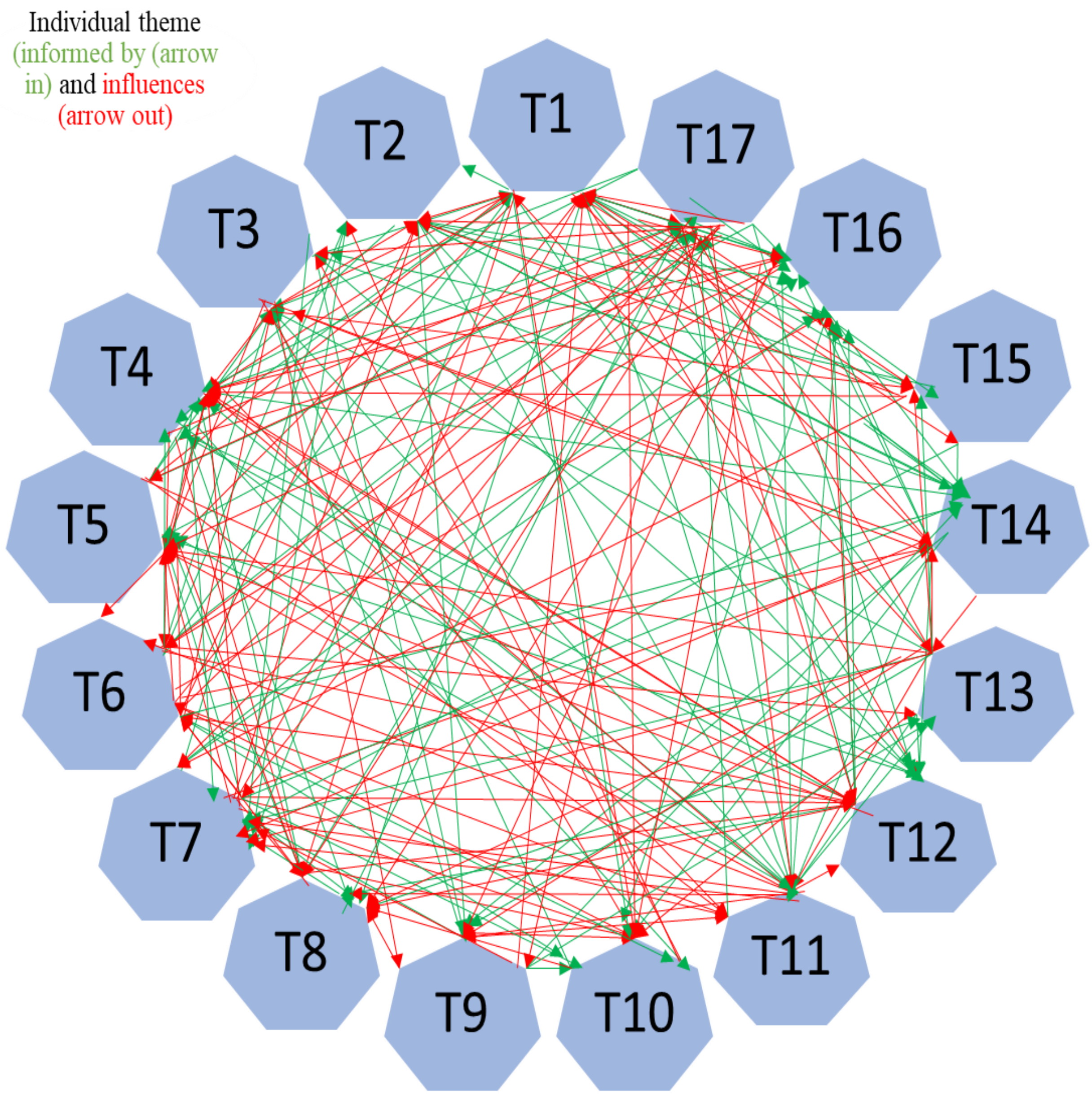
ES Theme	**Theme function**	**Theme is informed by:** (total number)	**Theme influences :** (total number)
T1	Developing	T3, T6, T13, T17, T14, T11, and T15 (7)	T2, T4, T8, T5, T6, T10, T17, T14, T12, and T15 (10)
T2	Acting on	T1, T6, T7, T14, and T15 (5)	T4, T8, T5, T9, T10, T14, and T15 (7)
T3	Actively obtaining	T5, T6, T13, T9, T10, T17, T14, and T11 (8)	T1, T2, T4, T5, T6, T9, T10, T14, and T15 (9)
T4	Identifying	T1, T2, T8, T5, T6, T17, T11, T12, and T16 (9)	T8, T5, T6, T17, T12, T11, and T16 (7)
T5	Designing	T7, T8, T4, T17, T11, and T12 (6)	T11, T12, T4, T6, and T8 (5)

ES Theme	Theme function	Theme is informed by: (total number)	Theme influences : (total number)
T6	Regulating	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13, T14, and T17 (15)	T1, T2, T3, T4, T8, T5, T13, T9, T10, T17, T14, T12, T11, and T16 (14)
T7	Disseminating	T1, T2, T3, T4, T9, T15, and T13 (7)	T10, T11, T12, T14, T1, T2, T4, T5, T6 and T8 (10)
T8	Evolving	T1, T4, T12, and T17 (4)	T6, T10, and T12 (3)
T9	Responding	T2, T3, T13, and T14 (4)	T1, T7, T8, T10, and T11 (5)
T10	Influencing	T14, T16, T1, T4, T6, T7, and T9 (7)	T2, T3, and T8 (3)
T11	Implementing	T13, T14, T17, T1, T2, T3, and T4 (7)	T12, T4, T5, T6, T8, T7, and T9 (7)
T12	Maintaining	T13, T14, T17, T1, T2, T3, and T4 (7)	T16, T4, T5, T6, and T8 (5)
T13	Looking at	T11, T8, and T9 (3)	T10, T14, T15, T1, T5, and T7 (6)
T14	Resolving	T15, T16, T1, T2, T4, T6, T7, and T9 (8)	T3, T7, and T13 (3)
T15	Storing and retrieving	T13, T14, T3, and T7 (4)	T1, T2, T4, and T7 (4)
T16	Sustaining	T11, T12, T14, T17, T1, T2, and T7 (7)	T10, T4, T5, T6, T8, and T9 (6)
T17	Understanding	T16, T4, T8, T5, T6, T11, and T12 (7)	T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T13, T14, T15, and T16 (16)

Figure 59 is a graphical representation of the ES themes' functional interconnectivity. The arrows are used to show the influences and informing connections amongst the 17 themes.

Figure 59

ES Framework Theme Interconnections



Not all the themes are connected equally. The most important ES function by connecting points is T17 (understanding systemic role of ES), which influences all the other functions. In contrast, T14 (resolving perceptions), T10 (influencing the environment), and T8 (evolving the governance system functions) are shown to have the least influencing roles. This demonstrates the significant role that T17 (a Systems Theory-based, holistic view of the role of ES in CSG) plays in the framework ES functions. The ES function in CSG functions at its best when it is designed from Systems Theory-based principles. The T14 (resolving), T10 (influencing), and T8 (evolving) themes are those that tend to operate as individual activities and therefore have a minimal influence on the other themes.

T6 (regulating) is informed the most by the other themes, and T13 (looking at) is informed the least. Ashby's law of variety regulation states that to obtain the desired output, the system must adapt its regulation process to its environment (Raadt, 1987). For T6 (regulating) to perform its regulating function, it must have a wide-ranging input from its system's environment and internal functions. Thus, it is logical that it is highly interconnected in its metasystemic role in CSG. T13 (looking at) is a passive function, observing what is there and feeding what it "sees" back into the system. It essentially operates on its own to do the "looking" and is therefore minimally interconnected.

Figure 59 presents an image of an ES system. For the purpose of this research, a system is an abstraction, conceived of as a totality, as a whole unit, whose survival is secured by the simultaneous and harmonized functioning of its parts (Agazzi, 1978). The interconnected ES framework functions shown in Table 55 are an abstraction of their source data. When considered in totality, as a whole unit of interconnected functioning parts, the ES framework is a system that functions inside a system's CSG metasystemic functions. Analysts tend to focus on the parts of a system rather than seeing the whole. They tend to fail to see systems as a dynamic process (Senge, 1990). Thus, a better appreciation of Systems Theory (seeing the whole) should lead to more appropriate actions, better decision making, and support for system viability. System operators tend to take actions that produce improvements in a relatively brief time span. However, when viewed in systems terms, short-term intended improvements can often involve long-term issues (Senge, 1990). An appreciation of Systems Theory should lead system operators to recognize the use of and the problems with short-term reinforcing feedback. A systems view should enhance the understanding of the place of system stabilization feedback (requisite variety), leading to system regulation gradually. From a Systems Theory perspective, treating the ES framework's 17 themes as an integrated system presents similar opportunities to those recognized from a Systems Theory perspective. As discussed above, when the system's ES functions are functioning well together, system viability appears to be enhanced. The strength of the function of T17 (understanding the systemic role of scanning functions to enhance effective system governance) in a practical application is reinforcing of the impact of a systems approach to the ES framework function. Therefore, treating the ES framework's functions as an integrated system should be supportive of system viability.

The T10 function (system-environment influencing to prevent future problems) as evaluated in the FEMA-Katrina case study events had the lowest practical application percentage at 17%. T10 had the second fewest connection points in the ES framework themes' interconnection network at seven. T17 is abstracted from 24 and 63 files and code-references respectively, which by number, is seventh from lowest in both files and code-references amongst the 17 themes. Additionally, T17 was constructed from only three categories. This would make it seem to be less relevant than other themes due to its relatively low presence in the literature and its low practical value in real-life scenarios. T17 however, is the top theme in a newness evaluation that considers the age of the literature that supports it. T17 in this sense, is the newest theme. The newness factor explains its low presence in the literature field. However, T17's theoretical practical value was 100%. Its theoretical practical value is an indication of its relative importance in the functioning of the ES framework themes. The point to be made is that theme presence in the research literature field is not necessarily a good indicator of the value of the theme's function in the ES system. The value of a theme should be determined by its influence in the functioning of the ES framework in an applied setting. At the same time, the value of a theme's function in the ES system is dependent on the nature of the applied setting itself. Therefore, theme function value is a variable. It is situationally dependent and its presence in the literature field is an evolutionary process, changing over time as more is written about ES functions. It was not within the scope of this research study to evaluate the relative value of how the ES themes function in the ES system or to establish the precise research-based interrelationships. However, it is clearly indicated that this logic of interrelationship is strongly suggested.

In the context of CSG, Keating & Katina (2016) define a second order function as correction by system redesign, taking initiative to advance the governance of the metasystem. Gharajedaghi (2007) posits that:

> To change, systems need to go through an active process of unlearning. Unlearning is an iterative and collective process of the second-order learning. A participative and iterative design process with the aim of replacing the distorted shared images is the most effective learning tool to produce a second-order learning and a desired change in the behavioral pattern of a social system. (p. 473)

Ison et al. (2007) posit that a future environment cannot be objectively determined by present trends; that it must be chosen. They suggest that a shift towards the design of learning systems offers a better possibility to engage the situations of complexity, uncertainty and conflict exist in the future (Ison et al., 2007). Ison et al. (2007) state that the “design of a learning system might seemingly involve combining elements and processes in some interconnected way” (p. 1344).

The CSG reference model (Keating & Bradley, 2015) metasystem M4*’s function is defined as system learning and transformation. System learning, as discussed above, stems from second order functions.

The second order functions in the ES framework are listed in Table 56.

Table 56

Second Order ES Framework Functions

Theme	**Theme function**
T1	Developing system knowledge
T4	Identifying system transformation objectives
T5	Designing ES processes
T6	Regulating internal-external variety
T8	Evolving governance system functions
T11	Implementing ES system models
T12	Maintaining a model of the governance metasystem
T16	Sustaining system identity

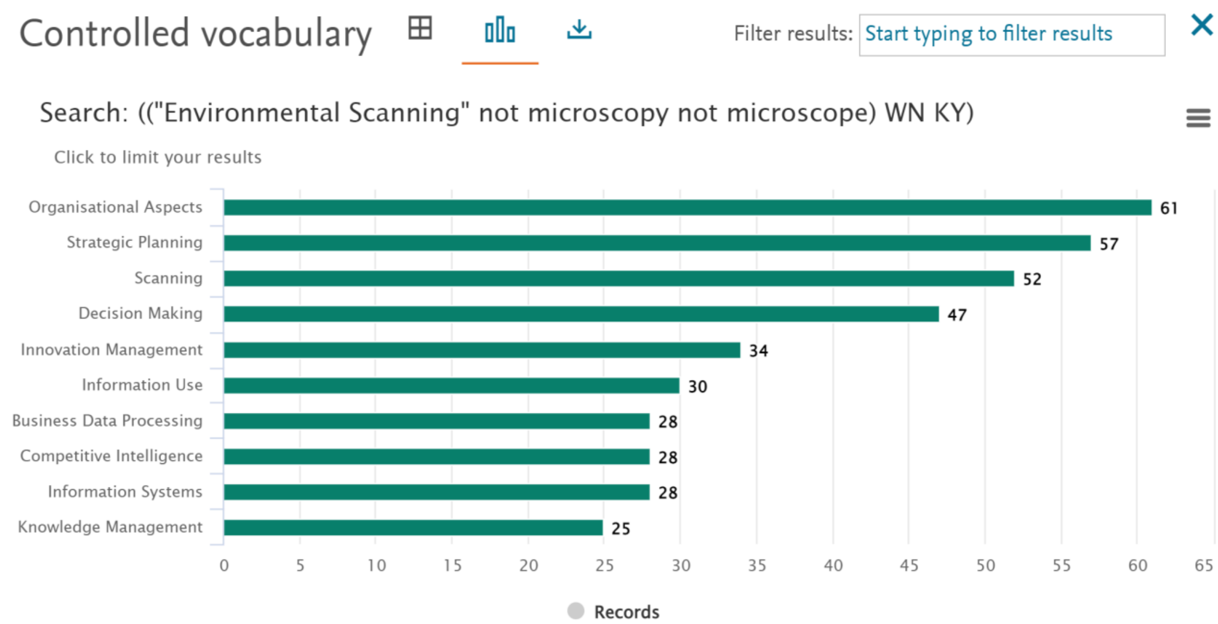
These eight ES framework functions were evaluated at an average 25% practical effectiveness in the FEMA-Katrina case study. At the same time, the same eight functions were evaluated on average as 75% hypothetically practical. The low practical effectiveness score in the evaluated FEMA-Katrina events indicates that these functions were poorly or not at all exercised. But from a hypothetical perspective of possible value, the eight functions were highly valued as potentially having positive influence on the event outcomes. These two evaluations support Gharajedaghi's (2007) and Keating & Katina's (2016) position that for a system to change, redesign must happen. Thus, a system's second-order ES functions are supportive of system viability by taking initiatives to advance a system's governance function. They create a learning system as defined by Ison et al. (2007) that is a part of a system's ES function. This insight enhances the CSG reference model's description of the M4* function.

6.3.1.1 ORGANIZING ES LITERATURE FOR ASSESSMENT

In Chapter 2, a review of the existing ES literature indicated that writings on this topic were relatively few, were diverse from their respective field of study viewpoints, were not grounded in any one perspective, and had multiple definitions and applications of how ES functions. The categorization of such a broad source of literature into a research supporting perspective was problematic. This is where the built-in capability of Engineering Village was helpful. Engineering Village indexers choose terms from the controlled vocabulary list to describe the articles they are indexing. Controlled vocabulary is used to standardize the way the articles are indexed. The controlled vocabulary function was immensely helpful in providing a basic categorization capability to the search that returned 400+ articles. Figure 60 shows the ES search results from Engineering Village categorized by top 10 controlled vocabulary. The full search returned 160 controlled vocabulary items.

Figure 60

Engineering Village Search Results Organized by Controlled Vocabulary



To use the controlled vocabulary function to categorize the search results required additional actions to reduce the 160 category fields to a research useable number. To do this reduction of categories, a filter was developed to apply to the search results. The filter eliminated all categories not closely related to the research topic. Next, categories were combined based upon their similarity. Finally, the top eight categories were selected as they contained about 90% of all the search result records. The filtering resulted in a source item categorization that provided for organization of the source material into these eight categories discussed in Chapter 4. Having a categorization of the source data provided a means to categorize and organize any additional literature that was brought into the research library other than through Engineering Village. The categorization had the additional purpose of demonstrating breadth of source data in support of enhancing the generalizability of the research results. It also demonstrated the predominant fields of study where the ES literature was being studied. Table 57 lists these eight categories.

Table 57

Source Data Categorization

Category	**Category**
CSG and Governance	Management
ES and Systems Theory	Managerial Cybernetics
Futurism	Marketing
Information Science	Planning

Each of the categories has a forward-looking context to it, which is a fundamental aspect of ES. This could also indicate categories where ES has not been prevalent in the literature e.g., artificial intelligence, product development, and supply chain management from the search results in Figure 60. These low-production areas could be either developmental with more works on ES being developed, or simply a lack of awareness of the value of ES in their fields of study.

The ES framework's 17 themes are not equally supported in the literature. Figure 61 shows the literature support for each theme. The files column is the number of difference source articles that were cited in constructing the theme. The themes are listed in the order of their presence in the research literature.

Figure 61

ES Framework Research Literature Theme Support

Name	Files
ES theory-- ES functions support complex system viability through regulation of internal and external v	150
T1-Developing system knowledge from environmental information (data) to support system future	127
T2-Acting on information from the external environment to create system value	96
T3-Actively obtaining (proactive scanning) system external environmental information to support sy	94
T4-Identifying system transformation objectives in support of future system viability	94
T8-Evolving the governance system functions in support of future system viability	81
T5-Designing environmental scanning system processes for internal and external functions to supp	67
T6-Regulating internal-external variety generated from external turbulence to support system viabil	62
T7-Disseminating essential environmental information (internal-external) throughout the system to	59
T13-Looking at (viewing) the external environment to identify information of interest (passive scann	58
T9-ES system responding rationally to environmental turbulence to support system viability	26
T10-System-environment Influencing to prevent future problems	24
T17-Understanding the systemic role of scanning functions to enhance effective system governance	21
T14-Resolving perceived-actual environmental trends to support effective decision making	18
T12-Maintaining a model of the governance meta-system to support reducing system dilemmas	13
T11-Implementing ES system models for effective scanning in changing environment	12
T15-Storing and retrieving scanned information for future use	9
T16-Sustaining system identity through environmental changes for system survival	7

However, if the 17 themes are listed in order of their value in the FEMA-Katrina case study face validation, their order of priority is different from the presence in the literature ranking. See Table 58. The Table 58 data indicate that based upon the face validation results, theme presence in the literature is not closely associated with theme value in a practical setting. Four of the top six themes by value are at the bottom of the presence in the literature ranking. This could be indicative of the need for more development in ES functions to support improved system viability.

Table 58

Theme Literature Presence vs Value and vs New Themes

Theme	Theme % Yes hypothetical practical value from FV case study	Theme	Theme presence in literature-ranking by % of total articles cited	New themes not in CSG reference model
T1	100	**T1**	85	**T3** Actively obtaining
T7	100	**T2**	64	**T17** Understanding systemic role of ES functions
T13	100	**T3**	63	**T10** Influencing system environment
T14	100	**T4**	63	**T8** Evolving governance functions
T15	100	**T5**	54	**T9** Responding rationally to turbulence
T17	100	**T6**	45	**T11** Implementing ES system models
T2	92	**T7**	41	**T12** Maintaining governance system model
T6	92	**T8**	39	**T14** Resolving perceived environmental trends
T3	88	**T9**	39	**T15** Storing and retrieving data
T4	75	**T10**	17	**T16** Sustaining system identity
T8	75	**T11**	16	
T9	75	**T12**	14	
T11	75	**T13**	12	
T12	75	**T14**	9	
T16	75	**T15**	8	
T5	67	**T16**	6	
T10	50	**T17**	5	

Analysis of Table 58 shows that six of the ten new themes are ranked in the botton seven of 17 themes that are ranked by their presence in the literature. The ten themes that are new to CSG are relatively less present in the literature. This could indicate that they are newer, evolving functions, compared with the other themes that have a greater literature presence. Of the ten new themes to CSG, only three are in the top 10 of 17 themes by overall value. Given that three-fourths of the FEMA-Katrina event evaluations were about poor performance, the low top 10 value ranking possibly indicates that the new themes were too new to be effective or were just not present.

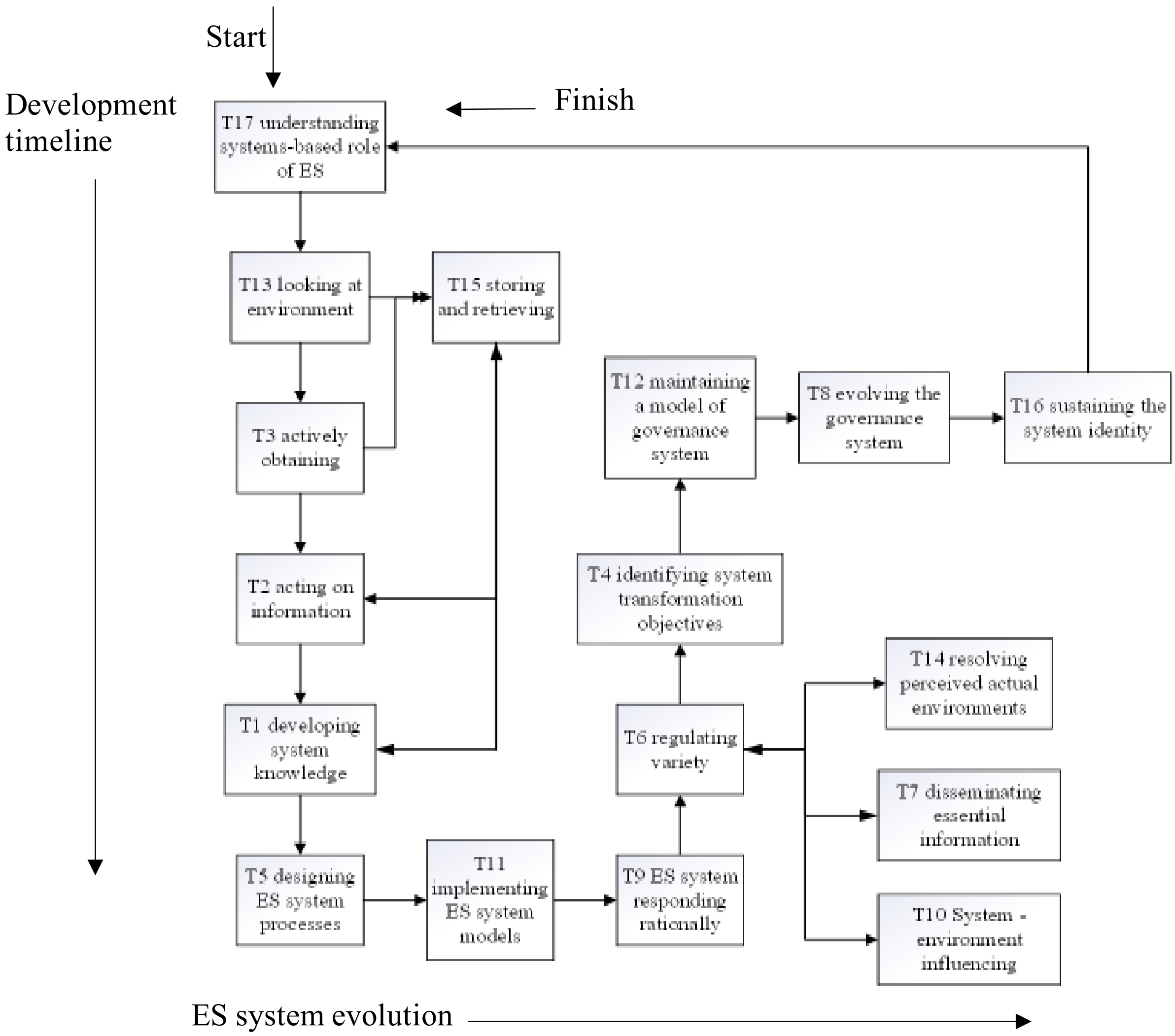
Both of these analyses imply that the functions of ES in CSG are still evolving in the literature and in practice. This indicates that there is ongoing opportunity for ES functions in CSG to continue to expand in value and contribute more to a system's viability.

6.3.2 CONTRIBUTIONS TO PRACTICE

The functions of the ES framework have been adressed above as to how they relate to presence in the literature, practical and hypothetical value, existing VSM and CSG functions, and as an ES system. Another view to the ES functions in the framework is about how they function on a timeline basis in a system. In a hypothetical situation, where a system has little existing ES system function, how would the functions in the ES themes operate to evolve the ES system performace? Figure 62 is a time-based example of how the ES themes might function as a system from a defined starting point and evolve from an ES system's perspective. The starting point is with T17, understanding the need for a Systems Theory-based functioning of ES. This starting point is based upon a system that is new, naive, or has just decided a change of some kind is needed to remain or become viable or to improve their viability position. The development timeline moves through the set of ES functions that engage with the environment to begin learning about what is challenging the system's viability. This is essentially first order learning. After designing a Systems Theory-based ES process at T5 (Designing), the ES system evolves into second order learning functions that lead to regulating external variety and continually adjusting to external changes in a purposeful manner. This second order functioning sustains system identity, T16, that in turn feeds the need for understanding the systems-based role of the ES function (T17). Since this is a closed-loop process, repetition through the process cycle of ES functions supports changing the system's operations sufficiently to sustain or improve system viability. If the T6 regulating variety function is managing the system's external variety (requisite variety position), the ES process should support the CSG metasystemic functions to remain viable, to be in a condition of stability.

Figure 62

ES System Development Evolution Diagram



Applying the ES framework functions from a systemic, evolutionary process perspective is a new suggested contribution to supporting evolution of the CSG metasystemic functions, that in practice could conceptually enhance the ability of a system to remain viable in a changing environment.

For the purposes of this research, a good governance system is defined as one where the nine CSG metasystemic functions operate effectively individually and together such that the system of interest is stable in a changing external environment. This definition is derived from the FEMA-Katrina face validation case study results from the application of the ES framework. The case study indicated that for the negative outcome events, there was one or more major weaknesses in one or more of the 17 themes' functions. Conversely, the case study indicated that for the four positive outcome events, all 17 of the ES framework functions were performing well.

When the ES framework functions operate positively together, the ES system appears to have the ability to absorb more variety than when there is one or more poorly performing functions. This provides a kind of buffer to increasing external changes. However, with catastrophic events like Katrina, the magnitude of the external variety readily overloads the capability of the ES system and system viability suffers. The internal confusion caused by a massive amount of unabsorbed internal variety (left over from external change impacts) can have a very damaging effect on system viability. The example of this from the case study material is the realignment of FEMA under DHS after 9-11, but before Katrina. This realignment greatly reduced FEMA's internal flexibility to respond to environmental input that resulted in a large amount of internal unabsorbed variety, leading to inferior performance in many functional support areas.

Having a well-performing ES system across all 17 functions appears to be a hedge against negative impact from external variety changes. Some amount of external variety can be absorbed before excess variety begins to dominate the system's functions and viability. The increased understanding of the systemic approach to ES functions where the whole matters more than the sum of the parts is the beginning of improving system viability.

From the case study literature, it appears that FEMA's operational system was designed to be able to respond to a large, well-categorized event. When Hurricane Katrina became recognized as an unexpected catastrophic event, FEMA was overwhelmed. FEMA's governance system was apparently designed to a known, planned condition. When this condition was exceeded, FEMA's ability to regulate the greater than expected variety was overwhelmed. Its governance function was not able to govern the external input in a manner to sustain its expected production. Internal unabsorbed variety had overtaken FEMA's ES system. FEMA's ES system design was not flexible enough to adapt to the input it was receiving. In cybernetic terms, the FEMA system failed to function to meet the condition of requisite variety. This resulted from poor ES system design, lack of awareness of the concept of variety regulation (Ashby's law), or a lack of a systemic view on FEMA planning and response operations.

Designing a system's ES system to have flexible capacity and rapid responsiveness to many environmental changes (high variety) and to design into the system's ES function sensors for weak leading indicators of future changes, would be more supportive of system viability than a fixed ES system design.

Evaluating the functioning of the ES framework's themes in the FEMA-Katrina case study provided a set of observations about the role of each theme's functions in a practical setting. The evaluation data in Appendix K show that the ES framework's functions are applied differently in different situations, make different contributions in different situations, and work together differently in different situations. These differences imply that if the ES framework's functions can be evaluated, they would create a unique identifier for any given situation. Table

59 was developed from Appendix K data. The table shows the evaluation of the positive contribution of the function of each ES framework theme in the FEMA-Katrina scenarios selected for evaluation.

Table 59

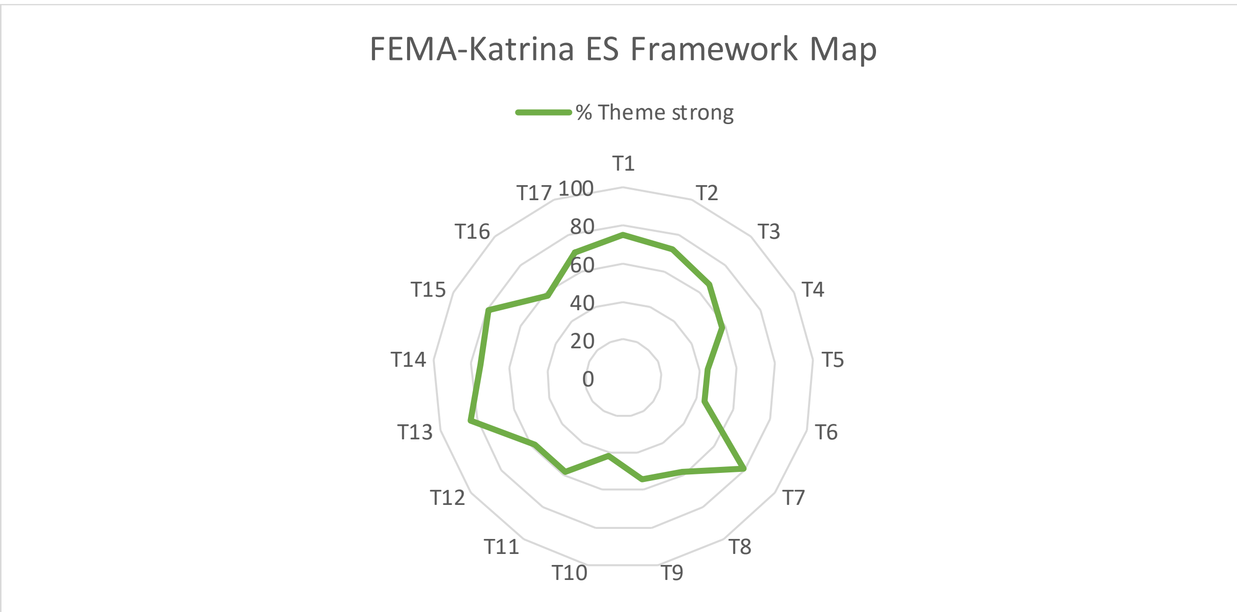
Theme Positive Contribution Evaluation

Theme	Theme Overall % Yes (value)	Theme function
T1	75	Developing
T2	72	Acting on
T3	67	Actively obtaining
T4	58	Identifying
T5	47	Designing
T6	69	Regulating
T7	79	Disseminating
T8	58	Evolving
T9	54	Responding
T10	42	Influencing
T11	58	Implementing
T12	58	Maintaining
T13	83	Looking at
T14	75	Resolving
T15	79	Storing and retrieving
T16	58	Sustaining
T17	63	Understanding

Figure 63 represents the data in Table 59. It shows the relative positive value of the function in each of the ES framework's themes from the FEMA-Katrina scenarios. Given that the ES framework themes function differently in different scenarios, it is posited that that their measurement is a unique reflection of the ES system at the time of the evaluation. If their measurement is unique and situational, then evaluating the ES framework themes over time should reflect the changes in the ES system's performance. This evaluation over time could provide practitioners with a means to identify overall system performance against a baseline, other organizations, different situations, or against improvement objectives.

Figure 63

ES Framework Theme Positive Values in FEMA-Katrina Case Study



The ability to evaluate and measure the ES framework's functions' performance has the potential to be a valuable tool for supporting CSG's ES metasystemic functions. This could then help to improve a system's viability by improving its ES system functioning.

Another aspect of the data presented in Figure 63 is the identification of the poor performing ES Framework functions. Identification of a poor performing positive function could be indicative of an ES system pathology, defined as "deviations or shortcomings in subsystem functions that are considered to be instrumental for system viability" (Katina, 2015a, p. 149). A pathology is used to describe system issues that might affect the performance of the system of interest. Identifying systemic issues affecting system performance is foundational to system development efforts and ultimately to system success (viability) (Katina, 2015b). Pathology in the ES framework functions would be indicative of excess system variety that is causing ES system (and thus system level) turmoil. Therefore, ES system pathologies could be a measure of effectiveness of the ES regulation of the variety function. It could be possible to identify a set of potential ES framework pathologies based on the developed Systems Theory-based construct for ES in CSG. Also, there is the concept of prioritization of pathologies such that efficient investment of limited system resources could be pursued. A set of measures might be developed to indicate the relative importance of identified pathologies and aid in ES framework pathology prioritization.

Measuring and prioritizing ES framework function pathologies could be supportive of improving the ES framework functions that lead to improved system viability.

Extreme events, often referred to as "black swans," are some of the most difficult events to predict. Black swan events are highly consequential but unlikely events that are easily explainable – but only in retrospect (Taleb, 2007). Taleb (2007) posits that as the world gets more connected, black swans are becoming more consequential with greater impact on businesses (systems). This situation would suggest that the ES framework functionality should be assessed in terms of low probability but high impact external events in support of system viability. Taleb (2007) suggests eight approaches to dealing with black swan events. Table 60 presents eight black swan activities derived from Taleb (2007), describes them, and then associates the activities to the functions in the ES 17 themes. From Table 60 there is one or more ES framework themes that could perform the suggested black swan detection activity.

Table 60

Black Swan Event Detection Activities and Related ES Framework Themes

Black swan event detection activities	**Description of black Swan activities**	**ES Framework relevant Themes**
Keep your eyes open for black swans.	Search the external environment and realize when it is not normal, one that was not predicted based upon past activities.	T2, T3, T13
Do not stick to traditional beliefs.	Revise your beliefs when confronted with contrary evidence. Be willing to admit wrong, failure, and unfamiliarity.	T5, T14
Know where you can take large risks and where you cannot because of the possible negative outcomes.	You cannot help taking risks. But sometimes risk taking is dangerous, and sometimes it is benign.	T2, T4, T8, T11
Know that in many cases, you cannot know. Think outside your usual, customary conceptual categories.	Eliminate alternatives that you know are wrong rather than always trying to find out what is right.	T2, T4, T9, T14
As a forecasting period lengthens, prediction errors grow exponentially. Suspend judgment where evidence is lacking and be wary of overly precise predictions.	Multiple, parallel option thinking can be more useful. Often you should focus only on consequences, not overly precise probabilities.	T3, T4, T5, T11
Expose yourself to "positive black swans" Look for asymmetries.	Hedge against negative ones. Move toward actions where favorable consequences are greater than unfavorable ones. Maximize the possibilities of serendipity by operating in between extremes.	T1, T2, T3, T4, T5, T8, T10, T11, T14,
Look for the non-obvious. Seek out disconfirming evidence for pet theories.	Look for events that would refute current theories, rather than just stacking up confirming evidence for the	T1, T2, T3, T14

Black swan event detection activities	Description of black Swan activities	ES Framework relevant Themes
	sake of consistency and turning out any evidence that contradicts current notions.	
Avoid dogmatism. "De-narrate" the past and remember that historic practices projected forward can mislead.	Think and assess with independent thought. Avoid group think and specialist advice.	T1, T2, T3, T4, T5, T9, T14

The listing of ES framework themes that can support black swan event detection is reinforcing the value of the ES framework in practical settings. This is especially important given the severity of negative black swan events. However, there are six ES framework themes that at initial assessment may not play a contributing role or possibly may play a negative role in black swan event management: T6, T7, T12, T15, T16, and T17. As an example, T16, sustaining system identity through environmental changes, may be counter to the avoid dogmatism activity discussed in Table 60. T3, actively obtaining environmental information to support system planning, is considered supportive of identifying black swan events because of its active function. However, if T3 overlooks weak signals and the planning resulting from this active scanning input takes the system in a direction that is unprepared for a black swan event, catastrophe could be the result of excess internal variety. All the ES functions require further assessment of their actions in the ES system to determine if they require modification in support of a smoothly operating ES system considering both black swan and predictable events.

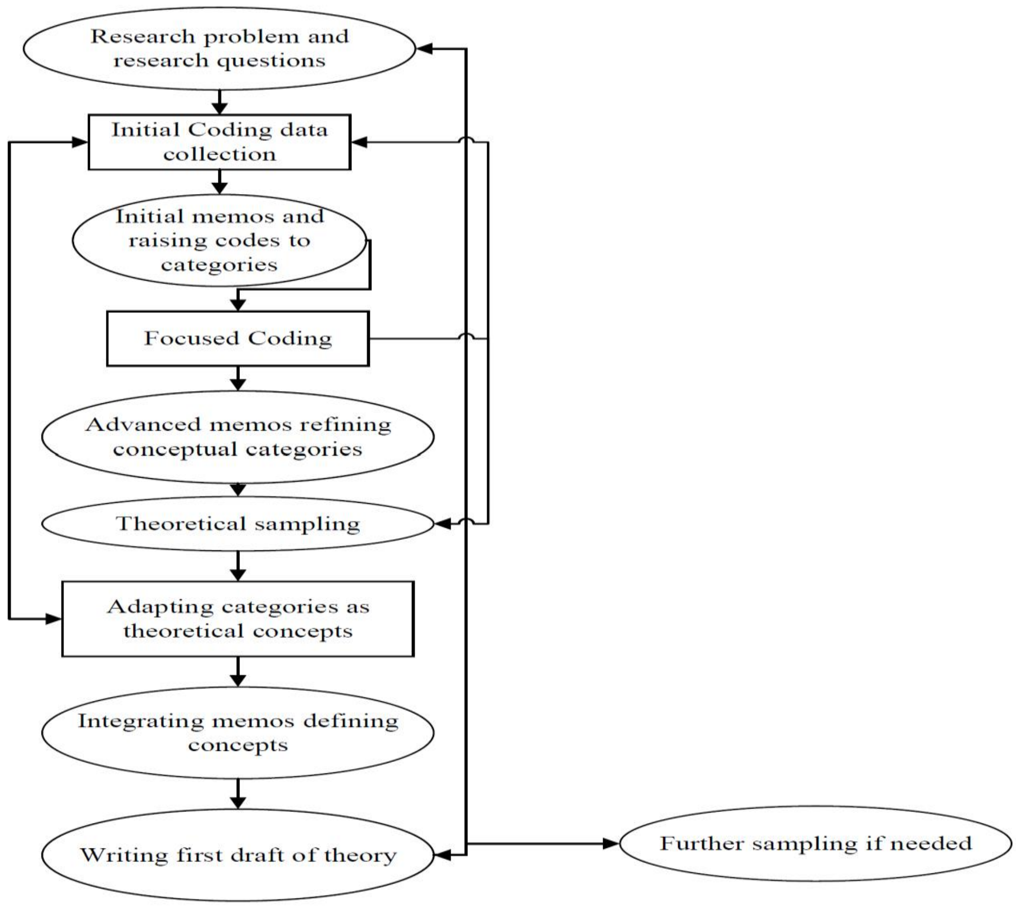
The value of case study methodology is measured by the degree to which the events studied can be generalized to other situations (Schell, 1992). The case study in this research effort was able to build knowledge from observation of a phenomenon (FEMA-Katrina system) that occcured within a contextually rich environment. As a research strategy, it was holistic in nature, looked at a strategically selected case, made use of analytical comparisons of sub-cases, and was aimed at description and explanation of complex and intertwined attributes, structures, and processes in the ES framework. Though it was part of a face validation, several implications for practice emerged from the study. These practical implications are readily applicable to other cases, e.g., the positive value map technique. The case study methodology contributed value to this research effort.

6.3.3 CONTRIBUTIONS TO METHOD

The classical GTM identified in Figure 64, that is derived from the works of Charmaz (2006), was not sufficient without modification to deal with the extant source literature used in this research project.

Figure 64

Classical Grounded Theory Method Charmaz (2006)



The classical GTM, developed in the sociology field, and primarily in the nursing profession, typically involves interviewing subjects to develop transcripts that are then coded to construct a grounded theory (Hussein et al., 2014). The number of subjects to be interviewed is determined by the researcher as a function of the needs of the research project. Hennink et al. (2017) suggested that 16 to 24 interviews were generally sufficient to meet both meaning and data saturation. With the thousands of data elements to analyze with the GTM, the classical method approach appeared to be insufficient. While language, textual data, time, and interview settings are important when analyzing GTM data, the clasical GTM focus is on behavior and its meanings that take place during social interaction (Hussein et al., 2014). Preparing for and interviewing live subjects is a significant focusing event for data generation, it has a predetermined purpose. Feedback on the process is close to immediate and adjustments can be made by the interviewer as the process unfolds. The classical GTM requires rich data, defined as when researchers seek thick descriptions by writing extensive field notes of observations, gathering thorough narratives from interviews, and collecting written personal accounts (Hussein et al., 2014). Charmaz (2006) posits that rich data provides the researcher with concrete and dense information to construct a thorough analysis of the data and aids the researcher going beneath the surface of the participants' social and subjective life. Thus, beginning the GTM with rich data that is focused on the research objective is a significant aid in working through the GTM.

This research was in contrast to the classical GTM data source and collection with selecting and coding 150 different source items, primarily journal articles, where the researcher cannot directly interview and reach back to the subject (author) for the purpose of adjusting the research method to achieve the research objectives. In addition, the data at this point is not rich as defined by Charmaz (2006). None of the primary GTM reference documents specifically addressed using an extant literature library as the data source to constuct an ES theoretical framework. The GTM references did discuss the use of extant literature as a credible research source, but it was always in the context of supporting other data sources, primarily interviews. This difference in data sources was the prime reason the classical GTM needed to be modified to achieve the research goals.

The starting point with 150 items in the research library was driven by the ES literature presence in eight fields of study. To take a broad generalizability approach, each of these fields needed to be considered in the library. The initial coding process itself took over six months due to the volume of literature to be coded. Table 61 presents the differences in this reseach application of the GTM from what could be considered typical or classical in the Social Sciences.

Table 61

Research GTM Differences from Classical

GTM Activity	**Classical GTM**	**Modified GTM for this Research**
Research library	Set of interviews, rich data, focused on research objectives, literature developed later as part of theoretical	150 reference items from eight fields of study that generated 4783 code-references
Coding method	Preferred method is In Vivo Coding from interview texts	In Vivo Coding, Process Coding, Simultaneous Coding, Descriptive Coding due to need to manage large volume of codes and codes with same meaning but different names
Initial Coding	Normal	1306 open codes necessitated collective codes, several layers of collective codes to collect like codes before codes could be analyzed
Axial Coding	Normal	Normal but 78 categories resulted
Sensitizing Concepts	Several, typically identified in advance to focus coding	20 concepts identified, was implemented after Initial Coding was done to help reduce data from 1306 open codes to manageable collection of codes for analysis, subsequently, Axial Coding was started over to construct categories from the codes in their new

GTM Activity	Classical GTM	Modified GTM for this Research
		alignment, but not for the purpose of substantiating the sensitizing concepts
Selective Coding	One theory	17 themes to abstract to theory level
Saturation	Comes relatively quick with focused research and focused coding	Large volume of data took several months to reach data saturation, then validate it with additional journal articles
Framework development	Not a typical product	Necessary to relate the 17 themes together and to construct an umbrella theme-a single outcome
Memoing	Very lengthy and detailed to each code	Used the code descriptions as memos originally, began detailed memoing with selective coding due to volume of data
Time input	Research dependent	Extensive due to nature of data source and number of open codes developed
Support resources	Standard with MS Office products	Selected NVivo and Mendeley® as support tools to manage and search volumes of data, to readily keep memos tied to data, to have technical support with the tools to perform search, analyze, and report functions for volumes of data
References manager	Typical academic	Due to volume of source files, needed robust reference manager, chose Mendeley

In summary, the modifications made in this research effort to accomodate the large volume of source data included: use of a robust reference manger, applying several layers of collective codes, applying sensitizing concepts after Initial Coding, and learning about and applying a robust coding support tool.

These modifications did not change the overall approach to the GTM applied in this research. They supported getting through the overall approach compared to the more typical

GTM application in the Social Sciences. The outcome of the GTM in this research is grounded in the original source data. The data's DNA, its historical lineage for transparency of the grounding, was captured in NVivo.

These GTM modifications contributed to the development of the research methodology by providing practical modifications that support the GTM being applied to a robust extant literature research library or a robust source data of any kind where 100s of codes would be anticipated. Using extant literature as a research source is perhaps more applicable in the Engineering Sciences than the focused interviews typical of the Social Sciences. Given that generalizability leads to the external validity canon in traditional (positivist) research, selecting broad ranging research sources for supporting a more robust extensibility of the research for the GTM is indicated in the Engineering Sciences. The constructivist view of generalizability is transferability which in the Social Sciences generally happens as context applicability. This research effort demonstrated a modified approach that fit in between these two canonical requirements.

Sensitizing concepts have been discussed in several sections, Chapters 4 and 5 and above in Chapter 6. Their application in the GTM is not an unusual application. The timing of their application in classical GTM and in this research effort was different. In the classical method they are typically identified in advance and guide the development of open codes in the Initial Coding process. This researcher did not intend to use sensitizing concepts initially as the research question was very broad - "what is." To identify and apply sensitizing concepts before coding began could possibly have guided the research outcome more than the raw literature itself, specifically, when looking for a "what is…" outcome. When applying the sensitizing concepts after Initial Coding had begun, there is a concern that the concepts could have too strong a role in constructing categories and themes. To counter that concern, Axial Coding was started over with the codes and collective codes aligned under the sensitizing concepts. This resulted in categories being constructed that were grounded in the source literature and not driven by a sensitizing concept directly. This method modification, to re-start Axial Coding, was essential to keep the selected sensitizing concepts from driving the outcomes. The sensitizing concepts were supportive in organizing a large volume of data but were not determinant in the category and theme construction. The source data determined category and theme construction. This method modification may be helpful to future research efforts where sensitizing concepts are applied after Initial Coding.

6.4 FUTURE RESEARCH DIRECTIONS

During the Progressive Coding process, a number of codes were identified from the research literature that did not support the objectives of this research effort. They did not align with the developing categories and themes. They were collected and analyzed like any of the codes but kept in a separate collective code category. After Selective Coding was completed, the codes were reviewed again to determine if any codes fit or would lead to new categories. Abstracting these codes into categories provided the following category list: scanning behaviors, issues identified with the ES process, and scanning sources. Table 62 lists these categories and expands upon the collective codes within each catgegory. Each of these categories would be a potential topic for future research in ES. The categories have roots in the ES literature base and are closely related to ES functions exisiting and/or newly identified, but were not contributory to ES functioning in CSG as defined in this research effort.

Table 62

Code Categories Not Related to Research Objectives

Code categories not supporting this research effort	Code category collective code elements
Scanning behaviors-how scanning is to be performed	• Scanning methods • Scanning scope • Scanning frequency • Conditions for scanning • Scanning skills identification
Issues identified with the ES process-research literature based critique of the ES processes	ES processes failing in complex environments • ES functions limited in complexity • Difficulty focusing on weak signals • Failure to construct models of one-time events • Only seeing expected problems • Failing under illusion of control • Failure to anticipate changes • Failure of strategies to reorient creates misalignment with the external environment • Not detecting asymmetric effects • Scanning input lost from internal complexity • Passive and reactive scanning not effective in today's complexity Scanning concerns • Scanner bias • Scanning benefits overstated • Undirected scanning • Manager environmental impressions • Preference for reaction on intuition versus facts • Lack of ES structure causes knowledge losses • ES functions not evolving with complexity • Short term focus • Information overload • Big ideas, small outcomes • Ineffective interpretation, not timely and poor data sources • Reacting to thinly-linked information that is predictive ES functions difficult to implement • ES concept too difficult to implement • ES functions not known about • Lack of systematic behavior • Lack of systems thinking • Lack of management support

Code categories not supporting this research effort	Code category collective code elements
	• Inadequate infrastructure ES system not in sync with business strategy • Cost-benefit not supportive • ES analysis not related to system strategic issues • ES information not linked to planning process • Executives not relating ES to strategy Not realizing importance of ES functions • ES functions not accepted • Illusion of control predisposes formal ES functions • Cultural values prohibit information sharing • System internal processes repress scanning functions • ES trapped in metaphorical flat land • ES not regarded as important ES restricted to external world only • Easier to focus on internal world • Substituting internal focus for external • Internal scanning not recognized • Defensive reaction to internal variety Failure by systems to act on ES generated information • Lack of focus on decision maker's needs Oversimplifying the external environment • Overlooking phenomenon that do not respond to empirical thinking • ES not related to environment-comeptitive strategy
Scanning sources-environmental data sources as input to the scanning process	• Scanning source data quality • Missing important data sources • Stable environments creating low-rich data sources • Poor scanning material content

During the entire Progressive Coding process, NVivo was utilized to capture concepts that were outside the scope of this research effort but were considered by this researcher potentially interesting for future development. Some of these items are derived from the research literature while others are derived from this researcher's analysis of the research literature. Twenty-five items were captured. Table 63 lists these 25 items for consideration for future research directions.

Table 63

Items to Consider for Future Research Directions

Item	Item discussion for future research direction
1	The ideas developed here could be studied in a single organization in further depth than was possible here and could provide further explanation for ES use in different contexts. This would facilitate deeper investigation of the organizational variables and contingencies that affect scanning in systems.
2	Exploring the causal relationship between organizational strategy and environmental scanning activity.
3	Examine whether information flexibility is an important scanning function, and whether it is correlated with CEO and organizational characteristics.
4	Explore how media complement one another, and whether cues picked up in one medium are used to corroborate information from another medium. Future research may also determine whether designers of information systems should try to provide only certain types of data through formal channels, and the extent to which the best view of the environment comes from which multiple information sources.
5	Explore the debate about whether formal versus informal sources of information provide better input to the organizational planning process through ES.
6	Explore the detailed linkage between environment, scanning, and actual strategic adjustments. Unraveling the sequence of activities associated with interpretation of the environment and strategic responses may provide a stronger normative basis for saying how systems can be designed to increase performance considering strategic and environmental contingencies.
7	Explore how management of an organization should continue to take environmental forces (both internal and external) seriously as a way of controlling and minimizing the impact of environment instability.
8	What frameworks can be constructed to direct the development of ES or the analysis of ES effectiveness?
9	What are the pathological diagnostics for ES as part of complex system governance?
10	What tools or techniques can be developed to assess ES effectiveness?
11	What methods would be employed to select the proper ES tools?
12	How can ES systems be deployed in different settings?
13	What are the best practices for ES that lead to greater system viability?
14	What is a holistic approach to expanding research in ES? This approach would treat the ES function as part of a governance function, thus would consider how it functions with other important governance functional elements.

Item	Item discussion for future research direction
15	Consider a study designed to measure how environmental uncertainty and the capabilities of the system under study can influence the scanning process.
16	Consider ES strategies that might include development of functions for ES to identify issues such as cyber-attacks, cyber-threats, cyber-incidents, data breaches, and phishing. These mechanisms might prove instrumental in enhancing the viability of a system of interest.
17	Future research should evaluate and refine the framework posited in this study. In addition, future studies might add weak signal detection to the model as a measure of scanning effectiveness. Future research on ES should acknowledge the complexity and wide range of organizational decision makers involved in the process.
18	A potentially useful extension to the investigation on hierarchical level and functional specialization would be to relate ES and the use of acquired information to the managerial decision-making roles suggested by organization theory.
19	Weak artificial intelligence could be an interesting research track for researchers in the field to provide an ES tool to enhance system variety regulation.
20	How can ES be better positioned organizationally in addition to external variety regulation? What does internally generated variety look like? What ES functions would be needed to regulate internal variety? How would internal and externally generated variety affect each other? Which type of variety has a greater impact on system viability?
21	The immune system is a standby subsystem with no direct input from the top level of the entire system. It has the ability to observe and intervene on lower levels and has a bottom-up channel to initiate corrections on the top level, if necessary. It can react quickly and pass by all middle hierarchical levels to overcome delays or even resistance. A suggested study on ES functions that can find similar structures contributing to the viability of organizations would be of future interest.
22	Where does excess external variety go in system M3 or 4? Consider developing this aspect of variety regulation in the next generation of the CSG reference model.
23	Refining the application of extant literature as the prime data source for the GTM as an alternative to in-person interviews.
24	Developing a written approach to the application of sensitizing concepts to guide the focus of large volumes of codes without unduly guiding the development of categories.
25	Developing a research-canon guide for the application of the GTM in Engineering Sciences to streamline future research efforts.

6.4.1 FORMULATION FOR FUTURE TESTING THE ES FRAMEWORK

A testable hypothesis is a hypothesis that can be supported or not supported because of testing, data collection, or experience (Johansson, 2016). Kirchner (1989) discusses the minimum testability of a hypothesis as: hypothesis must be clear, its terms unambiguous, it must be intelligible in terms of observable phenomenon, and it must generate both confirmatory and falsifying prediction phenomena. Table 64 applies Kirchner's (1989) criteria to the ES Framework for the purpose of evaluating its future testability. The ES framework's umbrella theme states the hypothesis that could be subject to testing as: *ES functions support complex system viability through regulation of internal and external variety induced by external changes.*

Table 64

Results of Applying Kirchner's (1989) Testable Criteria to the ES Framework

Criteria for testability	**Result of applying criteria to ES framework**	**Discussion of criteria application**
Hypothesis must be clear	The ES framework was constructed from a broad and in-depth literature base. Its derivation can be traced back to the source literature from which it was constructed.	The construct of system viability and variety regulation has been developed and exploited in the field of CSG. This research both substantiated existing and extended further the CSG metasystemic ES functions. This clarity supports formulation of hypotheses for testing that can be clearly delineated.
Its terms must be unambiguous	Each of the key words in the ES framework have been defined in the research project and are found in the extant literature supporting the research effort.	There are no new terms that need further clarification.
It must be intelligible in terms of observable phenomena	The ES framework was applied in a practical setting where its practical and hypothetical applicability could be face validated.	The face validation case study using FEMA-Katrina indicated that the ES framework themes could be testable in the future
It must generate confirmatory	The face validation demonstrated that the ES framework themes were both	The face validation data indicated that when the ES

Criteria for testability	Result of applying criteria to ES framework	Discussion of criteria application
prediction phenomena	present and useful in a practical setting and that the themes could be evaluated. The theme evaluation demonstrated their positive contribution to system viability when they were present and applied.	framework themes were present and utilized the FEMA-system events generally had positive outcomes. When external variety was effectively regulated, the FEMA-system performed well. This indicates potential future ES framework testability.
It must generate falsifying prediction phenomena	The face validation demonstrated that the ES framework themes were both present and useful in a practical setting and that the themes could be evaluated. The theme evaluation demonstrated that when they were not applied the system outcomes were generally poor.	The face validation data indicated that when the ES framework themes were not present or were ineffectively utilized the FEMA-system events generally had negative outcomes. When external variety was not effectively regulated, the FEMA-system performed poorly. This indicates potential future ES framework testability.

Based upon Kirchner's (1989) criteria for a testable hypothesis, the ES framework is capable of empirical verification so that it can be ultimately confirmed or refuted. The ES framework's testability supports future efforts to seek its external validity. Several testable hypotheses for the ES framework are: (1) system viability (dependent variable) is correlated to ES effectiveness (independent variable), (2) variety regulation from external disturbances (dependent variable) is correlated to ES framework functions (independent variable), and (3) system viability (dependent variable) is correlated with changing external disturbances (independent variable).

6.5 CHAPTER SUMMARY

Chapter 5 provided the results of applying the Grounded Theory method in this research. Chapter 6 offers the conclusions and implications from the Chapter 5 research results.

The conclusion of this research is that the ES framework provides a theoretical structure for insight into the influence of Systems Theory regarding ES functions as they act in the CSG metasystemic functions, or act to enable conditions necessary for the execution of ES in the CSG metasystemic functions. The actions of the ES framework functions lead to system viability by regulating external variety.

The contributions to theory included supporting the existing ES functions in CSG from a literature-based perspective and expanding the functions of ES in CSG by 10 new functions. Table 65 summarizes this research's contributions to theory.

Table 65

Summary of Research Contributions to Theory

Summary of research contributions to theory
ES framework's functions play a rigorous role in the operation of the CSG metasystemic functions.
Treating the ES framework's functions as an integrated system is supportive of system viability.
The ES functions in the framework have situational value differences.
A system's second-order ES functions are supportive of system viability by taking initiatives to advance the governance of a system's metasystem. They create a learning system that is a part of a system's ES function.
A method has been developed for organizing ES literature for assessment.
Analysis shows that the functions of ES in CSG are still evolving in the literature and in practice.

Table 66 summarizes this research's contributions to practice.

Table 66

Summary of Contributions to Practice

Contributions to Practice
Applying the ES framework functions from a systemic, evolutionary process perspective is a new contribution to supporting the evolution of the CSG metasystemic functions, that in practice, could conceptually enhance the ability of a system to remain viable in a changing environment.
Having a well-performing ES system across all 17 functions appears to be a hedge against negative impact from external variety changes.
Designing a system's ES system to have flexible capacity and rapid responsiveness to many environmental changes (high variety) and to design into the system's ES function sensors for weak, leading indicators of future changes would be more supportive of system viability than a fixed ES system design.
The ability to evaluate and measure the ES framework's functions' performance has the potential to be a valuable tool for supporting CSG's ES metasystemic function. This could help to improve a system's viability by improving its ES system functioning.
Measuring and prioritizing ES framework function pathologies could be supportive of improving the ES framework functions that lead to improved system viability.
All the ES functions require further assessment of their actions in the ES system to determine if they require modification in support of a smoothly operating ES system considering both black swan (low probability but high impact) and predictable events.
Though it was part of a face validation, several implications for practice emerged from the case study method. The case study was a valuable method in a face validation of the ES framework.

Table 67 is a summary of this research's contributions to method.

Table 67

Summary of Contributions to Method

Summary of contributions to method
The modifications made in this research effort to accommodate the large volume of source data included: use of a robust reference manger, several layers of collective codes, sensitizing concepts application after Initial Coding, and need for a robust coding support tool.
Contributions to the research method were made by providing practical modifications to the classical GTM for a robust extant literature research library or a robust source data of any kind where 100's of codes would be anticipated.
A method modification, to re-start Axial Coding, was essential to keep the selected sensitizing concepts from driving the outcomes. This method modification is helpful to future research efforts where sensitizing concepts are applied after Initial Coding.
Sensitizing concepts applied after Initial Coding were necessary to support organizing a large volume of data but were not determinant in the category and theme construction.

Future research directions were summarized in Table 62 and Table 63.

A formulation for future testing of the ES framework was provided and the potential for development of hypotheses for deductive theory testing was demonstrated for the ES framework.

The canons of science relating to this qualitative research were discussed in Chapter 3, section 3.2.4. They are credibility, transferability, dependability, and confirmability. Each of these canons has been demonstrated in this research project and are presented in summary in Table 68. The demonstration of the canons of science serves to support the appropriateness of utilization of the GTM in the non-traditional disciplines such as Engineering Management and Sytems Engineering.

Table 68

Demonstration of the Canons of Science in This Research Effort

Canons for a quality qualitative (inductive) research paradigm	**Attributes of canon characteristics**	**Method canons demonstrated in this research**
Credibility	• Accurate identification and description of variables and research participant units • Triangulation • Transparency in analysis • Inductive reasoning	• Chapter 3 detailed the inductive reasoning approach in the research methodology. • The Grounded Theory research method was transparently detailed Chapter 4. Chapter 4 identified all the relevant research variables. The research results in Chapter 5 included a face validation of the resultant ES framework.
Transferability	• Applicability to other contexts • Purposive sampling	• The research library was compiled of texts from eight fields of study giving a broad base to the GTM from the source literature in support of generalizability of the research findings. • The sampling was per the GTM. The GTM was validated by scholarly experts.
Dependability	• Transparency: rigorous documentation of the process and research design, consistency	• Chapters 3, 4, and 5 rigorously documented the research methodology, research design, and results.
Confirmability	• Objectivity	• The face validation case study demonstrated that the ES framework was applicable in a practical setting. The ES framework was shown to be testable.

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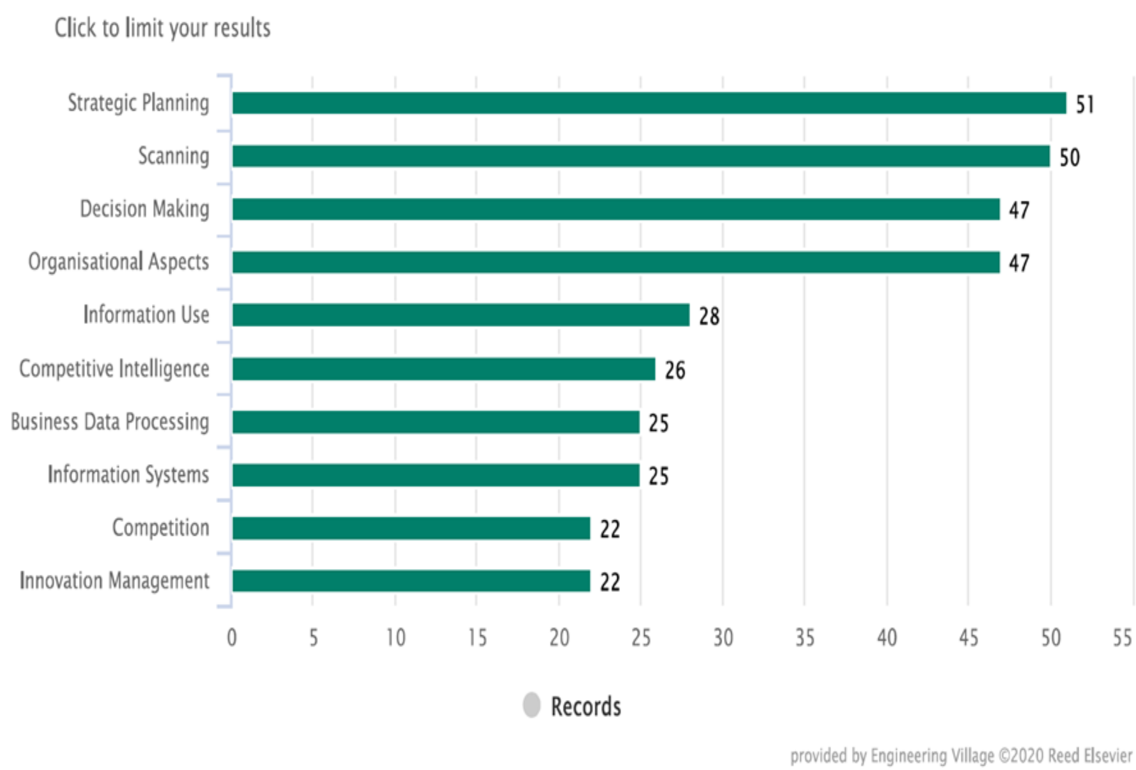
APPENDIX A

ENGINEERING VILLAGE SEARCH RESULTS FOR ES RELATED LITERATURE

Appendix A (in screenshot format) shows the results of an ES search performed in February 2020 with the ODU Engineering Village search engine to provide a multifaceted perspective on the status of ES literature development. Engineering Village was the available search engine providing the greatest variety of categorization of search record returns. This effort was for the purpose of beginning to understand the nature of the ES literature field to support the ES literature review. Engineering Village was not the only search engine used in selecting ES literature for coding but was used as the starting point for learning about the ES literature.

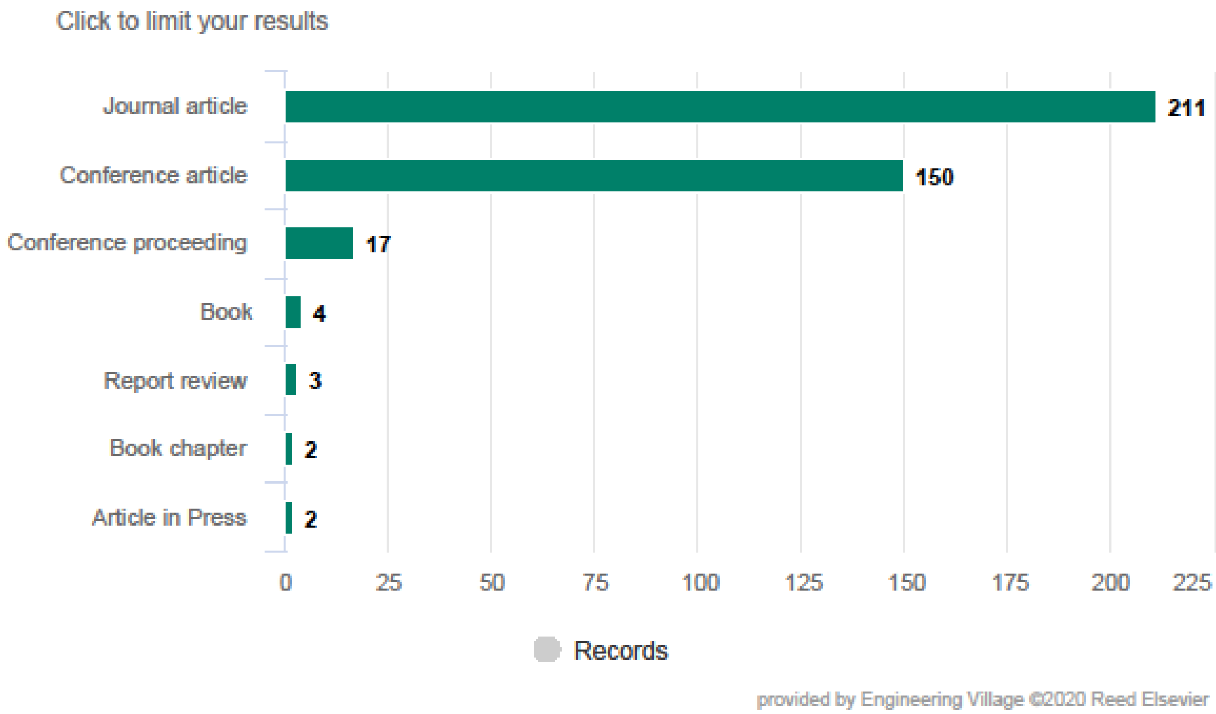
The first chart was the result of searching for ES and categorizing the results by topic material. The top four groupings indicate that ES has primarily been written about in strategic planning, ES as its own topic, decision making, and aspects of organizational management. The purpose of the charts is to demonstrate the presence of ES-related literature from multiple perspectives in the engineering field of study. The chart below shows the number of ES records (categories of literature format) that are present in the search engine database under the listed focus areas on the left side column. These are the focus areas that were used to identify related ES literature to be coded in the Grounded Theory Method.

TOPICAL CATEGORIZATION OF ES ARTICLES



The second chart from Engineering Village for ES related literature was categorized by type of record identified in the search, with journal articles being the most prevalent record type found. Books and book chapters were the least populated categories of ES literature.

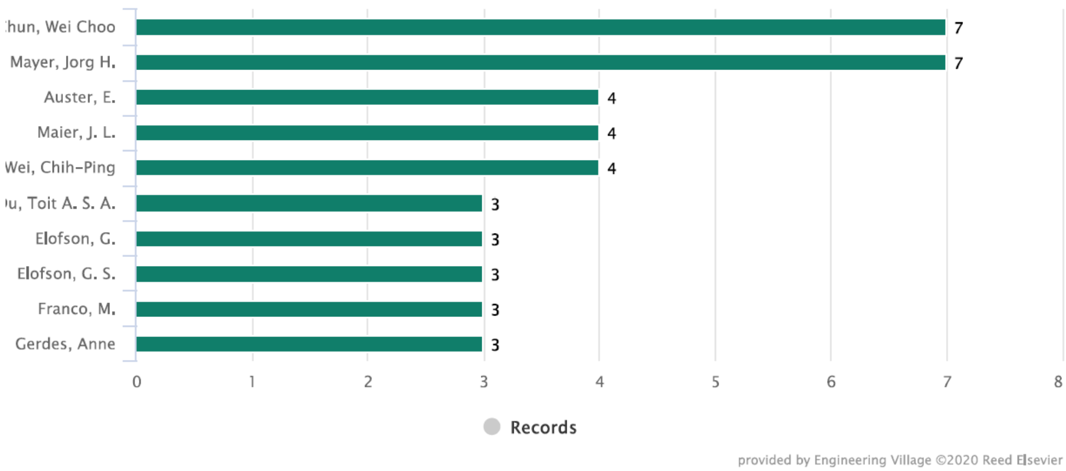
ES TYPE OF RECORD CATEGORIZATION



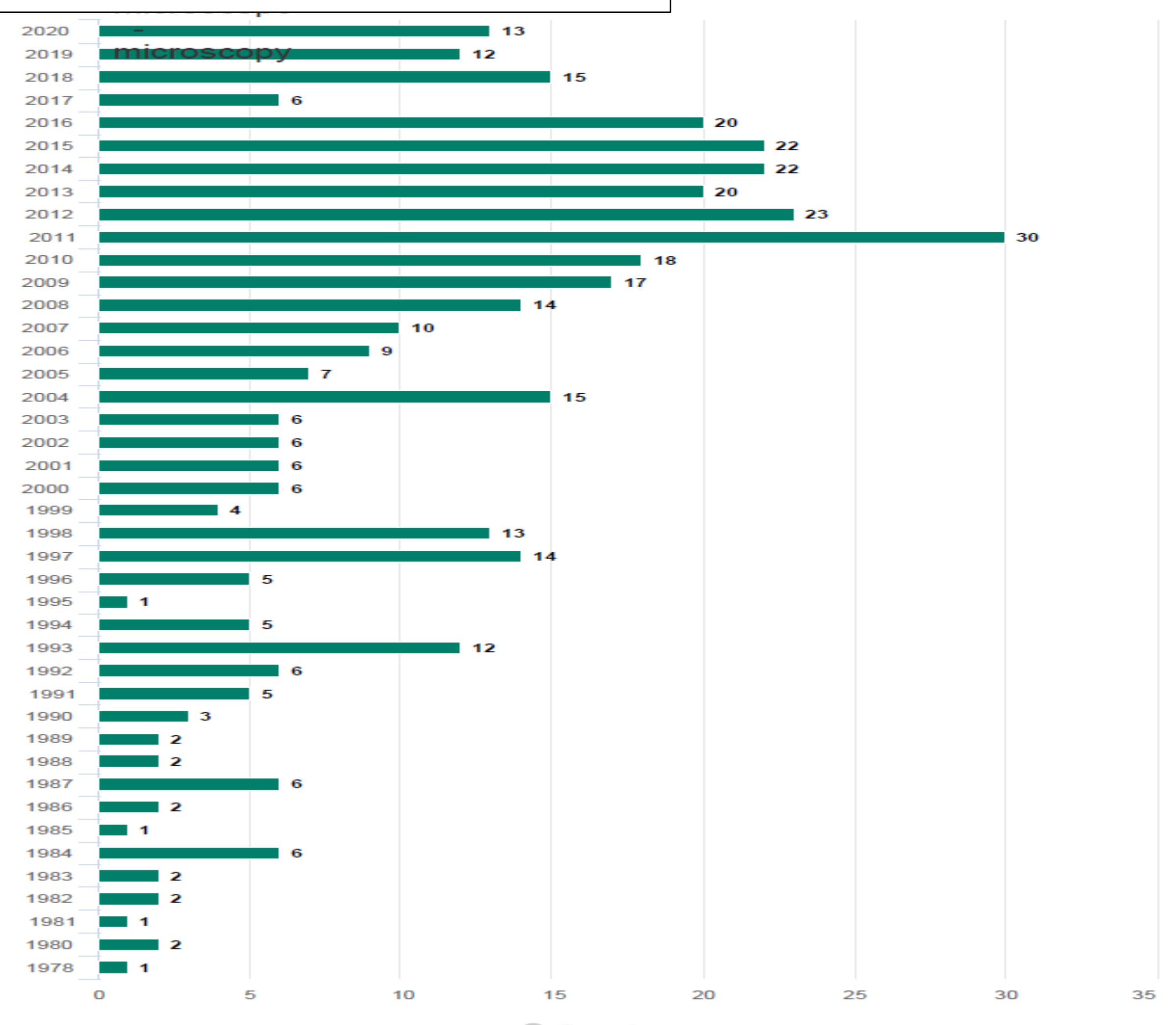
The third categorization was by authors who wrote ES articles. This categorization lists the top ten authors of ES articles with Choo and Mayer having written the most in this database.

The fourth categorization of ES literature was articles published by year. This result shows the period of greatest publishing was from 2009 through 2016. However, more articles were written prior to 2009 than up through 2020.

ES ARTICLE AUTHOR CATEGORIZATION

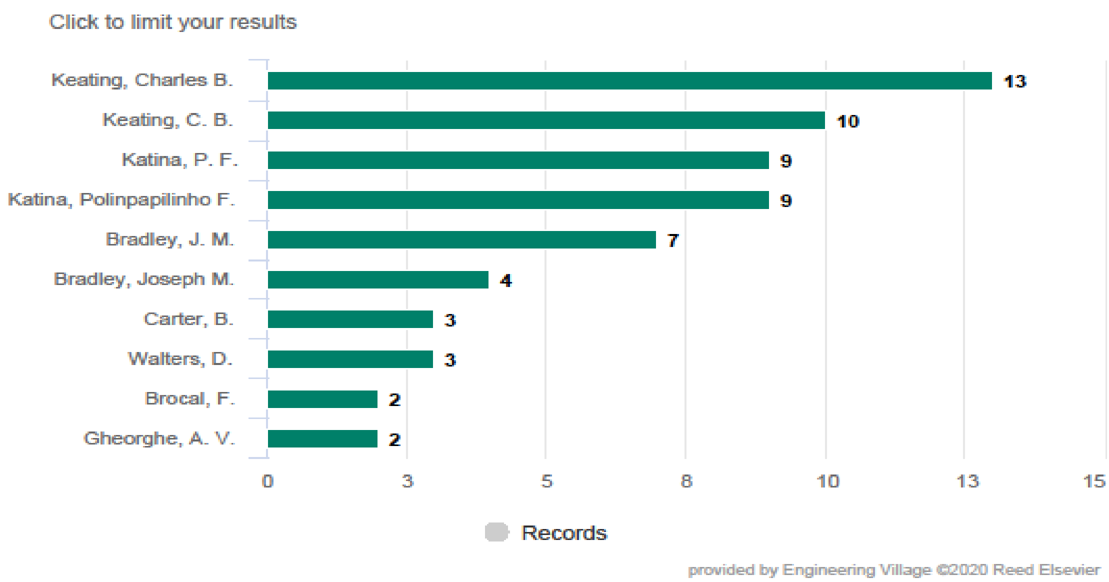


ES ARTICLES BY YEAR CATEGORIZATION



The fifth ES search result categorization was for authors of CSG articles. The categorization shows that this evolving field's authors are primarily from ODU where the CSG field of study is being developed.

CSG AUTHOR CATEGORIZATION



APPENDIX B

CONSTRUCTIVIST GROUNDED THEORY REFERENCES

Appendix B is the summary of the major authors of the constructivist GTM that were consulted in the development of the research methodology presented in this paper. Not all these authors are cited in this dissertation but are listed for reference purposes. Charmaz (2006) developed the constructivist GTM and is the prime author used to develop this research methodology and the specific GTM applied. The authors listed in paragraph 2 also wrote about the constructivist GTM and were referred to, at least in part, for the development of this research methodology. They are listed for reference purposes.

1. Charmaz authored or co-authored the following articles about the constructivist GTM: Charmaz, 1996, 2000a, 2006a, 2008, 2014, 2015a, 2015b, 2016, 2017, 2020; Charmaz & Belgrave, 2019; Charmaz & Bryant, 2011; Charmaz & Thornberg, 2021; Tweed & Charmaz, 2012.

Reference citation	**Reference title**
(Charmaz, 1996)	The search for meanings—grounded theory
(Charmaz, 2000a)	Constructivist and objectivist grounded theory
(Charmaz, 2006)	Constructing grounded theory: a practical guide through qualitative analysis
(Charmaz, 2008)	Grounded theory as an emergent method
(Charmaz, 2014)	Constructing grounded theory
(Charmaz, 2015b)	Teaching theory construction with initial grounded theory tools: a reflection on lessons and learning
(Charmaz, 2015a)	Grounded theory: methodology and theory construction
(Charmaz, 2016)	The power of constructivist grounded theory for critical inquiry

Reference citation	Reference title
(Charmaz, 2017)	Special invited paper: continuities, contradictions, and critical inquiry in grounded theory
(Charmaz, 2020)	“With constructivist grounded theory you can’t hide”: social justice research and critical inquiry in the public sphere
(Charmaz & Belgrave, 2019)	Thinking about data with grounded theory
(Charmaz & Bryant, 2011)	Grounded theory
(Charmaz & Thornberg, 2021)	The pursuit of quality in grounded theory
(Tweed & Charmaz, 2012)	Grounded theory methods for mental health practitioners

2. Authors other than Charmaz that wrote about the constructivist GTM are listed below:

   Bozkurt & Sousa-Poza, 2005; Carmichael & Cunningham, 2017; Egan, 2002; Glaser, 2007; Heylighen, 2000; Kenny & Fourie, 2015; Mills et al., 2006b, 2007; Nagel et al., 2015; Ramalho et al., 2015; Seidel & Urquhart, 2016; Yarwood-Ross & Jack, 2015.

Reference Citation	Reference title
(Bozkurt & Sousa-Poza, 2005)	A comparison of the canons of science used in positivistic research and constructivist/naturalist research
(Carmichael & Cunningham, 2017)	Theoretical data collection and data analysis with gerunds in a constructivist grounded theory study
(Egan, 2002)	Grounded theory research and theory building
(Glaser, 2007)	Constructivist grounded theory?
(Heylighen, 2000)	Foundations and methodology for an evolutionary world view: a review of the principia cybernetica project
(Kenny & Fourie, 2015)	Contrasting classic, Straussian, and constructivist grounded theory: methodological and philosophical conflicts
(Mills et al., 2006b)	The development of constructivist grounded theory
(Mills et al., 2007)	Grounded theory: a methodological spiral from positivism to postmodernism

Reference Citation	**Reference title**
(Nagel et al., 2015)	When novice researchers adopt constructivist grounded theory: navigating less travelled paradigmatic and methodological paths in PhD dissertation work
(Ramalho et al., 2015)	Literature review and constructivist grounded theory methodology
(Seidel & Urquhart, 2016)	On emergence and forcing in information systems grounded theory studies: the case of Strauss and Corbin
(Yarwood-Ross & Jack, 2015)	Using extant literature in a grounded theory study: a personal account

APPENDIX C

GROUNDED THEORY RESOURCES CONSULTED THAT WERE NOT SPECIFICALLY CONSTRUCTIVIST

The GTM has several different forms. Even though there are different forms, there is a commonality to the GTM in that all forms are grounded in their source data. The listed authors below were consulted, at least in part, in the development of this research's Grounded Theory methodology. They are listed here for reference purposes. They did not author specific articles about the constructivist approach to the GTM.

Annells, 1996; Birks & Mills, 2015; Carpenter, 1995; Chiovitti & Piran, 2003; Corbin & Strauss, 1990; Crownover, 2005; Egan, 2002; Glaser et al., 2013; Glaser & Holton, 1967; Glaser, 1978; Goulding, 1999; Hallberg, 2006; Heath & Cowley, 2004; Howard-Payne, 2016; Kenny & Fourie, 2015; Lapan et al., 2011; Lo, 2016; Reiger, 2019; Strauss & Corbin, 1994, 1997; Timmermans & Tavory, 2012

Reference citation	**Reference title**
(Annells, 1996)	Grounded theory method: philosophical perspectives, paradigm of inquiry, and postmodernism
(Birks & Mills, 2015)	Essentials of grounded theory
(Carpenter, 1995)	Grounded theory research approach
(Chiovitti & Piran, 2003)	Rigour and grounded theory research
(Corbin & Strauss, 1990)	Grounded theory research: procedures, canons, and evaluative criteria
(Crownover, 2005)	Complex system contextual framework (CSCF) a grounded-theory construction for the articulation of system context in addressing complex systems problems
(Egan, 2002)	Grounded theory research and theory building
(Glaser et al., 2013)	What Grounded Theory Is….

Reference citation	Reference title
(Glaser & Holton, 1967)	The discovery of grounded theory
(Glaser, 1978)	Theoretical sensitivity: advances in the methodology of grounded theory
(Goulding, 1999)	Grounded theory: some reflections on paradigm, procedures, and misconceptions
(Hallberg, 2006)	The "core category" of grounded theory: making constant comparisons
(Heath & Cowley, 2004)	Developing a grounded theory approach: a comparison of Glaser and Strauss
(Howard-Payne, 2016)	Glaser or Strauss? Considerations for selecting a grounded theory study
(Kenny & Fourie, 2015)	Contrasting classic, Straussian, and constructivist grounded theory: methodological and philosophical conflicts
(Lapan et al., 2011)	Qualitative research: an introduction to methods and designs
(Lo, 2016)	Literature integration: an illustration of theoretical sensitivity in grounded theory studies
(Rieger, 2019)	Discriminating among grounded theory approaches
(Strauss & Corbin, 1994)	Grounded theory methodology
(Strauss & Corbin, 1997)	Grounded theory in practice
(Timmermans & Tavory, 2012)	Theory construction in qualitative research: from grounded theory to abductive analysis

APPENDIX D

INITIAL LITERATURE REFERENCES FOR CODING

The GTM begins with selected reference materials that are then subjected to a coding method that breaks down the volume of text into abstracted code word representing the context of the text. 124 references were selected through a filtering process to develop the initial list of reference articles that were then subjected to coding. The below table lists those 124 reference articles with the author's citation, the field of study that the reference article came from, and the title of the reference article. The full reference is listed in the References section.

#	Citation	Source field	Title
1	(Bradley et al., 2016)	CSG	Complex system governance for acquisition
2	(Calida, 2013)	CSG	System governance analysis of complex systems
3	(Calida, 2016)	CSG	Complex system governance: moving diverse theory to practice
4	(Davies, 2002)	CSG	Models of governance-a viable systems perspective
5	(Espinosa, 2015)	CSG	Governance for sustainability: learning from VSM practice
6	(Jessop, 2003)	CSG	Governance and meta-governance: on reflexivity, requisite variety, and requisite irony
7	(Katina & Bradley, 2016)	CSG	Towards a systems theory-based curriculum for complex systems governance
8	(Katina et al., 2017b)	CSG	A Systems-Based framework for design and analysis of an R and D structure
9	(Keating & Bradley, 2015)	CSG	Complex system governance reference model

#	Citation	Source field	Title
10	(Keating & Katina, 2016)	CSG	Complex system governance development: a first-generation methodology
11	(Keating & Katina, 2019)	CSG	Complex system governance: concept, utility, and challenges
12	(Katina et al., 2017a)	CSG	Complex system governance for critical cyber-physical systems
13	(Keating, 2014a)	CSG	Governance implications for meeting challenges in the system of systems engineering field
14	(Keating, 2015)	CSG	Complex system governance: theory to practice challenges for system of systems engineering
15	(Keating et al., 2014)	CSG	Complex system governance: concept, challenges, and emerging research
16	(Keating et al., 2015)	CSG	Challenges for developing complex system governance
17	(Albright, 2004)	ES	Environmental scanning: radar for success
18	(Aldehayyat, 2015)	ES	Environmental scanning in business organisations: empirical evidence from a Middle Eastern country context
19	(Auster & Choo, 1994)	ES	CEOs, information, and decision making: scanning the environment for strategic advantage
20	(Baugh, 2015)	ES	Environmental scanning implications in the governance of complex systems
21	(Beal, 2000)	ES	Competing effectively: environmental scanning, competitive strategy, and organisational performance in small manufacturing firms
22	(Borges & Janissek-Muniz, 2017)	ES	Individual environmental scanning as a barrier to collective processes in the organizations: a view based on the illusion of control
23	(Choo, 2001)	ES	Environmental scanning as information seeking and organizational learning

#	Citation	Source field	Title
24	(Davis, 2008)	ES	Does environmental scanning by systems integration firms improve their business development performance?
25	(Hambrick, 1982)	ES	Environmental scanning and organizational strategy
26	(Heylighen & Joslyn, 2001)	ES	The law of requisite variety
27	(Heylighen, 1992)	ES	Principles of systems and cybernetics: an evolutionary perspective
28	(Huffman, 2004)	ES	Why environmental scanning works except when you need it
29	(Jain, 1984)	ES	Environmental scanning in US corporations
30	(Jiang & Gallupe, 2015)	ES	Environmental scanning and business insight capability: the role of business analytics and knowledge integration
31	(Keating & Katina, 2011)	ES	Systems of systems engineering: prospects and challenges for the emerging field
32	(Lauzen, 1995)	ES	Toward a model of environmental scanning
33	(Lenz & Engledow, 1986)	ES	Environmental analysis units and strategic decision-making: a field study of selected "Leading edge" corporations
34	(Lewis & Stewart, 2003)	ES	The measurement of environmental performance: an application of Ashby's law
35	(Mayer et al., 2011)	ES	Improving the applicability of environmental scanning systems: state of the art and future research
36	(Mayer et al., 2013)	ES	More applicable environmental scanning systems leveraging "modern" information systems
37	(Mendelow, 1981)	ES	Environmental scanning - the impact of the stakeholder concept
38	(Morrison, 1985)	ES	Establishing an environmental scanning process
39	(Renfro & Morrison, 1984)	ES	Detecting signals of change the environmental scanning process
40	(Richardson, 2004)	ES	Systems theory and complexity: part 2

#	Citation	Source field	Title
41	(Robinson & Simmons, 2017)	ES	Organising environmental scanning: exploring information source, mode, and the impact of firm size
42	(Robinson et al., 2020)	ES	Consolidation and fragmentation in environmental scanning: a review and research agenda
43	(Skyttner, 1996)	ES	General systems theory: origin and hallmarks
44	(Smeltzer et al., 1988)	ES	Environmental scanning practices in small business
45	(Subramanian et al., 1993)	ES	Environmental scanning in US companies: their nature and their relationship to performance
46	(Terry, 1977)	ES	Mechanisms for environmental scanning
47	(Thomas, 1980)	ES	Environmental scanning—the state of the art
48	(Tonn, 2008)	ES	A methodology for organizing and quantifying the results of environmental scanning exercises
49	(Von Bertalanffy, 1972)	ES	The history and status of general systems theory
50	(Voros, 2003)	ES	A generic foresight process framework
51	(Waelchlif, 1992)	ES	Eleven theses of general systems theory (GST)
52	(Wambua & Omondi, 2016)	ES	Factors influencing the environmental scanning of organizations in manufacturing sector: a case study of Kenya breweries limited
53	(Whitney et al., 2015)	ES	Systems theory as a foundation for governance of complex systems
54	(Yasai-Ardekani & Nystrom, 1996)	ES	Designs for environmental scanning systems: tests of a contingency theory
55	(Vahidi et al., 2018)	ES	Researches status and trends of management cybernetics and viable system model
56	(Bussey, 1996)	Futures	The foresight principle: cultural recovery in the 21st century (review)

#	**Citation**	**Source field**	**Title**
57	(Conway, 2009)	Futures	Environmental scanning: what it is, how to do it...
58	(Conway, 2012)	Futures	Doing environmental scanning an overview guide
59	(Dunagan, 2012)	Futures	Designer governance
60	(Gilbertson & Campbell-Hunt, 1990)	Futures	Quick environmental scanning. A New Zealand application
61	(Glenn & Gordon, 2009)	Futures	Environmental scanning
62	(Slaughter, 1999)	Futures	A new framework for environmental scanning
63	(Voros, 2001)	Futures	Reframing environmental scanning: an integral approach
64	(Zhang et al., 2012)	Futures	Perceived environmental uncertainty, information literacy and environmental scanning: towards a refined framework
65	(Abels, 2002)	Information sys.	Hot topics: environmental scanning
66	(Bouhnik & Giat, 2015)	Information sys.	Information gatekeepers – aren't we all?
67	(Choo, 1999)	Information sys.	The art of scanning the environment
68	(Du Toit, 1993)	Information sys.	Significance of the quick environmental scanning technique (QUEST) for information services
69	(Frolick et al., 1997)	Information sys.	Using EISs for environmental scanning
70	(Maier et al., 1997)	Information sys.	Environmental scanning for information technology: an empirical investigation
71	(McCann & Gomez-Mejia, 1992)	Information sys.	Going 'on-line' in the environmental scanning process
72	(Ackoff, 1967)	Management	Management misinformation systems
73	(Choo, 1993)	Management	Environmental scanning: acquisition and use of information by managers
74	(Wilson & Coreia, 2001)	Management	Factors influencing environmental scanning in the organizational context
75	(Costa, 1995)	Management	An empirically based review of the concept of environmental scanning

#	Citation	Source field	Title
76	(D'aveni, 1989)	Management	The aftermath of organizational decline: a longitudinal study of the strategic and managerial characteristics of declining firms
77	(Daft et al., 1988)	Management	Chief executive scanning, environmental characteristics, and company performance: an empirical study
78	(de Geus, 1997)	Management	The living company: habits for survival in a turbulent business environment
79	(Elenkov, 1997)	Management	Strategic uncertainty and environmental scanning: the case for institutional influences on scanning behavior
80	(Gordon & Narayanan, 1984)	Management	Management accounting systems, perceived environmental uncertainty and organization structure: an empirical investigation
81	(Hagen & Amin, 1995)	Management	Corporate executives and environmental scanning activities: an empirical investigation
82	(Leonard, 2000)	Management	The viable system model and knowledge management
83	(Milliken, 1987)	Management	Three types of perceived uncertainty about the environment: state, effect, and response uncertainty
84	(Ojo & Abdusalam, 2011)	Management	Scanning the business environment and its implications on organisational performance: a case study
85	(Oreja-Rodríguez & Yanes-Estévez, 2010)	Management	Environmental scanning: dynamism with rack and stack from Rasch model
86	(Robinson & Simmons, 2017)	Management	Organising environmental scanning: exploring information source, mode, and the impact of firm size
87	(Samsami et al., 2015)	Management	Managing environmental uncertainty: from conceptual review to strategic management point of view

#	Citation	Source field	Title
88	(Saviano & Di Nauta, 2011)	Management	Project management as a compass in complex decision-making contexts: a viable systems approach
89	(Tversky & Kahneman, 1986)	Management	Rational choice and the framing of decisions
90	(Zhang et al., 2011)	Management	The contribution of environmental scanning to organizational performance
91	(Barak, 1984)	Marketing	Teaching environmental scanning: an experimental approach
92	(Frazier, 1983)	Marketing	On the measurement of interfirm power in channels of distribution
93	(Saxby et al., 2002)	Marketing	Environmental scanning and organizational culture
94	(Silverblatt & Korgaonkar, 1987)	Marketing	Strategic market planning in a turbulent business environment
95	(Spitz & Ludlow, 2015)	Marketing	Futuristics and innovation in marketing
96	(Stanwick et al., 1991)	Marketing	Environmental scanning, environmental uncertainty, and the capabilities of the firm: a proposed framework
97	(Beer, 1979)	Managerial Cyber.	The managerial cybernetics of organization. The heart of enterprise
98	(Ashby, 1958)	Managerial Cyber.	Requisite variety and its implications for the control of complex systems
99	(Babatunde & Adebisi, 2012)	Managerial Cyber.	Strategic environmental scanning and organization performance in a competitive business environment
100	(Beer, 1984)	Managerial Cyber.	The viable system model: its provenance, development, methodology and pathology
101	(Beer, 1994)	Managerial Cyber.	Decision and control: the meaning of operational research and management cybernetics
102	(Beer, 2000)	Managerial Cyber.	Ten pints of Beer
103	(Kets de Vries & Miller, 1984)	Managerial Cyber.	Neurotic style and organizational pathology

#	Citation	Source field	Title
104	(Espejo, 1994)	Managerial Cyber.	What is systemic thinking?
105	(Ireland, 2014)	Managerial Cyber.	Systems fundamentals
106	(Leonard, 2009)	Managerial Cyber.	The viable system model and its application to complex organizations
107	(Nechansky, 2013)	Managerial Cyber.	Issues of organizational cybernetics and viability beyond Beer's viable systems model
108	(Pickering, 2002)	Managerial Cyber.	Cybernetics and the mangle: Ashby, Beer and Pask
109	(Haque & Haque, 2016)	Managerial Cyber.	The law of requisite variety and the organizational performance: an empirical analysis of the Pakistani cellular sector
110	(Beer, 1981)	Managerial Cyber.	Environments of decision system four
111	(Cumming & Colllier, 2005)	Managerial Cyber.	Change and identity in complex systems
112	(Espejo, 2000)	Managerial Cyber.	Giving requisite variety to strategic and implementation processes: theory and practice
113	(Gershenson, 2015)	Managerial Cyber.	Requisite variety, autopoiesis, and self-organization
114	(Schwaninger, 2004)	Managerial Cyber.	What can cybernetics contribute to the conscious evolution of organizations and society?
115	(Ackoff, 1974)	Planning	The systems revolution
116	(Bryson, 1988)	Planning	A strategic planning process for public and non-profit organizations
117	(Clemens, 2009)	Planning	Environmental scanning and scenario planning: a 12-month perspective on applying the viable systems model to developing public sector foresight
118	(Fahey & King, 1977)	Planning	Environmental scanning for corporate planning
119	(Fahey et al., 1981)	Planning	Environmental scanning and forecasting in strategic planning—the state of the art
120	(Haynes, 1974)	Planning	Towards a concept of monitoring

#	Citation	Source field	Title
121	(Hayward, 2004)	Planning	Facilitating foresight: where the foresight function is placed in organisations
122	(Kahalas, 1977)	Planning	Long range planning—an open systems view
123	(Narchal et al., 1987)	Planning	An environmental scanning system for business planning
124	(Stubbart, 1982)	Planning	Are environmental scanning units effective?

APPENDIX E

PEER REVIEWER QUALIFICATIONS

GTM scholarly peer experts were identified to support the credibility of the research design by assessing the GTM process applied in this study. To select peer experts with scholarly credibility to assess this research method, a set of scholarly criteria was developed and applied to possible peer expert candidates. The peer expert selection criteria are listed in the peer qualification questionnaire presented below.

PEER REVIEWER QUALIFICATIONS

Each expert should meet the following criteria: a. Has earned a PhD or is a PhD candidate, b. has published or been involved in publishing articles of scholarly literature on topics involving systems theory, c. has spent over 10 years in study and research relating to systems theory, and d. has applied the GTM to a systems theory-based research project.

Systems Theory experience-minimum 10 years

Dates From – To
Job Title, Company

Describe your responsibilities and achievements in terms of impact and results. Use examples but keep it short.

Related Education-PhD/PhD Candidate

1. Degree Title, School

It is okay to brag about your GPA, awards, and honors. Feel free to summarize your course work too.

2. Degree Title, School

It is okay to brag about your GPA, awards, and honors. Feel free to summarize your course work too.

GTM related skills

List GTM projects, participating projects, any experiences with GTM

List your related strengths in GTM

Publishing activities related to Systems Theory

List any articles, books, papers published, co-authored, or involved with in any form

APPENDIX F

PEER REVIEW GTM ANALYSIS WORKSHEET QUESTIONS

The form below is a copy of the base form that was provided to the scholarly peer reviewers of the GTM applied in this research project. The form lists the 13 areas to be evaluated on a four-point Likert scale and provides the evaluation criteria for each grading descriptor. The application of the Likert scale in this research is for the purpose of facilitating data collection and is not intended to be used as a research instrument. Written comments were solicited in support of each analysis question. The written comments were collected into a single document file and then coded for collective meaning.

<table>
<tr><td></td><td colspan="4">GRADING SELECTION DESCRIPTORS</td></tr>
<tr><td>Descriptors</td><td>UN</td><td>AD</td><td>VG</td><td>EX</td></tr>
<tr><td>Description of descriptors</td><td>unsatisfactory</td><td>adequate</td><td>very good</td><td>exceptional</td></tr>
<tr><td></td><td>Provided data fails to meet the intent of the minimum standards for the analysis question</td><td>Provided data meets the intent of the analysis question</td><td>Provided data clearly demonstrates a response that is more than the analysis question minimum</td><td>Provided data clearly demonstrates the analysis question and then goes beyond the scope of the analysis requirement</td></tr>
</table>

<table>
<tr><td>Analysis question</td><td>Grading descriptor</td><td>Reasoning and comments on grading descriptor</td></tr>
</table>

1. The Research Questions Are Appropriate for a Grounded Theory Study.		
2. Data collection and analysis are interrelated processes.		
3. Concepts (codes) are the basic units of analysis.		
4. Categories must be developed and related to themes.		
5. Sampling in grounded theory proceeds on theoretical grounds.		
6. Analysis makes use of constant comparisons.		
7. Patterns and variations must be accounted for.		
8. Process must be built into the theory.		
9. Writing theoretical and coding memos is an integral part of doing grounded theory.		
10. Hypotheses (themes) about relationships among categories are developed and verified as much as possible during the research process.		
11. Broader structural conditions must be brought into the analysis, however microscopic in focus is the research.		
12. Constructivist Grounded Theory (Charmaz) attributes are present.		
13. Scholarly peer overall assessment of the credibility canon of the GTM is presented for this research.		

APPENDIX G

LISTING OF RESEARCH LIBRARY REFERENCES

This appendix lists all the filtered journal and book reference articles that were coded as part of the GTM and lists the source field of study the articles originated from. The citation details are listed in the References section. The first 124 references were those that were initially coded. The remaining 26 references were added into the coding process after the Initial Coding had been accomplished because of the constant comparative method necessitating additional information to be brought into the coding process. The total list of the 150 reference articles is the reference library that was subjected to coding in support of this research effort. The list shows the author citation, the field of study the reference article was taken from, and the title of the reference article. The full reference identification is given in the Reference section.

#	Citation	Source field	Title
1	(Bradley et al., 2016)	CSG	Complex system governance for acquisition
2	(Calida, 2013)	CSG	System governance analysis of complex systems
3	(Calida, 2016)	CSG	Complex system governance: moving diverse theory to practice
4	(Davies, 2002)	CSG	Models of governance-a viable systems perspective
5	(Espinosa, 2015)	CSG	Governance for sustainability: learning from VSM practice
6	(Jessop, 2003)	CSG	Governance and meta-governance: on reflexivity, requisite variety, and requisite irony

#	Citation	Source field	Title
7	(Katina & Bradley, 2016)	CSG	Towards a systems theory-based curriculum for complex systems governance
8	(Katina et al., 2017b)	CSG	A Systems-Based framework for design and analysis of an R and D structure
9	(Keating & Bradley, 2015)	CSG	Complex system governance reference model
10	(Keating & Katina, 2016)	CSG	Complex system governance development: a first-generation methodology
11	(Keating & Katina, 2019)	CSG	Complex system governance: concept, utility, and challenges
12	(Katina et al., 2017a)	CSG	Complex system governance for critical cyber-physical systems
13	(Keating, 2014a)	CSG	Governance implications for meeting challenges in the system of systems engineering field
14	(Keating, 2015)	CSG	Complex system governance: theory to practice challenges for system of systems engineering
15	(Keating et al., 2014)	CSG	Complex system governance: concept, challenges, and emerging research
16	(Keating et al., 2015)	CSG	Challenges for developing complex system governance
17	(Albright, 2004)	ES	Environmental scanning: radar for success
18	(Aldehayyat, 2015)	ES	Environmental scanning in business organisations: empirical evidence from a Middle Eastern country context
19	(Auster & Choo, 1994)	ES	CEOs, information, and decision making: scanning the environment for strategic advantage
20	(Baugh, 2015)	ES	Environmental scanning implications in the governance of complex systems
21	(Beal, 2000)	ES	Competing effectively: environmental scanning, competitive strategy, and organisational performance in small manufacturing firms

#	Citation	Source field	Title
22	(Borges & Janissek-Muniz, 2017)	ES	Individual environmental scanning as a barrier to collective processes in the organizations: a view based on the illusion of control
23	(Choo, 2001)	ES	Environmental scanning as information seeking and organizational learning
24	(Davis, 2008)	ES	Does environmental scanning by systems integration firms improve their business development performance?
25	(Hambrick, 1982)	ES	Environmental scanning and organizational strategy
26	(Heylighen & Joslyn, 2001)	ES	The law of requisite variety
27	(Heylighen, 1992)	ES	Principles of systems and cybernetics: an evolutionary perspective
28	(Huffman, 2004)	ES	Why environmental scanning works except when you need it
29	(Jain, 1984)	ES	Environmental scanning in US corporations
30	(Jiang & Gallupe, 2015)	ES	Environmental scanning and business insight capability: the role of business analytics and knowledge integration
31	(Keating & Katina, 2011)	ES	Systems of systems engineering: prospects and challenges for the emerging field
32	(Lauzen, 1995)	ES	Toward a model of environmental scanning
33	(Lenz & Engledow, 1986)	ES	Environmental analysis units and strategic decision-making: a field study of selected “Leading edge” corporations
34	(Lewis & Stewart, 2003)	ES	The measurement of environmental performance: an application of Ashby's law
35	(Mayer et al., 2011)	ES	Improving the applicability of environmental scanning systems: state of the art and future research
36	(Mayer et al., 2013)	ES	More applicable environmental scanning systems leveraging “modern” information systems

#	Citation	Source field	Title
37	(Mendelow, 1981)	ES	Environmental scanning - the impact of the stakeholder concept
38	(Morrison, 1985)	ES	Establishing an environmental scanning process
39	(Renfro & Morrison, 1984)	ES	Detecting signals of change the environmental scanning process
40	(Richardson, 2004)	ES	Systems theory and complexity: part 2
41	(Robinson & Simmons, 2017)	ES	Organising environmental scanning: exploring information source, mode, and the impact of firm size
42	(Robinson et al., 2020)	ES	Consolidation and fragmentation in environmental scanning: a review and research agenda
43	(Skyttner, 1996)	ES	General systems theory: origin and hallmarks
44	(Smeltzer et al., 1988)	ES	Environmental scanning practices in small business
45	(Subramanian et al., 1993)	ES	Environmental scanning in US companies: their nature and their relationship to performance
46	(Terry, 1977)	ES	Mechanisms for environmental scanning
47	(Thomas, 1980)	ES	Environmental scanning—the state of the art
48	(Tonn, 2008)	ES	A methodology for organizing and quantifying the results of environmental scanning exercises
49	(Von Bertalanffy, 1972)	ES	The history and status of general systems theory
50	(Voros, 2003)	ES	A generic foresight process framework
51	(Waelchlif, 1992)	ES	Eleven theses of general systems theory (GST)
52	(Wambua & Omondi, 2016)	ES	Factors influencing the environmental scanning of organizations in manufacturing sector: a case study of Kenya breweries limited
53	(Whitney et al., 2015)	ES	Systems theory as a foundation for governance of complex systems

#	Citation	Source field	Title
54	(Yasai-Ardekani & Nystrom, 1996)	ES	Designs for environmental scanning systems: tests of a contingency theory
55	(Vahidi et al., 2018)	ES	Researches status and trends of management cybernetics and viable system model
56	(Bussey, 1996)	Futures	The foresight principle: cultural recovery in the 21st century (review)
57	(Conway, 2009)	Futures	Environmental scanning: what it is, how to do it...
58	(Conway, 2012)	Futures	Doing environmental scanning an overview guide
59	(Dunagan, 2012)	Futures	Designer governance
60	(Gilbertson & Campbell-Hunt, 1990)	Futures	Quick environmental scanning. A New Zealand application
61	(Glenn & Gordon, 2009)	Futures	Environmental scanning
62	(Slaughter, 1999)	Futures	A new framework for environmental scanning
63	(Voros, 2001)	Futures	Reframing environmental scanning: an integral approach
64	(Zhang et al., 2012)	Futures	Perceived environmental uncertainty, information literacy and environmental scanning: towards a refined framework
65	(Abels, 2002)	Information sys.	Hot topics: environmental scanning
66	(Bouhnik & Giat, 2015)	Information sys.	Information gatekeepers – aren't we all?
67	(Choo, 1999)	Information sys.	The art of scanning the environment
68	(Du Toit, 1993)	Information sys.	Significance of the quick environmental scanning technique (QUEST) for information services
69	(Frolick et al., 1997)	Information sys.	Using EISs for environmental scanning
70	(Maier et al., 1997)	Information sys.	Environmental scanning for information technology: an empirical investigation
71	(McCann & Gomez-Mejia, 1992)	Information sys.	Going 'on-line' in the environmental scanning process
72	(Ackoff, 1967)	Management	Management misinformation systems

#	Citation	Source field	Title
73	(Choo, 1993)	Management	Environmental scanning: acquisition and use of information by managers
74	(Wilson & Coreia, 2001)	Management	Factors influencing environmental scanning in the organizational context
75	(Costa, 1995)	Management	An empirically based review of the concept of environmental scanning
76	(D'aveni, 1989)	Management	The aftermath of organizational decline: a longitudinal study of the strategic and managerial characteristics of declining firms
77	(Daft et al., 1988)	Management	Chief executive scanning, environmental characteristics, and company performance: an empirical study
78	(de Geus, 1997)	Management	The living company: habits for survival in a turbulent business environment
79	(Elenkov, 1997)	Management	Strategic uncertainty and environmental scanning: the case for institutional influences on scanning behavior
80	(Gordon & Narayanan, 1984)	Management	Management accounting systems, perceived environmental uncertainty and organization structure: an empirical investigation
81	(Hagen & Amin, 1995)	Management	Corporate executives and environmental scanning activities: an empirical investigation
82	(Leonard, 2000)	Management	The viable system model and knowledge management
83	(Milliken, 1987)	Management	Three types of perceived uncertainty about the environment: state, effect, and response uncertainty
84	(Ojo & Abdusalam, 2011)	Management	Scanning the business environment and its implications on organisational performance: a case study

#	Citation	Source field	Title
85	(Oreja-Rodríguez & Yanes-Estévez, 2010)	Management	Environmental scanning: dynamism with rack and stack from Rasch model
86	(Robinson & Simmons, 2017)	Management	Organising environmental scanning: exploring information source, mode, and the impact of firm size
87	(Samsami et al., 2015)	Management	Managing environmental uncertainty: from conceptual review to strategic management point of view
88	(Saviano & Di Nauta, 2011)	Management	Project management as a compass in complex decision-making contexts: a viable systems approach
89	(Tversky & Kahneman, 1986)	Management	Rational choice and the framing of decisions
90	(Zhang et al., 2011)	Management	The contribution of environmental scanning to organizational performance
91	(Barak, 1984)	Marketing	Teaching environmental scanning: an experimental approach
92	(Frazier, 1983)	Marketing	On the measurement of interfirm power in channels of distribution
93	(Saxby et al., 2002)	Marketing	Environmental scanning and organizational culture
94	(Silverblatt & Korgaonkar, 1987)	Marketing	Strategic market planning in a turbulent business environment
95	(Spitz & Ludlow, 2015)	Marketing	Futuristics and innovation in marketing
96	(Stanwick et al., 1991)	Marketing	Environmental scanning, environmental uncertainty, and the capabilities of the firm: a proposed framework
97	(Beer, 1979)	Managerial Cyber.	The managerial cybernetics of organization. The heart of enterprise
98	(Ashby, 1958)	Managerial Cyber.	Requisite variety and its implications for the control of complex systems
99	(Babatunde & Adebisi, 2012)	Managerial Cyber.	Strategic environmental scanning and organization performance in a competitive business environment

#	Citation	Source field	Title
100	(Beer, 1984)	Managerial Cyber.	The viable system model: its provenance, development, methodology and pathology
101	(Beer, 1994)	Managerial Cyber.	Decision and control: the meaning of operational research and management cybernetics
102	(Beer, 2000)	Managerial Cyber.	Ten pints of Beer
103	(Kets de Vries & Miller, 1984)	Managerial Cyber.	Neurotic style and organizational pathology
104	(Espejo, 1994)	Managerial Cyber.	What is systemic thinking?
105	(Ireland, 2014)	Managerial Cyber.	Systems fundamentals
106	(Leonard, 2009)	Managerial Cyber.	The viable system model and its application to complex organizations
107	(Nechansky, 2013)	Managerial Cyber.	Issues of organizational cybernetics and viability beyond Beer's viable systems model
108	(Pickering, 2002)	Managerial Cyber.	Cybernetics and the mangle: Ashby, Beer and Pask
109	(Haque & Haque, 2016)	Managerial Cyber.	The law of requisite variety and the organizational performance: an empirical analysis of the Pakistani cellular sector
110	(Beer, 1981)	Managerial Cyber.	Environments of decision system four
111	(Cumming & Colllier, 2005)	Managerial Cyber.	Change and identity in complex systems
112	(Espejo, 2000)	Managerial Cyber.	Giving requisite variety to strategic and implementation processes: theory and practice
113	(Gershenson, 2015)	Managerial Cyber.	Requisite variety, autopoiesis, and self-organization
114	(Schwaninger, 2004)	Managerial Cyber.	What can cybernetics contribute to the conscious evolution of organizations and society?
115	(Ackoff, 1974)	Planning	The systems revolution
116	(Bryson, 1988)	Planning	A strategic planning process for public and non-profit organizations
117	(Clemens, 2009)	Planning	Environmental scanning and scenario planning: a 12-month perspective on applying the

#	Citation	Source field	Title
			viable systems model to developing public sector foresight
118	(Fahey & King, 1977)	Planning	Environmental scanning for corporate planning
119	(Fahey et al., 1981)	Planning	Environmental scanning and forecasting in strategic planning—the state of the art
120	(Haynes, 1974)	Planning	Towards a concept of monitoring
121	(Hayward, 2004)	Planning	Facilitating foresight: where the foresight function is placed in organisations
122	(Kahalas, 1977)	Planning	Long range planning—an open systems view
123	(Narchal et al., 1987)	Planning	An environmental scanning system for business planning
124	(Stubbart, 1982)	Planning	Are environmental scanning units effective?
125	**References added in later in coding process**		
126	(Morrison, 1992)	ES	Environmental scanning
127	(Tang, 2016)	ES	Making innovation happen through building social capital and scanning environment
128	(Du Toit, 2016)	ES	Using environmental scanning to collect strategic information: a South African survey
129	(Abu-Rahma & Jaleel, 2019)	ES	Perceived uncertainty and use of environmental information in decision making: the case of the United Arab Emirates
130	(Buche & Querrec, 2011)	ES	An expert system manipulating knowledge to help human learners into virtual environment
131	(Kayode et al., 2020)	Management	Environmental scanning: a strategic management practice tool for increasing smes performance in Southwest, Nigeria
132	(Chouk et al., 2020)	ES	Overview of the research on strategic environmental scanning and competitive intelligence

#	Citation	Source field	Title
133	(de Vasconcelos et al., 2021)	ES	The importance of environmental scanning: a study on the Brazilian hotel industry
134	(Cutting et al., 1990)	Information Sys.	Information theater versus information refinery
135	(Duan et al., 2020)	Management	Understanding the impact of business analytics on innovation
136	(Elofson & Konsynski, 1991)	ES	Delegation technologies: environmental scanning with intelligent agents
137	(García-Carbonell et al., 2021)	Futures	Facing crisis periods: a proposal for an integrative model of environmental scanning and strategic issue diagnosis
138	(González-Ibáñez & Shah, 2010)	Information Sys.	Group's affective relevance: a proposal for studying affective relevance in collaborative information seeking
139	(Ikebujo, 2020)	ES	Environmental scanning as a process of strategic decision-making-a review
140	(Katopol, 2014)	ES	Managing change with environmental scanning
141	(Lekkas et al., 1995)	Planning	Development of distributed problem-solving systems for dynamic environments
142	(More et al., 2015)	Planning	Improving long-term strategic planning: an analysis of STEEPLE factors identified in environmental scanning brainstorms
143	(Wertheim, 2002)	Management	Negotiations and resolving conflicts: an overview
144	(Phornlaphatrachakorn & Na-Kalasindhu, 2020)	Management	Strategic management accounting and firm performance: evidence from finance businesses in Thailand
145	(Pryor et al., 2019)	ES	Top executive goal orientations' effects on environmental scanning and performance: differences between founders and nonfounders
146	(Sun et al., 2021)	Information Sys.	Roles of dynamic capabilities and knowledge management

#	Citation	Source field	Title
			strategies on organizational performance
147	(Temtime, 2006)	ES	Monitoring environmental complexities and changes: some lessons from small firms
148	(Weick et al., 2005)	ES	Organizing and the process of sensemaking
149	(Yolles, 2006)	Managerial Cyber.	Organizations as complex systems: an introduction to knowledge cybernetics
150	(Zhang et al., 2012)	ES	Perceived environmental uncertainty, information literacy and environmental scanning: towards a refined framework

APPENDIX H

SIMPLIFIED CODE DATABASE (CODE DNA)

The text displayed below is an Excel® spreadsheet abstract from the research NVivo code database. It displays codes down to the fourth tier. There are eight tiers of nested codes, with the highest level identified as an umbrella theme, and the lowest level as an open code from the Initial Coding process. The Axial and Selective Coding processes combined codes together into similar-meaning tiers. The code tier structure is given in the table below. Each tier is an abstraction of the tier below it and supports the tier above it. The abstractions come from the abductive inference process. The tier structure is necessitated by the considerable number of open codes. In lieu of having hundreds of open codes with single code-references supporting them, this researcher chose, for practical purposes, to combine open codes with similar meaning code-references into higher tiered sub-codes that "collected" open codes of similar meaning. The abductive inference process operated primarily at the collective-code and higher tier levels but supported this collecting of similar codes. Constantly comparing several hundred codes in a meaningful way was not practical without reducing the numbers to a practically manageable number. This was done by abstracting open codes of similar meaning into larger code groupings. The code data in this appendix is structured starting from collective code line items (no numbers) into categories, identified as C1,2,3…. The categories are then abstracted into themes identified as T1,2,3… (e.g., T1-C1 representing theme 1 and category 1 for that theme). The 17 themes support the one umbrella theme. The set of 17 themes is the ES framework grounded in Systems Theory in response to research question 1. Each line of text below the bolded category designator (e.g., **T1-C1**) is either a collective or open code. The indented lines of text are wrap around text from the line above to stay within the appendix margins. The themes and theme supporting categories are listed in NVivo sort order which is based upon the number of source references that the codes are abstracted from, starting with T1 citing the most sources references and T16 having the fewest. What is not shown in the list below is the code structure below the collective code, down the code tier structure to the code-reference. An example of that structure was provided in Chapter 5 and is detailed by numbers in Appendix I.

Code tier structure

Tier Level	Tier Name
1	Umbrella Theme
2	Theme
3	Category
4	Collective-code
5	Sub-code (1)
6	Sub-code (2)
7	Sub-code (3)
8	Open code

ES theory-ES functions support complex system viability through regulation of internal and external variety induced by external changes

T1-Developing system knowledge from environmental information (data) to support system future viability

T1-C1-Developing actionable system knowledge to improve system viability

developing system knowledge by analyzing trends, patterns, and precipitating events in the internal & external environment

informing the development of the system strategic plan

developing scenarios to position the System for future viability.

developing models of the system's present, future, and environment of the system to ensure

future viability
scanning for knowledge
developing system knowledge by measuring performance
developing system intelligence by harnessing oceans of data with an information theatre
developing a knowledge cache with IT tools to monitor the environment
creating knowledge to output to the environment
providing a base of objective qualitative information about the environment;
the system should be integrating all the information collected.
perform its information providing role for the company's strategic decision making
T1-C2-Identifying future issues critical to system development
planning for future
identifying knowledge with aim of anticipating threats and opportunities
Identifying future relationships critical to system development
describing important future developments
imagining future details for system responsiveness
proposing solutions to problems
seeking a connection with future events
extrapolating into the future
allowing for changes
anticipating situations of discontinuity
ES external products
exploiting markets to determine opportunities for action
Focusing on critical success factors
focusing on long range development for viability
identifying major trends impacting systems
implementing structural or strategic adaptions
T1-C3-Encouraging interest in the internal-external environment to improve system awareness
enhancing environmental perceptions
generating environmental awareness
coordinating externally
coordinating internally
fitting with the environment
necessitating understanding of the environment
discussing what is happening
encouraging system agents to become interested in the external environment
focusing internally
listening practices
outlining relevant factors
plotting impactful issues
presenting internal problems
T1-C4-Becoming aware of weak signals in the environment for proactive decision making
anticipating environmental changes
translating external influences into useful information
identifying and processing weak signals
amplifying weak signals to generate environmental scenarios
differentiating weak signals from routine vibrations

distinguishing relevant indicators foreseeing changes from mass of data
Extracting cause-effective chains from weak signals to prevent problems
finding weak signals for proactive decision making
giving guidelines to identify patterns for strategic advantage
opening out mind space to see weak signals
proactively showing weak signals is unclear in turbulence
scanning for wildcards
spiral dynamics for filtering perceptions

T1-C5-Generating actionable knowledge from the environment for decision making

apprehending knowledge
bringing knowledge into the system for value creation
exploiting external information for intelligible knowledge
using descriptors to indicate relevant events
collecting knowledge
managing knowledge
Turning circumstances into actionable knowledge
entering of knowledge
facilitating the important role of information collection and analysis for strategic decision making
generating early warnings
generating information about competitors and customers
generating knowledge
Only relevant information that may have an impact on the enterprise should be included in the system.
pulling information together to support decision making
shaping diverse potential scenarios
transforming data into strategic advantage

T1-C6-Sensemaking of environmental data to develop actionable knowledge

sensing environment trends
affecting environmental relevant knowledge development with affective relevance in information seeking
sensemaking for opportunities
interpreting the environment for actionable information
materializing meaning from environmental data
sensemaking for developing plausible images of the external environment
sensemaking for future action-oriented decision making
sensemaking for threats
sensemaking of environmental data for future oriented, actionable information
sensing for control of environment
sensitizing an organization to the changing needs and wishes of its customers;
turning environmental circumstances into actionable information

T1-C7-Foreseeing changes in the external environment to develop actionable knowledge

learning of opportunities to correct system design errors
identifying challenges

Identifying environmental patterns, activities, or events
capture emanating problems
focusing on environmental disturbances
foreseeing environmental influences
identifying trends
isolating environmental change for closer attention
scanning external environment for opportunities and threats
reflecting upon environment to identify strategic positions
T2-Acting on information from the external environment to create system value
T2-C1-Acting on environmental information to anticipate future changes
adapting to environmental changes as system learning
Acting on environmental information to benefit the system
acting on environmental intelligence for action
changing entry point to match shifts
concentrating forces for analysis
counterbalancing operational values for system eudemony
creating internal tensions for system identity requisite behavior
distributed problem-solving leads to continuity of knowledge
expert systems monitoring knowledge can be used to solve a problem automatically
guiding investment priorities
information that impacts the future of the institution and its programs.
learning about events and trends in the external environment;
T2-C2-Processing scanning inputs for system wide implications and decision making
Processing internal inputs to the system of interest
processing external inputs to the system of interest
flowing of information for decision making
scanning results integrating with system strategy
sharing scanning results for evaluation
facilitating and developing strategic thinking in organizations.
Processes inputs for system wide implications
T2-C3-Acting on scanned information for decision making
processing of environmental information for consistent decision, action, and interpretation
Reporting trends in the environment
scanning for SWOT analysis
Emerging from interactions between a system and its environment
exchanging information with environment for survival
integrating scanned information into decision making
knowing actions to select from available actions
looking for change actively
reasoning with cause-effect chains
securing information across sectors for competitive advantage
acting on environmental information
being prepared for environmental shifts
early warning system of possible changes

forcing engagement between scanning and operations
generating scenarios to support decision making
making subjective assessments of environmental information value
providing intellectual stimulation to strategists in their decision making;
representing a wide range of knowledge and changes
scanning for anticipatory management
scanning for success
scrutinizing environmental developments for most impact
selling information to get along
sharing information for management action
T2-C4-Responding to internal-external environmental information to improve system performance
responding to perceived environments
responding in more timely and effective manner
responding to competition
responding to internal system flux
responding to markets
responding to scanned info for performance
T2-C5-Using scanned information for strategy development
scanning usefulness for strategy development
Accurate analysis of environmental information is the basis for anticipating the future
enabling decision makers to translate environmental understanding to planning and decision making
providing useful strategic information, which is achieved by focusing on target information needs, allocating effort among those exposed to relevant information, and having an effective system for storing, process
sensitizing to relevant trends
to understand external forces of change so that they may develop effective responses that secure or improve their position in the future”
T2-C6-Screening large bodies of information for relevancy to system goals
Establishing information refineries to harness environmental data
making sense of the data;
screening and analyzing information relevant to system goals
screening input information that can intake to system
Screening large bodies of information for specific purposes
T3-Actively obtaining (proactive scanning) system external environmental information to support system planning
T3-C1-Actively searching and capturing pertinent emergent environmental conditions and events in support of strategic decision making
scanning for future planning
acquiring information for strategic implications
Gathering information to respond to external changes
picking up environmental signals
scanning actively

scanning product development for future planning
scanning the external environment
active searching
detecting information
scanning external sources
searching formally
examining the external environment
exploring external environment
identifying relevant information
searching informally
collecting useful information from environment for future planning
scanning external environment for information to key managers
scanning the task environment
employing structured data collection and processing systems for planning
scanning focuses on external forces
scanning the horizon
semantic searching
semantic searching to predict future events
ES typically does not have to deal with purposely obfuscated information
satisficing searches when goal and process clarity are high
scanning is an active process
scanning the general environment
scanning the societal environment
scanning with dual mode of searching and reasoning
T3-C2-Proactively researching the environment for information leading to better performance
identifying relevant environmental information
scanning externally for information
scanning for environmental researching
development of a systemic worldview for environmental influence that focuses on proactive vs. reactive engagement with the environment.
obtaining accurate insights for satisfying customers
scanning data from the competition
T3-C3-Proactive information seeking for system learning and use
ES is seeking information
targeting information needs
developing a systems-based framework for holistically sensing environmental information
organized learning as a governance practice
proactive engagement with the environment
Seeking signs of change.
systematic listening in competitive environment as a scanning function
T4-Identifying system transformation objectives in support of future system viability
T4-C1-Identifying mechanisms for valuing system intelligence
Selecting issues and trends for reaction
guiding future development

organizational learning for change
Learning for correcting system design errors
organizing in response to the environment
balancing between present and future for informed decision making
continuously adapting to environmental changes
signaling change
Generating system awareness to facilitate system adaption
aligning perceptions to real environment
allocating functional responsibilities for change
correcting metasystem design error
improving internal operations and processes
improving performance with systems thinking
Scanning with EIS
addressing wicked problems and undecidable issues
anticipating variation
changing system policy and identity
Identifies mechanisms for Double Loop Learning
invoking minimal constraints for performance
overcoming system internal divisions
scanning intuitively
scanning to cause a wicked problem between past and future to enhance viability
Scanning using AI
scanning with artificial neural networks
T4-C3-Assisting in strategic decision making for improved performance
Assisting strategic decision making using external information
facilitating decision making
scanning related to improved system performance
helping decision making process
scanning to develop and modify strategy
classifying patterns of indicators in the environment
scanning for making timely responses
T4-C4-Facilitating planning for transformation of the system
Facilitating planning from environmental changes
fostering system transformation
T4-C2-Innovating through the ES functions for sustained system development during environmental changes
Enhancing innovation with scanning to focus on forward looking
Scanning a driver of system innovation for strategic change
Unleashing innovation to mitigate limitations on how to reach a preferred future
Organizational innovativeness related to ES for system survival
T4-C6-Setting goals in response to system forecasts
setting degree of openness
assisting in setting goals in response to environmental forecasts
developing change towards higher integration by identifying opportunities

resisting obstructions to obtain goals
T4-C7-Guiding future product development to improve system performance
exploring new market segments
positively affecting entrepreneurship development
real-time monitoring of products
sensitizing an organization to the changing needs and wishes of its customers;
T4-C5-Knowledge tracking to create pathways of action
action research resulting from migrating knowledge
creating directed pathways
creating improvement
examining interactive change from knowledge tracking
examining organizational change from a knowledge perspective,
exploration and explanation of organizational change from a knowledge perspective
knowledge a driver of viability
knowledge definition
T4-C8-Modeling the environment to invent the future to reduce fear
Modeling to invent future
T4-C9-Distributed problem solving to provide better solutions to environmental complexity
Improving system performance with distributed problem-solving techniques
Problem solving with expert systems to enhance solution sets
Environmental knowledge development is enhanced with distributed problem-solving processes
T8-Evolving the governance system functions in support of future system viability
T8-C6-Detecting and correcting governance system design issues in order to keep pace with external changes
system controlling for stability in turbulent environment
enhancing performance with ES
learning for transformation
achieving congruence between environment and system structure
detecting and correcting system design issues
experimenting for improvement
enhancing system value
interacting internally for change
causal mapping
developing competence from ES outcomes
developing effective responses to improve future position
gatekeeping for preservation
modernizing the system to keep pace with changes
shaping possible, diverse scenarios
T8-C2-Mind-shifting thinking for building responsiveness to future events
mind-shifting towards future external issues
developing responses for improving the future
affecting continued existence
exploring new ideas
futuristic scanning for objective setting

T8-C3-Evolving the system design in response to environmental changes
Evolving the system design for changes in the environment
matching opportunities with capabilities
continuous dialogue between models of future and self to manage dilemmas
external positioning for profit
reorganizing in response to change
T8-C1-Regulating the system's governance function to deal with emergence
regulating the system internally-externally
emergent governance to regulate unpredictability
thinking for governance
governance accommodating wide range of evidence
governance function dealing with rapidly changing environment
governance function evolving with changing world
governance of system command structure
governance to consider both internal-external system nature as integral and intrinsic
governance to establish stability
governance to provide viability in complex systems
governance to weather the turbulence of emergence
redesigning governance
scanning in system governance
T8-C7-Analyzing governance system design issues for improved system performance
learning for system success
answering key questions
detecting of metasystem error
determining stakeholder required outputs
learning for system efficiency
providing analysis of metasystem design errors
providing for second order learning
providing identification of metasystem design errors
T8-C4-Syntropic behavior to avoid disorientation in complexity
establishing common world view for action
generating a syntropic effect in bringing together the efforts to achieve goals,
system design becoming a pathway of reference to follow
T8-C5-Developing a capacity for self-assessment to improve governance design
developing a capacity for self-assessment
governance responsibility for self-assessment
governing processes include self-assessment
T8-C8-Restructuring from knowledge tracking to respond to environmental issues
broadening perspectives by knowledge tracking in support of restructuring (Codes)
comprehensive ES for restructuring
T5-Designing environmental scanning system processes for internal and external functions to support system present and future viability
T5-C1-Designing scanning processes to ensure ES is effective for future planning
designing the governance system for sensing the environment

designing for system capabilities
designing for change in governance
developing scanning design processes
identifying scanning needs for design purposes
scanning designs related to organizational strategy
designing through environmental issues
designing an ES system
designing strategies to cope
scanning systems advanced
designing a communications strategy
participating in scanning design
scanning design scenarios
scanning designs related to organizational culture
Assigning scanning responsibilities to support decision making
designing an expert system for monitoring system knowledge
designing for minimal critical specifications
designing future courses of action
designing scanning framework
scanning design approach associated with organizational culture and generic strategy
understanding collectivities for future design challenges
understanding collectivities for future design challenges (2)
T5-C3- Improving ES system design by recognizing ES system pathologies
ES functions difficult to implement
ES processes failing in complexity
ES function declines as environment perceived to be more complex
T5-C2-Scanning design strategy needed to pursue system adaptive strategy
scanning as a strategic activity
scanning design elements supporting strategic decision makers
scanning processes influenced by internal and external factors
developing external scanning focus
integrating scanning activities into planning processes
QUEST scanning technique design for examining future trends that impact system strategies
scanning function investment is for the long term
taking on a more adaptive outlook
widening and deepening the system scanning frame
T5-C4-Linking ES system design to contextual factors for effective scanning functions
effective scanning systems impacted by contextual variables
Modern IS influencing ES system conceptual design
communicating ES system design top down
delegating responsibility for ES functions
delegating scanning systems responsibilities
environmental conditions impacting ES system design
ES system design role by mediating

Executing the environmental scanning designs
performing system design withing system context
selecting most important scanning areas
T6-Regulating internal-external variety generated from external turbulence to support system viability
T6-C1-Reducing external variety to achieve requisite variety with the internal system
Filtering to reduce environmental variety
managing the external environment
reducing environmental variety for desirable performance
screening large body of information for relevancy to system goals
unfolding complexity to achieve requisite variety
buffering to weaken environmental influence
decreasing uncertainty in response to disturbances
ES systems cannot track every possible event
information refineries for reducing environmental variety
alternative groupings necessary in evolving system
bounded rationality and cognitive reapportionment to reduce limited capacity in assessing environmental information
distributed problem solving supports improved system coordination
expert systems can be used to reduce environmental knowledge base complexity
reducing information variety through CAS
segregating them from environmental factors and may prevent or permit entry of matter, energy, and information.
system under capacity for environment complexity
T6-C3-Designing the system for variety regulation (Internal-external)
matching environmental variety
designing for system requisite variety to maintain viability
disposing of internal and external variety to maintain existence
matching environmental complexity for pro-action
modeling mechanisms for variety regulation to deal with environmental complexity
achieving requisite variety in contemporary systems with new technologies
engineering regulatory capacity to deal with environment generated variety
adapting at same rate as environment change rate
Applying systems approaches to organization design in order to achieve requisite variety
controlling span of data management without losing information
integrating requisite variety into governance functions
maintaining constancy in face of environmental influences
system regulation to match internal and external variety
T6-C2-Generating internal variety to meet environmental input
developing internal variety to meet environmental contingencies
amplifying information
increasing variety of options to respond to environmental changes
developing capacity for requisite response
generating internal variety to control environmental variety

amplifying information to conserve variety
autopoietic production of complexity greater than the environment
developing less biased environmental interpretations
Distributed problem solving to amplify internal variety
increasing variety of actions to take
using information to reduce equivocality
T6-C6-Scanning internally to identify absorbed and residual internal system variety to help plan for the future
scanning internally
scanning influenced by organizational factors
identifying internal factors that will determine the future
actively monitoring internal actions for oscillations
obtaining scanning information from internal sources
T6-C4-Developing absorptive capacity for environmental data to support system development
assimilating new external information to commercial ends (ACAP)
creating competitive advantage from absorptive capacity
absorption of environmental variety
Absorptive capacity to align internal and external rates of change
enhancing system innovation through business analytics
filtering information for system resonance
having capacity to make sense of things
using business analytics to enhance ES effectiveness
T6-C5-Active controlling to prevent variety transmission
reducing equivocality
active controlling to meet external complexity
controlling to prevent transmission of environment variety
controlling system variety higher than environmental variety
controlling to balance emergence and self-organization
controlling to reduce impact of environmental perturbations on system internal states
deliberately cultivating a flexible repertoire
reducing blind sidedness for greater anticipatory management
T6-C7-Manipulating the system's environment through political negotiation to enhance system viability
Changing a system's external environment through political negotiation
T7-Disseminating essential environmental information (internal-external) throughout the system to support decision making
T7-C1-Communicating internally about future events to support decision making
providing scanning information for strategic decision making
disseminating internal and external information in the system
external intelligence gathering and communicating internally
communicating for sensing of the environment
communicating internally for decision making
strategic environmental scanning leading to profitability
communicating about future issues

communicating results
communicating within
Presenting external information for executive decision making
information use and management as a core scanning function
inputting to governance system for foresight
scanning contributes to increased internal communication for the decision-making process
scanning reduces the internal time lag of recognizing environmental changes
T7-C2-Exchanging information between the system and its environment for survival
systems exchanging information with their environment
boundary-scanning for horizontal information exchanges
exchanging information for use by the system
exposing the system to relevant information
feeding information to develop operational plans
T7-C3-Gatekeeping for distributing information to facilitate adaption
sharing new information within the system
gatekeeping information channels to disseminate information
T7-C4-Facilitating environmental intelligence to expand system understanding
facilitating expanding awareness
Providing for communication access throughout the metasystem
T13-Looking at (viewing) the external environment to identify information of interest (passive scanning)
T13-C1-Monitoring critical aspects of the external environment for relevant information
monitoring critical aspects of the external environment
monitoring for sensing of the environment
Monitoring their environment
monitoring indicators
observing variables
monitoring environmental changes to prepare for future
monitoring information
monitoring the external environment
T13-C4-Viewing the external environment for changes and opportunities
viewing information
conditioned viewing
directed viewing
long term viewing
opening up viewing with interior consciousness to reduce scanning blindness
visioning the external environment
T13-C2-Looking at information for topics of interest
looking at information (viewing)
passive scanning associated with internally focused strategies
information capturing
Looking for forecasts of experts
Looking for indirect effects.
looking for information for planning and decision making

looking for key issues to anchor scanning function
looking for things that are likely to happen
seeing the environment
T13-C3-Sensing the external environment for information in response to perturbations
obtaining existing external data
finding information
passive observation of the environment
passive sensing of the environment
reacting to the environment
T9-ES system responding rationally to environmental turbulence to support system viability
T9-C1-ES key to surviving in environmental uncertainty
scanning in turbulence
Scanning in environmental dynamism to be competitive
aligning ES functions for survival in rapidly changing environment
studying turbulence for strategic thrusts
scanning in hostile environment
T9-C3-Greater ES flexibility needed to deal with increased turbulence
Increasing scanning in increasing environmental complexity
environmental turbulence influences ES
scanning in rapid changes
scanning amount related to environmental uncertainty
scanning for sensitivity to the environment
The system should be flexible and adaptive to changes in the environment.
T9-C2-Shaping scanning functions in environmental complexity for strategic decision making
applying artificial neural networks to gather environmental information
enabling decision makers to understand external environment
expert knowledge-based systems to gather environmental data
it helps an organization capitalizing early on opportunities;
providing an early signal of impending problems;
quantifying dynamics in turbulent environments
serving as a court of appeal within and over governance disputes
shaping ES functions to respond to environmental changes
T9-C4-Requiring alertness to world views to be comfortable with complexity
Being comfortable with uncertainty to be able to see into the future
being uncomfortable with uncertainty when scanning
environmental scanning is to identify changes that will influence an enterprise's activities.
responding rapidly to challenges in a timely and effective manner.
T9-C5 Improving system image by demonstrating responsiveness to a changing environment
improving the image of the organization with its publics by
showing that it is sensitive to its environment and responsive to it.
T10-System-environment Influencing to prevent future problems
T10-C1-System-environment influencing for survival
boundary spanning to link a system with its environment
System-Environment influencing for system survival

adequate exchanges with environment for survival
giving and receiving system inputs and outputs with the environment
establishing organizational to environment connections
influence diagramming for probable future scenarios
liaising with environment
T10-C3-System influencing its external environment to meet system needs
System proactively influencing its environment for strategic decision making
intervening into the environment
capacity to influence the external environment
influencing one's environment
T10-C2-System permeability to external information to support influencing the environment
external information influencing internal decision-making process
continuously redesigning the system to change
customer integrations creating ES information
environmental influences on a system
permeability to external influences
positioning the organization in response to environmental information
taking energy from the environment
T17-Understanding the systemic role of scanning functions to enhance effective system governance
T17-C3-Considering systemic functions that contribute to system viability
scanning in complex environment
scanning with systems thinking
considering systemic functions that contribute to system viability
scanning with systemized approach
T17-C1-Offering a systems-based approach for universal applicability and easy deployment for successful governance
offering a systems-based approach for universal applicability, easy deployment, and successful results
T17-C2-Understanding governance with a systems holistic approach for system sustainability
understanding governance with a systems holistic approach
enabling decision makers to understand interconnections
T17-C4-Developing a systems-based framework for proactively and holistically analyzing and engaging the environment
developing a systems-based framework for holistically analyzing the environment
T14-Resolving perceived-actual environmental trends to support effective decision making
T14-C3-Scanning behaviors influenced by perceived environmental uncertainty affecting decision making
ES function declines as environment perceived to be more complex
Scanning behaviors influenced by perceived environmental uncertainty
(opportunity assessment), which enables a manager to perceive various types of information in the uncertainty environment
T14-C1-Scanning occurring through perception filters conditioning what can be seen
scanning occurring through perception filters

T14-C2-Decision making through environmental perceptions influencing managerial decision making
decision making through environmental perceptions
first step in the ongoing chain of perceptions and actions leading to an organization’s adaptation to its environment
T14-C4-Awareness of environment perception and reality-construction for enhanced performance
awareness of environment perception and reality-construction for enhanced performance
talking an environment into existence to materialize meaning
T12-Maintaining a model of the governance meta-system to support reducing system dilemmas
T12-C2-Constructing models of the governance system to enhance system understanding
embracing a model of the system to support governance processes
Governance model resting in systems theory and management cybernetics
conceptualizing a systems existence for enhancing understanding
creating a model of itself (the system)
governance as a network of intelligent entities to support better habits of thought
using sophisticated technologies to deal with complexity
T12-C1-Modeling a system's environment to support envisioning the future
continuous dialogue between models of future and self to manage dilemmas
creating a virtual environment
modeling the anticipated future
operating in a virtual environment outside reality
providing an environment through simulation
simplifying system models to reduce complexity but remain congruent
virtual environment immersion for learning
T11-Implementing ES system models for effective scanning in changing environment
T11-C2-Maintaining system models to support ES system designs
modeling of system environment to guide ES strategy
maintaining models of the current and future system for long range strategic development
improving an organization’s abilities to deal with a rapidly changing environment in various ways
T11-C1-Implementing scanning system design models to support system viability
modeling the scanning system for long-range development viability
T15-Storing and retrieving scanned information for future use
T15-C1-Storing scanned information for future use
storing scanned information for future use
T15-C3-Managing information as the core of the scanning function
managing information as the core of the scanning function
plotting the issues which are likely to impact on the company so it can be prepared to respond to them when they arise.
T15-C2-Retrieving non-trivial data for future use
retrieving non-trivial data for future use
T15-C4-Establishing information refineries to influence system strategy
establishing information refineries
information refineries influencing system strategy and structure

T16-Sustaining system identity through environmental changes for system survival

T16-C1-Sustaining system identity in dynamic limitations as a solution to problems

sustaining system identity in dynamic limitations

T16-C2-Determining future system identity by a chance event

future system identity may be determined by chance

APPENDIX I

CODE DNA BY THEME AND NUMERICAL COUNT

This appendix is the code DNA structure of the research code database. It is summarized at the category level and at each code level above category. The table lists the number of total codes that are databased underneath each category, and the sum of their source references and code-references. For example, category T1-C1 has 144 codes that are abstracted into the category description. Those 144 codes include references to source literature 127 times, and those 144 codes are comprised of 665 code-references from those 127 source file references. Examples of code and category structure are shown in Chapter 5. The Theme's numbers are the sum of the categories' numbers underneath them. The source file numbers are not additive as the numbers represent the unique occurrences of the source references in each category and theme. For example, Theme 1 has 127 unique source files that were referenced in constructing that theme. T1-C1 has 116 unique source files that were referenced in constructing that category. 116 of those from the category are part of the 127 at the Theme level. Each of the 1306 codes is traceable in NVivo to the source file text code-reference and are counted in the numbers in this table. An example of this structure was provided in Chapter 5.

	Number of total codes in level	**Number of source files referenced in level**	**Number of code-references embedded in level**
Umbrella Theme: ES functions support complex system viability through regulation of internal and external variety induced by external changes	1306	150	3414
Theme 1: T1-Developing system knowledge from	232	127	1051

	Number of total codes in level	Number of source files referenced in level	Number of code-references embedded in level
environmental information (data) to support system future viability			
T1-C1-Developing actionable system knowledge to improve system viability	144	116	665
T1-C2-Identifying future issues critical to system development	19	48	86
T1-C3-Encouraging interest in the internal-external environment to improve system awareness	14	16	28
T1-C4-Becoming aware of weak signals in the environment for proactive decision making	13	21	35
T1-C5-Generating actionable knowledge from the environment for decision making	16	22	40
T1-C6-Sensemaking of environmental data to develop actionable knowledge	16	19	54
T1-C7-Foreseeing changes in the external environment to develop actionable knowledge	10	71	143
Theme 2: T2-Acting on information from the external environment to create system value	81	96	325
T2-C1-Acting on environmental information to anticipate future changes	20	67	160
T2-C2-Processing scanning inputs for system wide implications and decision making	15	37	58
T2-C3-Acting on scanned information for decision making	23	33	57
T2-C4-Responding to internal-external environmental information to improve system performance	6	21	33
T2-C5-Using scanned information for strategy development	11	7	10
T2-C6-Screening large bodies of information for relevancy to system goals	6	5	6
Theme 3: T3-Actively obtaining (proactive scanning) system external environmental information to support system planning	60	94	391
T3-C1-Actively searching and capturing pertinent emergent environmental conditions and events in support of strategic decision making	46	86	357
T3-C2-Proactively researching the environment for information leading to better performance	6	18	21
T3-C3-Proactive information seeking for system	8	9	13

	Number of total codes in level	Number of source files referenced in level	Number of code-references embedded in level
learning and use			
Theme 4: T4-Identifying system transformation objectives in support of future system viability	99	94	361
T4-C1-Identifying mechanisms for valuing system intelligence	46	59	140
T4-C2-Innovating through the ES functions for sustained system development during environmental changes	9	6	29
T4-C3-Assisting in strategic decision making for improved performance	10	43	103
T4-C4-Facilitating planning for transformation of the system	2	26	35
T4-C5-Knowledge tracking to create pathways of action	8	2	14
T4-C6-Setting goals in response to system forecasts	4	6	19
T4-C7-Guiding future product development to improve system performance	4	4	4
T4-C8-Modeling the environment to invent the future to reduce fear	1	2	2
T4-C9-Distributed problem solving to provide better solutions to environmental complexity	15	2	15
Theme 5: T5-Designing environmental scanning system processes for internal and external functions to support system present and future viability	72	67	191
T5-C1-Designing scanning processes to ensure ES is effective for future planning	22	46	93
T5-C2-Scanning design strategy needed to pursue system adaptive strategy	9	8	21
T5-C3-Improving ES system design by recognizing ES system pathologies	31	29	60
T5-C4-Linking ES system design to contextual factors for effective scanning functions	10	6	17
Theme 6: T6-Regulating internal-external variety generated from external turbulence to support system viability	83	62	231
T6-C1-Reducing external variety to achieve requisite variety with the internal system	25	28	64
T6-C2-Generating internal variety to meet	11	15	49

	Number of total codes in level	**Number of source files referenced in level**	**Number of code-references embedded in level**
environmental input			
T6-C3-Designing the system for variety regulation (internal-external)	13	23	50
T6-C4-Developing absorptive capacity for environmental data to support system development	8	7	26
T6-C5-Active controlling to prevent variety transmission	9	6	10
T6-C6-Scanning internally to identify absorbed and residual internal system variety to help plan for the future	6	15	19
T6-C7-Manipulating the system's environment through political negotiation to enhance system viability	11	3	13
Theme 7: T7-Disseminating essential environmental information (internal-external) throughout the system to support decision making	23	59	138
T7-C1-Communicating internally about future events to support decision making	14	48	116
T7-C2-Exchanging information between the system and its environment for survival	5	13	16
T7-C3-Gatekeeping for distributing information to facilitate adaption	2	6	10
T7-C4-Facilitating environmental intelligence to expand system understanding	2	2	2
Theme 8: T8-Evolving the governance system functions in support of future system viability	81	81	231
T8-C1-Regulating the system's governance function to deal with emergence	15	12	38
T8-C2-Mind-shifting thinking for building responsiveness to future events	11	17	25
T8-C3-Evolving the system design in response to environmental changes	6	13	16
T8-C4-Syntropic behavior to avoid disorientation in complexity	3	3	4
T8-C5-Developing a capacity for self-assessment to improve governance design	3	1	3
T8-C6-Detecting and correcting governance system design issues in order to keep pace with external changes	33	58	116

	Number of total codes in level	Number of source files referenced in level	Number of code-references embedded in level
T8-C7-Analyzing governance system design issues for improved system performance	8	8	23
T8-C8-Restructuring from knowledge tracking to respond to environmental issues	2	1	6
Theme 9: T9-ES system responding rationally to environmental turbulence to support system viability	29	26	64
T9-C1-ES key to surviving in environmental uncertainty	5	11	23
T9-C2-Shaping scanning functions in environmental complexity for strategic decision making	12	6	15
T9-C3-Greater ES flexibility needed to deal with increased turbulence	7	10	14
T9-C4-Requiring alertness to world views to be comfortable with complexity	4	2	10
T9-C5-Improving system image by demonstrating responsiveness to a changing environment	1	1	2
Theme 10: T10-System-environment influencing to prevent future problems	18	24	63
T10-C1-System-environment influencing for survival	7	15	37
T10-C2-System permeability to external information to support influencing the environment	7	6	12
T10-C3-System influencing its external environment to meet system needs	4	10	14
Theme 11: T11-Implementing ES system models for effective scanning in changing environment	4	12	24
T11-C1-Implementing scanning system design models to support system viability	1	1	4
T11-C2-Maintaining system models to support ES system designs	3	11	20
Theme 12: T12-Maintaining a model of the governance meta-system to support reducing system dilemmas	13	13	41
T12-C1-Modeling a system's environment to support envisioning the future	7	3	11
T12-C2-Constructing models of the governance system to enhance system understanding	6	12	30

	Number of total codes in level	**Number of source files referenced in level**	**Number of code-references embedded in level**
Theme 13: T13-Looking at (viewing) the external environment to identify information of interest (passive scanning)	30	58	189
T13-C1-Monitoring critical aspects of the external environment for relevant information	8	33	74
T13-C2-Looking at information for topics of interest	9	14	33
T13-C3-Sensing the external environment for information in response to perturbation	5	12	17
T13-C4-Viewing the external environment for changes and opportunities	8	23	65
Theme 14: T14-Resolving perceived-actual environmental trends to support effective decision making	8	18	37
T14-C1-Scanning occurring through perception filters conditioning what can be seen	1	7	12
T14-C2-Decision making through environmental perceptions influencing managerial decision making	2	6	7
T14-C3-Scanning behaviors influenced by perceived environmental uncertainty affecting decision making	3	10	13
T14-C4-Awareness of environment perception and reality-construction for enhanced performance	2	4	6
Theme 15: T15-Storing and retrieving scanned information for future use	7	9	17
T15-C1-Storing scanned information for future use	2	5	10
T15-C2-Retrieving non-trivial data for future use	1	2	2
T15-C3-Managing information as the core of the scanning function	2	3	3
T15-C4-Establishing information refineries to influence system strategy	2	1	2
Theme 16: T16-Sustaining system identity through environmental changes for system survival	9	7	21
T16-C1-Sustaining system identity in dynamic limitations as a solution to problems	7	6	19
T16-C2-Determining future system identity by a chance event	2	2	2
Theme 17: T17-Understanding the systemic role of scanning functions to enhance effective system	17	21	40

	Number of total codes in level	**Number of source files referenced in level**	**Number of code-references embedded in level**
governance			
T17-C1-Offering a systems-based approach for universal applicability and easy deployment for successful governance	2	4	5
T17-C2-Understanding governance with a systems holistic approach for system sustainability	6	3	3
T17-C3-Considering systemic functions that contribute to system viability	6	14	24
T17-C4-Developing a systems-based framework for proactively and holistically analyzing and engaging the environment	3	3	8

APPENDIX J

EXAMPLE OF MEMOING AT THEMATIC/THEORETICAL LEVEL

This appendix is the Fifth pass thematic development memo copied from the researcher's NVivo Notes-Memo Database. It is shown as an example of thematic memos that were written into NVivo during the Progressive Coding process as it was being performed. This is raw data that was recorded in annotation style as the coding process was being performed. It is listed by date when the work was done, it captures the thinking behind changes to the coding database, it is written from the researcher's perspective at time the note was made. It is not in formal grammar format.

-10/06/21-begining 5th pass. 5th pass will deal largely with categories and themes not working at open code level unless indicated. Thematic development appears saturated from the pass 4 efforts to pull out and identify any new thematic directions and none were found outside of what was already in place. In fact, some consolidation is to be considered due to overlap in some topical areas. Pass 5 will examine the independence/overlap in themes and categories with the intent of combining if close or substantiate if mostly independent or create a new thematic direction. This function is part of constant comparative method and thematic saturation demonstration, and theory assessment. To assess the thematic saturation point in pass 5, the following algorithm will be applied:

- Do the embedded concepts exhaust the variation in types of themes?
- Is each of categories/themes conceptually grounded in systems theory principles?

- Should the categorization of the themes be refined to encompass additional types and strategies or to eliminate one or more of them?
- No matter the number of categories, are they both exhaustive and mutually exclusive?
- Do I have the data to describe the causes and conditions for, and consequences of, using these themes?
- Are the themes both explicable and understandable to an evaluating audience?

-looking at the affinity diagram, T3 and 13 have the least overlap with 5. T 4,5,9 have the most with 14. T3 and 13 were actively separated in pass 4 as separate ES functions having 3 active, 13 passive, and theme descriptions now state the same. T4,5,9 also seem independent from pass 4 analysis. T13 & T2 should be examined due to similarity in word structure. T13 has 1 category and 12 codes, which makes it hard to compare due to minimal supporting data. I will attempt to combine codes into categories if functions can be aligned closely. The result is 3 new categories for looking, sensing, viewing, all are passive. Also, will change theme to drop "bringing in," it is not reflected in the categories/codes and thus is a separate, new function now for T2 alone. Changed theme "for what" to "identifying information of interest". T13 is now 4 categories and 47/116 (47 source references and 116 code-references) and thematically independent from T2.

-I think next, I will map out all the categories to look for similarities in functions to validate theme development and separation.

-Need to reassess T7, too many open codes, needs categorized to align with others. Constructed 3 new categories from the open codes, so T7 is 4 categories and 58/139 references and stands well on its own thematic direction.

-T8 needs open codes categorized. Structured to 5 categories of similar functions 37/85 references. Categories need to be defined and documented to keep abstractions clear.

-10/7/21-performing thematic assessment of categories to themes resulted in several moves between T1 and T2 to better align the category functions with the thematic topics. No changes to themes. T19 distributed problem solving, does not have enough strength to stand on own and was folded into T4 as a transformation objective. T4 has strong thematic alignment now.

-T19 eliminated as the data behind it was not sufficient to keep it when compared to the strength of T4, but its thematic intent was captured and carried forward in T4.

-T17 was amplified to its purpose of system survival, a key repetitive theme in the literature base. T15 innovating was clarified as ES as the source not the object of innovating within the system. T9 needs further examination as a stand-alone or is it part of system transformation? It is about the ES function responding to change, not system transformation, not system design. Will revise wording to ES system "responding" and consider still as stand alone. Now we must look at variety engineering and is there a combining or enough strength to stand alone with T6, 10, 9,18. T18-C2 is not proactive in manipulating, just modeling what is there. It appears to fit better under T12. Moved it and added some open codes under T12 to it that thematically fit ok. Reworked T12 to create two categories at 10/20 references. I think T18-C1 changing in a systems environment is a very directed variety regulation function and thus should be combined into T6 as a new category and theme. T18 was eliminated (basically becomes the category). T18 renamed from T18-C1 and expanded to open codes under the new theme (former category) with 10/31 references but no categories. T18-C1 was redesignated as T6-C7 for closer thematic alignment.

-10/8/21-T20 redesignated T18 as admin move.

-Revised the umbrella theme (theory) after reviewing all the themes, now 18 themes, to reflect that the variety regulation is that which is caused by external change, not normal internal system variety, but includes internal variety (excess) resulting from external changes. Internal system variety generated by the system exclusive of external perturbations is an excellent research project of significant interest but is not part of this research as the literature field selected was focused mainly on external changes, also not much is written about internal induced changes. In practicality, we often see with people or leadership, policy changes causing system commotion and variety that needs regulated.

-ES theory-ES functions support complex system viability through regulation of system variety induced from changes in the system of interest's external environment-added the word functions as that is the action part of ES in this research and specified the system of interest. Will need more word work but is a work in progress in pass 5. The theme level ES functions seem to be pointing thematically towards variety regulation from external events planned or unplanned as closely related to system present and future viability. This seems logical in that if the external induced variety is not absorbed intentionally, it could become disruptive to the system which in turn, if not managed, could lead to a reduced or negative system viability trend.

-10/9/21-continued pass 5 by comparing categories to themes and categories to categories looking for thematic development or alignment. Relooking at open codes where no categories exist and how to improve the message for those themes versus listing a bunch of open codes to align like others. Sent Dr. Keating an update on pass 5 for discussion on process and thematic development thinking.

-T1-reviewed and corrected admin for several categories from T2 that were moved into T1. All now align thematically well; 6 categories 119/892 references make it solid in the data.

-T2-needs revised for better category alignment. Categories all refer to information not knowledge that is to be acted on. Removed knowledge and replaced with information. T1 is about developing knowledge, T2 is about acting on information for results. Moved codes off theme into categories as appropriate. Now 7 categories 107/456 references for good thematic alignment and references support.

-10/10/21-T3-changed theme active word to proactive for clarity purposes and to align with themes from C2/3 categories functions. Completed T3 categories at 86/270 references in good thematic alignment.

-T4-all good.

-T5-3 open codes need to be dispositioned for alignment purposes, not thematic. Also, categories need code references moved to codes for better clarity and thematic alignment. Reduced to 2 categories by abstracting codes and reassigning one to another theme as a better functional alignment. Completed pass 5 at 50/101 references.

-T6-C3,2,1 each have code-references assigned that need to be added to existing or new codes. All dispositioned by abductive inferences. Now 7 categories 52/209 references and no open codes

-T7-needs codes removed from categories. T7 now has 4 categories, no open codes. 59/138 references in good thematic alignment

-T8-2 categories need open codes unloaded for better alignment C4/5. Completed with 38/86 references remaining. Open codes moved need compared across categories for thematic alignment or direction.

-T9-all ok.

-T10-has 2 open codes to restructure. 3 categories 20/57references aligned. All categories now have no direct codes.

-T11-7 open codes to consider. Restructured T11 into two categories and realigned open codes to relevant categories. Completed at 15/38 references.

-T12-C2 has code references assigned that need to be redistributed to open codes. Completed internally as thematic alignment was close. 2 categories now have no direct codes 13/42 references.

-T13-C2,3,4 have code references assigned that need redistributed to open codes thematically. Completed with 4 categories 47/126 references.

-T14-has no categories and 5 codes. Need to determine if T14 is really a category or an independent theme. It could be under T4 system transformation objectives, T6 variety regulation, or T10 influencing; decided it is independent, important and is an ES developmental function not previously considered in CSG functions but needs category support. Resolved to 4 categories. No new thematic meanings developed. Resolved to 13/28 references.

-10/11/21-T15 start 4 open codes no categories to resolve. Will turn codes into categories, only 4 of them for conformance purposes, not thematic development. Converted to 4 categories as is, 5/25.

-T16-starts as 7 open codes. Moved one code out to a better category for alignment, combined one code into another for a category as functions were similar. T16 complete at 4 categories 7/15 references.

-T17-has 9 open codes no categories. Combined open codes into 2 categories. With 7/21 references it is slightly weak, but still thematically relevant.

-T18- has 12 open codes. All codes are combined into 4 categories with no thematic development changes ending with 8/17 references. I still need categories definitions to complete pass 5 work alignment.

10/14/21-seems like a bunch of data has been lost and not saved, unexplainable as I save every change in NVivo. Found a need to reload a saved version of NVivo data file to return to data as it was.

-Changed umbrella theme to clarify external variety induced only, thus residual variety internally to be regulated, not internally generated variety, even though it is present.

-As part of constant comparative method, reviewed each collective code set aside as not part of research scope. Scanning sources-- no changes. Scanning behaviors-- moved viewing and searching into appropriate themes as these are basic functions of ES. Moved several open codes to themes from scanning behaviors to be analyzed in future passes. Several codes in scanning issues moved to pathologies category.

-All open codes assessment completed, pass 5 completed.

-Next pass will need to review thematic consistency, ensure code alignment by function and abstraction is verifiable, review set-a-side codes again for incorporation as existing or new directions.

-Reviewed (thematic saturation checklist) for status:

- Do the concepts exhaust the variation in types of themes? **Not yet**, there is still combinations that appear to be possible, not sure all themes are truly independent from each other, and still have a considerable number of codes taken out of play to review again if they are not relevant or if they are new directions that need included.

- Is each theme conceptually grounded in systems theory principles? **Yes,** as the research database was comprised of systems theory-based articles, and the sensitizing concepts were taken for systems theory-based literature. Theoretical directions may not be consistent with existing systems theory-based concepts, but that is what the research is about in part, constructing new directions.
- Should the categorization of the themes be refined to encompass additional types and strategies or to eliminate one or more of them? **Yes, a work in progress**
- No matter the number of categories, are they both exhaustive and mutually exclusive? **Not yet**, a work in progress
- Do I have the data to describe the causes and conditions for, and consequences of, using these themes? **Yes, the data exists now**, but more may be coming as codes continue to be abstracted, added, or removed.
- Are the themes both explicable and understandable to an evaluating audience? **Not yet**, they are a work in progress but after pass 5 have some definition to them and some good reference strength. I do not want to limit them but need to keep looking for new directions being inferred, but not force creation of a new direction if there is a stronger path to abstracting into existing directions.

Summary: thematic/theoretical saturation is not present. Although progress through pass 5 is evident and there is a sense of convergence in the number of open codes, categories, and themes that increasingly demonstrates that the data fits into existing data structure upon close analysis.

APPENDIX K

ES FRAMEWORK FACE VALIDATION ASSESSMENT DATA

This appendix is the raw data in XLS format from the assessment of the ES framework themes in a practical setting of FEMA actions in Hurricane Katrina. The data is presented in three sections, one for each ES framework construct. Within each section are four referenced events from the literature bank that are used to assess each of the ES themes associated with each of the three framework constructs. The appendix is ordered by the ES framework constructs with external changes first, regulating variety second, and system viability last.

Umbrella theme: *ES theory--ES functions support complex system viability through regulation of internal and external variety induced by external changes*

Table headings and definitions (identified here to reduce repeated space use in the data table)**:**

Reference literature: The excerpts taken from the FEMA-Katrina reference material to be assessed with the ES framework. They are identified by a number that comes from their position in the reference item database for each construct. Not all identified reference items were used. The table below indicates which source each of the applied references was taken from.

Construct	**Appendix reference item**			
Regulating variety	6 House FEMA Investigation	5 Federal Response to Katrina	9 Federal Response to Katrina	36 House FEMA Investigation
System viability	3 FEMA Failures During Katrina	20 FEMA Failures During Katrina	36 FEMA Failures During Katrina	55 FEMA Failures During Katrina

Construct	Appendix reference item			
External changes	1 Federal Response to Katrina	6 Federal Response to Katrina	23 House FEMA Investigation	16 House FEMA Investigation

Construct: The FEMA-Katrina reference material is mapped against the three ES framework constructs as a sensitizing concept function

Theme: Refers to the ES framework 17 themes that are specifically relevant to the reference literature excerpt

Relevancy: Is ES theme function hypothetically present in the FEMA governance system actions?

Theme Function Practical Value: Value discussion related to reference event-was the ES theme function applied or not in the reference event outcome? Was the function strong enough to influence the outcome?

Theme Function Hypothetical Practical Value: If the theme is relevant, could its application have had a positive contribution to the reference event outcome?

Reference literature	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
	External changes				

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
Reference 1 First, the sheer amount of destruction over such a large area created an enormous demand for emergency assistance such as fuel, medical supplies, food, shelter, and water. This demand, coupled with the austere conditions throughout the Gulf Coast following Katrina's landfall, exceeded FEMA's standard disaster delivery capabilities and processes.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	no-no evidence of scanning so that was overwhelmed with variety in environment	yes-having real time input could have allowed for proactive response to emerging issues
		T2-**Acting** on information from the external environment to create system value	yes	no-FEMA pre-supposed an outcome that was not sufficient for the changes, they were too late to act to create system value	yes-acting on the predicted information could have improved the outcome
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-FEMA was totally overwhelmed with the external variety and driven into inferior performance	yes-a plan to escalate response based upon input could have improved outcome
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	no-there was no evidence of designing system changes to match expected environmental changes, resulting in inferior performance	yes-a purposeful plan to learn while the event was unfolding could have accelerated responses

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	no-the viewing of the environment was hindered by the severity of the storm, but it was viewed after the event had passed to begin recovery operations	yes-real-time input could cause system response in real-time versus after the event
		T9-ES system **responding** rationally to environmental turbulence to support system viability	yes	no-ES system was so overwhelmed by the external variety that the response was not rational compared to the need, it was underwhelming	yes-a plan to respond to input could have mitigated some bad outcomes
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	no-no evidence of a scanning system that would support better governance, the system by default was ad hoc and thus lagged the need, the scope, and the FEMA performance	yes-input to the system during event could help preparing response
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-perception that FEMA standard response would be sufficient was overcome by actual environmental trends that prevented effective decision making	yes-taking model predictions from Hurricane Pam modeling and adjusting for actuals could help response planning
		T11-**Implementing** ES system models for effective scanning in	yes	no-there was no evidence of a scanning model in place that	yes-taking model predictions from Hurricane Pam

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		changing environment		would have helped the FEMA respective	and adjusting for actuals could help response planning
		T16-**Sustaining** system identity through environmental changes for system survival	no	no-FEMA's identity was eroded through the event due to inferior performance as their governance system could not manage the external variety from the event	not relevant
Reference 6 Although FEMA had planned to place all evacuees into temporary housing by October 1, nearly 16,000 victims of Hurricane Katrina and Hurricane Rita, which made landfall near the Texas-Louisiana border on September 24, still remained in shelters in mid-October.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	no-FEMA was not proactive in scanning and was unable to match variety in environment	yes-more real-time data could help planning for recovery
		T2-**Acting** on information from the external environment to create system value	yes	no-FEMA was not able to act on housing information to meet stated objective of 1 October	yes-better variety regulation could have helped housing planning
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-FEMA was not able to regulate the variety in housing needs to meet stated objective	yes-better variety regulation could have helped housing planning

Reference literature	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	no-FEMA did not demonstrate any ability to design ES systems to improve performance and thus did not meet stated objectives	yes-a plan to collect progress could help decision making
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	no-FEMA was able to look at the environment to determine shortfall in housing, but was unable to process the info into decision making capability to meet objectives	yes-a plan to collect progress could help decision making
		T9-ES system **responding** rationally to environmental turbulence to support system viability	yes	no-FEMA was not able to respond to environmental turbulence in housing logistics to meet stated goals	yes-a plan to collect progress could help decision making
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	no-FEMA did not demonstrate any understanding of systemic role of ES functions and thus was not able to improve performance	yes-a plan to collect progress could help decision making
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-the perceived FEMA response did not meet the actual needs thus missed housing objective	yes-a plan to collect progress could help decision making
		T11-**Implementing** ES system models for effective scanning in	no	no-FEMA did not appear to have any	not relevant

Reference literature	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		changing environment		knowledge of ES models	
		T16-**Sustaining** system identity through environmental changes for system survival	no	no-FEMA did not appear to have any mechanism for protecting identity as best responder to disasters	not relevant
Reference 23 The other thing that I find interesting is that in all these scenarios that I'm sure you've thought out, did FEMA bother to realize that it is the 28th of the month, a lot of people live on fixed income, be it a Social Security check or a retirement check, they've already made their necessary purchase for the month. What they could not envision is having to fill up their gas tank one more time, at almost 3 bucks a gallon just to get the heck out of there. What no one is really focused on is a heck of a lot of people who stayed behind were people with limited means.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	no-FEMA did not demonstrate proactive scanning in this event due to presumptive focus on external events.	yes-active feedback could have aided response
		T2-**Acting** on information from the external environment to create system value	yes	no-FEMA's scanning system did not proactively go far enough to	yes-using existing information could improve response

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				understand the changes in its environment to be effective	
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-FEMA showed little means of regulating variety that was introduced by the Katrina event, thus was overwhelmed into inferior performance	yes-a plan to escalate response from planned could have helped response
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	no-FEMA clearly had designed scanning processes, but these were fixed, did not evolve with the environment, and led to inferior performance	yes-a system could have helped response
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	no-FEMA had the ability to look at the environment, but the look was shallow and after the fact leading to inferior performance	yes-FEMA had the ability to look at the environment and react
		T9-ES system **responding** rationally to environmental turbulence to support system viability	yes	no-FEMA's ES system responded, but not rationally as it was overloaded quickly from environmental change and did not adjust, resulting in inferior performance	yes-FEMA's ES system responded, but not rationally as it was overloaded and could be enhanced

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	no-FEMA did not appear to understand the need for system scanning functions, resulting in inferior performance	yes-a system could have helped response
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-FEMA had a fixed mindset on scope of environmental changes that was perceived, but did not match what really happened, resulting in inferior performance	yes-real-time data could improve responses
		T11-**Implementing** ES system models for effective scanning in changing environment	yes	no-Hurricane Pam simulation was a model of what Katrina was shaping up to be, but the lessons learned from the model were not applied to the future event to improve performance	yes-interactive modeling could help response
		T16-**Sustaining** system identity through environmental changes for system survival	yes	no-FEMA did not show much attempt at sustaining its identity thru this event, as was overwhelmed by the variety internal and external from Katrina.	yes-FEMA's identity as first responder could have helped system response

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
Reference 16 Storm-track projections released to the public 56 hours before Katrina came ashore were off by only 15 miles. The average 48-hour error is 160 miles, and the average 24-hour error is 85 miles. The Hurricane Center's predicted strength for Katrina at landfall, two days before the storm hit, was off the mark by only 10 miles. The FEMA/NWS team had the best predictions yet to be able to prepare with.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	yes-FEMA and NWS (National Weather Service) modeling tools and environmental info mining into those models was the best yet experienced and provided for best possible warnings and alerts of the event.	yes
		T2-**Acting on** information from the external environment to create system value	yes	yes-FEMA/NWS team acted very forcefully on the environmental information provided	yes
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	yes-NWS modeling and predicting tools could take in all environmental information and provided the best accurate predictions to date of event behavior	yes
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	yes-NWS modeling and prediction tools are constantly being improved to improve results, with Katrina being	yes

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				best performance yet	
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	yes-NWS/FEMA viewing system performed very well in predicting Katrina path and strength	yes
		T9-ES system **responding rationally** to environmental turbulence to support system viability	yes	yes-NWS/FEMA response was identified as one of the best predictions yet for major events	yes
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	yes-NWS/FEMA team demonstrated an elevated level of scanning understanding in developing their system of governance for major disasters	yes
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	yes-models generate perceived environments, but the FEMA/NWS team resolves the models with environmental data to support effective decision making that was demonstrated during the approach of Katrina	yes

Reference literature	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		T11-**Implementing** ES system models for effective scanning in changing environment	yes	yes-the team demonstrated superb models that were applied in this event to provide most accurate predictions to date	yes
		T16-**Sustaining** system identity through environmental changes for system survival	yes	yes-the identity of the FEMA/NWS team was reinforced by this event from the accuracy of predictions and communications to those involved	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
	Regulating Variety				
Reference 6 Communicating via television or radio with families enmeshed in their weekend routines was difficult at best, as was finding drivers and other needed volunteers.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	no	no-theme function of obtaining information was missing due to preoccupation with weekend activities, if people had paid attention perhaps more would have been prepared and the variety of the story threats would have been reduced, media is a variety amplifier when	not relevant

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
				applied appropriately	
		T2-**Acting** on information from the external environment to create system value	yes	yes-theme function of acting was demonstrated by responding to storm predictions and attempting to inform the external environment and obtain drivers	yes
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-theme function was demonstrated by going to media as a variety amplifier, but timing reduced effectiveness over weekend	yes
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	no	no-theme function of designing not demonstrated, but would be outcome of lessons learned to improve variety generation	yes-an ES system design could have helped the planning response
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	yes-theme function of looking was demonstrated as it generated need to inform population	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	yes-theme function of disseminating demonstrated by use of media to inform population	yes
		T10-System-environment **Influencing** to prevent future problems	no	no-theme function of influencing the environment not demonstrated but could improve future system actions from lessons learned in wake of storm events, like redesigning levees to be stronger.	not relevant
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	yes-theme function of resolving demonstrated by attempting to educate population of storm info by public media	yes
		T15-**Storing and retrieving** scanned information for future use	yes	yes-theme function of storing/retrievin g was demonstrated in this activity by preparing statements and broadcasts for use in media broadcasts	yes
Reference 5 Ineffective communications between FEMA and other Federal departments and agencies prevented available Federal resources from		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	no-theme function of obtaining was demonstrated by FEMA system, but was not used effectively to regulate external variety	yes-real-time information could improve response

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
being effectively used for response operations					
		T2-**Acting** on information from the external environment to create system value	yes	no-theme function of acting was being demonstrated by agency communications, though being done ineffectively	yes-theme function of acting was being demonstrated by agency communications
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	no	no-theme function of regulating was not displayed, attributed to FEMA system dysfunction in communicating with other federal agencies	not relevant
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	no	no-theme function of designing not demonstrated during the event, after the fact lessons learned should improve the communications system with other agencies	not relevant
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	yes-theme function of looking at external environment demonstrated by generating the need to communicate its info with other agencies	yes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	no-theme function of disseminating demonstrated by need to communicate info to other agencies, was poorly done	Yes-disseminating the right information could help and effective response
		T10-System-environment **Influencing** to prevent future problems	no	no-theme function of influencing was not done, communicating after the fact is reactive	not relevant
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-theme function of resolving differences was not demonstrated, was needed for agency communications	yes-resolving perception could improve responses
		T15-**Storing and retrieving** scanned information for future use	yes	yes-information was objective to be able to receive and transmit to other agencies for response, just done poorly	yes
Reference 9 FEMA had not determined the capacity of existing Federal agency call centers and telephone banks to handle increased call volumes. Consequently, victims registering for assistance via telephone repeatedly encountered long delays and disconnected calls.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	no-theme function of actively obtaining external information was demonstrated, but was not fully developed to regulate variety being experienced	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
		T2-**Acting** on information from the external environment to create system value	yes	no-theme function of acting on information was not performed well, but was demonstrated and could have improved system response	yes
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-theme of regulating variety was not performed but is relevant and could have improved outcome	yes-theme of regulating variety was not performed but is relevant and could have improved outcome
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	no-designing function was not demonstrated, could have improved outcome if performed, should be result of lessons learned	yes-could have improved outcome if performed, should be result of lessons learned
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	no-viewing theme was ignored to measure needs for call centers resulting in inferior performance	yes-viewing call volumes could have escalated capability
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	no-disseminating function was not performed sufficiently to support system decision making needs	yes-disseminating a key to improved response
		T10-System-environment **Influencing** to prevent future problems	no	no-influencing function is not relevant or useful to this situation	not relevant

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-theme function of resolving perceptions was not performed causing a poor system response.	yes-perceptions resolved for reality could have improved capability
		T15-**Storing and retrieving** scanned information for future use	yes	no-theme function of storing and retrieving was performed, just not sufficiently for the need	yes
Reference 36 FEMA's liaison arrived at the state's EOC (Emergency Operating Center) on Saturday, August 27. FEMA's Emergency Response Team-A (ERT-A) arrived the same day, August 27, when the state activated its EOC.19 On August 28, MEMA (Mississippi Emergency management Agency) reported that FEMA was deploying resources to a Regional Mobilization Center in Selma, Alabama, and that FEMA's ERT-A would be able to supply large quantities of water and ice to the hardest hit areas.		T3-Actively **obtaining** (proactive scanning) system external environmental information to support system planning	yes	yes-theme function of actively obtaining storm prediction resulted in significant advance preparation	yes
		T2-**Acting** on information from the external environment to create system value	yes	yes-theme of acting on information led to early planning and	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				preparation that reduced the impact of the event	
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	yes-theme of regulating variety was demonstrated by early arrival and pre-staging logistics to reduce impact of event	yes
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	yes-theme of designing ES system processes led to advanced staging in safe locations for logistics to reduce event impact	yes
		T13-**Looking at** (viewing) the external environment to identify information of interest (passive scanning)	yes	yes-theme function of looking at resulted in early arrival and pre-staging of support materials to minimize impact of event	yes
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	yes-theme function of disseminating information was demonstrated by pre-staging support to minimize event impacts	yes
		T10-System-environment **Influencing** to prevent future problems	yes	yes-theme function of influencing was demonstrated by pre-staging logistics to reduce event impacts	yes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	yes-theme function of resolving perceptions was demonstrated by arriving early and prestaging	yes
		T15-**Storing and retrieving** scanned information for future use	yes	yes-theme function of storing and retrieving was demonstrated from the plans pulled to pre-stage equipment	yes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
	System Viability				
Reference 3 FEMA's Director, Michael Brown, lacked the leadership skills that were needed for his critical position. Before landfall, Brown did not direct the adequate pre-positioning of critical personnel and equipment, and willfully failed to communicate with Secretary Chertoff, to whom he was supposed to report.		T1-**Developing** system knowledge from environmental information (data) to support system future viability	yes	no-theme function of developing system knowledge was not exercised during this event causing negative outcome	yes-developing knowledge could have improved the response
		T4-**Identifying** system transformation objectives in support of future system viability	no	no-theme function of identifying transformation objectives was not demonstrated weakening	not relevant

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				future system viability	
		T2-**Acting** on information from the external environment to create system value	yes	no-theme function of acting on information was demonstrated; it was done very poorly	yes
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-theme function of regulating variety was not demonstrated and led to inferior performance	yes-regulation could have helped situation
		T8-**Evolving** the governance system functions in support of future system viability	no	no-theme function of evolving governance function was not demonstrated or relevant to event	not relevant
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	no	no-theme function of designing was not demonstrated	not relevant
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	no-theme function of disseminating environmental information was done very poorly	yes-disseminating could improve the outcome
		T9-ES system **responding** rationally to environmental turbulence to	yes	no-theme function of responding to turbulence was demonstrated but very poorly	yes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		support system viability			
		T10-System-environment **Influencing** to prevent future problems	no	no-theme function of influencing the environment was not demonstrated	not relevant
		T12-**Maintaining** a model of the governance meta-system to support reducing system dilemmas	yes	no-theme function of modeling was not demonstrated	yes-modeling could help knowledge
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	no-theme function of understanding was not demonstrated	yes-improved understanding could have helped
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-theme function of resolving perceived trends was not performed	yes-resolving perceptions could help
		T15-**Storing and retrieving** scanned information for future use	yes	no-theme functions of restoring/retrieving were demonstrated in support of communication, but poorly done	yes
		T16-**Sustaining** system identity through environmental changes for system survival	yes	no-system identify function was lost in inferior performance	yes-identity could help with organization boundaries

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
Reference 20 FEMA funded and participated in this disaster simulation exercise in which a fictional, strong category three — with qualities of a category four — hurricane named Pam hit the New Orleans area. Emergency officials from 50 parish, state, federal, and volunteer organizations faced this scenario during the five-day exercise held at the Louisiana State Emergency Operations Center in Baton Rouge.		T1-**Developing** system knowledge from environmental information (data) to support system future viability	yes	yes-developing system knowledge was demonstrated through the modeling exercise with intent to improve future performance (viability)	yes
		T4-**Identifying** system transformation objectives in support of future system viability	yes	yes-system transformation was intended to happen from lessons learned from Hurricane Pam exercise	yes
		T2-**Acting** on information from the external environment to create system value	yes	yes-acting on previous information was used to create models for Hurricane Pam exercise with intent to improve performance (thus system value)	yes
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	yes-an outcome of successful and accurate modeling is to be able to prepare for real event that was modeled for purpose of supporting	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				system viability in future	
		T8-**Evolving** the governance system functions in support of future system viability	yes	yes-governance system evolution was intended outcome of the Hurricane Pam modeling event to improve system (FEMA) viability	yes
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	no	no-there was no evidence of designing ES system functions, modeling was based upon using what was already present or from history	not relevant
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	yes-outcome of modeling was distributing lessons learned to improve system (FEMA) response	yes
		T9-ES system **responding** rationally to environmental turbulence to support system viability	no	no-ES system responding rationally was not demonstrated as simulation was being applied	not relevant
		T10-System-environment **Influencing** to prevent future problems	yes	yes-the outcome of the simulation event was intended to improve the response environment to reduce future issues	yes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T12-**Maintaining** a model of the governance meta-system to support reducing system dilemmas	no	no-the simulation event could become a baseline for future simulations with upgraded info from lessons learned, but there was no sign of that	not relevant
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	no	no-no evidence existed of systems thinking and understanding the systemic role of ES functions, though this action could have improved results	not relevant
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-the model created outcomes to be used to improve performance, but from the reports, some of these outcomes were not applied to improve decision making.	yes
		T15-**Storing and retrieving** scanned information for future use	yes	yes-the simulation used much stored data and created data that was stored for lessons learned	yes
		T16-**Sustaining** system identity through environmental changes for system survival	yes	yes-purpose of simulation was to enhance role of FEMA's performance during actual event thus sustain its	yes

Reference	**Construct**	**Theme**	**Relevancy**	**Theme Function Practical Value**	**Theme Function Hypothetical Practical Value**
				positive identity during national disasters	
Reference 36 The HSA (Homeland Security Act) transferred FEMA functions, personnel, resources, and authorities to the DHS (Department of Homeland Security) Emergency Preparedness and Response (EP&R) Directorate. The emergency management community has complained since 2003 that FEMA was being systematically dismantled, stripped of authority and resources, and suffering from low morale, in part because of the Department's focus on terrorism.		T1-**Developing** system knowledge from environmental information (data) to support system future viability	yes	no-developing system knowledge was actually reduced under the move of FEMA to under DHS, reducing regulation of variety	yes-a knowledge management system could have helped in face of loss of experience
		T4-**Identifying** system transformation objectives in support of future system viability	yes	no-system transformation objectives were present but were misguided by the DHS takeover and resulted in inferior performance	yes
		T2-**Acting** on information from the external environment to create system value	no	no-acting on external info was not present in this activity	not relevant

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-objective was to improve performance by adding in DHS skills, but resulted in poorer performance during Katrina reducing system viability	yes
		T8-**Evolving** the governance system functions in support of future system viability	yes	no-did not work however to evolve the governance by combining FEMA with DHS	yes-a plan for governance would have helped
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	no	no-designing ES systems was not part of this activity, but if had been included, could have resulted in fewer issues in getting data to DHS from FEMA	not relevant
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	no-disseminating information was key to the alignment with DHS, but was poorly implemented and resulted in inferior performance and reduced system viability	yes-would help the communications
		T9-ES system **responding** rationally to environmental turbulence to support system viability	no	no-ES system was not active during this activity	not relevant

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		T10-System-environment **influencing** to prevent future problems	yes	no-influencing the environment for better performance could have been a good outcome but was lost in the DHS takeover function	yes-could help predict outcomes and response needed
		T12-**Maintaining** a model of the governance meta-system to support reducing system dilemmas	yes	no-maintaining a model of the governance system could have helped in the DHS takeover but was not done	yes-model could help knowledge development
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	no	no-ES functions were not evident in any of the takeover objectives	not relevant
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-resolving perception could have led to a better merger with DHS, but perception caused a loss of touch with reality resulting in poor System performance	yes-perception resolving would help decision making improve
		T15-**Storing and retrieving** scanned information for future use	no	no-using environmental information did not play a role in DHS merger	not relevant
		T16-**Sustaining** system identity through environmental changes for system survival	yes	no-sustaining the FEMA good identity through the changes would have helped performance, but was not	yes-could have helped retain key people

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
				done as lost key personnel	
Reference 55 In a catastrophic disaster, FEMA needs a "push" system in which FEMA officials anticipate needs (e.g., for food, water, medical supplies, ice, tarps, generators) and push the commodities to the parishes without receiving the request		T1-**Developing** system knowledge from environmental information (data) to support system future viability	yes	no-system knowledge was not applied to FEMA system design changes with DHS, resulting in reduces system viability	yes-could have helped changes
		T4-**Identifying** system transformation objectives in support of future system viability	yes	no-transformation objectives were identified, but were not directed towards future system viability, resulting in inferior performance	yes
		T2-**Acting** on information from the external environment to create system value	yes	no-information from Hurricane Pam desktop was ignored in trying to create value by moving FEMA into DHA, resulting in inferior performance	yes-modeling info could help knowledge
		T6-**Regulating** internal-external variety generated from external turbulence to support system viability	yes	no-regulating variety was crushed by putting FEMA under DHA, putting FEMA viability in jeopardy from	yes-plan to regulate could have improved outcomes

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
				inferior performance	
		T8-**Evolving** the governance system functions in support of future system viability	yes	no-system governance functions were to be improved with the DHS merger, but the merger was done without a systems view and resulted in reduced FEMA capability	yes
		T5-**Designing** environmental scanning system processes for internal and external functions to support system present and future viability	yes	no-with the merger into DHS it would be even more important to design the scanning system to be responsive to the environment due to the additional layers that DHS brought to the structure, but was not done, resulting in inferior performance	yes-a ES system could help
		T7-**Disseminating** essential environmental information (internal-external) throughout the system to support decision making	yes	no-the essential information about system performance needed to make the merger more powerful than the separate agencies was not made available or was not listened to, resulting in a structure that	yes-disseminating supporting information could have helped

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
				was reduced in effectiveness leading to inferior performance	
		T9-ES system **responding** rationally to environmental turbulence to support system viability	yes	no-with the merger FEMA system dynamics were ignore or overlooked, resulting in an agency with reduced capability to respond to environmental turbulence	
		T10-System-environment **influencing** to prevent future problems	yes	no-the merger with DHS was a good opportunity to redesign the FEMA system environment to be more proactive and of push nature versus pull, but this did not happen and resulted in inferior performance	yes
		T12-**Maintaining** a model of the governance meta-system to support reducing system dilemmas	yes	no-a model of the new governance system would have been a great tool to ensure that system dilemmas could be avoided, this did not happen	yes-model could have created knowledge

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
				and resulted in inferior performance	
		T17-**Understanding** the systemic role of scanning functions to enhance effective system governance	yes	no-scanning functions do not appear in any of the evidence for FEMA operations, leading to the conclusion that they were largely ad hoc versus engineered for performance, resulting in reduced system viability	yes-ES functions could have helped
		T14-**Resolving** perceived-actual environmental trends to support effective decision making	yes	no-perceptions were not resolved into facts, resulting in poor decision making in the merger of FEMA leading to inferior performance and reduced system viability	yes-resolving perceptions could have aided decision making
		T15-**Storing and retrieving** scanned information for future use	yes	no-the performance information available for supporting the merger appears to not have been a key player in the merger re-design, resulting in inferior performance	yes-could help knowledge retention
		T16-**Sustaining** system identity through environmental	yes	no-FEMA system identity was largely lost in the merger	yes-could have helped in retaining key personnel

Reference	Construct	Theme	Relevancy	Theme Function Practical Value	Theme Function Hypothetical Practical Value
		changes for system survival		with DHS, resulting in inferior performance and significantly reduced system viability	

APPENDIX L

EXPLANATION OF THE FUNCTION OF THE ES FRAMEWORK THEMES IN SUSTAINING SYSTEM VIABILITY BY REGULATING SYSTEM VARIETY INDUCED FROM EXTERNAL CHANGES

The table below is the detailed explanation of each of the 17 abstract theme's function as it acts in the ES framework. Each theme's function and the outcome of that function, if implemented, is given. Each theme's role in regulating variety is given. The theme explanations come from the abstracted category data the supports the theme abstraction. The function explanation also lists what other themes are influence by the given theme, and then lists the themes that inform the given theme.

Theme	Theme ES function	Resultant outcome	ES function explanation
T1	Developing system actionable knowledge	Support system future viability	The purpose of developing system actionable knowledge about the future environment is to support effective, proactive decision making that supports system development in response to environmental changes to keep the system viable. This is a second order function acting on input from other functions. In particular, developing knowledge from weak or fringe signals that could be indicative of needed change. Developing knowledge can come from modeling, data mining, envisioning, extrapolations, developing future scenarios, developing new products, identifying development opportunities, identifying future relationships, and informing the development

Theme	Theme ES function	Resultant outcome	ES function explanation
			of the strategic plan. Developing actionable system knowledge about the future is a way to amplify system variety to meet variety in the external environment to support system viability. T1 influences: T2, T4, T8, T5, T6, T10, T17, T14, T12, and T15. T1 is informed by: T3, T6, T13, T17, T14, T11, and T15.
T2	Acting on external information	Create system value	Acting on, processing, and responding to external information is a two-part proactive function. T1 develops knowledge, T2 turns it into system value by: understanding future external changes, system wide implications input to strategy, decision making to improve system performance, and strategy development to meet system goals. Acting on external information plays a role in regulating variety by acting on valuable information, filtering out non-relevant information. T2 is informed by: T1, T6, T7, T14, and T15. T2 influences: T4, T8, T5, T9, T10, T14, and T15.
T3	Actively obtaining external information	Support system planning for better system performance	Actively obtaining external information is a proactive function. It involves the functions of: actively searching, proactively researching, and proactive information seeking. The purposes of these functions are for strategic decision making and system learning that both support system planning. T3 is a precursor to T1 in that T3 brings in information that can be turned into actionable knowledge. Actively obtaining is part of regulating external variety by obtaining relevant information to system governance. T3 is informed by: T5, T6, T13, T9, T10, T17, T14, and T11. T3 influences: T1, T2, T4, T5, T6, T9, T10, T14, and T15.
T4	Identifying system transformation objectives	Support of future system viability	Identifying system transformations is a second order function. It takes actionable knowledge from T1 and identifies mechanisms, innovates, assists strategic decision making, facilitates planning, tracks knowledge, sets goals, defines future product development, models the external environment to invent the future, and

Theme	Theme ES function	Resultant outcome	ES function explanation
			distributes problem solving. The outcomes of the transformation functions are: sustained system development, system intelligence, improved performance, creating pathways of action, systems forecasts, and reduced system fear. T4 is a system variety amplifier by using future knowledge to transform the system now. T4 is informed by: T1, T2, T8, T5, T6, T17, T11, T12, and T16. T4 influences: T8, T5, T6, T17, T12, T11, and T16.
T5	Designing ES system processes	Support system present and future viability	T5, designing ES system processes is an active, second order function involving: purposefully designing scanning processes, developing a scanning system design strategy, improving the existing ES system design, and linking ES system design to system contextual factors. By designing an ES system process the system gets: effective future planning, system adaptive strategy, recognizing ES system pathologies, developing effective scanning functions. T5 is informed by: T7, T8, T4, T17, T11, and T12. T5 influences: T11, T12, T4, T6, and T8. By having a purposefully designed ES process, a system would be able to better regulate external variety as it occurs in contrast to an ad hoc scanning system.
T6	Regulating variety from external disturbances	Support system viability	T6 is an expansive but fundamental proactive and second order function that acts by: reducing external variety, generating internal variety, designing the system for variety regulation, developing absorptive capacity, active controlling, scanning internally to identify absorbed or residual variety, and manipulating the system's environment to reduce variety. All these functions act to meet a requisite variety condition where the number of states that system's governance mechanism can attain (its variety) must be greater than or equal to the number of states (induced by external changes) in the system being controlled for the system to be viable. T6 is both a theme and a Systems Theory-

Theme	Theme ES function	Resultant outcome	ES function explanation
			based construct constructed from this research. T6 is informed by all the themes that participate in regulating variety except for T15 and T16. T6 influences: T1, T2, T3, T4, T8, T5, T13, T9, T10, T17, T14, T12, T11, and T16.
T7	Disseminating system information	Support decision making	T7 functions are: communicating internally about future events, exchanging information, gatekeeping to distribute information, and facilitating developing external environmental intelligence. System survival, decision making, adapting to external changes, and system understanding are the outcomes of T7 functions. T7 functions in regulating variety by filtering external and internal variety to relevant system information that can be used for decision making. T7 is informed by: T1, T2, T3, T4, T9, T15, T13. T7 influences: T10, T11, T12, T14, T1, T2, T4, T5, T6 and T8.
T8	Evolving the system's governance functions	Support of system future viability	T8 is an active, second order function that includes: regulating the governance function, mind shifting thinking towards the future, evolving the system's design, syntropic behavior (orderliness), developing a capacity for self-assessment, detecting, and correcting governance system design issues, and restructuring from knowledge tracking. The outcome of these functions is: dealing with emergence, responding to future events, avoiding disorientation, improving system performance, and responding to external changes. T8 is informed by: T1, T4, T12, T17. T8 influences: T6, T10, and T12. Evolving the system's governance functions is a regulating method to deal with increasing external variety.
T9	Responding rationally to environmental turbulence	Support system viability	T9 is a passive function that includes: performing scanning, shaping scanning functions, scanning flexibility, alertness to world views, improving system image by demonstrating responsiveness to external changes. T9 occurs after external events have changed. T9 is informed by T2, T3, T13, and

Theme	Theme ES function	Resultant outcome	ES function explanation
			T14. T9 influences: T1, T7, T8, T10, and T11. Rational response is one sufficient to absorb external variety. The outcome of T9 functions is system survival, making strategic decisions, being comfortable with complexity, dealing with environmental turbulence, and being responsive to environmental changes.
T10	System-external environment influencing	Preventing future problems	T10 is a proactive function that includes system boundary permeability, boundary spanning for environmental linkage, intervening, and a system-to-environment and environment-to-system relationship for the purpose of influencing change in the external environment. The outcome of the environmental influencing is the prevention of future problems. This is variety amplification by the system to meet external changes. It is a proactive form of regulating variety by attempting to shape the external environment so that the future environmental changes are a known quantity. T10 influences: T2, T3, and T8. T10 is informed by: T14, T16, T1, T4, T6, T7, and T9.
T11	Implementing scanning system design models	For effective scanning in changing environment	T11 is a proactive, second order function. It consists of implementing and maintaining a system ES model. The output of the function is an effective scanning system in a changing external environment. T11 is part of regulating variety by changing the design of the ES system to be effective at regulating external changes. T11 influences: T12, T4, T5, T6, T8, T7, and T9. T11 is informed by: T13, T14, T17, T1, T2, T3, and T4.
T12	Maintaining a model of the system's governance meta-system	Reducing system dilemmas	T12 is an active, second order function that constructs and maintains a model of the system's governance meta-system. The outcome of the T12 function is reducing system dilemmas, envisioning the future, and enhancing system understanding. T12 acts to regulate external variety impacts by maintaining the meta-systemic model up to speed with system transformation changes that are induced by external variety. T12 is informed by: T13, T14, T17, T1, T2, T3, and

Theme	Theme ES function	Resultant outcome	ES function explanation
			T4. T12 influences: T16, T4, T5, T6, and T8.
T13	Looking at the external environment	Identifying information of interest	T13 is a passive function in that it is looking at what already exists. It consists of: monitoring critical aspects of the external environment, looking at existing information, sensing the external environment for information, and viewing the external environment for changes. The outcome of these functions is finding relevant information, finding topics of interest, sensing perturbations, and finding environmental changes and opportunities. T13 does not directly support regulating variety as it is passive, and its purpose is to identify information. It could support external variety reduction by filtering what it is looking at in lieu of the entire environment. T13 is informed by: T11, T8, and T9. T13 influences: T10, T14, T15, T1, T5, and T7.
T14	Resolving perceived to actual environmental trends	Support effective decision making	T14 is a proactive function. It involves removing perception filters, reducing perceptions in favor of reality, reducing perceived uncertainty, and being aware of reality construction. The outcome of T14 is better system decision making to enhance performance based upon facts not perceptions that could be misleading. Perception filters could amplify the impact of external variety as internal energy could be wasted on erroneous information and poor decision making, allowing residual variety to grow. Resolving perceptions is a kind of variety regulation that helps a system make better decisions, thereby reducing residual variety. T14 influences: T15, T16, T1, T2, T4, T6, T7, and T9. T14 is informed by: T3, T7, T13.
T15	Storing and retrieving scanned information	Future use by the system	T15 is a passive function. This function involves the storing and retrieving of non-trivial information so as not to amplify external variety, to manage information as core to the scanning function, and be establishing information refineries. The

Theme	Theme ES function	Resultant outcome	ES function explanation
			outcome of these functions is future use information, support for the scanning function, and using stored information to influence system strategy. T15 is informed by: T13, T14, T3, T7. T15 influences: T1, T2, T4, and T7.
T16	Sustaining system identity through environmental changes	System survival	T16 is an active, second order function. It is sensitive to the impact of chance events and dynamics in the system's environment that could cause the system to lose its identity. The outcome of this function is the system maintaining its identity through external changes to support its viability. T16 is informed by: T11, T12, T14, T17, T1, T2, and T7. T16 influences: T10, T4, T5, T6, T8, and T9. For system identity to be sustained in environmental churn, external variety must be regulated to absorb any internal residual variety that could pressure system identity.
T17	Understanding the systemic role of ES functions	Enhance effective system governance	T17 is a passive function that includes: offering a systems-based approach for universal applicability and easy deployment, understanding system governance from a systems theory-based approach, understanding systemic functions contributions to system viability, and developing a systems-based framework for proactively engaging the environment to regulate variety. The outcome of this function is an enhancement to system governance that stems from an understanding of ES's system role. It influences each of the 16 other themes. It is a strong basis for the variety regulation function that leads to system viability. It is not inherent in today's systems and needs to be introduced and learned until it is part of the system's knowledge. T17 is informed by: T16, T4, T8, T5, T6, T11, and T12.

VITA

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Dale Baugh has been a student in the Engineering Management and Systems Engineering department at Old Dominion University (ODU) since 2014. He has focused on research in the areas of Systems Engineering, System of System Engineering, Management Cybernetics, and Complex System Governance. He has authored four peer reviewed papers. Prior to becoming a student at ODU, he served in leadership and technical engineering management positions for over 32 years in the U.S. Navy (Commander, Puget Sound Naval Shipyard and Industrial Maintenance Facility, Deputy Commander for Industrial Operations and Logistics, Naval Sea Systems Command, Fleet Maintenance Officer, U.S Fleet Forces, and a nuclear ship operator and maintainer) and as an engineering director and manager in private industry (HII-Newport News Shipbuilding and HII-Mission Technologies). He holds a B.S. in Ocean Sciences from the United States Naval Academy (USNA), a M.S. in Ocean Physics from the Naval Postgraduate School (NPGS), an Executive MBA from Carnegie Mellon University, and a Ph.D. in Engineering Management from Old Dominion University. He is a member of the American Society of Naval Engineers (ASNE), the The Flag and General Officers Network (TFGON), the Southeast Public Service Authority (SPSA), is a certified Naval Nuclear Engineer, and is a member of Phi Kappa Phi Honor Society.